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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 direc ly 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-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 340).

Part III, a safety bulletin of Flight Safety Foundation, Inc. entitled "Seeing the Shear" discusses the wind shear hazard.

Part IV presents the list of laws and regulations relating to aircraft accident investigation as published in Accident Digest No. 11 together with all amendments received by ICAO up to 25 May 1962.

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 - 1960

Reports of fifty aircraft accidents occurring during 1960 in commercial air transport operations have been received by ICAO and are summarized in the present Digest. (One of these, the report of the Northwest Airlines, DC-7C ditching in the Pacific Ocean in July 1960 was a "late arrival" and does not appear in Tables A and B, but its classification appears at the end of the Summary - No. 42.) In addition, three reports, two involving training flights in large aircraft and one involving a demonstration flight, have been included in this Digest on the basis that they satisfy one or more of the following criteria.

1) World-wide interest in the accident, due to either

   a) major disaster aspect which had 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.

Concerning the accidents occurring in commercial air transport operations they may be classified as follows:

Scheduled operations	38
International	11
Domestic	27
Non-scheduled operations	11
International	7
Domestic	4

Also included in this Digest at the beginning of Part I are summaries concerning accidents which occurred in 1957 (one case), three which happened in 1958 and ten of the year 1959. The final reports on these accidents were recently released following lengthy investigations. These accidents do not appear in Tables A and B; they have, however, been classified in accordance with pages 16 - 20 of the Third Edition of the Manual of Aircraft Accident Investigation, and the classification appears at the end of each of the summaries concerned.

The classifications in Tables A and B follow closely the suggestions contained in the Third Edition of the ICAO Manual of Aircraft Accident Investigation. They have, however, been based on accident reports which have been founded on a variety of reporting and analysing techniques. Only a portion of the total number of accidents investigated by States are released for general publication or sent to ICAO. No effort has been made in this publication to classify 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 the cause 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 indicated without comparison with other sources, such as those published by national administrations.

Although considerable care has been taken in drawing up Tables A and B to ensure that the classification conforms with the findings of the reports from States, the very brevity of the tables 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.

A survey of the commercial air transport accident reports for 1960 suggests that the following features are worthy of attention:

i) 46.9% of the accidents reported occurred during the approach and landing stages and of these 17% were collisions with terrain or water and 13% collisions with objects. The remaining 70% were of various types and included three mid-air collisions and one explosion in flight, caused by a high explosive device and two overshoots, one of which was due to aquaplaning on the runway.

ii) 32.7% of the accidents reported occurred during the en-route phase. Of these, 31% were collisions with rising terrain. The remaining 69% were of various types; among them were two structural failures, one of which was due to flutter involving whirl mode oscillation of the outboard nacelles, one propeller overspeed, one fire in flight, and one explosion in flight due to high explosive in the passenger cabin. Three accidents were due to engine failure during normal cruise.

iii) 20.4% of the accidents reported occurred during the take-off and climb stages. One aircraft collision on the ground is recorded, and in another case the emergency condition was due to the failure of the distributor valve of the governing mechanism of the propeller, resulting in overspeeding and the detachment of propeller and reduction gear.

It should be noted that since Digest No. 12 also contains the summary of the accident report of a KLM L-1049 that occurred on 14 August 1958, in which propeller overspeeding was suspected, the proportion of propeller overspeeding cases, as contained in Digest No. 12, amounts to 3 in 53, or about 5.65%. Two of the three summaries contain detailed analyses of the causes and effects of this type of accident, which can entail serious consequences. In one of the cases the need for a strict observance of engine maintenance conditions is emphasized.

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 - 1960 (based on phase of operation)

Phase of Operation	No.	Type of Accident	No.	Description	ICAO Ref.	Type ** of Opera-tion	Page
Take-off (20.4%) *	10	Collision - birds	1	Bird ingestion caused loss of airspeed and control.	AR/722	S	277
		Collision - rising terrain	1	Pilot did not comply with departure procedures.	AR/718	NS	266
		Collision - aircraft - on ground	1	Misused the brakes and controls while on the ground.	REP/GEN/8	S	158
		Stall	1	The pilot was forced into instrument flight immediately after the aircraft became air-borne and was unable to cope with the situation.	AR/651	NS	216
		Loss of control	2	Undetermined.	REP/GEN/12	S	133
				Loss of control during premature liftoff.	AR/693	NS	299
		Emergency condition - forced landing	1	Rupture of the distributor valve of the port propeller.	AR/629	S	156
		Emergency condition - engine failed - take-off	2	Malfunctioning of the left engine shortly after take-off but after V_2 (the take-off safety speed).	AR/680	S	329
				Undetermined - most likely a defective fuel or ignition system.	AR/696	NS	246
		Undetermined	1	Turbulent conditions most probably encountered during which stall occurred at low altitude.	REP/GEN/1	NS	239
En route (32.7%)	16	Collision - rising terrain	5	Error of judgement, tried to land, when VFR, at a closed airport where no radio aid was available and when he was near more suitable airports.	AR/627	S	150
				Misjudged weather conditions and perform-ance capabilities of the aircraft.	AR/653	S	213
				Navigational error - struck mountain.	AR/652 AR/679 AR/701	NS S S	168 309 197
		Airframe - air	2	Flutter induced by oscillations of the out-board nacelles caused the right wing to separate in flight.	AR/676	S	137
				Fatigue failure of main rotor blade.(helic.)	AR/687	S	221

* Percentages are based on the total number of 1960 accidents classified - 49

** S = Scheduled NS = Non-scheduled

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TABLE A:- ACCIDENT CLASSIFICATION - 1960 (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)		Emergency condition - engine(s) failed during normal cruise	3	Delayed arming of the engine ice protection systems resulted in the loss of engine power and attendant electrical energy required to unfeather propellers and relight sufficient engines to maintain flight.	AR/688	S	100
				Fatigue fracture of reduction drive ring gear.	REP/GEN/1	S	117
				Exhaust valve failure resulted in a complete loss of power.	REP/GEN/1	NS	261
		Loss of control	1	Entry into a severe thunderstorm resulted in loss of control or one of the main parts sheared off or was completely damaged.	AR/689	S	274
		Propeller failure	1	No. 3 propeller oversped.	AR/640	S	253
		Explosion in flight	1	Dynamite explosion in the passenger cabin.	AR/639	S	96
		Fire in flight	1	Heavy fuel leak from a sheared or cracked fuel pressure pipe was ignited by sparks from the generator.	AR/659	NS	248
		Undetermined	2	Pilot was flying in poor visibility conditions for which he was not qualified - this may have led to the accident being caused by reasons of a psychological nature.	AR/665	S	116
				The cause of the accident was not determined.	AR/669	S	205
Landing (46.9%)	23	Collision - rising terrain	1	Aircraft was flown below prescribed minimum altitude on approach and hit hill.	AR/658	S	135
		Collision - ground	2	Descended below the minimum flight altitude for undetermined reasons.	AR/663	S	108
				Approached at below the prescribed minimum altitude; the altimeter settings differed.	AR/662	S	271
		Collision - water	1	Undetermined.	AR/660	S	184
		Collision - object	3	Improperly planned and executed approach. Hit dike.	AR/686	S	262
				Misjudged actual height of aircraft a few moments before landing. Hit rubbish heap.	AR/681	S	305
				Flew below the approved minimum IFR altitude and struck trees.	AR/648	S	120

* Percentages are based on the total number of 1960 accidents classified - 49
** S = Scheduled NS = Non-scheduled

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TABLE A:- ACCIDENT CLASSIFICATION - 1960 (based on phase of operation) (continued)

Phase of Operation	No.	Type of Accident	No.	Description	ICAO Ref.	Type ** of Operation	Page
Landing (cont'd)		Heavy landing	1	Adopted a final approach path which resulted in a heavy landing - major structural failure occurred in the port wing.	AR/625	S	111
		Collision - aircraft - both airborne	3	Non-observance of the instructions issued by Rio Control.	REP/GEN/8	S & M	124
				Pilots did not see each other in time to carry out avoidance action.	REP/GEN/5	S & P	174
				Jet went beyond its clearance limit and the airspace allocated by ATC.	AR/713	S & S	314
		Stall	1	Failed to take proper action to counteract loss of speed and height in the final approach turn.	AR/630	S	159
		Explosion in flight	1	The accident was caused by an exploding device.	AR/664	S	162
		Wheels-up landing	2	Poorly executed instrument approach necessitating a go-around which was initiated too late and improperly executed.	AR/690	S	164
				Breakage, for undetermined reasons, of bolt connecting shaft of actuating cylinder to retraction tube.	REP/GEN/15	NS	250
		Loss of control	2	Attempted a VFR approach during instrument conditions.	AR/702	S	296
				Undetermined.	REP/GEN/8	S	204
		Emergency conditions - engines failed - landing	1	Left engine failure followed by malfunctioning of the right engine.	AR/661	NS	229
		Overshoot	2	Aquaplaning - low frictional values during this condition prevented the captain from obtaining effective braking.	AR/682	NS	287
				Approached at too high an airspeed and aircraft touched down too far along the runway and failed to stop.	AR/707	S	335
		Undershoot	1	Misjudged threshold height prior to touchdown.	REP/GEN/17	S	154
		Groundloop	1	Failure of 0 ring seals in right-hand brake unit.	REP/GEN/17	S	219
		Gear retracted	1	Pilot inadvertently raised the undercarriage lever.	REP/GEN/1	S	294

* Percentages are based on the total number of 1960 accidents classified - 49

** S = Scheduled NS = Non-scheduled

TABLE B:- ACCIDENT CLASSIFICATION - 1960 (based on accident causes)

Causal Factor	No.	Description	No.
Pilot (55.1%) ★	27	- inadvertent gear retraction	1
		- continued VFR into unfavourable weather	3
		- exceeded ability - experience	2
		- improper use of miscellaneous equipment	1
		- improper IFR operation	9
		- exceeded stress limits - aircraft	1
		- improper in-flight planning	1
		- misuse brakes - general	1
		- misuse brakes - ground	1
		- failed to maintain flying speed	1
		- navigational errors	1
		- failed to observe aircraft	1
		- misjudged distance	3
		- continued into known unfavourable conditions	1
Power plant (14.3%)	7	- propeller	2
		- fuel system	1
		- engine structure	4
Airframe (4.1%)	2	- wings	1
		- helicopter	1
Landing gear (4.1%)	2	- brake	1
		- main gear	1
Weather (2%)	1	- thunderstorm	1
Miscellaneous (8.2%)	4	- passenger - exploding device	2
		- aquaplaning	1
		- bird collision	1
Undetermined (12.2%)	6	-	6

★ the percentages are based on the total number of 1960 accidents classified (49)

PART I

No. 1

Air France, Lockheed 1049G, F-BHMK, accident at Orly Airport, Paris, France 6 December 1957. Final report was released in Le Journal Officiel de la République francaise, dated 30 May 1961.

Circumstances

Three Air France captains were performing a semi-annual check flight aboard the aircraft under the supervision of an instructor. The fourth and final landing was being carried out at Orly at night on runway 26L using ILS GCA approach with a ceiling of 60 m (200 ft) and a forward visibility of 1 600 m (1 mile). According to witnesses, after making a normal approach, the aircraft tilted sharply to the left, touched the ground 400 m beyond the runway entry and then climbed a few metres; at this moment a fire developed on board, and the aircraft broke in pieces along the runway beginning 700 m from the runway threshold lights. The aircraft came to a halt outside the runway after the separation of the left wing and the right wing tip. The 6 crew members immediately evacuated the flaming wreckage. There were no fatalities. The accident occurred at 1800 hours GMT.

Investigation and Evidence

The Aircraft

Its certificate of airworthiness was dated 31 January 1957. The aircraft was last inspected by the Véritas Agency on 22 July 1957. It had flown 3 075 hours since manufacture and was scheduled for a major overhaul on 8 December 1957 (i.e. two days after the accident).

The Crew

The instructor and pilot-in-command

The instructor held a valid airline transport pilot's licence and a navigator's licence. He had flown a total of 9 044 hours including 3 331 hours of night flying. He had flown 385 hours on the subject type aircraft including about 19 hours as pilot instructor at the Orly personnel training section. During the preceding two months he had flown 42 hours on this aircraft type, and was classified in Category A (for landing minima).

The pilot performing the landing under supervision of the instructor

He held a valid airline transport pilot's licence and had flown 11 961 hours of which 4 070 were by night and 1 079 were on this type of aircraft. He was classified in Category B (for minimum landing requirements).

The two other captains were also undergoing a periodic check. The two flight mechanics held valid licences and had considerable flying experience.

Weather

Orly Region - conditions between 1700 and 1800 hours

low overcast, hazy; stratus clouds, indistinct base at 50 to 60 m, upper limit towards 600 m; horizontal visibility - at runway station 26G it varied from 1 300 to 2 000 m.

1740 hours		1 300 m
1800	"	2 000 m
1810	"	1 300 m

temperature: 1.1 to -1.3°C at the meteorological office;

temperature above ground: negative from the ground to approximately 600 m, positive from 600 to approx. 2 500 m, negative above approx. 2 500 m

Icing conditions, therefore, prevailed for an aircraft flying between approximately 50 to 600 m. Icing conditions were probably slight as is generally the case in a stratus; however, the aircraft may have encountered heavy icing at the upper limit of the layer just at the base of the point of inversion of temperature.

The Flight

The aircraft took off from Orly at 1417 hours GMT and the first part of the exercise was held at Reims Airport.

The second part of the check was at Orly where the crew was authorized to perform several GCA monitored ILS approaches on runway 26. Two of the captains each performed an approach followed by a touch-and-go landing. Then the third captain took his place in the left-hand pilot's seat.

He was told to perform an aerodrome circuit similar to that carried out by the two preceding pilots. It was then decided to conclude the check by a final approach, the fourth at Orly, allowing him to remain in the left-hand seat.

A stabilized approach was performed very accurately; the aircraft made its approach at 200 ft with a landing weight of 97000 lb, the runway was visible and the aircraft crossed the threshold lights at a speed of about 120/125 kt, dropping 450/500 ft per minute with flaps extended 60%. The manifold pressure reading was 27 inches.

At the beginning of the flare-out the aircraft was still almost on course but drifting slightly to the right.

The pilot tilted the aircraft to the left in order to bring it back on course. The resulting bank seemed excessive to the instructor, who judged that it was due to a manoeuvring difficulty which the pilot could not handle.

The instructor kept the aircraft airborne with engine power and then took over the controls reopening the throttle; at this point a fire could be seen from the ground.

As soon as the instructor became aware of the fire on board, he decided to pancake the aircraft on the runway as quickly as possible.

A violent impact then occurred followed by disintegration of the aircraft and a general fire.

Ground marks

The dispersal pattern of the wreckage plotted on a chart at a scale of 1/1000 showed that the main body of wreckage lay 60 to 80 m from the left side of the runway and approximately 1 150 m from the runway end.

A large section of the left wing with its engines and the detached left landing gear remained in the centre of the runway 1025 m from the runway's end.

In brief, the following evidence was found along the direction of normal landing:

1) **Fragments from** the left navigation light indicated a contact on the right half of the runway towards the fifth marker (250 m);

2) A skid mark to the left of the right landing gear, located in the centre of the left half of the runway 370 m from the runway approach end;

3) A double set of marks:

   - right landing gear extending over some 40 to 700 m starting near the marks along the runway;

   - left landing gear and forward landing gear, one third as long, beginning 30 m further down the runway.

The above-mentioned marks were accompanied by propeller scores and by marks of impact of the wings, the right wing first, then the left with smashing of the marker and other breakage including that of the left landing gear, which appears to have definitely collapsed at this moment.

Owing to the need to clear runway 26L as quickly as possible because of atmospheric conditions, such units as the left wing, the left landing gear, etc. were removed; consequently the lack of time permitted only a cursory on-the-spot examination of these units.

Detailed investigation was thus carried out on parts that had already been moved and, consequently, certain data given below should be considered and interpreted with caution.

Main wreckage (including the fuselage from the cockpit to the tail assembly and part of the right wing) - it was largely destroyed by fire. The left wing was torn out at its root. Part of the right wing with engines Nos. 3 and 4 as well as the right landing gear still remained attached.

Cockpit

It was difficult to examine the cockpit since it burned after the aircraft had come to rest. While it was possible to ascertain the general position of the controls, no useful information could be obtained from the instrument dial readings since the instruments were electrically operated, and the pointers had returned to zero.

Pilot's instrument panel

throttles:	on reduced
reverse lever:	inactive
propellers:	high pitch
flap control:	near 0
flap indicator:	near 100 %
de-icer control:	off
elevator tab:	near neutral
rudder tab:	index showing 1/2° to the left
aileron tab:	index position could not be ascertained

Propellers

The hub mechanism of propellers Nos. 1, 2 and 4 was broken. Propeller No. 3 appeared to be only slightly damaged - the three blades were in the feathered position.

Discussion

Meteorological conditions

The visibility and ceiling observations taken at the runway entry at the time the aircraft landed were as follows: visibility 2 000 m or less, height of cloud base 60 m (ill-defined).

The conditions were adequate for carrying out a landing. Under training conditions, landing trials are conducted under a "curtain" of 30 m (to provide an adequate safety margin), namely, at half the prescribed critical height for a scheduled flight. The landing, therefore, was undertaken and conducted in accordance with the regulations.

However, the aircraft switched to visual flight only a few seconds before reaching the approach end of the runway - this accounts for its slightly oblique position at the last moment.

Conditions favourable to icing already existed in the cloud layer between 50 and 600 m, which were the altitudes within which the aircraft had performed aerodrome circuits at Orly.

The crew, in fact, did observe moderate icing which may have reduced the aerodynamic qualities of the aircraft upon landing.

Aids and Ground Services

The control tower personnel, particularly the radar monitor, noticed nothing abnormal during the approach.

The landing aids were operating normally.

Two characteristics of the approach lights on runway 26 are worthy of note. They are not aligned with the runway centreline but constitute an extension of the left edge of the runway. Owing to the configuration of the terrain, its length is reduced to 560 m (1840 ft).

The Aircraft

It had been overhauled and maintained in accordance with procedures. No defect had been observed by the crew. Examination of the wreckage did not yield evidence to show that the aircraft was in other than a satisfactory operating condition.

Reconstruction of the flight path

Based on testimony of ground personnel, the crew members and the marks noted on the runway, the final approach and landing phase of the flight were reconstructed.

At a point 1 600 m from the approach end of the runway the aircraft was slightly to the left of the runway centreline and 10 m above the glide path. It was flying under ILS with radar control.

The breakthrough to visual flight conditions occurred at a point 200 or 300 m before the first approach lights i.e. 800 m from the approach end of the runway.

The aircraft crossed the runway threshold at a height of about 15 m at a slightly oblique angle to the right of the runway centreline; 150 m beyond the threshold, the aircraft was still deviating slightly to the right so that, at only several metres' height, it was flying approximately over the right edge of the runway.

At a point approximately 200 m beyond the threshold, the aircraft performed a sudden manoeuvre producing a sharp transversal inclination which brought the left wing in contact with the right edge of the runway.

Between 200 and 500 m, the aircraft veered back sharply to the left; thereafter manipulation of the throttle and the ailerons brought it back to the right at the moment when the pilot-in-command, after deciding to accelerate the engines, was warned of fire on board.

Because the fire was spreading rapidly the aircraft was then forced violently to the ground. It struck the ground to the right and to the left successively and crashed approximately 700 m beyond the runway threshold. It then broke up.

The path which had been tangent to the left edge 500 m from the runway entry returned to alighment with the centreline about 1 000 m from this entry at a point where the detached left wing came to rest.

The main body of the wreckage which had continued towards the left, describing a very tight arc, finally came to a stop 1 150 m from the entry and 70 m away from the edge of the runway.

Piloting

The aircraft broke through at 200 ft with the runway in sight and crossed the threshold lights flying at a speed of 120/125 kt roughly along the runway's centreline. The pilot reduced throttle and began his flare-out.

The throttle reduction and the beginning of the flare-out appeared normal but the aircraft deviated to the right side of the runway so that the instructor warned the pilot "to keep centred". The pilot adjusted to the left by means of the ailerons, then the instructor himself re-opened the throttle in order, as he said, "to steady the aircraft".

The effect of the instructor's warning apparently prompted the pilot to manoeuvre sharply in order to bring the aircraft back to the left at the moment when the flare-out had already begun. The accident was, perhaps, attributable to the following:

a) while still flying at insufficient speed, the aircraft was held in an excessively inclined position close to the ground and the wing made contact;

b) or, that since the speed was insufficient (owing to icing) to perform a turn, the aircraft made contact with the ground on the left before it could recover.

In any case, the instructor took over the controls too late and under unfavourable conditions.

Certain factors may be pointed out respecting the two pilots involved in this accident:

1) the instructor is 35 years of age, and the pilot is 44;

2) the instructor received his airline transport pilot's licence in 1947 and has been an Air France captain since 1951, whereas the pilot received his licence in 1941 and has been flying operationally as captain since 1944;

3) the instructor has logged 385 hours as captain of Super Constellations as against 1078 hours for the pilot. Their flying times are 9 044 and 11 960 hours respectively;

4) at the time of the accident the instructor had logged only some 19 hours in the Constellation in the capacity of instructor at the Orly personnel training centre.

For psychological reasons, these factors could have influenced the behaviour of these pilots.

Probable cause

The Board considered that the accident was the result of excessive corrective manoeuvres performed at the time of contact with the runway ... icing on the aircraft might have reduced its aerodynamic qualities.

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ICAO Ref: AIG/ACC/REP/GEN/No. 5 - France

Training Landing Loss of control Pilot - misuse, flight controls

No. 2

Air France, DC-3, F-BAOA, accident at Poitiers-Biard Aerodrome, France on 8 January 1958. Final report of the accident was released in Le Journal Officiel de la République française, dated 30 May 1961.

Circumstances

The aircraft was on a training flight and was carrying 8 persons - one pilot-in-command/instructor, one flight mechanic, four trainee pilots and two passengers. During the flight the trainee pilot at the controls was carrying out a break-through and landing procedure on one engine, which was discontinued in its final phase owing to the landing gear having locked too late. When power was re-applied the aircraft veered to the right and crashed into the buildings of an army munitions dump on the edge of the aerodrome. Three crew and one of the passengers were injured as a result of the accident which occurred at 1315 hours GMT.

Investigation and Evidence

The aircraft had a certificate of airworthiness valid until 28 April 1958. At the time of the accident 247 flight hours had elapsed since the last major overhaul. The left and right engines had operated for 53 and 805 hours respectively since their last major overhaul.

The pilot-in-command/instructor held a valid airline transport pilot's licence, and at the time of the accident he had logged a total of 8 141 hours of flight, 427 of which had been on the DC-3 type of aircraft.

The trainee at the controls at the time of the accident had a valid commercial pilot's licence and had flown about 6 000 hours in all, 63 of which were on the DC-3.

The mechanic aboard the aircraft had flown 128 hours, 127 on the DC-3 aircraft and only approximately 50 hours as sole mechanic on board.

The meteorological conditions were as follows: visibility 20 km; wind westerly 4 m/s*; cloud 5/8 cumulus, base 800 m.

The Training Flight

F-BAOA was on a pilot training exercise that involved landing with one engine out and re-application of power following missed approach practices.

Having arrived at Poitiers at 1115 hours, the aircraft subsequently took off at 1245 hours to perform the aforesaid emergency procedures on the aerodrome. The aerodrome commander accompanied the crew to ascertain the IFR operating conditions at Poitiers.

Because of the imminent qualification of the trainees as pilots-in-command, the instructor did not sit in the co-pilot's seat but stood behind the pilot at the controls.

Since a hood was used to simulate instrument flying conditions, a safety pilot occupied the co-pilot's seat.

The first trainee took off for a homing exercise on the MF marker with one engine out, a break-through procedure, and a go-around power.

The second trainee replaced him for a similar exercise ending, however, with a real landing to enable the aerodrome commander to disembark and proceed to Limoges.

* 7.8 kt approximately

The left engine was re-started and the pilot, after having completed an aerodrome circuit, began a relative bearing variation on the radio beacon.

Shortly before arriving abeam of the radio beacon the right engine was cut off. The trainee-pilot ordered retraction of the landing gear and re-application of power on the right engine.

The outbound segment was normal. It lasted two minutes and twenty seconds. The turn and return were correctly performed and brought the aeroplane above the radio beacon into proper alighment 4 minutes later, at a height of 300 ft.

The hood for the simulated instrument conditions was then removed and the pilot began his descent. The landing check-list was run through except as regards the landing gear which, because of its drag, should be extended only when it becomes certain that the landing will be completed.

Moreover, so as to avoid having to re-start the engine on the ground, the engine was set to windmill during the approach.

Extension of the landing gear was ordered when the aircraft arrived above the radio beacon, and the windmilling began only at an altitude of 200 ft.

Above the approach end of the runway, at an altitude of approximately 100 ft, the mechanic announced that the landing gear was not completely extended.

The pilot called for take-off power and retraction of the landing gear just when the mechanic announced that it was locking in extended position.

The aeroplane began to veer to the right while the mechanic took the controls of the right engine to attempt to increase its power.

Speed fell and the veering to the right increased. The aeroplane was headed for the munitions dump. It struck two sheds in succession and came to a standstill without fire breaking out.

Reconstruction of the flight path

The final approach, re-application of power, and veering to the right were observed by an instructor of the Poitiers flying club, who, on board a Stampe, was waiting to take off.

This witness saw the plane in descent, with its landing gear extended, and aligned with the centre line of the strip. The beginning of the landing seemed normal up to touchdown. At that moment (600 m beyond the end of the runway), he saw the DC-3 pick up speed and 100 m further on it started to veer to the right at ground level. He thought this manoeuvre odd since the speed of the aeroplane appeared to him to be insufficient. The aircraft recovered opposite the munitions dump.

The plane struck the corner of a first building with the right side landing gear and the right engine. Without reducing the speed of the aircraft considerably, this impact caused it to veer markedly to the right. The nose of the plane then hit the ground and while it continued to move tail end forward, the trailing edge of the right wing hit a second building. This impact tore off the right wing and stopped the turning movement causing the fuselage to break, by inertia, at the level of the emergency exits. The aeroplane came to a stop a few metres farther on.

The distance of less than 60 m between the first point of impact and the place at which the plane came to a standstill, the reconstruction of the movements, and the relatively small magnitude of the various impacts, indicate that the speed of the aircraft was very low at the time of impact.

Discussion

When training crews for emergency or distress manoeuvres, the risks that have to be accepted are necessarily greater than those obtaining in normal operating conditions.

It should be borne in mind, however, that a normal flight can end up in the conditions of these training flights and thus present the same hazards.

For this reason it is necessary to consider the details of this exercise (right engine failure and simulated 100 m ceiling) as circumstances of the accident and not as the cause thereof.

It can, therefore, be recognized that the flight was quite normal up to the time of the power reduction on the active engine, a few seconds before reaching the approach end of the runway.

At that moment the landing gear was not locked, compelling the pilot to re-apply power.

Had the landing gear not been so slow to extend, it is probable that the landing would have been completed satisfactorily.

But it is possible that the power reduction, without prior check of the position of the landing gear, was associated with an intentional reduction in speed which prevented the aircraft from being kept under control when power was re-applied symmetrically.

The slow extension of the gear and the failure to check that it had locked appear to be the initial causes of the accident. However, it should be mentioned that landing procedures with one engine inoperative prohibit extension of the gear, whose drag is considerable, before having ascertained positively that the landing can be completed. Verification of its proper positioning can then only take place at a time when the pilot is engrossed in navigating his plane.

In addition, when power was re-applied, the retraction of the landing gear ordered by the pilot was not executed, a fact which apparently played a significant part in the crucial phase of the veering to the right. The recent qualification of the mechanic (120 flying hours), who was concentrating on getting the second engine operative again, would account for this omission.

Finally, the windmilling right propeller undoubtedly contributed to a great extent to the veering to the right.

It would seem that the decision taken by the instructor to let the engine windmill was aimed not only at avoiding the inconvenience of additional operations on the ground but also, to an extent, at preserving an additional margin for possible manoeuvres.

The fact that this engine not only did not provide any power but, on the contrary, slowed the aircraft was the decisive cause of the accident.

Examination of the right engine showed that it was in good working order, and trials made on identical engines in similar conditions of temperature gave positive results.

It is likely that the mechanic's lack of "know how" was at the root of this engine failure.

Lastly, the presence of a munitions dump less than 500 m away from the intersection of the runways could have turned this serious accident into a real tragedy. That this was avoided was due only to chance.

Probable cause

The accident was due to the successive appearance of two incidents during a training exercise:

- slowness of the landing gear to extend;
- failure of the right engine to pick up power.

The crew, which included a pilot under training and a mechanic with limited experience, did not properly coordinate their actions.

The instructor, because of his position in the cockpit, was unable to assist.

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ICAO Ref: AIG/ACC/REP/GEN/No. 5 - France

Training
Landing
Emergency manoeuvres
Crew - did not properly coordinate their actions.

No. 3

Réseau Aérien Interinsulaire, Catalina PBY 5, F-AOVV, accident in the lagoon at Raiatea, Leeward Islands, French Polynesia, on 19 February 1958. Report from La Direction de l'Aviation civile dans le Pacifique-Sud as released in Le Journal Officiel de la République française, dated 30 May 1961.

Circumstances

When making the final approach to a calm water area at a very low altitude and under visual flight conditions, the pilot initiated a shallow turn to the right, banking slowly. During this manoeuvre, at 1 400 m from the approach end of the alighting channel, first the right wing-tip float, then the right wing caught the surface. The aircraft struck the water violently and, about 10 minutes after the accident, sank in 36 m of water. Of a total of 3 crew and 23 passengers aboard the aircraft, the 3 crew members and 12 of the passengers were killed in the accident. The aircraft was destroyed. The accident occurred at 1850 hours GMT.

The accident site was 1 400 m from the southeast extremity of the water area and 150 m to the west of Motu Taoru islet in the Te Ava Piti passage.

Investigation and Evidence

The Aircraft

It was owned by the Territory of French Polynesia and operated by Réseau Aérien Interinsulaire.

Since its last periodic overhaul the airframe had flown about 94 hours. The engines and propellers had flown 27 and 127 hours respectively since their last overhaul.

A preflight inspection of the aircraft was carried out by the chief engineer of R. A. I. at the Papeete seaplane base.

Crew Information

The pilot-in-command was a former military pilot in the naval air force. He jointed the Trapas Company in August 1947 as a Catalina pilot. From February 1948 on he apparently had no opportunity to pilot seaplanes again until November 1955. He then came to Tahiti and flew 21 hours while replacing a Catalina co-pilot with R. A. I. In January 1958 he returned to Tahiti to replace a pilot-in-command, who was on leave, and since then he had logged 15 hours 40 minutes of flight. Before resuming the duties of pilot-in-command on a Catalina he piloted the aircraft for 1 hour 30 minutes under the direction of another Catalina pilot-in-command. During the 48 hours preceding the accident he had flown 2 hours 40 minutes on this aircraft type.

He held valid airline transport pilot and navigator licences and also had type ratings as pilot-in-command on DC-3, DC-4, DC-6 and Catalina aircraft, as well as a valid instructor's rating and an international restricted radio telephone operator's certificate.

The co-pilot also had a valid airline transport pilot's licence and type ratings as pilot-in-command on NC 701, DH 89, JU 52, DC-3, DC-4 and PBY 5 aircraft, the last obtained on 12 February 1958. He had flown a total of 6 000 hours 55 minutes as of 1 October 1957. His flying time on the Catalina PBY 5 was about 92 hours, 37 of which were flown within the two preceding months and 2 hours 40 minutes in the preceding 48 hours. Before arriving in Tahiti on 15 November 1957, he had never piloted a seaplane.

The flight mechanic had a valid licence and ratings on the DC-3, Grumman Mallard and the Catalina. He had flown a total of 1 323 hours 45 minutes as of 18 February 1958. On the Catalina PBY 5 he had flown 1 050 hours - about 37 of which were flown during the two preceding months and 2 hours 40 minutes during the previous 48 hours.

Loading and Trim

The total take-off weight of the aircraft and the maximum licensed weight were both 28 000 lb. The load sheet indicated a total weight of 28 027 lb but allowing for the gasoline consumed in warming-up the engines, the aircraft certainly weighed less than the 28 000 lb declared by the captain before take-off.

At departure the aircraft carried 700 US gallons (4 200 lb) of gasoline and 60 US gallons (450 lb) of oil.

At the time of the accident, i. e. after 10 minutes of engine warm-up and one hour of flight at cruising speed, there remained approximately 600 US gallons of gasoline and 59 US gallons of oil.

The position of the centre of gravity recommended by the operating manual for this aircraft was between 22. 9 and 28. 5%. According to the load sheet signed by the captain, the centre of gravity was at 28. 2%.

The Accident

At 1752 hours GMT the aircraft left Papeete for the Leeward Islands. The first stop was Raiatea, an island 118 NM from Tahiti. During the flight, which was through cloud, the pilot maintained contact with Papeete control tower on 3 023 kc/s (tower) and 8 845 kc/s (en route air-ground watch), transmitting his positions and weather observations in the normal way. He reported mediocre visibility over the route as a whole. At no time did he report mechanical difficulties, but he was concerned with the weather conditions at Bora Bora, an island situated 23 NM to the northwest of Raiatea, where visibility was very poor - 1 km with rain.

The aircraft was supposed to alight on the Uturoa water area (principal town of Raiatea) where forward visibility was 10 km. The sky was overcast: altostratus at 2 000 m, with low clouds (1/8 fractocumulus) at 400 m. The lagoon was grey and smooth since there was no wind.

After informing the Papeete control tower at 1840 hours that Uturoa was in sight, the pilot asked Bora Bora for a new QAM (the latest meteorological observation), and asked for the Bora Bora locator to be switched on when he left Raiatea: estimated time of departure: 1930 hours. Papeete replied that in one minute the QAM would be supplied by the meteorological services at Bora Bora and that the NDB would be functioning at the time indicated. The captain asked Papeete on what frequency the QAM would be given, presumably in order to obtain a fix more rapidly, and announced that he was going to try and pick it up directly and would, therefore, stop receiving for a few moments.

At 1852 hours, immediately after receiving the QAM, Papeete called the aircraft again to enquire if he had received it satisfactorily. The operator was not surprised to receive no reply because the crew never reply when carrying out take-off or landing manoeuvres.

Manoeuvres immediately preceding the accident

It was possible to reconstruct, from the statements of survivors and witnesses, the route taken by the aircraft as it circled the aerodrome.

Arriving from the southeast, the aircraft flew over the water area from southeast to southwest. After passing "le Régent" cape where the wind cone is located, it made a 180° right turn, crossing the outer reef. The downwind portion of the aerodrome circuit was carried out over the sea.

According to the precise statement of an R. A. I. employee who followed, by means of headphones, the exchanges of conversation over the aircraft interphone, it would appear that the checks prescribed in the operating manual were carried out as the aircraft circled the aerodrome. The wing-tip floats were lowered when F-AOVV was in the downwind position, just after it had passed the Te Ava Piti passage.

The pilot had started his last turn over Avera Iti Bay, about 5. 5 km from the edge of the water area at an altitude which it was impossible to determine from the statements of witnesses.

The aircraft approached at a speed of 80 mph, descending normally and smoothly. When it passed Ava Piti it was below the tops of the coconut palms - at about 10 m therefore.

About 300 m further on, i. e. 1 400 m from the edge of the water area, it was performing a shallow turn slightly banked to the right, still descending sharply. The right wing-tip float caught the water and was torn off, then the right wing and the nose of the aircraft struck the water violently. At no time did the witnesses see the aircraft initiate the manoeuvre which would bring it into the slightly nose-up configuration, an indication that the pilot sees the water and is preparing to alight.

The force of the shock swung the aircraft around about 90° to the right.. An opening appeared at the level of the first passenger compartment located immediately behind the crew compartment. Then the whole of F-AOVV sank below the surface except for the left wing and the stern section of the fuselage. The survivors were able to escape by the opening mentioned above and by the rear door.

Examination of the wreckage

The divers' statements permitted a general assessment to be made of the damage suffered by the aircraft, before parts of it were towed to where the water was 10 m deep and then onto dry land on Taoru Island. The following is a summary of the divers' written statements with supplementary details which they gave verbally.

Fuselage -

The fuselage was lying on its right side, the nose of the aircraft having been completely crushed. There was a gaping hole in the side of the fore passenger compartment. All the afterbody appeared to be in good condition. The emergency exit located in the rear was open.

Wings and engines -

The wings, which were only held onto the fuselage by the aileron control cables, were tilted upright on the leading edges at an angle of about 60° to the hull. The two engines were still in position, and there was no evidence of fire. The engine cowlings were about 20 m away and the missing propellers were never found. The right wing tip was considerably damaged and had apparently struck the seabed with sufficient force to aggravate the damage resulting from impact on the surface of the lagoon. In addition, a tear roughly 1. 20 m in length extended along the lower surface of the same wing (made by the right strut or the propeller). The left wing with its wing-tip float extended was intact.

When the aircraft was towed into water 10 m deep by traction from the Lotus' windlass, the aileron control cables snapped. The wing, now severed from the hull, slid down to a depth of 46 m. As it was becoming dangerous for the divers to descend to such a depth with the limited equipment available to them, (Cousteau outfits) it was decided to abandon the recovery of the wreckage of the wing and engines, since the atmospheric conditions were deteriorating. The lumps of coral scattered over the bottom of the lagoon had seriously aggravated the damage already caused to the hull, which did not make the examination thereof any easier.

The left undersurface of the hull (extending forward from the crew compartment to about one metre from the first step) was all in one piece while virtually all the right undersurface of the hull had been ripped away and was missing. A metre from the first step, the hull was sliced, due to shear failure of the fixing rivets at the general level of the torque corresponding to the amount of the adaptable landing gear.

The cockpit was sliced about 20 cm in front of the metal sheet which reinforces the hull in the plane of the propellers, flush with the front of the bulkhead behind the pilots' backs.

In the metal, which was moreover twisted inwards, the cut was so clean that it must have been made by the right propeller. The entire nose of the aircraft was missing as was also the instrument panel. The upper part of the cockpit remained except for the two sliding panels of the emergency exits.

The section of the fuselage containing the two passenger compartments in the centre of the aircraft was crushed, apparently as a result of the salvage operations.

The rear of the fuselage, particularly the end of the compartment near the left rear exit, and all the empennage, were practically intact.

The four wing struts were still attached to the fuselage at the bottom, but the fittings attaching them to the wings had been wrenched off.

Overall examination of the wreckage revealed that the metal plating was in good condition and the cables and pulley-wheels which looked like new, were well lubricated and had been properly maintained. The rudder controls and control column were found to be badly bent. None of the various control cables was cut (with the exception of the aileron cables which were severed during salvage operations).

The right wing-tip float bore traces of impact: the plating was crumpled and the right side of the front was dented, all of which led to the conclusion that the float struck the water at an angle of 45° while the aircraft was sliding slightly to the right.

Most of the floor of F-OAVV was never recovered; in the rear compartment the bolts which mounted it had been sheared flush with the floor.

No seat or seatbelt was recovered.

Although the engineer's instrument panel was recovered, it did not provide any useful information as the needles had shifted since the accident. The altimeter for instance, (which was set at 1,005 mb whereas the correct setting would have been 1011 mb) indicated 3 200 m.

A radio receiver was discovered tuned to 13 Mc/s which did not correspond to the frequencies used during the flight.

The elevator tabs were correctly at the low position to assist the pilot to level off at the moment he alighted.

The rudder tab was over to the left thus assisting the pilot to turn to the right.

It must be noted, however, that each tab had a severed control cable when the wreck was brought up, and it would therefore have been possible for the tabs to have moved in any direction.

Causes of the Accident

Meteorological conditions:

The combination of a completely overcast sky (with a layer of altostratus over the whole region and some fracto-cumulus at 400 m) and the absence of any wind or any ripples on the smooth grey surface of the lagoon was conducive to the appearance of mirages and would make it difficult for the pilot to judge his exact altitude above the water area during the most delicate manoeuvre of the flight, namely the alighting. Reports of witnesses clearly showed that there had been no attempt to level off the descending aircraft, so the pilot evidently did not see the water.

Although there was no wind, the position in which the wind cone had earlier come to rest led the pilot to come in to alight on a northwesterly course which is only done about once every twenty landings at Raiatea. Furthermore, even through a layer of altostratus the sun could be troublesome. Facing northwest as he alighted, the pilot had the sun almost at his back. It should be noted that when alighting from the southeast the aircraft was obliged to fly a right-hand circuit in order not to fly over the town or land, and when making a right turn the first pilot's vertical visibility is diminished.

Finally, as the pilot was manoeuvring to bring the aircraft into proper alignment, the right wing dropped below a safe altitude.

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ICAO Ref: AIG/ACC/REP/GEN/No. 5 - France

Scheduled
Landing
Collision - water
Pilot - failed to level off

No. 4

KLM, Lockheed Constellation L-1049H, PH-LKM ("Hugo de Groot"), accident over the Atlantic Ocean near Ireland on 14 August 1958. Findings of the Accident Investigation Board as released by the Director General of Civil Aviation, The Netherlands - 9 June 1961.

Circumstances

PH-LKM took off from Shannon Airport, Ireland at 0305 hours GMT as scheduled flight KL 607E to Gander, Newfoundland. On board were 91 passengers and 8 crew. Normal radio contact with the aircraft was maintained until 0340:48 hours following which nothing further was heard from the aircraft. At 0847 the Shannon Air Traffic Control Unit instituted the alert phase, and search and rescue action was initiated. Approximately 110 NM west of Ireland wreckage of an aeroplane was observed at 1345 hours. When salvaged the wreckage proved to be parts of PH-LKM. No one survived the accident.

Investigation and Evidence

Background Information on the Investigation

As the accident occurred outside the territorial waters of Ireland, the chief investigator ordered a preliminary investigation to be made. The Director of the Aeronautical Inspection Division of the Department of Civil Aviation assumed the responsibility of supervision of this investigation and the Inspector of Accidents, Department of Civil Aviation, was sent to Ireland as representative of the preliminary investigator and to take delivery of the salvaged wreckage.

Basic evidence for the inquiry consisted of: salvaged wreckage, watches, clothing and the recovered bodies of victims. (A medical examination of the victims was held on their arrival at Galway, and it was continued in The Netherlands.)

The wreckage was examined by experts of the Department of Civil Aviation and of KLM assisted by a police expert in Amsterdam, the Forensic Science Laboratory at The Hague and the Federal Bureau of Investigation in Washington. An expert of the National Aero and Astronautical Research Institute examined the recovered watches.

In addition, an investigation was made into military and civil aviation movements and military operations involving rockets or missiles near the accident site and at the approximate time of the accident.

The Crew

The eight crew aboard were the captain, a first and second officer, a first and second flight engineer, a purser, a steward and a stewardess. All held valid licences, and had extensive experience on Constellation L-749/1049 aircraft as well as considerable recent experience during the two months preceding the Accident. Some of the crew members had been on duty on an international flight during the two weeks before the accident and had then had a few days rest.

During the year preceding the accident the captain had been tested on his ability to perform emergency procedures (the so-called "proficiency check") and the month before the accident he had demonstrated his ability to fly the route Amsterdam - New York. He was known as an exacting pilot who saw to it that the crew members performed their duties properly, and he possessed a very great sense of responsibility.

The Aircraft

Based on the American Certificate of Airworthiness for Export, a Netherlands certificate of validation for this aircraft was issued which was valid until 21 April 1959.

At the time of the accident the aircraft had a cabin seating capacity of 100 seats.

From the time of construction of the aircraft until its departure from Schiphol for this flight - Schiphol - Shannon - Gander - New York the aircraft had flown a total of 886 hours. It had been subjected to a No. 2 inspection before departure from Schiphol, and a new maintenance certificate was then issued which was valid until 1 046 flying hours had been logged. The aircraft, its engines and propellers had been inspected at the prescribed times. The technical history of the aircraft gave no indication with respect to its maintenance (by KLM) of any doubtful element relating to the airworthiness of the aircraft.

It appeared from examination of the history of the automatic pilot that a malfunction had been observed eight times and once marked aileron deviation had occurred. Despite lengthy testing, this last phenomenon could not be reproduced nor could the cause be determined. Upon the request of the Board, the National Aero and Astronautical Research Institute at Amsterdam undertook an investigation into the possible causes and consequences of the malfunction observed in the automatic pilot. KLM in the course of its investigation of the malfunction replaced all components of the aileron part of the amplifier, so that the origin of the malfunction was presumably located in the less accessible parts of wiring or connections. Furthermore, a defect would not constitute a dangerous situation since a single pilot can fly the aircraft if the automatic pilot were defective. The Board, therefore, agreed that KLM could not be blamed in any way with respect to the measures taken to remove the malfunction.

The Flight

Amsterdam - Shannon

The flight originated at Schiphol Airport and was scheduled to New York via Shannon and Gander. This portion of the flight was normal except towards the end. When it was in contact with Shannon radar and thereafter with the Shannon control tower its transmissions were heavily distorted and scarcely audible, while its reception of messages from Shannon radar was weak and distorted.

This disturbance in the radio communications was very likely caused by interference from a radio station transmitting on the same frequency; the short duration of the disturbance is particularly indicative of this influence which has, in practice, occurred several times.

At Shannon a normal transit inspection of the aircraft was carried out under the supervision of the aircraft's flight engineers, who were also licensed aircraft maintenance engineers. Everything appeared to be in order.

Shannon – Gander

The captain checked and signed the flight plan for the Shannon - Gander portion of the trip which had been drawn up by the SABENA flight operations officer. Inasmuch as another KLM aircraft was flying to Gander at almost the same time, it was suggested that the captain of PH-LKM should fly at an altitude of 16 000 ft (4 850 m) and this course of action was agreed upon.

The captain was then informed of the weather conditions expected along the route. At about 5 000 m, i.e. the cruising altitude, the weather was mainly good. Between Shannon and 20°W the weather would be affected by a disturbance southwest of Ireland causing thickly stratified clouds between 3 000 and 6 000 m with some cloudiness below. From there to the ground there would be rain and drizzle.

Light to moderate icing was expected in the stratified cloud layer above the $0^{o}C$ level (approximately 3 000 m).

From the forecast for the more western part of the route, it appeared that the crew were justified in executing the flight.

The take-off weight of the aircraft did not exceed the maximum allowable, and the centre of gravity was within prescribed limits.

The KLM - aircraft maintenance engineer, who had been in the cockpit immediately before departure of the flight for Gander said the captain at that time was in the left-hand pilot's seat, the first officer was in the right-hand pilot's seat and one of the flight engineers was at the flight engineer's panel behind the right-hand pilot's seat. Part of the cockpit check had been performed in his presence by the first officer and the flight engineer. The starting of the engines and other pre-flight operations proceeded in a normal manner.

Reconstruction of the presumed flight path follows:

It appeared that the aircraft took off from runway 23 at 0305 hours and proceeded in a slightly climbing right-hand turn on its track on a true heading of 278^{o} According to reports, the aircraft passed the Kilkee Beacon at 0316 and reached an altitude of 1 824 m at 0320, of 1 980 m at 0322, of 3 190 m at 0334 and 3 650 m at 0339.

The aircraft was cleared to climb to 4 850 m on a radial of 292^{o} (true heading 278^{o}) on the north side of the airway reckoned from the VOR beacon near Shannon. At the request of Shannon Air Traffic Control the aircraft relayed a message to another aircraft (TWA 6951) at 0340 hours. At 0340:48 PH-LKM informed Shannon Air Traffic Control that the TWA aircraft had received the message and ended the communications which had been quite normal and without interference during the entire flight i.e. including the last message.

When it was established that all radio contact with the aircraft was lost, extensive search, rescue and salvage action was undertaken. The final result was that only 34 bodies and some debris were salvaged. Attempts to recover the wreckage had to be abandoned -

1) because of the great depth of of the ocean in the general area of the accident, and

2) because the exact location of the wreckage was not known.

Examination of the salvaged wreckage

The wreckage consisted of the backs of seats, the wheels with tires and parts of the nose gear, ceiling panels, wall lining, floor covering and wall partitions from cabin and cockpit, the four life rafts, cushions, handbags, life jackets, the emergency radio, mattresses, a piece of metal construction of a wing section. From the recovered nose gear it was deduced that it had been retracted and locked at the time of the accident.

The safety belts were still attached to some of the seats. None of these belts showed signs of tear or other damage to indicate that the belts had been subjected to great forces. As they were found unfastened, it was presumed that they were not fastened when the accident occurred. Damage to the seat remnants indicated that the seats from which they were torn were struck from behind by round objects. This gives rise to the assumption that the passengers were not fastened to their seats with seat belts and that at impact they were thrown against the backs of the seats in front of them. The deformation and damage to the backs of the seats indicated that the folding thereof was obstructed by objects (i.e. persons) wedged between the backs of the seats and the seats themselves. The damage to the seats indicated that they were exposed to large progressive inertia forces, which can only have occurred at the moment when the aircraft moving in a forward direction struck the water. The wreckage gave the impression that the slope of the flight path was not very great at the moment of impact. The four life rafts were all recovered; the very slight damage sustained by them was believed to have been caused while the rafts were still folded in the wing recesses.

Results of the examination of the victims

The injuries to the 34 victims recovered showed a striking similarity. This justifies the assumption that the victims were submitted to deceleration acting mainly in the direction of the longitudinal axis of the aircraft.

There were no indications of poisoning by carbon monoxide, fuel or its deritives, or indications of explosions, fire or radioactive contamination. All showed traces of prolonged immersion in water, but there were no signs of drowning.

There were indications that the injuries may have been incurred in two stages -

1) the fat and bone marrow embolisms which were observed; and

2) the injuries with and without haemorrhages.

The victims had no injuries which indicated that the safety belts were fastened at time of impact. Nothing definite could be established as to the duration of the interval between the two stages mentioned above. At present, medical science has not reached the stage where it is possible to say the minimum period of time that is required to cause such embolisms to appear.

As it is known that pulmonary fat embolism, or at any rate, the forming of noticeable pulmonary fat may occur, though to a slight degree, in cases of sudden death with serious damage to the cardiovascular system, and although this may also occur in cases of serious dysbarism, it gives ground to the supposition that if a two phase trauma occurred, the interval between need would have been of very short duration, perhaps in the order of a few seconds.

1) Of the 34 victims recovered 26 were identified. No flight crew members among them.

2) None of the victims was found to be wearing a life jacket.

3) Only three of the victims were wearing watches. From the indications of the watches, the expert estimates that the impact of the aircraft with the surface of the water did not occur earlier than 0345 hours GMT, or later than 0355 hours GMT.

Analysis

The data available to the Board concerning the accident was incomplete as there were no eye witnesses' statements nor radio messages after the aircraft reported normally at 0340:48 hours and only a limited number of pieces of wreckage were available.

It was believed that the aircraft crashed into the sea between 0345 and 0350 hours, i.e. 5 to 10 minutes after the last radio contact. It must be assumed that the flight proceeded normally up to an altitude of about 4 000 m, where the aircraft was probably at a distance of about 110 NM from Shannon near 12°W. It is certain that the aircraft had not yet reached the assigned cruising altitude when the accident occurred. The mean position of the the ships which picked up objects from the bottom of the sea about a month after the accident was 53°12.5'N, 11°53'W. This position, marking the site of the contact with the water, is in agreement with the position which can be inferred from the flight data and from the location of floating debris, taking into account the effects of the ocean currents and wind.

The flight crew had considerable experience on this aircraft type. There were no indications that fatigue had played a part in the accident. In the medical data available on the flight crew there were no indications of any impairment or illness whatsoever which might have led to a sudden incapacity to carry out their duties. Based on the known habits of the captain, it can be assumed with a high degree of probability that during the climb he did not leave his seat, had fastened his safety belt, had flown the aircraft manually, and in an emergency situation would have given all his attention to the manoeuvring of the aircraft and would not have been able, therefore, to transmit a message to the ground.

There was no reason to doubt the airworthiness of the aircraft.

Although a malfunction of the automatic pilot had occurred eight times, which one one occasion had resulted in the defective operation of the aileron, KLM had taken appropriate measures to remove the defect. Such a defect was able to be excluded with a reasonable degree of certainty as being the cause of the accident. Firstly, it was considered highly improbable that the captain was using the automatic pilot at this stage of the flight, and secondly, if he had done so the study by the National Aero and Astronautical Research Institute showed that even if such a defect had occurred it should not have led to an uncontrollable flight since in such a case the captain is able by a moderate effort to check a malfunctioning automatic pilot and restore the aircraft to its original flight attitude.

Following the departure from Shannon the weather conditions were favourable. There was no weather phenomenon which would have endangered the safety of the flight.

A collision with aircraft, guided missiles or rockets was out of the question as there were none in the area when the accident occurred.

Because of the relatively short period that this aircraft was in use, the occurrence of a failure due to structural fatigue may be excluded. There was no evidence to indicate sabotage, explosion, fire or radioactivity. Examination of the victims of the accident gave no indication of a bomb explosion, carbon monoxide posoning, or traces of explosive decompression. Decompression of the cabin at the differential pressure at the time of the accident may only have occurred at the result of the opening of a door which had not been closed properly and could not have had serious results for the occupants, except for those who were near the opening in the fuselage. For these reasons, disintegration of the aircraft resulting from explosive decompression of the fuselage was ruled out as a possible cause of the accident.

The condition in which some of the life saving equipment was found following the accident indicated that it had not been made ready for use. This fact, the type of damage to the seat backs and the injury pattern of the recovered victims indicated that the captain did not intend to ditch the aircraft. The lack of any radio message also points in this direction.

As the factual data and the conclusions derived therefrom gave no indication as to the cause of the accident, the investigation then proceeded to consider possible defects which might account for the accident.

During the 5 to 10 minutes which elapsed from the end of the last radio message at 0340:48 to the impact with the water between 0345 and 0350 hours, no messages or emergency calls were received from the aircraft either by Shannon Air Traffic Control or any other aeronautical radio station. In this brief space of time the actual cause of the accident must have appeared, and the descent from about 4 000 m to sea level must have taken place.

If something happened which made the electrical system inoperative e.g. a short circuit or damage resulting from a propeller strike, this still does not explain why no use was made of the emergency radio equipment which is not connected to this system.

The absence of any radio message reporting a ditching leads to the supposition that the descent was not made due to a decision of the captain, such as would have been the case had he become aware of an emergency situation, but it was rather directly attributable to the emergency situation itself in which the attention of the crew was entirely occupied with the operation of the aircraft so that there was no opportunity to transmit a message.

The nature and similarity of the injuries sustained by the recovered occupants as well as the similarity in the type of damage to the seat backs point to the conclusion that all, or at least those passengers who were subsequently found, were in their seats with their seat belts unfastened at the time of impact with the water.

Furthermore, it appeared that some of the passengers still had loose dentures in their mouths. From this the Board deduced that during the descent the aircraft did not make abnormal movements such as to throw the passengers off their seats. The movements may, however, have been so violent that the passengers could not use their hands for other safety measures than holding onto their seats. As to whether the aircraft reached the sea intact or whether it was still controllable or not could not, in the opinion of the Board, be answered with any degree of certainty.

Of the various suppositions considered during the investigation as to what actually happened, the Board felt that the only acceptable hypothesis was that of a compound malfunction of the governor of one of the outer propellers which resulted in "overspeeding" to such a degree that an uncontrollable flight condition developed.

The type of engines with which the aircraft was equipped has been liable to fractures in one of the driving gears of the blower (bell-gear). On connecting the gears the gearload can be high which may lead to fracture of the gear. At the time the emergency occurred, the aircraft was at an altitude where the gear mechanism was activated. The possibility of fracture of the bell-gear should, therefore, be seriously considered. In the period between 10 October 1957 and 13 May 1959 such a fracture occurred 18 times with KLM with this engine type.

The crew can become aware of such a fracture in several ways. The fracture will lead to a decrease of the manifold pressure and the engine power, which values can be read from the instruments; the fracture can increase friction, which will lead to a rise in the oil temperature, which can also be read. This defect will cause the crew, probably after some unsuccessful attempts to remove it, to shut off the fuel supply to the engine concerned and to feather the propeller; however, between observing the first irregularities and these actions, taking into account the attempts to restore normal conditions, a considerable amount of time - in the above-mentioned 18 cases up to 30 minutes - may elapse.

Upon fracture of the bell-gear, just as with fracture of other engine components, metal particles may infiltrate into the oil system. This system also supplies the propeller governor with oil. It is possible that a metal particle - roughly even ten seconds after the break occurs - may reach the governor and then prevent the proper operation of the sleeve valve or a valve, so that these elements can no longer shut off the oil supply to the pitch regulating mechanisms of the properller blades. The propeller pitch will then no longer adapt itself to the existing flight conditions but may be excessively reduced until the limit is reached, which is set by a stop device, - the flight fine pitch (f.f.p.) stop, (pitch of 14° at 75% of the propeller radius). In this situation the propeller is windmilling and drives the engine; it produces a drag instead of a thrust and rotates at a high rpm ("over-speeding") despite the cutting off of the fuel supply.

The crew may become aware of this malfunction by the high tonal pitch of the rapidly turning propeller, by observation of the rpm indicator, while the turn and bank indicator will vary considerably. The change from propeller thrust to propeller drag provokes a rotation around the vertical axis of the aircraft which produces a rolling moment and, at the same time, the decelerated slipstream behind the defective propeller also causes a rolling moment in the same direction. The procedure to be followed by the pilot when overspeeding is noted should be to cut off the fuel supply to all engines and to actuate the feathering button of the defective propeller.

In the above-mentioned 18 cases, a moderate case of overspeeding occurred only once, which indicates that the pitch regulating mechanism is not especially sensitive to the presence of metal particles in the oil. Also, in this case the propeller could be feathered. On 26 October 1960 a fracture of some other engine components and not of the bell-gear produced a case of overspeeding of an outboard engine as a result of oil pollution. The captain of the aircraft concerned made a statement to this effect at the public inquiry of the Board on 28 April 1961. The propeller could not be feathered, and the controllability of the aircraft presented no difficulties.

In the investigation of the PH-LKM accident, a particular study was made, by the National Aero and Astronautical Research Institute, of the question of the effects of overspeeding on the controllability of the aircraft.

Calculations were made by the Institute. The Board came to the following conclusions on the basis of its report and of the statements made by an expert witness, (an engineer-pilot with the National Aero and Astronautical Research Institute), at the public inquiry on 28 April 1961.

When overspeeding occurs and the propeller pitch limitation takes effect by means of the f.f.p. stop, the aircraft's movements are impaired. However, the pilot may adjust them without difficulty through appropriate handling of the controls. A situation of this kind must have arisen during the above-mentioned flight at a flying speed presumably lower than that of PH-LKM. Consequently, the impairment was less serious. If, however, at the same time a metal particle shuts off a second valve, the ensuing increased oil pressure may lift the f.f.p. stop. If this happens the propeller pitch will decrease even more, which process, in this case is further accelerated by the activation of the feathering motor mechanism. As a consequence, the propeller drag attains a very high value and consequently the rotational speed of the aircraft around its longitudinal and vertical axes will be much greater than in a case of overspeeding at the f.f.p. In particular, the magnitude of the bank leads to an uncontrollable flight condition; the aircraft will attain a high rate of descent and with the accompanying increase in flying speed the propeller drag increases and, consequently, its effect. A calculation based on a pitch angle of 4^{o} at 75% of the propeller radius demonstrates that even if the other engines are cut off immediately upon the occurrence of overspeeding, and the pilot takes action within three seconds, by vigorous movements of the airleron and rudder controls, the aircraft may fall definitively out of control. The operation of the ailerons by the pilot should be the first reaction in the case of a high angle of bank. This is, however, not sufficient to bring the aircraft back to normal. If in both cases the rudder control were also operated, it is highly probable that this action would be too late to ensure return to a controlled flight situation. The investigation revealed, therefore, that overspeeding of the propeller may cause a a disastrous situation which develops so quickly that action by the pilot is useless. In such a case, however, it is necessary that besides the regulator sleeve of the governor, the valve also which controls the f.f.p. stop is blocked by metal particles in the oil. Such a double malfunction has not as yet occurred, as far as is known. In view of the very dangerous situation is provokes, it may well have been the cause of this particular accident. Though the degree of probability that these two defects will occur simultaneously, is small, it is, of course, possible as the two defects have a common cause, i.e. the presence of metal particles in the oil. After the accident the governor of the propeller type concerned has, on the advice of the manufacturer, been provided with a device which makes feathering possible, independent of the position of the regulator sleeve valve.

This device can also become inoperative through oil pollution but the chance of simultaneous failure of both feathering devices is considerably smaller than the chance of failure of one single device which, as experience with many cases of oil pollution due to engine malfunction has shown, is in itself very slight.

Conclusions

On the basis of the evidence available and the investigation of possible serious threats to safety, the Board cannot establish the cause of the accident with certainty. Moreover, investigation of the possibility that the cause of the accident may have been a bomb explosion has yielded no conclusive facts to support such a hypothesis. The statements in the press to this effect have either been based on misunderstanding or else were tendentious. On the other hand, the Board attributes a high degree of probability to the hypothesis that the cause of the accident is related to "overspeeding" of one of the outboard propellers resulting from oil pollution after a gear had been damaged when the supercharger of the corresponding engine was accelerated (shifted). This probably took place close to the time of the accident. The overspeeding of the propeller, owing to the obstruction of metal particles in the regulator valves, may have been such as to cause the propeller pitch to decrease and the propeller could not be feathered. This condition might provoke a flight disturbance which could be corrected only by prompt and powerful handling of aileron and rudder controls. In view of the rapidity with which this defect develops and taking into account that recognition of the nature of this malfunction requires a certain time, it is not always possible for the crew to intervene early enough to restore conditions of controlled flight.

With respect to the presumed cause of the accident, the Board has no grounds to suppose that the occurrence of the presumed malfunction might be attributable to neglect on the part of maintenance personnel or to incorrect measures taken by the crew or that the crew had been at fault in piloting the aircraft after the malfunction had occurred.

The Board has noted with satisfaction that after the accident the propeller governors corresponding to those used by KLM have been provided with a device which is designed to improve the reliability of the feathering mechanism.

Based on the results of the investigation, the Board recommends that in order to reduce the risk of malfunctions of the propeller pitch regulating mechanism due to oil pollution, the oil feed lines serving the propeller mechanisms should be separated from those of the engines.

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ICAO Ref: AR/683

Scheduled
En route
Collision - water
Undetermined

No. 5

Línea Expresa Bolívar, C-46D, YV-C-LBI, crashed on la Culata Peak, Mérida State, 21 January 1959. The report was released by the Directorate of Civil Aviation, Venezuela.

Circumstances

The aircraft was cleared for departure from Mérida for a flight to Maracaibo via Lagunillas and was cleared to fly at 7 000 ft. It took off at 1505 hours with 2 crew and 2 passengers aboard. As the pass "El Callejón" was cloud-covered, the aircraft made a 180° turn over Ejido and continued on a 30° heading. The new course was also through cloud and the aircraft was flying on instruments. Approximately 20 miles northeast of Mérida the C-46 hit La Culata Peak at an altitude of 13 500 ft when still climbing on its northeast heading. All occupants of the aircraft were killed.

Investigation and Evidence

The Aircraft

The aircraft had a valid certificate of airworthiness. On departure from Mérida its gross take-off weight was about 15 875 kg, or 35 000 lb and its centre of gravity was within the established limits.

The Crew

The two crew members held commercial licences which were in order except for the pilot-in-command's, whose medical certificate had expired on 11 January 1959. The pilot-in-command had flown a total of 9000 hours, and the co-pilot had flown 2000 hours on this aircraft.

Search and Rescue

Following notification of the Directorate of Civil Aviation at 1725 hours on 21 January that the aircraft was missing, an investigating commission was immediately sent to Mérida where it arrived the next day at 0935 hours. The commission was provided with information concerning the heading taken by the subject aircraft on its flight to Maracaibo. A four hour search was then conducted without success as there was zero visibility over the area where the aircraft was believed to be. However, the next day, 23 January, the aircraft's wreckage was finally located at 0755 hours.

Ground search operations started in the afternoon, and the scene of the accident was reached on 24 January at 1030 hours.

Technical Examination at the Accident Site

Indications were that on first impact the aircraft was climbing and turning left. First impact was made by the left wing tip, which struck the upper part of the peak. On impact, the left engine and propeller were hurled backwards, and the engine was found about 600 m from the wreckage of the tail unit, which had broken away from the rest of the fuselage and fallen backward. This was due to the configuration of the plane in flight i.e. in a left turn. The rest of the fuselage and the right wing passed between the two peaks and crashed on the other side of the summit. The left fuel tank disintegrated on impact and a small fire occurred. There was no evidence of fire before impact.

The aircraft broke up in approximately the following order: left wing, tail unit, main part of the fuselage, right wing.

The undercarriage and flaps were retracted, and the propellers showed normal operation up to the time of the accident.

All flight instruments were completely destroyed, so that it was impossible to establish the heading, altitude and time of the accident.

Conclusions

Analysis of the facts and circumstances of this accident revealed that the aircraft was in good operating condition, airworthy, and operating normally up to the time of first impact; at no time was an emergency declared.

Weather conditions at the time of the accident were 7/8 with cumuli.

The pilot assumed a heading of about 30° instead of going out through the pass where the peaks are less high, and very probably failed to relate his climb to the altitude of La Culata Peak. It is also most likely that he approached the peak from the leeward side, which would make the conditions still more unfavourable.

Most probably the pilot had no means of establishing his position in that area; consequently, he should have taken more precautions in climbing. The best course of action was to climb higher over the Mérida airfield, then to proceed on his heading at a safer altitude until he had passed the Culata Peaks.

Probable Cause

The accident was due to flying the aircraft at insufficient altitude over an area apparently unfamiliar to the pilot.

Recommendations

The following recommendations were submitted following the investigation of the accident:

1) installation of a radio beacon at Vigía and another at Ejido;

2) the only means of entering and leaving Mérida Airport should be by an ADF procedure over Vigía and Ejido;

3) any procedure to enter or leave Mérida otherwise than by Vigía and in completely normal weather should be prohibited.

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Non-scheduled
En route
Collision - rising terrain
Pilot - Improper in-flight planning

ICAO Ref: AIG/ACC/REP/GEN/No. 20 - Venezuela

No. 6

Pakistan International Airlines Corporation, Viscount 815, AP-AJE, accident at Karachi Airport, Pakistan, on 14 August 1959. Report released by the Director General of Civil Aviation, Pakistan.

Circumstances

The aircraft was on a training flight of four hours duration which commenced at 1430 hours GMT. Aboard the aircraft were an instructor and two captains of Pakistan International Airlines, who were undergoing command training. The aircraft returned to the base at 1639 hours and, after being granted permission from the aerodrome control to carry out some more flying, took off at 1648 hours for further training exercises. At 1707 the aircraft was cleared to land, as requested, but it did not land, declaring that it was going around again as it was not properly lined up (presumably on ILS). It was again cleared to land as it approached a second time. On this occasion also the aircraft did not effect a landing although it came very low over the runway with engines Nos. 3 and 4 inoperative and carried out an overshoot on the two port engines. This resulted in an almost 90° yaw to starboard very low over the runway. Soon thereafter, the right wing of the aircraft hit a blast pen wall. This was followed by an explosion and outbreak of fire as the aircraft crashed. The instructor died on the way to hospital, one captain was killed instantly, and the other sustained serious injuries. The accident occurred at 1714 hours GMT.

Investigation and Evidence

The Aircraft

The aircraft held valid Certificates of Registration, Airworthiness and Maintenance. It was empty as it was engaged on a training flight.

The Crew

The captain, who was acting as instructor on the flight, held a valid air transport rating issued by the United States of America with Viscount type endorsement, and this rating had been validated for the exercising of the same privileges in Pakistan. Whereas three other captains in Pakistan International Airlines had been given specific training and were checked out as training captains by the Vickers' Test Pilot, there was no evidence of such a training and checking out of the captain, who was acting as instructor on this flight.

Technical Investigation

There was no failure or malfunctioning of any of the power units, flight controls, ancillary services or the airframe of this aircraft.

The flap setting was between 32 and 40 degrees, and there was no evidence of flap being in asymmetric condition.

Engines Nos. 1 and 2 were under considerable power at the time of impact, but engines Nos. 3 and 4 were not, and their propellers were found in the feathered position.

Strip examination of the fuel pumps showed considerable sulphide corrosion which affected their efficiency and performance. The corrosion was due to contaminated fuel. This, however, had not in any way contributed to the accident.

General Comment

Training was being undertaken at night because of the non-availability of aircraft during daylight hours.

Probable Cause

The training captain attempted a manoeuvre in disregard of the prescribed limitations of such a manoeuvre. A two-engine overshoot was attempted at a very low height and below the prescribed minimum speed, when the aircraft was committed to a landing. This resulted in a violent yaw and sharp drop which could not be controlled. The training captain was conversant with the minimum requirements of a two-engine overshoot of the Viscount 815 aircraft but appears to have overestimated its performance.

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ICAO Ref: AIG/ACC/REP/GEN/No. 6 - Pakistan

Training Landing Loss of control Pilot - attempted a two-engine overshoot at a very low height and below the prescribed minimum speed.

No. 7

American Airlines, Boeing 707-123, N 7514A accident near Peconic River Airport, Calverton, Long Island, New York on 15 August 1959. Civil Aeronautics Board (USA) Aircraft Accident Report File No. 1-0057 released 25 April 1961.

Circumstances

Jet transition training flight 514 was the second of two training flights scheduled for this aircraft on 15 August. It carried five crew members - one captain-instructor, two captain-trainees, one flight engineer-instructor and one flight engineer-trainee. The aircraft took off from Idlewild International Airport at 1340 hours eastern daylight time on a VFR flight plan direct to Fire Island, then V-16 to Peconic River Airport. It accomplished high altitude airwork after take-off to permit sufficient fuel burnoff for airport transition training which was planned at Peconic River Airport. The aircraft was in the Peconic area from 1511 until the accident occurred. During this time several manoeuvres were carried out including full-stop landings, crosswind landings and take-offs, a high off-set approach, simulated engine(s) out landings and a no-flap aborted approach to landing. The aircraft did not retract its landing gear following the last aborted approach to landing on runway 23 but continued in the traffic pattern at an estimated altitude of from 1 000 to 1 100ft. The crew reported on left base leg for runway 23, was given clearance to land, and was informed that the wind was from 230° at 10 to 15 kt. The last communication from the crew was the acknowledgement of landing clearance and wind information, at which time nothing of an unusual nature was reported. At 1641 hours eastern daylight time it crashed in an open field approximately 3 miles northeast of the Peconic River Airport, fatally injuring its five occupants. A severe kerosene-fed fire followed impact.

Investigation and Evidence

The Aircraft

N 7514A, a Boeing 707-123, was manufactured on 5 June 1959. It had approximately 736 hours of flight time. The aircraft was equipped with four Pratt and Whitney turbojet, model JT3C-6 engines.

The Crew

All three captains held valid airline transport pilot certificates of competency*.

Experience

Captain-instructor

He had flown a total of 18 000 hours as of 13 January 1959, had completed the special Boeing 707 ground training courses, and had over 210 hours in Boeing 707 aircraft, 188 hours of which were as an instructor. He had flown with about 30 students in the jet transition programme.

Captain-trainees

Both of the captain-trainess had over 20 000 flying hours and had completed the special Boeing 707 ground training courses. They had the following number of hours to their credit on Boeing 707s:

1)	9:55	hours	pilot time
	14:52	"	(training) observation time
	23	"	(line) observation time
	16	"	simulator time

* equivalent to "licence" in international usage

2) 9:10 hours pilot time
29:18 " (training) observation time
25 " (line) observation time
19:30 " simulator time

The flight engineer-instructor had flown a total of 5 000 hours including about 150 in Boeing 707 aircraft. He had over 164 hours as a flight engineer-instructor and had completed a special Boeing 707 ground training course consisting of 152 hours.

The flight engineer (trainee) had flown over 10 200 hours as of 29 May 1959. He had completed the special Boeing 707 ground training course, had performed two periods of Boeing 707 training and had accumulated a total of 7:30 hours of Boeing 707 aircraft time. He also had 19:30 hours of Boeing 707 simulator time to his credit.

Eyewitnesses' Accounts

Several eyewitnesses living near the impact area, who were accustomed to Boeing 707 aircraft flying in the vicinity, were of the opinion that the aeroplane was lower, slower and making less noise than usual. Some observed smoke coming from the engines on one side of the aircraft prior to impact.

One eyewitness, a private pilot, was practising landings and take-offs from a small field 1/2 a mile from the impact site. He was flying a J-3 Cub airplane on a southbound heading at an altitude of approximately 300 ft when he observed the Boeing 707 to his left at an estimated altitude of 600 ft. He observed the Boeing 707 start a shallow turn to the left (south) and estimated the separation between the two aircraft as approximately 800 to 1 000 ft. He testified that he did not feel concerned about the possibility that the two aircraft were on a collision course and believed no evasive manoeuvres were required.

The Wreckage Area

The wreckage area was confined to approximately the wing span of the aircraft in width and 1-1/2 times the length of the aircraft, with a few components strewn in the direction of travel nearly 500 ft from the point of initial impact. Ground impact was along a direction of 282° magnetic.

Aircraft Damage

No semblance of a recognizable cockpit or passenger cabin remained; the identifiable pieces from both were scattered throughout the wreckage area. The wing outer panels broke off just inboard of the outboard nacelles and were partially consumed by fire. The inboard panels were broken into several sections with the upper skin sections receiving less heat damage than the lower sections. The tail surfaces received relatively little impact damage.

Technical Investigation

Attempts were made to determine whether there had been a flight control failure prior to impact. Many components of the aircraft's flight control system between the flight control surfaces and the cockpit were so badly destroyed by impact and subsequent fire that their condition prior to impact could not be established. No indication of any pre-impact malfunction, failure, or unairworthy condition could be found in an examination of those flight control components that withstood impact and the subsequent fire.

The turbojet engines were found completely detached from their respective pylons. Nos. 1, 2, and 4 engines were found just forward of their initial point of contact and they were inclined, forward end up, about 30° with their compressor ends resting on the forward edges of the engine impact holes. These engines had rotated about their longitudinal axes in a clockwise direction. All fire damage to the engines occurred after impact.

The engines and accessories were shipped to the American Airlines shop at Tulsa, Oklahoma, where they were disassembled. No evidence of operational failure or distress was revealed during the disassembly and examination. All engines were producing appreciable power at impact. Nos. 3 and 4 engines were more severely damaged by rotational interference than were Nos. 1 and 2. Engine instru-instrument readings obtained were so variable that no pattern could be established; however, the oil temperature gauge readings were: No. 1, 105°C; No. 2, 105°C; No. 3, 70° C; and No. 4, 74°C.

The hot sections of all engines were free of any evidence which would have indicated they had been subjected to over temperatures. Bearings of all engines were normal except for damage resulting from impact loads and the drying effects of heat from the ground fire.

Nothing of an unusual nature was found in the maintenance records.

Flight tests

Tests were conducted subsequent to the accident in which a light aircraft and a Boeing 707 participated in an exercise to determine whether or not the close proximity of the J-3 Cub would have required evasive action on the part of the 707 crew. Four passes were made in which the small aircraft approached the 707 from the right on a collision course but slightly below the 707. the four passes were conducted as follows:

	Boeing 707 altitude	J-3 Cub altitude
1st pass	1 000 ft	400 ft
2nd pass	800 ft	400 ft
3rd pass	600 ft	300 ft
4th pass	600 ft	300 ft

An experimental pilot for Boeing Airplane Company testified that should all control pressure be relaxed during an approach manoeuvre while simulating failure of 50% of the power units concentrated on the right side with landing gear extended and flaps 30° extended, the Boeing 707 would yaw and roll to the right. About 5 to 7 seconds would be required to stop the roll before the aircraft reached a 90° bank. Recovery could be accomplished by applying full opposite aileron and rudder and reducing power on all engines. During such a manoeuvre, the pilot stated, the aircraft could lose as much as 600 ft of altitude.

Flight Recorder and Analysis of Tape Reduction Data

N 7514A was equipped with a Lockheed Aircraft Service, Inc. , flight recorder in accordance with Sec. 40. 208 of the Civil Air Regulations. * The record made by this instrument provides information enabling reconstruction of the complete flight path. The flight parameters are recorded by styli, which are mechanically linked to sensors and move vertically across a foil tape. As the aluminum alloy foil is fed past the recording styli, lines are embossed on the surface. One spool will accommodate approximately 100 ft of foil, which allows approximately 150 hours of recorder operating time.

The flight recorder installed in N 7514A was a model "C" recorder, and was certified as meeting Federal Aviation Agency Technical Standard Order C-51.

* "A flight recorder which records time, airspeed, altitude, vertical acceleration, and heading shall be installed on all airplanes of more than 12 500 lb maximum certificated take-off weight which are certificated for operations above 25 000 ft altitude, and shall be operating continuously during flight."

Note:- Although the Civil Air Regulations do not require a flight recorder to be operating during training, test, or ferry flight operations of a scheduled air carrier aircraft, nevertheless, the flight recorder aboard N 7514A was operating during this training flight.

It was severely damaged by crushing and fire; however, most of the recorder mechanism was functional. The recorder was opened at the scene of the accident and a preliminary reading of the data was made by a Board employee. Subsequently, the entire flight recorder, including the foil, was taken to the manufacturer where a more detailed reading of flight data was accomplished with the use of precision equipment. Following this examination by the manufacturer the data tape was released by the Board to Boeing Airplane Company for further study. Analysis of the tape reduction data follows:

The downwind leg was made on a heading of approximately 55°; speed was reduced from an indicated airspeed of approximately 200 kt to 170 kt; and altitude was decreased from about 1 850 to 1 700 ft. During the turn to the base leg the aircraft descended from 1 700 ft to approximately 1 100 ft in the turn. The base leg was flown on a heading of approximately 305°, an indicated airspeed of approximately 165 kt, and an altitude of approximately 1 050 ft. Acceleration during the downwind and base leg was maintained at approximately one g.

The first indications of other than normal flight began about 15 seconds before impact. At this time the aircraft was pushed over and rolled into a left bank. It was time to commence a left turn to the final approach and the increasing compass heading, due to gyro gimbal error, shows the roll which was also verified by witnesses.

At this point - still according to the tape reduction data - the aircraft yawed rapidly to the right. The yaw angle has been estimated as high as 17°, which is well beyond the 11 to 14° angle than can be successfully controlled with full opposite use of the lateral control devices. The crew, for some unknown reason, failed to recognize and correct the development of this yaw and the aircraft continued to roll to the right.

When the aircraft passed the 90° bank position, it was yawed right approximately 20°, resulting in approximately a 30° nosedown attitude. The yaw was at its maximum angle and the roll rate had reached approximately 40° per second.

As the aircraft passed the inverted position the yaw angle was reduced considerably, indicating that some corrective action had been taken in the form of advancing the thrust levers on Nos. 3 and 4 engines and applying full left rudder and aileron. Positive acceleration was held at 1-1/2 to 1-3/4 g.

As the aircraft passed the 270° roll position it was in a zero yaw condition. Acceleration was held at about 2 g which is in the buffet range and is the tightest pullout that the aircraft could make. The power was then nearly symmetrical.

The aircraft struck the ground in a nearly wings-level attitude, yawed to the left approximately 12°, with considerable and nearly symmetrical power. The attitude was approximately 12° nosedown but the angle of impact was approximately 26°, giving a floorline angle of attack of 14°. The yaw and nearly stalled condition indicated on the flight recorder trace were verified by the ground impact marks at the crash site.

Power at Impact

There was no control or actuator position by which power being produced at impact could be determined. The energy expended in halting rotation of the engines, as evidenced by the extent of damage from rotational interference, was the primary means of determining the approximate power at impact. Rotational damage indicated all engines were producing appreciable power at impact. The condition of the compressors of Nos. 3 and 4 engines suggests slightly more power was being produced by these engines than Nos. 1 and 2. However, the readings of the four oil temperature gauges indicated more power was being produced by Nos. 1 and 2 engines than by Nos. 3 and 4. This apparent conflict of factual evidence could be explained as follows. Somewhere in the pattern the Nos. 3 and 4 engine thrust levers were retarded to simulate a multiple engine failure and Nos. 1 and 2 engines were advanced to sufficient power to maintain an indicated airspeed of approximately 160 kt. Nearly full power would have been required on Nos. 1 and 2 engines to maintain altitude with gear down and flaps extended to 30°. The exact point at which power was reduced on Nos. 3 and 4 is debatable; however, since the oil temperature readings for these engines were determined to be 70 and 74°C., respectively, it must be concluded that power was reduced early in the pattern, as evidenced by the engine cooling that occurred. Then at the start of loss of control, while operating with Nos. 3 and 4 engines reduced to idle thrust, their power levers were advanced quickly to the full-thrust position. The higher power established by advancing the thrust levers would not be reflected on the oil temperature gauges during the elapsed time to ground contact. In view of the relatively low altitude at which control was lost, it is concluded that this sequence of events occurred.

Delay in Acceleration Time of Jet Engines

Another factor in this accident was the delay in acceleration time of jet engines engines after thrust lever advancement. The delay in engine acceleration from idle to full power could be as high as six seconds. The Boeing Airplane Company recommends that all thrust levers be retarded immediately in case of any out-of-control situation and thrust levers then be advanced on all engines together. The rolling manoeuvre could have been stopped rapidly by reducing power to engines Nos. 1 and 2, since the yawing forces and the high unequal rudder forces would have been eliminated. However, even if this procedure had been followed it is questionable whether sufficient altitude remained to effect complete recovery.

In the flight configuration that had been established, the asymmetrical power condition would tend to create yaw to the right and would require the application of opposite controls, particularly left rudder, to compensate for the unbalanced thrust.

Rudder Characteristics

The rudder characteristics of the Boeing 707 are such that when yaw angles in excess of approximately 10° are attained, the rudder effectiveness deteriorates quite rapidly with a resultant loss of directional control. This can produce a dangerous flight condition. In order to minimize the probability of large yaw angles during flight with both engines on one side inoperative, directional control must be maintained with the rudder. Excessive aileron or bank angles should not be used to maintain directional control. Yaw angles of approximately 10° require nearly full aileron control to maintain heading when inadequate rudder is applied. There is also a noticeable stiffening of rudder pedal forces during the last two or three degrees of rudder deflection. Therefore, the pilot must be certain to depress the rudder pedal fully whenever a manoeuvre requires full rudder deflection. It is extremely important that the employment of rudder be positive and properly timed.

It is apparent that roll due to yaw resulted either from a lack of application of sufficient rudder, or an inadvertent release of left rudder. Since there is a noticeable stiffening of rudder pedal forces during the last two or three degrees of rudder deflection, it is possible that in this manoeuvre, where full rudder was needed to make the turn to final approach with Nos. 3 and 4 engines at idle thrust, full left rudder was not utilized. If this were the case, a yaw of as much as or more than 10° could be brought about as the aircraft was banked to the left. Such a yaw would produce a violent roll to the right due to the aerodynamic response of the aircraft to yaw.

The student might have released the controls after assuming the instructor was taking over to initiate evasive action following his observance of a light aircraft low and to the right of the Boeing 707's flight path. Subsequent flight tests revealed that the light aircraft could have been an alarming factor and a possible cause for evasive action on the part of the Boeing 707 crew. The instructor, sitting on the right side, could have indicated that evasive action should be taken and in the process of his taking control of the aircraft, the student relaxed rudder pressure before the instructor assumed control of the rudders. These circumstances pertaining to the presence of a light airplane are conceivable; however, certain points are difficult to resolve. First, it is believed that a prudent instructor would keep ahead of the manoeuvre, especially in jet transition training and particularly in the type of manoeuvre being conducted, and prevent the development of a critically unsafe condition. Secondly, the testimony given by a Boeing test pilot attested that evasive manoeuvres could be accomplished successfully even though the aircraft was in an asymmetrical power condition.

Conclusion

After due consideration, the preponderance of evidence suggests that the most logical fact for the loss of control was either the lack of application of sufficient rudder, or an inadvertent release of left rudder for some unknown reason. The delayed corrective action, together with the decision to advance power on the idled engines instead of reducing power on the good engines, permitted the yaw and induced roll to become severe and uncontrollable.

Probable Cause

The crew failed to recognize and correct the development of excessive yaw which caused an unintentional rolling manoeuvre at an altitude too low to permit complete recovery.

Recommendation

On 12 January 1960 the Board recommended to the Administrator, Federal Aviation Agency, that flight recorders be installed in all new transport-type airplanes and presently operating turbine-powered transport-type airplanes. Subsequent to that date and as a result of the information gained from the flight recorder in this accident, the Board has expressed the opinion to the Administrator, Federal Aviation Agency, that recorders should also be installed and operating during the training, test, and ferry flight operations of these air carrier airplanes. It is the Board's belief that in these latter operations, the airplanes are subjected to the same environmental factors and flight loads experienced in scheduled service.

Follow-up action

Subsequent to the accident the FAA discontinued the requirement that Boeing 707 aircraft make actual landings with simulated failure of 50% of the power units concentrated on one side of the aircraft during training flights, type ratings, and proficiency checks. These manoeuvres may be simulated at an appropriate higher altitude.

On 5 February 1960 Boeing Airplane Company issued a service bulletin approved by the FAA for an improved rudder modification, which adds boost power to the wider ranges of directional movement and gives increased control capability at low airspeeds and minimum gross weights. This modification also replaces the original rudder with an improved version.

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ICAO Ref: AR/673

Training
Landing
Loss of control
Pilot - improper supervision of flight

No. 8

Transports Aériens Intercontinentaux, DC-7, F-BIAP, accident at Bordeaux-Mérignac Airport, France, 24 September 1959. Final report was released in Le Journal Officiel de la République française, dated 30 May 1961.

Circumstances

F-BIAP had arrived from Paris and after a two hour stop took off at 2223 hours GMT from runway 23, weighing 132 671 lb, as a scheduled flight to Bamako, (Mali) and Abidjan (Ivory Coast). Visibility was good despite a light drizzle. The wind was from 340° at 3 kt; the night was clear. After leaving the ground normally and reaching a height of less than 30 m the aircraft overflew a zone without luminous ground markings. It did not gain altitude but came in contact with the edge of a pine forest 2 950 m from the point at which power was applied and along the extended centreline of the runway. Nine crew members and 45 passengers were killed in the accident. Eleven other passengers were injured. The aircraft was destroyed by impact and fire. The accident occurred at 2224 hours GMT.

Investigation and Evidence

The Aircraft

Its Certification of Airworthiness was dated 28 November 1957 and the aircraft was last inspected by the Bureau Véritas on 13 August 1953, when it was classified in Category V - valid until 13 February 1960. The documents relating to the aircraft contain no indication of any malfunction or faulty maintenance.

The Crew

There were 9 crew members aboard the aircraft at the time of the accident.

The pilot-in-command held a valid airline transport pilot's licence valid until 4 February 1960. He had flown 11 704 hours including 3 659 hours of night flying. His flying time on the aircraft type involved in this accident was 479 hours including 210 hours of night flying.

The co-pilot also held a valid transport pilot's licence valid until 27 November 1959 and had flown a total of 10 829 hours - 1 907 of which were of night flying. He had flown 312 hours, including 159 hours of night flying on this aircraft type.

The flight also carried 2 radio navigators (one a trainee), 2 flight engineers (one a trainee), 2 stewards and one hostess. All had standard qualifications and training with good aviation backgrounds.

Loading of the Aircraft

The aircraft's take-off weight was 60 179 kg (132 671 lb). A slight error was made in the loading sheet, in which the conversion was given as 132 393 lb. The maximum authorized take-off weight for the segment Bordeaux - Bamako was 61 462 kg. The weight of the subject aircraft was, therefore, 1 283 kg below this figure and was also 4 685 kg below the maximum acceptable take-off weight for an aircraft of this type. (Maximum authorized take-off weight - DC-7C performance = 64 864 kg).

Position of the Centre of Gravity

The take-off weight and the position of the centre of gravity were carefully calculated and their value was well within authorized limits, thus providing a considerable safety margin.

The chart showed a take-off figure of 27.8%, which placed the curve within the area recommended by the manufacturer's technical notes.

Erasures on this document indicate a last minute change in the position of the centre of gravity. This was done at the request of the pilot-in-command, who considered that the proposed position was too far to the rear, so three large suitcases and a chest, weighing a total of 200 kg were loaded into the hold of the forward cabin instead of in the lower rear hold ZA as originally planned.

As a result of this decision, the lower rear hold ZA was loaded to a weight of 740 kg instead of 940 kg and the forward hold to 559 kg instead of 359 kg. The previously prepared loading sheet was corrected accordingly. The captain personally supervised the loading operations and approved the load distribution.

No negligence or error was noted in these operations that might have jeopardized the safety of the aircraft.

Weather Conditions

The information supplied by the local meteorological services as well as the testimony and statement of the pilot of Super Constellation, F-BHBJ, which took off ten minutes before F-BIAP is as follows:

> Visibility 15 km; surface wind 320/340, 2 to 4 kt; ceiling over aerodrome aerodrome 8/8 altocumulus, base at 3 000 m, stratus at about 500 m in the south sector; light intermittent rain which became heavier (increased shortly after the accident and helped to limit the spread of fire); atmosphere relatively warm and humid, temperature 20.5°C.

It was a moonless night, and the runway lights were clearly visible. The line of the horizon and ground relief were fading out along the runway extension. No light was visible along the runway extension at this hour of the night.

It should be noted that the report of the Air France pilot is indicative of a wind gradient increasing with altitude and slightly unfavourable in the lower layer.

The Flight

The aircraft had come from Paris and was to leave for Bamako (Mali) after a two-hour stop.

An IFR flight plan listing Abidjan (Ivory Coast) as alternate aerodrome was filed with the aerodrome control reporting office. The expected flight time was 7 hours and 43 minutes, endurance 11 hours. The plan listed 60 persons on board, an error which was subsequently corrected. For this flight there were 9 crew members aboard and 56 passengers, including two infants.

F-BAIP took off at 2223 hours. From this point the take-off was reconstructed from testimony as follows:

> normal take-off at intersection of runways; altitude approximately 20 m at runway end; climb of a few metres, apparently followed by level flight; slight drop, again followed by levelling off; further slight drop, following which witnesses observed an explosion.

Comments on the Take-off

F-BIAP took off exactly 15 minutes after leaving the apron and 9 minutes after positioning itself for run-up at the end of the runway.

The flight plan of the Super Constellation which took off ahead of it provided for flight at level 100 on the Bordeaux-Dakar segment, while F-BIAP was to fly at level 120 on the Bordeaux-Bamako segment.

Both aircraft were cleared to take off via marker GS at level 60. They took off from the same runway. The prescribed ten minute separation was enforced and complied with.

Runway 23 was selected in view of the lightness of wind (slightly right rear), because it is the longest for night operations (2 080 m lighted) and because it enabled pilots to follow a climb-out track that avoided major turns after take-off.

It should be noted that the aircraft took off without headlights, though it was observed that they were tested during the waiting period at the end of the runway.

All witnesses remarked upon the low altitude of the aircraft after a clean take-off. They seem to have been struck by this abnormal behaviour even before the explosion.

None of the witnesses made specific reference to the operation of the engines.

Examination of the wreckage and technical investigation

The aircraft crashed in a fairly dense pine wood. An old trench runs through the wood, slightly offset from the extended centreline; the tree tops are about 22. 50 m above the runway threshold elevation. *

The aircraft approached the edge of the wood at right angles, and the point of contact showed clearly on the trees.

The right wing of the aircraft was very quickly splintered into many fragments, while, because of the old trench, the fuselage and the left wing remained almost intact. The aircraft gradually tilted onto the right wing. The first explosion occurred about 200 m beyond the edge of the wood, the aircraft then rolled to 90° and finally turned over on its back, striking the ground 350 m from the edge of the wood. The tail assembly and part of the fuselage slewed round and came to rest in a direction opposite to the original axis of movement.

The swath cut in the pine trees by the passage of the aircraft was first straight and parallel to the take-off flight path, then curved off to the right up to the point of the final crash.

The wreckage was distributed at four main points:

1) at the edge of the wood

2) 100 m beyond

3) 200 m from the edge of the wood where the first explosion occurred

4) about 350 m from the edge of the wood - the main part of wreckage.

Fire first broke out among the pines when the right wing broke off, then around the point of final impact, but the ground was damp enough to prevent spreading. The fire was rapidly brought under control by the firefighters and rescuers. The

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* It may be noted that the maximum height of the trees projected 1. 50 to 2 m above the take-off surface specified by ICAO in Annex 14 and defined as a 2% slope beginning at a point 60 m (200 ft) beyond the runway threshold. This projection is meted on the aerodrome obstruction chart prepared by the Aeronautical Information Service. It was not material in the case considered, inasmuch as the first points of impact (approx. 16 m above the reference elevation) were 5 m below the take-off surface.

destruction by dislocation and fire was such that it was difficult and frequently impossible to check certain items in the burnt, partly melted and highly distorted wreckage.

Despite the degree of destruction sustained the components of the power units, particularly the engines, did not show any sign of defects or of breakage occurring prior to the crash. Furthermore, the double tachometer found jammed at 2 950 rpm confirms these observations.

A flight recorder was in operation on F-BIAP. It was found in the wreckage and examined jointly by the technical and legal investigators in the laboratories of the Brétigny Flight Testing Centre.

Although fire damage to the recorder was slight and it had fully resisted impact, prolonged exposure to heat* had destroyed the photographic recording film by chemical fogging. Thus, no conclusions of significance to the enquiry could be reached.

The configuration of the aircraft at time of impact

By analysis of testimony, examination of the results of the technical investigation and observations made at the site, particularly on the first trees broken by the aircraft, it was possible to some extent to reconstruct the configuration of F-BIAP at the time of impact.

The aircraft was exactly on the extended centreline of the runway almost 16 m above the level of the runway end. The landing lights and all landing gear were retracted, gear locked; the flaps were still extended (perhaps at an angle of about 10^{o}); the elevator tabs were in neutral; all four engines were on take-off power not yet throttled down.

The aircraft was in level flight, perhaps very slightly nose-up, with zero bank.

Experimental Measurements

Take-off and beginning of climb in normal conditions (Bordeaux)

For the purpose of obtaining concrete representation of the relations between the main flight parameters of a DC-7C on normal take-off, a recording of the parameters was made by means of a high speed A 13A recorder from the Flight Testing Centre, on board DC-7, F-BIAQ.

To this end, a take-off was performed at Bordeaux with weight and position of the centre of gravity very similar to those of the subject aircraft (132 230 lb, 27. 6% for the recording and 132 671 lb, 27. 8% at the time of the accident).

Results of the recordings were put in graphical form, showing airspeeds, climbing speeds and altitudes as functions of time.

The graphs showed that on the normal take-off of F-BIAQ the accident site was overflown at a height of about 90 m.

Since other findings based on this recording proved to be of interest, the Board requested a more thorough study of the reconstruction of the take-off during which the accident occurred.

Reconstruction of take-off and beginning of climb (Brétigny)

It was judged necessary to make a further recording of the take-off parameters in conditions as similar as possible to the known circumstances of the accident.

For this purpose the flight path followed at Bordeaux by F-BIAP was

* The recorder was located at the position of the flight radio operator, therefore in an area of intense fire of long duration.

reconstructed on 9 April 1960 at the Brétigny Flight Testing Centre.

The DC-7, F-BIAR, was loaded to practically the same weight (132 600 lb) as F-BIAP (132 671 lb) and to the same position of centre of gravity (27.8%).

A camera-equipped theodolite, in direct radiotelephony contact with the aircraft, filmed a flight path copied upon that of the accident.

A motion picture camera installed on the pilot's right filmed the pilot's instrument panel during take-off.

Lastly, a very high speed A 13 recorder from the Flight Testing Centre was mounted on board and the parameters - times, speeds, altitudes - as well as the "pip" of the various operations, were continuously recorded.

In addition, to evaluate the effort which the pilot had to exert on the control column in order to follow the selected flight path under weight and position of the centre of gravity conditions similar to those of the accident, an Arsenal type dynamometric handle was installed on the control grip and used on a simulated take-off performed at an altitude of 1 500 ft.

Tables were prepared which showed firstly the results of the measurements of times, indicated speeds and altitudes obtained from the recordings, and secondly, their comparison with the readings of the panel instruments filmed at the same times.

On the basis of these tables, considerable differences were apparent between some of the instrument readings and the values recorded by the theodolite and the SFIM recorder.

Since the accuracy of the recordings was satisfactory, it must be concluded that the elements at fault were the instrument readings on take-off. Although there was some turbulence when the Brétigny take-off was performed, this comment remains valid and is explained later in this summary.

Finally, the efforts measured on the dynamometric handle, which can only be operated with one hand, were of the order of two to five kilogrammes maximum on either side of the trimming position (there was slight turbulence at the time of the reconstruction). Consequently, under the weight and position of the centre of gravity conditions thus produced, and with the elevator tab in neutral position, the average effort required to maintain the flight path such as that of the accident - very different, therefore, from that of normal climb-out - is practically negligible for a pilot using both hands on the control grip.

Theories Considered as to the Cause of the Accident

I - Failure of one or more Power Units

The fuel samples taken during refuelling were analysed and found to conform with applicable specifications.

Inspection and testing of the propellers, domes and governors did not disclose any sign of mechanical failure, and these findings confirm the date obtained from the double tachometer recovered.* All four engines were developing full power on take-off. They had not yet been throttled back.**

* This tachometer corresponds to two engines on the same side, but it was so much damaged that it was impossible to identify its number, hence to locate it to port or starboard.

** Use of take-off power was restricted to 90 seconds on DC-7 aircraft (TAI operations manual.)

Finally, a particularly significant point, worthy of stress, is that the aircraft was exactly aligned in its take-off direction.

II - Faulty handling of landing gear or flaps

The landing gear was found retracted and locked, and it was stated in the testimony that it was retracted at the moment the aircraft passed over the runway end (this operation generally requires twelve seconds).

There was no mechanical evidence that any flaps were retracted at the time of impact. In addition, the position of the recovered actuating cylinders seems to indicate that they were still extended (to about 10^{o}).

It therefore seems likely, as throttles had not yet been reduced, that the flaps were still at the take-off position, or that, if the order to retract them had been given, such action could only have been in its initial phase.

III - Malfunction of the flight controls

The DC-7 design precludes take-off if the controls have not been released from the parking position.

Furthermore, the investigation disclosed nothing that would support the theory of a blocking of the controls in flight.

IV - Flutter of control surface

No evidence gathered from the wreckage or generally from DC-7 operation offered any substantiation of this hypothesis, although it was given careful consideration.

V - Occurrence of incidents in the cockpit

The occurrence of an incident in the cockput, assuming even the most unlikely emergencies (sudden indisposition of one of the pilots), and including cases previously observed (activation of the fire warning tell-tale light, breakdown of the lighting system, production of toxic vapours) may prevent the holding of the climbout path either by partly incapacitating a crew member or by distracting his attention, and this hypothesis cannot be ruled out a priori.

VI - Faulty readings of one or more flight instruments

During the initial climb phase, an incorrect flight path may result from faulty readings of one or more flight instruments owing to malfunction, imperfect operation or setting error, for example:

a) Artificial horizon

An incorrect position of the silhouette cannot be ruled out, since it is adjustable. Furthermore, although observation of the silhouette can be very useful in stabilized climb, it would be hazardous to use it as a reference on take-off and climbout since, as explained in the following chapter (take-off and climbout technique), it is subject to an erection system and indicates an apparent vertical which deviates from the true vertical for as long as the aircraft is subject to horizontal acceleration.

b) Anemometer

The presence of water in the lines producing readings below actual, for example, is highly unlikely on a DC-7. Additionally, the same deviations would have to be assumed on the anemometers of both the pilot and the co-pilot.

Furthermore, during acceleration of the aircraft, the indicator needle may be 10 kt behind the speeds which should normally be indicated.

c) Altimeter

A setting error, if overlooked up until climbout, could mislead the pilots as to true altitude; the setting is, however, a compulsory item on the pre-take-off check list and was also brought to the crew's attention by control before take-off.

With respect to the accuracy of the readings, except for a negative peak, not operationally significant, when passing V_2 (i.e., at the time of the variation of incidence), the readings very slightly behind the true altitude figures can produce only a favourable effect on the conduct of the flight.

d) Rate-of-climb indicator

When the rate of climb varies, the instrument needle, in many cases, is very far from showing the derivative of the altitude, and consequently cannot be taken as a reference for the rate of climb. The readings of this instrument are truly reliable only under conditions of stabilized climb.

The above-recalled peculiarities of the readings of certain flight instruments during take-off and climbout* are common knowledge among pilots. Taken separately, they do not appear conducive to an accident.

The Board devoted further study to them in relation to the reconstitution of flight paths considered in the following paragraphs.

e) Take-off and climbout technique

The Bordeaux recording of a take-off and first segment of normal climb under weight and position of the centre of gravity conditions similar to those of the subject aircraft showed that:

- release of brakes being zero point on the time coordinate, longitudinal acceleration decreases almost to zero between the time + 40 seconds and the time + 60 seconds, then becomes slightly positive again between 60 and 70 seconds, the average increase in speed being 0.7 kt per second (0.36 m/sec/sec).

* that is, while the aircraft is close to the ground, particularly during the period of acceleration.

The Brétigny recording of a flight path reproducing that of F-BIAP at the time of the Bordeaux accident showed that:

- the average increase in speed for the time period, from time + 40 seconds to time + 70 seconds (end of level flight) was 1. 3 kt per second (0. 67 m/sec/sec).

The difference in longitudinal acceleration in the two cases is therefore 0. 6 kt per second (0. 31 m/sec/sec).

Moreover, the increase in speed as a function of time (which is relatively slight) is difficult to follow accurately on the anemometer, because of the rather closely spaced graduations on the three inch dial and of the oscillations of the needle due to irregularities of aerodynamic flow and to vibration.

It should also be noted that it is not a general practice during take-off to relate the speed and distance parameters to elapsed time. Finally, after passing the runway end, the pilot no longer has any distance reference.

The foregoing comments can also be expressed as follows:

Recording of a take-off followed by normal climbout gave the following results at a point 2 950 m from application of full power after deduction of relative wind speed:

- time: 52-6/10 seconds (approximately);
- altitude: 80 m;
- speed: 140 kt (IAS)

The recording made at Brétigny of the reconstitution of the F-BIAP flight path at Bordeaux gave the following results 2 950 m from application of full power, after deduction of relative wind speed:

- time: 52 seconds;
- altitude: 16 m;
- speed: 152 kt (IAS).

A difference of 64 m in altitude, consequently in rate of climb, is reflected by a difference in speed (12 kt at the time of the accident) which is the more difficult to measure as the anemometer pointer is not stabilized during this entire period.

In a normal take-off, the additional 12 kt of speed required to attain 152 kt would be reached only about 7 seconds later, that is almost exactly at time + 59 seconds, corresponding approximately to another 600 m along a horizontal projection of the flight path.

The above, added to the total lack of accurate references (time or distance) as was previously observed, shows how the pilot is prevented from detecting an abnormal longitudinal acceleration which in any case is very slight.

Such being the case, the position must be considered of a pilot taking-off at night from a well-lighted runway and suddenly plunged into total darkness after clearing the runway end, in spite of the good visibility conditions existing. At this stage the pilot must start flying on instruments, but he needs a few seconds to accommodate his vision to the instrument panel, particularly as the graduations on three inch anemometers are set rather close together. Thus, there is an appreciable lapse before he is able exactly to read the indicated speeds.

Moreover, it should be noted that the exact flight conditions are not conveyed to the pilot by other instruments:

1. The gyroscopic horizon, since the rise is not interrupted during periods of longitudinal acceleration, may introduce errors up to a maximum of 6^{o} during such phase of flight (in the film from the Brétigny reconstitution, the artificial horizon remained nose-up throughout, despite a period of level flight of over 8 seconds duration).

2. The rate-of-climb indicator lacks precision and its readings are considerably delayed (in the film made at Brétigny, the horizon remained constantly positive: on the average, 200 ft throughout the entire level flight segment).

3. The altimeter in this area first indicates a loss of altitude, then stabilizes with considerably delayed readings; it should be noted that the size of this instrument's calibrations makes it difficult to evaluate altitude within an accuracy margin of less than 25 ft; though not very precise, the altimeter still remains the sole instrument giving acceptable readings* during this flight phase.

4. The efforts required on the control column (which of course depends on the position of the centre of gravity and on the trimming of the aircraft) in normal cases such as that of the Bordeaux accident, and which were measured during the Brétigny flight, are insufficient when a levelling-off occurs without the pilot's knowledge, to warn him to set an adequate positive rate of climb.

Several of the factors, together with a slightly unfavourable wind gradient in the lower layer, may have been involved in the case of the subject accident; visual reference to the ground being precluded by darkness, a loss of altitude or an insufficient rate of climb after take-off could be detected only by thorough checking of the altimeters.

In this respect, however, it should be noted that the operation manuals for DC-7s in force at the time of the accident, in dealing with the sequence of operations in the cockpit during climbout, refer only to the anemometer.

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* after the effects of variation of incidence at V_2 time and ground effects have worn off.

Probable Cause

The Board considered that the accident was probably caused by the most unfavourable combination of several of the factors set forth under "Theories Considered as to the Cause of the Accident."

The reconstructed flights* showed that during the first segment of climbout, and during a very short critical phase** a slight increase in speed will produce a considerable decrease in rate of climb or even a slight loss of altitude.

In view of the rapid sequence of cockpit operations during this phase, together with the rapid variation in flight parameters, and the lack of precision - even inaccuracy - of readings of certain instruments, and lacking time reference and external visual references, a pilot may follow a line of flight that will bring the aircraft back near the ground *** if, during this period, optimum climbing speed is not maintained and the altimeter is not carefully watched.

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* the findings of which check with the calculation of total energy.

** about 10 seconds beginning 40 seconds after full throttle.

*** when despite good visibility but owing to lack of illuminated reference points, the pilot cannot see the ground.

ICAO Ref: AIG/ACC/REP/GEN/No. 5 - France

Scheduled Int.
Take-off
Collision - object, trees
Cause: various factors
Rapid sequence of cockpit operations, and variation in flight parameters, lack of precision of readings of instruments, and lacking time reference and external visual references ... pilot during this period must maintain optimum climbing speed and watch altimeter carefully.

No. 9

Braniff Airways, Inc., Lockheed Electra, L-188A, N 9705C, accident near Buffalo, Texas, on 29 September 1959. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 1-0060, released 5 May 1961.

The investigation of this accident produced such a voluminous quantity of data that the report was confined to the discussion and analysis of only the data considered to be apropos to the consideration of probable cause.

Circumstances

The flight was scheduled between Houston, Texas and New York International Airport with stops at Dallas, Texas and Washington, D. C. The aircraft departed Houston at 2237 hours central standard time and reported to San Antonio Centre over the Leona VOR at 2305 at an altitude of 15 000 ft. It then made its final radio contact with company radio at 2307 hours. Structural failure of the aircraft occurred at 2309 hours while on course to the next fix, Trinidad intersection. Following break-up the aircraft crashed and was further destroyed by ground impact and fire 3.19 nautical miles east-southeast of Buffalo. All occupants, twenty-seven passengers, six crew members and one company employee were killed.

Investigation and Evidence

The Aircraft

N 9705C was a new aircraft which had only flown a total of 132 hours 33 minutes. Thus, none of the periodic inspections, the first of which was to have been at 205 hours, had become due. All of the customary preflight service checks were performed during the ten days the aircraft was in use. All pilot complaints (squawks) had been signed off as corrected.

Several incidents and accidents involving Electras occurred during the course of this investigation, all of which were also investigated. None of these was considered to have any association with this accident except the accident to a sister aircraft at Cannelton, Indiana on 17 March 1960*.

The Crew

The three flight crew were all well qualified and experienced airmen despite the fact that each had flown less than 100 hours in Electra aircraft.

Weather

Weather at 2300 hours was good at the flight's altitude. There were scattered clouds above 20 000 ft, and visibility was 10 - 15 miles.

Atmospheric turbulence could not be logically linked to the accident. At the time it occurred the aircraft was operating in the clear, well removed from the closest significant convective activity. The necessary parameters for the formation of clear air turbulence were not present (i. e. vertical or horizontal wind shear, strong jet stream, sharp upper trough).

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* A summary of this accident is also included in this Digest.

Reconstruction of the flight

Due to a mechanical discrepancy involving No. 3 generator, the aircraft's departure from Houston was delayed about 22 minutes. The actual gross weight of the aircraft at take-off was calculated to be 83 252 lb, including 17 000 lb of fuel, and was 16 548 lb less than the authorized gross weight of 99 800 lb.

The aircraft was cleared for an IFR flight and was airborne at 2244. Houston departure control advised that it had the flight in radar contact and requested it to report when established outbound on the 345^{o} radial of the Houston omni directional radio range. Flight 452 complied with the request, was cleared to 9 000 ft and was advised to contact San Antonio Centre on 121. 1 Mc/s upon passing the Gulf Coast intersection. Reporting over the Gulf Coast intersection at 2252, the flight was issued its destination clearance to the Dallas Airport via direct to Leona, direct to Trinidad, direct to Forney, direct to Dallas, to maintain 15 000 ft. It was then cleared to climb to its cruising altitude. It advised it was over Leona at 05 at 15 000, and shortly thereafter contacted company radio advising the generators were then functioning correctly but that there had been insufficient time for maintenance to insulate the terminal strip on No. 3 propeller at Houston, and it would like to have it done in Dallas. Another item for maintenance followed. No. 3 fuel tank sump pump had become inoperative shortly after take-off. This was the final transmission from the flight. Two minutes later the structural failure occurred.

Statements of Witnesses

There was in this accident one condition which fixed the sequence and established to some extent a time boundary between two important elements of observation: (1) the sound, variously described as "jet noise", "low flying aircraft", "unsynchronized motor", and (2) the observation as "a large orange ball of fire". Six witnesses were indoors when startled by a noise of sufficient intensity to get them to look or go outside. All witnesses who were indoors first heard a noise which was followed by a ball of fire.

Several gave reasonably good descriptions of objects silhouetted between them and the ball of fire. This information correlated well to fix the geographic position and an approximate altitude band for the fireball. When plotted, the altitudes of sighting varied from 17 000 ft to about 24 000 ft. While the variation here is wide, it does indicate that the fireball was at high altitude and probably no lower than the 15 000 ft reported on the radio by the crew.

Using a speed of sound of 1 088 ft/sec, which is the standard-day average between sea level and 15 000 ft, it can be shown that from a simultaneous noise and light at 15 000 ft, an observer directly below would hear the sound about 14 seconds after seeing the light. An observer three miles away would not hear the sound for an additional six seconds. (Normal temperature variations and even strong winds will make only negligible differences in time). The loud continuing noise, then, had to occur 14 or more seconds prior to the appearance of the fireball, plus the time interval between the witness observations of noise and light.

Analysis of the witnesses' statements showed that the information provided by a majority of the witnesses was reasonably consistent. The average time from noise (at the source) to the appearance of the ball of fire was in the order of 33 seconds, with the largest variation from the average being about eight seconds.

The witnesses who saw the fireball from inception agreed that there was no prolonged fire, but rather a small one which grew quickly into a large orange or red ball and then disappeared in a few seconds. Several witnesses observed that just prior to extinguishment, a smaller fire emerged from the large ball and fell to the northeast, dying out well before reaching ground level.

Wreckage Distribution and General Damage

The wreckage was distributed within a long, narrow ellipse, the major axis of which was approximately coincident with the 344° radial of the Leona omni range. The first item found at the southern edge of the wreckage pattern was a 9 inch section of hydraulic line from the left heat exchanger, and its position was fixed as 17.4 miles north of the Leona station. Proceeding northerly from this point toward the main wreckage, the major components were located in the following order: No. 1 propeller and gearbox; left wing (including No. 1 engine and the No. 2 power plant); No. 4 power plant; left outboard stabilizer section; right outboard wing panel; followed by the main wreckage area consisting of fuselage, empennage, No. 3 power plant, and right wing stub.

The wreckage was strewn for a total distance of 13 900 ft from the first recovered item to the nose crater, with some lateral spread of the debris, due in part to wind effect, the lighter pieces being generally east of the more dense ones. Two parts of high density, and therefore subjected to only slight trajectory deviation, were the No. 1 propeller and gearbox package and the No. 4 power plant. The direction between these was 341° magnetic.

At the main area, 3.19 miles from the highway intersection in Buffalo and on a bearing of 92.75° from that intersection, there were three basic concentrations of wreckage, one around the nose crater, one at the centre section crater, and one at the tail cone.

The material at and west of the nose crater (about 4 ft deep) was, without exception, identified as fuselage and fuselage-contained components.

The second concentration was approximately 200 ft northeast of the nose crater and in a heavy growth of scrub oak. The material in this vicinity consisted of the centre section, right wing fragments, the No. 3 power plant, rear cabin structure, and components related to these portions of the airframe.

The tail section was located 250 ft northwest of the centre section, with the rudder and elevator control cables lying across the tops of the intervening trees.

Systems

The cockpit of the aircraft was almost completely demolished. Those portions recovered were found at the bottom of the crater made by the nose of the aircraft. Study of this debris along with the remains of flight and power plant instruments yielded no information significant in establishing the cause of the accident.

The flight engineer's log sheet for 2300 hours, which was recovered, indicated altitude 15 000 ft; indicated airspeed 275 kt; indicated outside air temperature 15°C. The engine and airfoil anti-icing systems were off; engine instrument indications appeared normal.

Damage to the airframe had been so great that no aircraft system, as such, survived. In addition, impact and fire had destroyed or damaged individual systems' components to the extent that functional checks were generally impossible.

The following aircraft systems were examined to the extent possible:

Hydraulic and electrical systems - no indication of operational distress;

Radio - no sign of malfunctioning, no evidence of fire or overheating;

Air conditioning system - inspection of recovered duct sections and the outflow control valve disclosed no indication of smoke or fire damage;

Instrument and autopilot systems - all recovered instrument system components were destroyed by impact with the exception of the two fluxgate compass transmitters;

Control surface booster assemblies - individual components capable of operation were given functional tests. All discrepancies noted were attributed to crash impact damage with the exception of a failed electrical lead at the load sensor of the elevator boost assembly. The load sensor was subsequently examined by the National Bureau of Standards whose report states, in part, "The break in the stranded wire in the sensor unit was probably caused by several cycles of reversed bending, rather than by a single tensile or bending load." It is not known whether the failure occurred prior to or as a result of the accident. It may well have broken during the violent shaking which could have preceded the inflight breakup. If the failure existed in flight and the aircraft were being flown on autopilot the automatic elevator trim feature would be inoperative and any change in longitudinal trim would be accommodated by the autopilot. With the autopilot holding against an out-of-trim condition, up to the limit of its authority, sudden release of the autopilot would result in a relatively mild pitchup or pitchdown, depending upon the direction of trim imbalance. This would not create a hazard or place the aircraft in an attitude from which recovery would be difficult.

Air start system - the left air compressor assembly of the air start system was recovered at the left wing impact site. The compressor had been consumed by fire. The right compressor assembly was demolished by impact but showed no evidence of fire.

Fire extinguishing system - the selector valves were in their normal positions, and none of the fire bottles had been discharged by crew action.

Fuel - the four fuelling valves were functionally checked and then dismantled and inspected. Each valve required replacement of its impact-damaged solenoid, after which its mechanical functioning was found to be within operating limits. Inspection disclosed no defects or abnormal wear. No significant contaminants were found within the valves.

Anti-icing system - insufficient recovery was made of anti-icing system components to provide any useful information.

Power Plant

A great amount of the power plant investigative effort was directed toward determining if a failure or malfunction of any of the engines, propellers, or their associated systems had contributed to or caused the accident. This activity covered the following areas:

1. Oil systems for significant contamination.

2. Propeller reduction gear and accessory drive systems for gear and/or bearing failures.

3. Torquemeters for rotational interference.

4. Power section rotors for overtemperature indications, bearing failures or rotor failures.

5. Fuel pumps and fuel controls for failures.

6. Propeller pitch change mechanisms and controls for failure.

Detailed examination in these respects did not reveal any evidence of failure or malfunction of the power units prior to the start of the separation of the No. 1 engine power section at the air inlet housing to the compressor split line.

Some witnesses reported hearing noises which from their various locations suggested possible engine overspeeding. Examinations of the engines and propellers were made in detail for overspeed evidence of the kinds that were noted during development tests. The first evidence of overspeed from tests, perceptible turbine and compressor tip diameter growth and resultant compressor tip rub, occurs at 20% overspeed (16 600 engine rpm). At increasingly higher overspeeds, compressor tip rub is more pronounced, turbine blade tip rub and some bearing distress becomes evident. No measurable growth of turbine or compressor diameters or bearing distress of the kind associated with overspeed was noted. Based on propeller development work, the first evidence would be brinelling of the blade bearing races and it would occur at about 53% (21 120 engine rpm) overspeed. Forty-one per cent (19 500 engine rpm) overspeed tests showed no brinelling. No brinelling of the kind that would result from overspeeding was noted on any of the propeller bearing races.

In other words there was no evidence of overspeeding, though in view of the tolerance of both the engine and propeller to overspeeding before any physical evidence develops, 20% and 53% respectively, lack of this evidence does not permit concluding an overspeed of a lesser amount did not occur. However, it is difficult to project an overspeed as such into an accident of this kind. The following devices are incorporated in the engine propeller design to protect against overspeeding and/or high drag: (1) fuel control overspeed governor, (2) negative torque signal, (3) safety coupling, (4) hydraulic and mechanical low pitch stops, (5) beta followup, and (6) pitch lock. These features, some of which function entirely independently, provide multiple protection against power plant induced drag of a degree which would present airplane control or structural loading problems.

Attention was directed to the No. 3 power plant by unusual markings on the safety coupling, the 50% closed position of the electrically operated oil shutoff valve and the totally closed position of the actuator of the electrically operated fuel shutoff valve located within the fuel control.

The safety coupling functions to disconnect the propeller from the engine in the event other protective devices have failed to function and the propeller is furnishing energy (negative torque) by windmilling action to drive the engine. This action by the safety coupling is generally termed "decoupling" and occurs when negative torque reaches approximately 1 700 shaft horsepower. Comparison of the marks on the inner and intermediate members of the No. 3 coupling with like marks on couplings known to have operationally decoupled and ratcheted revealed a dissimilar pattern. Metallographic and visual study revealed that high negative torque loads were applied while the intermediate member was out of alignment with the outer member. Impact loads between the inner and intermediate members were applied in both the positive torque and axial direction.

Evidence indicating that emergency action may have been taken with respect to No. 3 power plant was not supported by the physical condition of the engine and propeller. This power plant was the last to separate from the airplane, possibly at contact with the ground. That the oil shutoff valve was only partially closed indicates the operation was prematurely terminated, most likely by a loss of electrical power. It appears that emergency action with respect to this engine was initiated just prior to or during breakup by either the crew or by actuation of the control due to disruption by the airplane breakup. Any significance of these valves with respect to the accident is not discernible.

Separation of the No. 1 engine at the air inlet to compressor case split line occurred early in the sequence of events as evidenced by the parts forward of the separation line being the first major component along the flight path. No. 1 propeller blade angle and markings on the load side of the compressor extension and stub shafts' splines indicate power was being produced when the separation occurred.

The propeller, engine gear case, air inlet housing, and the quick engine change structure of the No. 1 power plant separated as a unit as a result of failure of nacelle and/or QEC* longerons at the QEC - nacelle fittings. The engine unit aft of the compressor front face remained in the No. 1 nacelle and descended with the left wing.

With reference to this statement the following should be noted. This separation occurred following failures in the QEC which permitted movement of the rear of the engine. Had the engine separation occurred first the repeated markings made on the adjacent shrouding by the clamp on the rear of the engine would not have occurred. It was concluded that the normal support provided by the mounts at the reduction gear case was disrupted, thus permitting loads generated by the rotating propeller to be transmitted through the engine structure causing gyrations of the rear of the engine within the confines of the adjacent shrouding and ducting. Separation at the air inlet and compressor case junction occurred in an upward and slightly to the left direction with the forward portion also rotating clockwise about a centre five to six inches outside the bolt circle positioned radially about the 11:00 o'clock position. This separation occurred by tension failures of the 1/4 - 28 cap screws and pullout of the 5/16 - 24 inserts. A study of this separation failed to reveal any evidence of repetitive relative motion as separation occurred. The loading necessary to bring about this separation could have occurred only after the QEC structural integrity was disrupted, and propeller-generated loads that were intended to be absorbed by the Lord mounts which support the reduction gear assembly were instead transmitted rearward through the intact engine structure.

Interference of the first stage compressor blades with the air inlet housing occurred on the No. 1 engine of this aircraft and on the Nos. 1 and 4 engines of the Electra involved in the accident at Cannelton, Indiana. There was separation in flight of some portion of these three engines. These similar circumstances cannot be accepted as coincidental since like circumstances prevailed in each case. It is believed this rotational interference was caused by air inlet case deflection due to abnormal loads being applied through the engine torquemeter housing and struts. Furthermore, these abnormal loads followed disruption of the engine supporting structure such that loads normally taken out by the forward QEC Lord mounts and structure were, instead, imposed on the engine structure. It follows that the basic engine structure forward of the compressor must have been intact in order to transmit propeller generated case distorting loads. The design strength of the basic engine structure is materially greater than that required by the Civil Air Regulations for its supporting structure. This suggests that structural damage due to overloads by whatever means would be confined initially to the supporting structure. Thus, the previous conclusion that engine supporting structure disruption preceded the engine structure damage is further substantiated.

Marks were made by contact of the leading edge of the first stage compressor blades with the surface of the shelf just rearward of the inlet guide vanes. Rubs were confined primarily to the areas between 3^o and 90^o and between 176^o and 230^o, starting from the top and progressing clockwise. The rub marks were not truly circumferential in that those between 3^o to 90^o angled forward about 6^o and

* quick engine change

those between 176° and 230° angled rearward about 3°. The directions are referenced to the counter-clockwise rotation of the compressor rotor.

The internal spline on the compressor stub shaft and the male spline of the compressor extension shaft showed contact marks on their normally loaded sides. The contact marks were made during the final 1/8-inch mesh of the splines as separation occurred.

No. 1 propeller blade angle when recovered was in the order of 51° to 56°. The remaining propellers were at or near feathered.

Structures

All aircraft structure was examined for break patterns, fire damage, stress patterns, explosive damage, and mechanical defects, with many of the individual pieces and/or sections being subjected to laboratory examination and evaluation. All of the structural damage was classed as from one or more of the following: airborne disintegration, ground impact, airborne fire, and/or ground fire. After a basic study of wreckage distribution, it became evident that the aircraft had experienced airborne disintegration which broke the aircraft up into a number of major sections, as mentioned in the section - "Wreckage Distribution and General Damage".

The Breakup

The fact that the aircraft broke up violently was self-evident. The breakup process was both quick and with little or no warning. This was clear for two reasons. First, only one of the aircraft's 37 passenger seats recognizable as such was found with the safety belt fastened, and this probably means there was no time to order their fastening. Second, the final radio message preceded the breakup by an interval of something less than two minutes and that message gave no hint of trouble.

A definite sequence of failures and breakages appeared discernible. Separation of the left wing and the No. 1 gear box propeller and QEC (quick engine change) structure occurred at about the same time; it was impossible to say which went first. The horizontal stabilizer then broke up under the impact of parts coming from the wing; wing planking from the right wing tip came free; the No. 4 power plant tore loose; and the right wing outboard of No. 4 separated. All of these events happened in a short period of time. Somewhat later, at much lower altitudes, the fuselage broke in two separate portions at a point about halfway back.

The left wing struck the ground butt-end first, right side up, after passing through trees approximately 50 to 70 ft high. Included with the left wing were the left landing gear, No. 2 QEC unit and the No. 1 engine (minus propeller, gear box, air inlet housing and QEC structure). The wing was subjected to intense ground fire as a result of the ignition of fuel from the No. 1 fuel tank. The ground fire area extended 150 to 200 ft ahead of and approximately 100 ft behind the wing, but laterally only a few feet beyond the tip and the root. Some portions of the left wing in the trees showed no evidence of fire, whereas others directly over the principal wing wreckage showed light deposits of smoke. The starter compressor (magnesium), located normally in the rear of the No. 2 nacelle area, was completely consumed by fire and its louvered cover panel lying under it showed signs of heavy black smoke exiting through the louvers; however, the adjacent cover panel was found outside of the ground fire area and showed no evidence of ever having been subjected to fire or heat. The initial left wing separation occurred between the No. 2 nacelle and the centre section. During the mockup of this area, approximately 80 per cent of the lower planking in the No. 2 fuel tank area was accounted for and fitted into place. The upper planking of this area, in contrast to the lower planking, had been shattered into many small fragments. This made it difficult and in many cases impossible to fix the exact location for each piece; some pieces could only be fitted into a general wing station area.

The physical evidence was summarized as follows:

1. Inflight fire was confined to the extreme inboard portion of the left wing, causing heat damage to the left windows to the rear of the wing trailing edge and sooting of the left rear fuselage.

2. The No. 2 fuel tank showed no evidence of internal pressure or explosion and the planking fragments were burned and sooted in a random pattern.

3. The left inboard leading edge, the lower planking and the rear spar showed that the left wing failed at the inboard one-third of the No. 2 tank in upward bending and noseup torsion. The relatively small fragments of the upper planking indicated a strong probability of failure resulting from a high positive load.

4. The wing station No. 83 closing rib of the left leading edge showed metal-to-metal scratches. Microscopic examination disclosed three to four changes of direction in these predominantly vertical marks.

5. The fracture faces of lower wing plank No. 3 at wing station No. 65, left, showed evidence of having recontacted each other after the fracture occurred. Microscopic examination revealed at least three cycles of recontact.

6. The forward attach point of the No. 1 QEC upper outboard longeron showed heavy compression loading prior to failure and further disclosed multiple directions of local bending in the several longeron members.

7. The forward attach area of the No. 1 QEC upper inboard longeron revealed a tension failure followed by a recontact of the fracture faces in a would-be compression load.

8. The electrical connectors and their wiring at the No. 1 nacelle firewall were failed in multiple directions of bending.

9. At the No. 1 firewall, the fuel line was bent up/inboard and down/outboard prior to ultimate failure which was up/outboard.

10. Found in the No. 1 nacelle shroud were indentations which were made by the antiswirl assembly clamp bosses. There were also multiple clamp marks around the shroud but less pronounced than those at the clamp splitline.

11. Both No. 1 gear box Lord mounts showed evidences of repeated yaw loads and some indication of rear load. The rear mount disclosed excessive relative motion of the mount with respect to the nacelle structure.

12. The No. 1 engine's first stage compressor blades rubbed the inside of the air inlet housing.

13. Examination of the structure for fatigue produced completely negative results.

In reference to the localization of the left inboard wing fire, at no point could there be found a continuous fire or heat pattern across the rear portion of the wing, particularly along the spar, the back side of which is white, and the upper trailing edge surface, the under side of which is white. This material was clean. Two of the flap beams, flap station No. 174 and flap station No. 106, showed some sooting; however, the soot marks were not continuous across break lines. The inboard flap beam at wing station No. 72 was completely clean. This beam went into the main wreckage area with the centre section. The flaps themselves had fire patterns on them; however, at any point where there was a fire pattern it could be shown that it did not exist prior to the breakup of the flap and most of this fire occurred in the area where the flap was torn through as a result of wing failure. Inboard of the station No. 72 flap beam there was evidence of inflight fire, and such would be expected since there was a ball of fire passing through this area at the time of wing failure. The only point at which fire or heat can get into the fillet area on the rear portion of the wing is through a small opening under the fillet and above the junction point of the upper cap of the rear spar to the fuselage. This area was completely clean and showed no evidence of soot, fire or heat. This area, incidentally, is white and would show soot very readily. The only other way to get heat into the fillet area from outboard would be through the leading edge and through a similar opening from the leading edge into the fillet area; however, this did not get sooted in any way. It was noted during the mockup period that the trailing portion of the wing fillet makes a scoop or funnel capable of holding several gallons of kerosene, and ahead of this area there is a place where additional fuel could be trapped for a short period of time. This could contribute to a more prolonged fire than might normally be considered possible.

The following negative points must be considered along with the positive evidence in the wreckage:

1. In the 2307 radio call to the company the only maintenance items reported were an inoperative No. 3 sump pump and the bonding of a terminal strip. This was only two minutes prior to the accident.

2. There was no turbulence along the route of this flight at operating altitudes.

3. There was no record of this aircraft being subjected to a hard landing or to any appreciable turbulence during its 100-plus hours since manufacture. There could be found only one incident of any possible maltreatment of the airframe. This occurred on 22 September 1959 during a training flight wherein the pilot entered a secondary stall following an improperly executed stall recovery. Any likelihood of damage resulting from this manoeuvre was evaluated and dismissed.

4. According to ARTC records there was no conflicting traffic of aircraft operating on flight plan. The U.S. Navy advised that there were no aircraft operating from the only Navy facility in the area and further that no other Naval command had aircraft operating in the vicinity of Buffalo. The Air Force reported no local flights from Barksdale Air Force Base between the hours of 2200 and 2400. Connally Air Force Base had aircraft in the area, but all had landed prior to the time of the accident. Carswell Air Force Base had two KC-135's on IFR round robins at accident time. (If these two had been in the Buffalo area IFR, ARTC should have had a record of this.)

5. In all of the examination, testing, and analysis of the flight control systems, boost and autopilot, no phenomenon could be produced which would produce or lead to a structural failure. (There was further work done in this area after the Cannelton accident.)

There is one other very important consideration. This is the Cannelton, Indiana, accident of a similar Electra, which also experienced a wing failure (right) and loss of QEC units to form a similar destruction pattern of the Buffalo accident. While a mirror image type of pattern itself is not positive proof of similarity of cause, there are indications of oscillatory motions of wing and outboard QEC structure in both the Buffalo and Cannelton wreckages.

Following the accident at Cannelton, Indiana, Lockheed undertook a re-evaluation programme in which the entire Electra concept and design was audited. An enormous quantity of data was produced, the majority of which was negative. It is sufficient for the purpose of the report to state that, insofar as causal factor is concerned, only one area of the programme is significant. This is the phenomenon known as "whirl mode"*, an oscillation which under certain conditions can produce flutter.

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* ICAO Note: For a detailed discussion of "whirl mode" and Lockheed's Electra re-evaluation programme following the accident at Cannelton, Indiana, please refer to the Cannelton summary on page 137.

Causal Possibilities

Certain causal possibilities can be eliminated from further discussion because of a complete lack of evidence or evidence to the contrary:

1. collision with another aircraft;
2. structural failure due to turbulence during this flight;
3. structural failure from fatigue;
4. structural failure as a result of boost and/or autopilot malfunction;
5. sabotage.

The shattered upper planking of the left inboard wing suggested a strong possibility of failure due to excessive positive loading. The horizontal tail or rear fuselage showed no such evidence; however, Lockheed testified that at 275 kt IAS (last known airspeed) the wing and tail were about equally critical under positive loading. There was further testimony that above 275 kt the wing becomes the more critical of the two.

This leads to the premise that high-load wing failure (if it existed) occurred at an airspeed in the order of 275 kt (cruise) or higher. Such an overload failure, with boost, autopilot, and turbulence out of the picture, would have to develop from a pull-up manoeuvre brought on by collision avoidance or following loss of control. Since there was no known conflicting traffic, there is nothing to substantiate a theory of collision avoidance.

Loss of control has occurred in other instances because of a pilot's inattention to duty resulting in a dive or diving spiral. An analysis of a plot of the witness sightings, however, places the ball of fire at or above 15 000 ft. If, then, the ball of fire (wing-tank fuel ignition) was at or above 15 000 ft it would require a climb, intentional or not, prior to any loss of control of a type which would create excessive airspeed. (Note: It is extremely difficult to conceive of a recovery from an "unusual position" causing structural failure without first having excessive speed, particularly at the gross weight of this aircraft at the time of the accident.) This hypothesis cannot be maintained for it first presupposes a climb for which there would be no known purpose. If it be argued that the climb is unintentional, it becomes necessary to assume an extremely lengthy inattention. It must also be remembered that a scant four minutes prior to impact, or about three minutes prior to the witnessed noise, the flight reported at 15 000 ft.

All this leads to a conclusion that, even with indications of high positive loading, there is a causal factor far more insidious than excessive air loads.

It thus becomes necessary to consider "whirl mode", a phenomenon shown by wind tunnel tests and analysis to be a potential destructor. Some evidence of oscillatory motion was found in the left wing and No. 1 QEC/nacelle. While this is not positive evidence of whirl mode, it is certainly compatible with the motions shown by tests to exist during the latter stage of excitation.

Another factor which is compatible with, but not proof of, whirl mode is the intense noise attested to by ground witnesses. Analyses by Lockheed and Board technical personnel have shown that during whirl mode the propeller tips approach sonic velocity without increase in rpm or airspeed, and probably produce a noise in the order of 120 db. The witnesses heard such a noise at a time which would place the noise about 33 seconds prior to the fuel ignition. Analysis has shown that whirl mode, from inception to destruction, would last about 20 to 40 seconds. No avenue of investigation has revealed any other reason for the sound described and later identified by the witnesses.

As mentioned earlier, the left wing showed indications of high positive load. This is in complete contrast to the right wing failure at Cannelton. There is no way to establish with any degree of certainty this difference in wing failure patterns, but it is possible to rationalize a possibility. The first impulse of a pilot, when subjected to either severe vibration, a runaway propeller noise, or both, is to slow the aircraft down. Normal action would be to reduce power and to climb. Of the two, climbing is the more immediately effective, particularly in the Electra, which takes several minutes to reduce speed from 275 to 200 kt by power reduction. There is, then, the possibility that in the excitement and in his desire to slow down quickly, the pilot exerted back pressure sufficient to fail the wing earlier than if failure had resulted from oscillation alone. This is not to imply that the pilot applied a stick force capable of failing a structurally sound wing, but rather that his action dictated direction and time of failure.

There remains one point, the element of "prior damage" which cannot be satisfactorily explained. According to Lockheed, the stiffness factor of the QEC must be substantially reduced to produce an undamped whirl mode, or propeller precession. This suggests damaged or failed structure, engine mounts, or engine structural components. No such evidence was found. The No. 1 QEC and power plant were examined minutely for fatigue, with negative results. No other type of failure was discovered which could be definitely considered damage prior to whirl mode, QEC failure, and impact. There is serious doubt whether such a determination could be made with any degree of accuracy. For example, there were several pure tension and compression failures in the QEC structure which could have occurred prior to whirl mode or early in the precession. Furthermore, there was nothing in the aircraft's recent history, such as hard landings or turbulence, to indicate the possibility of prior damage, nor was there on the final flight, as far as can be determined, any incident leading to structural damage prior to the accident.

Conclusions

There was in this investigation no positive indication of the cause. For this reason, an attempt has been made in the report to eliminate certain possibilities by application of the available evidence to each of them. Once these possibilities have been disposed of, the only remaining causal factor for which there is some known basis is the condition of whirl mode. The probability that this accident was so caused is supported by the following:

1. So far as is known, the aircraft was in straight and level flight and at a normal cruise speed with no serious mechanical problems.

2. A sound identified as a supersonic or high speed propeller occurred 30 seconds prior to fuel ignition (wing failure).

3. There was structural damage evidence compatible with oscillatory motion of the No. 1 QEC and the left wing.

4. First stage compressor blades of No. 1 engine rubbed the air inlet housing supports.

5. The probable cause of a similar accident of another Electra was due to whirl mode.

If prior damage is a requirement for the necessary reduction in stiffness, it must be assumed that the evidence of such damage was either obliterated in the crash or never existed in a discernible form.

Probable Cause

The probable cause of this accident was structural failure of the left wing resulting from forces generated by undampened propeller whirl mode.

Scheduled
En route
Airframe - air
Airframe - wing

ICAO Ref: AR/674

No. 10.

Civil Air Patrol, Aeronca L-16 A N 9330H and Cessna 140, N 1652V, mid-air collision near North Philadelphia Airport, Philadelphia, Pennsylvania on 30 September 1959. Report by the Civil Aeronautics Board (U S A), File No. 2-1408, released 17 May 1961.

Circumstances

The Aeronca left North Philadelphia Airport at 1355 hours eastern standard time on a local training flight. The aircraft carried no radio. It was away from the field for 10 to 15 minutes then, on its return to the airport, it began to carry out touch-and-go landings on runway 15.

At 1400 the Cessna departed Lake Susquehanna Airport, Blairstown, New Jersey, for North Philadelphia Airport. At about 1420 the North Philadelphia Airport tower received a radio call from the aircraft asking for landing instructions. The tower cleared the aircraft to enter the landing pattern and to land on runway 15. No traffic information was given to the pilot at this time.

The mid-air collision occurred approximately 500 ft from the approach end of runway 15 while both aircraft were lined up on their final approach. The Cessna crashed, killing the pilot, whereas the pilot of the Aeronca was able to regain control of his damaged aircraft and effect a successful landing.

Investigation and Evidence

Experience of the Pilots

The pilots of both aircraft held valid private pilot certificates. The Aeronca's pilot had flown 600 hours, and the pilot of the Cessna had 122 hours to his credit.

Weather

The weather conditions at the time of the collision were scattered clouds at 4 000 ft, high broken clouds; visibility 15 miles; temperature 83°F; surface winds from the south-southeast at 13 kt.

The Airport and Control Tower

The field elevation of North Philadelphia Airport is 120 ft; the recommended traffic is left, to be flown at an altitude of 1 000 ft above the ground.

The control tower at North Philadelphia Airport is an FAA tower which operates on a 24-hour basis. It is staffed by a chief controller and three air traffic control specialists, all of whom had control tower operator certificates with senior ratings. No scheduled air carriers land or take off from North Philadelphia Airport, and traffic consists mostly of light single and twin-engine transient or locally based aircraft. The tower makes no recordings of radio transmissions or receptions.

The tower was equipped with a portable traffic light (Aldis lamp) which is directional and emits an intense, narrow beam of light. The colour of the light (white, green, or red) is controlled by the operator through a system of levers and triggers in the two handles. Signals may be discernible to the pilot of any aircraft visible to the tower operators and to which the light is directed.

A small extension from the lamp glows when the light is actuated by a trigger, indicating that the light is operating. The tower controller could not remember whether he saw this indication when he directed the light toward the Aeronca. However, he stated the light did function correctly when checked immediately following the accident.

The disadvantages of the use of the light are that the pilot cannot constantly look at the control tower while flying his airplane and could inadvertently miss a signal directed toward him; the information transmitted by the light signal is limited; and no accurate sighting device is provided.

There was conflicting testimony between the North Philadelphia Control Tower operators and pilots who fly non-radio aircraft as to whether preventive control was in effect at the airport. * "Preventive Control" applies at locations which have locally based squadrons or groups of military aircraft, or local civilian operators, or schools such as North Philadelphia Airport. In such cases mutual agreements and arrangements must must be made with the responsible heads of these groups prior to the inauguration of preventive control. Such control is not to be employed for transient aircraft.

No evidence could be found to indicate that an agreement or prearrangement had been made in accordance with Section 3.700 of the ANC Manual between the North Philadelphia Airport Control Tower and the Civil Air Patrol, or between the tower and the civilian flying school based at the airport, as related to the use of negative or "preventive control". Nevertheless, several witnesses, including the FAA Supervising Inspector of the Philadelphia General Safety District Office, stated it was the practice of North Philadelphia Airport for nonradio-equipped aircraft to continue an approach and land without light communications. In the absence of radio communications or any light signal, any aircraft may land or take off at any airport without prior approval.

The Collision

It occurred while both aircraft were lined up on their final approach. The Cessna was directly below and a little to the right of the Aeronca. The Aeronca continued to descend after the Cessna levelled off and initial impact occurred between the forward left wingtip of the Cessna and the underside of the Aeronca right aft lift strut midway at the strut brace position. The Cessna proceeded under the Aeronca's wing and the leading edge of the Cessna's vertical stabilizer contacted the Aeronca's right aileron, bending the Cessna's stabilizer and rudder 90° to the right to a flat position. Both aircraft momentarily locked together and entered a bank to the left. The Aeronca managed to turn inside the Cessna and pull up. According to the pilot of the Aeronca, the Cessna then pulled up and struck the Aeronca a second time, this time in the area of the right wing struts. A dent was also made in the underside of the leading edge of the right wing. The Cessna pilot lost control of his aircraft and it plunged to the ground. Collision impact caused binding of the Aeronca's right aileron and subsequent partial loss of control. However, the pilot succeeded in landing on runway 15 with no further damage. Ground impact of the Cessna occurred 75 ft from the approach end of runway 15 and 375 ft to the left of the runway 15 centreline.

Analysis

Although there was conflicting evidence as to the positions of the aircraft in the traffic pattern, the Board believed that the actual positions of the aircraft were as follows: The Cessna entered the landing pattern behind, to the right of, and below

* The ANC Manual states: "Preventive Control is defined as a system of control whereby useful preventive advice is given to pilots of aircraft in the air and a routine approval of the pilot's anticipated actions is eliminated.... The pilot is expected to continue flight including landing in a normal manner unless otherwise advised by the airport traffic controller."

the Aeronca. The Aeronca pilot could not have seen the Cessna without looking back to his right and down. This is quite unlikely since his attention would have most likely been directed to the airport and runway which was to his left as he flew the downwind and base leg.

Considering the relative speeds of the two aircraft, with the Cessna being somewhat faster, the Board believes the two aircraft could maintain this position throughout the traffic pattern until turning onto the final approach. The fact that the Aeronca was on the inside during the turns onto the base and final approach, and therefore travelling the shorter distance, was compensated for by the relatively faster speed of the Cessna. The two 90-degree turns that each made, served to close the gap between the two aircraft and placed the Cessna under the Aeronca on final approach just prior to collision.

The Aeronca pilot stated that because the air was rougher than usual, he was flying at a slightly higher airspeed which tended to give his aircraft better landing characteristics. When both aircraft were on final approach the tower operator instructed the Cessna pilot by radio not to land. The Cessna pilot acknowledged these instructions and was observed to level off. It was at this point that the collision occurred. Since the Cessna pilot was not told why he was not to land, it can logically be assumed that having received this instruction he levelled the nose of his aircraft and applied power for an aborted landing. The Cessna pilot, having altered his glide angle to level flight and increased his airspeed, overtook and collided with the Aeronca which was descending. The damage to the aileron of the Aeronca and the rudder of the Cessna attested to the fact that the Cessna was moving faster than the Aeronca at the moment of collision.

The tower operator stated an alternating green and red warning light was given the Aeronca pilot while the aircraft was on the downwind leg and while turning on the base leg, and a steady red light was directed toward the Aeronca until the aircraft collided. Whether or not a warning light or a signal to give way or whether such signals were directed to the right aircraft is questionable. The portable traffic lamp was checked immediately after the accident and determined to be in proper working order. It is possible that a warning light was given while both aircraft were on the downwind leg. With both pilots at this time concentrating on the landing end of the runway and with the tower positioned off to the rear of each pilot's left shoulder, it is reasonable to assume that a light given while the aircraft were in this position could have been missed by both pilots. When both aircraft turned onto base leg, their positions would have enabled their pilots to see the warning light if given, which, according to the tower controller, was meant for the pilot of the Aeronca which he believed was the second aircraft.

When the two aircraft turned onto final approach, the possibility of either pilot seeing a light signal from the tower is greatly increased. Yet neither pilot took action indicative of his having seen a light signal. It is reasonable to assume that had the Cessna pilot seen a red warning light shining in his direction he would have used his radio to inquire whether it was meant for him. Had the Aeronca pilot seen the light he would have discontinued his approach and circled to the left.

It is entirely possible that the reason for neither pilot seeing a light was because the tower operator directed the light to the second aircraft, which was the Cessna, while mistakenly thinking it was the Aeronca. Since the Cessna pilot was receiving his instructions by radio, it is unlikely that he would be observant of a light signal from the tower.

Part 60 of the Civil Air Regulations clearly states the responsibility of pilots to observe and avoid other aircraft.* Had the Cessna pilot observed the Aeronca he no doubt would have asked the tower whether there was other traffic in the landing pattern. Had the Aeronca pilot seen the Cessna he no doubt would have been particularly observant for a light from the tower and would probably have circled to put himself at a farther distance from the Cessna. It is evident that had either pilot observed the other aircraft while in the traffic pattern he would have taken some action to ascertain whether the other aircraft was also in the pattern. It is further evident that each pilot continued his landing approach unaware of the presence of the other and without accurate visual or timely verbal warning from the tower until too late to avoid a collision.

Under Part 60 of the Civil Air Regulations, a pilot would be expected to clear his position in preparation for landing, and clear himself in each turn, should he make turns to the base leg and final approach. In the absence of a sequence and on the basis of the clearance received, it was not imprudent of the Cessna pilot to assume that the area was clear of conflicting traffic. Nevertheless, the pilot of the Cessna should have observed the Aeronca as he entered the downwind leg if he had properly cleared his position as he entered. He should also have observed the Aeronca as he turned left to the base and final approaches since the Aeronca was inside of him and slightly above his altitude. The entry of the downwind leg at a 45° angle for an approach to landing is for the purpose of determining whether other traffic is in the landing pattern and to ensure an orderly entry to traffic, proper spacing for prevention of a collision, and to prevent aircraft from overtaking other aircraft in the traffic pattern.

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* "60.12 Careless or reckless operation. No person shall operate aircraft in a careless or reckless manner so as to endanger the life or property of others ... (c) Lack of vigilance by the pilot to observe and avoid other air traffic. This includes failure of the pilot to clear his position prior to starting any manoeuvre, either on the ground or in flight ... "

"60.14 (d) Overtaking. An aircraft that is being overtaken has the right-of-way, and the overtaking aircraft, whether climbing, descending, or in horizontal flight, shall keep out of the way of the other aircraft by altering its course to the right, and no subsequent change in the relative positions of the two aircraft shall absolve the overtaking aircraft from this obligation until it is entirely past and clear ... "

"60.12 (e) Landing. Aircraft, while on final approach to land, or while landing, have the right-of-way over other aircraft in flight or operating on the surface. When two or more aircraft are approaching an airport for the purpose of landing, the aircraft at the lower altitude has the right-of-way, but it shall not take advantage of this rule to cut in in front of another which is on final approach to land, or to overtake that aircraft ... "

"60.15 Proximity of aircraft. No person shall operate an aircraft in such proximity to other aircraft as to create a collision hazard ... "

Part 26 of the Civil Air Regulations prescribed certain procedures and practices which certificated air traffic control tower operators should follow.* Part 617.21 of the Administrator's Air Navigation Regulations (14 CFR 617) provided that "an airport traffic control tower is responsible for the issuance of clearances and information to pilots of aircraft for the purpose of protecting air traffic by aiding pilots in the prevention of collision between aircraft ... in the traffic pattern." Section 60.60 of the Civil Air Regulations defines air traffic control as "a service operated by appropriate authority to promote the safe, orderly and expeditious flow of air traffic." The duties of the airport traffic controller, therefore, include assisting the person in command of an aircraft by providing such advice and information as may be useful for the safe and efficient conduct of the flight. The failure of the tower controllers to observe the Aeronca accomplishing touch-and-go landings on runway 15 indicated a neglect of these responsibilities and duties.

The Board believed that the air traffic controllers should have used every means at their disposal, including radio communication, to warn the radio-equipped aircraft of any dangerous situation which might cause a collision. Failure to advise the Cessna pilot by radio while on the downwind and base leg after it appeared that the Aeronca was not altering course was one of the causal factors in this accident.

The Board concluded that the Cessna pilot, after being cleared by radio, entered the traffic pattern outside of, below, and slightly behind the Aeronca which was already in the traffic pattern accomplishing touch-and-go landings. The Aeronca was hidden from the view of the Cessna by the left wing of the Cessna, the Cessna being below and to the right rear of the Aeronca. Each pilot continued his landing approach unaware of the presence of the other and without accurate visual or timely warning from the tower until too late to avoid a collision. Visual light indications that were given were mistakenly directed to the Cessna which the tower controller believed was the Aeronca. The Cessna pilot had the best opportunity to observe the Aeronca as he traversed his 45^{o} entry to the downwind leg. He remained behind, slightly below, and to the right of the Aeronca throughout the remainder of the traffic pattern. The Cessna pilot's failure to observe the Aeronca was due to either a blind spot caused by a portion of the Cessna blocking out his view of the Aeronca, or his failure to adequately clear himself as he entered the downwind leg, and as he made his left turns to the base leg and final approach. After the Cessna pilot received the warning from the tower not to land during the final approach, he levelled off, overtook the Aeronca which was descending, and collided with it.

Probable Cause

The probable cause of this accident was the failure of FAA tower personnel to issue accurate visual and timely verbal air traffic advisories and the failure of the pilots of the two aircraft to maintain proper vigilance to avoid collision.

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* "26.26 Exercise of Authority. A certificated air-traffic control-tower operator shall control traffic in accordance with the procedures and practices prescribed by the Administrator to provide for the safe, orderly and expeditious flow of air traffic..."

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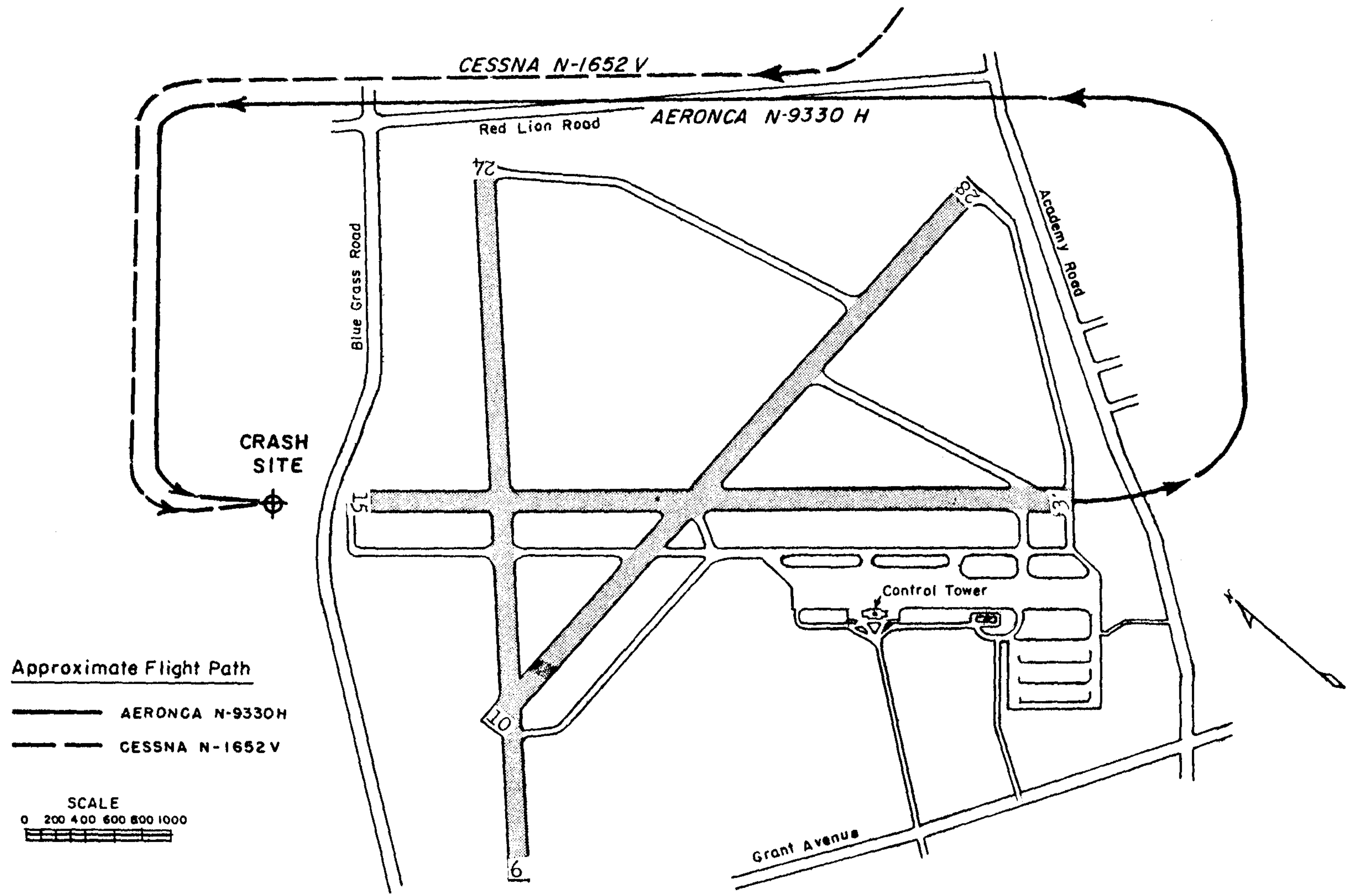
Private
Landing
Collision - aircraft - both airborne
Other personnel - improper operation, ground facilities
&
Pilots - failed to observe other aircraft

ICAO Ref: AR/678

FIGURE 1

COLLISION OF CESSNA 140, N-1652V, AND AERONCA L-16, N-9330H NEAR NORTH PHILADELPHIA AIRPORT

September 30, 1959



No. 11

Piedmont Airlines, Douglas DC-3, N 55V, accident on Bucks Elbow Mountain, near Charlottesville, Virginia on 30 October 1959. Civil Aeronautics Board (USA) Aircraft Accident Report released 24 April 1961.

Circumstances

Flight 349 was a regularly scheduled flight between Washington, D. C., and Roanoke, Virginia with intermediate stops at Charlottesville and Lynchburg, Virginia. The aircraft departed Washington at 1949 hours eastern standard time on an instrument flight plan and the clearance specified a routing over airway V-140 (see Figure 2) and a cruising altitude of 4 000 ft. It proceeded to the Springfield, Virginia radio beacon where it entered V-140 airway and followed the airway from Springfield to the Casanova VOR station.* The centreline of the airway over this segment is defined as the 260° radial of the Casanova VOR. At 2012 the flight reported that it was over Casanova at 2010 at 4 000 ft and estimating the Rochelle intersection at 2024, with Charlottesville next.

(At Casanova, V-140 airway turns left and from Casanova to the Rochelle intersection the airway is defined as the 239° radial of Casanova VOR; the distance is 31 NM. The Rochelle intersection is the 239° radial of the Casanova VOR and the 335° radial of the Gordonsville VOR.)

About 2018 the aircraft made a routine inrange report to the Piedmont ground radio station at Charlottesville Airport. The flight was provided with the latest altimeter setting, 30.47", and the current surface wind, which was calm. Normally, the operator would also furnish the latest ceiling and visibility observation... he failed to do so. (Ceiling was 1 500 ft broken, 4 000 ft overcast; visibility 10 miles).

Immediately after 2025 the flight reported it was over the Rochelle intersection at 2025 at 4 000 ft estimating the Charlottesville Airport at 2030. Washington Air Traffic Control Centre acknowledged and cleared the flight for an instrument approach. One minute later the flight stated, "You can put us out of four thousand." This was the last transmission from the aircraft. It crashed at 2040 hours on Bucks Elbow Mountain, 13 miles west of the Charlottesville-Albemarle County, Virginia, Airport killing the crew of 3 and 23 of 24 passengers aboard - the sole survivor was seriously injured. The aircraft was demolished.

Investigation and Evidence

Description of Impact

The aircraft crashed where the upslope of the 3 100 ft mountain was nearly 30°. It crashed against the rocky slope on a magnetic heading of 340-350° and at an elevation of about 2 600 ft. Initial contact occurred when the right wing of the aircraft struck and cut through several trees which progressively tore off the right wing outboard of the landing light. At initial impact the right wing was down about 10° from level, and the aircraft was descending slightly. The aircraft was yawed to the right and rolled to the right when, about 180 ft farther, it crashed against the upslope. In the final impact the forward fuselage rearward to the centre section was destroyed. Most of the fuselage from over the centre section rearward to the cabin door was destroyed or badly crushed.

* VHF omnidirectional radio range

The Wreckage - Findings following Examination

Examination of the wreckage revealed no evidence of malfunction or failure of the airframe or power plants. There was no indication of an inflight fire; all major components of the aircraft were located in the immediate crash zone, and it was clearly evident that both engines a and propellers were capable of normal operation prior to impact. The landing gear was extended at impact, and the flaps were fully retracted. There was nothing found indicating that an emergency existed before the accident. These findings, reached by examination of the available physical evidence, were substantiated by the observations of the sole survivor.

Although the radio and navigational equipment from N 55V was badly damaged and some portions were destroyed, information which was important to the investigation was available. Examination of the omni equipment disclosed that both receivers were tuned to 115. 3 Mc/s; the Gordonsville omni range frequency. It was also learned that the right omni bearing indicator was set to select the 301-degree radial or the radial which passes through the Earlyville homer. The radial selected on the other unit could not be determined.

Examination of the various components of the red and green ADF units disclosed both receivers were positioned to select band 1, the 200-410 kc range.

Weather

The weather observations for Charlottesville around the time of the accident were:

2000 ceiling measured 1 500 ft broken, 4 000 ft overcast, visibility 10 miles, wind calm

2100 ceiling measured 1 500 ft broken, 2 400 ft overcast, visibility 10 miles, wind calm

Conditions would have been much worse in the area near and parallel to the mountains west of Charlottesville where the mountains were obscured, and visual flight would not have been possible.

At the altitudes used by this flight the winds aloft were southerly and averaged about 15 kt.

Groundwitnesses

An intense search resulted in the finding of a series of ground witnesses who had heard a low flying aircraft. Because of weather conditions, consistently described as cloudy and foggy, none had seen the airplane but a flight pattern based upon the aircraft engines' sound was revealed. For several reasons the soundpath was attributable to Flight 349. Most important was the fact that the sound proceeded to and stopped abruptly in the accident area. Other reasons were the coincidence of time when the aircraft was heard with the estimated progress of Flight 349, the knowledge that no other known aircraft operated coincident with the soundpath, and to some degree the correlation between the sound movement and the survivor's recollections. Because the path was 8 - 11 miles west of the airport, a final reason was added when at least three persons on the airport specifically listening for Flight 349 stated they did not hear it. From the sound path information it was apparent the aircraft approached the accident location on a southwesterly course approximately parallel to the prescribed instrument approach path from the Rochelle intersection to the Charlottesville homer, but 8 to 11 miles west of the normal track. The information showed that the southwesterly course was maintained to the Crozet area located 8 - 11 miles abeam of the designated area for the instrument approach procedure turn. It was clearly apparent that in the Crozet area the flight executed a turn from its southwesterly heading to a northwesterly heading. By its amount and its north-south orientation, this turn was coincident with the turning portion of the procedure turn immediately prior to the inbound heading of 342°.

After the turn the flight flew northeast for, as near as can be determined, a distance of two to four miles and crashed against the side of Bucks Elbow Mountain. It crashed on approximately the heading of the inbound portion of the procedure turn with the landing gear extended. The elevation of the crash, however, was about 400 ft below the altitude specified for the procedure turn.

From all this evidence it was most apparent to the Board that the accident took place while the general manoeuvring requirements of the instrument approach were being flown 8 - 11 miles west of the designated manoeuvring area prescribed for the approach.

The Approach Procedure

The approach procedure for the Charlottesville Airport is an ADF (automatic direction finder) procedure performed on a Piedmont-owned and operated homer beacon facility. The night landing minima for Piedmont DC-3 aircraft are: ceiling 400 ft; visibility 1 mile.

The current Federal Aviation Agency approach procedure as applicable to Flight 349 would begin at the Rochelle intersection. According to the procedure in effect at the time of the accident, when Rochelle was reached the flight would transition off V-140 airway in a left turn to a heading of 212°. It would then establish and fly a 212° track to the Charlottesville (CHO) homer beacon, which transmits on 284 kc/s. As an additional aid, though not required, the company owns and operates another homer beacon Earlyville (EVL), which transmits on 266 kc/s. Charlottesville, the outer homer, is located 4.3 NM from the approach end of runway 3 and about 15.5 miles from the Rochelle intersection.

In normal execution of the instrument procedure most Piedmont pilots use both homer facilities - tuning one ADF to the Charlottesville homer, and the other to the Earlyville beacon. In addition, many also check passage of the Charlottesville homer by using the Gordonsville VOR, set to the 287° radial which passes through the homer. Some, at the same time, also check passage of the Earlyville facility by using the second omni range set, tuned to the 301° radial of Gordonsville.

When Board investigators attempted to plot the Rochelle intersection and airport locations, it was noted that the magnetic heading from Rochelle to the Charlottesville homer, as depicted on the ACA Form 511 and thus on the approach plate, was in error. The correct heading should have been 201° instead of 212°. The error resulted from not amending the heading when, several months earlier, the course of V-140 airway was shifted slightly. However, concerning this accident the error loses significance as according to Flight 349's flight plan the correct heading was used. Further, the use of tracking procedures in flight would eliminate the effect of the erroneous heading. Nevertheless, the attention of both the FAA and the company was immediately directed to the error for correction.

According to the procedure, upon reaching the Charlottesville homer beacon an outbound track of 207° should be flown, normally for 1 to 1-1/2 minutes. This is followed by a standard procedure turn on the southeast side of the track. Using the standard procedure turn, the outbound heading is 162° and the inbound heading is 342°. The final approach track to the airport is 027°.

Descent below 3 000 ft is not authorized prior to the final approach; then a descent is permitted to not less than 2 200 ft before reaching the Charlottesville homer. Thereafter, descent may be continued to the authorized minimum altitude of 1 039 ft, or 400 ft above airport elevation.

From the Rochelle intersection the entire instrument approach to landing in the DC-3 takes approximately 15 minutes. From Rochelle to the inbound heading of the procedure turn about 10-11 minutes' time is normally required. Based on the reported time of Flight 349 over Rochelle, 2025, and the crash time indicated by the survivor, 2040, the elapsed time was about 15 minutes.

Reconstruction of the flight-path

It was the opinion of the Board that the accident occurred for operational reasons. It, therefore, sought a determination in this area which would account for the flight path of the aircraft being parallel to, but 8 - 11 miles west of, the proper track. It also sought a situation which would develop easily and, because it is probable that the captain was flying, one which escaped observation by the copilot. It also sought a situation in which the precarious lateral error would not be readily detected as such by either pilot. Because of a number of unknown elements and the inherent intangibles of the operational situation, it is doubtful that any analysis can determine the sequence of events with complete definitiveness. Nevertheless, the Board believes it reached a determination which best satisfies the aforestated requisites and the known factors.

It was the Board's opinion that the laterally erroneous flight path developed from an initial navigational error at the Casanova VOR and it occurred as an omission in that the flight did not turn in conformity with the V-140 airway from the inbound radial of 260° to the outbound radial of 239°, a left turn of about 20°. It is believed that the flight continued on the 260° radial until it reached the 335° radial of the Gordonsville VOR at a location approximately 13 miles northwest of the Rochelle intersection. It was the Board's opinion that at this location, which was believed by the pilots to be Rochelle, the flight turned left to and flew the approximate heading indicated by the flight plan and log to be flown from Rochelle, 200°.

The Board's opinion as to the sequence of events was based upon several factors. The first was the results of an analytical time, distance and groundspeed plot. It is probable that the flight flew about 15 minutes after reporting Rochelle until it crashed... this time being considerably longer than the time normally required to fly from Rochelle to the inbound heading of the procedure turn, shows a greater distance must have been flown. A plot of the probable flight path in reverse was, therefore, prepared using the time flown, a reciprocal of the soundpath, and the estimated groundspeed of the DC-3. This showed that 15 minutes before the accident the aircraft would have been over an area about 13 miles northwest of Rochelle intersection.

The second phase of this work was a radius of action plot from the Casanova VOR. Based on the elapsed time between the Casanova and Rochelle reports, 15 minutes, it was determined that the flight would have flown 33 miles. A line of position with a radius of 33 miles from Casanova was found to intersect the initial plot at a location which was approximately 15 minutes from the crash or again about 13 miles northwest of Rochelle.

At the completion of this work two additional significant factors were apparent. The point of intersection of the plots was closely coincident with the 335° radial of Gordonsville. Secondly, the heading to the location of intersecting plots from Casanova was the 260° radial of Casanova and the same as the inbound radial to Casanova from Springfield.

At Casanova the co-pilot made the position report and most probably recorded it in the flight plan and log. Thereafter he would be expected to tune his omni range set to the Gordonsville frequency and select the 335° radial in order to identify the Rochelle intersection. Considering the small amount of turn required at this time, the first actions could have diverted his attention for the period during which the captain would normally have made the turn. Tuning his omni range set to Gordonsville, though necessary, would also reduce his opportunity to observe by VOR indications the relative position of the aircraft to the course of the airway. Additionally, there was indication that the captain flew with a lower than average level of instrument panel illumination. In the Board's opinion these factors are valid reasons in this instance for the co-pilot not having detected the navigational omission.

After reporting Rochelle and turning to the southwest heading it is likely that both pilots believed the aircraft was describing a groundpath west of, but only a short distance west of, the normal track from Rochelle to the Charlottesville homer. It is the Board's opinion that at this time the flight was, in fact, 13 miles northwest of Rochelle. While this position was only two to three miles farther than Rochelle from the Casanova VOR, the position placed the southwest course of the flight 8 to 9 miles west of the specified track. The location also positioned the flight about 10 miles farther from the homer facilities than from the Rochelle intersection.

It is believed that this latter factor could work to obscure the lateral error which existed during the southwest portion of the flight path. The greater distance from the signal source would reduce the angular displacement of the ADF presentation. Thus, if the aircraft was positioned 10 miles farther from the signal source than it was believed to be by its pilots, the angular deflection of the ADF presentation caused by the lateral course error could be obscured considerably by the greater distance. For example, the ADF presentation 24 miles from the signal source and eight to nine miles west of track is not alarmingly different than the presentation 12 miles from the signal source and three miles west of the prescribed track. Similarly, the ADF presentation 19 miles from the signal source and eight to nine miles west of track is not alarmingly different than the presentation seven miles from the signal source and three miles west of the track desired. In addition, as the flight progressed toward the facilities but from a greater distance than believed by the pilots, the increasing angular displacement of the ADF needles showing lateral error could be interpreted as a closure on the signal source. The Board believed the foregoing discussion to be a valid consideration in the reason that the pilots were not alerted early in the approach to the large lateral track error.

On the other hand, the Board was aware that as the flight proceeded on the southwest course the rate of progression of the ADF needles to the left 90-degree abeam indication would have been much slower as the result of the greater distance and time to be flown. At the 90-degree position the angular spread between the needles would have been much narrower

9 to 10 miles west of the homers than three to four miles west of the homers. Further 90° abeam of the signal source, a 20-degree relative bearing change on a flight path three to four miles west of the homer, would take 30 to 40 seconds as contrasted to approximately 1-1/2 minutes on a flight path about nine miles west of the homer. In addition, the ADF presentation during the period the flight turned from the southwest heading until it struck the mountain would have been incompatible with a close-in position. The Board believed that these factors should have served to alert an attentive pilot that the lateral course error was of considerable magnitude.

Navigational equipment and instrument approach facilities

As it was apparent that the aircraft flew a ground track well west of the desired track the possibility that faulty operation of ground navigational and instrument approach facilities might have caused or contributed to the erroneous flight path was thoroughly investigated. This work revealed normal operation of the facilities, and no condition which would impair flight conformity along V-140 or the execution of a normal instrument approach on the homer facilities.

The airborne navigational equipment was determined by physical evidence to have been properly tuned for an instrument approach utilizing the ADF equipment on which the Charlottesville approach was based. Because of this it was of primary concern to the investigation whether or not the ADF cockpit presentation was accurate. Most important in this determination were the positions of the ADF loops relative to the crash heading and location. The extended bearings of the red and green ADF loop positions passed nearly through the location of the respective homer beacon to which each was tuned. Also, the angle formed between the bearings subtended an arc at the homers equal to the distance between them. The Board did not believe these loop positions to be a matter of coincidence but rather direct evidence the ADF's were functioning normally at the time of the accident. Furthermore, the elapsed time between reporting Rochelle to the crash apparently exceeded the normal elapsed time from Rochelle to the inbound heading of the procedure turn by several minutes. Believing the flight operated in instrument weather conditions and made the final turn abeam of the procedure turn area, it is probable the turn was started with reference to the ADF indications. The Board considered it improbable that the ADF presentation would be accurate in showing the aircraft abeam of the facilities and inaccurate shortly before this indication. It is equally improbable that such inaccuracy would be followed by an accurate presentation at the time the crash occurred.

The Captain (medical aspects)

During the course of the investigation the aeronautical history of the captain was reviewed. His training, qualifications and proficiency reports were satisfactory. He had flown in and out of Charlottesville and over the route involved for several years on a regular basis. He had flown a total of 5 101 hours of which 4 771 were in DC-3 aircraft.

To the Board there were numerous factors which were obviously inconsistent with the captain's record. Some were:

the apparent navigational omission;

a non-adherence to precise tracking procedures;

a descent below the authorized procedure turn altitude;

failure to note that the time for station passage was in excess of that commensurate with a close-in position, and the ADF indications were not compatible with the normal procedure turn presentation;

failure to request the latest Charlottesville weather when the communicator did not furnish it;

not using the altimeter setting given in response to the inrange report.

The Board believed these factors were not only inconsistent with the captain's reputation as an exacting pilot but were indicative of a serious departure from the high standard and quality of performance expected during an instrument operation. A comprehensive investigation was then made into the personal background of the captain.

The captain had, for several years, been under severe emotional strain. He had received psychotherapy in 1953-1954; he obtained further psychiatric counselling in 1957; intensive psychotherapy was resumed in May 1959, which he underwent several times a week thereafter; his last appointment was the night before the accident. This latter treatment involved the services of two psychiatrists. In the course of this treatment the first psychiatrist prescribed certain psychotropic drugs. After trials on Compazine, Prozine, Sparine and Thorazine, Prozine was prescribed in August 1959 in a dosage of three or four times daily and was reissued on 18 September 1959. This prescription specified an amount which, if taken as directed, would have been sufficient to last until two days before the accident.

On 23 September 1959, however, the captain commenced psychotherapy under the second psychiatrist who prescribed no drugs. The Board was unable to determine whether or not the captain continued to take the medicine in the prescribed manner during the latter treatments, although there is evidence that he took the earlier trial prescriptions.

The Board evaluated the background and history of the captain including the data set forth above. In addition, it submitted all the available information concerning this captain to particularly qualified medical experts for evaluation as to its significance with respect to this accident.

The consensus of opinion was that the captain was so heavily burdened with mental and emotional problems that he should have been relieved of the strain of flight duty while undergoing treatment for his condition. Preoccupation with his problems could well have lowered his standard of performance during instrument flight. Furthermore, with respect to this accident, the consensus was that the emotional and mental problems were of far greater importance in causing the preoccupation than the use of psychotropic medication would have been.

Drugs - General

The Board considered that the investigation of this accident demonstrates the need for re-examination of the use of drugs which may affect the faculties of a flight crew member in any manner contrary to safety.

Since World War II there have been great advances in pharmacology and whole new families of drugs have become easily available to the public, either over the counter or by prescription. Since 1953-54 one of the most significant advances has been in the field of psychopharmocology. There has been a proliferation of drugs which influence the state of mind, are employed in the treatment of mental disorders, or are used as psychic energizers. Within this group of drugs the so-called tranquillizers are being widely used by the public.

The basic question which the Board believes must be resolved, therefore, is how does the use of these drugs relate to the safety of flight. For example, within the framework of the present Civil Air

Regulation covering the use of drugs,* should these drugs be classified as "... drug which affects his (crew member) faculties in any manner contrary to safety ..." The Board is of the opinion that the answer to the question is a qualified "yes". In great part this decision is reached from review of military research into the relationship of drugs to the flying profession. The basic conclusion derived from this reasearch can be stated quite simply: If a flight crew member's personal situation demands tranquillizers he should be removed from flying status while on the drugs.

Probable Cause

The probable cause of this accident was a navigational omission which resulted in a lateral course error that was not detected and corrected through precision instrument flying procedures.

A contributing factor to the accident may have been preoccupation of the captain resulting from mental stress.

Recommendation

The Board believed that the facts disclosed by this investigation demonstrate the adverse effects of serious emotional and mental stress on airman proficiency and performance. It further believed that the early recognition and correction of such conditions which might tend to impair an airman's proficiency and performance would be beneficial to flight safety. Accordingly, the Board recommended that the Federal Aviation Agency, appropriate segments of the aviation industry, and the medical profession initiate exploratory studies in this field.

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* Section 43.45 Use of Liquor, Narcotics and Drugs. No person shall pilot an aircraft or serve as a member of the crew while under the influence of intoxicating liquor or use any drug which affects his faculties in any manner contrary to safety. A pilot shall not permit any person to be carried in the aircraft who is obviously under the influence of intoxicating liquor or drugs, except a medical patient under proper care or in case of an amergency.

ICAO Ref: AR/675

Scheduled
Landing
Collision - rising terrain
Pilot - improper IFR operation

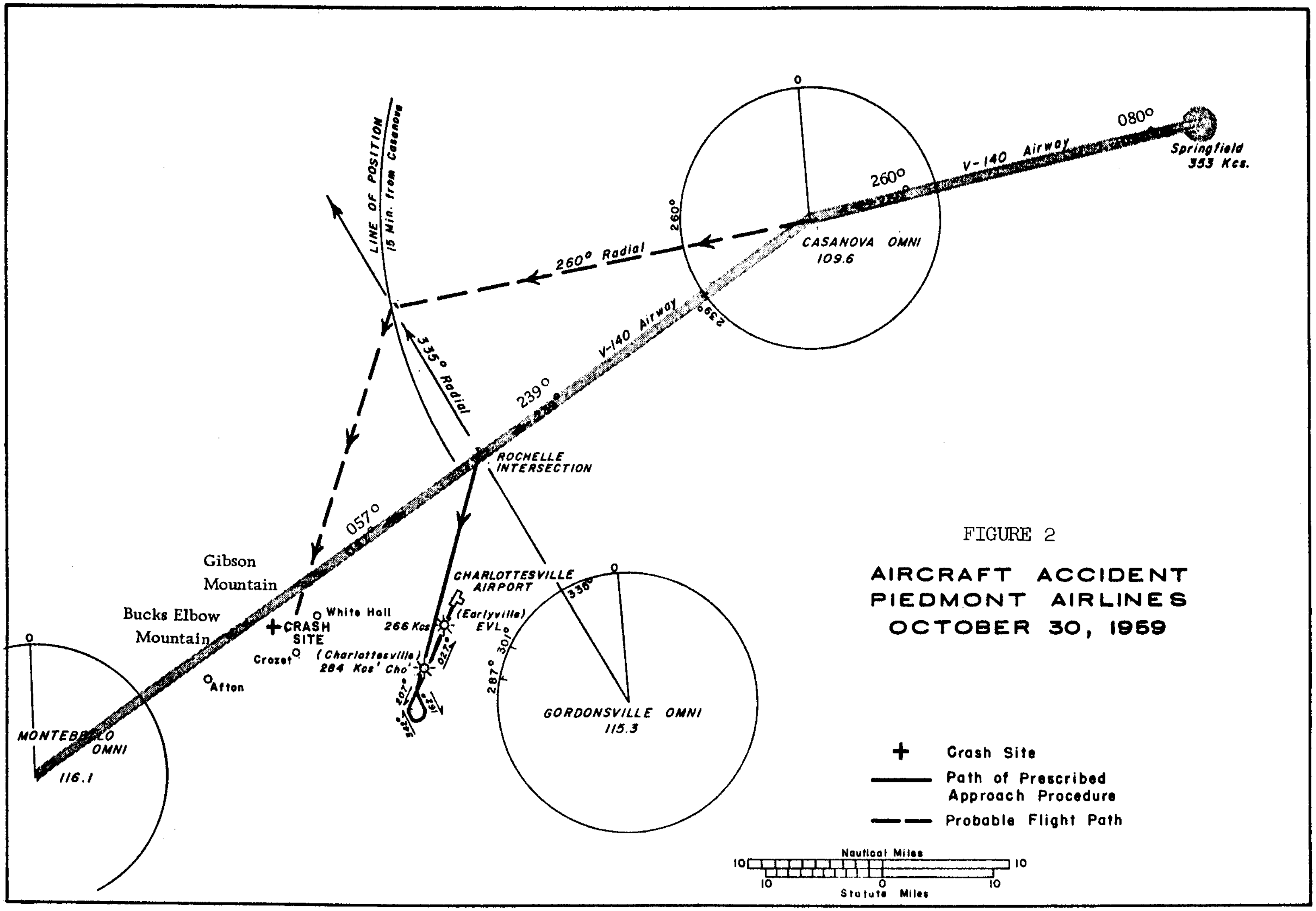

FIGURE 2

AIRCRAFT ACCIDENT
PIEDMONT AIRLINES
OCTOBER 30, 1959

No. 12

National Airlines, Inc., Douglas DC-7B, N 4891C, accident in the Gulf of Mexico, 16 November 1959. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 1-0071, released 14 June 1962.

Circumstances

Flight 967 was scheduled between Miami, Florida and New Orleans, Louisiana, with a stop at Tampa, Florida. While en route to New Orleans from Tampa with 36 passengers and 6 crew aboard the aircraft crashed into the Gulf of Mexico at approximately 0055 hours central standard time. The bodies of a few of the occupants were found and a small amount of floating debris. However, the main wreckage was never located in spite of several well-planned searches. All passengers and crew perished in the accident.

Investigation and Evidence

The aircraft was owned by Delta Air Lines, Inc. and operated by National under an approved equipment interchange agreement. It had a total operating time of 6 578 hours. Both the aircraft and its power plants had satisfactory maintenance records.

The crew members were all well-qualified and experienced, and no suggestion of their unfamiliarity with the equipment was brought out during the investigation.

The manifest listed 36 passengers for the Tampa-New Orleans segment of the trip. One of these was not aboard, although a final passenger count showed 36 passengers on departure from Tampa. Investigation disclosed the last minute boarding of the aircraft at Tampa by a person using another person's ticket.

The Subject Flight

The aircraft took off from Tampa at 2332 hours. It was cleared over the established route across the Gulf from Tampa to New Orleans at 14 000 ft altitude. The flight reported at 0005 to Tampa and at 0031, 0034 and 0044 to Pensacola. Pensacola cleared it from NL1* direct to the MSY (New Orleans) omni via the 116° radial, and to descend and maintain 6 000 ft at the pilot's discretion. The clearance was accepted and the flight stated it would remain at 14 000 ft a little longer. At 0044 it advised FAA Pensacola that it would change over to company frequency and would report when leaving 14 000 ft and 7 000 ft. It also contacted New Orleans company radio confirming the ATC clearance and reporting the weather to be ceiling and visibility unlimited with low solid (undercast) to the west-northwest. This is the last known radio contact with Flight 967. No radio message of impending trouble was received.

Two military radar stations had the flight under surveillance. The first at Dauphin Island, near Mobile, Alabama, reported that the flight continued on flight plan course during the entire time it was under their surveillance. Nothing unusual was observed. The point of fade from the scope was normal and within correlation limits.

The second radar station at Houma, Louisiana, picked up the flight at 0046, on track and at 14 000 ft altitude.

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* a customary reporting point.

For 3-1/2 to 4 minutes the flight continued on a normal track of approximately 296°M. It was then observed to turn right approximately 70° and disappear from the scope at 0051 at Lat. 29°13'N. and Long. 88°40' W.* The radar observer testified that this disappearance was characteristic of a target going below the scope's limits. No other object was indicated on the scope. The position at which the aircraft went off the military radar scope was used as a focal point of search when the aircraft remained unreported.

Search and Rescue Facilities

A National Airlines Convair left Miami for the subject area (Lat. 29°13'N, Long. 88°40'W) at 0545 under the command of the company's chief pilot. The Convair was then spiralled over the spot down to an altitude of 500 ft through a stratus deck with a base of approximately 800 ft, and tops of 1 200 to 1 400 ft. The search party aboard the Convair decided that the last known radar position should be searched first. The aircraft was then flown in a northerly direction for some 5 to 10 miles from the point of spiral-down, whereupon floating debris was seen. An oil slick estimated to be a mile long and possibly 400 yd in width ran in a north-south direction. The oil appeared to be rising from the northernmost point of this oil slick.

While circling and observing, the National Convair called Coast Guard aircraft with continuous transmission, allowing the latter to home on the area, which is about six miles south and five miles east of the radar-observed descent.

Coast Guard and civil surface craft immediately searched the area exhaustively and retrieved everything sighted. Besides bodies of victims, liferafts and lifevests, a highly diversified quantity of buoyant debris was found entirely from within the cabin and baggage compartments directly below it. This material totalled possibly less than 1% of all such material within the fuselage.

Post mortem examinations of the nine victims recovered indicated that all had received traumatic injuries. All had been seated at the time of impact. No seat belt abrasions were found. The inertia of the bodies was plainly downward and forward and the forces at impact were severe. None had been subjected to fire or smoke before death. Some showed distinct evidence of burning on portions exposed above their waterlines. A considerable amount of the floating debris also exhibited signs of burning but only above waterlines. An examination of the liferafts and lifevests indicated that they had not been used for their intended purposes or prepared for such use.

Witness

The United States Coast Guard maintains a manned lookout tower at Pilottown, Louisiana, for observing surface craft approaching and departing the port of New Orleans. The tower is about 30 miles west of the crash site. The coastguardsman on duty saw an unusual light in the sky at an angle which he estimated as about 15° above the horizontal and in the general direction of where N 4891C was lost and at about the time it was lost. He did not log the incident. His testimony indicated that the light was red or dark red, appearing suddenly, lasting a "couple of seconds", and then producing a vertical, white light which fell with a white trail. He estimated that the white trail took three or four seconds to go "straight down", and that the initial red flash was "almost as big as the sun". He heard no noise. At the time of these observations the stars were visible, the weather was hazy and there were no surface craft within his range of vision. Subsequent investigation has failed to reveal the use of any marine

* This position is about 108 miles east-southeast of New Orleans, about 30 miles east of Pilottown, near the mouth of the Mississippi River and very nearly on the planned course.

signal flash or pyrotechnic, which might have had a somewhat similar appearance, at the time and place.

Subsequent Search

The Board obtained search assistance from the United States Navy. The Navy utilized several vessels equipped with advanced apparatus and manned with skilled specialists. Unfortunately, these searches were not successful.

In November 1960, a commercial organization was engaged to conduct a one-month search using techniques proven effective in prospecting for underwater oil structures. It was possible to cover only 29.75 sq. mi. of an area selected after an analysis of wind and current factors and the results of all previous searches. This search was also unsuccessful.

Charts during the several searches, with search areas well delineated, were coordinated within the various agencies to preclude duplicative and omissive effort. These charts have been preserved for possible future use.

Passenger Information - further details

William Allen Taylor, of Tampa, Florida, disappeared 15 November 1959 after telephoning his employer he would be late for work. A few moments before the departure of Flight 967 from Tampa, Taylor purchased a flight insurance policy in the amount of $37,500 from a coin-operated machine at Tampa International Airport, making his son the beneficiary and showing his destination as Dallas, Texas. National Airlines records do not show a ticket issued in his name and he was not carried on their records as a passenger on Flight 967. Taylor's body was not among those recovered.

Robert Vernon Spears, of Dallas, Texas, was listed as a passenger on Flight 967. He was subsequently apprehended by Federal authorities in Phoenix, Arizona, for having unlawful possession of Mr. Taylor's vehicle.

The Board, with the aid of the Federal Bureau of Investigation, has thoroughly investigated Mr. Spears' activities in order to determine whether they might have had a bearing upon the accident. It was unable to find any such relationship.

Probable Cause

Because of the lack of physical evidence, the probable cause of this accident is unknown.

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ICAO Ref: AR/712

Scheduled
En Route
Undetermined

No. 13

Trans World Airlines, Inc., Lockheed Constellation L-1049 H, N 102R crashed southeast of Midway Airport, Chicago, Illinois on 24 November 1959. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 1-0072, released 12 May 1961.

Circumstances

After taking-off from Midway Airport, Chicago, on scheduled cargo flight 595 to Los Angeles, California, the crew received a fire warning on No. 2 engine as the aircraft began a left turn. The engine was shut down, and the tower was advised that the aircraft was returning to land. It proceeded in a continuing left turn around the airport in an elliptical pattern and below the clouds based at 500 to 600 ft. In the turn to final approach to runway 31 it banked in excess of 45° during which it developed an excessive rate of sink. The descent continued until the aircraft crashed and was demolished in a residential area about 1/4 of a mile southeast of Midway Airport. The 3 crew aboard were killed, and 8 persons on the ground were fatally injured.

Investigation and Evidence

The Aircraft

The aircraft was airworthy and properly loaded at time of take-off. At departure the aircraft's gross weight was 126 606 lb - the allowable gross weight being 127 400 lb. Also the allowable landing weight was about 115 000 lb.

The Crew

The crew members were properly qualified to carry out this flight. There was ample opportunity for them to obtain sufficient rest prior to the flight, however, it appeared questionable as to whether the captain and the flight engineer took full advantage of this opportunity.

Weather Conditions

Ten minutes prior to the accident the United States Weather Bureau reported the Midway weather as follows: partial obscuration, scattered clouds at 600 ft, measured 900 foot overcast; visibility 3 miles; light rain, fog and smoke; wind west 10 kt; temperature 39; dewpoint 38, and altimeter setting 29. 33. Remarks: 2/10 of sky obscured by fog.

According to the conditions reported, the flight should not have encountered structural icing or significant turbulence at the time of the accident.

Reconstruction of the Flight

Following a delay at Midway Airport (due to the breakdown of loading equipment), which put the flight 2 hours and 20 minutes behind schedule, the aircraft received an ATC clearance to Los Angeles. It took off at 0531 hours central standard time having filed an IFR flight plan. The take-off appeared normal to the tower operators. After 1 minute and 13 seconds the crew advised that they were starting a left turn. Seven seconds later they informed the tower of the fire bell on No. 2 engine, that the engine had been shut down, and the flight was returning. The flight was cleared for runway 31 or any other and when asked whether it wanted a Kedzie* localizer approach or whether the aircraft would make it VFR, the flight replied ... "VFR". It then acknowledged the clearance to land. Total elapsed time since take-off was then 2 minutes and 47 seconds. Forty-three seconds later the tower operator saw the aircraft crash into houses and burst into flames. A total time of 3 minutes and 30 seconds had elapsed. The exact time of the accident was established as 0535 hours. A power failure was recorded at that time when the aircraft hit powerlines.

The total distance the flight travelled over the ground from the beginning of its take-off roll to the point of impact was about 8 statute miles. This flight path was elliptical in shape, and at no time was the aircraft more than two miles from the airport.

Witnesses' Statements

They stated that the aircraft banked in excess of 45° during the left turn to the final approach heading. It lost altitude as the turn progressed and when it reached an altitude described as just above the tops of the trees the wings were almost level and the nose was raised slightly to a climbing attitude; however, the rate of descent continued until the aircraft struck the trees and buildings. Witnesses along the flight path and within one mile of the impact area indicated that the engines sounded as though they were labouring to keep the aircraft airborne.

The Wreckage

The wreckage examination revealed that the left main and nose gear assemblies were up but unlocked, and the right main gear was up and locked at impact. The wing flaps were extended symmetrically about 13 inches or 24% of their full travel, and the wing flap control valve and follow-up mechanism were positioned for flap movement toward the "up" position. The wing flap control lever was about 1/8 of an inch aft of the full forward position and bent over 80° toward the captain's seat. It was jammed in that position as a result of the impact and appeared to have been in that position prior to impact. Retraction time for the wing flaps from a setting of 60% to fully retracted is about 15 seconds provided the landing gear is not retracted at the same time.

The No. 2 engine had been shut down and its propeller feathered. There was no evidence of any inflight fire; however, the fire extinguisher had been activated in the No. 2 engine. There was no evidence of structural failure prior to impact or any indication that the cargo may have shifted.

Test flight following the accident

On 23 January 1960 a test flight in the same type aircraft was conducted by the Lockheed Aircraft Corporation at Los Angeles, California. Conditions surrounding the fatal flight were simulated as nearly as possible. Definite stall warnings were apparent to the pilot in all of the test runs and recoveries from the stall buffet zone could be made with a loss of no more than 200 ft of altitude. On one of the runs the aircraft was banked up to 42° and the airspeed allowed to drop to 108 kt indicated. A fairly rapid rate of sink developed and the aircraft was not yet in the stall buffet zone. No enough power was available to keep the aircraft in level flight and a loss of several hundred feet was necessary to acquire enough airspeed to recover from this sinking condition. The pilot described the aircraft as being on the backside of the power curve.

* Kedzie is a low frequency compass locator radio beacon at the outer marker of the ILS approach to runway 31L at Midway, 3.3 NM on an extended centreline from the approach end of runway 31L. To fly this approach an aircraft should be on the heading of that runway at 1 500 ft msl (about 900 ft above the ground) and prepared to start a descent to that runway as it passes over the beacon.

On this flight the wing flaps were retracted from 60% to 0% and from 80% to 0%. Simultaneously with these flap retractions the landing gear was retracted from the "down and locked" to the "up and locked" position. The retraction times respectively were as follows: Flaps: 21 seconds; gear: 19 seconds; flaps: 24 seconds; gear: 15 seconds.

Analysis

The flight's rejection of an offer to alert the emergency crews indicated they were not extremely concerned for their safety and had the situation pretty well in hand. It further suggested that the crew was certain there was no actual fire in the No. 2 engine.

For the flight to have made a Kedzie localizer approach would have necessitated their climbing to an altitude which would have put them in the overcast and consumed considerably more time. Their decision to stay VFR below the clouds was reasonable; however, this did make it necessary for them to fly at an altitude between 400 and 600 ft above the ground.

In anticipation of landing, a gear-down, flap-extended configuration was established on the downwind portion of the traffic pattern. The wing flaps were at least in the take-off position of 60% and had been allowed, presumably, to remain so extended since take-off, because less than one minute had elapsed from start of take-off roll until the fire warning, and at that time the captain planned to return to land. The track over the ground on the "downwind" curved toward the runway. When the aircraft was positioned to start the turn to final approach a sharp turn was needed to avoid overshooting the extended centreline of runway 31L.

The Board believed the captain attempted such a turn, and in doing so combined a very steep bank with high gross weight and three-engined aircraft configuration in such a manner that the aircraft entered a regime of flight describable as being on the backside of the power curve. More power and altitude than was available to him was needed to safely recover the aircraft. At some point in this turn the captain very probably decided to discontinue the landing approach and attempted a "go-around". Hence, he called for gear up at or near this same point, but for an unexplained reason the wing flap controls were positioned for flap retraction.

The Board believed an accident such as this is a certainty when at low altitude an excessive rate of sink is coupled with the additional loss of lift caused by the simultaneous retracting of the wing flaps from 60 to 24%. The flap setting of 24% was their intransit position as the aircraft struck the ground.

Probable Cause

The probable cause of this accident was the manoeuvring of the aircraft in a manner that caused it to develop an excessive rate of sink while in the turn to final approach.

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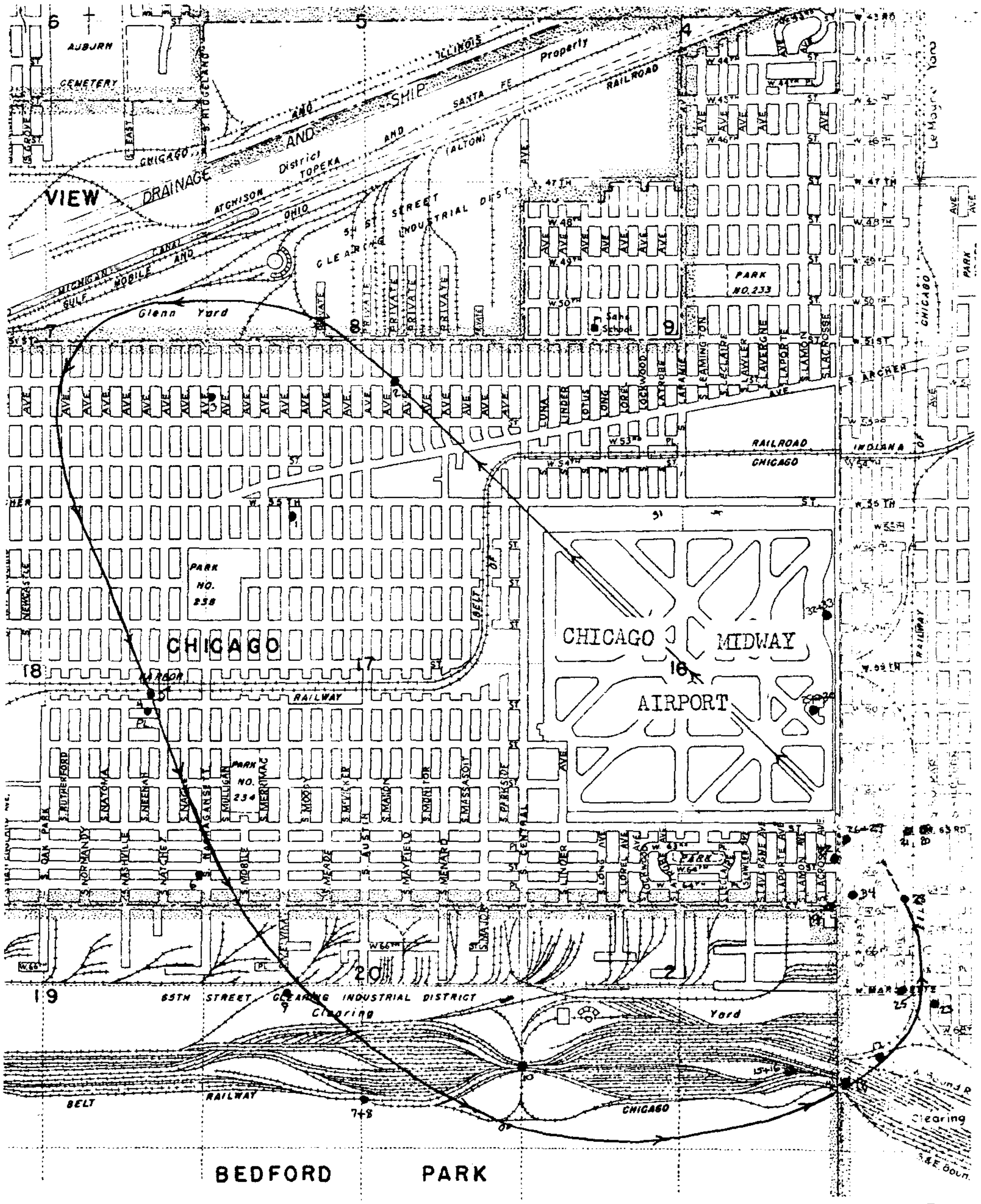
Scheduled (cargo)
Landing
Emergency condition - precautionery landing
Pilot - manoeuvring of the aircraft in a manner that caused it to develop an excessive rate of sink.

ICAO Ref: AR/677

ACCIDENT TO TWA, CONSTELLATION, N 102R, AT MIDWAY AIRPORT,
24 NOVEMBER 1959



APPROXIMATION OF PROBABLE FLIGHT PATH AS DERIVED FROM WITNESS STATEMENTS

0 1/2 1

SCALE OF MILES

FIGURE 3

No. 14

Alitalia, Viscount 785, I-LIZT, crashed at Ciampino Airport, Rome, Italy on 21 December 1959. Report released by the Ministero della Difesa-Aeronautica, Italy.

Circumstances

During a semi-annual flight crew check involving emergency landing practice with two engines out (Nos. 3 and 4), and while in the approach-to-land phase, the aircraft went into a right bank when approximately 400 m from the threshold of runway 16R. It struck the ground at 0716 Z with the right wing tip first and then with the nose and finally with the tip of the left wing. The two pilots were killed, and the aircraft was destroyed. There was no fire.

Investigation and Evidence

The Aircraft

The aircraft was airworthy before and during the flight. The centre of gravity position was within the limits permitted by the Certificate of Airworthiness.

Periodic maintenance checks had been carried out at the specified intervals. No piece of equipment or system had operated beyond the specified periods since the last overhaul. The "technical specifications" issued by the Italian Aeronautical Registry (R.A.I.) for the aircraft, its components and systems had been fully complied with.

Crew Information

The instructor had obtained a civil pilot's licence - class 3* in 1950, had been a pilot-in-command since 1954 and held ratings for the following types of aircraft on which he had flown the following hours:

SM. 95	394. 39
Convair	2996. 37
Viscount	816. 21
DC-6	1001. 50
DC-7	566. 20
DC-4	2246. 18

In 1959 he had acted as pilot-in-command on the following aircraft, Convair (133. 30 hours), DC-7 (281. 28 hours), Viscount (502. 01 hours).

In December he had flown on Viscounts only; he was assistant chief pilot and check pilot for Alitalia's Viscounts.

On 19 December he had flown back to Rome at 1250 hours on a Frankfurt-Rome flight in his capacity as check pilot for Viscount aircraft. He had been off duty on 20 December and the following day was again on duty as check pilot for the semi-annual check out of the pilot-in-command of the subject flight.

The pilot-in-command had obtained his civil pilot's licence - class 3 - in 1958, held ratings on the following aircraft, and had logged the following flight times on each of these types:

DC-3	104. 02 hours
DC-6	3584. 22 hours
DC-6 training	210. 41 hours
DC-7	187. 29 hours
Viscount	1507. 46 hours

* equivalent to airline transport pilot's licence.

During 1959 he had flown on DC-7 and Viscount aircraft as follows: DC-7 (187.29 hours), Viscount (652.24 hours). In November and December he had flown exclusively on the Viscount 785D. On 18 and 19 December he was off duty, and on 20 December had flown as pilot-in-command on a Viscount flight Rome-Milan-Zurich and return, departing from Rome at 1013 hours and returning at 1833.

His flight of 21 December was so that he might undergo the semi-annual check in accordance with the Alitalia training programme.

As regards the seating positions of the two pilots in the aircraft during the flight, it is believed that the instructor was in the right-hand seat (as he should have been to perform his duties) and the pilot-in-command was in the left-hand seat. Examination of the injuries confirmed this assumption.

Weather

The weather conditions were normal. There was a downward trend in the cloud covering. A few minutes before the final portion of the traffic circuit the aircraft was temporarily in a fog area.

Communications with the Tower

Up until the last minute of flight the training programme was carried out normally. In the communications between the aircraft and the control tower there were no indications of the aircraft or its systems malfunctioning.

Guidance from the tower was continuous. After clearing the aircraft to land (last minute) the operator broke off visual contact with the aircraft until the moment when he saw it on the airfield - no longer aligned with the runway. The last radio contact with the tower was one minute prior to the accident.

Reconstruction of the flight

At 0617 hours the aircraft, while still parked on the tarmac of the west terminal, requested clearance from the control tower to start up the engines for a local training flight of one hour's duration. At 0618 it was cleared to taxi to the top of runway 16R and there was given QNH 30.01, wind 160° 15 kt.

A total of five take-offs were made at 0625, 0635, 0643, 0651 and 0700 hours. The first four circuits over the aerodrome were performed with power on all four engines and with the following times from take-off to take-off: 10 minutes, 8 minutes, 8 minutes and 9 minutes.

During the fifth circuit the aircraft requested clearance to perform a go-around which it carried out with three power units operative; clearance was given and the manoeuvre was completed at 0705 hours.

The sixth circuit was then carried out with power on three engines only and, having obtained clearance, the aircraft performed a second go-around, this time with only two engines operative, specifically port engines Nos. 1 and 2.

During its seventh circuit around the airport, and with power on engines Nos. 1 and 2, the aircraft reported at 0712:30 that it was on the downwind leg at an altitude estimated to be approximately 1 000 ft.

At 0713:45 the aircraft reported to the tower that it was on the base leg at an altitude of about 1 000 ft and was then given clearance to enter the final portion of the traffic circuit.

At 0715 - one minute prior to the accident - the aircraft reported on final at a distance of approximately 3 200 ft from the threshold of runway 16R and was given clearance to land. At this point communications were broken off with the tower and the aircraft began the last phase of the flight during which the accident occurred. It can safely be assumed that at that time the aircraft was following the normal procedures at a speed of approximately 130 kt and that the landing phase was progressing normally.

It is believed that the aircraft had assumed the landing configuration and had descended below 500 ft when an additional emergency occurred the nature of which it has not been possible to determine; that the aircraft then assumed the balked landing configuration at a point estimated somewhere between 700 and 500 m from the threshold, a height between 350 and 300 ft and a speed which, in the configuration of the aircraft (flaps 20°, undercarriage retracted - full power on port engines - right engines with feathered propellers) no longer made it possible to maintain directional control of the aircraft.

Near the threshold of runway 16R which it is believed was overflown at approximately 100 ft, the aircraft, lacking sufficient directional control, went into a right bank, attempted to recover from it, then nosed down on the right striking the ground with the right wing tip after a curved flight path of approximately 400 m from the threshold of runway 16R.

Sequence of Impacts and Failures

The sequence of impacts and main failures resulting from the accident may be reconstructed as follows:

1) impact of right wing tip on the ground;

2) separation of wing tip and its projection tangentially to the flight path approximately 90 m from the point of impact; separation of a further wing section which was projected some 15 m beyond the first part;

3) separation of power unit No. 4 which was projected approximately 80 m from the above-mentioned pieces of wreckage;

4) impact, while in nose-down position, of the front of the fuselage approximately 60 m from the initial point of contact of the right wing with the ground.

5) the aircraft then pivoted around its nose with engines Nos. 1 and 2 still running and the propellers on minimum pitch - until the left wing, which had by then lost all its lift and was heavier than the right wing section, struck the ground with the leading edge near the top and broke away from the fuselage approximately 25 m from the point of impact of the nose section.

Between the time of impact of the nose of the fuselage and that of the left wing, the following failures occurred:

a) failure of the left wing spar as a result of forward momentum;

b) disintegration of the fuselage section ahead of the leading edge of the wing;
(The various parts of this section were spread over an area 60 m long and 30 m wide along the flight path.)

c) separation of power unit No. 2;

d) separation of left wing;

e) overturning of engine No. 1 on back of wing.

The remaining portions of the aircraft continued their motion as a result of the force of inertia until they came to rest with the tail turned towards the right wing at a point some 70 m away from the point of contact of the nose of the aircraft.

Discussion

Since the technical investigation revealed the following facts:

right undercarriage : uplocked

left undercarriage : near uplock position

nosewheel : near downlock position

flaps : found at 20° (take-off position) had been set at a greater angle (i. e. landing position)

and since

a) in the case of uplocking of the undercarriage with only one pump operating (engine No. 3 feathered) it is necessary to have 20 - 25 seconds and the undercarriage operation is the last to be performed for the re-application of power;

b) and since about 6 seconds are required to reduce the flap extension from 32° to 20°, it is deduced that -

the emergency that led the pilots to re-apply power must have occurred during the interval between 6 seconds and 20 seconds before impact of the aircraft with the ground.

It is considered more likely that this occurred 20 seconds prior to the impact in view of the fact that the right undercarriage was in the uplocked position.

Point of re-application of power

Conditions existing at point of re-application of power:

speed	115 kt
height	200 to 300 ft
distance from threshold	500 to 700 m
time of impact	-18 seconds to -15 seconds

The fact that no damage was found in the flap system or in the directional controls and the typical flight path of the aircraft from the area close to the threshold up to the point of impact, as observed by eye witnesses, lead to the belief that the speed during re-application of power was lower than that required for minimum directional control for that particular configuration (115 kt).

Since on p. 3. A. 6 of the Alitalia Viscount Operations Manual the go-around procedure with two engines is set forth as follows:

> "The decision to go-around with two power units operative must be made at an altitude that will allow sufficient time for complete retraction of the flaps and undercarriage."

The speed should be 125 - 130 kt I. A. S. to ensure adequate directional control of the aircraft.

It is deduced that the speed at which the decision to initiate the go-around procedure was below that established in the Operations Manual for the manoeuvre in the particular attitude and dropped during the manoeuvre to a value below that (115 kt) of minimum control with two engines inoperative on one side.

It is observed that ICAO Annex 8, AMC* 2, para. 4. 2. 1, defines the minimum control speed with one power unit inoperative but not with two engines inoperative (4-engined aircraft).

Even other authoritative airworthiness regulations (F. A. A. and A. R. B.) do not cover the case of minimum control speed with two power units inoperative on one side.

This explains why the above characteristic speed does not appear in the Flight Manual of the Viscount 785-D, I-LIZT, prepared by the A. R. B. (Air Registration Board) and approved by the R. A. I. (Registro Aeronautica Italiano).

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* acceptable means of compliance.

Examination of the Alitalia flight training programme for the half-yearly check of pilots of Viscount aircraft indicated that the test includes landing and go-around with two power units inoperative, propellers feathered on one side, and the other two operative. This procedure is in accordance with that given in the training courses imparted at Vickers on its own traffic-free field. But this procedure may not cater for the possibility of carrying out a balked landing in the case of an emergency that could occur during the last minute of flight, and therefore may not provide safety guarantees particularly on heavy traffic airports.

Conversations with pilots-in-command of Viscount 785 aircraft of Alitalia indicated that:

a) they were thoroughly familiar with the "balked landing with two engines" procedure described in the Alitalia Viscount Operations Manual, "Operational Procedures" page 3. A. 6.

b) they did not appear to have sufficient training

1) on the exact determination of the safety altitude to which reference is made in the above-mentioned procedure;

2) on the actual possibilities of directional control of the Viscount during re-application of power with two power units operative on one side and two feathered, carried out following an emergency at limits below those established in the said procedure.

The technical examinations and the statements given have not made it possible to determine the nature of the additional emergency that induced the pilot to attempt the balked landing procedure.

The additional emergency may have been of the type that precludes landing in spite of the closeness to the runway.

It is obvious nevertheless that: the emergency go-around was carried out below the limits established in the flight manual in the belief that, even though the aircraft was below such limits, it was still possible to maintain directional control.

Probable Cause

The accident was attributed to a balked landing manoeuvre carried out below the speed limits for safe directional control of the aircraft during a critical situation that developed in the last phase of the landing in the course of a simulated emergency exercise with two power units inoperative (Nos. 3 and 4) and two operative (Nos. 1 and 2).

Recommendations

This accident is the fourth to have occurred during a training flight with asymmetrical power* and these accidents have been attributed to operation below the speed limits for directional control in the corresponding configuration. The Board, therefore, having examined the Alitalia

* 1) Trans-Australia Airlines, Viscount 720, crashed after take-off at Mangalore Aerodrome, Victoria, Australia on 31 October 1954. (A summary of the final report appears in ICAO Circular 47-AN/42, Aircraft Accident Digest No. 6).

2) British European Airways Corporation, Vickers-Armstrongs Viscount, G-AMOM, crashed on take-off from Blackbushe Airport, England, on 20 January 1956. (A summary of the final report appears in ICAO Circular 54-AN/49, Aircraft Accident Digest No. 8).

3) Pakistan International Airlines Corporation, Viscount 815, AP-AJE, accident at Karachi Airport, Pakistan, on 14 August 1959. (A summary of this accident appears in this Digest).

training programme for the semi-annual flight check of their line captains and the circumstances in which the accident to I-LIZT occurred, considers that it should make the following recommendations with a view to preventing the recurrence of similar accidents:

Recommendation No. 1

Airlines that carry out flight training programmes for pilots should be urged:

a) to ensure that full training is given on all types of emergencies, in particular on types of emergencies likely to be encountered with the particular type of aircraft they operate;

b) to ensure that the training programmes on emergencies are carried out with appropriate techniques guaranteeing the safe completion of the exercise in the case of additional unexpected emergencies;

c) to ensure that training on the limits of directional control be carried out at a safety altitude;

d) to ensure that the procedures set forth in the training programme faithfully duplicate the procedures contained in the flight manual;

(In the case of training flights for which no detailed specifications are contained in the flight manual, the carrier should, before carrying out the training exercise, obtain from other reliable sources (manufacturer, other carriers or direct trials) all the data required for the safe conduct of such training exercises.)

e) to supplement the training of flight personnel on the proper operation of the aircraft with full information on the consequences of operation beyond the limits specified in the flight manual for each configuration manoeuvre and for every emergency situation envisaged;

f) to include in the Operations Manual all such safety information considered useful for thorough and unequivocal interpretation of the flight manual;

g) to supplement their own Operations Manuals with all reliable data not contained in the flight manual and likely to prove useful in particular circumstances during operation of the aircraft;

h) to enjoin on pilots to inform the air traffic control authorities of the sequences of emergency manoeuvres planned for training flights and test flights, and to carry out such manoeuvres only after receiving specific authorization.

Recommendation No. 2

Air Traffic controllers should be advised that simulated emergency exercises are to be considered as actual emergencies for which the normal emergency measures should be provided.

Recommendation No. 3

The authorities responsible for airworthiness regulations should:

a) define, in the case of four-engined aircraft, the minimum control speed with two power units operative on one side, and prescribe the insertion of this information in flight manuals;

b) consider the desirability of developing a Standard which would rule out consideration - in the established landing characteristics - of limit speeds below the minimum flight control speeds for configurations with asymmetrical power.

Recommendation No. 4

The authorities responsible for civil aviation regulations should:

a) examine and approve the ground and flight training programmes for civil crew members and control the practices followed and the actual carrying out of these programmes;

b) suspend or at least limit the authorizations to carry out simulated emergency training flights over busy airports;

c) check initially and periodically pilots' knowledge of flight manuals and their ability to interpret correctly the contents thereof.

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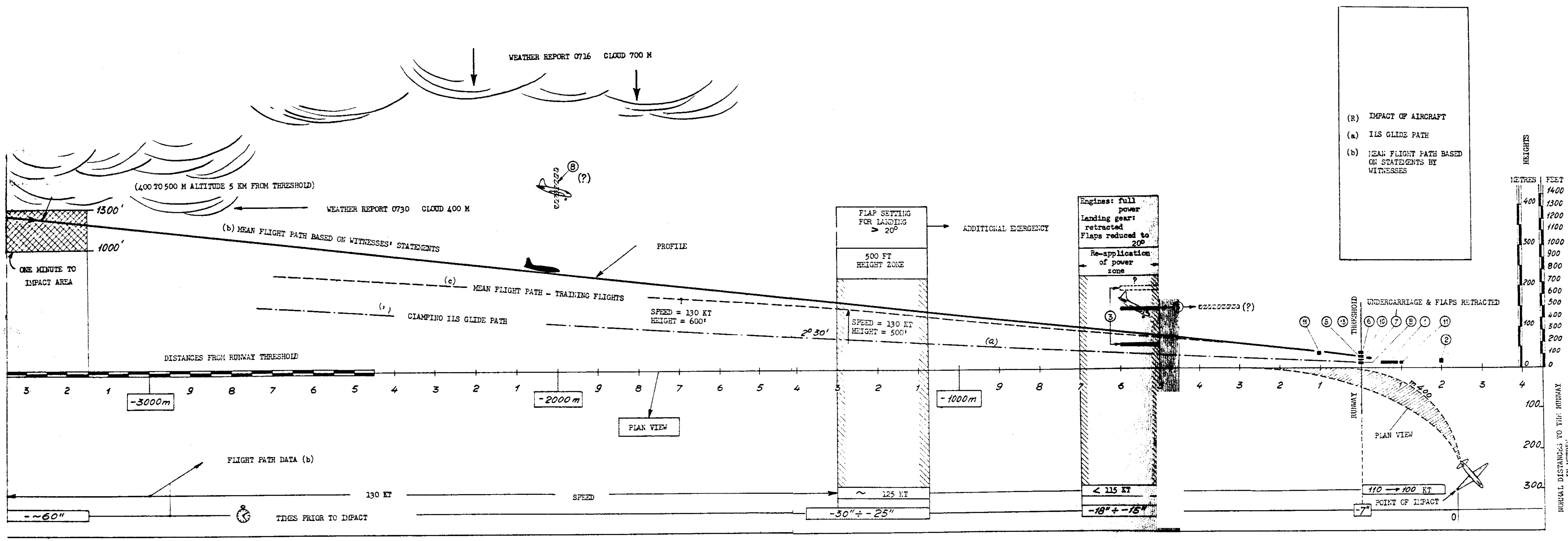
ICAO Ref: AR/666

Training Landing Loss of control Pilot - failed to maintain flying speed during a simulated forced landing

RECONSTRUCTION - FLIGHT PATH - SPEEDS - TIMES
LAST MINUTE OF FLIGHT

FIGURE 4

ALITALIA ACCIDENT OF 21 DECEMBER 1959



No. 15

Indian Airlines Corporation DC-3, VT-CGG, accident 4 miles NW of Taksing, North East Frontier Agency on 3 January 1960. Report No. 1/2/60/Acc. released by the Office of the Director General of Civil Aviation, India.

Circumstances

During a supply dropping sortie from Jorhat to Taksing the aircraft crashed at 1040 hours Indian standard time during a turn in the narrow valley of the River Yume Chu. The 9 persons aboard were killed, and the aircraft was destroyed by impact and fire.

Investigation and Evidence

The Aircraft

It had a Certificate of Airworthiness valid until 12 June 1960. The aircraft had been inspected and issued a daily certificate of safety for flight the night of 2 January. VT-CGG had flown 17 868 hours since manufacture and 1 344 hours since the last Certificate of Airworthiness renewal.

Crew and Passenger Information

Aboard the aircraft were nine persons - the pilot-in-command, co-pilot, and one supernumerary crew member, (who were all captains), a radio officer, four ejection crew and one passenger.

Pilot-in-command

He was an approved check pilot for the screening of pilots for operating as pilots-in-command over certain dropping zones. He was also the officer in charge of freighter and supply dropping operations for the Calcutta and Assam regions. He had flown a total of 13 763 hours which included 480 hours of supply dropping experience in the NEFA area. This was, however, his first flight to Taksing.

Co-pilot

His total flying experience amounted to 6 566 hours. He had flown in the NEFA area as co-pilot only and had 224 hours to his credit in such operations during 1958. This was his first flight to Taksing.

Supernumerary crew member

He had flown 4 863 hours in all. He had previously flown on supply dropping sorties in the NEFA area as a co-pilot and had to his credit about 300 hours in such operations during 1959. He had only flown to Taksing once in the capacity of co-pilot on 13 October 1959.

The Passenger

Prior to the flight of 3 January a signalman asked the pilot-in-command whether he might fly on VT-CGG. It appears that permission was refused. It could not be established, subsequently, whether in the last minutes prior to the subject flight permission had been granted by the pilot to this individual.

A relative of the passenger stated that he saw the latter getting aboard VT-CGG. The officer commanding, Taksing, confirmed that "nine bodies were accounted for" in the wreckage of the aircraft. It was, therefore, believed that there were nine persons including the signalman, on the aircraft at the time of the accident.

The traffic assistant, who prepared the load sheet, stated that to the best of his knowledge, there were only eight people aboard the aircraft.

Weather

It was not a factor in the accident. At the time of the accident visibility was unrestricted, and there was no strong wind.

According to the existing procedure, no briefing concerning the weather en route is given by ATC to the pilots of aircraft operating in the NEFA area.

Loading

According to the load sheet and cargo manifest, there were four flying crew and four ejection crew on board. The freight was 6 715 lb, and the total all-up weight of the aircraft was shown as 26 727 lb. The cargo and passenger manifests were not signed by the pilot nor by the traffic assistant.

Figures shown in the load sheet, not based on actual weights, were 500 lb for the four flying crew and 500 lb for the four ejection crew. There was no definite instruction regarding the weight to be taken for crew members, i. e. whether to put actual weight or to take an average. The traffic assistant thought that there were three crew going on the flight. As he did not know their actual weights he put down an approximate figure of 500 lb in the crew column. However, he later found out that four crew would be going, but did not change the weight figure because the aircraft was still 173 lb under the limit.

The normal figure taken for the weight of a crew member is 170 lb, and therefore the total weight of four crew would be 680 lb instead of 500 lb. Taking a minimum of 130 lb* each for four ejection crew and the signalman aboard, the total weight of these five persons would be 650 lb. The gross weight of the aircraft given in the load sheet as 26 727 lb would then be increased by 330 lb which would amount to 27 057 lb, i. e. 157 lb over the maximum permissible weight for take-off for operation as a freighter aircraft as per the Certificate of Airworthiness. Strictly speaking, however, the concession permitting the maximum take-off weight of 26 900 lb cannot be applied to this flight as the ninth person was not of NEFA personnel. (DGCA endorsement No. 8/564(ii)/1957-AI(1), dated 16. 4. 1959, permits Indian Airlines Corporation to carry four NEFA personnel in addition to the crew of eight on supply dropping flights.)

At the time of the accident the aircraft's all-up weight was calculated to be approximately 24 484 lb.

Lashing

In accordance with IAC's current practice for these supply dropping operations, the supervision of the distribution of the load aboard the aircraft and the lashing and securing of the freight were done by the ejection crew. No trim sheet was prepared, and the centre of gravity was not determined before take-off.

It was determined that the practice followed by IAC Jorhat regarding the preparation of traffic documents and distribution and lashing of freight for NEFA flights was not satisfactory. Measures taken by the Civil Aviation Department to ensure that the centres of gravity of Dakota aircraft were determined appear to have been ineffective.

The Flight

The purposes of the flight were to operate supply dropping sorties from Jorhat and also the co-pilot and supernumerary crew member were to be screened as pilots-in-command for the Taksing dropping zone.

The pilot gave the details of the flight on R/T as: "Flying time 2 hours 50 minutes, dropping zone Taksing, endurance 4 hours". After obtaining the clearance, the aircraft took off at 0932 hours.

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* in the absence of actual weighing, the average weight of an adult male may be assumed to be 160 lb . . . Notam No. 82 (1949).

Six minutes later it reported it was 12 miles out and changed over to W/T. At 0940 hours it reported that it was "bound for Taksing ... estimating Taksing at 0515Z ... flying under visual meteorological conditions". That was the last contact with the aircraft. It was expected that the aircraft would contact Jorhat Control Tower when over the dropping zone. At 1041 Jorhat ATC inquired as to the aircraft's position, but there was no reply. Other unsuccessful attempts were made to contact the aircraft. At about 1530 a member of the rescue party confirmed that the aircraft had crashed.

The aircraft apparently entered the valley of the Yume Chu River then flew in a northerly direction along the west bank of the river as dictated by the terrain. The valley which the pilot had entered was closing in. Under these circumstances he appears to have executed a steep turn in an attempt to get back to the dropping zone. The fact that he made a right-hand turn as against the normal left-hand turn, and the fact that the aircraft was fully loaded (having been overloaded at time of take-off), possibly aggravated the situation further and created conditions favourable to a stall. The height of the aircraft above the terrain was insufficient to effect a recovery.

Two witnesses stated that the aircraft did not make the turn in the usual place. The normal places of turn before coming in for dropping are two miles east and west of the Taksing dropping zone. In the west it is between the first and second ridges immediately west of Taksing village. The dropping is in both directions, i.e. 90° and 270° and is restricted to parachute drops only as this permits the drop to be made from a higher altitude. Such a circuit is a left-hand one. The place of the accident was about two miles further to the west of the normal turning place.

The Accident Site

The accident occurred about four miles northwest of the Taksing dropping zone. The aircraft crashed on the thickly wooded slope of the western bank of the River Yume Chu about one mile northwest of the confluence of the Yume Chu and Chayal Chu Rivers. The slope of the valley on the western side is about 60° (to the horizontal) and is covered with dense forest. The barren rocky face of the opposite bank was even steeper. The location of the wreckage was 2 000 ft higher than the river bed. The width of the valley at the level of the wreckage site was about 3 000 ft. The height of the wreckage was approximately 9 000 ft asl.

The height of the dropping zone at Taksing is known to be about 8 200 ft and the area between the dropping zone and the accident site is covered with dense forest on a series of mountain ridges on either side of the river which flows from west to east. Aircraft engaged in supply dropping approach from the east, fly over the dropping zone at about 1 000 ft and then turn back by executing a left turn. To the south of the dropping zone is a peak of about 18 000 ft asl, and on the north the mountains rise to an estimated height of 12 000 ft. The contours and location of rivers denoted on the maps currently in use cannot be taken as accurate. However, the location of the peak points is considered to be fairly accurate and taking these as references the coordinates of the place of the accident have been estimated as 93°14'E and 28°23'N.

The Wreckage

The path of the wreckage trail, the angle of the propeller slashes on trees and the nature and extent of the damage to the aircraft clearly showed that the aircraft was in a substantially nose down attitude when it struck the ground.

The wreckage did not indicate any sign of pre-crash failure. There was no question of a structural failure in the air, or any explosive damage.

The complete fuselage except for the tail cone was smashed. One of the altimeters was recovered from the wreckage and the setting corresponded to the altimeter setting given by ATC at the time of departure from Jorhat. No other useful information could be obtained from the broken and burnt pieces of controls and instruments.

Screening of Pilots

There are two kinds of dropping zones and landing grounds. One is known as "normal" on which no screening is necessary, and on which any pilot who has more than 2 000 hours in command on DC-3 aircraft can fly as a commander. The second kind is "more difficult" and is operated by the new commanders only after they have been screened. First officers are not screened but are only required to have 1 000 hours on DC-3's. The two pilots being screened on this flight could have flown in command without screening in any of the normal dropping zones. Whenever a pilot has to be screened for captaincy on any dropping zone the check pilot goes with the normal crew, thus combining the screening mission with the dropping or landing operation. On 3 January such was the situation on the subject flight.

The Taksing dropping zone was opened in August 1959 and since that time nine pilots had flown over it for supply dropping. According to the Operations Manager, IAC, Calcutta, these pilots were not screened by any approved check pilot. His statement, that it would be impossible to check all pilots for operations to all the dropping zones, could not be accepted. From a statement of the then officer in charge of NEFA operations it was clear that the Taksing dropping zone was one for which pilots must be screened.

Examination of the flying records of the check pilot on the flight of 3 January showed that this was his first flight to Taksing in any capacity. He was, therefore, not familiar with the terrain. A command pilot familiar with the dropping zone should have accompanied him on his first flight there. Instead, his first flight to Taksing was for the purpose of screening two other pilots.

As stated previously, this was also the co-pilot's first flight to Taksing, and the supernumerary pilot had been there once as a co-pilot.

Probable Cause

The accident was attributed to an error of navigation which caused the pilot to enter a wrong valley. During an attempt to turn back in a restricted area, the aircraft stalled and crashed. The fact that this was the pilot's first flight to this dropping zone, and he was not familiar with the terrain, contributed to the accident.

Recommendation

The dropping zone should be thoroughly surveyed by the check pilot before the screening of other pilots is undertaken.

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ICAO Ref: AR/667

No. 16

National Airlines Inc., Douglas DC-6B, N 8225H, exploded in flight near Bolivia, North Carolina, on 6 January 1960. Civil Aeronautics Board (USA) Aircraft Accident Report File No. 1-0002 released 29 July 1960.

Circumstances

Flight 2511 departed New York International (Idlewild) Airport at 2334 hours eastern standard time (5 January) on an IFR clearance scheduled as a nonstop flight to Miami, Florida. The flight proceeded routinely in accordance with its flight plan until shortly after passing Wilmington, North Carolina. At 0231 (6 January) it contacted the company radio station at Wilmington while over Carolina Beach at 18 000 ft, and transmitted a routine progress report. Shortly after the completion of this radio contact a dynamite explosion occurred in the passenger cabin. Following this explosion the aircraft entered a wide descending right turn and crashed 1-1/2 miles northwest of Bolivia, N. C., at 0238 hours, some 16 miles west of its intended route. All 29 passengers and 5 crew aboard were killed.

No reference is made in this report concerning the placing of the dynamite aboard the aircraft or of the person or persons responsible for its detonation. The malicious destruction of an aircraft is a Federal crime. After the Board's determination that such was involved, the criminal aspects of this accident were referred to the Department of Justice through its Federal Bureau of Investigation.

Investigation and Evidence

The Wreckage

Examination of the aircraft structure and the wreckage distribution indicated that an inflight disintegration of the aircraft had occurred, which initiated at a point in the fuselage near the leading edge of the right wing on the right side of the passenger cabin. The portions of wreckage recovered in the Kure Beach area (16 miles east of the Bolivia site) were all from this general location.

After the fuselage wreckage was positioned on the mockup, it was found that approximately 90% of the fuselage plating or skin had been recovered and identified. Most of the missing pieces of the fuselage apparently came from an irregular-edged, triangular-shaped area above and extending forward from the leading edge of the wing on the right side of the fuselage. Numerous small fragments of upper fuselage shell structure from this triangular area, totalling about 20 sq. ft. of surface, were found and identified, but their small size prevented their being positively located within this area. Examination of the fuselage in close detail indicated that the forces which caused the cabin wall failure emanated from within.

The wreckage examination disclosed no evidence of any malfunction or failure of the aircraft, its power units, propellers, or systems prior to the inflight disintegration.

A review of the aircraft records and the maintenance and overhaul records showed that all work had been properly accomplished and adequately supervised.

Human Factors

The finding of the body of one of the passengers some 16 miles from the main wreckage area (Snow's Marsh, on the west side of the Cape Fear River - see Figure 5), where all the other bodies were recovered, was considered significant in that it clearly showed that some type of cabin failure had occurred early in the sequence of events. The examination of the passenger's body showed that the injuries sustained were significant in nature as they were not of the type normally associated with an aircraft accident. The existence of an explosive force in close proximity to this passenger was indicated by the avulsion (tearing away) injuries noted, the traumatic amputation of the lower extremities, and the fragmentation of muscle tissue manifested by tears in a longitudinal direction and loss of much skin, and the splinters of bone found in random directions to the main bone shaft of the fingers of the right hand. In addition, numerous particles of metal, fibre, cloth, wire and other objects found in the body tissue could only have resulted from the detonation of an explosive in close proximity to this passenger. Medical experts with extensive experience with battle field "land-mine injuries" and other injuries resulting from explosives indicated that the injuries sustained by the body found at Snow's Marsh could only have been caused by an explosive blast.

Structures - Analysis

A lengthy and detailed study of the wreckage was conducted to determine the cause of the initial aircraft structural failure. The possibility of several different failures was considered. These included: A fatigue failure of the cabin structure followed by explosive decompression; a propeller blade failure followed by cabin penetration and explosive decompression; the malfunction of the cabin pressurization system causing a structural failure; foreign object penetration; a lightning strike; fuel vapour explosion; oxygen bottle explosion; and the possibility of the detonation of an explosive substance within the aircraft.

The nature of the initial damage, the intensity of the force involved, and the location from which the force emanated, together with the check of the aircraft structure and its systems, eliminated the possibility of a fuel vapour explosion.

The study and analysis of the wreckage revealed information which in effect eliminated all of these possibilities except for the possibility of the detonation of an explosive substance within the aircraft.

The extreme force of the agent causing the initial cabin failure strongly indicated that a highly explosive substance was involved. The deformation of the structure surrounding the focal point of the damage was similar to that resulting from the detonation of a high explosive. The fragmentation of the cabin structures adjacent to the focal point of the structural failure also indicated that a high explosive was the causal agent.

Sodium carbonate, sodium nitrate, and complex mixtures of sodium-sulfur compounds found in the air vent of the passenger cabin are typical of the residues found after the detonation of dynamite. The presence of nitrate traces on a life jacket found in the Kure Beach area also substantiated the fact that an explosive substance was set off in the passenger cabin. Manganese dioxide is commonly found only in the black mix portion of a dry cell battery. This substance, found on one of the cabin windows, and on a triple passenger seat indicated the presence of a dry cell battery within the immediate explosive force area. The blast damage pattern seen in the cabin structure and to the passenger seats showed that the focal point of the explosion was beneath the triple seat next to the right cabin window of seat row No. 7.

The nitrate traces found on the life jacket and the presence in the air vent of the residues usually found after the explosion of dynamite in addition to the other facts set forth conclusively show that a dynamite explosion was set off in the passenger cabin.

Reconstruction of the Flight

The flight plan filed by the captain of the flight requested routing as follows:

Radar vectoring to Coyle VOR, V-1 airway to Wilmington, N. C. control 1150 to West Palm Beach, Florida, and V-3 airway to Miami, Florida, requesting an altitude of 18 000 ft.

Following take-off from Idlewild at 2334 hours eastern standard time (5 January), the flight proceeded in a routine manner in accordance with its flight plan and clearance. During the flight, in addition to the communication contacts with FAA centres, the aircraft maintained contact with National Airlines company radio stations located at Idlewild, Washington and Wilmington. At 0213 hours (6 January) it contacted the company radio at Wilmington on 128.7 Mc/s and reported it was over Kinston at 0210, at 18 000 ft. The flight was informed at this time that the Wilmington altimeter setting was 30.17 in. Hg. At 0231 it reported to company radio at Wilmington as over Wilmington at 0227, at 18 000 ft estimating Azalea at 0302 hours, with Gateway as the next checkpoint. The flight reported that at the time of this radio contact they were over the Carolina Beach radio beacon (an "H" facility which is located 16 NM from the Wilmington VOR on a heading of 200 degrees), that the flight had been on instruments to Cofield (VOR), then in and out of the clouds, and was now on top for the first time. The company radio operator logged the time of the termination of this message as 0231. This was the last contact with Flight 2511. At approximately 0233 a dynamite charge was exploded, initiated by means of a dry cell battery within the passenger cabin and at a point beneath the extreme right seat of seat row No. 7. The dynamite explosion severely impaired the structural integrity of the aircraft and after making a wide descending right turn, it experienced inflight disintegration and crashed at 0238.

Weather

Analysis of the weather existing prior prior to and at the time of the accident clearly indicated that weather was not a factor in this accident.

The winds aloft at the time of the accident, which were in excess of 100 kt from the west-southwest at 18 000 ft and in excess of 85 kt between 18 000 and 12 000 ft, clearly explain why many small light pieces of the aircraft cabin wall were not found. These parts drifted east-northeast from the point of the initial explosion and fell into the ocean. This is also verified by the subsequent finding of a number of these missing parts which had washed up along the beach.

Probable Cause

The accident was caused by the detonation of dynamite within the passenger cabin.

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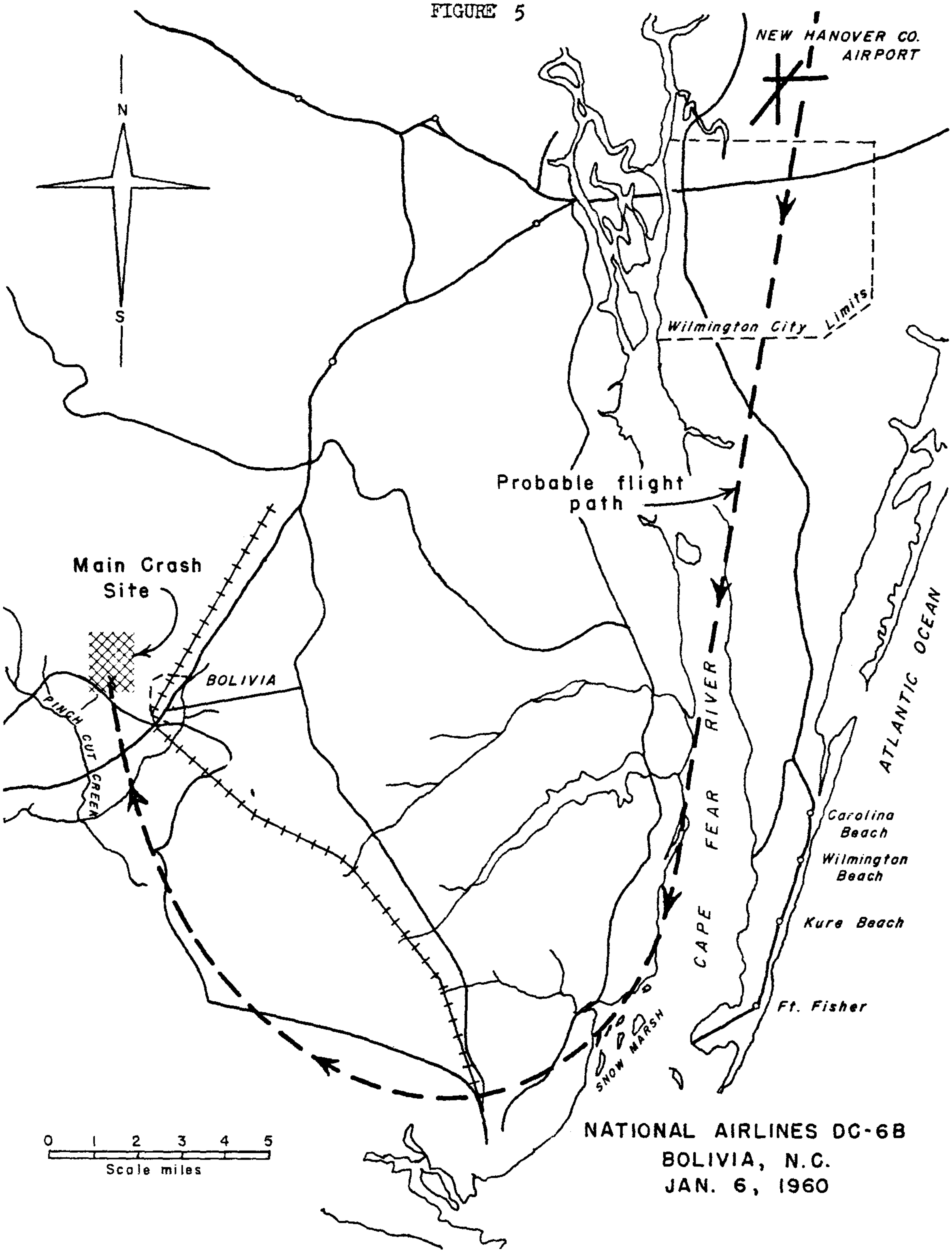
ICAO Ref: AR/639

FIGURE 5



NATIONAL AIRLINES DC-6B
BOLIVIA, N.C.
JAN. 6, 1960

No. 17

Capital Airlines, Inc., Vickers-Armstrongs Viscount, N 7462, accident near Charles City, Virginia, 18 January 1960. Civil Aeronautics Board (USA) Aircraft Accident Report File No. 1-0001, released 20 September 1961.

Circumstances

The aircraft was en route to Norfolk, Virginia from Washington, D. C. carrying 46 passengers and 4 crew when it crashed and burned killing all persons aboard.

The delayed arming of the engine ice protection systems while flying through icing conditions caused eventual flame-out of the four engines. This condition existed for sufficient time to cause a drop in battery electrical energy, preventing the unfeathering and relighting of sufficient engines to maintain flight. The aircraft was then dived in an effort to attain sufficient airspeed to drive the propellers out of the feathered positions by windmilling. At the same time, multiple attempts were made to relight one or more engines. Successful relights were either interrupted by autofeather action initiated by premature advancing of the throttles prior to complete light up of an engine or prevented by insufficient battery electrical energy. No. 4 engine was eventually relit, and the crew had just successfully relit No. 3 engine when the aircraft struck the ground in a level attitude with no forward velocity.

Investigation and Evidence

The Aircraft

Since new the aircraft had accumulated 9 247 hours.

The aircraft's gross weight at time of take-off from Washington was 60 863 lb. It should have been 61 083 lb due to the additional stewardess and company mail. The maximum take-off gross weight for runway 18/36 at Washington National Airport is 64 500 lb. The maximum take-off gross weight for landing at Norfolk is 60 945 lb.

The Crew

The captain held a valid airman's certificate with an airline transport pilot's rating for airplane multi-engine land, and DC-3, DC-4, Lockheed Constellation, and Vickers Viscount aircraft type ratings. He had flown 20 850 hours of which 3 560 were in the Viscount. His last semi-annual proficiency check of 19 July 1959 and his last line check of 12 January 1960 were satisfactory.

The co-pilot was properly certificated and had flown a total of 5 215 hours of which 2 952 had been as co-pilot on the Viscount.

The Flight

The flight was cleared at 2135 hours eastern standard time as follows: "Capital 20 cleared to the Norfolk Airport via direct Springfield, Victor 3 to Brooke VOR, flight plan route, maintain 5 000 ft, cross Springfield at 3 000 ft, maintain 3 000 ft until two minutes past Springfield, cross Brooke at 5 000." Take-off was at 2140 hours.

It proceeded to over Springfield where it switched to the Washington Air Route Traffic Control frequency and was cleared to climb to and maintain 8 000 ft. Subsequently, its clearance was amended to proceed via Victor 3 Brooke, Victor 286 Tappahannock, Victor 213 Hopewell, direct Norfolk, maintain 8 000 ft. The flight reported to Norfolk Centre when over the Tappahannock low frequency range at 2201, at 8 000 ft and estimated Hopewell VOR at 2212. At approximately 2205, four minutes past Tappahannock, the following clearance was issued to Capital Flight 20: "Capital 20 cleared to the Norfolk ILS outer marker from over Tappahannock, Victor Airway 213 Hopewell, then via the Hopewell 140 degree radial to Deep Creek, direct to the Norfolk outer marker, to maintain 8 000 ft, contact Norfolk radar on frequency 118.5 over Hopewell." The crew's acknowledgement of this clearance was the last radio contact with the aircraft. All radio communications were normal, the pilot was making good his calculated groundspeed up to this time, and there was no indication of any difficulties. Impact occurred at approximately 2219 hours.

Weather

Shortly after departing from Washington Flight 20 would have been in the clouds and would have remained in the clouds during a substantial portion of its climb to the cruising altitude of 8 000 ft. While the aircraft probably was out of clouds a portion of the time en route, it is considered that it was in clouds more than half of the time or approximately 10 to 15 minutes. During this period and prior to descent near the accident site, the aircraft would have been experiencing sub-zero temtemperatures. At the same time, Flight 20 would have encountered light and occasionally moderate showers.

Cloud tops along the route were generally from 10 000 to 13 000 ft and could well have been lower locally. Ceilings ranged mostly between 100 and 400 ft with visibilities five miles or less in fog. Clouds were layered with the base of the upper deck about 6 000 ft and the tops of the lower deck between 3 000 and 4 000 ft. Drizzle was associated with the fog at a number of locations, while rain showers of varying intensity occurred along the route.

A small but intense low pressure system and its associated frontal structure moved northeastward from south of the accident site to a location about 35 miles east-southeast of the site at the time of the accident. This system was accompanied by high gusty winds, heavy showers, turbulence, and some thunderstorm activity and hail. Pilot reports, radar reports, and ground witness statements indicated quite clearly that the latter weather conditions affected neither the immediate area of the accident site nor the route from Washington to the accident site.

The freezing level in the Washington area was near 5 000 ft, while the temperature at 8 000 ft was minus 8°C. The temperature at 8 000 ft over the accident site was approximately minus 4°C, and the freezing level was near 6 000 ft.

Upon descending below 6 000 ft near the accident site the flight would have encountered temperatures above freezing. The aircraft would have broken out of the upper cloud deck at this altitude and would have entered the lower clouds at about 3 000 to 4 000 ft. From this altitude to ground impact the aircraft would have been in clouds with the possible exception of the final 100 to 400 ft. Light-to-moderate turbulence would have been encountered en route.

An analysis of the weather indicated the temperature and moisture content of the air at 8 000 ft, the flight's assigned altitude, were conducive to icing to the extent that 1/4 to 1/2 inch of airframe ice accumulation could have built up on the portions of the airframe of N 7462 while en route to the accident site.

Engines - General

All four power units were found in their correct positions in relation to the wing. Engines Nos. 1 and 2 had few impact rotational rub marks appearing on the turbine and compressor assemblies. There were no bent or displaced vanes on the first and second stage impellers of these engines. However, these engines did have static press marks on reduction gearing made at impact by the transfer housing retaining studs. Impact damage occurring in the compressor sections of these engines was very light, and the eye casings were not damaged by rotational forces. The torsion shafts of the compressors had not failed.

Investigation of Nos. 3 and 4 engines revealed significant radial rub marks on reduction gearing and transfer housing retaining studs. The impact damage occurring in the compressor sections of these engines was very heavy. The impellers had some rotational damage. The eye casings had been rubbed by the rotating guide vanes. Both torsion shafts and both second stage impeller shafts had failed. There was also evidence of radial rub marks on the face of the turbine discs, and metal spatter was present on the nozzle guide vanes and turbine blades of Nos. 3 and 4 engines.

In the investigation of this accident, the Board undertook to determine the number and reasons for the known instances in which Rolls-Royce Dart engines inadvertently shut down in flight. The review showed that the reasons for engines losing power simultaneously have been generally due to either late selection of the anti-icing equipment, or to fuel starvation caused by ice formation in the fuel lines, and/or the presence of a large amount of water in the fuel. There have been a total of 18 reported cases involving 18 airplanes in which multiple engine loss of power has occurred. However, in all of the instances which deal with late selection of the anti-icing equipment, the engines either recovered normally or were successfully relit. It was only in the cases - eight in number - which were concerned with ice in the fuel line or excessive water in the fuel that difficulty with relighting occurred. This information is based on reports received by Rolls-Royce from airlines on a world-wide basis and covering approximately 11 million engine flying hours.

All refuelling activities of Flight 20 were investigated and found to be negative as far as contamination of fuel was concerned. The investigation also revealed that the hot-air gate valves of the four engines were in the closed position at the time of impact. Had a blockage in the fuel lines existed due to ice, the hot-air gate valves would have automatically opened to permit the hot air to pass to a heater in the fuel supply line.

The Board then directed its attention to the possibility that the flight experienced flameout of a sufficient number of its engines engines to preclude flight.

Anti-icing equipment

The principle of the anti-icing equipment on this aircraft is to permit a small build-up of ice on the engine cowls of each engine and then to turn on the electrical current to actuate the engine cowl anti-icers so that the ice breaks off and goes into the engine.

Incorporated in the engine cowl ice-protection system is a thermostat for each engine. Each thermostat is located in the inlet duct of the cabin inter-cooler which is in the belly of the aircraft. In order to complete the electrical circuitry of this system, the arming switches in the cockpit must be placed in the "ON" position.

Each individual thermostat senses outside air temperature and varies the heating from a rapid and short cycle (fast) ... two minutes duration, to a slow and lengthened cycle (slow) ... six minutes duration.

Early testing of the cowl anti-icing system was directed towards determining the correct length of time which the anti-icing equipment should be "ON" and the length of time which the heat to the cycle-heated pads of the engine cowl should be "OFF". As a result of this testing, a cycling time was selected and incorporated in the present Viscount cowl anti-icing system. This system, when armed, would be able to combat the worst icing conditions. The anti-icing installation aboard Flight 20 was approved by both the British Air Registration Board, and the American Civil Aeronautics Administration (Federal Aviation Agency) as fulfilling the necessary requirements for such a system.

To avoid excessive accumulation of ice on the power units of the Viscount, the power unit ice-protection system should be switched "ON" during every flight at all times when the indicated outside air temperature is below plus 10°C, except when it is certain that icing conditions will not be encountered. One of the first visual indications of ice is its formation on the windshield wipers. By the time this is apparent, a fair amount of ice could have accumulated on the engine cowls. The anti-icing system should be turned on well in advance of anticipated icing conditions in order to allow the inlet duct to warm up enough to prevent excessive ice from forming. If ice has been allowed to accumulate and the system is armed late, heating underneath the ice formation is quite rapid since the ice acts as an insulator. If ice has formed and the ice protection system is turned on, sufficient heating occurs in approximately 30 seconds and de-icing will result. Under these circumstances, there is a good possibility that the entire ice accumulation around the inlet duct circumference will slip off and go through the engine en masse. The release of a large amount of ice from the inside part of the nose cowling, due to the late arming of the engine ice protection system, would have been sufficient to flameout any of the engines.

Change 15

Change 15 of the Air Registration Board Manual had the sanction of the United Kingdom ARB and became a mandatory change for all United States air carriers using Viscount aircraft. It established the following procedure should icing conditions be encountered before the ice prevention system could be switched "ON".

"1. Switch 'ON' ice protection systems on engines 1 and 3.

2. Observe that the cycling lights indicate correctly.

3. If both engines run normally for three minutes, switch 'ON' the ice protection systems on engines 2 and 4.

4. If descending into air conditions where the temperature is above 0°C indicated, it is advisable to discontinue the descent until all four engines are running normally, i. e., for six minutes."

The Capital Airlines Flight Manual did not include the information about selective de-icing of engines that had accumulated a buildup of ice prior to arming the ice protection system, nor did it make note of the inadvisability of descending into temperatures above 0°C until the ice protection system had been turned on and the engines operated normally for a period of at least six minutes. In fact, the checklist in effect at the time of the accident directed the pilot to descend to warmer air to de-ice his engines normally. This checklist, effective 26 March 1957, read as follows:

"Flame Out - In Icing Conditions

1. Feather propeller.

2. Relight immediately, or descend below the freezing level to allow the engines to de-ice naturally."

Reconstruction of the flight

The Board had no factual information as to the precise sequence of events which occurred at 8 000 ft when flight 20 began to have difficulty. However, the facts the Board does have support a probable sequence of events.

2201 hours — aircraft reported over Tappahannock low frequency range at 8 000 ft and estimated Hopewell VOR at 2212... the flight was cleared to the Norfolk ILS outer marker... transmission completed at 2205.

The accident site is approximately 40 NM south of Tappahannock and about 14 minutes elapsed between the completion of the transmission and impact which occurred at approximately 2219 hours. During this period of night flight the crew was confronted with a sudden emergency which required their complete attention as no attempt was made to contact anyone by radio to declare an emergency or to request descent to a lower altitude.

The Board believed that between 2205 and 2219 hours, all four engines of the aircraft ceased to deliver power and their propellers feathered, and that this was due to the late arming of the ice protection system. The first flameout could have been followed immediately by other flameouts or there could have been an undetermined period of time between the flameouts. The delay in arming the ice protection system was probably due to one or more of the following factors:

1) the captain was apparently not aware of Change 15 of the ARB Manual, stipulating that "the ice protection systems for all four engines must be switched 'ON' during every flight at all times when the indicated outside air temperature is below plus 10°C, except when it is certain that no icing will be encountered";

2) late anticipation, i.e. the captain may not have taken action to arm the system until he observed visible indications of ice accretion;

3) variations in the outside air temperature gauge and the anti-icing thermostatic probe indications due to variations in compressibility, e.g. with indications of plus 5°C, the actual temperatures could have been as low as plus 2°C.

When the flameout occurred, the crew would presumably have followed their current Viscount emergency checklist which called for an immediate relight or a descent to below the freezing level to allow the envine to de-ice naturally. During this time, attempts might have been made to start the flamed out engine or engines. The Board believed that more than one engine must have flamed out before the descent was begun. Had only one engine flamed out, the crew would most likely have continued their flight at the assigned altitude.

Prior to beginning the descent, the aircraft would have been operating near V_{no} - the normal operating limit speed of 237 kt. During the descent, the throttles of any remaining engines could have been moved toward the closed position and to below the auto feather arming position. This throttle reduction might also have been required if the aircraft had penetrated an area of light to moderate turbulence en route.

During the descent, the aircraft would be entering progressively warmer air. Any remaining engines would have been operating at a low rpm, JPT (jet pipe temperature), and thrust setting, and could have flamed out either because of ice ingestion brought about by the warmer air, or because the anti-icing system was left "ON" during descent to warmer air. Additional drag would have been experienced by the windmilling of the remaining propellers since they would not auto feather until the throttles were advanced to above 13 400 rpm - the auto feather range.

Having followed the then used checklist by descending to a lower altitude, the crew would level off after reaching an altitude where the outside air temperature was above freezing and go through the standard drill for relighting without further loss of altitude. As the throttles of the engines that had been operating at the beginning of the descent were advanced, the propellers would auto feather if they had flamed out due to ice ingestion during the descent. By this time, the complexity of the situation would have magnified itself to extreme proportions. The air speed would drop off rapidly, and the aircraft would continue to lose altitude.

The crew would then try jointly to restart any of the engines and to keep control of the aircraft, sacrificing speed for altitude. It is estimated that considerable altitude would have been lost and that three or more minutes would have elapsed since the emergency occurred. During this time numerous efforts would have been made to restart the engines. However, battery energy would have fallen below the required voltage necessary to successfully unfeather a propeller and relight an engine.

Discussion

A study of numerous Capital Airlines Viscount flights operating at night disclosed that the electrical load being used aboard N 7462 at the time of the emergency was from 500 to 600 amps. If the electrical system were not switched over to the emergency bus system during an emergency in which several engines cease to operate and their propellers automatically feather, all the electrical units in use would continue to draw their energy from the battery. The flight test demonstrated that under similar flight conditions using approximately the same electrical load, the battery energy would fall within 1-1/2 to 2 minutes to below the required voltage necessary to successfully unfeather a propeller and relight its engine. One or more engines running with generator "ON" would supply sufficient electrical energy to feather or relight any of the Viscount engines. A fast windmilling propeller would also furnish enough rotational motion and, in turn, sufficient electrical energy to accomplish propeller unfeathering or engine relight.

If the engines could not be started, efforts could be made to drive the propellers out of feather by windmilling. The aircraft would have to be dived to approximately 150 kt to drive the outboard engines, Nos. 1 and 4, out of feather. Approximately 180 kt of airspeed would have to be attained to drive the inboard engines, Nos. 2 and 3, out of feather.

The fact that engines Nos. 3 and 4 were found to be developing power at impact indicated that these engines were successfully started at some time before impact. If two of the engines were operating continuously, it is doubtful that the aircraft would have lost altitude since it is certificated to maintain altitude at maximum gross weight with two engines inoperative. Since the investigation revealed power was available on engines Nos. 3 and 4 at impact, and something adverse occurred between 8 000 ft and impact, it is logical to assume if the crew had available to them energy to relight, then relight would have been experienced and sufficient altitude would have been maintained.

No. 4 engine was successfully driven out of feather position and relit. During this time, relighting attempts caused an accumulation of fuel to be deposited in the burners, so that explosive relights occurred, bringing about noises of engine surging and backfiring heard by witnesses.

The crew now used full power on the No. 4 engine to assist in checking the severe settling of the aircraft, causing the aircraft to turn to the left. During the last circuit, and as No. 3 engine started, the aircraft was probably operated with full cross controls and was settling rapidly. In order to stop the unwanted turn, it is probable that the crew reduced power on No. 4 engine, with the thought of advancing power on Nos. 3 and 4 engines together after the turn was stopped. Such a reduction of power at a time when full opposite control was being used would arrest the turn but cause greater settling of the aircraft. An application of power was made at or about the time of tree contact. However, it was too late to develop power on No. 3 engine or to supply sufficient power for a climbout. It is possible the crew observed the ground just before impact and applied back elevator pressure on the control column, causing the aircraft to whipstall. The aircraft then struck the ground before it whipped into the steep nose down attitude characteristic of the whipstall.

Flight tests disclosed that with three engines inoperative and full power on No. 4

engine, full left rudder and full right aileron, much difficulty was experienced in the attempt to maintain directional control and the result was a slow turn to the left. When power was removed from No. 4 engine, the aircraft would enter a high rate of descent.

Numerous "earwitnesses" reported hearing "popping noises" or "cutting in and out" of an engine or engines as the aircraft made several circuits to the left just prior to impact. In evaluating the auto feathering and relighting procedures, the Board believed a logical explanation for these reported sounds can be given. The auto feather feature is armed and capable of operation throughout the range of throttle positions from cruise to take-off, i. e. from 13 400 to 14 500 rpm. Below cruise throttle position the throttle switches are open, and the auto feather feature is ineffective. During rapid acceleration the throttles may reach the position at which these switches are set before the torque pressure has had time to rise above 50 psi. However, in the event the relight is not completed the propeller will go toward the feather position. This process is of very short duration and does, in fact, assist the acceleration.

If partial relight should occur, the throttle may be closed and opened rapidly to about 12 000 rpm, to effect a complete relight. In the event this action does not achieve a complete relight, it is then necessary to refeather and wait two minutes for fuel drainage before repeating the unfeather procedure. However, in an emergency, successive attempts to relight may be made.

In the event the high pressure cock is not placed in the feather position subsequent to the propeller auto feathering, fuel could collect in some parts of the combustion chamber. In addition, if the throttle were partially open and the unfeathering switch operated to obtain unfeathering oil pressures and ignition, there could be an explosive relight. This action could be repeated a few times within the 30 seconds relight-time-switch cycle, thus giving rise to a "popping noise".

The Board believed that Nos. 1 and 2 propellers were auto feathered - a condition which was substantiated by the fuel found in the snout area of the No. 3 combustion chambers of these engines. Furthermore, fuel in this location supports the assumption that the high pressure cock was in the open position.

The Board believed that the most likely sequence of events, based on the reported engine sounds and the known procedures for accomplishing a relight of Dart engines, consisted of an attempt to drive the propellers out of feather by windmilling, followed by multiple attempts to relight one or more engines. Successive relights were interrupted by auto feather action initiated by premature advancing of the throttle prior to complete lightup.

During the investigation No. 3 engine igniter points were found considerably eroded. This raised some speculation as to whewhether such a condition could be a factor in delaying relight of No. 3 engine until just prior to impact. The igniter boxes of all four engines were bench checked and found to be capable of operation. Investigation revealed that the erosion noted on these igniter points was the result of time in service since overhaul and not a contributing factor in this accident.

During this investigation the Board found that Change No. 15 to the ARB Flight Manual had been disseminated to all Viscount operators for a period of 19 months prior to the accident and included in the manuals carried in the Capital Airlines' Viscounts, but the material had not been incorporated into the Capital Airlines Flight Training Manual furnished to all the Capital Viscount pilots and utilized in the ground school instruction for Viscount aircraft. Nor was this material incorporated in the pilot emergency and routine checklists. The Board's investigation revealed also that at the time of and subsequent to the accident, many Viscount pilots of Capital Airlines were not aware of the change to arm the power unit ice prevention system at plus 10°C instead of at plus 5°C, despite the fact that this change became effective in July 1958.

Probable Cause

The accident was attributed to the delayed arming of the engine ice protection systems while flying in icy conditions, resulting in the loss of engine power and attendant electrical energy required to unfeather propellers and relight sufficient engines to maintain flight.

Follow-up Action

Subsequent to this accident, the Board made several operational studies of inflight procedures practiced by Capital Airlines Viscount pilots in connection with the use of the engine ice protection system. As a result of these studies, the Board, in a letter dated 14 July 1960, disclosed to the Federal Aviation Agency that Capital Airlines Viscount pilots were still not following proper procedures relating to the use of the ice protection system.

As a result of this accident, Capital Airlines dropped the phrase "descend to warmer climate for relight" from its emergency checklist and instructed its Viscount pilots that relight could be accomplished at any altitude if the proper drill were followed. Capital Airlines also adopted a system of checking pilots to ascertain that they had the benefit of the latest operating information.

ICAO Ref: AR/688

No. 18

Scandinavian Airlines System, SE-210 Caravelle, OY-KRB, crashed at Esenboga Airport, Turkey, on 19 January 1960. Report issued by the Directorate of Civil Aviation, Ministry of Communications, Turkish Republic, 25 January 1961.

(In preparing its report the Turkish Accident Investigation Team took into consideration the report, dated 12 November 1960, prepared by the Directorate of Civil Aviation, Denmark).

Circumstances

Aircraft OY-KRB was on a scheduled flight between Copenhagen and Cairo. After taking-off from Istanbul the flight continued to Ankara, the next scheduled stop. When approaching to land at Esenboga Airport the aircraft collided with the ground about 6 NM from the threshold of runway 03. Seven crew members and 35 passengers lost their lives. The aircraft was completely demolished.

Investigation and Evidence

The Flight

SK 871 was a scheduled international public transport flight, the first stage of which appeared to have been uneventful, and, apparently, everything was normal when the flight was taken over by Ankara control at reporting point Göynük, at 1826 hours GMT.

The aircraft arrived over Ankara range station at 1841 at flight level 135 descending to flight level 120 in accordance with the clearance given. It changed over to the tower frequency and received further let-down and approach instructions. The crew acknowledged receipt of the instructions and the flight reported Ankara range station inbound at 1845 at an altitude of 6 500 ft descending.

At 1847 the aircraft struck the ground at an elevation of 3 500 ft, between Ankara range and the Airport. Apparently, after reporting it continued on a heading of 031 degrees, descending to the impact point.

The Aircraft

The aircraft had a valid Certificate of Airworthiness. It was properly loaded at departure from Istanbul, and the gross weight and the centre of gravity were within the prescribed limits. Inspection and maintenance procedures of the aircraft and its components were carried out in accordance with established regulations.

The Crew

The crew were all duly certified, and their physical examinations and proficiency checks were current.

The captain had 310 hours flying experience with this type of aircraft and his total flight time with SAS was 8 000 hours. His flight time in the last 30 days totalled 39 hours.

The first officer had flown 280 hours on Caravelle aircraft and his total time with SAS was 1 971 hours. Flight time in the last 30 days totalled 24 hours. The third crew member, a qualified co-pilot, had flown 250 hours on this type of aircraft.

The Weather

En route weather was generally as forecast; however, local weather between Ankara range and Esenboga Airport consisted of mixed snow and rain and low ceilings associated with a cold front passage. During the descent, after initially reporting over Ankara range, weather conditions were such that the crew members could probably have observed the city lights of Ankara through intermittent clouds. After crossing Ankara range inbound, the crew must have continued the flight in instrument conditions down to the point where the accident occurred.

Communications and Navigational Aids

The instrument landing system was in use on a test basis. Other navigational aids utilized were functioning normally and communication between the aircraft and Esenboga tower was normal.

The Wreckage

From the marks of the first impact and from relative positions of the more significant parts of the wreckage, it was established that the aircraft hit the ground in a normal flight attitude in a 5^{o} nose up position at an approximate airspeed of 160 kt. Initial impact marks were made by the landing gear and the right speed brake. Impact force was of such a magnitude as to initiate disintegration of the aircraft. The aircraft continued on the initial impact path for a distance of approximately 700 m. Fire was confined to the central section and remaining portions of the passenger cabin and left wing.

Rescue and fire fighting personnel reached the scene of the accident promptly.

Technical Examination of the Wreckage

Since the aircraft was completely demolished by impact, the inspection of the wreckage was very difficult. No malfunction was proved to be a contributing factor to the accident.

Conclusions

The investigating team arrived at the following conclusions:

1. The aircraft had a valid airworthiness certificate and had been maintained in accordance with established procedures;
2. The weight and centre of gravity of the aircraft were within authorized limits;
3. The crew were duly licensed and trained;
4. Prior to the accident no malfunctioning was reported from the aircraft;
5. All ground equipment was serviceable, normal and operational. The pilots did not report any abnormal operations;
6. All ground communications had been carried out in the normal manner and in accordance with the directives;
7. The aircraft was 1 100 ft lower than the altitude it ought to have been at the site of the accident and 200 ft lower than company established landing minima.

Probable Cause

The accident occurred because of an unintentional descent below the authorized minimum flight altitude during final approach to Esenboga Airport.

The reason for this descent could not be ascertained due to lack of conclusive evidence.

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ICAO Ref: AR/663

FIGURE 6

SAS, SE 210 Caravelle, OY-KRB, accident at Esenboga Airport, Turkey, 19 January 1960
Main wreckage area

No. 19

Aerovías Nacionales de Colombia, S. A., Lockheed Super Constellation, HK-177, Accident at Montego Bay Airport, Jamaica, West Indies, on 21 January 1960. Report dated 27 February 1960 of the Public Inquiry carried out in accordance with the Air Navigation (Investigation of Accidents) Regulations, 1953 (Jamaica).

Circumstances

The aircraft took off at 1035 hours* on 20 January from Idlewild Airport, New York, on scheduled flight 671 to Bogotá, Colombia, via Montego Bay and Kingston, Jamaica and Barranquilla, Colombia. Thirty minutes beyond Wilmington, North Carolina, engine No. 3 malfunctioned and as a precautionary measure this engine was stopped and the propeller was feathered. The aircraft was diverted to Miami, Florida where it arrived at 1657 hours. Following the fitting of a replacement propeller governor, a further defect in No. 2 engine was discovered during pre-flight checks. This was rectified at 2330 hours. For the next segment of the flight to Montego Bay, the captain ordered the co-pilot to undertake the take-off, en route flying, descent and landing. The co-pilot was to occupy the right-hand seat in accordance with Company practice. The aircraft was airborne at 0012 hours (21 January) and the flight to Montego Bay appears to have been uneventful. Shortly before arrival overhead, a standard instrument approach clearance was obtained from air traffic control, and a normal instrument approach procedure appears to have been carried out. On completion of the procedure turn at 2 000 ft, the airfield was sighted and the approach continued visually. The co-pilot continued to control the aircraft with the captain monitoring events and operating the radio equipment. The aircraft made an initial contact with the runway, bounced into the air and re-alighted on the runway. When the fuselage finally came to rest 1 900 ft from the threshold of the runway, 200 ft to the left of the centreline on a heading 130° to the runway, it was completely inverted and fires were burning almost all the way around it. Of the 7 crew and 39 passengers (including an infant) aboard, nine survived - three crew members from the cockpit and four passengers and two crew from the rear passenger compartment. The accident occurred at approximately 0224 hours.

The Aircraft

It held a Certificate of Airworthiness valid until August 1960. There was no evidence that the aircraft was not properly maintained, laden or trimmed or that its documents were not in order or that any technical defect was present in the aircraft which could have contributed to the accident.

Its estimated weight on reaching Montego Bay Airport was 110 000 lb, i.e. well within the maximum permissible landing weight of 113 000 lb.

Structural design strength data

In evidence, the following data, pertaining to the design of the aircraft, was given:

The aircraft structure was designed to withstand a rate of sink during landing of 10 ft/s.

The static rating of the tires used on the aircraft was 34 500 lb each, and the maximum deflection load without damage was in the order of 115 000 lb each, making a total load capacity of each pair of wheels of 230 000 lb, which could be transmitted to each oleo leg.

* All times in this summary are GMT minus 5 hours.

It would be necessary to apply 192 000 lb to each undercarriage unit axle in order to cause a sufficient deflection to bring the wheel hubs in contact with the brake assemblies.

The force necessary to bottom an undercarriage oleo strut, which was correctly charged, was 187 000 lb.

The rate of sink necessary to bottom an oleo strut as above, at an aircraft landing weight of 110 000 lb would be between 12 to 14 ft/s, that is 2 to 4 ft/s above the design maximum.

The tire marks on the runway threshold, presuming a landing weight of 110 000 lb with a forward speed of 115 kt, represented an aircraft sinking speed in excess of 10 ft/s.

The Crew

The captain was in command of the aircraft, but at the time of the accident the co-pilot was in control. The captain held a Colombian Airline Transport Pilot's Licence valid to 22 January 1960 (i. e. the day after the accident). He also held an Instrument Rating for Lockheed 1049 aircraft and a valid Radio Telephony Operator's Licence. He had been a pilot for fifteen years and had flown a total of 12 206 hours. Of this total about 9 208 hours had been as captain and about 2 998 as co-pilot. Of the hours as captain, 3 450 hours had been in command of Super Constellation aircraft. His last proficiency test was carried out on a 1049 aircraft on 7 September 1958 and his last instrument rating renewal on 15 and 16 July 1959 was on a 749 type aircraft.

The co-pilot held a Colombian Commercial Pilot's Licence valid to 26 August 1960 and endorsed with an Instrument Rating in respect of Lockheed 1049 aircraft. He had been a pilot for six years during which time he flew approximately 5 158 hours - all of which were as co-pilot. Of this total about 2 348 hours were spent on 1049 aircraft and 753 hours of this time were logged since 1 January 1959. His last proficiency check on 1049 aircraft was in September 1959 and his last instrument rating renewal was in June 1959, on 749 type aircraft.

The flight engineer held a Colombian Flight Engineer's Licence valid to 17 November 1960 endorsed for Lockheed 1049 E/G aircraft. He had been a flight engineer for eight years during which time he had flown 5 202 hours, 2 778 hours of which were on 1049 aircraft.

These three crew members were among those who survived the accident.

Fatigue

The crew went on duty at 0900 hours on 20 January and remained on duty for 17 hours and 24 minutes, i. e. within the permitted maximum of 20 hours. However, the report states: "To provide against fatigue by prescribing that the crew shall not remain on duty for more than 20 hours or be engaged in flying for more than 12 hours would seem to lose sight of factors that in themselves may bring on fatigue. The nervous strain brought on by handling an aircraft with one engine not functioning properly may itself be equivalent to more than 20 hours of ordinary duty. Also, the variety of duties should be taken into account."

"The crew of HK-177 flew some six hours or more over the United States of America. Over such territory the work load is heavy. To that load was added the strain of a malfunctioning engine, the anxious wait for repairs to be done in Miami and the renewed anxiety when the second engine started to give trouble as well as the wait to have it repaired. The accumulation of such circumstances might very well have affected the pilot sufficiently to cause an error of judgement."

The Weather

The Montego Bay weather report at the time of the accident was overcast estimated 2 000 ft, visibility 4 NM, wind 030/18 kt, intermittent rain.

Reconstruction of the Approach

HK-177 maintained an undesirably high flight path at distances within one nautical mile of the runway threshold. In order to make a height reduction sufficient to effect a landing, power had to be reduced, and this was done so as to produce a rate of descent that must have exceeded 1 200 ft/min. Such a rate of descent (20 ft/s) was greatly in excess of what is considered to be normal practice, and if maintained to the point of contact with the runway must result in major structural damage to the aircraft. The pilot's efforts in the final stages of the approach arrested the rate of descent by some measure, but the procedure adopted was insufficiently effective to prevent a severe impact with the runway.

Left wing fracture

The left wing of the aircraft had broken away outboard of the Station 80 wing joint, and through No. 2 fuel tank. On examination, failure appeared to have originated with a relative upward movement of the rear spar, as a result of which it had broken across Station 87 at the bottom boom, and Station 70 at the top boom. Remains of the bottom wing skin had a failure pattern consistent with a nose down-wing torsion, and the detachment of the wing had been completed by the the failure of the front spar in a tip upwards direction. All the sections of this failure appeared to be caused by overstressing, and no evidence could be found to suggest previous damage to the wing, or fatigue failure.

The Fire

It started as the second contact with the runway was made. The fracture of the left wing through No. 2 fuel tank released the fuel which ignited. The fire was sustained by 2 600 gal of aviation fuel on board at the time.

A member of the Airport Fire Service was on the lookout for the arrival of HK-177. He was, therefore, able to alert the whole Service at the onset of the fire. The Montego Bay Fire Brigade was also summoned. Both Services turned out promptly, however, the fire was so intense and severe that they were not able to reach the fuselage for perhaps twenty minutes from the start of the fire.

The Airport Fire Service

The Airport Fire Service is subject to the control of the St. James Parish Council. The senior officer at the Airport Fire Station is under the direct supervision of the Superintendent of the Montego Bay Fire Brigade.

At the airport were a foam tender, a nurse truck and a rescue tender. This equipment, apart from the capacity of the nurse tender, is in accordance with the Colonial Office requirements for an airport such as Montego Bay. The capacity of the mobile water supply was 1 350 gal, whereas the requirement demands one of 1 800 gal. This deficiency did not, however, hinder the work of the fire fighters. There was the main supply of water at the fire station (a few hundred yards from the scene of the fire) as well as an abundant source of open water at hand in which the aircraft was partially immersed.

Evidence established that the fire station was reasonably well organized much on United Kingdom lines and that the station records, standards of training and apparent efficiency were satisfactory. However, no matter how efficient the fire service and irrespective of the scale of the equipment employed, it was clear that the nature of the blaze precluded the degree of control necessary to effect rescue within the three minutes during which life was estimated to exist on board.

In the Singapore disaster of G-ALAM* it seems to have been recognized that the fire hazard to a crashed aircraft varies from a fire that can be extinguished with a hand extinguisher to one that would be uncontrollable despite any equipment. The fire on HK-177 was adjudged to fall within the latter category.

Probable Cause

The cause of the accident was the adoption of a final approach path resulting in a heavy landing during which a major structural failure occurred in the port wing in the immediate vicinity of Station 80 joint caused by the transmission of stresses through the undercarriage in excess of those which would be encountered if the rate of sink of the aircraft at the time of impact had been controlled within the designed maximum of 10 ft per second.

The primary responsibility for the safety of an aircraft and its complement is vested in the captain. However, there is evidence of mitigating circumstances in that the errors of judgement that precipitated the disaster reflect some deficiency of knowledge which should have been instilled in the training and flight proficiency checking of the pilots of HK-177. A measure of responsibility for the accident must, therefore, devolve on the supervisory and advisory authorities for the overall conduct of the operation.

Recommendations

It was recommended:

1. that emergency exits be provided in public transport aircraft on a scale which relates to the seat density of each compartment, rather than to the overall seat capacity of the aircraft;
2. that consideration be given to the placarding of the instructions appertaining to the method of operating emergency exits, in such a manner that they can be read with the aircraft in the normal or inverted positions;
3. that all compartment doors in aircraft interiors be constructed in such a manner that ample clearance is provided between them and their respective door jambs to minimize the possibility of jamming due to distortion of the door frames;
4. that a fracture joint be provided down the length of each internal compartment door suitably placarded which can be split by pressure from either side, by a perperson in distress;
5. that a latching hook be provided on internal compartment doors so that they may be secured ajar at the time of landing and take-off;
6. that in the case of traversing main cabin entrance doors quick release pins be provided which when removed liberate the door from such retaining mechanisms as may be utilized;
7. that regulations be imposed by the operator, having the effect of restricting the hours of duty and of flight carried out by flying personnel; and that these restrictions shall be related separately to each operation, having regard to the varying associated workload. Captains of aircraft shall be afforded guidance in the extent to which their discretion may be exercised in the application of these regulations.

* Summary No. 11 in ICAO Aircraft Accident Digest No. 6 - BOAC, Lockheed Constellation, accident at Kallang Airport, Singapore on 13 March 1954.

8. that consideration be given to the introduction of legislation which would require that provisions be made to bring about the automatic discharge of all permanently installed fire extinguishing systems in an aircraft, through the medium of some form of impact or or inertia switch, so that all areas of known fire hazard could be evenly engulfed in fire prevention simultaneously;

9. that an emergency axe be provided in each compartment normally containing a crew station;

10. that the administrative control of an Airport Fire Service shall be vested exclusively in the Airport Manager, and not in the Parish Council, in view of the specialist nature of the fire fighting apparatus utilized, and the specific training necessitated by the particular duties inherent in aircraft fire fighting;

11. that aircraft operators be required to afford facilities to members of an Airport Fire Service, so that they may become familiar with the provisions for emergency, specific to the aircraft types utilized by them;

12. that every Airport exercising Air Traffic Control by radio-telephony record by means of an approved electronic device, all voice communications carried on all ATC radio frequencies. Such recordings shall be preserved for a minimum period of two months.

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ICAO Ref: AR/625

No. 20

Transportes Aéreos de Timor, Heron, CR-TAI, crashed into the sea between Darwin, Australia and Baucau, Portuguese Timor, on 26 January 1960. Conclusions of the Commission appointed by His Excellency the Overseas Minister as released by the Directorate General of Civil Aviation, Portugal.

Circumstances

The aircraft, a DH 114, Heron 2D, took off from Darwin Airport, Australia at approximately 2333 hours GMT on 25 January bound for Baucau Airport, Timor, where it was to arrive on 26 January at about 0153 hours GMT. The aircraft took the heading of Baucau at about 0010 hours when it talked by radiotelephony to aircraft CR-TAG, also of Transportes Aéreos de Timor, which was flying from Baucau to Darwin. All communications with CR-TAI ceased at that time. After the usual alerting procedures, a search and rescue operation was started, which lasted for some successive days with the participation of a great number of air and surface means, covering a large oceanic and land area.

The wreckage found was recognized as belonging to the missing aircraft and this led to the conclusion that it had crashed into the sea northwest of the Island of Bathurst at about 0015 hours on 26 January. All 7 passengers and 2 crew aboard the aircraft lost their lives in the accident.

Probable Cause

It was concluded that most likely the chief cause of the accident lay in the fact that the pilot was flying the aircraft in bad visibility conditions for which he was not duly qualified, and it was presumed that reasons of a psychological nature accounted for the accident.

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ICAO Ref: AR/665

No. 21

Pacific Western Airlines, Curtiss-Wright Super C-46, CF-PWD, accident at Port Hardy, British Columbia, Canada, 29 January 1960. Report No. 873 released by The Department of Transport, Canada.

Circumstances

The aircraft departed Port Hardy at 1723 hours as Flight 104 (scheduled) to Comox, British Columbia. Three crew and forty-eight passengers were aboard. After encountering difficulties with the right engine, the aircraft returned to Port Hardy and landed on runway 10 with the right engine shut down and the propeller feathered. The aircraft overran the end of the runway and came to rest about 800 ft beyond the east end of the runway in an area of swamp and tree stumps. It was damaged beyond economical repair, and seven persons suffered minor injuries. The accident occurred at 1758 hours Pacific standard time.

Investigation and Evidence

The Crew

The pilot-in-command holds a valid airline transport pilot's licence with a Class I instrument rating and has accumulated a total of 12 500 hours flying experience of which 88 hours and 53 minutes were flown on C-46 aircraft. In the 90 days prior to the accident he had flown 75 hours and 20 minutes on the C-46.

The co-pilot holds a valid senior commercial pilot's licence with a valid Class II instrument rating. He has accumulated a total of 11 500 hours flying experience of which 71 hours and 20 minutes were flown in C-46 aircraft during the 90 days prior to the accident.

Weather

At the time of the accident the Port Hardy conditions were: scattered cloud at 600 and 2 000 ft; overcast at 4 500 ft; visibility 5 miles in light rain and fog; temperature 44°F; dewpoint 43°F; wind from the southwest at 6 mph.

There was an extensive bank of fog off the approach end of the runway.

Port Hardy Airport

Runway 10 is 5 000 ft long by 150 ft wide, asphalt surfaced and in good condition. The approach end is 50 ft asl, and the eastern end is 43 ft asl. There is a maintained gravel overrun area at the east end of the runway, 300 ft long by 225 ft wide and a further rough unmaintained gravel area 325 ft in length.

Runway 10 is equipped with amber approach lights, green threshold lights and clear runway lights. All airport lighting was serviceable and operating at the time of the accident. The runway surface was very wet due to the steady rain falling.

Reconstruction of the flight

The flight had left Port Hardy at 1723 hours for a scheduled IFR flight to Comox to fly at 9 000 ft via Amber 1 airway - the airway distance is 111 NM. The trip was routine until Alert Bay, a distance of 21 NM from Port Hardy. At this time the crew noted the right engine oil temperature was 90°C, the oil pressure 65 psi, and the oil quantity 8 gal; this temperature is the upper limit of normal, and the pressure is below normal. The oil quantity had been checked as slightly below 25 gal for each engine prior to take-off. The aircraft was immediately turned around for a return to

Port Hardy. At about 1744 hours when the flight reported by Alert Bay, approach clearance was requested and provided immediately. About half way between Alert Bay and Port Hardy the right engine surged, and the propeller was immediately feathered. The oil quantity at this time indicated 5 gal. The flight broke out of cloud at 4 500 ft with the airport in sight, and the crew stated that they would use runway 10. The turn across wind for final approach was made at 2 000 ft with the undercarriage "up". Power was reduced on the left engine and the gear lowered. The aircraft descended to the top of an extensive fog bank on the approach to runway 10. This necessitated the reapplication of power to maintain the runway in sight. When clear of the fog, power was again reduced and full flap applied. The descent to the runway was at a steep angle with higher than normal airspeed. Touchdown was made about 1 200 ft from the approach end of runway 10. The aircraft rolled off the end of the runway and came to rest in a swampy stump-filled depression about 800 ft beyond the end of the runway.

Technical Investigation

A check of the aircraft's records revealed that it had a valid certificate of airworthiness.

There was no evidence to indicate any fault with the airframe, flying controls or engine controls up to and after the accident.

Left engine

The pilot-in-command stated that during the landing run he closed the throttle on the left engine, but the power did not appear to reduce. He moved the pitch lever for the left propeller toward the coarse position which resulted in a decrease in engine noise.

Tests on the carburettor and propeller controls of the left engine failed to provide any reason for the apparent refusal of the engine to slow down during the run.

Right engine

As failure of the right engine was reported, a detailed inspection of that engine was, therefore, made with the following results:

Removal of the fron oil scavenger pump revealed numerous pieces of metal in the pump inlet and in the opening in the nose section. The rear scavenger and pressure pumps and the oil screen were found to be clear indicating the failure to be confined to the nose section. As this was dismantled, approximately one third of the reduction drive ring gear Part No. 32456 was found broken, and this provided the origin of the loose metal found in the nose section. Other damage found was related to the rotating of pieces of varying size among the gears in the reduction gear train. The failure of the front scavenger pump would account for a buildup of oil within the engine resulting finally in the increased oil temperature and loss of oil reported by the captain prior to the engine surging which necessitated the feathering.

Detailed laboratory examination of the failed gear revealed it had failed from fatigue, the origin of which could not be located because of the polishing of the fractured faces and breakup of the parts. Metallurgical examination indicated the gear was probably manufactured from a steel other than that demanded by available drawings and the gear had not been heat treated in a manner which would result in the maximum desirable properties of the steel being obtained. War time manufacture of parts from substitute materials was not uncommon.

This gear had been fitted to the engine at its last overhaul about 367 hours previously. It was not possible at the overhaul facility to determine its previous history except that it had been removed from a "cannibalized engine".

Probable Cause

The right engine failed because of a fatigue fracture of the reduction drive ring gear necessitating feathering of the peopeller. Due to the presence of a fog bank, a steep approach was necessary with the result that the landing was made at a higher than normal airspeed which, coupled with reduced braking action on the wet runway, caused the aircraft to overrun the landing area.

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ICAO Ref: AIG/ACC/REP/GEN/No. 1 - CANADA

No. 22

Trans-Canada Air Lines, Lockheed 1049H, CF-TEZ, made a wheels-up emergency landing at Toronto Airport, Malton, Ontario on 10 February 1960. Report No. 885 released by The Department of Transport, Canada.

Circumstances

Flight 20 was a scheduled flight from Winnipeg, Manitoba to Toronto, Ontario. It carried a crew of six, fifty-three adult passengers and one infant. While carrying out an ILS approach to runway 10 at Toronto Airport, the aircraft struck a grove of trees. A wheels-up emergency landing was made on the runway, and the aircraft came to rest approximately 1 370 ft past the eastern end of the runway. The aircraft was substantially damaged. Two crew members and 3 passengers received minor lacerations. One other passenger sustained minor injuries. The accident occurred at 2105 hours eastern standard time.

Investigation and Evidence

The Aircraft

It had been issued a Certificate of Airworthiness. Its landing weight and centre of gravity were within limits, and there was no evidence of any malfunction of the engines or controls prior to the accident.

The Crew

Both the pilot-in-command and the first office held valid licences with class I instrument ratings. The pilot had flown a total of 15 664 hours of which 2 581 hours had been on Lockheed 1049 aircraft. The first officer had flown 2 835 hours of which 927 had been on the Lockheed 1049.

The crew had flown the same aircraft from Montreal to Vancouver the day before and had ample rest before the return flight from Vancouver. They had been on duty 11 hours before the accident occurred.

Weather

The captain stated that the last weather report he received was broken cloud at 1 100 ft with a somewhat higher overcast; wind from the east at 10 mph and 3/4 mile visibility. This is in agreement with the 2050 hours special weather observation.

The 2100 weather report, which was not available to the crew, was:

sky partially obscured with 6/10 fog and above that overcast with cloud at 1 000 ft, with 1/2 mile visibility;

2105 - the accident occurred;

2108 - ceiling zero, 1/4 mile visibility in light rain and fog.

These weather observations taken at Toronto Airport during the evening of 10 February show rapid deterioration in ceiling and visibility between 2050 and 2108 hours. The ceilometer recording shows that at about 2100 hours the ceiling was approximately 1 100 ft above ground, dropping approximately 3 minutes later to 150 ft above ground.

Airport

Runway 10 at Toronto Airport is 7 200 ft long by 200 ft wide. The runway lights are high intensity, clear and of variable intensity. The approach lights are high intensity clear bar lights at 100-foot intervals, extending 3 000 ft out from the end of the runway. The threshold of the runway across the end and on both sides is equipped with high intensity green lights forming bars. The runway and its associated lighting system was fully serviceable.

It was determined that certain trees in the approach area for runway 10 projected above the 1 in 50 slope; however, none of these trees were in the area where the aircraft struck. Action had been initiated before the accident date to remove these trees and TCA had been informed of their presence.

Reconstruction of the flight

Flight 20 departed Winnipeg at about 1715 hours. After reporting to the Toronto Air Traffic Approach Control, a series of clearances were issued while the flight was descending from 9 000 ft. During this phase, the ILS ground monitoring system showed that the localizer on runway 10 was not properly aligned. Flight 20 was being radar positioned for a low frequency range approach. The aircraft inquired concerning the runway 05 ILS and was informed that it was satisfactory but that the glid slope was unserviceable. The flight elected to make an ILS approach to runway 05 and was radar directed to a position for such an approach. Approach Control informed the flight that it was 2 miles from the Tango Beacon, and suggested that if it was too close, a 360° turn could be made. Flight 20 advised it could make the approach and was provided with a clearance in the event of a missed approach. At this point, the aircraft was cleared and changed to the control tower on 118.7 Mc/s. It reported over the outer marker and was cleared to land and provided with the wind and altimeter setting which were acknowledged. Flight 20 stated it was overshooting and was cleared to radar departure control on 119.9 Mc/s.

Radar cleared the flight to the Ash Beacon to make a right turn and climb to 3 000 ft. The flight was cleared to Toronto Approach Control and informed by Approach Control at 2058 hours that the runway 10 localizer was serviceable, but the glide path was unserviceable. Flight 20 was then radar directed to a position for an ILS approach. The aircraft advised that it was getting an indication of the glide path on its instrument. Approach Control acknowledged this but advised the aircraft to use it with caution. Flight 20 changed to Toronto tower and was provided with the wind and altimeter setting. The aircraft reported by the Yankee Beacon and was cleared to land. The aircraft crashed at approximately 2105 hours.

The Accident

The aircraft struck trees on the approach to runway 10, about 5 350 ft west of the approach end of the runway and on the extended centreline of the runway. The aircraft cut a path through the bush for a distance of 578 ft. The wheels were retracted and power was applied. The aircraft remained airborne and next made contact on the runway, 664 ft short of the east end where propeller slashes were apparent for a distance of 64 ft. The aircraft then skidded on the fuselage for a further distance of about 1 970 ft and came to rest 150 ft north of the extended centreline of the runway. The combined distance from first contact with the trees to where the aircraft came to rest was about 13 920 ft. The first tree was struck at a point 641.3 ft asl and the last tree at 637 ft asl. The approach end of runway 10 is 554.4 ft asl.

The Instrument Landing System

In respect to the runway 10 ILS, a Notice to Airmen, dated 28 January, had been issued which stated that the flight check for runway 10 ILS had not been completed, and it was to be used with caution. Pilots who had used the system during the evening of 10 February, prior to the accident, indicated it was operating normally. The aircraft's ILS receivers were removed, examined, tested and found to be functioning normally.

The ILS system was flight checked with Department of Transport and TCA aircraft following the accident and was found to be within allowable limits. It was brought to the investigators' attention that a TCA captain had experienced glide path deflections on two occasions on 10 February.

It was suggested that a large downward deflection of the glide slope may have existed and would have been a contributing factor to the accident. Extensive tests were conducted on the glide slope, and there was no evidence to support the suggestion that the glad slope was in any way abnormal at the time of the accident.

Altimeters and Barometric Pressure

The aircraft's altimeters were found to be normal when examined in the aircraft and were within limits when removed, calibrated and tested for leaks.

The pitot static system was tested after the altimeters were removed and found to be serviceable and free from leaks. Statements by the technicians who removed the instruments, indicate that the connexions were tight prior to the removal of the instruments.

The station barometer was tested and found to be functioning normally with an insignificant change since its previous testing.

There was a consistent +.02 "Hg difference between the station barometer and the Air Traffic Control altimeter setting indicators but the duty controllers did not apply the correction factor of -.02 "Hg to the altimeter setting which was given to the flight. This would introduce an altimeter error of +20 ft, however, the captain set his altimeter sub-scale to 29.21" Hg which reduced the ultimate error from this source to +10 ft. Granting the maximum possible errors from all sources, the aircraft, if flown at 865 ft (300 ft above the airport height) as indicated, would have been at a true altitude of approximately 796 ft asl and would have cleared the trees by approximately 155 ft.

Statements of the Crew

The first officer states that just prior to the approach to runway 05 when at about 3 000 ft, he noticed his altimeter, airspeed and vertical speed indicators all fluctuate. The vertical speed indicator showed a descent of 300 to 500 ft for about 4 to 5 seconds. He drew this to the captain's attention. The captain had been looking at the wing for ice and did not see the fluctuations but indicated he considered them due to the radar nose with the aircraft in the undercarriage down configuration. At the time, the first officer requested the flight engineer to monitor his airspeed and altimeter indications on the approach. On the approach to runway 10 there were no further erratic instrument indications noted. The first officer states they reported by the Yankee Beacon on final and he considered the descent normal, with the captain holding the localizer course with very little bracketing. He reports they were using company minima, for an inoperative glide path, which are ceiling 300 ft and visibility 3/4 mile. He informed the captain when they were at 965 ft asl, 100 ft above minimum, and again at 865 ft asl. He checked the captain again at 865 ft asl and at that time he had not seen anything outside the aircraft. Something caught his attention, and he saw the snow and trees much too close. He was reaching for the controls when the aircraft struck the trees. He stated that to the best of his knowledge his altimeter read 865 ft asl at that time. He had not seen any lights from the ground and did not see the runway lights until they were over the runway and close to the point of touchdown.

The captain reports they passed the outer marker and while descending he heard the first officer report 100 ft above minimum at 965 ft asl and at minima at 865 ft asl. At about 900 ft he reported he was adding power to hold 865 ft. He noted the first officer made a gesture toward the control column about the same time as

865 ft was called. The captain reports he was still flying on instruments at the time he struck the trees. He saw the approach lights after the impact. The captain states he applied power but did not feel that they were getting sufficient as he did not feel the surge of power or the acceleration he normally associated with full power. He, therefore, made his decision to land rather than attempt to overshoot. In respect to the application of power, the flight engineer states that following the impact they had 2 000 rpm, he selected 2 600 rpm on the master motor but the rpm stayed at 2 000. During the latter stage of the descent and during the approaches, both the captain and first officer considered they were having to use excessive power to hold normal airspeed settings. Following the impact with the trees, the captain reports his airspeed indicator dropped off to zero. This is supported by the fact that a small piece of wood had been driven into the pitot tube.

The crew stated that the lowest altitude observed on their altimeters was 865 ft asl. In this respect, the following points are noted:

a) the aircraft's altimeters were reading correctly on departure from Winnipeg;

b) the last altimeter setting provided to the aircraft was 29.22" Hg; the captain's altimeter was set at 29.21"Hg; the station barometer as reported on the 2100 hour weather report was 29.18"Hg;

c) the pitot static system was found to be serviceable and intact;

d) the aircraft's altimeters were correctly set and reading satisfactorily after the accident - they were calibrated and found to be within limits;

e) expert opinion states there were no unusual conditions that could have produced large pressure changes.

Probable Cause

The aircraft was flown below the approved minimum IFR altitude and struck trees which caused sufficient damage to necessitate an immediate wheels-up landing.

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ICAO Ref: AR/648

No. 23

Fleet Tactical Support Squadron One, U.S. Navy, DC-6, R6D-1, 131582 and Real Aerovías, DC-3, PP-AXD, collided over Guanabara Bay, Brazil, on 25 February 1960. Report released by the Brazilian Air Ministry (SIPAer).

(The Department of the Navy, United States of America, also conducted an investigation into all aspects of the collision. This investigation was accomplished with the full cooperation of the Brazilian Government and Real Airlines. At the request of the Government of the United States, and in view of the conflicting conclusions of the two summaries, the summary of the investigation carried out by the U.S. Department of the Navy is also published in this Digest on page 128.)

Circumstances

The Accident

At approximately 1607 Z on 25 February 1960, Douglas DC-6 aircraft, No. 131582 belonging to the Fleet Tactical Support Squadron One of the United States Navy and Douglas DC-3, PP-AXD, belonging to Consórcio Real Aerovías collided in flight south of Santos Dumont Airport, Rio de Janeiro.

The Flights

The DC-6 took off at 1125 Z from SAEZ (Buenos Aires) for Galeao (SBRJ) and its flight plan was confirmed and approved by ACC of SPBA when overflying Porto Alegre at an altitude of 3 900 m along Green 1 Airway between SBPA (Porto Alegre) and SBGL (Rio de Janeiro/Galeao). In accordance with the standard rules for IFR flight on the airway, it reported its position at 1556 Z at BAGRE, the fix located at the entrance from Green 1 Airway to the SBRJ approach zone to Rio Approach Control. Having received instructions to maintain its heading to NDB IH (Ilha Rasa) descending to 1 500 m, it reached the NDB at 1605 Z when it reported its new position to Rio Approach Control. It received new instructions from Rio Approach Control to arrive at NDB RJ (Santos Dumont Airport) at an altitude of 1 800 m and continue its flight and heading to NDB KX (in Duque de Caxias) descending to 1 500 m. The instructions were repeated by the controller as requested by the pilot of the aircraft. The pilot referred to Rio Approach Control when passing over RJ at 1 800 m at 1607 Z (the last report received from the aircraft).

It is most likely that the indication of position (vertical crossing) given by the radio compass was influenced by the steel cable which stretches between "Pão de Acucar" and the "Urca" Hills (a fact well-known to all pilots who fly in the Rio de Janeiro area, it being marked in the (ICAO) MP-R-134 issued on 19 April 1951.) This was deduced from the brief period of time which had elapsed between leaving NDB IH and the position (false position) of NDB RJ.

DC-3, PP-AXD, took off from SBCP (Campos) at 1510 Z (Santos Dumont-Rio) with a VFR flight plan for Green 1 Airway. When reaching position "Porto das Caixas" (fix located at the entrance from Green 1 Airway to SBRJ approach zone) the pilot, after reporting his position to Rio Centre, reported that he could not continue his visual flight, (he then flew at 1 650 m), and was authorized to change to Rio Approach Control Frequency for instructions. He was told to maintain 1 800 m until RJ position and thereafter was authorized by Rio Approach Control, at 1605 Z, to descend to 1 500 m where he could carry out the Victor Procedure, the procedure used for approach to Rio Airport.

After confirmation of the position, the DC-3, while descending and carrying out the standard 180° turn to the left, was hit on its right side in an upward direction by the U. S. Navy DC-6.

Weather Conditions in Rio APZ (Approach Zone)

When checking the weather prevailing on the day of the accident and weather conditions reported in the Weather Bulletin, it was concluded that on 21 February, between 1400 Z and 1700 Z, the SBRJ area weather was as follows: total covering of medium clouds, altostratus prevailing with their respective bases in altitudes of 2 400 to 3 000 m. Variable covering of 4 to 6 eighths of low clouds, predominantly stratocumulus whose bases were located at altitudes of 150 to 700 m. Precipitation such as light rain and intermittent drizzle - but this does not include the subject area. Visibility was reduced, mainly in the area where drizzle and damp fog existed, down to 2 000 m. The least affected was the Santos Dumont Airport Area. Surface winds blew predominantly from the sector 180 to 200° with speeds varying from 4 to 10 knots.

Investigation

The examination of the wreckage did not provide any clues as to technical failure. Due to the destruction of the aircraft because of the collision and the subsequent fall into the sea and to the ground, it was not possible to examine all parts as they could not be found.

In the light of the various hypotheses advanced, the most acceptable altitude at which the impact occurred was between 1 550 and 1 650 m - for the following reasons.

After reaching the position NDB RJ at 1 700 m, the DC-3, which had been authorized to continue descending, did so for approximately one minute until the collision. Taking into consideration its rate of descent of 150 m/min, we should deduct 150 m from 1 700 m and we would have 1 550 m as the probable altitude of the impact point.

The DC-3 would not have climbed as it was directed to descend to the initial altitude (1 500 m) and continue the Victor Procedure. In view of the fact that the pilot-in-command and the co-pilot knew the English language well, especially the latter as he had flown the international airways, they both should have heard Rio Approach Control's instructions to the American aircraft, directing it to cross NDB RJ at 1 800 m, and it appears logical that they would try to descend to 1 500 m as soon as possible.

The pilots of the American aircraft were unable to understand Rio Approach Control's instructions to PP-AXD as they were given in Portuguese and were, therefore, not aware of the movements to be expected in the traffic area. In view of the fact that their aircraft had been authorized to descend to 1 500 m before reaching the NDB IH, although they had received additional instructions after reporting at the NDB, the pilots could find it proper to descend to the first authorized altitude.

At 1556 Z, the DC-6 crossed the BAGRE position flying at 3 900 m as first authorized. As the contact with Rio Approach Control was only possible at 1558 Z, the time at which the instructions were received, it is likely that this aircraft began descending at 1559 Z in accordance with the squadron's DC-6 procedures. The recommended rate of descent is 300 m/min. If the flight began descending at 1559 Z and the recommended rate of descent was complied with ... 7 minutes elapsed, i. e. at 1606 Z (one minute after crossing NDB IH), a loss of 2 100 m would result which would bring the aircraft to an altitude of 1 800 m. From then on, using the standard rate of descent of 150 m/min, which is recommended for the last 3 300 m preceding the first authorized altitude, the aircraft would reach the impact point one minute later, that is, at 1607 Z close to the DC-3's flight altitude. Taking into account small time errors, altimeter adjustment and other minor errors, we would be able to estimate that the collision occurred at the approximate height of 1 600 m.

The Collision

It is not possible to be sure as to the aircraft sections which collided in view of the fact that neither the fuselage, the engines nor the left wing of the DC-3 were recovered or the important parts of the DC-6. The damage resulted from the impact of the two aircraft, their fall into the sea and further damage resulted when the same wreckage was picked up. On attempting to analyse the damage caused by the mid-air collision, it was deduced that the impact occurred at an angle of 70° between the longitudinal axes of both aircraft. This angle was based on their relative speeds and on the angle of the cut of the DC-3's left wing. Testimony of eyewitnesses, qualified from the aeronautical point of view, tend to support these deductions. It was believed that the DC-6 aircraft's nose hit the forward section of the DC-3's fuselage in an upward direction when the DC-6 was making the standard left turn and damaged the lower side of its left wing (where evidence of propeller blade marks could be found). The DC-3 pilot must not have seen the DC-6 beforehand as its position prevented it. When the DC-6 emerged from a cloud, seeing the DC-3's silhouette right at its nose or a little to the left, there was no time left for evasive action and the collision occurred. It is well-known that the large aircraft's reaction is slow even taking into consideration the fact that it has a highly skilled pilot.

Probable Cause

The accident was attributed to - error of personnel - pilot of the DC-6 - improper piloting procedure when flying on authorized instrument flight. The pilot disobeyed the instructions transmitted by Rio Approach Control.

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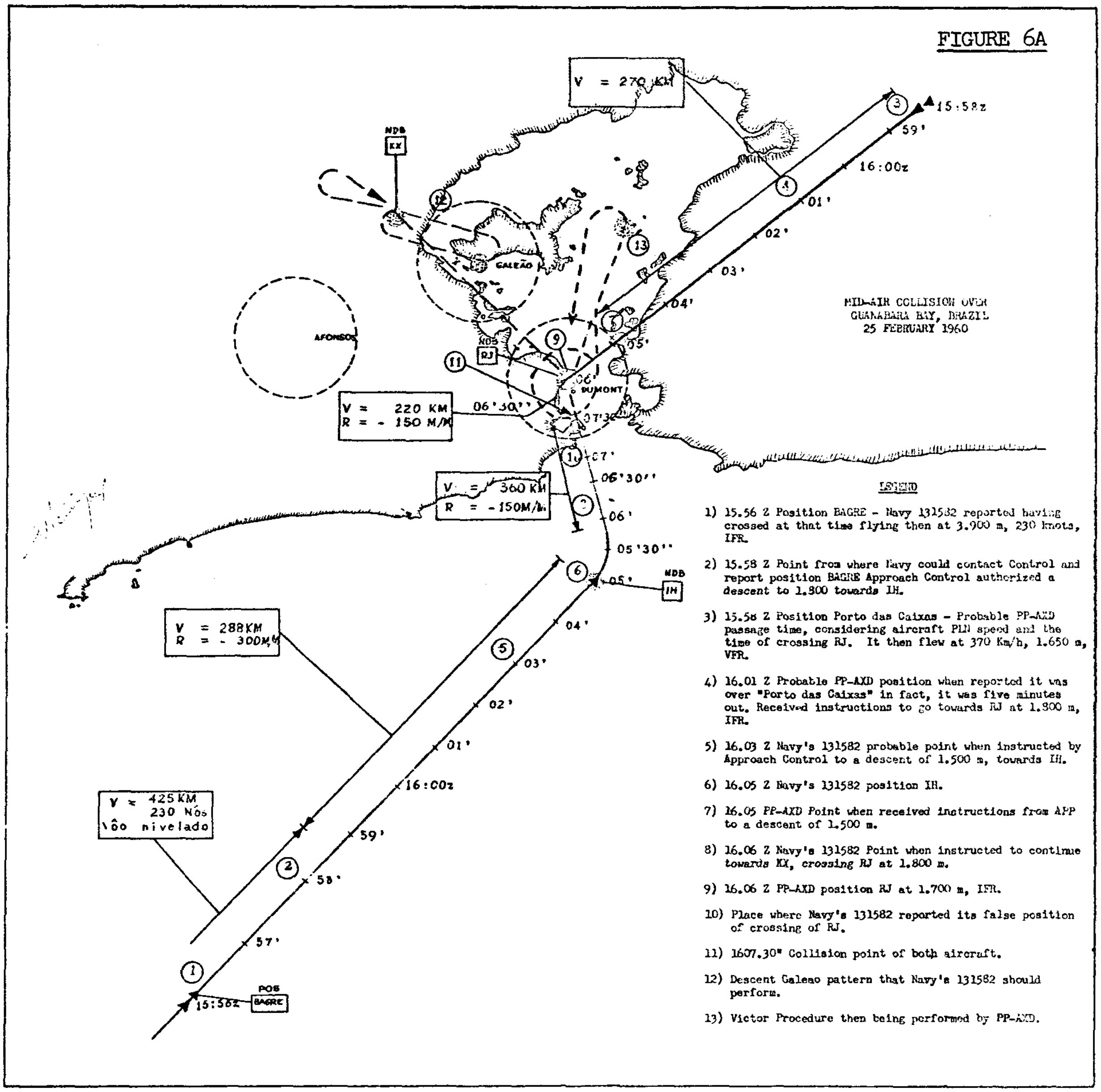
FIGURE 6A
MID-AIR COLLISION OVER
GUANABARA BAY, BRAZIL
25 FEBRUARY 1960
V = 270 KM
15:58z
59'
16:00z
01'
02'
03'
04'
05'
NDB
KX
GALEÃO
AFONSOS
NDB
RJ
DUMONT
V = 220 KM
R = - 150 M/M
06'30''
07'30''
07'
06'30''
06'
05'30''
V = 360 KM
R = - 150M/M
NDB
IH
V = 288KM
R = - 300M/M
V = 425 KM
230 Nós
Vôo nivelado
16:00z
59'
58'
57'
15:56z
POS
BAGRE
LEGEND
1) 15.56 Z Position BAGRE - Navy 131582 reported having crossed at that time flying then at 3.900 m, 230 knots, IFR.
2) 15.58 Z Point from where Navy could contact Control and report position BAGRE Approach Control authorized a descent to 1.800 towards IH.
3) 15.58 Z Position Porto das Caixas - Probable PP-AXD passage time, considering aircraft PLN speed and the time of crossing RJ. It then flew at 370 Km/h, 1.650 m, VFR.
4) 16.01 Z Probable PP-AXD position when reported it was over "Porto das Caixss" in fact, it was five minutes out. Received instructions to go towards RJ at 1.800 m, IFR.
5) 16.03 Z Navy's 131582 probable point when instructed by Approach Control to a descent of 1.500 m, towards IH.
6) 16.05 Z Navy's 131582 position IH.
7) 16.05 PP-AXD Point when received instructions from APP to a descent of 1.500 m.
8) 16.06 Z Navy's 131582 Point when instructed to continue towards KX, crossing RJ at 1.800 m.
9) 16.06 Z PP-AXD position RJ at 1.700 m, IFR.
10) Place where Navy's 131582 reported its false position of crossing of RJ.
11) 1607.30" Collision point of both aircraft.
12) Descent Galeao pattern that Navy's 131582 should perform.
13) Victor Procedure then being performed by PP-AX̃D.

Summary of the Investigation by the Department of the Navy, United States of America, into the cause of the collision of a U. S. Navy passenger plane and a Brazilian commercial airliner over Rio de Janeiro, Brazil, on February 25, 1960.

On February 25, 1960, at about 1:07 p.m., local Rio de Janeiro, Brazil time, a U.S. Navy R6D (four engine) transport aircraft and a Brazilian commercial DC3 (two engine) aircraft operated by REAL Aerovías Nacional collided in mid-air over Sugar Loaf Mountain, Rio de Janeiro. The accident took the lives of all twenty-six persons on board the Brazilian plane and all but three of the thirty-eight persons on board the Navy aircraft. All persons in the Navy plane were Navy military personnel in a duty status. According to medical authorities, death was instantaneous in practically all cases. The individuals who survived the disaster suffered only minor injuries.

The Department of the Navy's investigation included examination and analysis of available portions of the wreckage by qualified technicians; study of the flight, upkeep and overhaul history of the planes and their engines; examination of the qualifications, experience, and health of the pilots; collection of all weather data available and an analysis of the effects it might have had on the flight of the planes; study of the equipment, or lack thereof, available to assist pilots flying in the area; examination of the pertinent flight instructions and practices; and questioning of every person who might possibly be able to provide any information.

Facts Ascertained

The investigation revealed the following facts:

a. The planes - Maintenance logs show that the Navy R6D had been properly maintained, overhauled and checked in all respects. Similar information provided by Brazilian authorities established the same for the DC3. Brazilian and U.S. authorities collected all available parts of the wrecked planes. Each part recovered was studied and analyzed by experts. There was no indication of any material defect or malfunction.

b. The pilots - The pilot and co-pilot of the Navy plane were qualified, mature, and experienced R6D aviators without a blemish on their safety records. The pilot had made one prior landing during the previous year at the same airport (there are two main airports at Rio de Janeiro) the Navy plane was approaching at the time of the collision. The co-pilot had flown in and out of both airports at Rio de Janeiro several times during March 1959 and had made nine landings at the airport being approached by the Navy plane at the time of the accident. Both pilots were in excellent physical and mental health.

The pilot of the Brazilian plane was a qualified, mature and experienced aviator. He had over 7,622 flight hours, most of which were in the DC3 type aircraft. As a first pilot, he had 2,807.30 hours all of which were in DC3s. He possessed an Instrument Flight Rules Card valid until July 16, 1960.

c. Weather - At the Santos Dumont Airport, which was controlling the approaches of the planes and located about 2.4 miles north of the point of impact, the wind was from the southwest with a force of 5 knots. Visibility along the earth's surface under 700 meters (2,296 feet) was about 12.4 miles. At the ceiling of 700 meters (2,296 feet) the sky was about five-eights filled with large balls or rolls of rather dark cloud (strato-cumulus). At about 3,000 meters (9,840 feet) the sky was entirely filled with heavy and dark haze (alto-stratus). The temperature was about 75 degrees Fahrenheit.

There was no indication that the weather was a factor contributing to the accident other than that it made it necessary for the planes to approach in accordance with Instrument Flight Rules rather than Visual Flight Rules.

d. The airports - Rio de Janeiro has a great deal of air traffic, domestic and international, which results in considerable congestion in the air. There are two main airports. Santos Dumont Airport is the terminus for most local, intra-Brazil flights to and from Rio de Janeiro, and is located close to the heart of the city on a peninsula jutting out from the western shore of the harbor, a short distance north of Sugar Loaf Mountain. The approach control center for the Rio de Janeiro area is located at this airport. The other airport is the Galeao International Airport which is located on the outskirts of the city, about seven miles northwest of Santos Dumont. It is the terminus for international flights. The traffic control plan in effect at the time required planes from the south landing at Galeao (as was the Navy plane in this case), to fly over Santos Dumont and then proceed to Galeao. Planes from the northeast landing at Santos Dumont (as was the Brazilian plane), were required to cross the route of Galeao bound planes from the south over Santos Dumont, and to recross it south of Santos Dumont as they circled for landing.

e. Aircraft control including navigational aids - At the time in question, aircraft control and approaches to the airports for landing at Rio de Janeiro depended entirely on non-directional radio beacons and voice instructions by an air controller, except for one low frequency radio range. There was no surveillance radar or precision approach system, either of the Instrument Landing System (ILS) type or the Ground Controlled Approach (GCA) type.

Languages used in voice communications between a controller and aircraft were in accordance with the provisions of the International Civil Aviation Organization; Portuguese was used by Portuguese-speaking pilots, otherwise English, which has been established as the international aviation language. Controllers at international airports and for approaches thereto, were required to be able to give instructions to and receive transmissions from aircraft in English as well as Portuguese. At times English spoken by the controllers was difficult to understand, and controllers had difficulty understanding English-speaking pilots, especially when other than standard phrases were used. There were no devices to record what was transmitted or received by the controller.

In this instance all instructions given to the Brazilian aircraft were in Portuguese and those given to the Navy plane were in English. The same voice radio channel was used. The same controller acted in each transmission involved. He was qualified as a senior controller under standards set by the Brazilian Air Ministry. He had thirteen years of experience in air control work including two years and eight months at Santos Dumont Airport, during which he controlled United States aircraft on many occasions.

The radio beacons pertinent to the instant inquiry are designated RJ, IH, and KX. RJ is located at the Santos Dumont Airport. IH is located on a small island named Ilha Rasa nine miles south of Santos Dumont Airport. Sugar Loaf Mountain is situated in between these two beacons. Beacon KX is eleven miles northwest of RJ (Santos Dumont) in the vicinity of the Galeao Airport. All beacons were functioning properly. Nothing was presented to the investigation which indicated that any failure of ground equipment to perform as designed, or that a lack of information on the part of the pilots regarding proper approach procedures or geography of the area, contributed to the accident.

Events leading up to the Collision

The Navy aircraft was concluding a flight from Buenos Aires, Argentina, to Galeao International Airport following an appropriate established airway. Its flight plan called for Instrument Flights Rules flying at an altitude of 3900 meters

(12,792 feet) at 230 knots. Applicable approach instructions for flights from the south to Galeao Airport required aircraft to approach Rio de Janeiro almost directly from the south passing over radio beacon IH (Ilha Rasa), then northerly nine miles to radio beacon RJ (Santos Dumont Airport), and to continue northwesterly eleven miles to KX radio beacon for landing at Galeao. The Brazilian plane was concluding a flight from Campos, Brazil, which is northeast of Rio de Janeiro, and its destination was the Santos Dumont Airport. Its flight plan called for Visual Flight Rules at a speed of 146 knots. The applicable approach instructions for flights from the northeast to Santos Dumont Airport required aircraft to pass over the town of Porto das Caixas twenty miles northeast of Santos Dumont Airport, then to proceed southwest of the same radio beacon (RJ) at Santos Dumont Airport as flights from the south would pass over, and then to land at Santos Dumont.

The evidence concerning the approaches of the two planes consisted mainly of statements made by the controller and portions of a typed communication record recovered from the Navy plane. Although conflicting in some minor details, it substantially establishes the following course of events.

At about 12:56 p.m., local Rio de Janeiro time, the Navy plane reported to the controller at the Santos Dumont Airport that it was cruising at an altitude of 3900 meters (12,792 feet) on Instrument Flight Rules and estimated it would arrive over radio beacon IH (Ilha Rasa) at 1:03 p.m. The controller acknowledged receipt of the call and instructed the Navy plane to descend to 1800 meters (5,904 feet) and to report when over the IH (Ilha Rasa) beacon. Shortly thereafter the controller instructed the Navy plane to descend to 1500 meters (4,920 feet) over beacon IH (Ilha Rasa). Receipt of this communication was acknowledged by the Navy aircraft. At about 1:02 p.m., the Brazilian plane reported to the controller that it had passed over Porto das Caixas a minute earlier and that it was no longer able to proceed according to Visual Flight Rules. It requested instructions, but it did not give its exact position or its current altitude. The controller replied specifying that the aircraft should proceed to radio beacon RJ (Santos Dumont) at 1800 meters (5,904 feet). These instructions were given without requesting the plane's exact position, altitude, speed, or estimated time of arrival at any point. Approximately a minute later, the controller asked the Navy plane for its altitude and received the reply that it was then passing a an altitude of 2550 meters (8,364 feet). The receipt of this information was acknowledged by the controller at about 1:04 p.m. Within the next minute, the Navy plane requested clearance to proceed beyond radio beacon IH (Ilha Rasa). The controller immediately cleared the Navy plane to descend to 1500 meters (4,920 feet) and instructed it to notify the controller when it passed over radio beacon IH (Ilha Rasa); when it reached radio beacon KX; and when it passed 1800 meters (5,904). At about 1:05 p.m. the Navy aircraft reported to the controller that it was then over radio beacon IH (Ilha Rasa) and that he would report again when over radio beacon KX and when passing 1800 meters (5,904 feet) in his descent.

At this time, about 1:05 p.m., the evidence appeared clear that both planes were converging on the same point -- radio beacon RJ over the Santos Dumont Airport -- the civilian plane from the northeast and the Navy plane from the south. The civilian plane was approximately four minutes beyond Porto das Caixas toward RJ (Santos Dumont) proceeding from an unknown altitude which was probably lower than 1800 meters (5,904 feet) because it had been recently flying according to Visual Flight Rules and the weather conditions existing at the time and place would not encourage flight at a higher level while proceeding under those Rules. It was to arrive at RJ (Santos Dumont) at 1800 meters (5,904 feet). The Navy plane was at radio beacon IH (Ilha Rasa), nine miles south of RJ (Santos Dumont) descending from an altitude which was lower than 2550 meters (8,364 feet) and higher than 1800 meters (5,904 feet). It was to arrive at RJ (Santos Dumont) at an altitude of 1500 meters (4,920 feet). The pilot was fully cognizant of the fact that he was to report to the controller when he descended below 1800 meters (5,904 feet). According to the testimony of aviators who were familiar with the matter, the commercial plane was probably proceeding at a speed of about 125 knots and the Navy plane probably at between 140 and 150 knots. The closing speed thus would be about five miles per minute.

Believing that the Navy plane was then considerably higher than the Brazilian plane and descending to comply with the instructions to arrive at 1500 meters (4,920 feet) while the Brazilian plane was climbing to comply with the instructions to approach at 1800 meters (5,904 feet) which would ultimately place the Brazilian plane at an altitude higher than the Navy plane, the controller decided matters would be facilitated if the instructions were changed to reverse the situation. By such change, the Navy plane would remain higher and the Brazilian plane would not have to climb more than to 1500 meters (4,920 feet). The evidence as to what instructions the controller gave to effect this change, of necessity, consists almost entirely of the controller's own account of what transpired as presented in statements made by him shortly after the accident and testimony before the investigative body.

The Collision

Outlined chronologically, the following developments rapidly produced results culminating in the accident. The times indicated are calculated to the nearest minute.

1:06 p.m. Controller directed DC3 to proceed to Rio de Janeiro at 1500 meters (4,920 feet), and without waiting for an acknowledgement immediately attempted to deliver new instructions to the R6D: "to proceed to KX, passing RJ at 1800 meters, then descending to 1500 meters and 1200 meters, to call 'overhead station KX.' "

The R6D requested a repeat of the instructions which were repeated twice (a total of three times). The R6D made at least three transmissions during this exchange.

At this time a third aircraft exchanged communications with the controller.

1:07 p.m. DC3 reported that at 1:06 p.m. he had passed over RJ (Santos Dumont) descending from 1700 meters (5,576 feet) to 1500 meters (4,920 feet).

Controller immediately cleared the DC3, upon reaching 1500 meters (4,920 feet), to make a standard approach pattern involving a left turn bringing it across the route of the northbound R6D.

/The controller stated that at this point there was a transmission from the R6D which he understood to be to the effect that the R6D was passing RJ (Santos Dumont) at 1800 meters (5,904 feet). It appears that either the controller's statement, or the transmission, was in error for the R6D would not have been due over RJ (Santos Dumont) for at least another minute. If a transmission occurred it was probably an attempt to verify the last clearance which contained similar words./

1:07 1/2 p.m. The two aircraft collided over Sugar Loaf Mountain, about two and one-half miles south of RJ (Santos Dumont) on the route and at the distance along it that the R6D should have been, en route to RJ (Santos

Dumont), and at an altitude between 1500 and 1800 meters (between 4,920 and 5,904 feet). Clouds prevented each pilot from seeing the other aircraft. The aircraft collided at an angle of ninety degrees while the DC3 was on an easterly heading and the R6D on a northerly heading.

The right wing of the Brazilian plane was severed and the wreckage fell into the bay a short distance southeast of Sugar Loaf Mountain. The tail of the Navy plane was severed from the fuselage and the wreckage fell into the bay a short distance north of Sugar Loaf Mountain. The three survivors were seated in the tail section of the Navy plane. They were facing toward the rear since all the passenger seats of the plane faced in that direction. At the time of the accident, they had their seat belts fastened in accordance with the instructions of the light sign in the plane which had come on a short time prior to the collision. The tail section fell in an oscillating motion, like a falling leaf, and struck the water with the survivors' backs to the water. The rescue operations of the Brazilian authorities were instantly put into effect and as a result of the competency thereof the survivors were quickly located and afforded medical care.

Recapitulation

There was difficulty in communicating the intent of the controller that the R6D not go below 1800 meters (5,904 feet) until after passing RJ (Santos Dumont), particularly in view of the several changes in altitudes directed. There is doubt that the intent of the controller was ever properly understood by the R6D pilot. The controller assumed that the change could be understood and acted upon before the R6D descended past 1800 meters (5,904 feet). Congested communications and the short period of time available, coupled with the language problem, compounded an emergency situation unknown to both aircraft and not adequately appreciated by the controller.

Even if the R6D finally understood the 1800 meter (5,904 feet) clearance, it had descended through this altitude and had not been able to retain it prior to the collision.

The DC3 was somewhat higher than its assigned altitude.

Conclusions

The accident cannot be attributed to either of the aircraft involved, the manner in which either was operated, or to any significant actions or errors of the crews. The roles of the language problem, the lack of modern air navigation and control aids, and the methods of aircraft traffic control used at Rio de Janeiro, although extremely material, do not attain the status of immediate causes of the accident according to the evidence adduced. Had these matters been different, in one or more respects favorable to greater air safety, this accident might have been avoided. These problems were, however, common to the flights of all aircraft in the area and were well known by the pilots and controller to exist.

It is evident that uncertainty on the part of the controller as to the original position of the DC3; his underestimation of the time factors, including aircraft reaction time; and his lack of appreciation of the communications difficulties and the increasing seriousness of the situation, combined to create the conditions which led to the collision.

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No. 24

Alitalia, DC-7C, I-DUVO, accident at Shannon Airport, Ireland on 26 February 1960. Findings of the Inspector of Accidents, following his investigation into the cause of the accident, as released by the Minister for Transport and Power, Ireland, November 1961.

Circumstances

The flight on the Rome-Shannon-New York route was being made under the supervision of a check pilot. Aboard were 12 crew and 40 passengers. The aircraft crashed immediately following the take-off from Shannon on the Shannon-New York segment of the trip and was completely destroyed by impact and subsequent explosion and fire. One steward and seventeen passengers survived the accident.

Investigation and Evidence

The aircraft was duly certificated and had been properly maintained. It was within the permissible limits of weight and balance and was properly loaded and fuelled for the proposed flight.

The captain had considerable experience in the DC-6B aeroplane but was still under supervision when flying the DC-7C. This flight was being made under a check pilot's supervision.

The co-pilot, check pilot, check navigator and first officer were all fully experienced on DC-7C aeroplanes.

It was not possible to say which pilot was in the co-pilot's seat at take-off, but the recorded voice which spoke on the R/T was recognized as that of the first officer.

The Flight

Preparations for the flight had been satisfactorily completed.

The weather at Shannon at this time was clear but dark and partially overcast.

The take-off from runway 05 was normal except that the ground roll was probably slightly prolonged. The landing gear was retracted normally. A turn to the left was begun very shortly after gear retraction when the aircraft had climbed to about 165 ft. Power was reduced from take-off power to alternate climb power (2 080 BHP) shortly after the turn had been initiated. The flaps, which had been at either 20^{o} or 10^{o} initially, were not fully retracted prior to power reduction. Following power reduction, the aircraft accelerated instead of climbing and lost height while still turning. The landing lights were on during the flight. The aircraft struck the ground while still in a left turn - the point of impact being 65 ft amsl. The left wing tip made the initial contact. The left propellers (Nos. 1 and 2) and left wing struck the stone wall and grave stones of Clonloghan Church. The tips of No. 3 propeller first struck the wall and then made cuts in the turf. The speed of the aircraft at impact was of the order of 170 - 180 kt.

Results of the Technical Examination

No defect was found in the engines or propellers which might have been present prior to the impact. Nor was any defect found in the airframe or its systems or controls, the existence of which, prior to impact, might have caused the turn or loss of height. Two defects which might have been present before impact were found in the flight instruments. Of these, one found in the captain's rate of climb indicator might have had a significant bearing on the cause of the accident if it had occurred or been present during the flight prior to impact.

Other Possible Causes of the Accident

The evidence did not preclude the occurrence of some incident which caused the flight crew to initiate, either intentionally or inadvertently, a turn to the left.

The occurrence of such an incident, which might have been the observation of an incorrect indication on the captain's rate of climb indicator, or the incorrect setting of the flight director or some other matter not considered by the investigation due to absence of evidence, could have caused a distraction at a critical moment in the flight during which the acceleration and loss of height of the aircraft could have occurred. However, if it did, it is not considered likely to have been the sole cause of the accident.

Simple sensory illusion of the pilot during the acceleration and take-off of the aircraft could have occurred but, if it did, it also was not considered likely to have been the sole cause of the accident.

Probable Cause

No definite evidence leading to a particular reason for this accident was revealed by the investigation. It can only be concluded that the aeroplane lost height in a turn shortly after take-off and struck the ground.

A probable cause for this occurrence was not determinable from the evidence available.

Among the several possibilities examined, none warranted the status of probability.

The report stated that, since all the available evidence was carefully examined and assessed, it was considered that, unless further evidence should come to light which would warrant such a course, no useful purpose would be served by the holding of a public inquiry under the Accident Investigation Regulations.

Accordingly, the Inspector recommended that a public inquiry should not be held. The Minister, having considered the Inspector's Report, accepted this recommendation.

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ICAO Ref: AIG/ACC/REP/GEN/No. 12 - Ireland

No. 25

BOAC, de Havilland Comet 4, G-APDS, made an emergency landing at Barajas Airport, Madrid, on 14 March 1960 after it had hit a hill and lost the wheels of its main landing gear. Report, dated November 1960, released by the Director General of Civil Aviation, Spain.

Circumstances

During the approach to Barajas Airport the aircraft hit the "Pico del Guarda" in the municipal district of Paracuellos de Jarama and lost the wheels of its main landing gear. After impact the pilot requested an emergency landing, maintained the aircraft in flight over the aerodrome for about 13 minutes and at 2056 GMT landed it on runway 33. The fire trucks reached the scene of the accident immediately and blanketed the aircraft with foam. Of the 9 crew and 23 passengers on the aircraft, none was injured.

Investigation and Evidence

The Aircraft

It had a Certificate of Airworthiness valid until 12 August 1960, and had flown 1 858 hours, of which 80 had been since its last overhaul.

The Crew

The pilot's licence was valid to 21 May 1960. He had flown 693 hours on Comet 4 aircraft.

The co-pilot had flown 283 hours on Comet 4's, and the engineer and navigator had flown 663 and 291 hours respectively on them.

The Flight

The flight was a scheduled passenger flight from London to Santiago de Chile via Madrid, Dakar, Recife, São Paulo and Buenos Aires. It was routine until the final approach to Barajas. The pilot was cleared to approach direct from Torrejón (over which he was flying) to runway 23 at Barajas.

During the descent to runway 23 and slightly tilted to the left, the lower portions of the aircraft hit the surface of a ploughed field near the top of the Paracuellos Hills. The violent impact occurred between the surface and the main landing gear, the left wing tip, the nose wheel and other elements, breaking off parts which lay both close to the point of impact and at a considerable distance. The pilot then abandoned the attempt to touch down, flew over runway 23 and requested an emergency landing on runway 33.

An ILS approach was then initiated. Although considerably damaged, (engines Nos. 2 and 3 were almost completely inoperative), the aircraft was able to continue in flight and carried out various manoeuvres for about 13 minutes prior to landing. All that remained for the landing gear was the nose wheel and two stumps. The pilot made a perfect touchdown on runway 33 and only at the end of the run did the aircraft slew around to an angle of 90°, half off the runway and resting on one wing.

Damage to the Aircraft

The damage was as follows:

exhaust nozzles of the left wing engines were completely destroyed in their upper portion;

left flap scored on upper portion and outside middle, to the point of unserviceability; the rest was completely torn off;

fairing of left wing tip and navigation light housing damaged;

near left wing fuel tank torn off at the level of the leading edge;

left landing gear strut completely broken off at wing level;

right strut broken off 1.5 m below the wing;

lower fairing of right inboard engine broken away and practically unserviceable;

right flap partly torn loose;

slight dents in tail (lower fairing) and in the fuselage, 2 m behind the trailing edge of the wings, at their juncture with the body.

Probable Cause

While approaching the airport the aircraft was flown at an altitude lower than the spot height indicating the position of the Paracuellos Hills.

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ICAO Ref: AR/658

No. 26

Northwest Airlines, Inc., Lockheed Electra, L-188C, N 121US, accident near Cannelton, Indiana on 17 March 1960. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 1-0003, released 28 April 1961.

Circumstances

Flight 710 was scheduled between Minneapolis, Minnesota and Miami, Florida with an intermediate stop at Midway Airport, Chicago, Illinois. It departed Chicago at 1438 hours central standard time and was to cruise at 18 000 ft. All reporting points were made on time, and the flight was progressing according to plan. No difficulties were reported. At 1525 hours, following failure of the right wing the aircraft crashed about 6 miles from Cannelton, Indiana, killing all 63 persons aboard (i. e. 6 crew and 57 passengers).

Investigation and Evidence

The Aircraft

The aircraft had a total flying time since manufacture of 1 786 hours. The last major inspection was accomplished on 9 March 1960, 75 hours prior to the accident.

Review of the maintenance records of N 121US disclosed only one item that appeared of possible significance to the accident investigation. This pertained to a refuelling incident in which No. 3 fuel tank developed a leak at a nacelle wing fairing attachment crew location. The leak was attributed by Northwest Airlines personnel to rupture of the tank sealant by an excessively long screw. Although subsequent investigation disclosed that the tank had been overfilled, detailed study of the right wing wreckage, disclosed no structural damage or deformations due to overpressurization of the tank. A review of all other Northwest Airlines records pertinent to the airworthiness of this airplane disclosed nothing of significance.

Original Certification of the L-188

Application for type certification of the Lockheed Aircraft L-188 was made on 11 November 1955 with the result that the applicable airworthiness regulations were contained in Part 4b of the Civil Air Regulations effective 31 December 1953 and Amendments 4b-1 and 4b-2 of that Part.

In addition to the specific requirements contained in Part 4b, Section 4b. 10 of that Part states that an airplane shall be eligible for type certification if it complies with the airworthiness provisions established by the Part or if the Administrator finds that the provisions not complied with are compensated for by other factors which provide an equivalent level of safety. This section also requires the Administrator to make a finding that no feature or characteristic of the airplane would render it unsafe for the transport category.

Since the turbine-powered airplanes, at the time of this application, were still in the design stages, the Civil Air Regulations did not encompass airworthiness requirements specifically applicable to the unique design of these airplanes. Accordingly, the Civil Aeronautics Administration developed a set of special conditions to be applicable to this airplane type. The special conditions were developed through the activities of a Turbine-Powered Transport Evaluation Team composed of employees of the Civil Aeronautics Administration. During the certification process numerous amendments were made to Part 4b of the Civil Air Regulations which included many of the applicable special conditions to the

L-188. On 23 July 1957, the Civil Aeronautics Board adopted Special Civil Air Regulation No. SR-422, which became effective on 27 August 1957. This special regulation contained a revised set of performance requirements for turbine-powered airplanes and made applicable the provisions of Part 4b of the Civil Air Regulations effective on the date of application for type certification together with such provisions of all subsequent amendments to Part 4b, in effect prior to 27 August 1957, as the Administrator of Civil Aeronautics finds necessary to ensure that the level of safety of such airplanes is equivalent to that generally intended by Part 4b.

In view of Special Civil Air Regulation No. SR-422, the Civil Aeronautics Administration amended the set of special conditions applicable to the Lockheed L-188 to incorporate those provisions of Part 4b in Amendments 4b-3, 4b-4 and 4b-6 which were comparable to those specific special conditions previously established by the Administrator, as well as the performance requirements contained in SR-422. Those special conditions which were not incorporated in the aforementioned amendments were retained.

In order to monitor and approve the type certification of aircraft the Civil Aeronautics Administration established Regional Offices throughout the United States. In the case of the Lockheed L-188, Region IV was responsible for determining that the airplane type complied with the Civil Air Regulations and the applicable special conditions. For many years the Civil Aeronautics Administration has utilized a designee system to assure compliance with the Civil Air Regulations. The establishment of this system was due to the limited number of personnel available in the CAA's field offices. Under this system designated employees of the applicant are delegated to approve certain data, drawings, etc. The approval of the basic data and method of analysis was retained by the Civil Aeronautics Administration, but the actual analysis of the data was approved by the designees and reviewed by the Administrator. The only area of the certification process where designees are used quite sparingly is in the flight test area. In almost all cases the flight tests were conducted by Civil Aeronautics Administration employees.

On 22 August 1958 the Civil Aeronautics Administration issued type certificate No. 4A22 approving the Lockheed L-188A-08, and L-188C type airplanes.

Major Structural Difficulties Encountered after Certification

Subsequent to the delivery of the first few airplanes, Lockheed Aircraft conducted a flight test to determine the characteristics of a mechanical disconnect for the flight control boost system at the design dive speed of 405 kt. This flight test was conducted on 31 October 1959 and consisted of diving the airplane from cruise altitude with various boosters disconnected. On the second dive, with the speed maintained at or slightly below the speed for limit mach number, turbulence was encountered; the speed was dropped off 6 to 8 kt. After passing through the turbulence a fuel leak was observed from under the right wing. Ground inspection disclosed that the main damage was halfway between Nos. 3 and 4 engines. This consisted of some rivets with missing heads from which fuel was leaking; in addition, there was a shallow buckle near the rear beam just inboard of the No. 4 nacelle. The nature of the wing damage and subsequent inflight measurements indicated that the failure was due to high wing torsions.

As a result of this difficulty, the airplanes already delivered were speed restricted until a fix could be designed and installed. The resulting fix consisted of reinforcing the wing between the inboard and outboard nacelles.

During the original certification of the Electra the airplane was equipped with Allison engines and Aeroproducts propellers. Certification included a vibratory stress survey of the propellers. It was determined, based on past experience, that the inboard propellers were the more critical and only the inboard propellers were instrumented. Later a Hamilton Standard propeller was installed on the airplane and a new certification was sought. At this time it was decided to conduct the vibratory stress survey on one outboard and one inboard propeller. As a result of this test it was found that the outboard propellers were more highly stressed than the inboard propellers and that these stresses exceeded acceptable levels. This condition was caused by a higher than anticipated inflow angle due to a downward torsional bending of the wing with increasing speed. Outboard propeller blade stresses were reduced satisfactorily by reworking the nacelles to provide a 3^{o} uptilt of the propeller plane. Inboard nacelles were similarly modified to reduce cabin noises and vibrations.

Difficulty was encountered on the Electra airplanes with impact stresses during landing which caused cracks in the milled wing skin both outboard and inboard of the inboard nacelles and loosening of the fasteners attaching the upper and lower wing panels to the main landing gear ribs. As a result, Lockheed issued Service Bulletins 306 and 337 which required the installation of a doubler outboard and inboard of each inboard nacelle on the upper wing surface respectively.

In addition, difficulty has resulted from overpressurization of the fuel system. In one case where foreign material was in the fuel manifold system the fuel inlet valve was held in the open position after the tank was filled. Consequently, structural deformation of the wing resulted and an inspection of all fuel manifolds was conducted. Lockheed believes that if the correct procedures are followed during the refuelling operation such failures will not occur.

The Flight of 17 March 1960

Prior to departure from Minneapolis the crew was briefed by the company meteorologist on the present and expected weather conditions along the route. This briefing consisted of a general discussion of the synoptic situation, a review of the en route and terminal forecasts, together with all sequence and pilot reports. The meteorologist said that thunderstorms which were located in Florida were discussed as was the intensity of the jet stream over the southeastern States, the latter because it appeared to be growing in intensity. No mention was made, however, of any clear air turbulence being present along the route.

The trip to Chicago was routine. Some of the passengers said the landing at Chicago was very hard, others said it was normal.

At Chicago the captain reviewed the latest weather information pertaining to the flight.

The flight plan prepared by the crew and filed with company operations, indicated a flight from Midway Airport via Peotone, Illinois; Scotland, Indiana; Chattanooga, Tennessee; Atlanta, Georgia; Albany, Georgia; Cross City, Florida; Fort Myers, Florida; to Miami, Florida; a cruising altitude of 18 000 ft, a true airspeed of 337 kt, and an estimated time en route of 3 hours 37 minutes. The clearance given the flight by Air Route Traffic Control was, "NW 710 cleared to the Miami Airport, Peotone, Victor 171 to Scotland, flight planned route, maintain 18 000."

At take-off the gross weight of the aircraft was 107 661 lb (within the maximum allowable limitation of 110 590 lb for the segment to be flown). The centre of gravity was within prescribed limits.

The flight departed Chicago at 1438 hours. At 1445 it reported to the Indianapolis, Indiana, ARTC Centre over Milford, Illinois, at 18 000 ft and estimating Scotland, Indiana at 1512. At 1513 it reported over Scotland maintaining 18 000 ft and estimating Bowling Green, Kentucky at 1535. At this time the flight was advised by ARTC to contact the Memphis, Tennessee, ARTC

Centre on 124. 6 Mc/s at 1530. The 1513 contact was the last known radio communication with the flight.

Witnesses

Approximately 75 groundwitnesses who were near the accident scene and a number of airmen who were flying aircraft in the area at the time were interviewed.

The laywitnesses were located within an area that included the most distant places from which the aircraft could be seen or the aerial explosion heard by a person having normal vision and hearing.

A description of what the laywitnesses saw and heard follows: The time was 1515 hours. The weather was clear except for scattered cumulus clouds with bases at about 4 000 ft; visibility was good. The aircraft was flying in an approximate north to south direction, in level flight, and at a high altitude. Suddenly two puffs of white smoke were seen. Seconds later the these were followed by a large cloud of dark smoke. Two loud explosions were then heard and a large object was seen to emerge from the smoke cloud and fall nearly vertically, trailing smoke and flame. Smaller objects were later seen to fall. The fuselage continued in level flight for a few seconds and then fell to the ground describing a large trajectory arc as it did so. It struck the ground with such terrific force that debris was thrown nearly 250 ft into the air.

Six U. S. Air Force aircraft were on a refuelling mission in the area at an altitude of 31 000 to 32 000 ft. The airmen aboard these aircraft said that they first saw the smoke trail of this accident at 1532 hours. The cloud was the shape of a child's top, dark in colour as if produced by burning some product with a petroleum base. The bottom of this smoke disappeared into scattered clouds. A horizontal streamer of dark smoke which began a considerable distance north terminated at the smoke cloud.

The smoke cloud was first sighted when they were 26 NM north-northwest of it. Their bearing of approximately 170° nearly paralleled the course of Flight 710. They passed abeam of the smoke cloud at 1539, at which time they were about 12 NM west of it.

During the seven minute period, from first sighting the smoke to the abeam check, the smoke cloud and streamer retained its original form with little or no indication of dissipating or breaking up. The USAF airmen estimated the smoke cloud to be at an altitude of 25 000 ft.

Weather

The synoptic situation as reported on the surface weather chart for the mid-afternoon of 17 March 1960 was as follows: A low pressure area was centred over the northern portion of the lower peninsula of Michigan. This low pressure area extended to high levels (above 30 000 ft). A marked troughline at all altitudes extended southward from this low along the Illinois-Indiana border. A ridge of high pressure extended from the southern plains northeastward across Arkansas, western Tennessee, central Kentucky, and into southern Ohio.

The written forecasts published by both Northwest Airlines and the United States Weather Bureau and available to the crew of Flight 710 at Minneapolis and Chicago reflected the wind field as shown by the observed data. It is important to note, however, that neither of these sources of weather information mentioned the possibility of clear air turbulence along the route.

Examination of all the meteorological and operational evidence at hand revealed that at 18 000 ft in the vicinity of Cannelton, Indiana, the aircraft concerned was operating in an area devoid of clouds with the following significant meteorological characteristics:

1) just to the east of a marked trough line;

2) beneath and on the northern edge edge of a jet stream with high velocity southwest-northeast flow (increasing with height) at all levels from the surface to the jet stream;

3) marked horizontal and vertical wind shear;

4) pronounced horizontal thermal gradient and potentially unstable lapse rates.

The above summary is derived from ground-based meteorological observations and a substantial number of pilot weather reports.

The above factors and the magnitude of each clearly indicated that severe clear air turbulence was highly probable at the time and place of the accident. Pilot weather reports of actual clear air turbulence encounters on that date also afforded valuable information substantiating the above conclusion.

After observing and forecasting a wind field embodying widely recognized meteorological factors utilized in the forecasting of clear air turbulence, the Board believed that the responsible offices of the U. S. Weather Bureau and Northwest Airlines should have mentioned clear air turbulence in their forecasts.

Three separate and independent studies of the clear air turbulence situation as it relates to this accident were carried out by agencies other than the CAB (Weather Bureau, New York University, and Meteorology Research, Inc.). The conclusions reached in these studies are in exceptionally good agreement and support the conclusion of the Board's own study as summarized above. As mentioned previously, pilots flying at 31 000 ft observed a horizontal streamer of smoke extending southward to a smoke cloud with corkscrew-shaped base. Considering the characteristics of clear air turbulence as opposed to convective turbulence, it is not difficult to understand the persistence of a relatively well-defined smoke column.

Wreckage Distribution

The major portion of the aircraft struck the ground in a nearly vertical attitude in a field where the ground sloped to the south. Impact forces formed a crater which measured 30 ft across its top from east to west and 40 ft from north to south; it was 12 ft deep. Most of that portion of the aircraft which struck the ground forming this crater disintegrated and was buried within it. The impact explosion hurled small pieces of wreckage in all directions from the crater, the greatest distance being approximately 1 500 ft to the east and southeast. The heaviest concentration of wreckage scattered by the impact explosion was in the southeast quadrant within a radium of 100 ft from the crater.

The south end of the crater contained the No. 2 engine and propeller, parts of the left main gear, and wing structure, including flap pieces, aileron, and trim tab sections. The north end of the crater contained the fuselage structure, cockpit control system, electrical panel bits, various system components, nose gear pieces, elevator torque tubes and rudder post, bits of tail structure, servos, etc. Upon removal of the wreckage from the crater it was apparent that the fuselage with its tail, most of the left wing, and the No. 2 power unit had contacted the ground in an almost vertical nose down position. All structure removed from the crater was found to be severely fragmented from ground impact.

Trajectory Studies

The parts which separated from the aircraft in flight consisted of the complete right wing with power units, the outer end of the left wing and aileron, the No. 1 QEC (quick engine change) and nacelle, and the outboard portion of the left elevator.

Trajectory studies of pieces of the aircraft wreckage indicated possible differences in sequence of separation, particularly in regard to light pieces, depending on assumed variables. However, the studies indicated as most probable that the aircraft was in level flight at an altitude of 18 000 ft, and a true course of 170° at an indicated airspeed of approximately 260 kt during the disintegration. This analysis indicated that the first parts to separate were pieces of the right wing upper surface just outboard of the fuselage and that the power plant and wing disintegrations took place within a period of six to ten seconds. Disregarding calculated results involving light pieces and extremely short differences in items of separation, the trajectory analysis indicated also that separations of the left outboard power unit and the left outer wing structure began almost simultaneously with the right wing separation and that separation of the right outboard power unit began shortly afterward.

Systems

Impact and fire damage to components of the various systems of the aircraft precluded functional testing of the majority of such items. However, detailed inspection of all recovered systems' components, and functional checks of those items still capable of being tested, failed to disclose any evidence of operational distress or indication of malfunctioning of any component or system. The fuel dump valve and chute positions indicated that fuel dumping was not being attempted and the crossfeed valve positions were consistent with normal tank-to-engine fuel utilization procedures. Examination of the control surface boosters failed to show whether the autopilot was in operation or to indicate conclusively whether the boosters were in the "manual" or "boost" configuration.

Power Plant

The investigation revealed no evidence of malfunction or failure that contributed to the cause of the accident. Of the numerous items studied in detail, no one considered alone provided an answer as to the cause of the accident. However, the power plant investigation did provide information that can be correlated with other known facts and circumstances of the accident.

Circumstances of the separation within Nos. 1 and 4 engines are of primary significance and there were indications of similarity. The time interval between separations was very short, as evidenced by the locations where they fell and the trajectory studies with No. 1 separating first.

Obviously abnormal loads were required to bring about these separations since there was a complete lack of evidence of any progressive fatigue failure to the point where separation occurred under normal loadings. Likewise, it is not conceivable that fatigue cracks would start and progress practically simultaneously to failure in two different locations on the two engines. Furthermore, there is no structural failure history of this model engine to suggest such an occurrence.

Aluminum deposits on the thermocouples and turbine inlet guide vanes of Nos. 1 and 4 engines are believed to be significant. Such deposits are expected on turbine engines when the compressor blades contact and machine away aluminum particles while the engine is operating. These deposits on the two outboard engines that separated in the air cannot be accepted as coincidental. It is believed rotational interference, which resulted in the aluminum deposits, was caused by air inlet and compressor case distortion due to abnormal loads being applied through torquemeter housing and struts of these engines. Furthermore, the abnormal loads followed disruption of the engine supporting structure so that loads normally taken out by the Lord mounts and QEC structure were imposed on the engine structure. It follows that the basic engine structure forward of the compressor must have been intact in order to transmit propeller-generated case distorting loads.

A study of the pieces of the No. 1 reduction gear housing did not reveal any evidence of repeated contacts or movements of the parts; however, there were indications of changes in direction and a reversal of the relative motion of adjacent parts, specifically the part which includes the left strut eyebolt base and the adjacent piece which encompasses the left QEC to reduction gear mount pad, identified as pieces one and two, respectively. There are marks that were made by the forward side of piece two moving in the outboard direction and scraping against two corners of the castellated eyebolt nut. The location of the marks also indicated that piece two moved a short distance downward and forward. Abrasion marks on the edge of the fracture at the lower rear corner of the left mount pad indicated a slight downward, forward, and twisting of piece two with respect to piece one. These marks probably were made at about the same time that the nut was contacted; subsequently abrasion marks were made which indicated piece two moved upward and slightly toward the rear. These marks do not substantiate the propeller oscillation known as whirl mode*; however, they are not inconsistent with what might be expected were whirl mode to be in progress as breakup occurred.

The detailed examination of the outboard power unit support structures disclosed additional evidence of cycling in the form of damage due to repeated bottoming of the front Lord mounts, curved scratches on one of the swirl straighteners, and repeated interference of fractured surfaces. These, particularly the curved scratches on the swirl straightener, are indicative of the propellers having oscillated violently for a short period of time prior to the gross overall displacement which occurred during the disintegration of the power unit support structure. The energy associated with this violent oscillation obviously caused rapid progression of damage to the power unit support structure.

The fractures of the structure of the No. 4 engine did not reveal any markings which showed load reversals as separation occurred. The only indication of load reversals on this engine was at the front end of the compressor shaft extension where separation from the torquemeter occurred. Loadings on both sides of the splines, rearward upset of some of the spline ends, and light longitudinal markings in a rearward direction on some of the splines suggest some movement other than a straight pull away. Gross misalignment as would result from a whirling motion at the propeller, coupled with an rpm differential between the two separating parts, is compatible with the markings.

Examination of the Structural Wreckage

Examination and study of the aircraft's structural wreckage narrowed the failure areas of possible significance to the inboard portion of the right wing, the outboard engine support structures, and the left elevator. This work also eliminated the probability of structural failure due to fatigue cracking, missing parts, nonconforming materials, and overtorquing of nuts.

Although the outer end of the left elevator disintegrated because of flutter, the wreckage distribution proved that this occurred appreciably subsequent to the right wing separation and shortly before the fuselage struck the ground. In addition, the trajectory calculations indicated that at the time of the elevator flutter the airspeed was much in excess of the design dive speed. As a result, the disintegration of the left outboard elevator was a consequence of the wing separation and cannot be considered an indication of unairworthy conditions prior thereto. The only remaining parts of the aircraft which appear to have been involved in the catastrophic disintegration are the wing and engine support structures.

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* A discussion of "whirl mode" appears later in the summary.

A detailed study of the damage to the right wing structure between the fuselage and the inboard nacelle disclosed numerous indications of damage progression during rapid reversals of loading. The separation and upward buckling of the front spar cap flange from the vertical leg between stations 78 and 89 was one example. If this had occurred during a sustained up-gust or positive manoeuvre, it and the associated disruption of the wing box upper cover could result only in the wing folding upward during separation from the fuselage rather than rearward as it did.

In this same area of the wing the damage to the end ribs of the inboard hinged leading edge and the irregularly saw-toothed diagonal fracture lines in the bottom cover were further evidence of reversing loads, both bending and torsion. This type of damage progression appears to be consistent only with catastrophic flutter.

The rib and rib attachment damage found in this same area of the wing could possibly be entirely the result of abnormal reversing stresses associated with the flutter. However, the similarity of some of this damage to that found on other Electras after abnormal ground loading could be indicative of damage prior to the onset of flutter.

The left wing reconstruction disclosed that from an irregular fracture line (roughly centred at station 482) inboard to the fuselage, the left wing structure, aileron, and flap remained attached to the fuselage until it struck the ground. The portions of the left wing and aileron outboard thereof fragmented and separated from the airplane in flight. Study of the fractures in the outer end of the wing box section disclosed that they resulted from excessive fluid pressures pushing the upper and lower covers and the front and rear spars away from the intermediate truss-type ribs. Failure and separation of the outer end of the left aileron resulted from rearward bending as a consequence of the wing box section disintegrating.

Re-evaluation Programme (subsequent to the accident)

On 20 March 1960 the FAA issued, as a temporary measure, an emergency airworthiness regulation which reduced the Electra V_{no} from 324 kt CAS to 275 kt or 0.55 Mach. Following a meeting on 22 March with representatives of Lockheed, Allison (GMC), Electra operators, NASA, and CAB, the FAA took the following additional action:

1. Because this and a previous Electra accident were believed to have occurred at or near a cruising speed of 275 kt CAS, it was considered necessary to make a further speed reduction to provide an adequate safety margin. Consequently, a second emergency airworthiness regulation was issued on 25 March 1960 limiting V_{no} to 225 kt CAS or 0.55 Mach and establishing a V_{ne} of 245 kt CAS or 0.55 Mach. Also included in this second regulation were requirements calling for immediate propeller feathering if the torquemeter indicator registered zero or full scale; deactivation of the autopilot until appropriate modifications could be designed and installed; adherence to Lockheed prescribed procedures in refuelling operations.

2. Under emergency authority specified in Sections 40.21, 41.1 and 42.5 of the Civil Air Regulations, the FAA, in an amendment to the Operations Specifications, ordered a one-time inspection on all Electras within 30 days of the order date, 25 March 1960. The inspection included, in addition to the severe turbulence inspection specified in the Lockheed Structural Repair Manual, an internal examination of the entire wing with emphasis on wing ribs for damaged attachment tabs, buckled rib braces, loose or sheared rivets, and damaged or cracked clips. Additionally, a thorough inspection of the elevators, elevator tabs, and related attachments was also required during the same 30-day period. The amended Operations Specifications further called for daily inspections of power plant magnetic sump plugs; inspection of fuel tanks involved in a reported tank

overpressurization; structural inspections following any reported incidents of flight through severe turbulence, hard landings, or overweight landings.

3. On 25 March 1960, the FAA notified the Chiefs, Flight Standards Divisions that observance and surveillance of L-188 aircraft en route operation and training was to be increased for a period of 30 days. The telegram specified that inspections should be concentrated in the areas of flight planning, pre-flight, placard speeds, operating techniques, inadvertent entry into turbulence, abnormal equipment operation, post flight activities, and flight training.

On 25 March 1960, following several meetings in which the Electra problem was discussed, the Administrator requested the Lockheed Aircraft Corporation to conduct an engineering re-evaluation of the Electra. The objective of this programme was to reveal any design or operational characteristics of the airplane causing structural effects more critical than those provided for and possibly influencing disintegration in flight. Briefly, the programme encompassed flight tests, structures investigations, aerodynamics investigations, design studies and special investigations, and tests. Extensive assistance was provided by the NASA, Boeing, Douglas, and other organizations in carrying out this programme. A like programme, appropriate to the equipment, was also carried out with respect to the engines and propellers.

Included in the flight test programme were expanded measurements of wing and nacelle loads and stresses during smooth and abrupt manoeuvres, measurement of the dynamic response of the wing and nacelles during gusts, extension of flight flutter response tests, expanded measurements of internal loads and stress distribution in the wing and nacelles, and re-analysis of inflight loads measurements made prior to the accident.

Numerous stiffness and rigidity tests were made on Electra serial No. 1077 for use in flight dynamics analysis. Primary attention was directed to component rigidities from the outboard propeller plane through the engine, nacelle, and wing to the fuselage centreline. The effects of simulated failures at various points in the outboard engine/nacelle installation were measured, but not at any point in the wing structure itself.

In re-evaluation of the airplane control system and autopilot characteristics, special attention was directed to the influence of possible malfunctions, failures, and induced effects on the sudden buildup of destructive control forces. The investigation included both analytical methods and the use of an elevator system functional mockup. A rigorous series of tests was conducted on the mockup to induce oscillatory or other performance failures under extreme simulated failures and malfunctions in the system. Nothing was found that might have produced a hazardous situation under the flight conditions of the subject aircraft.

A comprehensive review was made of all strength analysis procedures covering methods of determining internal loads, allowable strengths, and margins of safety. In addition to review of the original analysis, refined procedures were applied to the wing, wing rib, and wing beam analyses. In addition, the effect of damaged ribs on other rib loads and on the rigidity and strength of the wing was computed. Since the QEC structure had previously been static-tested to ultimate strength, attention was focused on changes in the design loads imposed.

Reinvestigation of the structural loads was performed in regard to the following: wing loads in manoeuvres, wing loads due to gusts, landing loads, and loads produced by autopilot malfunctions. Loads and stresses determined in the above-mentioned flight tests were used extensively in this programme.

Reaudit of the flutter characteristics was divided into two areas of analysis and test. Analytical solutions were obtained by two independent processes of analog and digital. In the latter, 59 degrees of freedom were used. Wind tunnel tests were conducted on three different models. The first consisted of a nacelle-propeller model in the Lockheed 8 by 12 foot tunnel in which stiffness in pitch and yaw was varied over broad ranges. The second was an eighth scale half-span dynamic model of the wing with nacelles and propellers. This was tested in the Lockheed tunnel with varying engine-propeller stiffness and variations in wing fuel quantity. The third, an eighth scale model of the complete airplane, was tested in the NASA 19-foot Langley tunnel. More complete variations of engine-propeller stiffness and damping and wing fuel distributions were covered. In addition, the effects of propeller overspeeding were investigated.

The re-evaluation programme disclosed two discrepancies in the design of the airplane. One of these was that significant loads imposed on the wing intermediate ribs between the fuselage and outboard nacelles by shell distortion had not been included in the design loads. The other was that the dynamic response of the outboard nacelles in turbulence was different from that used in the original design, with the result that the torsional loading of the wing inboard thereof was increased. In addition, the re-evaluation programme disclosed that with the stiffness of a power unit-nacelle installation reduced below normal, propeller oscillations could become destructive at the operating speed of N 121Us at the time of the accident.

"Whirl Mode" (propeller oscillation)

Insofar as this accident is concerned, one development of the re-evaluation programme is most significant. This is that on the Electra "whirl mode" can under certain conditions cause flutter and structural disintegration.

This is true despite the fact that all of the flutter tests and analyses made by Lockheed during the original certification process and during re-evaluation showed the Electra to be flutter-free at and above normal operating speeds, and further disclosed that the wing has a high degree of damping. The latter means that an oscillating motion of the structure will die out rapidly when the exciting force is removed; the damping forces are those which take energy away from the oscillation. A small amount of damping is from internal energy absorption in the structure and in energy absorbers such as engine mounts. The most significant damping, however, is the result of aerodynamic forces acting in opposition, thus absorbing energy from the oscillation. Conversely, if a major change occurs that allows the aerodynamic forces to be additive to the exciting force, the oscillation grows and the result is flutter.

Since the Electra wing is basically flutter resistant, in order to produce flutter there must be an external driving force. The possible force generators are the control surfaces and the propellers. Analyses indicated that the control surfaces would not produce wing oscillations of sufficient amplitude to produce a failure, consequently further analyais was centred around the propeller.

Since the propellers are normally stabilizing, it was necessary to consider abnormal propeller behaviour such as overspeeding and wobbling. The studies and tests conducted during the re-evaluation programme proved that a wobbling outboard propeller caused by a weakened nacelle structure can induce wing oscillations.

Since a propeller has gyroscopic characteristics, it will tend to stay in its plane of rotation until it is displaced by some strong external force such as turbulence, an abrupt manoeuvre, or power surge. When such a force or moment is applied, the propeller reacts in a direction 90^{o} to the force. For example, if the propeller is displaced upward, the resistance of the structure applies a nosedown pitching moment, causing the propeller disc to swing to the left due to precession. The yaw stiffness resists this motion causing precession downward, resisted by pitching stiffness which produces a precessional swing to the right. This, in turn, is resisted to cause an upward precession to complete the cycle. This effect is termed "whirl mode" and its direction of rotation is counter to that of the propeller.

Normally, whirl mode can operate only within the flexibility limits of the engine mounting structure, and is quickly damped. If, however, the stiffness of the supporting system is reduced through failed or damaged power plant structure, mounts, or nacelle structure, the damping of whirl mode is reduced to a degree depending on the amount of stiffness reduction.

Power plant structural weakness or damage does not significantly change the conditions under which whirl mode may be initiated, but in three ways it makes the phenomenon a potential danger:

1. The greater flexibility of a weakened system can allow whirl mode more freedom, hence it can become more violent. In an undamaged system the stiffness increases with increasing deflections, but this is not necessarily true if the structure is damaged.

2. In a weakened installation, the increasing violence of whirl mode can further damage the supporting structure, in turn leading progressively to more violence and even further damage.

3. As the structural system is damaged reducing the spring-constant, the amplitude of whirl mode increases and the frequency decreases from its natural value to lower values which approach the wing fundamental frequencies.

The natural frequency of whirl mode in an undamaged installation is approximately 5 cps. The wing torsional frequency is about 3.5, and the wing bending about 2 cps, with some slight variation with fuel loading.

As whirl mode progresses in an overly flexible or damaged power plant installation, its frequency can reduce from 5 to 3 cps where it will drive the wing in 3 cps torsional and bending oscillations. These wing oscillations will reinforce and perpetuate the whirl mode. The three oscillations are then coupled at the same frequency of about 3 cps, thus becoming a form of induced flutter forced by a powerful harmonic oscillation. This pehnomenon can exist, as demonstrated in wind tunnel tests and in analytical methods, at an airspeed far below that at which classical flutter can develop.

The stiffness factor for an undamaged power plant installation is 15.9×10^6 inch pounds per radian (root-mean-square). The tests indicated that at this stiffness level, whirl mode cannot force wing oscillations at any speed below 120% of the design dive speed of the aircraft. If, however, the stiffness is reduced, forced oscillations become more likely depending on amount of stiffness reduction and on equivalent airspeed. More specifically, the data show that if the stiffness is reduced to some value less than 8×10^6 inch pounds per radian, whirl mode could become a driving force on the wing in the cruising speed range. The tests further showed that whirl mode of catastrophic proportions could develop, reduce its frequency, and couple with the wing in a period of from 20 to 40 seconds.

The re-evaluation of the Electra disclosed that the whirl mode can induce flutter in a wing highly resistant to flutter, trajectory studies disclosed that the indicated airspeed of N 121US was approximately 260 kt at the time of disintegration, study of the wreckage of N 121US disclosed that the right wing separation resulted from flutter, the outboard power unit nacelle disintegrations involved oscillations characteristic of the whirl mode, and analysis of the weather at the time and place of the accident disclosed the existence of clear air turbulence which can excite the whirl mode. It must be concluded, therefore, that the whirl mode provided the driving force essential to destruction of the wing. However, the sequence of events that led to the whirl mode becoming destructive at normal operating speed was not established.

One possibility is that in penetrating the clear air turbulence, no single pulse of which could cause an overload, N 121US may have been subjected to a rapid succession of impulses at the proper frequency to cause dynamic response damaging the engine support structure and enabling the whirl mode to become self-sustaining. However, uniformly timed impulses with sufficient energy at the necessary frequency are extremely improbable in natural turbulence, which usually has the characteristic of being random both in frequency and in intensity.

A second possibility is that there was sufficient prior damage in one of the outboard nacelles alone to reduce the stiffness to the range where, once excited by turbulence, the whirl mode was self-sustaining and rapidly became divergent. This possibility hinges on extremely severe prior damage, which does not appear likely to have escaped detection during the detailed examination and study of the wreckage.

A third possibility appears to be prior damage to the wing; for example, partially disrupted ribs, as suggested but not proved by evidence of rubbing between mating parts found on separate pieces of wreckage. With such a condition, penetration of severe clear air turbulence in the area of Cannelton could conceivably result in rapid progression of wing damage. This could also cause change in the already more critical than expected dynamic response sufficient to damage the outboard power unit support structures, thereby causing the whirl mode to become self-sustaining. Although extensive calculations by the manufacturer tend to discount the possibility of limited prior wing damage having any significant effect in this regard, no dynamic tests have been conducted to support the calculations. Due to the extremely complex interactions under dynamic conditions with damaged rib structure, it is concluded that only such tests of a full-scale structure could either prove or disprove this possibility.

The landing of N 121US at Chicago on the day of the accident may well have caused damage to the wing structure even though some of the passengers considered it a perfectly normal landing. This is due in part to the fact that a person senses only the resultant of the acting forces and that in parts of the cabin of large aircraft very high linear accelerations due to ground loads can be practically cancelled by very high angular accelerations. In addition, drag and side impacts on the landing gear sufficient to cause structural damage are smaller than damaging vertical loads with the result that they can occur without alarm. This is borne out by one Electra accident where rearward-acting ground impact loads on the main landing wheels were sufficient to destroy one wing and to collapse the opposite main gear, but the occupants in general had no idea of anything being amiss until the fuselage assumed an extremely abnormal attitude.

In conclusion, the investigation disclosed that the right wing failed due to flutter involving whirl mode oscillation of the outboard nacelles. Although contributory to the initiation of the flutter, the severe clear air turbulence above appears to have been insufficient to produce the nacelle damage necessary to make the whirl mode self-sustaining. It appears most probable, therefore, that there was unrecognizable prior damage in the wing, or in the wing and outboard nacelles, making the effects of the turbulence more critical than on an undamaged airplane.

Probable Cause

Flutter induced by oscillations of the outboard nacelles caused the right wing of the aircraft to separate in flight. Contributing factors were a reduced stiffness of the structure and the entry of the aircraft into an area of severe clear air turbulence.

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ICAO Ref: AR/676

No. 27

Sociedad Aeronáutica Medellín S. A., Curtiss C-46A, HK-516, accident on "Las Mellas" hill, "El Reposo" Estate, District of Carolina, Municipality of Planeta Rica, Córdoba, Colombia, on 19 March 1960. Report released by the Director General of Civil Aviation, Colombia.

Circumstances

Flight No. 901 was a scheduled flight direct from San Andrés Island to Medellín carrying 42 passengers and a crew of 4. Shortly after 1942 hours difficulty was experienced in the left engine and subsequently it advised Medellín that the engine was overspeeding and it was returning to Planeta Rica. It crashed at 2110 hours GMT, 11 km northwest of Planeta Rica, killing 3 crew and 22 passengers. The steward, the only surviving crew member, received minor injuries. The aircraft was destroyed. There was no fire.

Investigation and Evidence

Crew Information

The pilot had flown a total of 6 621 hours including 2 860 hours on this type of aircraft. He had been with the airline six years.

All four crew members held valid licences and medical certificates.

The Aircraft

The aircraft had a certificate of airworthiness valid until 10 February 1961. Its gross weight at the time of the accident was 18 728 kilos which is less than the maximum of 20 412 kilos permitted in the certificate of airworthiness. The centre of gravity was also within limits.

The aircraft had been flown a total of 15 876 hours, 5 461 since its last overhaul and 15 hours since the last periodic check.

Left engine	time since last overhaul	906 hours
(accessories):		
carburettor	" " "	756 hours
governor	" " "	439 hours
propeller	" " "	992 hours

Weather

The actual weather was as follows:

> mist, haze, rain, hail, electric storm, wind - northwest 30 to 45 kt; ceiling 8/8; completely overcast; visibility 1 000 - 1 500 m; temperature 27^{o}C; barometric pressure 29.86 in. Hg.

Navigational Aids

The aircraft's radio set and radio compass were functioning normally. Three aids were available to this flight - radio beacons SRS 380, CTG 1.610 and MDE 1.690. No aids were fitted to the aircraft. At the time of the accident the Planeta Rica Radio Beacon and the control tower services had been discontinued.

Reconstruction of the Flight

HK-516 departed San Andrés Island at 1711 hours GMT on a direct scheduled flight (IFR) to Medellín. The flight was to last approximately 3 hours and 25 minutes and the aircraft carried fuel for 5 hours and 20 minutes. At 1942 the aircraft reported Turbo in visual flight heading directly for Copacabana and flying in heavy rain. The surviving crew member and passengers said that shortly after this report the left engine developed trouble. Forty minutes later Medellín was informed that the aircraft was returning to Planeta Rica with the left engine overspeeding and gave its position as Caceres at an altitude of 7 200 ft in descent. At 2024 the aircraft was told to change to the airline's administrative frequency and the pilot spoke to the Superintendent of Maintenance about the possible causes of the malfunction. It was then decided to land at Planeta Rica. At 2030 hours GMT it reported it was flying over Caucasia at an altitude of 6 700 ft in descent estimating Planeta Rica at 2050. At 2044 it was at 3 500 ft when it entered a storm, heavy turbulence and visibility became zero. Shortly thereafter the aircraft crashed into a hill.

It had crashed on a 320° heading, 410 ft above sea level, i.e. 160 ft higher than the airport elevation. It was estimated that at the time of the impact the aircraft's flight path angle with the ground was 45°. It had first hit a tree during a sharp left turn at a speed of approximately 80 kt. The left wing had split across the middle and made the aircraft skid upwards on a small hill. The fuselage broke into three parts.

The landing gear was "up" at the time of impact and the flaps were at zero.

On the basis of statements of survivors and information received from the crew during the flight it was possible to determine that the left engine malfunction, which occurred after 2-1/2 hours of flight, consisted of an intermittent overspeeding accompanied by light knocking which was controllable by a lower rpm cruising setting. It was confirmed that the engine retained some power throughout the flight by the fact that from the time of the initial malfunction until about 30 minutes before the accident the aircraft maintained height, as well as by the fact that the pilot neither mentioned nor activated the left propeller feathering system.

On examination of the ignition system gasoline pump and propeller units (the propellers were not feathered), nothing unusual was found.

Defects found in the left carburettor are discussed below.

Discussion

The left engine accessories were recovered and upon examination revealed defects in the carburettor. After thorough tests and analysis, lack of fuel compensation was found as a result of a float deformation and an abnormal fuel flow which caused intermittent engine overspeeding. The investigators concluded that the carburettor failure was at no time a serious cause for concern, all the more so if it is borne in mind that the engine was still providing power and functioning, as confirmed by the crew reports and by the fact that the propellers were not feathered.

It was believed that the pilot decided to return to Planeta Rica because of the mountainous area ahead and in view of the engine difficulty he was experiencing.

He insisted on landing at Planeta Rica where all communication and radio facilities had discontinued operations at that time and a heavy local storm existed. This appears to have been an error of judgement because at a distance of not more more than 20 minutes flying time there were airports with good facilities and where the weather conditions were much better. The Planeta Rica control tower and radio beacon were not operating as a result of the schedule established by the Colombian Aerodrome Authority. It was not understood why the crew were unaware of the schedule since the airline uses that airport frequently, and the pilot had been with the airline six years. It was deduced that the pilot had underestimated the malfunction in the left engine.

Probable Cause

The accident was attributed to an error of judgement in that the pilot decided to land at an airport which was closed and where no radio aid was available at a time when he was in visual flight at an adequate altitude and close to several airports offering good characteristics and suitable weather conditions. In addition, the pilot underestimated the malfunction that at the time had developed in the left engine.

The following contributing factors intervened:

1. malfunction in the carburettor of the left engine resulting in intermittent overspeeding and slight coughing;
2. adverse weather conditions (namely, thick mist, rain, hail and an electric storm) which prevailed in the area and in the vicinity of Planeta Rica Airport at the time of the accident;
3. the lack of communications which prevented the pilot from being briefed on the weather conditions at Planeta Rica Airport and from being informed of the absence of tower or radio facility services owing to the time-table in force at the airport.

Recommendations

It was recommended that an improved communications service be established between the various stations and control towers operating within the country, with the express obligation to continue watch fifteen minutes following landing in sectors where flights are scheduled. In addition, for the information of all personnel concerned, it is essential to disseminate more widely the working schedule at the various towers and stations within national territory.

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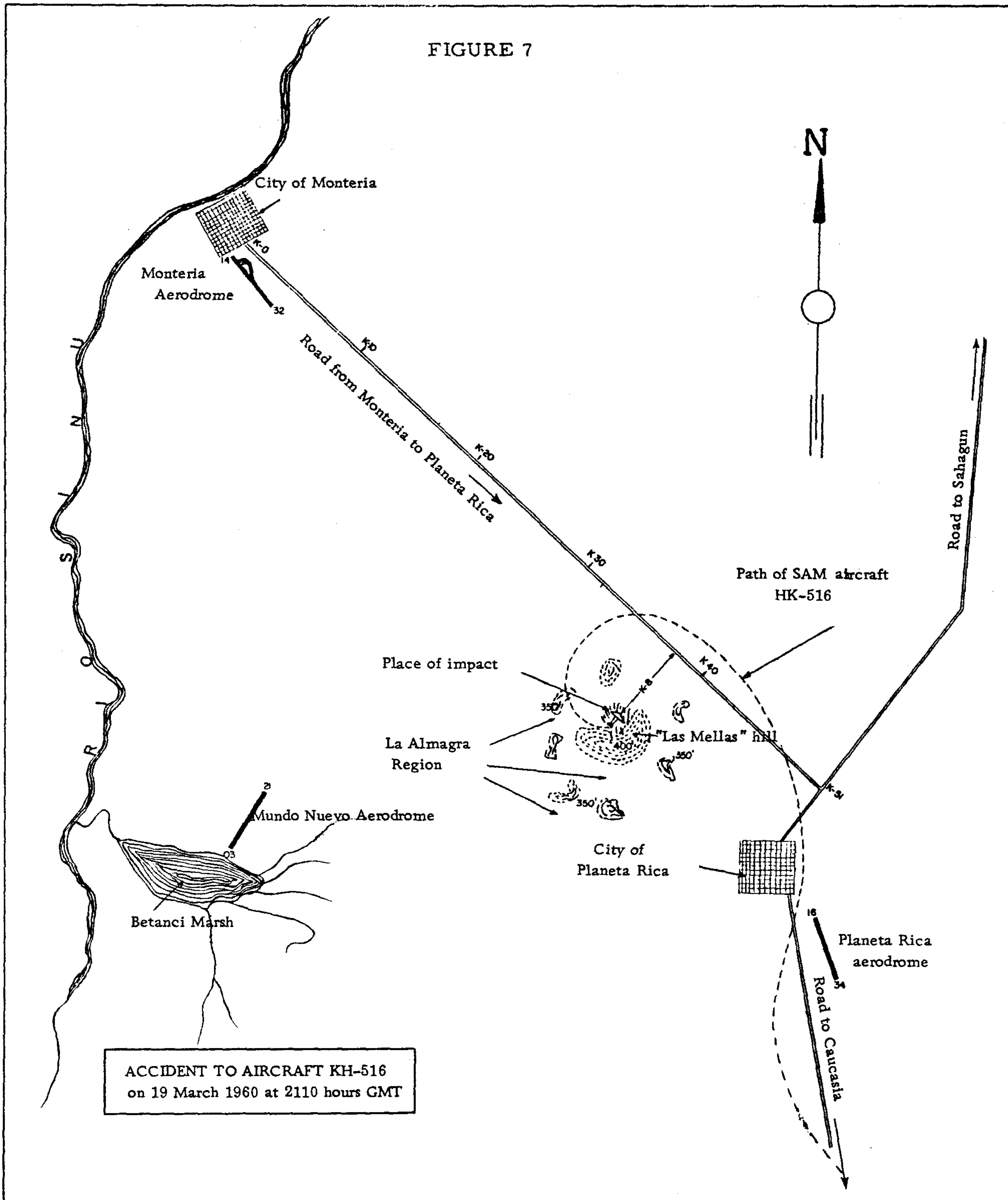
ICAO Ref: AR/627

FIGURE 7


N
City of Monteria
K-0
Monteria
Aerodrome
14
32
Road from Monteria to Planeta Rica
K-20
K-30
K-40
Road to Sahagun
Path of SAM aircraft
HK-516
Place of impact
La Almagra
Region
"Las Mellas" hill
400
350'
Mundo Nuevo Aerodrome
21
03
City of
Planeta Rica
K-51
Betanci Marsh
RIO SINU
16
34
Planeta Rica
aerodrome
Road to Caucasia
ACCIDENT TO AIRCRAFT KH-516
on 19 March 1960 at 2110 hours GMT

No. 28

Philippine Air Lines, Inc., DC-3C, PI-C97, accident at Larap Airfield, Camarines Norte, on 1 April 1960. Report released by the Civil Aeronautics Administration, The Republic of the Philippines.

Circumstances

The aircraft departed Manila for Larap at 0554 hours on a scheduled domestic flight and was carrying a crew of 3 and 31 passengers. The trip was uneventful until the landing at Larap during which the aircraft hit the embankment located at the north end of the airfield, approximately 77 ft before the runway markers. It bounced, and on the second touchdown, the main landing gears collapsed. The aircraft finally stopped 884 ft from the point of first contact, with its nose pointing to the west and its longitudinal axis inclined about 70° in relation to the runway's direction. There was no fire, but the aircraft was considerably damaged. No one was injured. The accident occurred at 0645 hours.

Investigation and Evidence

Investigation at the Accident Site

PI-C97 had come in for the landing from the north and had undershot the field with both main wheels hitting the edge of the rocky embankment of the runway. The impact blew off the left tire and sheared the upper end bolt fittings of both the left and right landing gear drag struts. The airplane bounced twice, then decelerated with both propellers intermittently biting the runway until the aircraft finally stopped.

The aircraft when inspected was intact, except for the left engine cowling, left propeller assembly and left landing gear tire, all of which were detached. The rear drag struts of both wheels telescoped through the mid-wing assembly with the upper ends protruding in the open, while the left propeller was embedded in the front section of the fuselage, with a blade penetrating through the flooring in the radio compartment.

Testimony - the pilot

He testified that the weather was good with ceiling and visibility unlimited, that they were on schedule and that there was nothing unusual in the performance of the airplane. About 10 minutes out of Larap he requested the surface wind and altimeter setting. Receiving the report of a calm wind and an altimeter setting of 29.92 he decided to make his landing towards the south. He manoeuvred the aircraft to join a right base leg at an altitude of 1 000 ft and then called for gear down. During the base leg he called for 1/4 flaps to establish his pattern airspeed. On turning final at about 500 ft he asked for 1/2, then 3/4 and finally full flaps maintaining 90 mph (IAS). Approximately 10 seconds before touchdown he started reducing his speed. He was aiming for the edge of the runway, and while applying back pressure on the stick, he hit the embankment. The aircraft bounced, and he waited for it to settle. When he felt the gears on the runway he slowly started to apply back pressure on the yoke. As the sinking was continuous, he realized that his gears were damaged. The pilot shut off the engines and tried to control the direction while the co-pilot was busy turning all switches to the "off" position. The aircraft finally came to a complete stop. He checked for signs of fire and as there were none he left the aircraft through the cargo door and went to open the main cabin door.

He also testified that he did not execute a downwind leg during his landing as the airport had a radio station. He had gone in directly for base leg and then turned to final.

- *the first officer*

He testified that at an altitude of 2 000 ft the pilot asked for gear down. The landing check list was then completed. at 1 200 ft the boosters were switched to "on", and the captain established his glide. The captain asked for one flap on base leg, two flaps on long final and three flaps halfway on final with the airspeed maintained at 100 mph. Full flaps were called for at about the edge of the runway - the airspeed was 90 mph. As the pilot levelled off, the airspeed was 85 mph. At this time they hit the embankment at the end of the runway.

The Airport

Larap Airfield has a runway 2 950 ft by 100 ft. It has a SIWL (single isolated wheel load) strength of 15 000 lb and is 12 ft asl. Its surface is crushed rocks. The hills on the approaches are known to cause downdrafts.

Analysis

The aircraft had been maintained properly in accordance with the airline's schedule, and evidence revealed that it was airworthy prior to the accident. The weather was not considered to have been a factor contributing to the accident. The runway was dry at the time of the landing. After the flight was informed of the calm wind condition it approached the field from the west, and a base leg and final approach were made on a 90° circuit. Witnesses testified that the approach was particularly and unusually low. The pilot stated that he came in at 90 mph with full flaps, with both engines functioning normally, and with the propellers in low pitch. The landing sequences were carried out normally without any flight operational variable that might have affected the landing.

Probable Cause

The pilot did not follow the standard traffic pattern for an uncontrolled aerodrome. He misjudged the threshold height prior to touchdown and undershot the field.

Recommendation

It was recommended that the pilot-in-command be required to undergo a check ride with a CAA check pilot before he returns to his flying duties as captain.

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No. 29

Líneas Aéreas de Nicaragua, Curtiss C-46A, AN-AIN, accident near Siuna Aerodrome, Nicaragua, on 5 April 1960. Report released by the Minister of Aviation, Nicaragua.

Circumstances

While taking-off from Siuna Aerodrome for a scheduled flight to Bonanza, Department of Zelaya, the aircraft crashed at 1439 hours GMT into a hillside, with a 10° slope, about 1-1/2 miles from the Aerodrome and to its left. It was completely destroyed by fire. One crew member and one passenger were killed in the accident.

Investigation and Evidence

Reconstruction of the Flight

Flight No. 01 originated at Las Mercedes Aerodrome, Managua, with a flight plan MANAGUA - SIUNA - PUERTO CABEZAS - BONANZA - SIUNA - MANAGUA. The aircraft took off from Siuna at 1438 hours (GMT) after receiving a weather report indicating wind north-northwest, velocity 8 to 10 miles. The undercarriage was retracted and the aircraft had reached about 150 ft when it made a slight turn to the left. At that moment, according to his own testimony, the pilot-in-command felt a sharp yaw to the left, indicating loss of power in the port engine.

The pilot-in-command applied full force to the starboard rudder and aileron controls in an effort to control the aircraft but was unable to feather the port propeller as his hands were occupied. He shouted the word "feathering" several times to the co-pilot who, as far as can be gathered from the limited evidence available, started to carry out the order. But when the pilot realized that it was impossible to maintain altitude above the terrain, he decided to attempt a landing. The aircraft then hit the hillside and caught fire. (The terrain in this region is rugged and mountainous, and the wind perpetually changes direction and speed).

Examination of the Wreckage

Both the cockpit and the central section of the aircraft were burnt out. The upper portion of the rest of the fuselage also caught fire, parts of the floor surface remained and the seats stayed in place with only the upholstery burnt. The horizontal stabilizers and elevator were damaged, but the rudder and vertical stabilizer remained intact. Both wings were destroyed by fire in the vicinity of the fuel tanks, although the booster pumps were found in place.

The rest of the starboard wing was completely destroyed on impact. The starboard aileron remained, with the covering fabric burnt. The rest of the port wing was damaged. The port aileron also had its covering fabric burnt. The undercarriage was retracted at time of impact.

The port engine was destroyed by fire in the accessories section. The port propeller was found attached, without damage, to the reduction gear casing, but with blade No. 1 bent forward, blade No. 2 bent inward and buried to a depth of 14", and blade No. 3 bent outward without further damage.

The starboard engine was destroyed by fire in the accessories section. Most of the intake pipes and cylinder heads were melted. The starboard propeller and complete reduction gear were torn free from the engine nose and were found 96 ft from the nose of the aircraft, higher up the slope, in the following condition: blade No. 1, tip broken off, leaving about 4 ft in length; blade No. 2, tip broken off, leaving about 5 ft in length; blade No. 3, only about 2 ft in length remained.

The Aircraft

It had flown a total of 5 650 hours; 1 677 since the last major overhaul.

The port and starboard engines had flown approximately 525 and 219 hours respectively since their last major overhauls.

On take-off from Siuna Aerodrome for Bonanza the aircraft's total weight was 38 936 lb, i.e. below the authorized take-off limit of 41 000 lb.

Probable Cause

During the investigation, when the port propeller was being dismantled, it was discovered that the distributor valve was broken from the base of the junction with the engine crankshaft, the first threads having broken. The break appeared to be due to fatigue. From the evidence, the rupture of the distributor valve of the port propeller appears to have been the main cause of the accident, additional factors being unfavourable terrain, wind and altitude conditions.

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ICAO Ref: AR/629

No. 30

Servicos Aéreos Cruzeiro do Sul S/A, DC-3, PP-CDS, accident at Pelotas, Rio Grande do Sul, Brazil, on 12 April 1960. Summary report released by the office of the Inspector General, Ministry of Aviation, Brazil.

Circumstances

During the take-off roll the aircraft turned its nose sharply to the left following a previous slight deviation to the right. The pilot estimated that he would clear the obstacles in the aircraft's path and initiated an early take-off, but the aircraft hit two other parked aircraft (PT-ABZ and PP-HDJ), struck the ground and caught fire after the last impact. The pilots of PP-CDS and 8 passengers were fatally injured. One other passenger received minor injuries. PP-CDS was destroyed, PT-ABZ was heavily damaged, and PP-HDJ was lightly damaged. The accident occurred at 1420 hours.

Probable Cause

The accident was attributed to pilot error - incorrect use of the brakes and controls while on the ground.

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ICAO Ref: AIG/ACC/REP/GEN/No. 8 - Brazil

No. 31

LLACSA S. A. , Curtiss C-46D, HK-390, accident near Eldorado Airport, Bogotá, Colombia, on 19 April 1960. Report released by the Director General of Civil Aviation, Colombia.

Circumstances

HK-390 departed Miami International Airport, Florida, at 1345 hours GMT, as scheduled passenger flight No. 503, for Bogotá, Colombia, with intermediate stops at Barranquilla and Medellín, Colombia. The two stops were made as scheduled and at time of departure from Medellín (2258 hours GMT), 51 persons were aboard, i.e. 7 crew and 44 passengers. Contact with Bogotá Air Traffic Control was established over Palanquero, and the aircraft was instructed to proceed IFR and maintain 13 500 ft. It called when over the Andes and Techo radio beacons as requested, reporting visual conditions at an altitude of 10 500 ft over the latter beacon. At 2403 hours the aircraft contacted the control tower at Eldorado Airport (Bogotá) and was given the following landing information: "Runway 12, wind calm, altimeter 30.33, restriction owing to aircraft accident in the safety zone near taxiway B". Shortly thereafter, the crew reported on the downwind leg, flying it long because another aircraft was taxying along the main runway towards the apron, and then reported base leg and final approach, concluding with the words: "I am landing". A few seconds later, at 2408 hours GMT, the control tower operator saw the aircraft crash to the ground. The aircraft was completely destroyed. Thirty-two persons were killed. Only one crew member, the pilot-in-command, was among the 19 survivors. He was seriously injured.

Investigation and Evidence

The Aircraft

Its certificate of airworthiness was valid until 4 October 1961. The weight and centre of gravity of the aircraft were within limits at the time of the accident. HK-390 had flown a total of 8 289 hours as of 19 April 1960, approximately 8 of which were since the last overhaul. The starboard and port engines had flown approximately 794 and 1 031 hours respectively.

The Crew

All 7 crew members carried valid licences and current medical certificates at the time of the accident.

Navigation Aids and Lighting

All the navigation aids at Eldorado Airport, as well as the runway lighting, were operating at the time of the accident. There was no approach lighting system at the Airport.

Weather

Weather conditions at the time were above the minima established for this Airport.

The Accident Site

The elevation of the accident site was 8 345 ft asl, and the site was on a magnetic bearing of 300° in relation to the Airport. The Airport's elevation above sea level is 8 355 ft.

The Wreckage

The main wreckage was located 400 m from the approach end of runway 12 at Eldorado Airport, sunk in a nearby pool.

It was estimated that the angle of the flight path in relation to the ground on principal impact was 15°, and that the aircraft had hit at an estimated speed of 125 kt. Following the first impact the aircraft travelled approximately 120 m before finally stopping. The landing gear was down at the time and the flaps were at 0°

On impact the fuselage was broken into two parts through station 481. The tail part suffered comparatively little damage and was found lying on the bank of the Bototá River, while the other part came to rest in the pool. Because of the difficulty in extricating the survivors, the fuselage, the engines and accessories had been considerably damaged and after the rescue operation were found to be in extremely poor condition. Examination revealed that the power units were out of position, and both wings were detached from the fuselage. The port engine showed signs of fire in the accessories casing. The nose and the cockpit were completely destroyed. No conclusions could be drawn from the position of the engine controls as they could have been shifted by the force of the impact, but they were all in reverse.

Reconstruction of the Final Portion of the Flight

The pilot received the landing instructions without difficulty. However, as another aircraft was taxying along the main runway at the time, the pilot-in-command flew a long downwind leg for the left turn into base leg. At the beginning of the turn into base leg the altitude was 9 300 ft and at the end of the turn the altimeter showed 9 100 ft. (In his testimony the pilot stated that a gust of wind made him lose speed and altitude in the base leg turn which was made at an altitude of 9 100 ft, as instructed, and the altimeters showed this altitude until initial impact.) The captain gave the order for the landing gear to be extended keeping the aircraft's speed at 125 kt. Light rain was falling at this time, and visual contact was lost at the start of the turn into final approach. The wind was calm, and there was no evidence of severe turbulence in the testimony of other pilots who landed immediately before the accident. The aircraft then went out of control and lost height so rapidly that it hit a tree 34 m high located some 3 000 m from the approach end of runway 12. In this impact, the pitot tube was lost and the tip of the starboard wing buckled. Although the pilot had applied full power, a second contact against a tree (22 m high) occurred, causing a strong vibration. The pilot attempted to reach the landing strip as the aircraft was aligned with the runway, which was in view, but was unsuccessful. The landing gear struck the embankment and the fuselage broke into two main parts. The port engine broke off and caught fire.

Discussion

The Investigation Board established that there was no mechanical failure. It may be concluded from the pilot's testimony that overextension of the downwind leg and failure to apply the power needed to maintain a level attitude naturally caused the aircraft to descend gradually. Although, in the circumstances, it is a remote one, the possibility should not be rejected that severe turbulence made the aircraft lose speed and height. What is certain, however, is that if the pilot had followed the proper procedure, he would have been able to regain control of the aircraft before the initial impact. The C-46 pilots who acted as advisers in the investigation agreed that the turbulence mentioned by the pilot-in-command could have been a stall warning furnished by the inherent aerodynamic qualities of the aeroplane which in this type appears as a strong vibration of the whole aircraft. Consideration was also given to the possibility that the pilot was flying in IFR and VFR at the same time, which would have accounted for a possible distraction that made him lose his flight position.

It was also found that although the pilot met the requirements laid down by the Civil Aviation Authority, he had little experience as a transport pilot.

Probable Cause

The pilot failed to take the proper action to counteract the loss of speed and height in the final approach turn.

Contributing Factors

1. lack of operational control by the airline concerned;
2. the pilot-in-command lacked experience as a transport pilot;
3. it is probable that the report from the control tower at Eldorado that the runway was restricted because another aircraft had crashed in the safety zone had a psychological effect on the pilot.

Recommendations

Every airport in the country conducting night operations, and especially the international airports, should be provided with a suitable system of high-intensity approach lighting.

Efficient fire fighting, medical, rescue and salvage services should be provided at all airports whose traffic warrants them.

Airlines should arrange for closer supervision of the operating technique of their pilots by means of training and half-yearly checks. The Civil Aviation Authority should lay down directives to that end.

ICAO Ref: AR/630

No. 32

Línea Aeropostal Venezolana, Douglas DC-3, YV-C-AFE, accident near Calabozo Airport, Venezuela, on 28 April 1960. Report released by the Directorate General of Civil Aviation, Venezuela.

Circumstances

The aircraft was on a scheduled flight and left Maiquetía with intended landings at Calabozo, San Fernando, Puerto Páez and Puerto Ayacucho. When it was 15 km from Calabozo Airport there was an explosion on board which totally destroyed the cockpit. Control was lost and the aircraft fell, rapidly striking the ground, about 4 km from the place where the explosion occurred. Three crew members and 10 passengers lost their lives in the accident. The aircraft crashed at 0822 hours.

Investigation and Evidence

Reconstruction of the flight path

According to witnesses, the aircraft was maintaining the correct course when the explosion occurred which totally destroyed the cockpit from station 0 to station 86 that is behind the pilot's seat. The aircraft maintained its flight attitude, then tilted on its left wing and plunged to the ground making a wide turn. Between the point where the explosion must have occurred and the place where the wreckage of the aircraft was found were some parts and components which belonged exclusively to the cockpit and forward cargo compartment.

Examination of the wreckage

A thorough study was made of all parts found in the last portion of the wreckage trail in order to determine the cause of the explosion. The sections of the outer covering, corresponding to the cockpit, appeared ripped apart along the line of the rivets which attached it to the structure. The bolts holding the upper cone of the nose had broken under the effects of stress.

The emergency exit for the crew, found at a distance of 500 m from the place of the accident, was buckled. Pieces of upholstering were found to have a gunpowder odour. In the seat lining and on a piece of cloth that must have been the captain's uniform, deposits were found of a powder that also smelled of gunpowder.

The investigation was then directed towards determining the original traces, which seemed to have been left by particles moving at high speed, together with those found on the door separating the compartments. When separating the layers forming the door, a particle was found with very special characteristics. It was, subsequently, sent to the laboratory of the Technical Police Department for detailed examination.

The explosive object

This object was carried aboard the aircraft by a passenger. Moments before the aircraft was to land in Calabozo, the first intended stop of this flight, the passenger went into the cockpit. The co-pilot, according to declarations made by two passengers who were fatally injured, entered the passengers' compartment to warn them of the danger. When the co-pilot tried to return to his seat the explosion took place. This statement was confirmed by the fact that the pilot's body and that of a passenger were found with lacerations and mutilations, while the co-pilot's body showed traumas and burns but no mutilation. Furthermore, the co-pilot was found with the passengers whereas the pilot was found 800 m from the accident site.

Observations

The investigation by the Judicial Police brought out the following points:

a) in the wreckage of the aircraft, a detective novel, entitled "Death in the Air", was found;

b) in a pocket of the trousers of the co-pilot a suicide note was found which recommended that after being read it be handed over to the next person (a passenger). It is assumed that it reached the co-pilot through the stewardess.

c) a metal particle found between the layers of the door separating the compartments was identified in the police laboratories as a fragment of a home-made grenade;

d) an investigation of the relatives of the victims made the authorities suspicious of a passenger. Sufficient evidence was found at his home to confirm that the passenger prepared the exploding device.

Conclusions

The Investigating Commission reached the following conclusions - the aircraft had been properly maintained, and there was no evidence of any breakage or structural or mechanical failure or defective performance of any component prior to the explosion.

Probable Cause

The accident was caused by an exploding device.

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ICAO Ref: AR/664

No. 33

Trans World Airlines, Boeing 707-331, N 765TW, landed "wheels-up" at New York International Airport, New York, on 9 May 1960. Civil Aeronautics Board (USA) Aircraft Accident Report File No. 1-0009, released 14 November 1961.

Circumstances

Flight 100 of 9 May was a regular non-stop flight from Los Angeles, California to New York, N.Y. There were 100 passengers and 9 crew members aboard the aircraft. Following departure from Los Angeles International Airport at 1606 hours GMT the flight flew eastward cruising at 33 000 ft. Once in the New York area it descended in preparation for an instrument approach to runway 22L at Idlewild. The flight was given the latest wind and altimeter setting and advised that the glide slope was inoperative. The aircraft was cleared to make a localizer approach and intercepted the localizer about 2 miles outside of the outer marker at an altitude of 1 500 ft. According to the captain's testimony the ILS approach was completely normal; airspeed was maintained constant at reference plus 10 kt (141K); rate of sink was maintained between 500 and 700 ft/min; and the aircraft was on the localizer from the outer marker almost all the way down.

While on the localizer and about two thirds of the distance from the outer marker to the runway, the autopilot, for unknown reasons, disengaged. Visual contact with the runway was established shortly thereafter. At this time the pilot said the aircraft was about 100 ft to the right of the runway and between 500 and 1 000 ft from the threshold at an altitude of approximately 400 ft. Approximately half way down the runway and at an altitude of "about 50 ft or perhaps less" he decided to abandon the landing and go around. Power was advanced and the command was given for 30° of flaps and for the gear to be raised. He believed the aircraft was in a climbing attitude - it was actually on the runway. Immediately after touchdown he heard the landing gear unsafe warning horn and closed the throttles. The aircraft settled to the runway and slid to a stop 500 ft from the end with all three landing gears retracted. The aircraft sustained major damage because of the contact with the runway and the ensuing fire. Firefighting equipment arrived at the aircraft promptly and immediately extinguished fires which had developed on engines Nos. 2 and 3. Eight of the passengers received minor injuries.

Investigation and Evidence

Weather

The weather conditions at the time of the landing were as follows: ceiling measured 400 ft variable broken, 700 ft overcast; visibility 4 miles in fog; wind from the south at 15 kt; altimeter setting 29.49.

The Aircraft

As a result of crew testimony and technical examination it was determined that all four engines and all aircraft systems were capable of normal operation prior to the accident. No evidence was found to indicate a malfunction in the autopilot. It was noted in the aircraft operating manual that actuation of the electric stabilizer trim thumb switch will disconnect the autopilot.

Training Programme

An average flight time of about 20-1/2 hours in the aircraft and 14 to 15 hours of simulator time is actually required for checkout. During this time, a TWA spokesman stated, considerable instruction and practice in standard go-around techniques are given from ILS approaches at an altitude of about 200 ft or more. The procedure taught is: advance power to take-off thrust; retract flaps to 30°; retract landing gear after positive rate of climb is assured. Since the accident, the witness said that the company has re-emphasized that the landing gear is not to be raised until a positive rate of climb is assured.

The operations manual also cautions against the use of 50° (full) flaps to correct for a high approach as excessive rates of sink might develop.

He also testified that company procedures prohibited the use of autopilot after passing the outer marker inbound if any component of the ILS is inoperative.

Reconstruction of the flight based on flight recorder information

The flight recorder was operating properly during the accident. The tape covering the last portion of the flight was read and found to contain rather significant information. Airspeed was found to have been about 165 kt at the outer marker inbound. It then increased to about 170 kt, for a period of about one minute. It then began to decrease to approximately 141 kt at the middle marker; then to about 128 kt at the first point of touchdown.

The acceleration trace indicated slight turbulence throughout the approach and a series of heavy accelerations at runway contact with several indicated peak loads of 3.2 and 4.2 g's.

The heading trace from the outer marker inbound was extremely erratic. The aircraft heading varied almost 30° during the approach.

The aircraft crossed the outer marker at about 1 200 ft. Its rate of descent during the next minute was about 100 ft/min. The rate of descent then increased to about 1 200 ft/min and the aircraft descended to about 650 ft. The descent continued at a much lesser rate for a short period and the aircraft then began a gentle climb as it reached the vicinity of the middle marker. Shortly after this the airplane was again dived at a rate of at least 1 000 ft/min until it contacted the runway.

Captain's testimony - Discussion

He cited three factors which accounted for his overshooting the runway:

1) no approach lights;

2) no glide path;

3) the automatic pilot became disengaged prior to the threshold of the runway.

The Board did not agree that these should have had any serious adverse effects on the completion of a properly executed instrument approach. The captain's allegation that the approach lights were not in operation appeared to be unfounded. He was aware that no glide slope was available on this runway and should have set up a constant rate of descent which would have brought the aircraft down its approach so as to break out of the overcast at the proper point. If he had felt that executing an instrument approach without a glide slope was not completely safe, then his only action should have been to proceed to his alternate where a safe approach could be made. No substantiating evidence was found to indicate a malfunction in the autopilot or to account for its disengagement as reported by the captain. Also, company regulations prohibit use of the automatic pilot for a coupled instrument approach when no glide slope is available. The flight path of the aircraft from the outer marker inbound was extremely erratic. Heading changes of more than 20° and rapid altitude changes such as were evidenced from the flight recorder readout could not have occurred unless this were true. It appeared that the aircraft was flown by hand or that it was on autopilot but being controlled by the pilot by means of the autopilot turn and pitch controllers. All the evidence indicates a lack of competency in the equipment and a lack of instrument proficiency.

With a properly executed approach, this aircraft should have broken out of the overcast at an altitude of approximately 400 ft (about 20 seconds), or almost 8/10 of a mile, before reaching the middle marker. At this point the runway would have been visible and the landing could have been made successfully. It was obvious to the Board that the approach was not executed in this manner.

Immediately upon breaking contact it should have been obvious to the crew that the aircraft was too high and too close to the runway and that the approach should have been abandoned. From the position described by the captain, a flightpath of 21° from the horizontal would have been required to land at the beginning of the runway. From the position described by the co-pilot, a flight path of about 9° would have been required. A normal approach would result in a glidepath of around 2-4°.

It is also evident that the captain continued his approach despite the fact that he was at an altitude of about 275 ft over the threshold. If it was not obvious to the crew that a go-around would be necessary when they first became contact, it most certainly should have been evident when they crossed the threshold at this extreme height.

In spite of this the captain continued his approach until approximately one-half of the runway was behind him. Then at an altitude of about 50 ft he initiated a go-around. He advanced the power levers, called for 30° of flaps, and gear up. Instead of applying take-off thrust, as called for in the go-around procedure, he advanced the throttles to approximately 2.0/2.3 EPR (engine pressure ratio). At 125 kt this would result in about 12 450 lb of thrust per engine. Under conditions existing on that day, the take-off power setting of 2.55 EPR would have been available which would produce 14 730 lb of thrust. Actually the airplane performance at 2.30 EPR would be good and a go-around possible; however, at 2.55 EPR it is probable that less altitude would have been lost during rotation to climb attitude and before a positive climb would have been effected.

It is also apparent that the captain did not make certain that a positive rate of climb had been established before ordering the landing gear retracted. The co-pilot, who actually performs the duty should make certain the aircraft is climbing and will not touch down before he moves the gear handle. He, as well as the captain, should have been aware that the aircraft was not climbing out when the gear was retracted. The duties he was performing were not so arduous as to prevent him from ensuring that a positive rate of climb had been established.

The evidence adduced during the investigation indicated a lack of training and competence in the aircraft which cannot be overlooked.

1) The captain said he was utilizing the VOR-LOC mode of the autopilot even though he knew that there was no glide slope signal ... as stated this is contrary to company regulations.

2) The altitude of the aircraft at the outer marker was 1 200 ft ... minimum authorized altitude at that point is 1 500 ft.

3) The aircraft airspeed varied considerably from that described by the crew members.

4) Both the rate of descent and the aircraft heading varied dangerously despite the testimony of the crew.

5) The application of power was made with little regard to established procedures with the result that take-off power was not used for the go-around.

6) The captain ordered the landing gear retracted prematurely and the co-pilot complied despite the fact that the aircraft was still descending.

Probable Cause

The probable cause of this accident was a poorly conducted instrument approach necessitating a go-around which was initiated too late and improperly executed.

ICAO Ref: AR/690

No. 34

Balair Ltd., DC-4, HB-ILA, accident in the Region of Mount Marra, Djebel Tereng, The Sudan, on 15 May 1960. Report dated 8 September 1960 was released by The Ministry of Communications, Republic of the Sudan.

Circumstances

En route to Niamey from Khartoum and flying at 8 000 ft amsl (2 435 m), the aircraft flew (at 1957 hours GMT) into a slope of the Djebel Marra Mountains* killing all 12 crew members. There were no passengers aboard. The aircraft was entirely destroyed by the impact and the raging fire which followed.

Investigation and Evidence

The Aircraft

There was no evidence that the aircraft was not airworthy at the time of take-off.

The Crew

All seven crew members held valid licences with appropriate ratings. Also aboard were five dead-heading supernumerary crew members or company officials.

Navigation Aids

It was assumed that the crew intended to use the El Fasher non-directional beacon. This beacon is positioned 1 NM north of the El Fasher Airport. It was established that the beacon was on during the whole night of 15 - 16 May. A check operated on 19 May at 0930Z showed that the coverage was actually about 30 NM and that a strong and reliable indication on the radio compass came only at a distance of about 20 NM.

* the highest peak is 10 150 ft amsl (3 042 m)

Reconstruction of the Flight

The trip originated in Geneva on 14 May and was to be a charter flight to Djeddah with a crew of 7 and 65 passengers aboard. Intermediate stops were made at Brindisi and Cairo. All passengers disembarked at Djeddah. The aircraft was then to fly empty to Dakar via Khartoum and Niamey. Arrival in Khartoum was at 1550Z. The Balair timetable stated that a 12-hour rest would be taken at Khartoum, however, for reasons unknown, the pilot-in-command decided to proceed directly to Niamey and Dakar after refuelling.

A flight plan, signed by one of the co-pilots, and filed at 1636Z, showed that the flight Khartoum-Niamey had been divided into nine legs.

Since the DC-4 has no pressurized cabin, a flight level of 80 (corresponding to 8 000 ft) had been foreseen for the first three legs. The crew were, however, well aware of the collision danger caused by the presence of the Marra Massif southwest of El Fasher, and intended to climb to 12 000 ft after El Fasher.

The aircraft departed Khartoum at 1726Z. At 1815Z the crew advised that the flight had reached the first reporting point (1440 N 31E) at 1804Z and that it expected to pass the second reporting point 1:03 hours later at 1907Z. At 1918Z it reported its position for 1906Z as 1415N 2756E (instead of 1410N 28E as indicated in the flight plan) and gave the expected time for the overflight of the El Fasher Beacon as 2001Z. This was the last transmission received by Khartoum Control.

Early on 16 May the wreckage was sighted east of Lake Deriba at about the 8 000 ft level. There were no survivors.

Position Reports

If the last reported position (1415N 2756E) of the aircraft was correct, the aircraft had to cover the distance from this reporting point to the crash point (13N 2420E), which is at least 210 NM, in the 51 minutes between 1906 and 1957; but this seems unlikely because that would mean for this leg a ground speed of about 250 kt which is unreasonable. The Board, therefore, believed that the two position reports given for 1804Z and 1906Z cannot have been accurate and that the elements employed in the dead-reckoning navigation must have been inaccurate.

If the aircraft was, at 1906Z, actually at the point 1415N 2756E, it had to cover the distance of the first and second legs (105 NM +180 NM = 285 NM) in 1 hr 40 min since take-off (1726Z). Taking about 15 minutes and 35 NM for the initial climb to flight level 80, this would mean 250 NM in 85 minutes or a ground speed of about 176 kt. A rise in the ground speed from 176 kt in the first two legs to 250 kt in the third leg cannot be taken into serious consideration under the prevailing weather conditions.

Ground speed and heading

The total distance from Khartoum to the crash site is about 500 NM and the total flying time is 2 hr 31 min. Taking as before 15 minutes and 35 NM for the initial climb to flight level 80, we have 465 NM in 2 hr 16 min or an average ground speed of 205 kt. The true airspeed given in the performance charts for the aircraft involved and for the existing flying configuration reads about 185 kt, and on the basis of the expected flying times given in the flight plan, it is determined that the calculation for the first two or three legs of the flight was based upon a ground speed of about 175 kt.

The Board believed that the aircraft progressed actually with an average ground speed of about 200 or more knots and that, after a flight of 2-1/2 hours, it was about 70 NM ahead of the estimated position. On the other hand a heading error of only 2 - 3 degrees during 2-1/2 hours may have been sufficient to bring the aircraft at the same time about 30 NM off track as it was.

Navigation

The crew apparently did not intercept the El Fasher beacon and were not able to make a homing on it. The Board believed that the crew must have tried to do so but for some reason they were not successful. Very probably the aircraft passed about 20 NM south of El Fasher and its beacon and they may have been abeam of it about 20 minutes before the crash i.e. between 1935Z and 1940Z. At the occasional check of the beacon made some days after the accident the emission was not very strong; at a distance of about 30 NM it could be heard with only 3/5 and the indication of the radio compass was still hesitating and ± 5 degrees. Sot it may have been possible that the crew, who probably watched the frequency of the beacon (394 kc/s) very closely, got some signals of the beacon; but these signals may have been rather weak and the indication of the hand of the radio compass may have been unreliable or seemed to be so; so the crew may have supposed that it was still too early because they expected to be overhead El Fasher only 15 - 20 minutes later, at 2001Z. They probably continued to watch this frequency, but as in fact, the distance aircraft - beacon increased again, it may be possible that soon no further useful information could be gained. Under those circumstances the crew probably relied exclusively upon the 1906Z fix and the 2001Z estimate for El Fasher and were perhaps not excessively concerned about their actual position and still waiting for the beacon. This would explain the absence of any communication with Khartoum Control before the crash.

The night was dark and the moon had not yet risen; a good fraction of the sky was slightly obscured by cirrus clouds. So the crew may not have been aware that they flew, at least during the last 2 or 3 minutes, at a very low level over ground and eventually the aircraft hit the slope in level flight and at full cruising speed.

Weather

At approximately 1630Z the crew were briefed on the weather situation, and the aircraft left Khartoum at 1726Z. It was not believed, therefore, that the crew had seen the 1700Z wind chart, which was as follows:

Winds at 8 000 ft level:

		Wind chart for 1100Z	for 1700Z
Port Sudan	(641)	10 kt/23	05 kt/01
Atbara	(680)	10 kt/28	10 kt/30
Khartoum	(721)	05 kt/26	15 kt/34
El Obeid	(771)	20 kt/06	15 kt/05
El Fasher	(760)	05 kt/02	10 kt/09
Geneina	(770)	10 kt/18	10 kt/05
Abéché	(756)	10 kt/16	"
Fort Lamy	(700)	20 kt/09	"

In the oral information the crew were told that they had to expect a variable but mainly easterly wind flow of about 8 kt for the section Khartoum - 20E and of 15 kt west of 20E.

The prevailing wind for the El Fasher area for the period 2000Z/2359Z between the levels 10 000 and 15 000 ft was 09/12 kt.

Up to 20E no significant weather was anticipated except for some medium clouds and a moderate chance of very isolated thunderstorms over the southern parts of the Marra mountains which would be well south of their track. West of 20E some local thunder was expected.

The Wreckage

The aircraft hit the slope at a cruising speed of 200 kt and a violent fire followed. 2 900 US gal of fuel had spilt and sprayed over the whole accident site. The cockpit was entirely destroyed. It was not possible to obtain any information from the instrument readings or the radio settings. It appeared that all four propellers had been in the cruising pitch at the time of the accident.

Time and Place of the Accident

A wrist watch found at the site showed that the hands had been at 8:57 at the moment of impact. It was believed that the watch belonged to a crew member and was set on Swiss time which is GMT plus 1 hour (or Sudan time minus 1 hour). From this the Board concluded that the accident happened at 1957Z ± one minute ... i.e. that the aircraft crashed about four minutes before the crew expected to be overhead the El Fasher beacon. The crash was about 60 NM west and about 30 NM south of El Fasher. The crew expected to be about 12 NM east of El Fasher at 1957Z. The Board was satisfied that the aircraft was about 72 NM ahead of its estimated position and at the same time 30 NM off track to the south.

Probable Causes

The Board considered that the probable causes of the accident were the following:

- the fact that the aircraft progressed actually at an average ground speed of at least 200 - 205 kt while the crew believed they were proceeding with not more than 175 - 178 kt as estimated before take-off;

- that a slight directional difference of 2 or 3 degrees may have existed between the calculated track and the actual flight path;

- that these two navigational inaccuracies could build up during a flight of 2-1/2 hours and could eventually result in a position error of about 70 NM to the west and about 30 NM to the south;

- that for reasons unknown to the Board the position report given for 1906Z and apparently established on the base of an astronomical fix must have been inaccurate and that the crew were, therefore, not able to be conscious of the discrepancies between their dead-reckoning and their actual position;
- that the aircraft flying at 8 000 ft hit a slope of the Djebel Marra mountains four minutes before the crew expected to be overhead the El Fasher beacon where they would have begun the climb to 12 000 ft and when, in their belief, the aircraft should have been still more than 60 NM away from these mountains.

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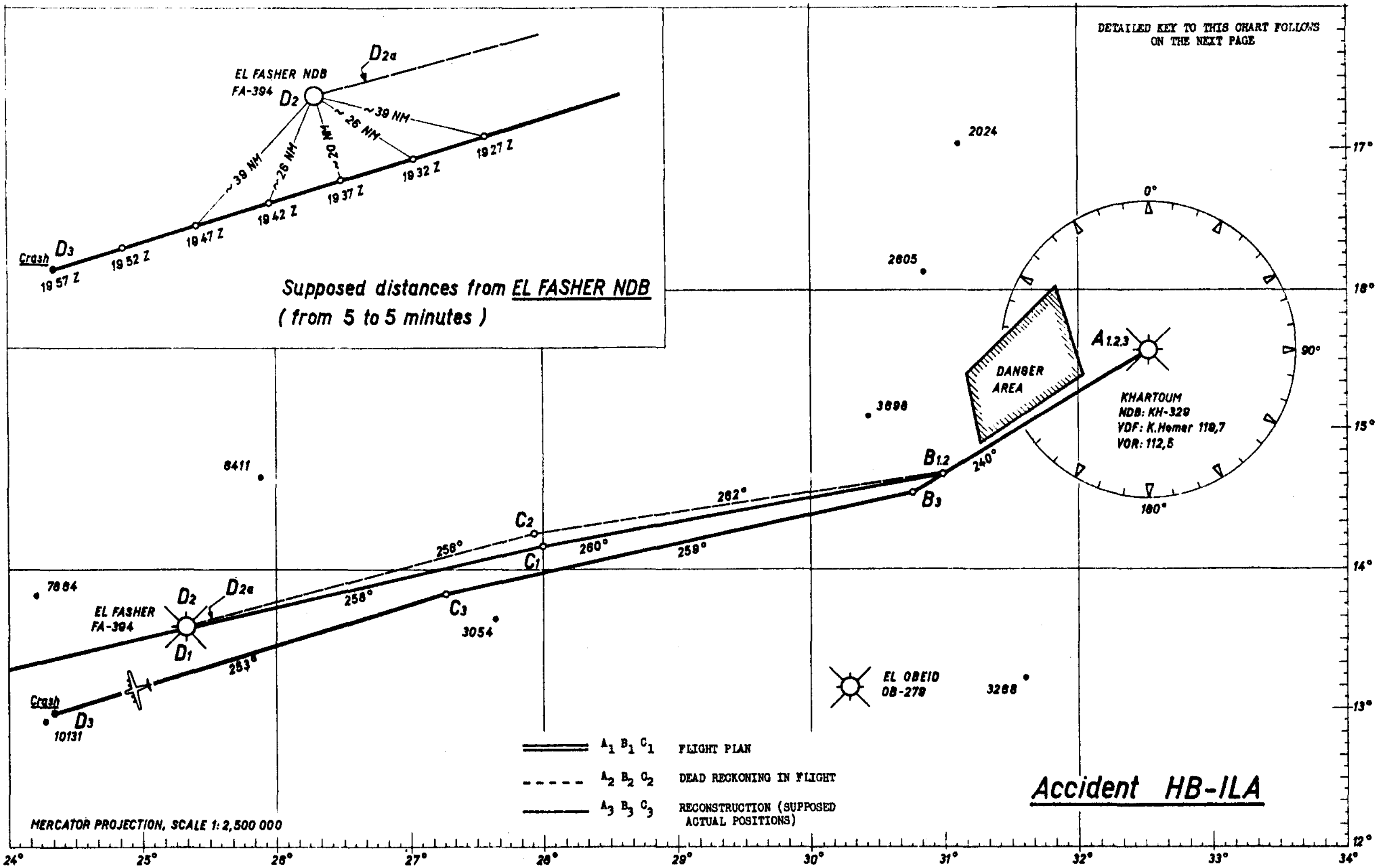
ICAO Ref: AR/652

FIGURE 8


DETAILED KEY TO THIS CHART FOLLOWS ON THE NEXT PAGE
EL FASHER NDB
FA-394
D2
D2a
~39 NM
~26 NM
~20 NM
Crash
D3
19 57 Z
19 52 Z
19 47 Z
19 42 Z
19 37 Z
19 32 Z
19 27 Z
Supposed distances from EL FASHER NDB
(from 5 to 5 minutes)
2024
2805
3898
6411
7884
3054
3288
10131
0°
90°
180°
A1.2.3
DANGER
AREA
KHARTOUM
NDB: KH-329
VDF: K.Hemer 119,7
VOR: 112,5
B1.2
B3
240°
262°
C2
C1
C3
256°
260°
259°
258°
253°
EL FASHER
FA-394
D1
EL OBEID
OB-279
A1 B1 C1 FLIGHT PLAN
A2 B2 C2 DEAD RECKONING IN FLIGHT
A3 B3 C3 RECONSTRUCTION (SUPPOSED ACTUAL POSITIONS)
Accident HB-ILA
MERCATOR PROJECTION, SCALE 1: 2,500 000
24°
25°
26°
27°
28°
29°
30°
31°
32°
33°
34°
12°
13°
14°
15°
16°
17°

ACCIDENT TO DC-4, HB-IIA, 15 MAY 1960 FIGURE 9

KEY TO CHART

I. FLIGHT PLAN

		Distance	Estimated Flight Time	Estimated Ground Speed
$A_{1, 2, 3}$	Khartoum Airport	—	—	—
$B_{1, 2}$	1440N 31E (first reporting point)	105 NM	0.44	climb 135 kt? cruise 175 kt?
C_1	1410N 28E (second reporting point)	177 NM	1.02	172 kt
D_1	El Fasher NDB ("FA") (third reporting point)	161 NM	0.55	175 kt

II. DEAD RECKONING IN FLIGHT

		Distance	Time GMT	Elapsed Time	DR-Ground Speed
$A_{1, 2, 3}$	Khartoum Airport	—	1726Z	—	—
$B_{1, 2}$	1440N 31E (first position report)	105 NM	1804Z	0.38 climb 15? cruise 23?	135 kt? 172 kt?
C_2	1415N 2756E (second position report)	181 NM	1906Z	1.02	176 kt
D_2	El Fasher NDB ("FA")	156 NM	est. 2001Z	est. 0.55	est. 170 kt
(D_{2a}	12 NM East El Fasher)	—	est. 1957	—	—

III. RECONSTRUCTION (supposed actual positions)

		Time GMT	Elapsed Time	Distance	Actual Ground Speed
$A_{1, 2, 3}$	Khartoum Airport	1726Z	—	—	—
B_3	1432N 3047E	1804Z	0.38 climb 15 cruise 23	120 NM 41 NM 79 NM	165 kt 205 kt
C_3	1350N 2715E	1906Z	1.02	212 NM	205 kt
D_3	crash point (1258 N 2420E)	1957Z	0.51	174 NM	205 kt

No. 35

Société Air Algérie, SE 210, Caravelle, F-OBNI, and University Aeronautical Club, SV 4C, Stampe, F-BDEV, in-flight collision near Orly Airport, France on 19 May 1960. Final report of the accident was released in Le Journal Officiel de la République française, dated 30 May 1961.

Circumstances

The Caravelle was on a scheduled flight from Algiers to Paris, carrying a pilot-in-command, two flight personnel, four cabin attendants and thirty-two passengers. The pilot was the sole occupant of the Stampe.

After passing the OE marker, the Caravelle, descending on a heading of 300/290, was starting its landing procedure for runway 20 Right at Orly; the Stampe, in level flight or slight climb on a heading of about 200, was coming from Challes and was to land at Saint-Cyr Airfield, passing round Orly Airport by the south. The collision occurred at 0946 hours GMT in visual meteorological conditions, at an altitude of about 1 000 m while the two aircraft were on approximately perpendicular headings, the Stampe being on the Caravelle's right. The Stampe was destroyed and the SE-210 substantially damaged. One of the Caravelle's passengers and the pilot of the Stampe lost their lives as a result of the accident.

Investigation and Evidence

The Aircraft

Both aircraft had valid certificates of airworthiness and had been examined by the Bureau Véritas early in 1960.

The Caravelle had flown approximately 316 hours. There was a partial breakdown of the automatic pilot in cruising flight, however, it appeared to have no bearing on this accident.

Since manufacture, the Stampe had flown 1 326 hours (1 hour since overhaul after an accident at Angers on 22 August 1959). It was not radio-equipped.

The Crews

Caravelle

The pilot and co-pilot had valid airline transport pilot licences valid until 4 November and 28 October 1960 respectively. The pilot had flown 6 131 hours, including 54 hours on SE 210. The co-pilot had 2 000 flying hours to his credit and had qualified on the Caravelle on 28 March 1960.

The flight engineer held a valid flight engineer's certificate and licence and had flown 6 800 hours, including 132 hours on SE 210.

Stampe

The pilot had a valid private pilot's licence and glider certificates A, B, C, D, E and partial F. He had flown 665 hours on aeroplanes and 255 hours on gliders. He had failed to obtain an instructor's rating because of inadequate theoretical knowledge, nevertheless, there was no doubt as to his seriousness and his practical qualifications as a pilot. It is certain that he considered himself responsible for the pilot who was following him and had organized his flight with that in mind.

Weather conditions observed at Orly

	0900 hours	
Surface wind	180°	10 kt
Horizontal visibility		30 km
Total cloud		4/8
Partial cloud	3/8 Ci at about 7 500 m 1/8 Ac at about 4 000 m 1/8 Cu humilis 850 m	

		1000 hours
Surface wind	180°	12 kt
Horizontal visibility		30 km
Total cloud		3/8
Partial cloud		1/8 Ci at about 8 000 m 1/8 Ac at about 4 500 m 2/8 Cu 1 100 m

A cross-section of cloud (0-2 000 m) for the Orly area was drawn up by the National Meteorological Service, indicating small cumuli in evolution with base about 1 000/1 100 m at the time of the collision.

In its weather description Orly noted: "Between 0800 and 1040, Cu humilis and Cu mediocris climbing and evolving, turning to Cu congestus."

Reconstruction of the flights which resulted in the collision

The following reconstruction of events preceding the accident is based on examination of the aircraft, a preliminary study of the tape of the Caravelle's recorder, recordings of the communications between Orly control tower and the Caravelle, and the statements of the crew of the Caravelle as well as those of the pilot of a second Stampe who saw the accident.

Caravelle

After a normal trip out of Algiers radio communications were discontinued with the Paris control centre (procedure Juliett*) and the aircraft reported to Orly It was cleared to enter the pattern in descent in visual flight for a landing on runway 20, rounded the OE marker in descent and prepared to make its last turn before final approach.

At a level of about 3 600 ft, with air brakes extended, rate of descent reduced (1 500 to 1 000 feet per minute), decreasing airspeed (260 kt) in order to extend the flaps, after emerging from the cloud cover the aircraft had just passed the OE marker and was on a heading of 300/290. The pilot-in-command was attempting to catch sight of a Convair on his left (in communication with the tower and also on approach for runway 20 Left), as well as of his runway, for the last turn into alignment. The co-pilot, while preparing to display his heading data, at that moment saw a light aircraft, green in colour, in the right fore sector, slightly high and very close; despite his action of pushing on the control column, collision followed immediately. The accident occurred 13 km from the Orly tower.

The Stampe was shattered, and the wreckage fell to the ground. The cabin roof of the Caravelle was torn open, and the engine of the Stampe was thrown inside.

The two jet engines, which were on a descent setting of 5 100 rpm were stopped by the débris absorbed and the damage caused to them, particularly on the right, where a wheel of the Stampe wedged in the intake. (The Caravelle's tail parachute, opened by the impact, was automatically released.)

The engineer was successful in restarting the engines, obtaining 8 000 rpm on the left and 5 000 rpm on the right.

The aircraft, with its radio out of commission, completed its approach and landed without further manoeuvring difficulties at 0950.

Stampe

Another Stampe aircraft, (herein called Stampe No. 2) had departed Chelles aerodrome at the same time as Stampe F-BDEV and was following F-BDEV at a distance of about 300 m on the left rear,

* an experimental jet holding and approach procedure

on a compass heading of about 200°. The sky was clear at that time except for a few isolated clouds and the visibility was excellent, when the pilot of Stampe No. 2 suddenly saw the Caravelle ahead of him and to his left.

At no time did he feel that F-BDEV and the Caravelle might collide. His only reaction was to wonder whether the latter would pass in front of or behind F-BDEV. It appeared to him that neither aircraft changed its course up until the time of impact which was marked by the appearance of a cloud of wreckage around the Caravelle. According to the statement of this witness, there seems to have been a maximum time lapse of 5 - 10 seconds between the moment when he first saw the Caravelle and that of the collision. His altimeter read 800 m, a figure which, when corrected, substantially agreed with that recorded on the Caravelle one minute after impact.

Remarks

In the course of their work, the investigators inquired into a number of points which, though their importance in or bearing upon the accident may vary in degree, nevertheless require statement.

Aerodrome surveillance radar

At the time of the collision the Orly aerodrome surveillance radar was under repair. However, it is far from certain that its normal use would have made it possible to avoid such a collision, since the echo of a Stampe is not as stable as would be desirable on the radar scope.

In addition, television relay to the tower of the ACC's 23 cm navigation radar is not normally usable at less than about 15 km from Orly.

Sounding of alert and rescue operations

As the damage to F-OBNI had caused failure of the transmitting system and the tear in the fuselage was on the side away from the tower, the alert could only be given — and was given, incidentally, by the local control officer — once the aircraft was on the runway. Furthermore, the accident occurred at the time of Mr. Khruschev's departure, a circumstance which caused some difficulty in organizing assistance.

International NOTAM of 14 May, international No. 513, national No. 6372

At the time of Mr. Khrushchev's presence in France, a notice to airmen (not applicable to French or foreign airlines for departure or arrival at Orly) prohibited flying, from 14 May at 1100 hours and until further notice, within the airspace comprised between 0 and 1 000 m above the Department of Seine-et-Oise, between national highways Nos. 7 and 19.*

On the basis of the statements of the commander of Chelles aerodrome, which duly received this NOTAM and displayed it, it is almost certain that the pilot of the Stampe (F-BDEV) was aware of the prohibition, and indeed it seems that if his course were liable to take him into the area in question, he would probably have crossed it above the altitude of 1 000 m**. It

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* It may also be noted that on its own initiative, Orly aerodrome had had all flights to Lognes suspended on the Thursday morning because of Mr. Khrushchev's departure.

** It is, of course, absolutely impossible to determine whether the altitude chosen by the Stampe pilot was selected in accordance with the prescriptions of the NOTAM or whether, as is equally likely, the pilot, in view of the existence of visual flight conditions, considered it safer for the young pilot following him, for whom he felt responsible, to stay high enough for easy navigation and greater safety in case of difficulty.

should in any case be noted that the accident occurred outside the airspace prohibited by the NOTAM.

Nevertheless, an important point arises from the fact that this NOTAM was issued in pursuance of a prefectoral order taken on the sole initiative of the Prefect of Seine-et-Oise and communicated by telephone to the air navigation service on 14 May at 0930, to apply at 1200.

It is thought regrettable that the civil aviation services were not consulted with reasonable notice, and attention must again be drawn to the fact that the interministerial decision prescribed for application of the order of 7 October 1948 (RAC-4-201), Article 4, was still not signed at the date of the accident, and that this has caused innumerable incidents.

Relative closing speed of the two aircraft and difficulties in the avoiding action

The investigation revealed that the collision occurred at an angle of about 13° to the F-OBNI axis, at a relative closing speed of the order of 150 m/s. In addition, the following remarks should be taken into consideration:

A) As a first approximation, it may be assumed that the image of the Stampe (profile 7m) on the windshield situated at 0.70 m from the eye of the observer will be given by:

$$\frac{i}{0.7} = \frac{7}{d} \quad \text{or} \quad i = \frac{4.9}{d}$$

So that:

- at a distance of 1 500 m (10 seconds before collision), the image measured about 0.35 cm;
- at a distance of 750 m (5 seconds before collision), the image measured 0.7 cm;
- at a distance of 150 m (1 second before collision), the image measure 3.5 cm;
- at a distance of 75 m (1/2 second before collision), the image measured 7 cm;
- at a distance of 35 m (1/4 second before collision), the image measured 12 cm.

B) In addition, if it is assumed that the average time for attentive scanning of the horizon visible from the Caravelle's cockpit is of the order of 10 seconds, and further, that the 0.7 cm image (5 seconds) is the first that could reasonably be perceived, there is very little chance that the pilot's eyes could rest precisely on that image of 0.7 cm and that he could have the entire 5 seconds available to evaluate headings and attempt avoiding action.

C) In addition, the fields of vision of both pilots were reduced by blind areas which could not be disregarded. On the Caravelle, the windshield frame cut off a sector within 12 to 16°, precisely the bearing of the Stampe (12 to 13°). In the Stampe, from the rear seat, the pilot's vision may have been decreased by his upper wing and his struts.

D) The presence of isolated clouds may also have contributed to concealing the two aircraft from each other. Also noteworthy is the azimuth of the sun, which, seen from the Stampe, was very nearly in the same direction as the Caravelle and 52° above the horizon.

E) Finally, it may be assumed that the times required for perception and identification of the image of another aircraft, estimation of headings and recognition of the risk of collision, then for the decision as to manoeuvres to be attempted, to say nothing of the reaction time of the aircraft itself, were likely to take up the major part, if not the totality, of the five-seconds lapse referred to above.

In exceptionally favourable conditions, with unused time reduced to a minimum, it does seem possible to conclude that the collision is unconnected with the avoiding action when the duration of the latter is less than 4 seconds.

Such being the case, it may be wondered what chances there were for each aircraft to observe the other and to take effective avoiding action.

A study of the circumstances of the Orly collision makes it seem likely, taking acccount of the above remarks, that no effective avoiding action, as of the moment when the two pilots could have seen each other, would in practice have made it possible to avoid the accident.

Analysis

The Stampe, F-BDEV, was flying in visual meteorological conditions under visual flight rules.

The Caravelle was also flying in visual meteorological conditions, but under instrument flight rules modified by a clearance for visual descent.

The point of collision is situated outside the geographical boundaries of the Orly reserved area* and within or at the boundary of the Orly-Brétigny control zone, which the meteorological conditions (VMC) permited the Stampe to enter.

The Caravelle crew were on the last turn before final approach, therefore in a delicate phase of flight; furthermore, in addition to the sight of the runway on his left, the pilot-in-command had to watch for another aircraft (Convair) landing on a parallel runway.

The NOTAM issued on the initiative of the Prefect of Seine-et-Oise was most probably known to the Stampe pilot. However, the pilot's intentions will remain unknown, and in any case, the collision occurred outside the area covered by the NOTAM.

The blind areas in the fields of vision of the two pilots may have prevented each one from perceiving the arrival of the other aircraft.

The small size of the Stampe and its colours (dark green and dull silver) presenting no brightness contrast against the ground, did not permit it to be distinguished by an aircraft coming from a higher altitude - even at a relatively short distance.

The azimuth of the sun at the time of the collision certainly constituted a hindrance for the Stampe pilot if he was looking in the direction of the Caravelle. The presence of scattered cloud may also have created a further hindrance.

Avoiding action taken less than five seconds before the collision actually occurred would not have been adequate to avoid it.

The collision altitude, as supplied by the recording tape, was of the order of 3 600 ft (setting 1 013 mb). RAC 1-4-02 stipulates:

"Except when climbing or descending, or except as otherwise provided by the appropriate authority, VFR flights conducted above the higher of the two following levels:

"a) Level corresponding to the reading 900 m (3 000 ft) on a pressure altimeter set to the reference pressure of the area in which the flight takes place (QNH or 1 013.2 mb);

"b) Level situated 300 m (1 000 ft) above the ground or water, shall be conducted in accordance with the rule of quadrantal levels corresponding to the magnetic track, as specified in Appendix C, using the altimeter setting proper to the areas in which the flight takes place."

The quadrantal sectors are 089 to 179° for 3 500 ft and 179 to 269° for 4 000 ft. Observation of quadrantal sectors did not

* at present in the course of amendment

apply for the Caravelle in descent for its approach.

The coordinates of the track of the Stampe (altitude/heading) are not accurately known and may give rise to interpretation. Possibly, F-BDEV may have been slightly climbing, in transition between the altitudes for the two quadrants.

Conclusions

Literal application of the Rules of the Air (RAC 1-3-02) elicits the statement that it was incumbent on both pilots-in-command to avoid collisions and that the pilot of the Stampe, being on the right, had the right-of-way (RAC 1-3-02 of 1 July 1959).

However, the results of the inquiry, set forth above, lead to the contention that such regulations are no longer adapted to the speeds and procedures practiced in airspace used by jet aircraft, the pilots of which cannot be sure of avoiding any risk of collision by visual means alone.

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ICAO Ref: AIG/ACC/REP/GEN/No. 5 - France

No. 36

Delta Air Lines, Convair 880, N 8804E, accident during take-off at Atlanta, Georgia, on 23 May 1960. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 1-0084, released 18 January 1962.

Circumstances

Flight 1903 was a training flight in order to give flight instruction to two captain-trainees prior to their checkout in the CV-880. The instructor-pilot was in the right (co-pilot's seat) and one of the trainees was in the left-hand seat. Also aboard were a second captain-trainee (in the observer's seat) and a flight engineer. Immediately after lift-off the aircraft assumed an extremely nose-high attitude and banked steeply to the left. It then rolled to a vertical right bank, the nose fell through, and the aircraft struck the ground. All four crew members were fatally injured in the accident which occurred at 1152 hours eastern standard time.

Investigation and Evidence

Reconstruction of the take-off

The training curriculum required that failure of an outboard engine at V_1 during take-off be simulated on this flight. It was not unusual to simulate this three-engine take-off at the Atlanta Airport.

N 8804E started its take-off roll at approximately 1151 hours. Acceleration appeared to be normal and the aircraft rotated at a point just west of the intersection of runway 27 and a taxiway paralleling runway 21 about 3 450 ft from the threshold. The liftoff appeared to be normal and at a point on the runway opposite the new fire station which is approximately 4 425 ft from the threshold. (Runway 27 is 7 860 ft long).

Within a few seconds after liftoff the attitude of the aircraft changed from normal to an angle of pitch described by many qualified witnesses to be as much as 45°. This abrupt nose-up was followed by a lowering of the left wing to an angle of bank estimated as 20°, and a change of heading to the left of about 45°. Witnesses described the flight of the aircraft at this point as a "left skid" or "slip" with the nose still extremely high. Next the aircraft rolled from the left bank to a vertical bank to the right. In this vertical right bank the nose fell through, and the right wing contacted the ground followed immediately by the nose of the aircraft. As the breakup progressed an intense fire developed which largely consumed the wreckage.

Wreckage examination

All aircraft systems and instruments were examined and no failure or irregularity was found. It was determined that the landing gear was fully extended and locked. The wing flaps were extended symmetrically to 20°. The spoilers were operable and the stabilizer was set 4-1/2 to 5° noseup. Information obtained from the remaining systems or instruments, i.e., engine performance gauges, etc., was determined to be unreliable because of the probability that impact forces would change the indications.

Examination of the wreckage did not reveal any evidence of structural failure prior to impact. In addition, no malfunction or failure in the control surfaces, control cables, or systems was found which could have caused or contributed to the unusual flight attitudes described by witnesses.

Examination of the engines showed that at impact Nos. 1 and 2 were producing thrust at an engine speed of at least 96%

rpm. There were indications of considerable damage and metal spatter from internal interference within the engine which occurred as breakup progressed and rotating parts were forced into stationary sections of the engines.

At impact engines No. 3 and 4 were operating at reduced speeds. There were no indications of pre-impact mechanical failure or malfunction in any of the four engines.

The CV-880 Training Programme and Related Incidents

The Delta Air Lines captain training programme for the CV-880 consists of 120 hours of ground school instruction following which each student must pass a written examination. Each captain-trainee then receives a minimum of 13 hours instruction in the CV-880 simulator and a minimum of 12 hours flight training. As in the simulator training, each captain is given practice in take-off procedures with one engine out at V_1, V_R* and V_2. In addition, practice is given in operation with two engines "out" with the second engine being "failed" after take-off at traffic-pattern altitude.

Several previous incidents during which heavy yaw rolling tendencies were encountered in the training programme were investigated. All were found to have involved simulated failure of an outboard engine at V_1. Testimony indicated that a directional oscillation developed with coincident rolling tendency after an initial yaw toward the "cut" engine. No extremely nose-high attitude was associated with any of these incidents. Recovery even in the most severe case was easily effected by nosing the aircraft down sufficiently to allow speed to develop. The instructor-pilot of the subject flight had been aboard during several of these incidents.

Analysis

The Board could not determine the reason for the abrupt "nosing up" of the aircraft shortly after liftoff. In its investigation the Board reviewed the manufacturer's performance records, flying qualities, and capabilities of the CV-880. No unusual or unsafe characteristics were noted, and nothing was found which could account for this unusual flight attitude.

It appears certain that the aircraft was in a stalled condition while in this extreme nose-high attitude. It also appears certain that a large amount of yaw to the right was present along with considerable skid or slip. In swept-wing aircraft these conditions can create an uncontrollable rolling moment to the right. Briefly, this is a result of greatly increased lift generated by the advance wing, coupled with a large decrease in lift on the retreating wing. The Board believed the description of the "flight path", as derived from witness statements, is entirely consistent with this assumption.

It is believed that the take-off incidents which involved heavy rolling immediately following liftoff were the result of overcontrolling by pilots unfamiliar with the extremely sensitive lateral control of the Convair. Again, nothing was found in any of these incidents which could help explain the accident, except that all occurred at low speeds on take-off with one engine out.

Several witness observations indicated that the No. 4 engine was throttled prior to liftoff. Under normal procedures for a training flight such as this, it is possible that an engine would be throttled after V_1 speed had been reached to simulate engine failure. Moreover, it is most likely that an outboard engine would be the one "cut", because its loss is more critical during this regime of flight. For these reasons,

* V_R = the rotation speed

and the fact that on impact No. 4 engine was at flight idle (66%), the Board believed it reasonable to assume that the No. 4 engine was throttled prior to liftoff. This condition is also consistent with the initial left wing-down attitude as a result of over-controlling, and was probably the reason a large degree of yaw developed.

The amount and distribution of fused metal found in the engines can be related directly to the temperatures at which the engines were operating. The minimum turbine inlet temperature necessary to fuse metal to the inlet guide vanes and turbine blades ranges from 750° to 850°F. Temperatures at least this high were therefore present in Nos. 1 and 2 engines. The amount of fused metal found in engine No. 4 was considerably less and that in No. 3 was the least of all four engines. The stabilized turbine inlet temperature at flight idle (66%) is 850° to 900°F. These temperatures are sufficient for fusion; however, the engine speed and airflow within the engine during breakup would be less and would account for the lesser amount of metal found in engine No. 4.

At 79% engine rpm stabilized turbine inlet temperature is from 850° to 915°F. During engine deceleration the transient temperature will fall below the given values at flight idle and rise to normal when engine speed has stabilized. The average time required for engine temperature to stabilize during deceleration from 103% to 79% is four seconds. Based on the lesser amount of fused metal, as compared to the other engines, it appears that temperatures in No. 3 were below those at stabilized flight idle. This indicates the engine was in a decelerating condition at the time of impact. It appears probable that this deceleration occurred within about two seconds during impact. This appears likely because if the engine had been cut as much as four seconds before impact, the temperature would have been stabilized in the 850° to 915°F range.

All attempts to correlate this information to the flight path of the aircraft are again irreconcilable. It is estimated that for at least five seconds prior to impact, the aircraft had to be in a rolling condition from a left to right bank. The final three seconds of flight must have been in a right wing-down attitude. Therefore, it appears that the engine cut on No. 3 would have to have occurred while the aircraft was rolling to the side on which power had already been reduced (No. 4 was at flight idle at liftoff). The Board believed it doubtful that No. 3 was retarded intentionally at this time because this would greatly increase the asymmetry of power and aggravate the yaw and tendency to roll to the right. It is also unlikely that the throttle was closed inadvertently.

Crew Information

The instructor-pilot held a valid FAA airline transport pilot's certificate with ratings for the DC-3, DC-4, DC-6, DC-7, Convair 340, Lockheed Constellation, C-46, DC-8 and Convair 880. He had flown a total of 13 197 hours of which 273 were in the DC-8 and 227 were in the Convair 880. His total jet experience of 500 hours included 208 hours of instructor-pilot time in the DC-8 and 179 hours of instructor-pilot time in the CV-880.

The pilot-trainee (in the left-hand seat at take-off) held a valid FAA airline transport pilot's certificate with ratings for DC-3, DC-4, DC-6, DC-7, Convair 340, Lockheed Constellation and DC-8. He had flown a total of 17 221 hours of which 14 were in the DC-8 and 10 were in the Convair 880.

The flight of 23 May would have completed his flight training in the CV-880 and would have prepared him for a type rating check-ride in the aircraft.

He had passed his most recent first class medical examination on 23 December 1959. At that time an electrocardiogram examination was given to him and noted as satisfactory. Immediately following the accident of 23 May an autopsy was performed which disclosed that his heart exhibited atherosclerosis to a marked degree. This condition was found to have decreased the inside diameter of the left main coronary artery of the heart 70 - 90 per cent; the circumflex coronary artery 25 - 100 per cent with evidence of an old occlusion; and the right main coronary artery 50 - 80 per cent.

In further study of this accident the Board attempted to determine if this captain had any history of heart trouble. None of the doctors known to have treated him, including an insurance doctor, had knowledge of this condition. In addition, several of his electrocardiographs were examined, and no abnormalities were present. Further, no evidence could be found from autopsy to indicate incapacitation as a result of a coronary thrombosis or infarction. Although the captain's atherosclerosis was considerably advanced for his age, the Board could not find evidence to support any sudden incapacitating condition on which to base a finding of probable cause of this accident.

Probable Cause

The probable cause of this accident was the stalling of the aircraft for reasons undetermined at an altitude too low to effect recovery.

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ICAO Ref: AR/692

No. 37

Trans-Australia Airlines, Fokker Friendship F-27, VH-TFB, descended into the sea near Mackay Airport, Queensland, Australia on 10 June 1960. Report, dated 8 December 1960, released by the Minister of Civil Aviation, Australia.

Circumstances

The aircraft was on a regular passenger flight from Brisbane to Mackay via Maryborough and Rockhampton. It was approaching Mackay Airport for a landing carrying a crew of 4 and 25 passengers when it descended into the sea 7-1/2 miles southeast of the Airport, at approximately 2205 hours eastern standard time. There were no survivors.

Investigation and Evidence

The Aircraft

A Certificate of Airworthiness for the aircraft was renewed on 27 May 1960 and was valid until 26 May 1961. VH-TFB was owned by the Australian National Airlines Commission and operated as part of Trans-Australia Airlines.

The Crew

The captain had sixteen years' experience as a pilot both with the Royal Australian Air Force and Trans-Australia Airlines. In August 1959 he was appointed as training captain for F-27 aircraft, and in November 1959 he became a check captain on this aircraft type*. At the time of the accident his first class Airline Transport Pilot's Licence was valid as was his first class Instrument Rating for various types of instrument flying. His total flying hours then amounted to 10 687, including 7 756 hours in command and 695 hours on Fokker F-27 aircraft. He was a fully trained, competent and experienced captain of high repute.

The co-pilot held a current and valid second class Airline Transport Pilot's Licence for Fokker F-27 aircraft, as well as a second class Instrument Rating endorsed for certain types of instrument flying. His total flying experience on the day of the accident amounted to 2 428 hours, including 247 hours as first officer on F-27 aircraft. These hours included 185 hours of night flying, of which for approximately 11 he had been in command, and for 174 hours he was first officer. On the flight of 10 June he was to undergo a proficiency check.

Evidence established that at the time of the accident both the pilot and co-pilot were fit and well, and there was nothing to suggest that there was any defect in their physical or mental condition which could in any way have contributed to the accident. There were no grounds for suspecting that they did not remain alert throutout the flight from Brisbane to Mackay.

Two stewardesses made up the remainder of the crew.

The Flight from Brisbane to Mackay

The aircraft departed Brisbane at 1711 hours and arrived at Maryborough at 1752. It then took off at 1812 on the next portion of the trip to Rockhampton where it landed without incident one hour later. Just prior to the landing at Rockhampton, the aircraft was advised of a special weather report which indicated shallow ground fog a at Mackay to a height of 20 ft with a visibility of 880 yd, and also that an alternate aerodrome would be required for the rest of the flight.

* with some 10 300 hours of flying experience of which 318 were on F-27 aircraft.

The aircraft was refuelled at Rockhampton and on take-off had a total of 700 gallons on board making its endurance 260 minutes. This was sufficient for a reserve of 208 minutes after the flight to Mackay; the flight from Rockhampton to Mackay being 52 minutes.

At Rockhampton the aircraft's take-off weight was 35 275 lb as against a maximum permissible take-off weight of 36 225 lb. The centre of gravity was within limits.

While the aircraft was still on the ground at Rockhampton the air traffic controller at Mackay issued a second special weather report at 1940 dealing with the presence of fog in which visibility was said to be fluctuating.

The flight departed Rockhampton at 1952 hours at which time the captain was occupying the left-hand seat. On departure the air traffic controller at Mackay was advised that the expected flight time to Mackay was 52 minutes at an altitude of 13 000 ft, that Townsville had been selected as the alternate and that the expected flight time from Mackay to Townsville was 55 minutes. The aircraft carried sufficient fuel (in addition to reserves) for these operations and for 100 minutes holding flight at Mackay, if necessary.

At 2017 the aircraft reported at the prescribed reporting point, Charon Point, 80 miles south of Mackay at 13 000 ft and gave its estimated time of arrival at Mackay as 2040. It was advised that Mackay Airport was closed to landings at that time, and the situation remained the same when the aircraft reached the point at which it would normally have commenced its descent to Mackay. The captain indicated that he would continue the flight at 13 000 ft and would hold over Mackay at that altitude.

At 2040 the aircraft reported over the top of Mackay and advised that he then had sufficient fuel for at least 100 minutes over Mackay. (Although the ATC Officer at Mackay believed that the communications at this time were between himself and the captain of the flight, the evidence did not enable the Chairman of the Board of Inquiry to reach a firm conclusion in this regard. Therefore, communications to the "pilot" mean either the captain of the co-pilot).

2045 ATC Officer advised the pilot that visibility was fluctuating between 2 and 2-1/2 miles along runway 14-32. The pilot replied that the airport lighting, the city area, and the surrounding country could be clearly seen, but that a belt of fog extending about 10 miles was situated to the southwest of the airport and was moving in a slightly northeasterly direction across the airport. The pilot then requested landing instructions.

The aircraft was cleared to make a visual approach with a view to landing on runway 14. The pilot was provided with details of wind velocity, QNH and the dry bulb temperature and was requested to report final approach. The instructions were acknowledged, he reported on final approach, and at 2055 the aircraft was cleared to land. At this time the control tower was in sight, and the visibility was such that the ATC Officer fully expected that a landing would be made.

As the aircraft approached close to the runway threshold at a height of about 50 ft, the pilot advised that a small patch of fog had suddenly appeared on the approach to the runway. It then flew along the runway at a height of approximately 50 ft and commenced to climb away. The pilot advised that he would look at the approach to runway 32 which is the same runway approached in the opposite direction.

The failure to land was a normal procedure in view of the conditions which prevailed. Any ground fog at low level along the line of the runway might appear much more of a hazard to the pilot than to the ATC Officer, who viewed the area from a different angle. The ATC Officer did observe that the aircraft's lights went slightly hazy as it broke off the approach.

The ATC Officer next observed the aircraft descending to approach runway 32. It reached a height of approximately 200 ft, but before crossing the threshold it began to climb along the line of the runway, and the pilot requested permission to hold over Mackay at 5 000 ft until an improvement in the weather occurred. This procedure was approved. The aircraft continued to hold over Mackay until about 2200.

(Throughout the intervening period there were frequent exchanges of information between the pilot and the ATC Officer as to the fog patches. From the airport it was observed that during this time visibility fluctuated between 3 miles and 400 yd. At 2140 it was reported by the pilot that the fog was clearing, and it was estimated that it should be clear of the field in about 20 minutes.)

At approximately 2202 the ATC Officer noted the conditions improved rapidly and visibility was continually improving. When the aircraft was thus informed, it replied: "Roger tower, will commence let down to approach on runway 32". The aircraft was cleared for a visual approach and was given the wind (calm) and QNH (1019 mb) and was asked to report on final approach. The ATC controller then confirmed with the fire crew that the dry bulb temperature was 13°C and passed the information to the aircraft twice (between 2200 and 2205). These messages were not acknowledged, and the Distress Phase was declared at 2210 hours eastern standard time.

Witnesses

The pilot said he would hold at 5 000 ft, and there was no evidence to support a conclusion that he did not hold at that height. Witnesses, who observed the aircraft in the course of its final descent, supported the view that there was nothing apparently abnormal in its rate of descent. A descent at a rate of about 1 000 ft/min down to that height from where an approach to land may commence is normal. The evidence as a whole justified the conclusion that the aircraft descended from 5 000 ft at about that rate.

The ATC Officer's recollection of the times indicated that the pilot commenced his final descent at about 2202 hours. If the aircraft was then at 5 000 ft, the rate of descent was somewhat abnormal and at a figure not consistent with other evidence. The Chairman stated that the evidence did not support the view that the pilot commenced his descent from a lower altitude.

The Chairman accepted 2210 as the time when the Distress Phase was declared, but for the rest, the crucial times given by the ATC Officer were estimates based upon his recollection of events, the precise times of which as they occurred he had no occasion to record, and which in the anxious time which followed he might be unlikely to recall with complete accuracy that night.

There was some evidence to support the view that a somewhat longer period than was suggested by the ATC Officer's evidence ensued between the aircraft's last communication and the ascertainment and transmission of the current dry bulb temperature reading.

It was concluded, following a consideration of the evidence, that the accident occurred at about 2205 hours and that the aircraft had descended from its holding altitude to sea level within a period of five minutes.

All radio navigational aids and airport lighting facilities were functioning satisfactorily.

The ATC controller properly performed all his duties in relation to the aircraft and is entirely free of any blame or suspicion of blame in relation to the accident.

The Final Descent

The holding flight over Mackay, which continued for about one hour, was observed by a number of local residents who were interviewed by the investigation team. The observations proved useful in determining the course flown by the aircraft in its final descent. From this and other evidence it became possible for the team to plot with some degree of accuracy the course taken by the aircraft in its final descent. The assumed course so plotted involves certain assumptions as to the height from which the final descent was commenced as well as the speed of the aircraft and its rate of descent. The assumptions so made were consistent with the available evidence, including conclusions drawn from the examination of the wreckage. With the exception of one witness, nothing abnormal was observed prior to the disappearance of the aircraft.

One woman testified to having seen what she described as a "red glow". What the witness described as a red glow may have resulted from an impression created by a particularly clear view of the rotating red beacon on the aircraft which she had seen previously. There was no evidence to support any conclusion that the descent into the sea was preceded by any signs of fire or explosion. On the contrary, the evidence supported the view that the descent was the regular descent of an aircraft in the vicinity of an airfield on which it was proposed to land. However, it does appear that the aircraft was as low as 500 ft when observed flying over the water within a minute or so of the accident. All this points to the conclusion that the cause of the accident is to be found, if at all, in something that occurred within the last two or three minutes of the flight.

Wreckage

The main portion of the wreckage of the aircraft was discovered on the sea bed on a true bearing of 154°, 5.63 nautical miles from Flat Top Island. The location was about 7-1/2 miles from the airport.

Soon after the accident the services of the Royal Australian Navy were offered to the Department of Civil Aviation to undertake the salvage of aircraft wreckage from the sea bed. This offer was accepted. The work was conducted with great care and skill, and a very large percentage of wreckage was successfully recovered.

It was the view of the Director of Air Safety Investigation that the portions not recovered appear to have no significant bearing on the cause of the accident.

Under the skilful direction of the Director of Air Safety Investigation, the work of establishing, collecting and collating facts from the examination of the wreckage and the study of testimonies of witnesses was performed by arranging the investigating team into working groups comprising the appropriate specialists and experts from the Department of Civil Aviation and Trans-Australia Airlines.

Each group received assistance as required from technical experts from the aircraft and engine manufacturers and from scientific or technical organizations by way of reports on specific examination of materials or components taken from the wreckage. The examination of wreckage was extremely thorough and the investigations extended from 11 June almost up to the date of the commencement of this inquiry (4 October 1960).

The complete report of this investigation was submitted to the Board and from that material and the evidence of witnesses concerned in the investigation, it was possible to reach a number of conclusions in relation to the probable course followed by the aircraft prior to impact and as to the condition of the aircraft at the time of impact.

Results of Technical Investigation

Power plant controls

They appear to have been fully serviceable before the impact, and the engines appear to have been under power at the moment of impact. It seems likely that the engines were operating at or about 10 400 rpm.

Propeller mechanisms

At the time of impact the angle of the blades was 33-3/4 degrees. This supports the view that the aircraft at the moment of impact was travelling at a speed of not less than 160 kt. 10 400 rpm would produce such a speed with the blades at such an angle. Experts who examined the aircraft's structure believed that the forward velocity would have not been less than 120 kt. This is consistent with the deduction drawn from examination of the propeller mechanisms.

From the evidence of those who examined the aircraft's structure, it may be deduced that the aircraft probably struck the water in a flat attitude between 5^{o} nose up and 5^{o} nose down, and banked to starboard at an angle of between 5 and 10 degrees. This deduction is consistent with the character of the final descent as observed by eye witnesses. Examination of the structure also led to the conclusion that the descent had been at not less than 900 ft/min.

Flight Control Systems

Examination of these systems indicated nothing to suggest that any part of the systems was not functioning correctly prior to the accident. At the time of impact, the flaps and landing gear were in the fully retracted position. Examination of the fuel, water methanol, pneumatic, oxygen, fire protection, anti-atmospheric, de-icing, pressurization and air conditioning systems revealed that they were fully serviceable with the exception of insignificant items.

Electrical equipment

No evidence was found that any of the electrical systems were not functioning correctly at impact. The expert responsible for the examination of the electrical equipment was of the opinion that there was positive evidence that the systems were functioning since so many circuit breakers were tripped. He maintained that electrical power must be applied to the circuits before the circuit breakers could trip. He considered it was impossible that the circuit breakers would have been tripped before the impact. One feature of this expert's evidence raises a matter of concern. It was found that the emergency inverter switch was on, and his opinion was that it had probably been deliberately switched on before the impact and not knocked on by forces generated by the impact. The emergency inverter provides an emergency power supply to some of the instruments on the captain's, or port side of the aircraft, and if it were on before impact it would suggest that the captain became aware of an emergency before the aircraft hit the water. It cannot, however, be determined with certainty that the emergency inverter was not switched on as a result of the impact and the damage which followed it. Observation of some of the relevant damage supports this latter possibility.

Cockpit

In the cockpit it was found that a number of the services for the port side facilities were switched off and a number on the starboard side were found switched on. This was so in relation to the electrical power generators, the pitot heaters, fuel filter heaters, and the engine intake, propeller, and wing air intake de-icing. It was not possible to reach a definite conclusion as to whether this situation was brought into being before the accident or as the result of forces generated by and after impact. One suggestion was that as on this flight the first officer was to undergo a proficiency check, and the captain, in the course of the final descent, asked him to assume some emergency and to carry out the operation to the point of moving the switches. It would be contrary to the usual practice, if such an exercise were in operation, that the captain would require the first officer to go to the length of activating the switches. Furthermore, the position of the switches as found does not conform to any known emergency procedure.

Instruments

The starboard and port clocks had stopped at 1005 and 1007-1/2 hours respectively. It was believed that the starboard clock's time indicated, with relative accuracy, the time of impact.

From the radio magnetic indicators it was possible to deduce that at the time of impact the heading of the aircraft was between 255 and 260 degrees. Both the port and starboard static pressure systems were selected to their normal static sources. Apart from certain abnormal dips and bends in the port and starboard pitot static lines, all damage to that system was consistent with forces generated by the impact. There was no evidence to indicate any malfunctioning of any of the instruments examined.

On examination it was noted that the port altimeter read 1 160 ft and the starboard altimeter read 7 800 ft. In view of the fact that the aircraft appears to have hit the water at a time when one would have expected its altitude to have been about 1 200 ft, it might be thought that the reading on the port altimeter is of some significance. The examiner was satisfied that it was not significant. It appeared that both altimeters had been accurately set to a barometric setting of 1019 mb which was the barometric pressure reading passed to the aircraft immediately before the accident.

Conclusions reached by the Director of Air Safety Investigation

A) No evidence was found of material or structural defects having existed prior to the accident, and all damage evident to the structure of the aircraft can be attributed to forces generated by impact with the water.

B) There were only three items of minor unserviceability discovered in the wreckage. It was not felt that they had any bearing on the accident. All other damage or abnormalities relating to the aircraft systems has been attributed to the forces involved in the impact.

The three items of minor unserviceability were -

a) one of the two 3/16" diameter bolts securing the down lock limit stop on the port main landing gear was sheared, probably as the result of being overtightened during maintenance. This appeared to have no adverse effect on the serviceability of the unit;

b) a bolt 1/8" in diameter and 5/8" in length was found in the body of the drain valve of the port fuel tank. Its only significance is in relation to an incident at Rockhampton where the port drain valve stuck open during refuelling operations and two gallons of fuel drained from the tank before the valve was reseated. It is clear the valve was seated properly at the time of the accident;

c) a pipe 1/8" in diameter which connects the blower duct and the pressure transmitter in the air conditioning system on the port side was found to be fractured adjacent to the transmitter. Even if this fracture occurred prior to the accident it had no effect on the safe operation of the aircraft.

There was one abnormality, namely certain dips and bends in the pitot static systems which cannot be attributed to forces involved in the impact. These are discussed at length later in the summary.

C) There was no evidence of fire or explosion having occurred at any time prior to or subsequent to the impact.

D) There was no evidence of any commotion or unusual act by any person having taken place within the aircraft at any time.

There was positive evidence that at least up until the time when the aircraft was given its clearance to make the final descent everything was normal - this was provided by information in a letter, written by one of the air hostesses aboard, which was recovered from the wreckage. Reference in the letter to the fact that the aircraft was "going to get into Mackay at last" seems to indicate that the letter was written during the holding flight and not prior to the earlier abortive attempt to land and was completed towards the end of the holding flight.

Possible sudden emergency

In the course of the investigation of the wreckage, the emergency inverter was found switched on. Consequently, the possibility of some sudden but undiscovered emergency having arisen in the last moments of the flight cannot be entirely dismissed.

One other circumstance which lends support to this possibility is the fact to which reference has already been made, that certain port side services were found switched off and corresponding services on the starboard side switched on. It seems probable that the condition of the cockpit facilities arose from the impact.

However, the possibility that this condition existed prior to impact cannot be entirely excluded. If it did so exist it may indicate no more than action taken in relation to an assumed emergency in the course of the first officer's check flight. The elements which weigh against this explanation are the probability that the captain was flying the aircraft at the time, and the unlikelihood that in any event the switches would in fact be activated in the course of a simulated emergency. If, therefore, the port side services were switched off before impact, this would suggest something unusual.

It may be that something unusual did occur which a most thorough examination of all apparent possibilities has failed to disclose.

Other Possible Causes

In searching for the cause, one leans to the conclusion that something happened within the last two or three minutes as a result of which the pilot was unaware of his actual rate of descent or that he was descending to an abnormally low altitude:

Two possibilities suggest themselves:-

1) that the instruments did not accurately record the altitude of the aircraft and the pilot was thereby misled into the belief that the altitude in the final stages was some 1 000 ft higher than was the fact;

2) that he misread his instruments, in particular his altimeter, or was relying on his visual observation of his surroundings without paying attention or sufficient attention to his instruments and was misled by his visual observation of the area of land and sea beneath him into the belief that the aircraft was higher than in fact it was.

Water in the Static Pressure System

The only possible plausible explanation of erroneous behaviour of the instruments of such a character as to cause or contribute to the accident is revealed in evidence in relation to the possible presence of water in the static lines of the pitot static system of the aircraft.

The pitot static system of an aircraft is designed to transmit air pressures which exist outside the aircraft to certain of the flight instruments.

The barometric pressure outside the aircraft is transmitted through the static pressure lines and the dynamic pressure through the pressure (pitot) lines of the system.

These pressures must be tapped from points outside the aircraft which are so located that the pressures there will not be affected by the presence of the aircraft itself. There are two independent sets of flight instruments in the aircraft. The pressures are transmitted to each set of instruments by means of two pipe lines and there is one set of two pipe lines on each side of the aircraft serving each set. The static pressure pipe lines with which we are concerned are connected with the altimeters, the vertical speed indicators and the airspeed indicators which are also connected with the pressure lines.

The static pressure lines in the Fokker F-27 proceed from the wing tips along the inside of the wing to the fuselage. Upon reaching the fuselage they proceed forward for a distance in the fuselage and then descend to a position underneath the floor of the cockpit and from there pass forward under the floor and up to the instrument panel.

Provision for drainage is made in the wing by the presence of a nacelle drain, and that provision for drainage is made near the point where the pipe proceeds forward from Station 3100 under the floor of the cockpit. (Station 3100 is the point where the descent from the top of the fuselage to the floor of the cockpit occurs).

Examination of the wreckage of the aircraft disclosed the following deficiencies in the routing of the pitot static plumbing:

1) there was a dip of some two inches in an unsupported section of the pitot and static lines in the port wing between Station 520 and the front spar bulkhead fittings near Station 0;

2) there was an upward bend of about 1/2 an inch in an unsupported section of the pitot and static lines in the starboard wing between Station 1040 and the front spar bulkhead fittings near Station 0. Between Stations 1040 and 520 there was a dip of 1-1/2 inches in the static line and a dip of 3/4 of an inch in an unsupported section of the pitot line;

3) the port system static line in the fuselage section had not been routed through a clamp at Station 5445. This deficiency is not considered to have had any adverse effect on the operation of the port pitot static system.

Expert opinion was that these deficiencies were not consistent with the damage to adjacent structures or fittings and that they were probably present in the aircraft prior to the accident.

The significance of these bends in the pitot static lines is that they could provide reservoirs for small quantities of water if water were present in the system.

In the course of the investigation, attention was given to the possibility of the pilot having been misled by false recording of his height by his altimeter. It was learned that a Fokker F-27 operated by the Department of Civil Aviation had displayed erroneous readings of the instruments operated by its port static pressure system, and that at the conclusion of each of two flights a small quantity of water had been drained from that system.

This incident led to initiation of experiments both on an operating aircraft and a ground rig for the purpose of determining what effect (if any) given quantities of water in the static pressure systems could have on the operation of the instruments.

Conclusions of the experiments

1) Water in the system on the starboard side would not produce errors in the altimeter on that side. The automatic pilot unit is connected under the floor of the cockpit to the static pressure system of that side of the aircraft. Even if water in significant quantities collected in that area of the line it would, in the main, pass into the automatic pilot unit and not proceed to the instruments. Normally, the first officer, not the captain, would be operating the aircraft on the starboard side. If, therefore, the first officer were operating the aircraft at the time of the accident, the result of the experiments leads to the conclusion that his instruments would not have been affected by any water in the system and he would not have been misled by them.

2) The same conclusion could not be reached as readily in relation to the system on the port side.

It is clear that the mere presence of water in the static pressure line in the wing, where the bends were present, would not have any critical effect on the instruments. In the circumstances of the fatal flight it could only have had such an effect if, in the course of the final descent, water present there had moved along the line and "toppled over" at Station 3100 into the cockpit area.

The justification for this view is that had water been present earlier in the line under the cockpit floor it would have manifested its effects during the abortive attempt to land when the aircraft descended from 13 000 ft to 50 ft.

All evidence supported the view that the pilot at that stage had the aircraft completely under control and that his instruments were operating normally.

Even if the presence of water in the wing lines be assumed, the experiments conducted on the rig indicated that it was unlikely to move to Station 3100 and topple over during the final descent from 5 000 ft.

However, it is not possible to reproduce on the rig the precise circumstances encountered in the holding flight which lasted for about one hour. During that period the aircraft was changing direction frequently and it is possible that the slopes so created might have moved water so that globules collected in the form of a slug which toppled over at Station 3100 during the descent.

The experiments indicate that with 7 c.c. of water acting in this way in the rig it would pass over the fuselage drain under the floor of the cockpit and proceed along the static pressure line towards the instruments. In so doing it would interfere with the transmission of air pressure to the instruments, and the altimeter would cease to measure the correct altitude. In fact in this situation, with the aircraft descending, the altimerer would indicate a descent but the descent so registered would be less than actual. The experiment showed that, as far as the test rig was concerned, if the water toppled at a simulated height of between 3 000 ft and 2 000 ft in a descent it would cause the altimeter to read about 1 000 ft at the time when the descent itself had reached sea level.

It is necessary to emphasize some other effects which the presence of water in sufficient quantities at the critical point would have had.

1) the vertical speed indicator would register a lower rate of descent than the actual rate;

2) the airspeed indicator would show a steadily increasing air speed which toward the end of the descent would read some 50 kt higher than it should; and

3) the attitude of the artificial horizon would show a much steeper descent than that indicated by the vertical speed indicator.

In a familiar operation of this kind the captain might sense that his descent was steeper than the altimeter indicated.

Incidents involving erroneous indications in altimeters on three Fokker aircraft were related to the Board. The incidents were not attributed to the presence of water in the critical section of the static pressure line ... no water was found in that section. The explanation of the incidents appears to be that there was some temporary obstruction of the static pressure system in the outer wing area due to the formation of ice. The temperature readings during the period in which VH-TFB was holding over Mackay negative any suggestion that the static pressure system in that aircraft was at the relevant time affected by the formation of ice in the static pressure lines.

Current operational procedures have made aircrews aware of the possibility of water contamination of instruments systems and if observed will prevent hazardous situations.

The first officer would have to have been engaged for about 1 to 1-1/2 minutes in an activity which prevented his noticing the readings on his instruments.

Water in the wing lines would be most likely to accumulate during the holding at 5 000 ft at the point where the lines turn fore and aft in the fuselage and would be unlikely to reach Station 3100 in the necessary 2 700 ft from commencement of the descent.

A representative of the Fokker Aircraft Company stated that the experience of those aircraft to date amounted to 70 000 flying hours, and although water has been found in the pitot static systems of such aircraft, as in other aircraft, it has never yet been found in a critical position in the system.

The final view of the Fokker Aircraft Company was as follows:

"For water in the static lines to have caused or contributed to the accident <u>each and every</u> of the following events must be <u>assumed</u> to have taken place:

a) that the captain was flying at the moment of impact ...;

b) that there was enough water to cause an eventual 1 000 ft error present in the horizontal lines behind Station 3100 prior to the accident the greater part of which must have been present in that location during all or most of the 34 flights prior to the last flight and that such water was all the time in such a form as not to show up by instrument fluctuations or instrument error ...;

c) that this water did collect at a position in the lines where it would be just poised to topple over and did not collect at such a position during any of the 36 preceding descents and that this water toppled over on the last descent - a fact that has not happened during any of the 70 000 flying hours of Fokker F-27s;

d) that the captain did not observe any fluctuations in the instruments during the period in which the water toppled over and prior to its reaching the critical bend which period would take about 1 000 ft descent;

e) that the captain ignored the airspeed indicator, rate of climb indicator, artificial horizon and his own sensory ability;

f) that the first officer did not monitor the captain's instruments;

g) that, in case the captain took over just about 1 to 1-1/2 minutes before impact and decided to "wipe off" a small amount of apparent excess altitude, he did not perceive the delay or lag in his instrument indications within the period of 10 or 12 seconds in which he would normally have expected to "wipe off" the excess height.

It was not established to the Chairman's satisfaction that the presence of water in the static pressure line caused or contributed to the accident.

The possibility of water having accumulated in the bends in the system cannot, however, be excluded. It is unlikely that such water, if present in the course of the final descent of the aircraft, found its way to the critical part of the system on the port side. If it did it was shown that it could result in a misrepresentation of the altitude of the aircraft in the course of that descent. It is not unlikely that the captain was piloting the aircraft at this stage. Having regard to the presence of fog in the area, and the earlier abortive attempt to land, both he and the first officer might have directed some of their attention to its possible presence. In these circumstances while it is unlikely, it does not seem impossible that they might not become aware of any abnormal behaviour of the instruments at the crucial time until it was too late.

The Chairman was not able to make a positive finding that water in the static system did not cause or contribute to the accident. It must be regarded as a possible though not probable cause.

Pilot error

It was not possible to determine whether the captain or first officer was flying the aircraft at the time of the accident.

The first officer was to undergo a proficiency check so it may be assumed that for some part of the flight at least he was at the controls.

The captain was in the left seat on take-off from Rockhampton. The starboard seat belt was around the body of the first officer when it was recovered.

However, there was no evidence as to which of them engaged in the final descent - other than the fact that the captain's injuries are consistent with the captain's seat being in the forward position at impact. From this alone a definite conclusion cannot be reached, although it was believed most likely that the captain flew the aircraft in the final descent.

The captain was highly competent and well experienced. In two minor respects he acted in a manner not consistent with regulations.

The error in the reading of the altimeter, which in the final stages would account for the accident is one in which a measurement in hundreds is mistaken for a height of over 1 000 ft and an ultimate misconception that a measurement of 100 ft was 1 100 ft. It seems unlikely that a captain with this one's experience would so misread his altimeter as to mistake a reading of 100 ft for 1 100 ft. It is difficult to attribute such an error to an experienced pilot, more particularly as such a misreading could only occur after he had descended to 100 ft without he or the first officer being aware that the aircraft was descending much too low. This could only occur after he had descended to 100 ft without he or the first officer being aware that the aircraft was descending much too low. It would seem that this could only offur if the attention of both of them were diverted from the instruments at the same time either by concern for the possible presence of fog or some other circumstance of which there is no evidence.

Similar considerations weigh against the possibility of the first officer getting so low without at least the captain observing on his instruments the excessive descent. If the aircraft followed a course similar to that which has been plotted as its assumed course, it was in the final stages of the descent in an area where there were no clearly visible land marks for guidance, and it is scarcely rational to assume that the pilot would disregard the safety provided by his instruments for his own inadequate visual observation.

The Chairman was not satisfied that the accident was due to an error of the pilot in reading the altimeter or to a complete or partial disregarding by him of the information his instruments provided.

However, some error by the pilot in flying the aircraft has not on the evidence been excluded as a possible cause of the accident.

Recommendations

Flight Recorder

It was impossible to reach any firm conclusion as to the cause of the accident. As there were no survivors there was no means of ascertaining what occurred on the aircraft in the last few minutes of flight.

It would, no doubt, have been enlightening to have a record of any conversation which took place between the captain and the co-pilot during that period and of the readings of the flight instruments up to the moment of impact.

Counsel for the Department of Civil Aviation informed the Board that the Department has since 1955 been engaged in work on flight recorders which would be capable of providing this type of information in the case of such an accident. Considerable development has taken place both in Australia and abroad in relation to such instruments, but the Department had not as yet* had presented to it an instrument which was sufficiently perfected to justify the installation of such instruments in aircraft in Australia.

It is recommended that the search for such an instrument should be pursued in the hope that satisfactory flight recorders can be installed at no distant date.

There would be a legitimate objection to the installation of such instruments if the recorded material were available to operators at the conclusion of every flight. However, instruments are in the process of development which will automatically obliterate earlier recordings as the flight proceeds so that only the events of an immediately preceding short period will at any time be preserved and that the whole recording will be obliterated immediately upon the pilot stopping the engines at the conclusion of each flight.

Altimeters

The possibility that some misreading of the altimeter contributed to the accident has already been discussed. It is not easy to devise an instrument of this character which will provide against the possibility of any human error, and modifications of existing methods of presentation, while avoiding one source of possible error, may but provide another.

Despite the difficulties which this problem presents, it is urged that investigations into improved presentation of height information should be pursued.

Radio altimeters are capable of providing information of the actual height of the aircraft above the terrain over which it is being flown. The Chairman was advised that no suitable equipment of this kind for installation in aircraft is at present available.

It is recommended that steps should be taken to develop an instrument suitable

* late 1960

for the purpose and that it should be an instrument employing a single pointer.

Descent Procedures at Mackay

It was recommended that consideration be given to revising the visual descent procedures employed at night at Mackay having regard to the large sectors where there are no visual clues such as the ocean area.

It is suggested that, when meteorological conditions permit, aircraft approaching the airfield at night should not descend below 1 500 ft until within seven miles of the airport as measured by D. M. E. This height is in conformity with the lowest altitude to which aircraft may descend at Mackay during an instrument approach before commencing final descent.

It may be that such provisions would be appropriate at other airports at which similar conditions prevail.

Modifications to Pitot Static System

In addition to the above recommendations it is appropriate to report that the Fokker Company proposes to make certain modifications in the pitot static system. These are designed to eliminate any possible risk that any small quantities of water which may enter the system will affect the operation of the instruments by movement along the lines towards the instruments. The Board was informed that work in this direction was going on with a view to making the drainage valves more effective by ensuring that any water passing to them is trapped and retained. Such modifications may have application in other types of aircraft.

Further precautions being taken with the present system which are significant are more frequent blowing of the lines to remove any water and an inspection of all Fokker aircraft with a view to eliminating any such irregular bends in the system as were found in VH-TFB.

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ICAO Ref: AR/660

No. 38

Pacific Northern Airlines, Inc., Lockheed Constellation, L-749, N 1554 V, accident on Mount Gilbert, Alaska on 14 June 1960. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 1-0019, released 15 March 1962.

Circumstances

While en route from Cordova to Anchorage, Alaska, Flight 201 failed to maintain its intended track and crashed, at 0447 hours Alaska time, into the sheer face of Mount Gilbert, Alaska at the 9 000-foot level. Mount Gilbert is approximately 28 NM to the right of the flight's intended checkpoint (Whittier) and is 9 646 ft in elevation. All 9 passengers and 5 crew members aboard the aircraft were fatally injured.

Investigation and Evidence

Reconstruction of the flight

Cordova was an intermediate stop on the flight from Seattle, Washington to Anchorage, Alaska. Routine briefing of the pilot on the weather he could encounter and the flight facilities and field conditions en route, were accomplished by the company dispatcher at Seattle prior to departure. The Pacific Northern operations office at Cordova has no weather briefing facilities.

At 0415 hours the flight was cleared to Anchorage Low Frequency range via direct Egg Island, Amber One and was to maintain 10 000. When the Anchorage weather conditions were broadcast by Cordova at the time of the flight's departure, the flight acknowledged their receipt. It advised Anchorage Air Route Traffic Control Centre (ARTCC) that it was climbing to 10 000 ft and was estimating Hinchinbrook at 0425. The aircraft was then cleared to maintain 9 000 ft. It was over Hinchinbrook at 0427 at 9 000 ft on instruments and estimated Whittier at 0447. The flight was instructed to contact Anchorage Approach Control at 0452 on 118.1 Mc/s. Flight 201 then asked for 11 000 ft, if available. The flight was advised that Anchorage ARTCC could approve 11 000 ft; however, there was company traffic inbound to Anchorage which would be descending. The flight was asked when it would begin its descent, and replied that Anchorage should disregard the request. The 0400 weather was then broadcast to the aircraft.

Anchorage exchanged traffic information between 201 and another inbound Pacific Northern aircraft on 118.9 Mc/s. This exchange of information was acknowledged by Flight 201 at 0432 and was the last radio contact between Anchorage and the flight. The accident occurred at about 0447 hours.

The Accident Site

Investigation disclosed that the aircraft struck the 70° ice slope of Mount Gilbert just below the summit at the 9 000-foot level, on a collision path of approximately 255°M. Mount Gilbert (elevation 9 646 ft) is in the Chugach Mountains about 50 miles east of Anchorage, Alaska.

The aircraft disintegrated on impact and the wreckage settled into deep snow below the impact area. A snowslide, resulting from the crash, carried pieces of wreckage down to the lower slope and buried most of it in an area extending from about 8 500 ft down to about 7 500 ft.

It was determined that the location of the wreckage precluded further investigation because:

1) most of the aircraft wreckage was buried in the snowfield;

2) large outcroppings of snow were hanging loosely over the scene ready to fall at any moment which could have created extensive snowslides and covered the remaining wreckage; and

3) ground parties would have had to proceed up a 45° slope over the crevasse-filled glacier.

There were no eyewitnesses to the accident.

The Aircraft

The aircraft maintenance programme and records for N 1554V were examined and found to be comprehensive and in good order. All airworthiness directives were complied with, and records revealed that all communications and electronic equipment were operating satisfactorily before the departure from Seattle.

Navigation Aids

The navigation aids from Cordova to Anchorage were flight-checked by FAA flight inspection following the accident and were found to be operating normally and within tolerances.

The Pilot-in-command

He held a valid airman certificate with an airline transport pilot rating for airplane multi-engine land, and DC-3, DC-4 and Lockheed Constellation aircraft type ratings. He had a total of 14 461 hours of flying time, 4 318 of which were in Lockheed Constellation aircraft.

The captain had flown the route from Seattle to Anchorage by way of Cordova frequently for approximately 15 years and was familiar with terrain, communication and navigation aids, weather characteristics, and airports along this route. Several of the company pilots, when queried, stated that they used and depended mostly on the aural signals of the low-frequency range when flying between Cordova and Anchorage but that they also used the ADF as a cross check. One of the pilots, who had flown with this captain on numerous occasions over this same route segment said that the captain always flew along the edge of the on course where he could hear the "A" signal, and that he used the ADF as a cross check. The company's Operations Manual also states that both aural signal and ADF must be used when flying on low-frequency airways.

Radar plots

Alaskan Air Command Regulation 55-33, dated 30 March 1959, entitled "Operations USAF Radar Advisory Service and Flight Monitoring Service in Alaska" provides for a radar advisory service which may be requested by a pilot and for radar flight monitoring in the absence of a request from the pilot. This regulation is supplemented by a "Joint Agreement Between the Fifth Region, Federal Aviation Agency and the Alaskan Air Command in Relation to the USAF Radar Advisory Service in Alaska", effective 10 July 1959, which establishes the policy and procedures for the provision of radar assistance by USAF Air Defence Radar units in Alaska to military and civil aircraft in flight, so as "to assist aircraft in flight to avoid existing areas of potentially hazardous weather, terrain, restricted areas, and other conditions hazardous to flight."

The radar operator at the USAF Air Defence Radar station located at Middleton Island had the aircraft under surveillance for about 30 minutes. The 0435 plot placed the aircraft about 20 NM to the right of its intended course along Amber One Airway. At 0440 Flight 201 was 28 NM to the right of its intended course and headed into glacial terrain with elevations above 10 000 ft. No attempt was made by the Air Defence Radar station controller to contact the flight nor did he notify the Air Defence Direction Centre of the hazardous situation as required by the joint agreement of 10 July 1959. Following the 0440 plot the radar image of the aircraft disappeared from the scope.

Navigation Aids - Discussion

The flight made a normal position report over the Hinchinbrook low-frequency radio station at 0427, and a radar plot three minutes later placed the aircraft on Amber One Airway. As stated, the two radar plots at 0435 and 0440 placed the aircraft 20 NM and 28 NM right of course, respectively. The accident occurred at 0447.

It is apparent that the directional difficulty which occurred began in the vicinity of the Hinchinbrook range. It was at 9 000 ft, on instruments and would be receiving its heading information from a fluxgate compass. Fluxgate compass headings are passed to a master direction indicator (MDI) which in turn furnishes headings to each of the radio magnetic indicators positioned in the captain's and co-pilot's instrument panels. The MDI also passes on directional information to the autopilot. Additional heading information would be received from the magnetic compass located in the centre of the windshield and the two directional gyro compasses located on the instrument panel. However, the magnetic compass in northern latitudes would be subject to magnetic disturbances.

Although such directional errors could have existed, the Board is aware that additional apparatus was available to the pilots to assist in their navigation.

Tests conducted on the RMI revealed that it could produce erroneous indications, and that the RMI card could assume a heading and remain steady even with a 90-degree change of heading of the aircraft. However, in order to accept the theory of the erroneous reading on the RMI card, one has to conclude that both crew members were oblivious to all other indications and that their attention was focused entirely on the RMI, and that they did not cross check any other instruments.

Erroneous fluxgate indications can occur for several reasons among which are:

1. Failure of an electrical component in either the fluxgate or the RMI amplifier.

2. A malfunctioning of the gyro caging mechanism.

3. Cycling of the gyro caging system with the aircraft not in level flight.

In one type of fluxgate compass malfunction the radio magnetic indicator card will not follow the turn and consequently heading information will be erroneous. This type of malfunction will result in a straight line course on an erroneous heading. In view of the fact that radar plots of the flight path of the aircraft indicated a gradual turn from a northwesterly heading to a west-southwesterly heading and the winds aloft were not of a magnitude or from a direction which would have resulted in such a curved flight path, a malfunction resulting in a "dead RMI card", does not seem likely. A second type of fluxgate malfunction involves a tilting of the stabilizing gyroscope. This results in heading error whereby the indicated heading is not the actual heading. The size of the error depends upon the amount and direction of tilt. The fluxgate compass contains a mechanism which automatically corrects gyro tilt. Therefore the flight path obtained by holding a constant indicated heading on the RMI will result initially in a curved flight path until the erection of the stabilizing gyro has been completed, at which time the flight path again becomes straight and will remain straight as long as the heading is maintained and a cross-wind is not present. The radar plots indicate that the aircraft was on a heading of 255° approximately seven minutes prior to impact and that this heading paralleled within 3° of the original intended course. This would indicate that if a gyro tilt error had occurred in the vicinity of Hinchinbrook the self erecting mechanism had corrected the error at this time. The ADF pointer would point to the selected station regardless of any fluxgate error.

At the position indicated by radar at 0440, some seven minutes prior to the crash, the ADF pointer would have indicated an approximate 35° deflection, indicating that the aircraft was substantially to the right of the course.

Of particular significance is the fact that Amber I Airway between Cordova and Anchorage is established by means of low-frequency radio ranges located at Hinchinbrook and Anchorage, using the west course of the Hinchinbrook Radio Range and the east course of the Anchorage Radio Range.

Utilizing the west course of the Hinchinbrook Radio Range, the "N" signal is north of the on course and the "A" signal is south of the on course area.

As stated, it was the captain's procedure to fly the Cordova-Anchorage segment of Amber I along the on course area where he could hear the "A" signal. In this instance it is apparent he did not. Had the crew been utilizing the aural signal to establish the flight on Amber I, any failure of the RMI and consequent erroneous heading would have been immediately apparent. The crew was in contact with Anchorage ARTCC and acknowledged receipt of company traffic information at 0432. At this time the aircraft was approximately 20 miles from the Hinchinbrook Radio Range and considerably away from the on course and even outside the bi-signal zone. The only signal which would be received at this point would be a clear "N" and the station identification. Had the crew utilized the aural signals to establish the aircraft on course on Amber I, this solid "N" signal would have alerted them to their off course position. The aircraft continued off course, however, despite the fact that a monitoring of the aural signal at any time during the flight would have alerted the crew to their perilous position and allowed them to return to the proper course. It is reasonable to believe, therefore, that the audible signal was not being utilized despite the fact that the company Operations Manual requires that both the aural signal and the radio compass shall be utilized when flying on low-frequency airways.

During the investigation of this accident the fact was brought out that although a blip of the aircraft's flight had been observed for 30 minutes, those seeing it had not considered it necessary to contact the flight because it was assumed that the pilot was deviating from his course so as to show his passengers a certain glacier, as pilots allegedly often did. However, it is doubtful that the ground was visible since the aircraft would have been flying in or above clouds along the entire trip from Hinchinbrook Radio to Anchorage.

Although the aircraft struck the mountain because of a deviation from its intended course, the Board believed the accident could have been prevented had the provisions of Alaskan Air Command Regulation 55-33 of 30 March 1959 and the Joint Agreement effective 10 July 1959 for radar flight monitoring in the absence of a request from the pilot been carried out.

Probable Cause

The probable cause of this accident was the failure of the crew to use all navigational aids in establishing the aircraft's position on Amber I Airway, thereby allowing the aircraft to deviate from course and fly over hazardous terrain.

A contributing factor was the failure of the Air Defence Radar, which had been tracking the aircraft, to notify either ARTCC or the crew that the aircraft was proceeding on a dangerous course.

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ICAO Ref: AR/701

No. 39

Air Carrier Service Corporation, Aero Commander, N 9367R, accident near Chakrata, Uttar Pradesh, India, on 19 June 1960. Report dated 20 August 1960 released by the Director General of Civil Aviation, India.

Circumstances

The aircraft took off from Palam at 0738 hours Indian standard time on a demonstration flight and failed to return after two hours when expected. Information was subsequently received that it had crashed near Matkangra Village, 1 1/2 miles north of Chakrata. Of the 6 persons aboard (i.e. 1 crew member and 5 passengers), two persons were killed instantly, two died later in hospital and two others were seriously injured. The aircraft was destroyed by impact. There was no fire.

Investigation and Evidence

The Aircraft

The aircraft had received a Certificate of Airworthiness on 24 May 1960. It had flown 77 hours 10 minutes since new and was not due for any major inspection (100 hours).

The pilot

He was the sole crew member. He had flown a total of 12 375 hours - 3 000 hours on light aircraft, 6 000 hours on DC-3 and the remainder on DC-4, C-46 and military aircraft. The pilot was checked out by the Company on N 9367R on 25 May 1960 after which he ferried the aircraft to India. His experience on Aero Commander aircraft amounted to 76 hours 30 minutes.

The Demonstration Flight

It was to be carried out on behalf of members of the Atomic Energy Commission who were interested in the purchase of this type of aircraft for carrying out airborne scintillometer surveys for uranium and other radio-active minerals.

N 9367R was airborne at 0738 hours and was cleared to climb in the northern sector on a track of 010° under visual meteorological conditions. At 0811 hours the aircraft asked for permission to descend from flight level 50. Under the impression that the aircraft was coming in to land, the Air Traffic Control cleared it to descend to 2 800 ft (the height at which aircraft are landed over by Approach Control to Palam), and the altimeter setting was given as 29.55 in. Hg. The aircraft was asked to call when Palam airfield was in sight, to which the aircraft replied: "I am reporting north. I am not returning to the field." There was no further contact with the aircraft. It crashed at 0845 hours Indian standard time,

The wreckage was located at a height of approximately 7 500 ft asl on the eastern slope of a mountain near Matkangra Village, 1 1/2 miles north of Chakrata. The accident occurred in a confined area where the valley ended.

The path of the aircraft in the last stages of the flight was discernible by the cutting of the branches of trees by the port wing and port propeller over a distance of about 120 ft. After traversing a further distance of 100 ft, the aircraft hit another group of trees, swerved to the left and crashed. The port engine broke off from its mount and fell about 200 ft ahead of the main wreckage. The port wing tip and portions of port outer wing and aileron had fallen at the foot of the trees which were hit first. The port engine cowlings and the battery were lying midway between the main wreckage and the port engine. All the aircraft components were accounted for, and there was no indication of any disintegration in the air.

Examination of the wreckage

The position of the engine controls, the feathering mechanism, the extent of damage to the propellers and the way in which the port engine had cut through the branches of trees, all indicated that the engines were working satisfactorily at the time of the accident. This was corroborated by statements of eye witnesses as well as by the survivors of the crash.

All-up weight of the aircraft

The all-up weight of the aircraft at time of take-off was estimated to be 7 208 lb. The maximum permissible weight of the aircraft is 6 500 lb. Hence the aircraft was overloaded by 708 lb at the time of take-off. (For the purpose of ferry delivery flights, however, a maximum of 7 500 lb gross weight is authorized.) As the aircraft had flown for about 1 hour 7 minutes, its all-up weight would have been reduced by about 220 lb, corresponding to the fuel consumed during the period. The aircraft would still be about 488 lb heavier than the maximum permissible weight at the time of the accident.

Statements of Eye Witnesses and Survivors

Reliable eye witnesses had seen the aircraft flying in the valley of the River Amlawa and at Sahiya it was estimated to be flying at about 500 ft above the terrain. The river bed gradually ascended towards Chakrata as did the aircraft. When it reached the west of the rifle range at Chakrata, it was at about 6 500 ft. At this point it took a turn to the right and continued ascending in the valley for a distance of about 2 1/4 miles where it ended in a cul de sac with peaks rising as high as 8 772 to 9 331 ft. The place of the crash is estimated to be about 7 500 ft asl.

The aircraft was said to be flying all the time in the valley below the summits which were on both sides, and it was climbing as the valley itself was rising. Assuming that the aircraft was climbing at the recommended climbing speed of 129 mph, the time required for the aircraft to travel from Sahiya where it was at a height of about 4 000 ft to the place of the crash, which is about 7 500 ft - a distance of about 8 1/2 miles, would be about 4 minutes, which shows that a total of approximately 3 500 ft were gained by the aircraft in about 4 minutes. This indicates a normal rate of climb with both engines operating.

According to one of the survivors, they required that an aircraft should fly at a height of about 400 ft above the terrain for the purpose of carrying out a scintillometer survey. This aircraft was apparently being flown at such a height in a valley. After the last turn of the aircraft, the valley rises steeply and then closes up. It appears that the pilot, on seeing high mountains ahead, attempted to climb the aircraft excessively which causes the stall warning system to function and sound the horn. The stall warning horn switch is actuated by a blade mounted on the leading edge of the starboard wing outboard of the nacelle. The switch is set to close the circuit and sound the horn at approximately 5 mph above the aircraft stalling speed.

From the manner and altitude in which the aircraft struck the trees on the extreme left of the valley, it is most probable that realizing the futility of any attempt to climb out, the pilot manoeuvred the aircraft to the left in order to take advantage of the very limited area available to turn the aircraft. This attempt was not successful.

The closing in of the valley was not anticipated by the pilot as he was quite new to the area and did not carry out a reconnaissance from a safe height before entering the valley.

The pilot had asked for and was given clearance for a local flight. The obvious intention, however, was to proceed to Chakrata, and he should have filed a flight plan accordingly. In its absence, Air Traffic Control were not aware of the exact whereabouts of the aircraft after its take-off from Palam.

Probable Cause*

The accident was attributed to the poor planning of a flight intended to be flown in valleys not familiar to the pilot. The aircraft was thus trapped in a restricted area. During an attempt to manoeuvre out of a closed valley, the aircraft struck trees and crashed.

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* Comment by the State of Registry of the aircraft
"We believe cognizance should be taken in the probable cause of the fact that the airplane was 708 pounds over the maximum certificated gross weight. Due to the adverse effect of this additional weight on the maneuverability of the aircraft it could well have been a significant factor in the probable cause of the accident."

ICAO Ref: AR/670

No. 40

Real S/A - Transportes Aéreos, CV-340, PP-YRB, accident at Guanabara Bay, Brazil, on 24 June 1960. Summary report released by the Office of the Inspector General, Ministry of Aviation, Brazil.

Circumstances

The aircraft was returning from Belo Horizonte in instrument meteorological conditions. It entered CTR RJ (Rio de Janeiro - Control Zone) and, being in constant contact with APP RJ (Rio de Janeiro - Approach Control), received instructions from the latter to follow the QUEBEC procedure. The aircraft reported its position to APP RJ when over the Ilha dos Ferros facility, whereupon it was cleared to descend. It initiated a procedural turn for a 036° heading and before reaching the position in which it was to have turned to a 216° heading, it unexpectedly crashed into the sea on a heading of approximately 350° at 1830 hours. The aircraft was completely destroyed and pieces of it were scattered over an area within a radius of 200 m. Five crew and 49 passengers were fatally injured.

Probable Cause

The cause of the accident was not determined.

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ICAO Ref: AIG/ACC/REP/GEN/No. 8 - Brazil

No. 41

Gulf Aviation Company Ltd., DC-3, VT-DGS, accident near Sharjah (Persian Gulf Area), 10 July 1960. Report released by the Office of the Director General of Civil Aviation, India.

(In accordance with Annex 13 to the Convention on International Civil Aviation, the inquiry was undertaken by the Indian authorities. The Airport Commandant, Bahrain Airport, acted as the accredited representative of Her Majesty's Political Resident, Persian Gulf and a Senior Inspector of Accidents of the Ministry of Aviation, United Kingdom, attended the inquiry as an adviser.)

Circumstances

The aircraft took off from Bahrain Airport at 0411 hours GMT on a scheduled passenger service to Doha (Qatar), Sharjah (Trucial Oman) and return. The flight had been cleared on an IMC (instrument meteorological conditions) flight plan to Doha where it landed at 0446 after an uneventful flight.

Departure from Doha was at 0516 hours and the aircraft was cleared to flight level 70 for the second segment of the trip. The aircraft reported to ATC Bahrain at 0604 hours that it was off Das Island at 0546 and stated that it was in contact with Sharjah and estimated its arrival there are at 0645. Bahrain ATC cleared the aircraft to the Sharjah frequency. The last contact of the aircraft with any ground station was at approximately 0605 hours when it reported to Sharjah that it was at flight level 70, estimating Sharjah at 0642. Sharjah advised the aircraft to call again when in VHF range. At 0635 Sharjah attempted to contact the aircraft repeatedly without success.

At a time estimated by the pilot of a Heron aircraft, approaching Sharjah from Das Island at flight level 50, as between 0644 and 0648 hours GMT, he heard VT-DGS call Sharjah twice on 3023.5 kc/s. No message was, however, transmitted, and the calls were not heard by Sharjah.

Search and rescue action was initiated promptly by Sharjah ATC when the aircraft failed to reach its destination. In spite of an extensive search, the aircraft was not located. The search was abandoned on 17 July 1960. Three crew and 13 passengers are missing and presumed dead.

Investigation and Evidence

The aircraft held a current Certificate of Airworthiness and was certificated for the flight.

The crew held valid licences.

Weather

Neither the crew nor the Operator's representative reported for a weather briefing. No route or terminal forecast was asked for or prepared for the flight.

No weather information was asked for by the crew or offered by any air traffic control unit during the flight excepting the actual weather included in the landing instructions at Doha. The crew were, therefore, not in possession of any forecast or actual weather information pertaining to this flight. This point is of special significance as poor weather conditions (poor visibility) prevailed throughout the route as well as at the destination airport where the visibility was

990 yd in thick dust haze at the expected time of arrival of the aircraft.

(i) Weather conditions prevailing at 0500-0800Z on 10 July 1960 on the route Doha to Sharjah and over the Hormuz Peninsula (as assessed by the Chief Meteorological Officer, Headquarters British Forces, Aden Peninsula)

The most probable conditions based on the information available is considered to be as follows for the route Doha to Sharjah:

Upper wind Doha to Sharjah at 7 000 ft	-	NW 15 kt becoming 10 kt towards Sharjah
Cloud	-	no cloud below aircraft
Visibility	-	2 NM becoming 700 - 1 000 yd towards Sharjah due to thick dust haze

No information was available for the Hormuz Peninsula, but conditions on the western side were probably similar to those obtaining at Sharjah.

(ii) Height of the top of rising dust or sand on the route

Top of thick dust haze was reported by aircraft to be 5 500 ft first half of the route rising to 7 000 ft the second half and with the sea stated as invisible from 2 500 ft near Sharjah.

(iii) No information available regarding turbulence but expectation would be of nil or light turbulence.

The following information regarding en route weather was obtained from the captain of a Heron aircraft operating the Das Island/Sharjah sector:

(Set course Das Island 0625 - overhead Sharjah 0718 hours)

".... I then requested descent clearance (from Sharjah). This was given down to 2.5 VMC if at all possible, which it wasn't and at 2.5 the aircraft was well and truly IFR. I hastily asked for further descent. If this was not given I would have turned 180° due to a chance the Dakota might have been using the standard let down. Eight miles from the coast I was contact. Visibility was about 1 000 yd on the surface, less in the air. First contact was about 1 200 ft but reasonable contact could only be made at about 800 to 600 ft." This flight experience a tailwind component of approximately 28 kt at flight level 50.

Navigation Aids and Radio Equipment

The navigation aids available at Bahrain, Doha, Das Island and Sharjah and required for this flight were functioning normally at the respective stations.

The radio equipment aboard the aircraft was adequate for utilizing the ground facilities required on the flight. There was no reason to doubt its serviceability.

Flight Plan

A flight plan concerning this flight of VT-DGS was submitted by a staff member of Gulf Aviation to the ATC officer on duty at Bahrain Airport at 0300 hours the morning of 10 July. In accordance with the usual procedure all entries were filled in by him. The true airspeed was entered as 150 kt and the elapsed times for the Bahrain/Doha and DohaéSharjah segments were given as 35 minutes and 1 hr 30 min respectively. The winds forecast were not taken into consideration. The endurance listed (6 hours) was also not consistent with the amount of fuel on board.

Fuel

The aircraft was refuelled at Bahrain .... 350 gallons were on board. The load sheet was prepared by a traffic officer of Gulf Aviation. The total all-up weight of the aircraft was 10 875 kilos at time of take-off. No trim sheet was prepared.

At Doha some freight was offloaded, but no fuel or freight was taken on. A load sheet was made out by a traffic officer of Qatar National Travel. He referred to the traffic documents of the previous sector in order to prepare the load sheet for the Doha/Sharjah segment .... a distance of 209 NM. When he spoke to the captain about the fuel figures the latter said that he had 200 gallons on board. This was the figure entered in the load sheet. In fact, according to calculations, the aircraft had almost 300 gallons on board. The endurance of the aircraft was, therefore, in the order of 4 hr 15 min. The flight from Doha to Sharjah was planned for 1 hr 30 min, leaving a further endurance of 2 hr 45 min remaining when above Sharjah. This would have been sufficient for the aircraft to return to Doha, or to proceed to Bahrain, a designated alternate, with sufficient reserve on board.

On departure from Doha the aircraft's all-up weight was 10 680 kilos.

Description of Terrain in the Accident Area

It was the opinion of responsible persons thoroughly familiar with the terrain to the east of Sharjah that because of the nature of some parts it may not be possible to locate wreckage in this extremely difficult country. The area has not been surveyed accurately. Air crews estimate the highest terrain to be 9 000 ft amsl. It consists of steeply rising ridges forming narrow ravines. An aircraft striking at the side of a ridge could disintegrate and slide down a ravine with little chance of being observed, especially from the air. The area is sparsely populated, principally by tribesmen.

Spasdomic reports of aircraft wreckage having been sighted continued to come in from various sources after the main search had been abandoned. In every case a search of the area referred to was carried out with negative results.

Discussion of Evidence

Operational control

The aircraft was on a charter to Gulf Aviation. According to a clause in the agreement between Kalinga Airlines and Gulf Aviation, the aircraft and crew were to remain at the disposal and under complete operational control of Gulf Aviation for the entire period of the charter whether the aircraft and crew were actually employed on any work or not.

The question as to who would be responsible for establishing and maintaining a method of supervision of flight operations was discussed with representatives of Gulf Aviation and Kalinga Airlines. Gulf Aviation were of the view that the responsibility for operating the aircraft rested with the owners of the aircraft. Kalinga, however, were of the opinion that all instructions regarding operational control could be given by Gulf. There is undoubtedly some ambiguity in the position which is undesirable. However, in the circumstances of the subject flight, it would appear that Gulf Aviation was the Operator and should have ensured that the operating crew were provided with an up-to-date copy of an Operations Manual. This was not done, nor did Gulf Aviation ensure that the statutory checks on the operating crew had been fulfilled.

Briefing

It is noteworthy that neither the pilot (nor any other crew member) visited Air Traffic Control or the MET office for briefing prior to the flight.

Facilities for weather briefing exist at Bahrain where there is a forecaster on duty 24 hours a day. In addition, the ATC authorities at Bahrain, Doha and Sharjah obtain and pass on the actual weather at the destination airports on receiving such a request from crew members. Quite frequently, however, on domestic flights of Gulf Aviation, information regarding actual weather is obtained by the crew on R/T from the destination airports. As stated, in this case no information regarding the forecasted or actual weather was asked for by the crew.

Weather Minima

The International Convention for Civil Aviation does not require States to establish weather minima for airfields and none had been established for the airfields concerned with this flight, nor had Gulf Aviation established minima for Dakota aircraft operating to these airfields.

The Gulf Aviation minima for sched uled operations at Sharjah, with Dove and Heron aircraft are:

Field Elevation	6 feet
Runway	A 11
Facility	NDB - VHF/DF
Landing and Take-off Minima:	
Critical Height (ab. field level)	400 feet
Runway Visual Range	1 200 yards

Kalinga's Operations Manual specifies weather minima for Dakota as -

"The following minima were applied for by day or night for all aerodromes in general:

Landing	: Cloud base 300 ft above the highest terrain within a radius of 5 NM and/or visibility 1.5NM
Take-off	: Cloud base 300 ft above the highest terrain within a radius of 3 NM and/or visibility 1 NM"

The surface visibility at Sharjah never exceeded 990 yd during the period of flight. However, the surface visibility at Bahrain, a designated alternate, was satisfactory.

Probable Cause

The probable cause of the accident was not determined.

It can only be a matter of conjecture as the wreckage was not located. All possible factors were explored, but none appeared plausible.

Absence of radio communication between the aircraft and Sharjah after the initial contact and the absence of any distress call might have led to the tentative conclusion that the aircraft had met with a catastrophic disaster while still over the sea. However, the interception of a radio call from the aircraft at about its expected time of arrival at Sharjah and the considerable tailwind on the route seem to indicate the possibility that the aircraft overflew Sharjah under conditions of poor visibility. It is noteworthy that that ETA given by the aircraft as 0642 did not allow for any appreciable tailwind component which was indicated by the evidence of the Heron pilot. Not accounting for this factor could have resulted in the aircraft's descent on its ETA into high ground to the east of Sharjah. It may also explain the inability of Sharjah to receive any message which may have been transmitted on VHF. However, the NDB at Sharjah was fully operational during the period of the subject flight and should have indicated to the pilot that Sharjah had been overflown unless the ADF system in the aircraft was mishandled or suffered a multiple failure.

Recommendation

When an aircraft is on charter from one operator to another the responsibility for establishing and maintaining a method of supervision of flight operations should be clearly defined.

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ICAO Ref: AR/669

No. 42

Northwest Airlines, Inc., Douglas DC-7C, N 292, ditched in the Pacific Ocean on 14 July 1960. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 1-0026 released 23 November 1962.

Circumstances

Flight 1-11, en route from Okinawa to Manila, Philippine Islands, was ditched at 0430 hours Manila time, 14 July (i.e. 2030 hours GMT, 13 July) in the Pacific Ocean, about 67 NM northeast of Manila Airport, after reporting fire in the left wing and the loss of No. 2 propeller. All 7 crew and 51 passengers aboard the aircraft were successfully evacuated. Of these, 44 received minor injuries and one passenger died.

Investigation and Evidence

Reconstruction of the flight

This scheduled passenger flight to Manila, The Philippines, had originated at Idlewild Airport, New York on 11 July. Following departure from Seattle, Washington it was diverted to Anchorage and Cold Bay, Alaska because of expected weather conditions further along the route. Its arrival at Tokyo, Japan at 1015 hours (13 July) was 7 hours and 20 minutes behind schedule. The next segment Tokyo-Okinawa was completed without difficulty, and the aircraft arrived at Okinawa at 1625 hours the same day.

Following a satisfactory run-up of the four engines at Okinawa the flight departed at 1712 hours for Manila, its final destination. The captain at this time was in the right-hand seat and the first officer was in the left-hand seat.

At about 1915 hours No. 2 engine experienced an appreciable power loss which was indicated by a drop in brake mean effective pressure and manifold pressure. Believing the difficulty was carburettor icing the crew applied alcohol to the carburettor, retarded the throttle, placed the mixture in auto-rich and applied carburettor heat. The engine ignition analyzer indicated nothing unusual. The oil quantity indicator for No. 2 engine showed only 30 gal at this time, i.e. 22 gal less than at departure from Okinawa.

The captain then noticed the oil-out temperature for No. 2 engine was rising, and the engine ignition analyzer showed irregular patterns on 5 or 7 cylinders. The crew tried to feather the propeller but were unsuccessful, and the engine rpm increased from 2 350 to 2 900. The oil quantity indicator for No. 2 engine was registering empty.

The flight advised Manila Radio at 1925 hours that "... No. 2 engine was 'runaway', unable to feather, requesting lower altitude." At 1930, two hours before sunrise, the aircraft was cleared to descend from its cruising altitude of 18 000 ft to 10 000 ft. The flight engineer tried to transfer oil from the reserve tank in an additional attempt to feather the propeller; however, it did not feather. After reducing the airspeed, the No. 2 engine rpm fluctuated between 2 150 to 2 350. It was also noted at this time that the No. 2 engine would not come out of high blower.

The Ditching

The captain and first officer then exchanged seats, and the descent to 10 000 ft was begun at an indicated airspeed of 130 kt with landing gear and flaps extended. The captain alerted the cabin attendants to prepare for ditching and to evacuate the hazardous area in line with the No. 2 propeller. The cabin attendants immediately began to secure the cabin for ditching. Lifevests were donned, emergency lights on the vests and in the cabin were turned on, and two of the four liferafts were positioned, one at the main cabin door and one at the emergency door on the right side of the aft compartment. Loose articles were secured. The captain and purser, through the use of the loudspeaker system, directed the passengers to remove their shoes, ties, glasses, and other pertinent objects. Because of the evacuation of the cabin area in line with the propellers, some passengers were directed to sit with their backs to the compartment walls.

At 1940 the captain declared an emergency and gave his 1920 position as 180 miles northeast of Jomalig Island on Amber 2 Airway, and requested an intercept by rescue aircraft. A Loran fix at 1950 established the aircraft's position as 100 miles northeast of Jomalig Island. This position was also transmitted to Manila Radio with advice that the flight was proceeding to the coastline due east of Manila. At this time the aircraft was at 9 000 ft and maintaining 130 kt.

Shortly thereafter, the engineer noted sparks and white smoke coming from the No. 2 engine. However, no flames were visible, and no evidence of oil was present on the wing or the engine nacelle. The captain and engineer concurred in an attempt to stop the engine rotation by actuating the firewall shutoff valve, thereby depriving the engine of lubricant. Sparks came from the engine, loud thumping noises were heard, and activation of the fire warning system occurred. Accordingly, the fire extinguishing system was used, but without effect. At this time the propeller wrenched free of the engine striking the fuselage about in line with its plane of rotation slashing a hole some 15 inches in diameter above the overhead rack at the first seat forward of the left restroom. A red glow was noted on the front casing and changed rapidly into a white glow. There was a continuous fire warning light from the No. 2 engine, and the fire extinguisher was again used but was ineffectual.

At 2020 the flight reported to Manila Radio that there was fire on the wing, that the propeller was gone, and a decision had been made to ditch. There was no further radio contact.

The aircraft then began a 3 000 ft per minute descent from 9 000 ft on a heading of 225° at an airspeed of from 100 to 115 kt with the gear and flaps down. The navigator and the engineer were ordered to proceed to their emergency stations in the cabin.

The descent was made on instruments and in darkness. Moderate rain showers increased the intensity of the magnesium fire in the No. 2 engine. At 1 000 ft indicated altitude, power was applied, the gear retracted, and the flaps were raised to the approach setting of 30°. An airspeed of approximately 100 kt and a descent rate of 100 to 200 ft per minute were maintained. On sighting the water the first officer advised the captain who immediately started the flaps up. The first officer then started them down again, at which time the captain pulled the control wheel all the way back. Seconds later the aircraft struck the water.

Upon final contact with the water, the aft end of the fuselage broke free at the rear of the pressure bulkhead and sank immediately. At the same time the right wing was torn free at the fuselage, and its two engines were torn out and sank. This wing floated for about three hours, temporarily serving as a liferaft for several passengers. The trailing edge of this wing was torn and jagged. The remainder of the fuselage, with the left wing attached, sank some 8 or 10 minutes after impact.

The ditching was at 2030, approximately 5 miles northeast of the nearest point of Polillo Island and in water 2 100 ft deep. The last occupant was out of the aircraft within five minutes. A U.S. Coast Guard amphibian and a U.S. Navy aircraft landed in the rough sea four and six hours, respectively, after the ditching. These two aircraft took aboard all survivors, and a fatality, and taxied 10 - 12 miles to the shelter of a harbour at Polillo Island.

Weather and Sea Conditions

Testimony indicated cloudy, windy weather with showers at the scene of the ditching. The crew of the Coast Guard emphibious aircraft, first to arrive at the scene, reported in part that the surface wind was from the northwest 12 to 15 kt, a sky condition of 3 000 ft scattered to broken clouds with rain, visibility unlimited except in rain, and a squall line slightly to the north of the rafts. The squall line subsequently passed over the rafts.

The crew of the Coast Guard aircraft reported the following sea conditions: primary swell from the east, 4 ft high, 210 ft between crests with a period of 7 seconds; a secondary swell from the northwest, 4 ft high, 75 ft between crests with a period of 4 seconds, and a wind-driven chop of 2 ft.

Analysis

Nothing unusual was disclosed from the past history of the engine and propeller, and an investigation could not be made of the aircraft's wreckage. Therefore, the probable cause of engine failure has to be based on flight crew testimony and on other established facts.

Based on the crew's testimony as to the sequence of events in the failure of No. 2 engine, it is probable that the initial failure occurred to components in the two-speed impeller drive system. Failures in this assembly result in an appreciable power loss and sudden drop in manifold pressure. When this type of failure occurs most of the supercharging effect is lost. The manifold pressure will drop momentarily and will then return to atmospheric pressure.

This type of failure required immediate feathering of the propeller. If this is not done, numerous metal particles are circulated throughout the engine causing contamination and failure of the bearings and bushings. Since the oil flow rate of the engine is approximately 50 gal per minute, it is evident that metal contamination to other parts can occur very rapidly.

The failure was not immediately diagnosed by the flight crew. Believing their difficulty was carburettor ice, they spent a period of time trying to restore power by use of remedial action associated with icing.

It was not apparent to the crew that an internal failure was in progress until the oil-out temperature started to rise. This rise in oil-out temperature is associated with master-rod bearing failures. When the bearings fail the master rods begin to overtravel and cause disintegration of the reciprocating assemblies. This fact is further substantiated by the second check of the ignition analyzer which showed extended patterns and a change in combustion in several cylinders of both rows.

It appears that the increase in engine rpm was due to contamination of the propeller governor. It is most likely that the pilot valve became stuck in the "up" position due to metal contamination, which would result in an overspeed. In addition, the other valves in the governor, including the feathering by-pass valve, could fail to function properly if the metal particles were restricting their movements.

The probability also exists of damage to the oil transfer bearing and seals as a result of contamination. If the oil transfer bearing assembly were in a state of failure, propeller oil pressure would be lost to the propeller due to high internal leakage, and the oil would collect in the nose case rather than flow to the propeller. A failure of this type would preclude feathering and cause propeller overspeed.

The propellers installed on the aircraft were equipped with the rpm-sensitive pitch lock assembly. This device prevents a propeller from uncontrolled overspeeding. The pitch lock becomes effective when an overspeed exceeds approximately 3 200 rpm. On the basis of the crew's testimony, it is evident that the pitch lock assembly prevented a severe overspeed which could have been as high as 4 500 rpm at the time of the initial trouble. It was testified that 2 900 rpm was the highest speed observed, and after reducing airspeed the rpm remained between 2 100 and 2 350 rpm.

Later in the sequence of events of engine difficulty, the crew stated that the oil quantity dropped to zero. The loss of oil quantity can be attributed to two most likely causes. As the failures in the engine progressed, some oil would be pumped overboard as a result of failures in the reciprocating assemblies. In addition, the metal contamination in the oil probably caused failure of the scavenger pump bushings and drives, and much of the oil was never returned to the oil tank. When the tachometer, fuel pressure, and oil pressure dropped to zero, it was evident that the internal failure progressed to a point where the pump drives and bushings seized and became disconnected from the rest of the engine.

Subsequently, heavy vibration developed, the propeller windmilled faster, and then separated from the engine. The separation of the propeller resulted from the lack of lubrication precipitated by the initial failure in the engine.

Conclusions

It was concluded that the No. 2 engine lost power because of a failure in the two-speed impeller drive system. This failure was allowed to progress until complete internal disintegration of the engine's parts occurred. Attempts to feather the No. 2 propeller failed because of metal contamination within the propeller governor and the engine. Friction heat at the propeller thrust bearing and reduction gear assemblies caused a magnesium fire in the nose case of No. 2 engine.

The crew decided to ditch the aircraft since the possibility of a structural failure of the wing existed because of the fire in No. 2 engine. Emergency evacuation operations by the crew were accomplished efficiently.

It was noted that the illumination by a one-cell flashlight permanently attached to the lifevests of survivors materially aided the occupants in the leferafts in locating survivors in the sea during hours of darkness. Although Northwest Airlines had lifevests with one-cell flashlights aboard this flight, the Board noted that such flashlight-equipped lifevests are not a standard requirement for overseas flight of U.S. air carriers.

Probable Cause

The accident was due to the internal failure of No. 2 engine, which resulted in oil contamination, loss of oil supply, subsequent loss of the No. 2 propeller assembly, and fire in flight, which necessitated a ditching.

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ICAO Ref: AR/733

Scheduled
En route
Emergency condition - forced alighting on water
Power plant - supercharger

No. 43

Ethiopian Airlines, Inc., Douglas C-47A, ET-T-18, accident 17 miles south of Jimma, Ethiopia, 15 July 1960. Report released by the Director General of Civil Aviation, Ethiopia.

Circumstances

The aircraft departed Bulchi, Ethiopia, as Flight No. ET-372 (scheduled) at 0904Z on a VFR flight to Jimma with 3 crew, 8 passengers and a cargo of coffee aboard. Due to the lack of communications facilities, no flight plan was filed. When approximately 10 minutes from Jimma (at 0931 hours) the flight obtained a report on the weather at Jimma and requested that the Jimma non-directional radio beacon be turned on. There was no further contact with the aircraft which crashed on a mountain side at an elevation of approximately 9 400 ft at 0940 hours. The pilot was fatally injured. There were no injuries of consequence suffered by any of the passengers. The aircraft received major damage to its wings and forward section, but the resiliency of the bamboo trees, with which it came in contact, reduced the force of initial impact and thus prevented greater damage to the passenger compartment.

Investigation and Evidence

The Aircraft

It had a Certificate of Airworthiness valid until 1 January 1961. The following are the flying times of the components of the aircraft:

Airframe

since date of manufacture	13 674 hours
since last overhaul (20. 5. 60)	182 hours 26 mins
since last periodic check (18. 6. 60)	87 hours

Engines

Left

since last overhaul (20. 5. 60)	182 hours 26 mins

Right

since date of manufacture	5 687 hours
since last overhaul	505 hours 56 mins

The maximum permissible gross weight for this flight, according to the Certificate of Airworthiness, was 25 500 lb. At the time of the accident the aircraft's weight was 25 467 lb. The centre of gravity was within limits.

Crew Information

The captain held an airline transport pilot's licence valid until 6 November 1960 and had flown approximately 3 755 hours of which 2 913 had been on this type of aircraft. He had also satisfactorily completed proficiency and route checks prescribed for captains on DC-3/C-47 aircraft.

The co-pilot held a commercial pilot's licence valid until 2 September 1960. He had flown 7 367 hours - 4 144 of which were on the C-47 and had completed proficiency and route checks prescribed for first officers on this aircraft.

The flight attendant had satisfactorily completed Ethiopian Airline's courses pertinent to flight attendants. He had flown a total of 1 755 hours in this capacity.

Weather

The weather conditions at the site of the accident were as follows:

- ceiling 5/8 stratus, 800 ft, 8/8 altostratus 8 000 ft; visibility 25 km.

Over the flight's route it was cloudy and heavy rain was falling. No weather forecast was made by the Department of Civil Aviation for the route or terminal concerned.

Navigation Aids and Communications

Aids used - Jimma R/T and NDB; reliable over a radius of 25 miles. No approved let-down procedure established.

The navigation aids were not factors contributing to the accident.

Communications were normal on the day of the accident.

Reconstruction of the flight

The aircraft had departed Bulchi at 0904Z on a VFR flight to Jimma and maintained an altitude of 7 000 ft. About 20 miles south of Jimma the pilot climbed the aircraft to 9 000 ft. At this time the aircraft was flying in precipitation below clouds and below the level of the hills in the area and at an indicated airspeed of 130 mph. Due to the reduced forward visibility caused by heavy rain, the pilot maintained visual contact with the ground through the side window of the open cockpit. At this time, due to the fact that the pilot was not referring to his airspeed indicator, the indicated airspeed fell to 95 mph. He was warned of this by the copilot. The pilot then eased the nose down and increased his indicated airspeed to 125 mph. In order to avoid the bad weather ahead he made a left-hand turn (around a hill) and found himself confronted by a 9 400 ft hill and insufficient manoeuvring airspace. In attempting to clear the high ground ahead by climbing, the aircraft stalled just before making contact with bamboo trees. It came to a stop heading almost 180° to the original direction of the flight approximately 100 metres from the first point of contact.

Fire did not break out partly because the bamboos acted as cushions, the ground was muddy, the weather was damp and cold, and also because the pilots took prompt precautionary steps.

Examination of the Wreckage

The aircraft was a total loss due to severe damage to the fuselage from the nose back to the bulkhead separating the crew compartment and passenger cabin. The centre section and passenger cabin were in good condition which accounted for the passengers' survival. The bottom of the fuselage was dented badly, and a stump was sticking up through the aft part. As cargo was still in it, and tools not available, removal of the flooring and inspection of the fuselage bottom under the main cabin were impossible.

The left wing had struck the ground thus curling the end up and bending most of the outer wing panel upward. The left wing also struck a large tree tearing off two or three feet of the wing tip. The leading and trailing edges of both wings were badly dented by contact with trees and both ailerons were completely torn up.

Both engines were torn loose at the mounts, and the left propeller was badly bent by contact with the ground. The horizontal stabilizers and elevators were also badly bent and damaged.

The investigation revealed that there was no structural failure of the aircraft, and the engines were operating normally.

Statements - General

According to maintenance and communications records, the statements of the two surviving crew members and the passengers, there were no indications of any mechanical difficulties before the accident. However, the majority confirmed that the aircraft was flying low, below the clouds and that it encountered fog and heavy rain shortly before the crash.

Probable Cause

The accident was caused by the following:

a) the pilot misjudged the weather conditions in that he continued to fly into deteriorating weather conditions while trying to maintain visual flight rules;

b) he misjudged the performance capabilities of the aircraft in that he attempted to climb at a speed below the minimum safe climbing speed of the aircraft.

Recommendations

Due to the mountainous regions over which the carrier operates, it is recommended that VFR flights shall be conducted so that aircraft are flown in conditions of visibility and distance from the clouds, equal to or greater than those specified in the following table:

Flight visibility	5 km
Distance from clouds	600 m (2 000 ft) horizontally
	150 m (500 ft) vertically
Distance from ground	200 m (700 ft) vertically

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ICAO Ref: AR/653

No. 44

Zone-Redningskorpset, de Havilland 89-A, OY-DZY, accident at Copenhagen Airport, Kastrup, Denmark, on 16 July 1960. Report, dated 8 September 1960, released by the Director of Civil Aviation, Denmark.

Circumstances

The aircraft was cleared at 1437 hours for take-off, on a non-scheduled flight, from runway 04 of Copenhagen Airport, on the following conditions: "VFR to Tirstrup, special VFR out of the control zone, left turn immediately after take-off." Immediately after becoming airborne it was seen to enter a right-hand turn. The turn continued and at an altitude of approximately 200 ft the right-hand turn tightened up, and the aircraft crashed at 1439 hours GMT into the Sound near the coast adjacent to the Airport. All 8 passengers were killed, and the pilot was seriously injured. The aircraft was completely destroyed.

Investigation and Evidence

The Aircraft

Due to the poor single-engine performance of this type of aircraft, OY-DZY was limited to VFR flights. As a result of this limitation the owner removed some items of communications and navigational equipment from the aircraft, however, the instrument equipment was left in place.

At the time of the accident the aircraft held a valid Certificate of Airworthiness.

Following the accident, the pilot testified that during the latter part of the flight he experienced some buffeting which he suspected might have been caused by one or more sections of the left-hand engine cowling being unlocked. Examination of the wreckage ascertained that all engine cowlings were properly mounted and locked at the time of impact. The directional gyro was known to be unreliable. However, other instruments were at hand which would have enabled the pilot to maintain control.

Take-off Weight and Centre of Gravity

Computations based on information received on the actual weight of pilot and passengers indicate that the take-off weight was 2 628 kg, and the centre of gravity was within the prescribed limits. According to the Certificate of Airworthiness the maximum permissible take-off weight is 2 604 kg, and so it must be concluded that OY-DZY in all probability was overloaded by approximately 20 kg. Flight tests have shown, however, that, for all practical purposes, a slight overload of approximately 20 kg has no effect on the stability and manoeuvrability of this type of aircraft. The overload did not contribute to the accident.

The Crew

The pilot was the only crew member aboard the aircraft. For this flight, according to the regulations, he was required to hold a commercial pilot's licence with a type rating at least on the de Havilland 89-A, a flight radio-telephone operator's licence, and a rating as pilot on non-scheduled domestic operations. He did not meet the third requirement, however, his qualifications were sufficient for the issuance of this rating.

He was granted an instrument rating on 24 June 1960, and the test was made on aircraft type KZ-IV*. As the equipment of this aircraft was not sufficient for a complete instrument rating test, the test was to be repeated in case the pilot applied for additional type ratings in respect of his

* Built by SKANDINAVISK AERO INDUSTRI A/S, Copenhagen, Kastrup.

commercial pilot's licence. Thus, his instrument rating ought formally to be valid for KZ-IV only. Also, the pilot had flown 190 hours on instruments on military and civil operations - 130 of which were as trainee - so he should have been fairly well acquainted with flight during IFR conditions.

Planning of the flight

Careful analysis of the available weather information indicated that the pilot was justified in planning the flight according to visual flight rules. In some places en route the weather was marginal for VFR flight and would, no doubt, have forced him to make deviations from the planned route.

Although it was not proven that the operations manager had passed the weather information on to the pilot, there is no reason to believe that this was not the case. The flight plan was not recovered from the wreckage, but there was evidence that it had been filled in and was carried on board the aircraft.

Weather

1357 hours (when taxiing from the south side of the Airport to the terminal building)

- wind 350°/12 kt, visibility 4 km, rain, 2/8 clouds in 800 ft, 8/8 clouds in 5 000 ft

On receiving this weather information the pilot realized that a special VFR clearance to leave the control zone was necessary. This clearance was granted by the air traffic control officer who also remarked: "You are going to get wet then."

Apart from the 1357 weather information, the pilot did not get any further information from air traffic control as regards visibility and cloud base. The air traffic control officer was not under any obligation to inform the pilot of the deterioration of the weather conditions. Although this might have been a natural additional service on the part of this officer, it must be admitted that he was justified in assuming that the pilot, being at the Airport himself, was aware of the changing weather conditions.

From this time on and up to the time of the accident the prevailing weather conditions in the Kastrup control zone were such that VFR flight was impossible as visibility and cloud base were less than 5 km and 300 m respectively.

The regulations, however, permit the air traffic controller on duty to grant a special VFR clearance for flight into or out of the control zone, provided that such flight may take place without hampering or endangering other traffic. This last provision is governing the granting of said special VFR clearance, but, furthermore, the controller takes into consideration that for flight outside the control zone, the minima: visibility 1.5 km, cloud base 500 ft, must not be violated.

Based on information available and on regulations in force, it was concluded that the granting of a special VFR clearance was justified. It is noteworthy that the intensity of the rain was increasing and, based on evidence, it is obvious that at the time of taxiing out and take-off the rain was extremely heavy.

The Flight - Discussion

Soon after the start of the take-off run, forward visibility decreased due to heavy rain, and the pilot, a short time after the aircraft became airborne, had to resort to instrument flying. Considering the limitations imposed on the operation of this aircraft and in view of the available runway length, the take-off should have been abandoned. The reason for continuing the take-off cannot be ascertained. The pilot may have expected to be on instruments for a very short time only and might have been influenced by the desire not to delay the flight. It is surprising that the pilot, when forced into instrument flight, did not avail himself to a greater extent of the instruments on board. The aircraft was adequately equipped for instrument flight, and the pilot was qualified for such flying. During the flight on instruments the aircraft stalled and, due to insufficient altitude for a recovery, it crashed into the sea.

Immediately after the aircraft became airborne the pilot had initiated a right-hand turn. This was contrary to the clearance received from air traffic control (see "Circumstances"). It was suggested that this right-hand turn was made in order to avoid passing the town at a low altitude - an unlikely possibility. The prevailing crosswind from the left together with the lack of control during the instrument flight most probably caused the aircraft to drift to the right.

Windshield wipers

OY-DZY was not equipped with windshield wipers, and no regulation required it to be so equipped.

Whether windshield wipers would have been of any appreciable help during the circumstances is extremely doubtful. The transition from visual flight to instrument flight might possibly have been postponed a few seconds, but it is considered likely that due to the very heavy rain the aircraft, even if it were equipped with windshield wipers, would have been forced into instrument flight if the take-off were continued.

Probable Cause

The pilot, immediately after the aircraft became airborne, was forced into instrument flight, a situation which he, under the prevailing circumstances, did not master, and the aircraft stalled at a very low altitude and crashed into the sea.

Recommendations

1. Action should be taken to ensure that when a company flight plan is required, a copy of such flight plan will remain on the ground in the care of the company.

2. Pilots must be reminded of their obligation to enter in the appropriate logbooks all remarks pertaining to the serviceability of aircraft, instruments, and equipment. Furthermore, the owners of the aircraft must be reminded of the fact that all instruments on board must be serviceable at take-off.

3. The feasibility of a requirement for windshield wipers on aircraft must be evaluated.

4. The VFR flight rules, in particular the conditions for granting a special VFR clearance to fly into or out of a control zone, and the services rendered to aircraft under those circumstances, must be revised.

5. A summary to this report is to be published in "Notices from the Directorate of Civil Aviation" so that other pilots may benefit from the lessons learnt.

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ICAO Ref: AR/651

No. 45

Philippine Air Lines, Inc., F-27 Friendship, PI-C501, accident at Bacolod City on 18 July 1960. Report released by the Civil Aeronautics Administration, Republic of The Philippines.

Circumstances

PI-C501 took off from Manila International Airport at 1430 hours on a scheduled domestic flight to Bacolod. The trip was normal. During the landing at its destination at 1603 hours the captain applied brakes to slow down the speed preparatory to turning into the north taxiway leading to the ramp. The right-hand brake did not, however, react causing the aircraft to swerve to the left shoulder of runway 30. The aircraft finally settled when its nosewheel struck in a soft spot beside a runway light about 10 ft from the taxiway. The aircraft was slightly damaged, and there was no fire. The crew of 4 and the 34 passengers aboard the aircraft escaped injury.

Investigation and Evidence

Captain's statement

He testified that he tried to counteract the swerving of the aircraft by applying the right-hand brakes together with the nose-wheel steering. Notwithstanding these corrective measures applied, the aircraft still continued to swerve to the left. He then applied the emergency brake in an unsuccessful effort to stop the aircraft. It came to a full stop only when its nosewheel stuck in the soft spot beside a runway light.

Damage

The runway light hit the fuselage skin on the belly at station 2760, tearing a hole of approximately 2 inches diameter. The landing light was also broken.

The right-hand landing gear was raised, and the wheels were removed in order that the brakes could be tested. It was found that excessive leakage occurred on the inboard and outboard brake units.

The right-hand brake units were, therefore, replaced. After the right-hand wheel assembly was reinstalled, the brake system was tested, and it was found to be satisfactory.

Probable Cause

The accident was attributed to the failure of the O ring seals in the right-hand brake units.

Brake Units - Follow-up Action

An alarming rate of failures of these units was experienced by the airline. As a result, all faulty brakes removed were tested, disassembled, and evaluated, and it was observed that there was evidence of excessive discing of the pressure plate, stationary and rotating discs resulting from overheating. This discing characteristic leads to binding and consequently aggravates the overheating. Moreover, the O-ring seals lose their sealing effect due to excessive heat, thereby allowing leakage of pneumatic pressure. A condition of undissipated heat in the brake system exists whenever the parking brakes are applied immediately after operation of the normal or the emergency brakes.

In view of the foregoing the following procedures were set out as follows:

1. Whenever the normal or emergency brake is operated during landing or taxiing on all occasions (regular, special, utility or transition flights) allow 10 minutes cooling time before applying the parking brakes.

2. Maintenance as well as station personnel concerned must install chocks immediately after the F-27 stops at unloading points.

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ICAO Ref: AIG/ACC/REP/GEN/No. 17 - The Philippines

No. 46

Chicago Helicopter Airways, Sikorsky S-58C helicopter, N 879, crashed at Forest Park, Illinois, 27 July 1960. Civil Aeronautics Board (USA), Aircraft Accident Report, File No. 1-0054, released 14 August 1961.

Circumstances

N 879 was serviced and scheduled to leave Midway Airport (Chicago) at 2230 hours central daylight time as Flight 698 for O'Hare Airport, 17 nautical miles away. It departed on schedule in VFR conditions. When it had cruised to about the halfway point of its trip, a part of one of the main rotor blades broke away. The helicopter began to descend with its landing lights on. Sounds similar to the rapid cracking of a bullwhip were heard by witnesses. Moments later, the tail cone and tail rotor separated from the aircraft, and the angle of descent increased. The helicopter spun around its vertical axis, crashed nosedown on its left side, and burst into flames in Forest Home Cemetery at 2238 hours. The two crew and eleven passengers were killed, and the aircraft was demolished.

Investigation and Evidence

The Wreckage

The wreckage covered an area extending 2 800 ft in the direction of 315° and 1 120 ft wide. The cabin, power plant, landing gear, main rotor mast, three complete main rotor blades, and about one third of the fourth blade covered an area approximately 50 ft in diameter.

The tail cone with the tail rotor attached was found back along the flight path approximately 990 ft from the main wreckage site. Farther back along the flight path an additional 1 900 ft, the investigators found the outer 19 ft of a main rotor blade (S/N 5434) lodged in a tree. The blade had fractured 102 inches outboard from the centre of rotation. There was no evidence of the fractured blade having hit any foreign object in flight.

Fatigue Fracture of the Rotor Blade

Examination revealed the presence of a fatigue area which had its nucleus at the surface of the lower external back-wall radius of the spar. The fatigue had progressed up the back of the spar and 1.2 inches forward into the upper surface of the "D" shaped member. The fatigue had also progressed forward along the lower surface for about five inches. The fatigue zone comprised about 57% of the total cross-sectional area at the time of the final separation failure.

History of the Blade (S/N 5434)

It was manufactured in October 1956. In June 1958, when it had been in service 180 hours 40 minutes, it was subjected to a quickstart.

All four blades were sent to the Sikorsky factory for repair. The 14 inboard pockets of blade 5434 were replaced at this time. In this replacement process the radius where the fatigue crack later started was refinished with a 240-grit paper and the new pockets were then bonded to the spar.

In May 1960, when the blade had a total time of 1 509 hours 29 minutes, it was again sent back to the Sikorsky factory for inspection and repair because of a reported vertical bounce condition. During this repair, no warpage or deformation was found, but three pockets were removed and replaced. However, the pocket at station No. 102, where the blade ultimately fractured, was not disturbed. The blade was again put back in service and had a total of 1 786 hours 6 minutes service time when the accident occurred. It had been approved for a service life of 2 450 hours by the FAA.

Blade No. 5434 had been installed on four different helicopters in its lifetime. It had been installed on N 879 on 19 June 1960, 156 hours and 24 minutes prior to the accident. Except for the quickstart incident (when installed on N 865) and the vertical bounce incident (when installed on N 866), no difficulties or unusual incidents occurred to the blade. Several vibration writeups were noted in the flight log of N 879 during the latter part of June and early July 1960, but there were no further vibration writeups after 17 July, when the tail rotor was balanced.

In its original manufacture the blade spar was anodized. When the blade was repaired in 1958, after the quickstart, and again in May 1960, for suspected warpage, Sikorsky records indicated that an alodine coating was applied as required. Neither spot tests nor spectrochemical examination revealed any evidence of an anodized or alodine coating where the fatigue crack originated. However, subsequent tests and study disclosed that the post accident cleaning process applied to the spar prior to its examination had removed the alodine coating. Alodine was in fact present on the undisturbed parts of the spar that had been repaired in 1958 in the same manner as the area of the fracture.

Metallurgical examination of the failed blade disclosed that it had been fabricated from 6061-T6 aluminum alloy and that the material complied with the requirements of the pertinent Federal specifications. No evidence of corrosion damage was found, but minute corrosion pitting could not be eliminated. After the accident, when it was initially believed that the alodine coating had not been applied to the spar, Sikorsky initiated a series of fatigue tests in a corrosive atmosphere to indicate the effect of minute corrosion pitting and their tests are presently under way.

Inspections

Chicago Helicopter Airways (CHA) performs the following inspections on their aircraft: a daily preflight; a No. 1 every 20 hours; a No. 2 every 55 hours; a No. 3 every 105 hours; and a No. 4 every 210 hours. The inspections are accomplished by a mechanic. Although the inspections cover many subjects, only that of blade inspection is discussed here.

Daily preflight and inspections No. 1 and 2 - it is required that the mechanic "inspect main rotor blades for dents, scratches, cracks, corrosion, and damage to spar pockets and trailing edge."

On inspection No. 3 it is required that the blades be cleaned with a dry rag before being viewed for cracks, dents, etc. Prior to inspection No. 4, the blades are removed from the rotor head and placed on a stand and washed with soap and water. The use of optical devices is not required unless something is found in the inspection that requires the use of a power glass to detect exactly what it may be.

All blade inspections had been performed on schedule. One hundred and eight hours and eleven minutes before the accident the blade was given a No. 4 inspection, and 40 hours and 2 minutes later it was again removed from the rotor head, washed, and inspected, because the main gear box and rotor head were due for a change. On the previous day, 3 hours and 1-minute blade time before the accident, it was given a No. 3 inspection. At no time in the history of the blade were any cracks reported as a result of company inspections.

Surface Finish

Because the surface finish could have a significant effect on the fatigue life of the blade, the Board conducted a review of Sikorsky's quality control procedures relating to obtaining the required finish.

A review of the Sikorsky engineering drawing from which the blade was manufactured disclosed that all external surfaces of the blade spar were required to have a 40 RMS* surface finish. Surface roughness measurements in the fracture area made by Sikorsky after the accident indicated the finish was within drawing specifications. Similar measurements made for the Board by the National Bureau of Standards indicated that the surface finish was 50 - 60 RMS.

The fatigue crack started from an area of sanding scratches made from 60 - 80 grit abrasive paper used in the finishing process during original manufacture prior to bonding the pockets to the spar. The crack originated at one of these deeper scratches that was nearly perpendicular to the longitudinal axis of the blade.

Until 1958, a 60 - 80 grit abrasive paper was used by the shopworkers to obtain the required 40 RMS finish. This grit paper was selected by the shop after evaluation as the proper grit to achieve the required finish. However, laboratory tests conducted after the accident showed that the actual finish achieved with this grit paper varied and was a function of the newness-oldness of the paper, the pressure applied by the sanding operator, etc. In fact, a 60-grit paper could be expected to produce a finish as rough as 110-120 RMS. This variability of surface finish, using 60-80 grit papers, was verified after the accident by examining the finish of other service blades produced at about the same time as the CHA blade. Discussions with shop inspection personnel revealed that the surface finish in production was judged on the basis of a visual examination and the inspectors' experience, and that, routinely, finish comparison blocks were not utilized.

In 1958 Sikorsky decided to incorporate as a product refinement a finer finish on the back corner of their S-58 blades in production or overhaul. At this time the shop began using a 240-grit paper to obtain the desired smoother finish. As stated, the back corner of the failed N 879 blade was refinished with this grit paper during the 1958 repair.

Certification of the Aircraft.

N 879 was certificated by the Civil Aeronautics Administration in 1957 under Type Certificate No. 1H11 which lists as certification basis for approval of the type design, Part 6 of the Civil Air Regulations, dated 15 January 1951, and Amendments 6-1 through 6-6. Fatigue requirements applicable to the main rotor structure are presented in paragraph 6.250 of CAR Part 6, and a method of rotor service life substantiation acceptable to the Administrator is included in Appendix "A" to Civil Aeronautics Manual 6. Basically, the FAA (CAA) approved method correlates measured flight stresses, loading spectrum, and the fatigue strength characteristics of the structure, utilizing the Cumulative Damage Theory to arrive at a predicted fatigue life for the rotor. Further, a suggested loading spectrum is presented in Appendix "A", and the minimum fatigue specimen testing for establishment of an S-n curve** is outlined. In addition, the calculated fatigue life is reduced by 25% in arriving at the service life of the component.

In complying with the fatigue requirements of CAR Part 6, Sikorsky followed the basic CAM 6 procedure, including additional conservatisms based upon their own experience. Their initial 1956 analysis indicated an infinite life for the outboard portions of the blade (N 879's blade failed in the outboard area) and a service life of 2 450 hours for the inboard portion of the spar. Accordingly, the blade retirement time was established at 2 450 hours. In early 1959, however, as a result of service

* The height of the roughness (average) is specified in microinches. The instruments are calibrated in RMS (root mean square) average or in arithmetic average.

** Established by testing samples at a fixed steady stress and varying the oscillatory component of the stress.

experience with their S-56 blade, Sikorsky re-evaluated the fatigue life of the outboard portion of their S-58 blade, utilizing new flight stress data and a lower S-n curve based on full scale specimens. This analysis indicated that the fatigue life of the outboard portion was 4 560 hours rather than "infinite" as calculated earlier; but since this calculated fatigue life was still appreciably greater than the fatigue life of the inboard spar, the service life of 2 450 hours was not changed. At the time of the accident the service life of the S-58 blade was still 2 450 hours, and a number of blades had successfully accumulated this number of hours and had been retired.

Following the accident to N 879, Sikorsky made a fatigue calculation for the back corner of the spar at the spanwise location where the CHA blade had fractured. This re-evaluation indicated that the spar at this location had a fatigue life of 4 690 hours, somewhat greater than the 1959 fatigue calculation - and still appreciably greater than the actual N 879 blade fatigue life of 1 786 hours. Still another fatigue calculation was made, using an estimated CHA spectrum, in the belief that their operation might be more severe than the conservatively modified CAM 6 spectrum. On the contrary, this calculation indicated a fatigue life of 5 960 hours, a value over three times greater than the actual life of the N 879 blade.

Since the original fatigue calculations and re-evaluations of these calculations all indicated that the predicted fatigue life of the blade in the fracture area was appreciably greater than the actual fatigue life of the N 879 blade, efforts were directed at uncovering factors which would account for this large reduction in fatigue life. Specifically, studies and tests were initiated to evaluate the possible deleterious effects of (1) quickstarts, (2) service environmental conditions, (3) manufacturing variations, and (4) CHA's routes and operating practices.

Fatigue specimens were prepared and tested to determine if precompression simulating "quickstarts" had the effect of lowering the fatigue life of the rotor. All of the precompressed specimens tested to date have fallen within the S-n scatter band of the non-precompressed specimens, indicating no adverse effect. Fatigue testing of service blades which have been subjected to actual "quickstarts" is planned, but the results of the precompressed fatigue tests offer no great promise for the planned tests.

Early suspicion was directed toward the adverse effect of the surface finish on the fatigue life. As indicated earlier, the fatigue crack started at one of the deeper scratches in the surface made from 60-80 grit abrasive paper used in the manufacturing finishing process. However, fatigue tests of specimens finished with various grit papers disclosed no significant decrease in fatigue life for finishes within the range of manufacturing variation.

An investigation was initiated to determine whether the actual CHA S-58 operating spectrum was more or less severe than the spectrum used in determining the blade life. Valuable data on leading spectra were already available as a result of the NASA's continual helicopter V-g-h-n programme; but specific data for CHA's S-58 operation had not been accumulated at the time of the accident. The NASA studies showed that the periodic loads developed in the various routine flight conditions constitute the principal part of the total fatigue loading on the helicopter, and that atmospheric turbulence and moderate manoeuvres have no significant effect on the fatigue life. The research findings have a bearing on the degree of confidence that may be placed in the suggested CAM 6 spectrum. However, the N 879 blade failure raised the question of some possible peculiar loading condition in the CHA S-58 operation. Sikorsky installed, with CHA's consent and assistance, a V-g-h-n type recorder in a CHA aircraft and accumulated some 87 hours of data under actual conditions. Preliminary evaluation of the data indicates that the CHA aircraft was operated substantially in accordance with recommended procedures, and that the CHA spectrum is not appreciably different from that assumed in the fatigue analyses. Sikorsky is also instrumenting one of their own aircraft to continuously record blade stress data and they plan to conduct a simulated CHA type of operation to further verify the adequacy of the design spectrum.

Soon after the accident to N 879, when it was established that the blade fracture was due to fatigue, the retirement or service life of the S-58 blade was reduced from 2 450 hours to 1 000 hours. In addition, the Board recommended to the Administrator that:

1) a searching review be made of the approximate ten-year old CAM 6 design procedure;

2) CHA be required to conduct a more thorough visual inspection for cracks at all numbered maintenance checks, and that

3) as a precautionary measure all blades subjected to quickstarts be retired from service until such time as it is demonstrated conclusively that such a condition does not adversely affect the blade fatigue life.

The Administrator has advised the Board that a revision of the CAM 6 design procedure is being studied; that a more vigorous blade inspection, as outlined in Airworthiness Directive 60-17-3, is being considered; and that it is his view that there is not sufficient justification at this time to require retirement of quickstart blades.

Analysis

The direct cause of this accident was metal fatigue of a main rotor blade. When the blade fractured the main rotor assembly became unbalanced and vibrations of a sufficiently destructive force developed and caused the tail cone to fracture. Loss of control resulted.

The prevention of similar accidents dictated uncovering all pertinent factors underlying the fatigue failure.

The problem of achieving a satisfactory or "safe" fatigue life for a component such as a helicopter blade is a function of -

1) design standards and procedures;

2) manufacturing standards and procedures, and

3) service conditions and practices.

It is becoming more generally recognized that these factors are so intimately involved with one another that tolerable reliability requires the fullest consideration of their interrelationship.

As stated previously, CHA's operation of N 879 was essentially in accordance with Sikorsky's general recommendations and as approved by the Federal Aviation Agency. Although preliminary evaluation of the recent Sikorsky flight history recorder data indicates no appreciable variations from the design spectrum, the Board believes this programme should be continued to ensure that there are no uncertainties in this important area. In this general regard, the Board is of the view that industry consideration should be given to installing flight history recorders on all newly introduced air carrier helicopters to verify design loadings early in the fatigue life of the aircraft.

Whether CHA's blade inspection programme was thorough enough to ensure detection of the fatigue crack before the final fracture is a difficult question to answer. That these procedures were in accordance with Sikorsky's general recommendations and were approved by the FAA was clearly established during the Board's investigation. The lack of precision possible in assessing the time over which the crack developed and progressed to fracture contributes materially to the difficulty of evaluating the adequacy of the inspections performed. From the evidence developed during the investigation, it is the opinion of the Board that inspections of the type conducted by CHA during their numbered 1, 2 and 3 maintenance checks were not conducive to crack detection on the lower surface in the fracture area. Moreover, it is difficult to believe that a fatigue crack would not have been detected at the time the gear box was changed on 13 July - 68 hours before the accident - if such a crack were present. This inspection, the equivalent of a No. 4 inspection, where the blades are removed from the helicopter and washed with soap and water before inspection, is considerably more thorough than the blade inspections during the Nos. 1, 2 and 3 checks, and most certainly would have uncovered a crack that had progressed beyond the pocket cutout.

However, it is more disturbing to consider that under the approved maintenance procedures, detailed inspections of the No. 4 check type occur at intervals of 210 hours and that the 13 July inspection was only incidental to a gear box change. In other words, in the 2 450 hour lifetime of the S-58 blade (this has since been reduced to 1 000 hours as discussed earlier), a minimum of only twelve detailed inspections would have been permissible. In view of the catastrophic nature of a main rotor blade failure, as demonstrated by this accident, and the demonstrated fact that a fatigue crack can develop and progress to failure in less than 68 hours, it is the Board's opinion that the required detailed inspections of the No. 4 check type should be spaced at shorter intervals. In the light of the foregoing, therefore, consideration should be given to increasing the frequency of detailed inspection as the service life limit is approached, or alternatively, and perhaps preferably, to integrate the inspection programme in a design reliability analysis to achieve a desirable level of safety.

Although during the early stages of the investigation the surface finish in the fracture area was thought to be a major factor in the premature failure of the CHA blade, subsequent investigation tended to disprove this conclusion. The surface finish of the N 879 blade was not significantly rougher than as required by the drawing. In addition, other blades contemporary to the CHA blade had even rougher finishes and some had accumulated sufficient hours to be retired from service. Furthermore, the design S-n curve, in effect, took into consideration these surface finish effects inasmuch as the fatigue specimens were finished in the same manner as production units. Finally, the fatigue testing done subsequent to the accident disclosed that surface finishes within the range of manufacturing variation fell within the S-n scatter band. For these reasons the Board concludes that the premature fatigue failure of the CHA blade cannot be attributed to surface finish effects.

The question of corrosion figured prominently in the early considerations of the cause for the premature fatigue failure of the blade. Until the later tests discounted the earlier finding that no alodine was present in the fracture area, it was thought possible that minute corrosion pits, too small to be detected by metallurgical examination because of the roughness of the finish near the fracture, might have precipitated an early fatigue failure. However, the Board believes that it may reasonably be concluded that alodine was present in the fracture area and that corrosion pitting did not play any significant part in the failure.

Except for the refinishing of the back corner radius, without applying the specified alodine coating, the 1958 "quickstart" repair was in accordance with approved procedures and appears not to have been a factor in causing the subsequent blade failure. This last conclusion is borne out by the results of the simulated quickstart specimen testing which disclosed no deleterious effects from precompression of the amount that would be expected from a quickstart. The full-scale testing of service quickstart blades may alter this conclusion, but it appears doubtful at this time.

The remaining area in which the cause for the fatigue failure may be, involves the design standards and procedures. As discussed earlier, the fatigue substantiation methods used by Sikorsky were approved by the Federal Aviation Agency. Furthermore these methods, or ones very similar to them, have been in use in the industry for many years. Although fatigue failures have occurred before to various helicopter components, including rotor blades, the failures could in just about every instance be attributed to factors not considered or foreseen by the designer in applying the approved methods or to factors relating to the service use or maintenance beyond the designer's direct control, such as operation outside of the recommended limitations, improper maintenance, etc. In the subject instance, the absence of such concomitant factors or, at least, the lack of conclusive proof that the existing factors (quickstart, corrosive effects, inspection techniques, etc.) contributed materially to the fatigue failure is reason enough, the Board believes, to question the conservatism of the approved design procedure. In this regard, extra margins, whether they be in the form of more frequent service inspections or in a more conservative design approach, should be required when the designer elects to use the "safe life" approach.

The Board is convinced that the facts developed during this investigation warrant detailed study by the industry and the Federal Aviation Agency so as to ensure that proper conservatism is included in the design procedures for air carrier passenger helicopters.

Probable Cause

The probable cause of this accident was the structural disintegration in flight initiated by a fatigue fracture of a main rotor blade.

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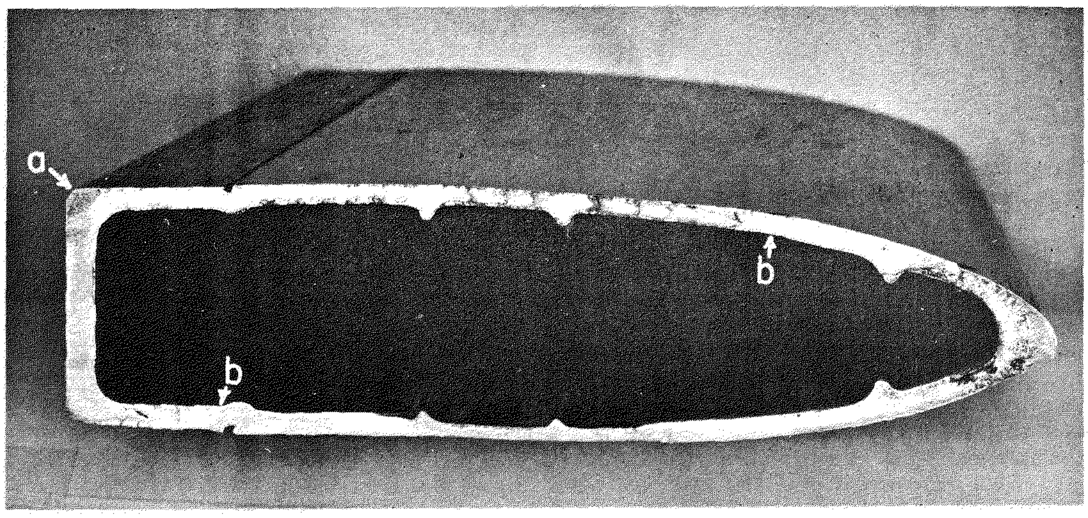
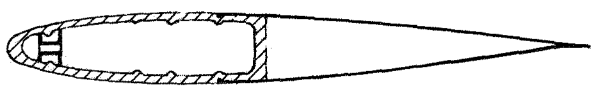
ICAO Ref: AR/687

FIGURE 10



Surface of the fracture in the blade from Chicago Helicopter Airways. Arrow "a" indicates the origin and arrows "b" the ends of the fatigue fracture.



Typical Blade Cross Section

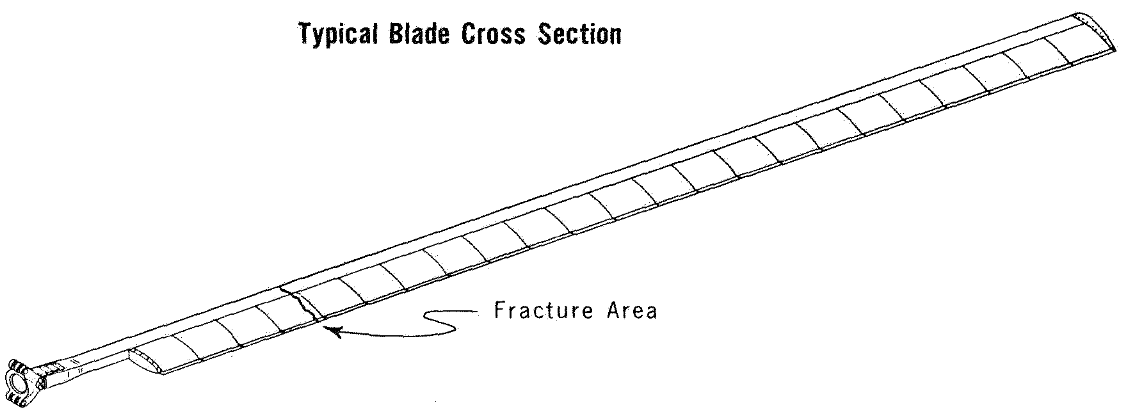


FIGURE 11 - **Main Rotor Blade**

FOREST PARK, ILLINOIS, CHICAGO HELICOPTER AIRWAYS, N-879, JULY 27, 1960

USCOMM--DC

No. 47

Deutsche Flugdienst (Frankfurt), Convair 240, D-BELU, accident at Rimini Airport, Italy on 31 July 1960. Report of the Commission of Inquiry appointed by The Minister of Defence and Aviation, Italy.

Circumstances

The aircraft was carrying out a non-scheduled flight from Dusseldorf to Frankfurt, Germany and Rimini, Italy, and was in the en route descent phase between Chioggia and Rimini at an altitude of approximately 5 000 ft when the pilots noted that the left engine was not functioning properly. The pilot-in-command of the aircraft put the malfunctioning engine on minimum power and continued his flight towards Rimini. Shortly before passing over the Rimini radio beacon at an altitude of approximately 1 500 ft, troubled developed in the right engine also. The pilot continued the flight but at a very short distance from the airport, with the left engine feathered and the right engine operating irregularly, he was compelled to make an emergency landing off the airfield. The aircraft touched down about 1 000 m from the beginning of runway 13 of Rimini Airport. Two pilots, one hostess, one mechanic (not a crew member), and 30 passengers were on the aircraft at the time of the accident - 1056 hours GMT. Of these persons, 3 crew received minor injuries, 1 passenger was killed and 5 were injured.

Investigation and Evidence

The Aircraft

It had a Certificate of Airworthiness valid until 30 November 1960. At the time of the accident its gross weight and centre of gravity position were within authorized limits.

The aircraft had flown 43 hours since its last periodic check.

*50% day, 50% night and IFR

Crew Information

Both pilots held valid airline transport pilot licences. They had received adequate training on the aircraft type involved in the accident. The pilot-in-command had flown a total of 1 700 hours* on the Convair 240. Two hundred and fifty of these hours had been flown during the last ninety days. This number of hours was considered to be a maximum limit under the Italian Regulations. Of the 1 700 hour total, 500 hours were flown as pilot-in command and 1 200 as co-pilot. The co-pilot had flown 900* hours on the Convair 240 of which 150 hours had been flown during the past ninety days.

There was no record of either of these pilots having been involved in any previous accident.

Weather

The landing conditions at Rimini Airport at 1100 hours were as follows: wind 050°, 2 - 4 kt; visibility 6 km; temperature 26.2°C; dewpoint 21.2°C; altimeter setting 1015.6; clear.

Navigation Aids

The equipment and aids available, which were all used except the ILS, operated efficiently.

Reconstruction of the flight

D-BELU departed Frankfurt for Rimini at 0836 hours on an IFR flight plan to fly at flight level 150. It was to follow Airways A-10 and A-12 with ETA Rimini at 1052 hours. Weather conditions were good.

At 1031 hours the aircraft reported over Chioggia at flight level 130, and Milan Air Traffic Control subsequently cleared it to proceed VFR to Rimini and instructed the flight to contact Rimini approach.

Six minutes later the flight was authorized by Rimini approach to leave flight level 120, as requested, and told to report over the radio beacon (Rimini) at 5 000 ft. Following this clearance the pilot adjusted the power for descent and lost 7 000 ft in six minutes with the power units operating normally.

At 1043 hours the aircraft advised Rimini tower of the failure of the left engine and asked for a direct approach. (At this point the statements of the pilot and the tower operator do not fully concur. Because of a temporary failure of the recording machines, the conversations between the aircraft and Rimini tower were not registered on the tape and, therefore, there is no means of checking the statements).

The remainder of the flight was as follows:

1048Z - the tower cleared the aircraft for a direct approach and asked it to report 5 NM from the runway

1050Z - aircraft requests QDM bearing (QDM 145° given)

1052Z - aircraft requests another QDM (QDM 104° given). (The pilot stated that before arriving over the Rimini beacon and again over the beacon at 1 200 ft the right engine showed signs of malfunctioning.)

1053Z - the tower asked the aircraft whether it was in sight of the airfield. It received a negative reply. The tower then requested the aircraft to report on the final portion of the traffic circuit to runway 13. (The pilot later stated that at this point the right engine experienced a further loss of power.)

1054Z - the tower sighted D-BELU on final and cleared it to proceed as No. 1 to land on runway 13.

1055Z - D-BELU was warned by the tower that it was too low on the last portion of the final approach. The aircraft did not acknowledge and immediately thereafter landed outside the field.

The pilot stated that he gave instructions to prepare for an emergency landing which took place at approximately 1056 hours. hours. The aircraft landed in a field where grape vines were strung between mulberry trees, after having avoided a high tension line and a farm house along its flight path. It slid about 100 m along the ground with its undercarriage retracted.

The second pilot stated subsequently that the flight times and the communications exchanged between the aircraft and Rimini tower were not exactly those described above. He, therefore, requested that the following report be submitted to the Investigation Board.

Position (1) - See Figure 12.

"At 1041 hours we flew over the southern limit of Comacchio Valley in descent."

Position (2)

"At approximately 1044 hours we reported to Rimini tower at 5 000 ft in horizontal flight. At that moment the BMEP pointer of the left engine started oscillating. We, therefore, adjusted the left engine at 20 BMEP. I called Rimini tower - 'We have trouble with our left engine. Request straight in clearance for runway 13 as No. 1, our estimate is 1052.' From position (2) to position (3) we continued to descend."

Position (3)

"Before arriving over radio beacon KR (Rimini) the right engine started vibrating. I immediately requested a QDM for the runway. Immediately after the right engine started losing power intermittently. I again called Rimini tower saying: 'We now also have trouble with our right engine. Request definite clearance as No. 1 for straight in to runway 13. We cannot go around. We cannot overshoot.' I then requested a second QDM."

Position (4)

"At 1050 hours we flew over and abeam radio beacon KR at 1 200 ft in descent. The pilot-in-command feathered the left engine. I cut out the fuel pump of the left engine. Up to that moment I had not received instructions to light up the emergency signal. I warned the pilot-in-command that there was a high tension line ahead and told him that if we continued to fly at that engine power we would not avoid the obstruction."

Position (5)

"After avoiding the high tension line, the power of the right engine decreased and it was obvious that we could not reach the runway. I wanted to call Rimini tower but at that very moment Rimini tower called us. 'D-BELU, we have you in sight, you are very low, you are very low for landing'. The pilot-in-command gave the order: 'Prepare for emergency landing.' Before the landing I cut out the master switch, the magnetos and the fuel pump. After the landing the flight engineer opened the doors and the passengers left the aircraft without panic."

The Wreckage

The wreckage was scattered over an area approximately 100 - 120 m in length and 25 - 30 in width. Ground marks indicated that the tail struck the ground first; the distance from this point to the point at which the front of the aircraft came to rest was about 150 m. During the landing the aircraft struck trees supporting grape vines and trees bordering the road crossed by the aircraft, breaking the first and uprooting the second. As a result of these impacts, the wings were demolished and torn off. The distance between the propeller blade scores was approximately 125 cm. Assuming that the propeller was turning at 1 000 rpm, the aircraft was travelling at a speed of approximately 100 km/h at the moment when the right propeller began to strike the ground.

Fuselage - Except for breaks and local deformations, the fuselage was generally intact with the tail assembly still attached with the exception of the left stabilizers which were sheared off near the middle. There was a fairly large hole near the first right forward window of the passenger compartment and a large dent in the rear structure with other dents and breaks caused by the dragging on the ground and the impact with the trees.

Wings - The wings were separated from the fuselage, each broken into two main parts; one containing the fuel tank and the other the wing tip section. The fuel tank of the right engine still contained (at 1700 hours on 2 August) approximately 500 litres of fuel. A sample was taken and sent to the Technical and Chemical Laboratory for complete analysis. The left tank was pierced near one of the corners and did not contain any fuel.

Power plant - The power units were torn free from the wings. The left engine, practically undamaged, was lying behind the rear part of the aircraft with the propeller in the feathered position; the blades were broken off at approximately 80 cm from the hub. The right engine was lying approximately 5 m to the right of the forward part of the aircraft, with its propeller and part of the reduction gear in the far side ditch of the road crossed by the aircraft. A piece of the casing with its magneto and the distributors was lying approximately 5 m behind the left engine.

Investigations and Special Tests

Left Wing Fuel Tank

The first on the spot investigation conducted by the Board forty-eight hours after the accident and the checks made by the Airport Commission a few hours after the accident, disclosed that the left wing tank did not contain any fuel.

On the other hand, the rescue personnel at the scene of the accident stated that they saw fuel trickling from this tank about half an hour after the accident. As indicated (under Wings) there was a small hole in one of the corners of this tank.

An attempt was made to determine whether the fuel, which was presumably in the tank at the time of the accident, (estimated amount was approximately 800 litres), could have spilled out and how long it would have taken to do so. Rather than remove the wing section for a complete examination of the tank, thereby running the risk of further damage and changing the positions of the wreckage, a practical test was conducted in situ by replenishing the tank with 800 litres of water. It was observed that the tank emptied in 25 minutes and that the liquid was completely absorbed by the ground.

This test was carried out before the detailed examination of the left engine provided clear indication of malfunctioning.

Augmentor Vanes

The augmentor vanes of the right engine were found in the closed position, i. e. in the position corresponding to operation of the anti-icing system of the wings and tail. This position should be considered abnormal for the approach phase with high outside temperatures.

A further anomaly was the fact that the actuator of the augmentor vanes of the right engine, although it was still perfectly attached to the lever of the right augmentor valve of the right engine, was in the retracted position, which position should correspond to the valve in the trail position.

It was found that as a result of the impact, the support of the actuator was pushed closer to the valve, thereby determining the motion of the levers of the augmentor vanes, and thus causing the augmentor vanes to rotate towards the closed position.

The conclusion was reached that the raising of the augmentor vanes in the closed position could not be attributed to the operation of the anti-icing system of wings and tail which would have led to the overheating of the right engine, but was instead the direct consequence of the impact.

Furthermore, the pilots, in reply to a specific question put to them by the Board, stated that they had never used the wing-tail anti-icing system during the flight.

Spark Plugs

Left engine - 31 new park plugs and 5 reconditioned ones

Right engine - front - 16 new spark plugs, 2 reconditioned spark plugs
back - 2 new spark plugs, 16 reconditioned spark plugs

The reconditioned spark plugs had undergone a single overhaul after 200 hours of operation.

The spark plugs were bench tested with the following results. The spark plugs of the left engine were within the tolerance limits both as regards the high voltage test and the operation test. The right engine's spark plugs were within the tolerance limits as regards the high voltage test and the operation test under pressure (7 kg/cm^2). Only 17 new spark plugs satisfied the test and 18 reconditioned ones did not pass it.

The "dimensional check" showed that the gap setting between the electrodes of the new spark plugs was within the tolerance limit (0.013" - 0.016") while that on the reconditioned spark plugs exceeded in many cases this limit (0.023" or more). The electrodes of the reconditioned spark plug were considerably worn down as compared with the new spark plugs.

Magneto and Distributor Cables

The cables, which were perfectly dry, were tested under a tension of 10 000 volts.

The following losses were found:*

Dispersion in Micro Amperes

Left engine		Right engine	
Left cable	Right cable	Left cable	Right cable
5	5	3	20

The insulation of all the cables was found to be within the tolerance limits. However, it was found that the dispersion was greater in the right cable of the right engine, that is to say on the cable marked deterioration of the insulation (spider web cracks).

Engine test

On 2 September the right engine of Convair 240, D-BESI, was ground tested so as to reproduce the operating conditions of the right engine of D-BELU.

The spark plugs and the cables of the magneto and distributors from the right engine of D-BELU were mounted on this test engine in the same position.

The ignition analyser was not mounted on the engine. The outside temperature was 19°C and the weather was damp.

Starting - normal starting of the engine but after a few minutes of operation considerable vibration occurred which ceased once the engine warmed up.

Magneto test - during the magneto test the ignitions were within the tolerance limits:

DROP 8 BMEP on left ignition
DROP 7 BMEP on right ignition

Power test for air temperature at the carburettor -

- starting with an air temperature of 25° at the carburettor, 2 300 rpm and full throttle, only the temperature of the air at the carburettor was increased up to 45°.

Starting values were:

rpm	2 300
manifold pressure	48" Hg.
BMEP	208
head temperature	170°
carburettor air temperature	25°

Terminal values were:

rpm	2 300
manifold pressure	45" Hg.

* It is believed that any dampness, as probably encoutered in flight, would increase the losses.

BMEP	192
head temperature	190°
carburettor air temperature	45°

To avoid any damage to the engine, no attempt was made to reproduce the extreme condition of 260° temperature at the heads which was experienced on the right engine of D-BELU, nor was the test extended beyond 10 - 15 seconds. The test, nevertheless, evidenced the drop in power as a result of the increase in air temperature at the carburettor.

Summary of Main Technical Defects Found During the Investigation

Left engine

The head of cylinder No. 4 was completely broken near the exhaust valve in the area between horizontal cooling gill No. 21 and vertical cooling gill (P). The failure was a typical fatigue failure and appeared blackened by exhaust gases, which indicated that the failure occurred in flight and not as a result of impact with the ground when the engine was already stopped, it having been feathered before landing.

Right engine

a) There was evidence of engine operation at high temperature for a short period:

- typical colouration of the piston heads, the exhaust valves, the exhaust pipes and the spark plugs;

- distortion of the points of the ground electrode of the reconditioned spark plugs, which were thinner than the points of the new spark plugs.

This condition did not cause any mechanical malfunctioning of the engine parts.

b) High tension cable between magneto and distributor. Spider web cracks on insulated bushing of a terminal of the high tension cable between the magneto and the right distributor of the right engine with signs of incipient perforation.

Spark plugs

On the reconditioned spark plugs of both engines:

- the gaps between points were beyond the tolerances;

- the points were worn down. All the spark plugs of the right engine showed a clear colouration typical of operation at high temperature.

Analyses

Fuel analysis

The analysis of the sample of fuel taken from the right engine fuel tank met the existing requirements.

Oil filter deposit analysis

It showed that the deposits consisted essentially of carbon particles; also present were minute metal particles consisting of lead for the most part and traces of iron and aluminum.

Analysis of Evidence

Left engine failure

The damage noted on cylinder head No. 4 of the left engine was the cause of the malfunctioning at 5 000 ft during the approach phase to Rimini. The general condition of the engine and of the damaged cylinder No. 4 indicated that the pilot's decision to reduce power on that engine was timely and appropriate. Upon noticing the malfunctioning of the left engine, the pilot followed, for about five seconds, the procedure laid down in paragraph 3-1-3

"Power Oscillation" in the Flight Manual and reduced power.

Following occurrence of malfunctioning of the right engine, he feathered the propeller of the left engine in accordance with the procedure set forth in paragraphs 3-1 and 3-2 "Engine Failure" in the Flight Manual.

Malfunction of the right engine

Shortly before and shortly after crossing the radio beacon, at an altitude of about 1 200 ft, the right engine experienced a sharp loss of power. This power drop was attributed to the following causes:

a) high temperature operation;

b) poor ignition.

a) High temperature operation

High temperature of the engine during the final phase of flight continued to increase until it reached values of 45 - 50°C of the air at the carburettor and 260° at the cylinder head.

The reason for these high temperatures was attributed to the following circumstances:

- high outside temperature;
- crabbing of the aircraft as a result of unsymmetrical power;
- nose-up flight at low speed;
- operation of engine at low rpm and high manifold pressure (2 300 rpm: 40"MAP);
- a possible lag of the barometric capsule of the automatic mixture control may have contributed indirectly to this increase in temperature.

b) Poor ignition

The unsatisfactory ignition timing may have originated

- in the forward spark plugs as a result of the inadequate insulation of the cable between the magneto and the right distributor;
- in the back spark plugs as a result of poor efficiency of the reconditioned spark plugs;
- in all the spark plugs because of reduced insulation as a result of the high temperature and the presence of lead bromide deposits.

Operation of the flight

As soon as the left engine started malfunctioning, the pilot-in-command put the right engine on the following power setting:

rpm	2 300
manifold pressure	37 - 40"

This power setting is the one specified in case of the malfunctioning of an engine:

a) paragraph 3-1-b states -

"Adjust power setting on operating engine as required."

b) in the "Power Setting Charts" of the airline which specified 2 300 rpm in such a case.

The flight as a whole was conducted according to the existing standards; the emergency landing was carried out expertly and calmly.

Conclusions

The landing outside the airport was due to the combination of two emergencies.

The first, resulting from the failure of the left engine which occurred during descent at an altitude of approximately 5 000 ft, and the second resulting from intermittent malfunctioning of the right engine which occurred during the approach phase at an altitude of approximately 1 000 ft.

In this critical situation and while at low altitude with unsymmetrical power available, reduced to nil at certain moments, the pilot corrected by gradually increasing the lift of the aircraft by decreasing power and speed until the aircraft assumed the minimum power configuration.

It is believed that failure to use the flaps in the landing phase was a proper decision taken to avoid striking a high tension line.

In the above-mentioned increasingly nose-up attitude the aircraft struck the ground at low speed with the tail skid and continued to slide on the ground with its undercarriage retracted.

Probable Cause

On the basis of the findings set forth above, the Commission unanimously agreed that the accident was to be attributed to the failure of the aircraft's left engine followed by the malfunctioning of the right engine.

Recommendations

1. Reconditioned spark plugs should not be used on twin-engined aircraft engaged in public transport of passengers.

2. A complete list of emergencies capable of easy and uniform interpretation should be issued for the same type of aircraft and for all operators using the aircraft.

3. The Flight Manual of the Convair 240 should be supplemented with detailed flight procedures to be followed, particularly during approach, in case of operation on one engine only.

4. The common sections of the Flight Manual of the Convair 240 and that of the Convair 340 and 440 should be standardized.

5. Whenever systematic failures are observed, particularly if they affect the available power, operators should be requested to issue specific cautionary provisions.

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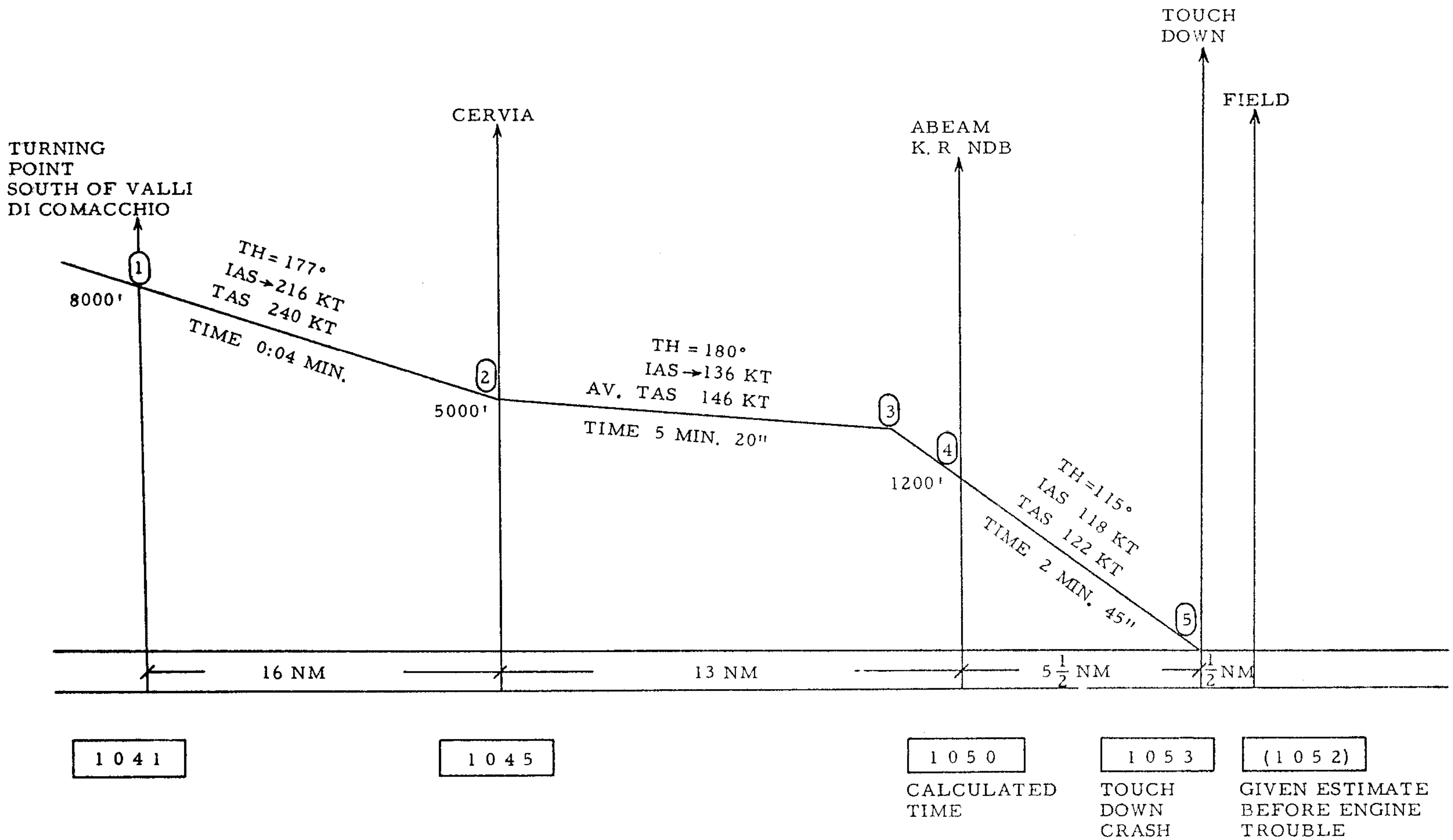
ICAO Ref: AR/661

ACCIDENT TO CONVAIR 240 OF DEUTSCHE FLUGDIENST
AT RIMINI AIRPORT, ITALY, 31 JULY 1960

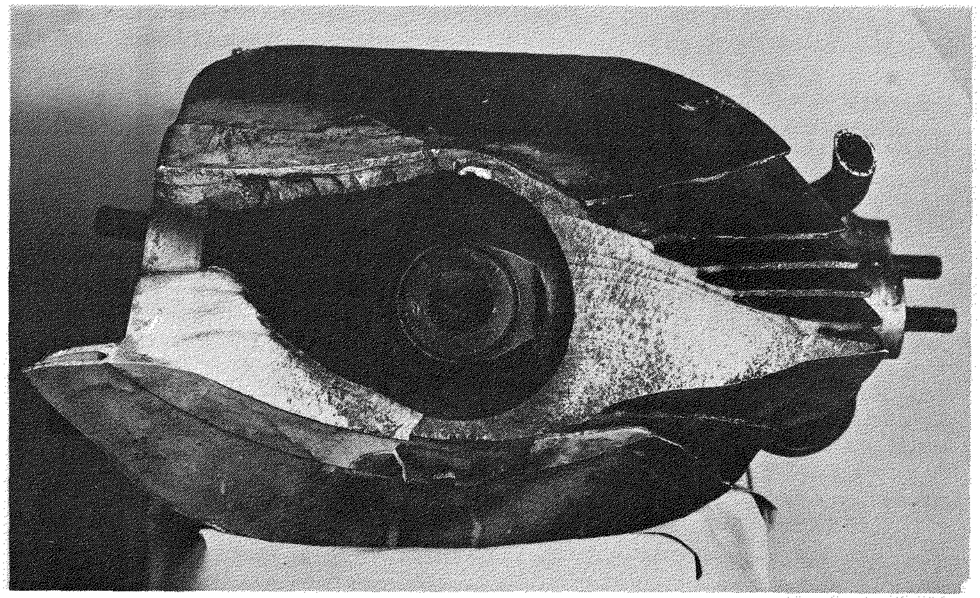
FIGURE 12

ROUTE CHIOGGIA - RIMINI



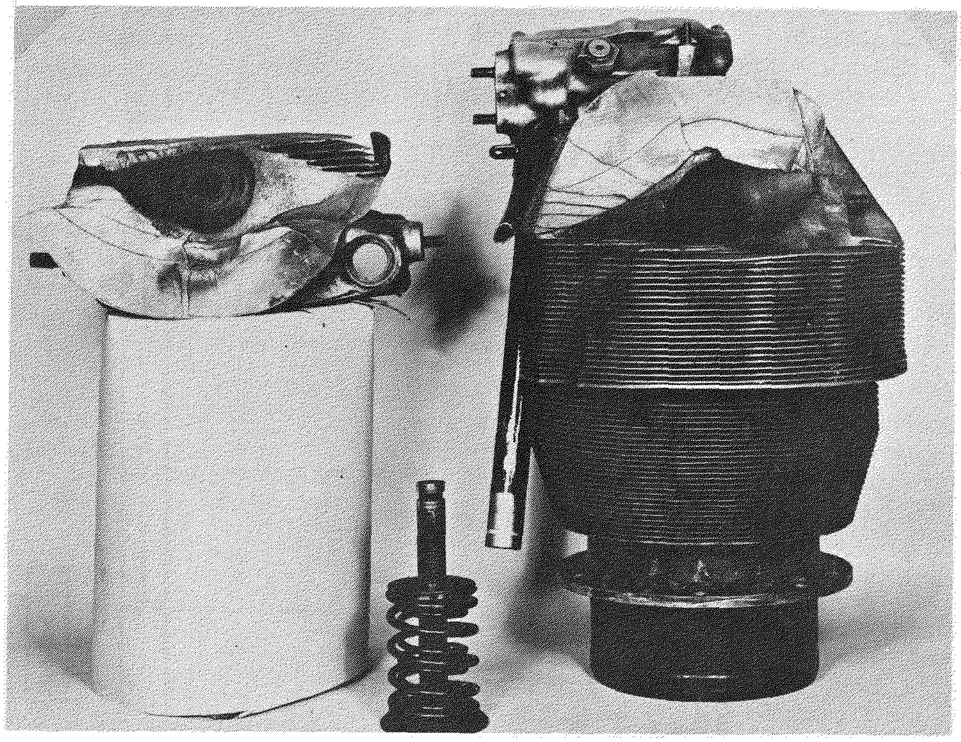
ACCIDENT TO CV 240, D-BELU, AT RIMINI, ITALY, 31 JULY 1960

FIGURE 13



CYLINDER HEAD - BROKEN NEAR THE EXHAUST VALVE. THE UPPER PART OF THE HEAD BROKE OFF ABOVE THE VALVE. (LEFT ENGINE, CYLINDER NO. 4)

FIGURE 14



THE PATTERN OF THE FRACTURES INDICATES THAT THE FATIGUE CRACK ORIGINATED AT THE POINT OF MINIMUM THICKNESS OF THE OUTER SIDE - THE FRACTURE SURFACES OF THE THINNEST WALL OF THE INNER SIDE INDICATE THAT THE FAILURE OCCURRED SUDDENLY.

No. 48

Pacific Western Airlines Limited, de Havilland DHC-2, CF-ICK (Seaplane), accident at Lorna Lake, British Columbia, 15 August 1960. Report No. 1086 released by the Department of Transport, Canada.

Circumstances

The aircraft, which was owned by Queen Charlotte Airlines and was being operated by Pacific Western Airlines Ltd., was being used to remove a party of six geologists from Lorna Lake. The first three members of the party were transported in the morning and at about 1330 hours Pacific standard time the pilot was departing from the lake with the last three members, when the accident occurred. The aircraft was subsequently located in Lorna Lake, substantially damaged and partially submerged. All four occupants (i.e. the pilot and 3 passengers) of the aircraft lost their lives as a result of the accident.

Investigation and Evidence

The Aircraft

The aircraft was airworthy at the time of the accident. It had flown 3 566 hours since manufacture, and the engine times were - 4 400 hours since manufacture and 530 hours since overhaul. Since the last periodic check, the aircraft and engine had flown 19 hours.

The exact weight of the aircraft at the time of the accident was not known but was similar to that of the first flight, which was well below the maximum permissible weight of 5 090 lb.

The Pilot

He held a valid senior commercial pilot's licence and had flown a total of 14 000 hours of which approximately 8 000 had been flown on float-equipped aircraft. He had acquired 3 000 hours of experience on the de Havilland DHC-2 aircraft of which 273 hours had been accumulated during the preceding 90 days. He was reported to have been a careful and competent pilot, familiar with mountain flying.

Reconstruction of the flight

The aircraft had been chartered to move six geologists and their equipment to Kamloops. On the first flight the aircraft arrived at Lorna Lake shortly before 0830 hours and took off again at 0480, when three members of the party and their equipment were flown out without incident. It is of interest to note that with favourable weather conditions the pilot was on the lake only about 15 minutes and on this flight took off from the lake in a northerly direction.

The pilot left Kamloops on his second trip at 1135 hours and arrived at Lorna Lake at 1255 hours. The last radio communication with him was at 1220 hours, and at that time he was over Pavilion Lake proceeding towards Lorna Lake.

When no further word was received from the aircraft, a search was started, and the wreckage was sighted floating in Lorna Lake at 2005 hours.

Lorna Lake

The lake is a banana-shaped glacial lake at an elevation of 6 180 ft. It is about 1-1/4 miles long, 300 yd wide at the widest point, and runs in a north-south direction. It is surrounded on three sides by mountains rising steeply to about the 9 000 ft level. At the north end the land elevation falls off and opens into a broad valley. A short valley, elevated above the lake level, runs to the southwest from about the centre of the lake.

The surface winds over the lake are reported to flow from south to north and pilots are in the habit of landing into the wind in a southerly direction and taking-off downwind in a northerly direction so as to avoid the encircling mountains.

With a favourable steady wind it is possible to take-off to the south into wind, make a 180° turn, and fly out in a northerly direction. The pilot was observed to have made such a take-off with CF-ICK on 8 August.

The Wreckage

The wreckage had drifted close to shore by the time the searchers reached it, and they secured it to a rock with nylon rope. Only about 8 ft of the tail and the rear end of the floats were above water at that time. The water was opaque and very cold, and it could not be determined what the condition was beneath the surface.

When the four occupants were recovered from the aircraft by a diver the next day, it was noted that two of their wrist watches had stopped at about 1330 hours. The diver was not able to discover the extent of the damage to the aircraft because of the coldness of the water and his inability to see beneath the surface. The lake water is full of alluvial silt and underwater visibility never exceeds about two inches.

Detailed examination of the recovered wreckage indicated that the aircraft had struck the water at a fairly high speed in a nose down and left float down attitude.

The following facts were noted:

propeller - it was in coarse pitch and only slightly damaged;

engine - most of the lines from fuselage to engine were broken, but there was no evidence that any unit had failed or become disconnected prior to impact;

- engine impact had been from the lower left and the engine was pushed back to the firewall.

fuselage - the main cabin structure was in fairly good condition except at the outer left top corner where the skin was pushed up and slightly back aft of the wing spar attachment fitting;

- the floor was in good condition, but the seats had been torn from the floor fastenings;

- there was a hole through the left side of the fuselage just forward of the fin where the heel of the left float had apparently struck;

- there was no damage to the empennage.

landing gear - the forward portion of the left float was torn off and was not found;

- the remainder of the front of the left float was flared upwards and to the left with an explosive appearance.

wings - both wings and lift struts were missing.

cockpit
- all damage to the cockpit was directed to the left and forward;
- the ignition switch was on "both;
- all cockpit selections corresponded to the settings at the engine and propeller, and were:

  carburettor heat - full cold

  emergency fuel and oil shut-off valve - open

  throttle - fully closed

  mixture - idle cut-off

  propeller - full coarse

The levers of the last three controls were bent far to the left and had cut into the guides so that it was clear the selections had been made prior to impact.

Technical Investigation

A strip down inspection of the engine was carried out, and no fault could be found in it or its accessories, ignition system, fuel system or oil system.

The carburettor was tested and functioned normally at all power settings. The fuel pump performance was satisfactory and well within the manufacturer's specifications.

Water had entered the fuel tanks, but a considerable quantity of fuel was present in the tanks and lines.

The lift strut breaks were significantly similar on both sides of the aircraft. The right fitting indicated the direction of wing separation as upwards and forward while the left fitting indicated the direction of left wing separation as upwards and to the rear. It was concluded that wing separation had occurred on impact, and calculations indicated a velocity range on impact of 65 to 100 mph.

Metallurgical examination and analysis of parts of the wreckage were carried out, and indications were that there had been no material failure prior to impact.

Impact Location

By relating the observed rate of drift of the wreckage when sighted to the time between the accident and its discovery, it was estimated that the wreckage had drifted about 500 yd in a northerly direction after the accident.

Another estimate of the drift was made by relating the area of the aircraft under water to the area exposed to the wind. Calculations using this method also indicated a drift of about 500 yd and a wind from the south averaging about 20 mph.

A paddle from the aircraft was found on a projecting point on the eastern shore about 470 yd south of the wreckage. There was an oil slick on the water close to shore just south of the point where the paddle was found, and just south of the oil slick a cap and portions of maps were picked up.

It was concluded that the impact had most likely occurred about 500 yd south of the wreckage and about 30 yd out from the eastern shore.

Recovery of the Wings

It was considered necessary to recover the wings to establish whether there had been any structural failure prior to impact. In August 1961 a search of the bottom of the lake with electronic metal detecting apparatus located the wings in 40 ft of water near the calculated point of impact.

Following examination, it was concluded that all damage to the wings resulted from impact with the water.

Weather

The nearest weather reporting station to Lorna Lake is located at Dog Creek, 44 NM to the northeast. Kamloops is about 108 NM in a southeast direction, and it is reported the pilot was aware of the forecast for that station.

Weather conditions at Lorna Lake at the time of the accident can be summarized by reference to three sources:

1. The leader of the geological party gave the weather conditions on the lake at 7:40 that morning as follows:

   a) the weather in the area was clear with excellent visibility and a few cumulus clouds in the distance;

   b) the temperature was either at or below the freezing point, and there was hoar frost visible;

   c) the wind was steady from the south at about 2 mph.

2. Pilots who have flown in and out of Lorna Lake agree on the following points:

   a) surface winds are usually from south to north and flow from the face of the glacier at the south end regardless of reported upper wind conditions;

   b) surface winds often change rapidly from calm to gusts of 40 to 50 mph and subside just as quickly;

   c) when the wind is blowing there is severe turbulence near the centre of the lake.

3. The Meteorological Branch (Department of Transport) provided the following assessment of probable upper winds in the vicinity of Lorna Lake at the time of the accident:

10 000 ft - 320° at 25 kt;
15 000 ft - 310° to 330° at 30 kt.

These conditions refer to undisturbed winds. It was stated by the Meteorological Branch that turbulent factors could play a dominant role in causing significant local changes in valuations in the vicinity of the 8 000 ft mountains. The synoptic situation in the vicinity of these mountains also indicates the possible development of mountain waves. When waves are present in the air flow over a ridge, areas of descending currents generally occur immediately downwind from the ridge and common values of these currents are of the order of 5 to 10 kt (500 to 1 000 ft per min).

Wind conditions

Investigators found that wind conditions in the immediate vicinity of Lorna Lake were very localized in nature, a condition frequently found in mountainous terrain, and bore little similarity to conditions reported as prevailing in the surrounding region.

Pilots reported they frequently encountered severe turbulence near the centre of the lake, with a downdraft of enough intensity to hold an aircraft on the water just as it was about to become airborne. It is the general opinion of pilots familiar with this lake that unusual and tricky wind conditions are common.

A scale model, encompassing the lake and about 20 sq. mi. of the surrounding terrain, was constructed and placed in a water tunnel where observations were made of fluid flow conditions in the vicinity of the lake surface. It was found that there was a decided tendency for a portion of the flow to curl downward from the peaks near the lake centre and then to reverse direction towards the south as it neared the lake level. A very complicated flow pattern was observed above the lake centre, with an additional current funnelling out of the valley on the western side.

Vertical profiles of the terrain surrounding the lake were drawn and studied. Maximum take-off, climb and turn positions of the aircraft were superimposed. It was concluded that with a smooth 20 mph wind from the south there would be sufficient room to take-off into wind, make a 180° turn and fly out to the north, but with adverse wind conditions and/or turbulence the successful outcome of such a take-off would probably be marginal. It is apparent that such a take-off or turn could place the aircraft in grave danger of being forced into the water or mountainside if severe winds and/or turbulence were encountered.

Downdrafts and gusting conditions are prevalent on and over the portion of the lake that the aircraft would have to traverse during a take-off to the south and subsequent turn and flight to the north. On several occasions these conditions were severe enough to cause experienced pilots to abandon an attempt to take-off.

A survey of actual wind conditions at Lorna Lake was carried out over a period of three days at the time the wings were salvaged. The result of this survey confirmed previous reports of conditions at the lake. Very severe periodic gusting, during which reversal of wind direction frequently occurred, was found to exist and is considered to be a further indication of the probability of the existence of mountain waves in the region of the lake. Wind conditions were not the same as those prevailing at the time of the accident, but the data gathered is sufficient to indicate that there are unusual effects.

Typical observed values were 30 mph from 260° to 31 mph from 090° in a period of 55 seconds with upper winds from 280° at 46 mph. With upper winds from 230° at 39 mph the same places gave winds from 180° varying from 10 to 45 mph in 25 seconds and 250° varying from 0 to 40 mph and back to 0 in 20 seconds.

Discussion

The pilot had flown in and out of the lake on different occasions and was familiar with local flying conditions. During his take-off to the south on 8 August, he told his passenger that he did not like operating from Lorna Lake. All evidence points to a take-off in a southerly direction and is an indication that the wind was from the south at that time.

In order to execute a 180° turn to the left the pilot would have to begin the turn well to the western side of the lake and even a tight turn would carry the aircraft close to the mountainside above the eastern shore. After considering all calculations, water tunnel tests and observed conditions, it appears that either during or shortly after recovering from such a turn he could well have encountered severe gusting and/or turbulence with the result that he lost control. A complete description of the previous southerly take-off on 8 August was obtained from the passenger and ground witnesses. The path of the flight, according to the passenger's statement is plotted on Figure 15. It was reported that during the turn the aircraft lost 50 ft of altitude from the maximum achieved height of 200 ft. The take-off run of 8 August was for a flight in which the aircraft was lightly loaded and only one passenger was carried.

There was no evidence to indicate any fault in the engine and the only reason that this possibility cannot be entirely ruled out is that the position of the mixture and propeller controls coincide with the manufacturer's recommended procedure to be followed when an engine fails on take-off. Failure to take further steps in the recommended procedure could mean that there was insufficient time to do so. It should be remembered, however, that there was no other evidence pointing to engine failure, and these selections could have been made when continued flight appeared impossible.

Considering where the impact occurred, there was ample space for an emergency landing. If an engine failure had occurred and the pilot attempted to make an emergency landing, the attitude of the aircraft at the moment of impact can only be explained by the loss of control. The probability of the pilot having been incapacitated was ruled out by medical evidence.

Although engine failure may be a contributing factor it can be ruled out as the probable cause. No evidence was found to indicate structural failure in flight or collision with the mountain side.

It is considered probable that in attempting to make the necessary 180° turn at the south end of the lake the pilot found that he was unable to climb and made a decision to abandon the flight. At that time a wind disturbance or reversal of direction could have caused the aircraft to stall at such a low height that recovery was not possible.

Probable Cause

While it was not possible to determine the cause of this accident conclusively, it is considered most probable that turbulent air conditions were encountered during which the aircraft stalled at too low a height to permit recovery.

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ICAO Ref: AIG/ACC/REP/GEN/No. 1 - CANADA

ACCIDENT TO CF-ICK, 15 AUGUST 1960

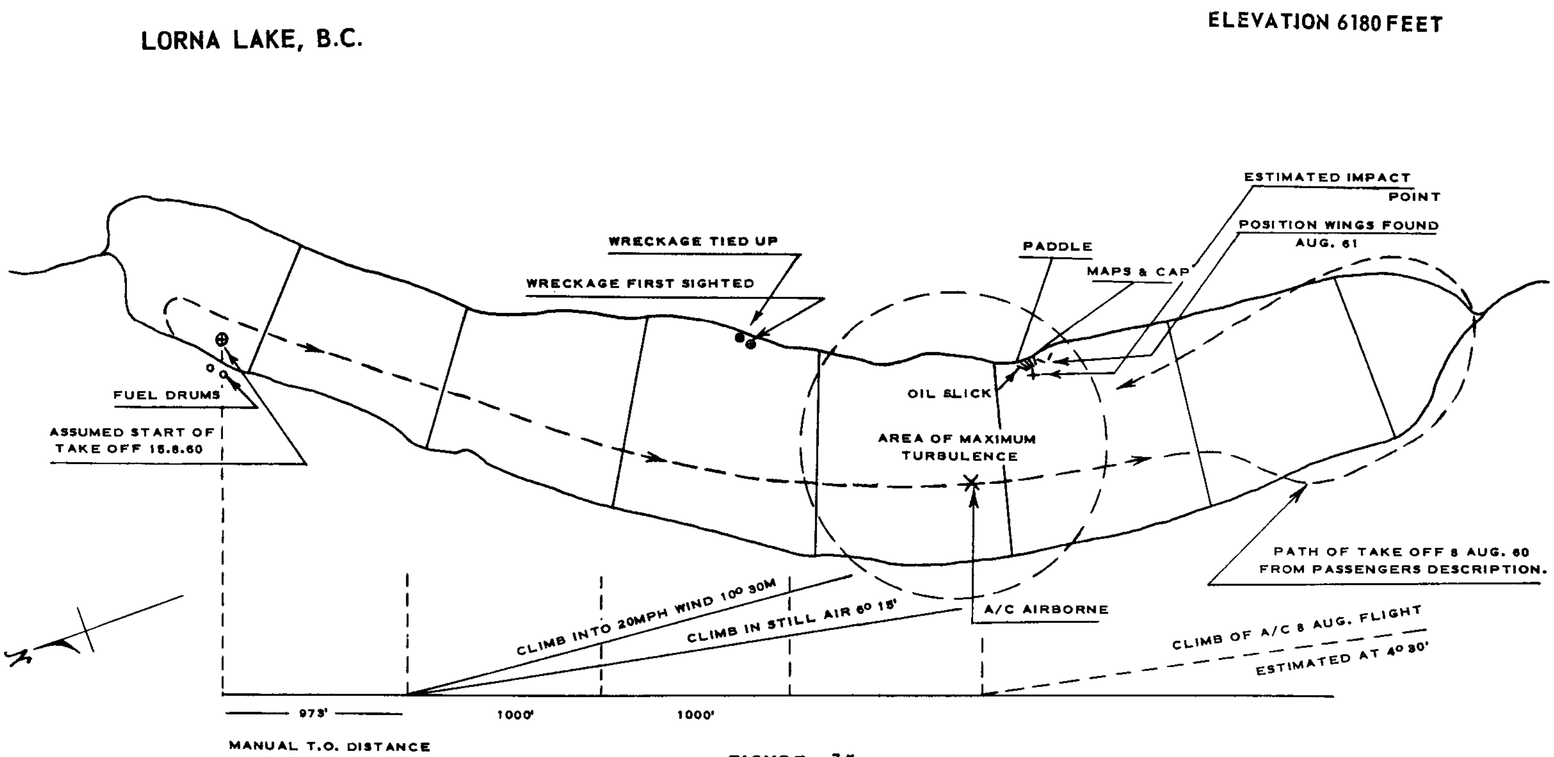

FIGURE 15

No. 49

Don Everall (Aviation) Co. Ltd., Viking G-AMNK, accident outside the harbour of Heraklion, Crete on 24 August 1960. Report released by the Directorate of Civil Aviation, Ministry of Communications, Greece.

Circumstances

The aircraft departed Elmdon Airfield, Birmingham, England on 23 August and was routed to Aden via Marseilles, Brindisi, Heraklion, Cairo and Jeddah. For reasons unknown instead of landing at Marseilles it stopped at Nice - this was the only change in its routing. It landed at Heraklion, Crete on 24 August at 0154 hours local time. Nothing out of the ordinary was reported to the Greek authorities or was written up in the aircraft's log book.

On 24 August following an examination by the ground engineer and a regulation check by the crew, the aircraft entered runway 27 and started to take off. After a run of about 1 800 m it became airborne. Apart from this long take-off run there was no evidence of any other unusual occurrence. While still in the initial stage of the flight immediately after take-off and at a height of 90 - 100 ft, sounds indicating an irregularity in the running of one or both engines was heard. At the height given above and at an approximate distance of 650 m from the end of the runway the aircraft began to lose height and to bank towards the left. It then crashed into the sea and was completely destroyed. All three crew members were killed.

Investigation and Evidence

The Aircraft

It had a valid certificate of airworthiness, was operationally fit and properly and legally disposed to carry out flights in general and this last flight in particular. It had been maintained in accordance with the existing regulations and the periodical maintenance checks had been carried out in accordance with the approved maintenance systems and procedures.

The Crew

They all held valid certificates and had sufficient experience in their various capacities. The captain, in particular, had considerable experience on the aircraft type involved in the accident.

After landing at Heraklion the crew of the aircraft did not rest as much as they might have after a tiring flight, or at least did not rest sufficiently. Witnesses gave evidence that they had consumed some beer. Although the quantity is difficult to establish, it was in any case in contravention of their own Company's rules. It should be noted that the consumption of beer did not take place immediately prior to the plane's take-off but during the period of the crew's stay at Heraklion (i.e. 19 hours 45 minutes).

(The ground engineer held a valid licence and was qualified to carry out the examination of the aircraft.)

The Runway and Loading of the Aircraft

The runway in question satisfies the requirements for length, breadth and surface laid down in the international regulations for the type of aircraft involved in the accident and the type of load carried.

Reference to the data supplied by the manufacturers shows that a Viking aircraft in the conditions applying required a distance of approximately 1 200 m for take-off. The actual distance taken was, therefore, about 600 m in excess of this.

The aircraft's cargo at the time of the accident consisted of 125 boxes of cigarettes weighing 2 662 kg. It also carried a tool box estimated as weighing 15 kg. By calculations carried out in conjunction with the customs authorities at Heraklion, it was established that the aircraft's take-off weight did not exceed the maximum permissible by more than 50 kg.

The Weather

At the time of take-off and the accident the meteorological conditions were favourable and could not have influenced the flight (wind calm, QNH 1017.6, temperature 22°C).

The night take-off from Heraklion had been planned by the flight operations manager of the company owning the aircraft in order to take advantage of the most favourable take-off conditions.

Technical Investigation

During the take-off run it is likely that one or both engines experienced a loss of power as the distance taken by the aircraft to become airborne was approximately 1 800 m.

The captain of a cargo ship, who had formerly been an aircraft pilot, said the aircraft passed low over the mast and the engines sounded as if they were not running properly.

It was not possible to establish the cause of the engine failure, and it is now difficult to ascertain the consequences of the infringement of the rules (as stated above) or the effect if the relevant aircraft drills had not been correctly performed. The fact remains, however, that with the Viking aircraft, when the propulsion system has failed during take-off it would be very difficult, if not impossible, to continue flight at the weight at which it was operating.

Discussion

Evidence indicated that

a) one of the engines was tested twice prior to take-off;

b) the aircraft travelled approximately 50% more than the normal distance required for take-off;

c) the gradient of climb of the aircraft was very small.

It is considered that one of the engines was not functioning correctly and the crew had not paid sufficient attention to this. This incorrect functioning resulted in limiting or excessively reducing the power of the engine during the final stage of the take-off and during the initial ascent. During the ascent the undercarriage was raised. The propeller of the engine that failed was not feathered. On the basis of further facts, in particular those relating to the examination of the aircraft's wreckage, it became apparent that -

a) there was no external evidence of the reason for the engine malfunction;

b) both the ignition and the fuel supply systems had been completely destroyed, and no trace of the magnetos was found.

It was concluded that the loss of engine power most likely resulted from a fault in the ignition system or in the fuel supply.

Probable cause

The cause of the engine failure was not established but the most likely reason appears to be a defective fuel or ignition system. The reason why it was not possible for the aircraft to maintain safe flight after the failure of the engine remains unknown.

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ICAO Ref: AR/696

No. 50

Trekair, Douglas DC-4, ZS-CIG, made a forced landing near El Badary, Assiut Region, Upper Egypt, United Arab Republic on 3 September 1960. Report released by the Director General of Civil Aviation, United Arab Republic.

Circumstances

Flight No. S-033 (Luxembourg-Johannesburg via Cairo and Entebbe) took off from Cairo Airport at 0431 GMT with 6 crew members and 61 passengers aboard. At 0540 GMT, at a height of 9 500 ft, zone 2 (of No. 2 engine) fire warning light came on and the bell rang. Engine No. 2 was feathered. Emergency drill was carried out immediately using both CO_2 bottles, however, it was not possible to put out the fire. The captain then decided to make a belly landing which was carried out, at 0554 hours GMT, in a sandy valley near El-Etmaniah, 30NM southeast of Assiut Aerodrome. Only 3 passengers and the co-pilot were slightly injured. Fire continued to spread after touching the ground, and the aircraft was completely burnt out. Ground fire fighting equipment reached the scene of the accident an hour after the crash and the fire was then extinguished.

Investigation and Evidence

The crew members were properly certificated, and the aircraft had a valid certificate of airworthiness.

The Wreckage

It was very difficult to identify the different parts and components of the aircraft as the majority of them had been either completely burnt or had melted. On inspection of engine No. 2 the following was observed:

the upper portion of the carburettor was completely burnt up to the pressure regulator as well as a portion of the carburettor housing on the supercharger casing;

the generator of No. 2 engine was badly burnt, and its segments showed signs of sparks;

all fuel hoses, oil hoses and hydraulic lines were completely burnt;

the engine control rods and mechanisms with their fork ends or attachment points were melted;

the bulkhead of engine No. 2 was destroyed and had a big hole at its starboard portion.

General statements of crew members

The captain, who said that he was also a check pilot, believed that the fire existed before the warning light came on. He stated that the co-pilot was actually controlling the aircraft at the time of the fire in flight.

On noticing the fire warning light the co-pilot immediately feathered engine No. 2 and asked the flight mechanic to check from the cabin window the extent of the fire. He pulled No. 1 and No. 2 fire extinguisher bottles, however, this was ineffective. The last part of his statement was similar to that of the captain.

The radio officer stated that he saw the fire at the right-hand side of the cowling at zone No. 2. It was yellow in colour, and there was no smoke.

The flight mechanic believed that the fire was coming from an area above the cooler in the bottom of zone 2, and it was of a white-orange colour with no smoke. Then it became intensive and the fire proof bulkhead started to melt at its top portion. He had the impression that the fire started from the generator.

Weather

At the time of the forced landing the wind was northwest, 5 - 10 kt, visibility was good, and there was no rain.

Probable Cause

The Board was of the opinion that the accident was caused by a heavy fuel leak from a sheared or cracked fuel pressure pipe, which was ignited by sparks from the generator.

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ICAO Ref: AR/659

No. 51

Balair Ltd., Vickers Viking, HB-AAN, accident at Basle-Mulhouse Airport, Switzerland, on 3 September 1960. Report released by the Federal Air Office, Switzerland.

Circumstances

The aircraft departed Southend, England at 1150 hours GMT on a charter flight to Basle-Mulhouse Airport, Switzerland, carrying 3 crew and 24 passengers. After leaving Southend the pilot had difficulty retracting the right landing gear. Even when he made use of the available emergency equipment he was not able to retract it. He then decided to continue on to Basle where he anticipated better weather conditions, greater ease in performing an emergency landing, and he could also obtain technical assistance from the airline.

On arrival over Basle-Mulhouse Airport the pilot tried again with all possible means to retract and lock the right wheel but without success. The wheel was out in a nearly vertical position and could move about 10° along the normal retraction and extension path. Having taken all the required safety measures, a forced landing was carried out. The aircraft landed on its fuselage and two propellers and slid along the runway without losing contact with it over a distance of about 250 m. There was no fire, and no one was injured as a result of the accident. The accident occurred at 1614 hours.

Investigation and Evidence

The Emergency Landing

With the agreement of the airline the pilot decided to perform the emergency landing after almost all of the fuel remaining had been used up. The airline officials recommended that a runway be used in preference to a grass strip and accordingly authorization was given for the aircraft to use runway 26, the most favourable in view of the existing wind condition.

Ground personnel were alerted and equipment was prepared. All necessary precautionary measures were taken by the captain aboard the aircraft for the safety of the passengers and crew.

The approach and landing were performed faultlessly. When the pilot was sure that the altitude for landing was correct he cut the fuel circuits and contacts just before reaching the runway threshold. The right wheel, which could not be retracted, contacted the ground and buckled. The fuselage made contact with the runway about 160 m from the threshold, and the aircraft slid 330 m before coming to a stop, resting on the lower part of the fuselage and the two propellers. Its path of movement was very close to the runway centreline.

Damage to the aircraft

Propellers: The tips of the eight blades are twisted and "filed" by the cement of runway. The propellers must be replaced.

Fuselage: The lower part of the fuselage is damaged over a 12 m length starting from the forward baggage hold. The outer covering was partly ripped off. The frames of the fuselage corresponding to this part of the aircraft were damaged in the lower part but do not seem however to have sustained any significant deformation.

Nevertheless, some distortion of minor importance is evident on the frames situated next to the doors of the forward and aft baggage holds.

Engines and engine cradles: These have been examined by experts of the Bristol Company; it would appear from this examination that neither the engines nor their mounts sustained damage in the accident.

Undercarriage: The left landing leg is intact.

On the right landing gear one of the attachments bolts of the cylinder level to the retraction tube was broken. The cylinder rod was bent forward near the body of the cylinder.

Wings: They sustained no damage.

The Right Landing Gear-Investigation

The aircraft was raised by two cranes, the hoisting cables of which had been attached to the propeller hubs. During the operation, it was observed that the right wheel, despite all efforts, could not be placed in the locked position. It was then observed that the cause of this anomaly was the connexion of the shaft of the actuating cylinder to the retraction tube. This assembly was dismounted, and the wheel could then be locked by pushing it forward.

The connexion of the shaft of the actuating cylinder to the landing gear strut is composed of a fitting with two bolts, which fit into two corresponding holes on the horn of the retraction tube and which pivot on the same axis.

The force of traction or thrust which moves the retraction tube up or down in retracting or lowering the landing gear is exerted equally on these bolts. It was noted that the forward bolt had been sheared off and that part of it remained in place on the horn.

This breakage provoked an imbalance in the forces exerted by the actuating cylinder on the two connexion points of the horn causing rotation of the horn, such rotation possibly reducing the vertical travel of the retraction tube and preventing the landing gear from reaching the locked position.

It was observed afterwards that the shaft of the actuating cylinder was bent forward just at the point where it left the casing. According to the checks made of the hydraulic system, there were no defects.

The Attachment Bolt

The bolt in question had been checked during the general overhaul of the landing gear in which the entire landing gear brace stout strut had been replaced. The bolts considered to be in good condition had been re-utilized. Since the overhaul the aircraft had accumulated 760 flying hours, whereas the assembly was expected to serve for a period of 3 600 hours. Furthermore, the salvaged bolt seemed to be in good condition. Upon first examination, the salvaged piece of bolt showed no sign of fatigue or defect. It was sent for verification to the E.M.P.A.*, the official Swiss materials control agency. Examination of the broken bolt showed a very smooth surface and a very fine grain at the point of breakage of the recovered part of the bolt, characteristics of rupture through shearing. There is no reason to believe that the rupture was due to fatigue or a fault in material.

On the basis of values obtained from Vickers, the resistance of the broken bolt was set at 94 kg/mm^2; the resistance of the two other bolts to the same construction

* Le Laboratoire Fédéral d'essais des matériaux

was set at 96 and 107 kg/mm^2. The Vickers workshops were able to identify the other two bolts as original parts; however it was not possible similarly to identify the broken bolt.

Stress Acting on the Attachment Bolt

The attachment bolts are subjected to stress only during landing gear retraction and extension operations. Once the landing gear is in place and locked either in the raised or in the lowered position, no force is exerted by the actuating cylinder. At the moment of landing, the efforts are sustained by the landing gear leg and possibly by the brace strut but these efforts are in no wise transmitted to the actuating cylinder assembly. If stress had occurred, it would have had to happen only after the landing gear had left the raised position and not yet reached the lowered position or inversely.

However, the aircraft had performed a normal landing at Southend. The gear had, therefore, been locked, otherwise it would have buckled towards the rear (on this type of aircraft the gear is hinged towards the rear). It can, therefore, be concluded that if stress had occurred, it would have been at take-off when the gear had been unlocked, that is, during the retraction operation. A study of the efforts to which a wheel is subjected during this operation reveals only two possibilities - either collision with an external object - in which case the occurrence would have attracted the attention of the crew - or the reaction of an abrupt braking on the wheel which was travelling at a high angular speed. This phenomenon is quite conceivable.

The general instructions given to pilots of Viking type aircraft are to brake the wheels before performing the gear retraction operation. Obviously, if this is done when the gear is locked, there will be no reaction on the gear actuating assembly; on the other hand, if this is done immediately after the gear has been unlocked, a force of extreme intensity directed towards the rear is applied to the wheel and tends to retract the landing gear. At this very moment, however, the landing gear is sustained by the actuating cylinder which exerts traction on it; consequently, it must absorb the kinetic energy thus transmitted, and the assembly is subjected to a sheer stress because of its force.

Under these circumstances, the actuating cylinder is subjected to two forces: a force is produced by the upward action of the cylinder along the shaft axis and the reaction force of the wheel, also applied in an upward direction along the shaft axis when the assembly is normal. This disequilibrium resulting from the breakage of the forward bolt displaces the support of the force outside the shaft axis. The resultant of the two forces will then tend to twist the shaft in a forward direction which, moreover, did actually occur.

The British Air Registration Board communicated the following on the subject: "Previous cases of failure of these bolts have occurred, but in each case it has been shown that the cause was either:

a) a "brush" take-off (the main wheels coming into contact with the runway whilst the undercarriage is in the process of retraction);

b) installing one of the two bolts into the fitting, and then producing alignment of the other hole by operating the undercarriage jack. This can produce partial or complete shear of the bolt first installed."

Probable Cause

The accident appeared to be caused by the fracture of one of the bolts connecting the shaft of the actuating cylinder to the retraction tube. It was not possible to determine with certainty whether the rupture had been caused by a wrong installation, brush take-off, or braking during retraction of the gear. According to the statements of the crew, the take-off was not a brush take-off.

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ICAO Ref: AIG/ACC/REP/GEN/No. 15 - Switzerland

No. 52

Aerolíneas Argentinas, Douglas DC-6, LV-ADS, disintegrated in flight near Salto, Uruguay, 7 September 1960. Report released by the Directorage General of Civil Aviation, Uruguay.

Circumstances

The aircraft took off from Presidente General Stroessner National Airport, Asunción, Paraguay on a regular flight to Ezeiza Airport, Buenos Aires (Argentina). Take-off was normal and the aircraft carried out routine en route communications with the control tower at Asunción and with the Monte Caseros and Resistencia stations. A few minutes after communicating with another aircraft in flight it was seen to fall in a field 12 km east-northeast of Salto (Uruguay). All six crew members and the twenty-five passengers were killed. The aircraft was destroyed.

Investigation and Evidence

The Aircraft

It had flown a total of 19 229 hours up to 6 September 1960, including 10 835 hours since the last general overhaul, and had made a total of 5 314 landings.

The aircraft's documentation was in order for this flight. Its last authorized Certificate of Airworthiness was to expire on 17 September 1960.

Engines - No. 1 had flown a total of 11 212 hours, including 292 hours since the last general inspection, and was authorized to fly up to a total of 12 720 hours.

No. 2 had a total of 11 080 hours, including 177 hours since the last general inspection, and was authorized up to a total of 12 704 hours.

No. 3 had a total of 4 263 hours, including 1 537 hours since the last general inspection, and was authorized up to a total of 4 525 hours.

No. 4 had a total of 11 103 hours, including 765 hours since the last general overhaul, and was authorized up to a total of 12 139 hours.

The propellers were all within the authorized times and limits.

The Crew

The six crew all had appropriate licences which were fully valid on the day of the accident.

The pilot-in-command had flown a total of 16 769 hours, including 417:25 hours as co-pilot and 1 456 hours as pilot-in-command on the type of aircraft involved in the accident.

The co-pilot had flown a total of 7 369:34 hours, with 1 353 hours as co-pilot on the subject type of aircraft.

Flight Plan

The aircraft had been loaded correctly and the position of the centre of gravity was within limits.

The following heights were assigned in the flight plan: take off and climb to 5 400 m which height was to be maintained as far as Gualeguaychú when the aircraft would begin descending to the Baires terminal area.

The Flight

At 0815 the aircraft communicated with Monte Caseros Station ... "Take-off from Asunción 0809, estimate Monte

Caseros at 0933 hours and Ezeiza at 1100". At 0905 the aircraft communicated with Resistencia Control Tower, giving a flight altitude of 5 400 m and saying it would reach Monte Caseros at 0931. At 0933 the aircraft gave its position as over Monte Caseros, estimating arrival at Ezeiza at 1045. At 0939 it was in touch (on frequency 118.1) with a seaplane, LV-AAO, which was then flying from Buenos Aires to Posadas and which it met near Concordia. In this conversation the radio operator of LV-ADS spoke with the radio operator of LV-AAO and asked him to call on another VHF frequency to arrange a later communication. The operator of LV-AAO replied that the request would have to wait as he was then occupied. He later stated that there was no indication of any difficulty at this time. According to the statement of the authorities at Salto City, the accident occurred at approximately 0944 hours, i.e. about 5 minutes later.

The Weather

A study was made of the weather conditions existing on the day of the accident. From that study it appeared that the meteorological conditions were not such as would endanger the stability of the aircraft or cause its failure.

The type and quantity of clouds existing did not completely cover the sky, and the pilot-in-command could have flown over or avoided them. Witnesses to the accident were also able to contribute their views on the conditions existing. ... "the weather was stormy with continuous drizzle, but the sky could always be seen between the broken dark clouds".

At this time the sky was covered by a layer of nimbostratus and fractostratus clouds with a ceiling of 200 to 300 m and a visibility of 6 to 8 km.

From a general review of the statements of the witnesses it was possible, early in the investigation, to exclude the possibility that the meteorological conditions had contributed to the accident.

Visual inspection of the aircraft's wreckage showed later that the safety belts of almost all the passengers were not in place as they would have been had the aircraft flown into a frontal zone of strong turbulence.

The Fall of the Aircraft

The investigating team questioned persons within a 50 km radius of the accident, who had seen the accident or had heard the noise of the aircraft's engines, in an attempt to determine the route flown by the aircraft. Statements showed that about 10 km from the accident site the engines were accelerated, which, according to witnesses, gave the impression of "a truck climbing a hill" or "stuck with the motor racing". A loud noise like thunder then was heard. From then on the engines continued to accelerate until the noise changed to a "strident whistle" or "like the noise made by a jet aircraft flying low". Then the witnesses saw a "fireball" between the clouds which instantly exploded and separated into two parts.

Wreckage

The accident occurred at an elevation of 60 m asl on rolling pasture land with a very hard surface. The main site was about 4 000 m in length by 3 200 m.

There were no parts or units of the aircraft remaining, only fragments, the largest being the left wing without the engines, the cockpit, and the right wing which was severely damaged by the fire.

Examination of both wings showed fractures contiguous to the points of attachment to the fuselage, the tearaway of four engines, through their mounts, the detachment of the two landing gear units and part of the ailerons and flaps before both wings, which fell separately to the ground. The largest part of the fuselage was the cabin section from the lavatory forward. The largest remaining part of the fuselage was a piece of the middle section and lower covering, then pieces of the side covering of the fuselage and the portion corresponding to the tail cone from the front spar of the tailplane; the rest of the fuselage was in smaller fragments which, along with the other pieces, were scattered at some distance over the area along a common path.

Engines

The detached engines fell near the wings, and were almost completely destroyed upon hitting the ground. Only No. 1 retained its propeller; the other engines fell without propellers; the No. 2 and No. 4 engines fell with their propeller shafts, and the No. 3 engine fell with its propeller shaft broken at the section where the propeller hub fastens.

Propellers

Propeller No. 1 remained with the engine, one blade receiving multiple fractures on impact with the ground; the remaining propellers lost their blades before reaching the ground.

The three blades of No. 2 propeller were found slightly damaged; one blade had marks of superficial damage occasioned by the impact and friction with other metal parts.

Propeller No. 3 had one whole blade and half of the end of a blade which had been struck on its leading edge; the remainder, one blade and the central part of the other were missing, as was the spinner and the pitch control mechanism.

During the removal of debris from the cabin, the shank of a propeller blade was found showing signs of exterior heating from friction. This led to the belief that it belonged to the No. 2 blade of the No. 4 propeller.

Fuselage

The cockpit capsized on its right side and was partially destroyed as were the controls, the instrument panel, radio equipment and facilities. All cables were cut off at the same transversal section, approximately that of the crew's lavatory. Only fragments were found of the fuselage from the cockpit to the tail unit.

Most of the passenger seats were loosened from their attachments, and only one of the safety belts was broken on impact.

The landing gear units were detached before the wing reached the ground due to the fracture of the joints connecting them to the main spar. The carbon dioxide bottles were almost empty, apparently operated either manually or by the tension of the cables when the control cabin was destroyed.

Examination confirmed that there were no traces at all of fire inside the passenger cabin or the freight hold.

The right wing was burned. Only the right half of the cockpit was destroyed by fire, the other side showed no signs of fire. Inspection of the aircraft and examination of the passengers and crew led to the conclusion that the destruction of the aircraft occurred at a high altitude.

Preliminary Deductions

From a study of the wreckage it was considered probable that the disintegration of the aircraft in flight occurred as a consequence of the detachment of propeller No. 3 whose propeller shaft was found broken. One of its blades hit propeller No. 4, and both propellers lost their blades through failure of the bolts of the respective propeller hubs.

Propeller No. 2 also lost its blades in flight through failure of the bolts in the propeller hub fastening.

Laboratory tests showed that several propeller blades hit each other in flight, unbalancing the No. 4 power unit and causing the wing to oscillate and vibrate; that in turn caused the bolts fastening propeller hub No. 2 to fail and the blades to tear away. The shank of the No. 2 blade of propeller No. 4 was found in the debris of the fire in the cockpit, and it is presumed that that projecting blade had cut through the covering on leaving the hub. This is based on a laboratory report. The destruction of the flight controls, the engines, cables and batteries below the cabin floor at the section of the lavatory, coincident with the plane of rotation of propeller No. 2, was at once attributed to the possible penetration of a propeller blade which, according to the location of the damage, must have come from the left side. This was subsequently confirmed on finding the portion of the left side cabin covering, with the initial perforation below the floor exactly at the section at which all the cables were cut.

Technical investigation and laboratory tests

Since power units Nos. 1 and 4 were damaged by impact with the ground, reference is made here to Nos. 2 and 3 only. Inside No. 2 engine the exhaust valve of the No. 2 cylinder appeared broken, and its head deformed through successive impacts between the cylinder and the piston, which proved the failure occurred at a very high temperature and the engine continued to function. The marks left by the impacts on the piston were limited, proving that the engine functioned only a short time in those conditions.

No. 3 engine was found half buried with the propeller shaft broken aft of the portion receiving the propeller hub, and it was greatly twisted - evidence of failure in operation. The frontal section of the crank case and the mounted accessories were all destroyed. Internally it was shown that the frontal series of connecting rods, the crank shaft, crank case and associated parts all failed while the engine was functioning. The condition of the undamaged engine instruments proved that they had worked with normal lubrication, while the parts destroyed in operation had worked for some time, with local overheating, before the internal failure that made it impossible to run due to obstruction of the parts, interlocking of the connecting rods, their auxiliary pins, the crank case, and counterbalancing of the cranks. The internal jamming could stop the engine while working without generating any power, and so it must have happened. The fact that it worked for some time up to the time of failure leads to the supposition that it could not be stopped immediately.

The propeller shaft failed due to torsional stress contrary to the normal transmission of power - in this case from propeller to engine in the direction of normal rotation. The sole torque was that produced by the propeller functioning as a windmill and the propeller inertia. The heavy torsional effect would appear in the case of the engine stopping suddenly due to internal jamming and the propeller inertia; which is what happened. It is presumed that all the abovementioned events had a single origin: propeller (and engine) overspeeding that could not be controlled, due probably to delayed circulation of the oil and/or irregular functioning of the automatic mechanism of the propeller governor and the failure of the system to reach the feathered pitch position. An exhaustive search at the accident site failed to reveal the propeller control device as well as the dome with the partial case and portion of the propeller shaft. These would have made it possible to determine the source of the failure and obtain samples of the lubricating oil for analysis. Inspection of the crank shaft and propeller shaft, which remained with the engine, showed, in addition to the fractures, strong overheating through friction, due to jamming, and burning of the lubricant; both parts were stuck due to jamming of their inner bearings and it was not possible to separate them. This proved the possibility of initial jamming in the bearings of the forward section master connecting rod when running at excessive speed.

The frontal bearing was not jammed but had a brilliant appearance due to working with limited lubrication, which loosened metal particles of the bearing; those particles, washed away by the lubricant, could cause obstructions and probably prevent the proper operation of the sleeve (pilot) valve of the propeller governor which would involve losing control over the rotational speed; thus, the propeller blades would be displaced to the flight fine pitch stop and with the increase in revolutions being unlikely not only slowing down the engine and the windmilling propeller but even changing to feathered pitch, the only way to stop the propeller.

Engine No. 3 - History

A general inspection of this engine was made on 31 March 1958 and the engine was installed in LV-ADR on 30 April 1958. It qualified at Ezeiza Airport (Baires) on 3 May 1958 for up to a total of 4 225 hours, and was in use until October 1958 except for an interruption of one month. In October the engine was removed from LV-ADR with a total of 4 086 hours and 1 360 hours 45 minutes since the last general inspection. The engine remained inactive until 21 July 1960 (i.e. 21 months) during which time it was rated for 1 800 hours from the last general inspection or a total time of 4 525 hours. This rating was noted on the engine's record and authorized by the Directorate General. On 4 August 1960 the engine was installed in LV-ADS in No. 3 position. It continued in service until the accident of 7 September 1960. The engine had a total of 1 537 hours from the last general inspection and a total time of 4 262 hours 48 minutes. Therefore, during one month it had accumulated 176.35 hours in the aircraft in question. The record begun on 6 June 1958 did not state that checks, dismounting, repairs or alterations had been carried out, save for maintenance inspections and replacement of parts or accessories, in either period of activity or of inactivity (the twenty-one months). More information, requested of the company, proved that the engine in question was dismounted from the LV-ADR aircraft with 1 360 hours 45 minutes since the last general inspection and 4 086 hours of total time in order to substitute it as a spare engine on the Trinidad route where it remained until it was again used in Argentina in July 1960. During its period of inactivity the engine received the protection and lubrication appropriate to prolonged storage. It did not follow from a study of the documentation that the Pratt and Whitney Bulletins Nos. 1666 and 1680 were applied to the engine in question. Both bulletins referred to "special cleanness and emptying of the deposit left by the lubricating oil in the crankshaft passage" - Bulletin 1666, and "providing an additional perforation in the passage of lubricating oil to the frontal trunnion, through deficiencies observed in service by users or companies" (Bulletin 1680). The objective of both bulletins is to avoid a shortage of oil and to prevent the metal of the frontal supporting bearing of the crank shaft from loosening and possibly jamming. Of these service bulletins, No. 1666 is not mandatory, that is for immediate application, recommending as it does that during complete dismantling general inspection shall apply. According to the record, that was not performed nor at the general examination carried out in the United States in March 1958... nor was it taken into account in applying the rating up to 4 225 hours in Ezeiza (Baires) in May of the same year. As for Bulletin No. 1680, it instructs the factory in order to assure better lubrication of the frontal bearing of the crank shaft engines in the process of manufacture. Also, new spare parts have a second perforation for lubrication and, at the option of the users, the old crank shafts of such engines and the available spare parts may be so modified upon receipt of instructions.

When that bulletin was issued and the company was made aware of its consequences, engine No. 33920 was in service on LV-ADR where it stayed until October when it was assigned as a spare on the Trinidad route.

According to a technical report from the company, dated 30 September 1958, concerning a similar accident to a DC-6 aircraft, LV-ADV, at Isla Grande, Brazil on 10 July 1958 which was caused by engine failure, both service bulletins were quoted, the first having been complied with, while compliance with the second was in progress for all the engines being overhauled collectively ... "with the understanding that such modification will in future preclude all possibility of similar failure". That did not cover engine No. 33920 then in service. The importance of such modification, while it was not clear in Bulletin No. 1680, was decisive as far as safety was concerned, since it resolved a lubrication deficiency. This was proved repeatedly in dismantlings and experiments of the effects on loss of control of the rotational speed of propellers in flight with consequences that were always serious; that was recognized by the Technical Service of Argentine Airlines in the aforementioned report, nevertheless, the engine in question remained inactive 21 months and then was put into service with a supplementary rating of 300 hours, to complete 1 800 hours from the last general inspection, bringing it up to 1 360.45 hours ultimately without considering the application of Bulletin No. 1680 and the unsuitability of extending the hours. In order to prove the reality of the danger, the frontal portion of the crank shaft and the propeller shaft were dismounted. It was not possible to separate the two because the bearings between the two parts were jammed. They were severed by a blow torch in order to reach the frontal trunnion. This proved that the latter lacked the supplementary perforation to assure lubrication that was directed by Bulletin No. 1680. Such evidence was confirmed by laboratory tests.

Original failure and process of disintegration in flight

From the analysis of evidence it was deemed probable that the original failure and subsequent events occurred as follows:

The failure experienced in engine No. 3 arose in the uncontrolled increase in revolutions of the engine and propeller (propeller overspeeding) with reduction in pitch to the minimum. That difficulty is unforeseeable and, in most cases, cannot be rectified by the engine controls nor by manipulating the control to feather the propeller.

In those conditions, propeller No. 3, far from producing thrust, offered drag by its windmilling rotation, which supposedly entailed a reduction in power of engine No. 1, in order to neutralize the disturbing moment, and to increase the power of engine No. 2, in order to maintain the power necessary for flight, which undoubtedly reduced the speed of the flight to the minimum. During the time engine No. 3 rotated uncontrollably internal failures occurred which caused the connecting rods, cranks, connecting pins, counterbalance and crank case to interlock; this resulted in a sudden internal braking which explains why the propeller, driving the engine, produced fracture of the propeller shaft through torsional stress transmitted from the propeller to the engine; that was evident in the permanent deformation in the shaft next to the plane of fracture, which coincides with the section where the hub is attached. At the same time the power unit must have undergone strong vibration which could have induced fractures in the fuel lines. That would explain the origin of the fire at No. 3 position as evidenced by the soot deposited in the parts of the retracted starboard landing gear assembly.

The detachment of No. 3 propeller caused one of its blades to hit the No. 2 blade of the No. 4 propeller, which made a similar impression on the leading edge.

Both propellers lost their blades which came loose from the hubs when two attachment bolts on each blade broke, causing strong vibrations and imbalance in the No. 4 engine which, with the No. 2 engine, probably had enough power to fly. These vibrations resulted in the whole wing shaking and gave rise to the loosening of the three blades of No. 2 propeller due to fracture of the attachment bolts and the subsequent tearing away of the four engines. The fact that No. 1 engine did not lose its propeller nor the latter its blades confirms the theory that its power and revolutions were already reduced. The engines were torn from the wing due to failure of the structure of the engine mounting, which was understandable as a consequence of the extensive oscillation of the wing, the resulting stress was due to the large amplitude and low frequency of the oscillations; it is estimated that the parts were torn away in the following order: No. 4 engine, No. 1 engine and propeller and No. 2 engine virtually simultaneously, and lastly No. 3 engine. It was established that the two simultaneous fractures of the wing in the centre section just at the sections of attachment to the fuselage were due to upward bending; flapping of the wing, no doubt, contributed to overstressing the structure. The loss of the four engines occurred in 14. 5 seconds, airspeed being reduced to 100 mph, but in that time the propeller of No. 2 engine fell apart and one of its blades penetrated the fuselage through the left side and cut the conductor cables of the batteries as well as the flight control and engine cables.

The aircraft may have nosed up because of two concurrent factors:

a) longitudinal imbalance from the loss of the four engines;

b) tension of the elevator cable due to impact of the propeller blade, causing action of the elevators and thus contributing to the rapidity of the manoeuvre, with no means of counteracting it.

The ultimate load of the wing could have been reached more quickly than if the aircraft had retained its engines by: reduction of the moment of inertia with respect to the transversal axis, along with greater angular acceleration by reduction of the load distributed over the wing, as represented by the four engines, the remainder of the aircraft retaining the central mass of the fuselage without variations in magnitude. The break off of the tail cone can be explained by the sudden action of the elevator control caused by the impact on one of its cables of the broken off propeller blade. The destruction of the fuselage and separation of the cockpit are attributable to the transverse oscillations of the wing that caused the loss of the engines, and the break up of the skin and structure were also influenced by the sudden decompression and the action of relative wind during the fall.

Conclusions

The cause of the accident was loss of control of No. 3 propeller and engine by "overspeeding" caused by a probable difficulty in the proper operation of the sleeve valve of the speed governor, as a consequence of the tearing off of metal particles from the front crank shaft bearing and that, while not positively jammed, it had operated with very limited lubrication, to an extent sufficient to cause abrasion of metal particles from the bearing.

These conclusions are confirmed by the fact that the engine in question had 1 360. 45 hours since the last major overhaul, had been withdrawn from service and, after 21 months of inactivity was installed on the subject aircraft without the special cleaning of the lubricating lines of the front bearing prescribed by Pratt and Whitney service bulletin No. 1666 and without addition of the auxiliary lubricating perforation of that bearing prescribed by Service Bulletin 1680.

Laboratory tests of the crank shaft and propeller shaft gave further proof of the presence of foreign matter in the lubrication channels. There is evidence of carbonized material at the places where blow torches had to be used to separate the parts and of pasty residues, characteristic of the residual deposits of oils, that lodge in the chambers and lines and cannot be removed by pressure washing, the condition being further aggravated by the admixture of anticorrosives for prolonged parking.

Service Bulletin No. 1666 dealing with internal flushing of the annular channel lubricating the front axle and bearing of the crank shaft is intended to apply to every major overhaul of the engine, and that operation is not shown in the record of work carried out in the United States; neither is there any record of removal of the propeller shaft bushing, which would make it unnecessary to flush the lines. As to Service Bulletin No. 1680, it is not mandatory and does not state the circumstances in which it is to apply, but its application requires total dismantling of the engine.

Probable Cause

The immediate cause of the accident was overspeeding of No. 3 propeller caused by irregular operation of the propeller governor, detachment of that propeller and impact with that of No. 4 engine, followed by disintegration of the aircraft.

The remote cause of the accident was insufficiently strict observance of engine maintenance conditions, because, while Pratt and Whitney Service Bulletins Nos. 1666 and 1680, dated 5 November 1957 and 15 May 1958 respectively, are not mandatory, the company should have taken account of the special circumstances in the history of No. 3 engine, which resulted in the destruction of LV-ADS.

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ICAO Ref: AR/640

No. 53

Pacific Western Airlines, de Havilland DHC-3, CF-CZP, made a forced landing at Berry Creek, Yukon Territory, Canada, on 9 September 1960. Report No. 1110 released by The Department of Transport, Canada.

Circumstances

The aircraft departed Fort McPherson, Northwest Territories at 1630 hours Pacific standard time on a proposed freight charter flight to Old Crow, Yukon Territories with a pilot and a company engineer aboard. After an hour's flying and when about 60 miles from the destination, the engine began to run roughly, failing completely before a suitable landing area could be reached. A forced landing was attempted in a slough; the engine was smoking badly, and the pilot had to use the side window to line up on his approach. A landing was made with full flap, the aircraft hitting the water hard, bouncing off to the side of the slough and landing on the bank. At this point the float struts broke, the switches were cut off, and the aircraft skidded a further 200 - 300 ft before coming to rest. There was no fire, and the occupants left the aircraft immediately. The engine failure occurred at 1725 hours.

The pilot was able to send out a distress call on 5680 kc prior to his forced landing and received a confirmation from Inuvik Radio Station.

Investigation and Evidence

The aircraft was owned by Canadian Pacific Air Lines Limited (Vancouver, B.C.) and was leased to Pacific Western Airlines (Edmonton, Alberta). A Certificate of Airworthiness had been issued for the aircraft, and the flying time since the last log-book certification was about 48 hours. There was no evidence of any fault in the airframe, propeller, or controls prior to the accident. An investigation showed that a failure had occurred in the No. 2 cylinder of the engine. It appeared that the exhaust valve failed first, causing subsequent damage to the intake-valve, the piston and the cylinder.

The underside of the fuselage, the main undercarriage attachment fittings and bulkhead, the fuel tanks, the left float and the propeller were substantially damaged; the float struts, wires, fittings and the right float being destroyed. The lower cowlings and augmenter tubes were crushed, and the oil cooler was damaged, No. 2 cylinder-head being split open due to an internal failure in the combustion chamber.

The pilot holds a senior commercial pilot's licence, and his total flying experience amounts to approximately 6 000 hours. He has flown 1 400 hours on this aircraft type, 300 hours of which were completed in the 90 days prior to the accident.

Probable Cause

An exhaust valve failure resulted in a complete loss of power and a forced landing on unsuitable terrain.

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ICAO Ref: AIG/ACC/REP/GEN/No. 1 - Canada

No. 54

American Airlines, Inc., Lockheed Electra, L-188A, N 6127A accident at LaGuardia Airport, New York, on 14 September 1960. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 1-0032, released 28 August 1961.

Circumstances

The aircraft departed Boston at 0716 hours eastern standard time for St. Louis, Missouri with a planned intermediate stop at LaGuardia Airport, N.Y. The flight was routine until during the approach at LaGuardia when the aircraft struck a dike at 0800 hours and crashed, severely damaging the aircraft. There were no fatalities.

Investigation and Evidence

Crew Information

About ten minutes prior to the flight's departure a crew change was made when a check pilot boarded the aircraft to flight check the flight engineer. This check pilot, by mutual agreement with the crew and in accordance with existing company policy, took over the left or pilot-in-command seat with the previously assigned captain moving to the jump seat.

The check pilot had flown a total of 14 082 hours of which 279 were in the Electra. His last first class medical examination was passed on 27 April 1960, and the medical certificate included a waiver specifying corrective lenses for near vision.

The other captain aboard the aircraft had a total flying time of 18 310 hours to his credit including 460 on Electras.

The remainder of the crew was made up of a first officer, a flight engineer and two stewardesses, who were all properly certificated.

The Aircraft

Company records indicated that the aircraft had been maintained in accordance with prescribed procedures and was in an airworthy condition prior to the accident. The aircraft had flown a total of 1 573 hours.

At the time of departure the aircraft's gross take-off weight was 91 367 lb, i.e. well under the maximum allowable gross take-off weight of 99 250 lb. Fuel on board weighed 17 600 lb and estimated fuel burnoff on the Boston-LaGuardia leg of the flight was 3 600 lb.

Runway 13-31

The runway is 5 347 ft long and 150 ft wide. The available length of this runway on the day of the accident was 4 899.5 ft. The decrease in length of 447.5 ft was necessary because of construction in progress on runway 4-22. The unusable portion was measured from the approach end of runway 13 and was marked by FAA approved marking criteria painted on the runway. Threshold lights were present on both sides of the paved runway surface. The approach plate, dated 15 August 1960, was in the pilot's flight manual and it showed the decreased runway dimensions.

The company's operations manual shows that for an Electra aircraft weighing approximately 87 767 lb and landing on runway 31 under the conditions which prevailed 14 September 1960, the minimum effective runway length required is approximately 4 010 ft. This includes crossing the end of the hard surface at a height of 50 ft, flaps in landing position four engines operating, propeller braking limited to ground idle power, and braking by means of wheel brakes. The above runway length of 4 010 ft includes a safety factor of 40% of this distance. The actual stopping distance required was estimated to be about 2 500 ft.

The Dike at LaGuardia Airport

LaGuardia Airport is bounded on three sides by water. Because the surface of the airport is located at a height nearly level with the water, a dike has been constructed around the water sides of the airport to prevent flooding. This dike is 161 ft from the approach end of runway 31 and stands approximately 8.2 ft above the runway surface and 13.7 ft above the mean water level. The dike is sodded and its top surface is somewhat irregular.

Obstructions to Air Navigation

TSO-18 (Standards for Determining Obstructions to Air Navigation), a publication of the FAA, prescribes, for an airport the size of LaGuardia, that any obstruction intersecting a glide slope plane of 40-1, shall be identified and marked as an obstruction. Further, that the marking shall consist of red lights on top of the obstacle for night identification, and orange and white checkerboard painting for daytime marking. The manual does not state specifically to what height the daytime marking must extend. The dike near the approach end of runway 31 was marked accordingly; however, these marks lacked reaching the top by approximately three feet.

Reconstruction of the flight

At 0752 the flight (No. 361) called LaGuardia approach control and reported it was over New Rochelle VFR. It was then given the following clearance: "American 361, LaGuardia approach control, at New Rochelle contact LaGuardia Tower 118.7, runway 31, wind west-northwest 18, altimeter 30.02, field information taxi eight closed, runway 31, 4 900 ft long, have you in radar contact..." The flight acknowledged and at 0755 reported to LaGuardia Tower that it was overhead and gave the wind as northwest 20 kt.

At 0800:27 the tower advised: "361 cleared to land." The flight acknowledged, and this was the last radio transmission from the aircraft.

The investigation revealed that all four main landing gear tires had struck the upper portion of the wooden bulkhead on the waterside of the dike. In going over the top of the dike the left wheels trenched to a depth of 9-1/4 inches and the right wheels 5-3/4 inches, the difference being the result of the irregularity in the dike surface. Accurate measurements indicated that the aircraft was 0.2 degrees right wing down and that the main gear was 1.3 ft below the top of the dike at the time of initial contact.

After initial impact, Nos. 1 and 2 propellers struck the ground 131 ft farther on. The aircraft rolled to the left and pitched down. In so doing it became inverted and reversed in direction. The left wing was torn off partially by the force against the landing gear when it struck the dike and tore completely away on contact with the ground. Fire which started in the left wing immediately upon impact and in the right wing during the rollover was confined to the exterior of the aircraft until all passengers had evacuated. The aircraft was substantially damaged by impact forces, smoke, and fire. It came to rest approximately 1 000 ft from the dike and 150 ft to the left of the left edge of the runway and heading approximately 153°.

Evacuation

When the aircraft stopped sliding, its occupants found themselves hanging upside down by their safety belts. To add to their confusion, the inside of the cabin was darkened by mud and soot on the outside window panes. The emergency lights in the cabin were not lighted.

The stewardesses, who were seated in the rear lounge, did an excellent job in allaying the fears of the passengers by quickly calling out the necessary instructions for debarkation. The lounge exit door was dislodged and partially open. The stewardesses and a passenger moved this heavy door sufficiently for it to be used as an exit. There was no panic and the evacuation was orderly.

Two airline mechanics who witnessed the accident drove to the schene immediately and were able to extinguish a fire by the buffet service door and open it. Passengers immediately began using this additional means of egress.

A male passenger (naval aviator) who was seated in the forward end of the aircraft opened an emergency window exit and left through it. He located the external emergency cable release for the sliding window on the captain's side of the cockpit, actuated it and helped the crew through the window to safety.

All 70 passengers and the two stewardesses were able to leave the aircraft in approximately three minutes. Only three of the five available means of egress were used.

Statements of the Check Pilot and Witnesses

The check pilot testified that he was attempting to land short and that for this type of landing the approach was completely normal until in the last few seconds a downdraft was encountered and the aircraft sank perceptibly. The left wing dropped, and corrective aileron was immediately applied. He said there was insufficient time to correct this by applying power. He further said that the air on final approach was smooth. After turning on final approach, power and airspeed were gradually reduced to 200 horsepower per engine and 120 kt. This airspeed was the last called by the first officer just before striking the dike.

The pilots of three aircraft awaiting take-off clearances at the runway ramp of runway 31 when the accident occurred said the approach appeared to be normal except that the aircraft was low when nearing the dike and appeared to settle.

The consensus of opinion of other witnesses was that the approach was normal in that it was neither a steep nor a low drag in approach.

Weather

The local weather observation required upon notification of an accident and recorded at 0814, indicated that the sky was clear; visibility 15 miles; and wind west-northwest 18 kt, with gusts to 24 kt. There were no pilot reports containing wind or turbulence information available for teletype or radio transmission prior to the accident.

Analysis

The investigation did not reveal any evidence of malfunction or failure of the aircraft or its components prior to ground impact.

The captain said that he was attempting to land short on the runway and would have done so if he had not encountered downdraft approximately 400 ft horizontally behind the dike, and that this downdraft caused the aircraft to sink rapidly 60 to 80 ft to a position beneath the top surface of the dike, from which he could not recover. He further said that the aircraft was functioning in a normal manner when the accident occurred.

It is believed that only light turbulence was encountered by the check pilot during the final approach and that a part of this may have been caused by surface wind flowing over the dike, producing a burble or eddy effect. Such an eddy effect, however, is not considered to have been significant in view of the height of the dike, wind velocity, type of aircraft involved, and the pilot's attested familiarity with this type of eddy.

The Board also recognized that a mental hazard may have been created by the construction work in progress at the end of runway 31, and that this could have furnished the motive for a short landing. Also, the top of the dike was not clearly defined during daylight hours, and this might have provided a margin for error if a pilot were attempting to cross the dike as closely as possible.

Notwithstanding these conditions, the Board believed that a pilot possessing the knowledge and skill expected of an air-line pilot should have considered all the existing conditions, allowed for them in planning the approach, and thus have avoided striking the dike by crossing it at a safer altitude.

Probable cause

The probable cause of this accident was the failure of the pilot to properly plan and execute the approach to a landing. Factors which may have contributed were the shortened runway and the unmarked upper portion of the dike.

Recommendations

As a result of this investigation and hearing, two recommendations were sent to the Federal Aviation Agency.

1. On 22 September 1960 it was recommended that the "Visual Glide Slope System", then undergoing tests by the FAA, be applied to LaGuardia Airport as soon as practicable.

2. On 13 December 1960 it was recommended in a letter to the Administrator that the present procedures for providing illumination of passenger exit markings be re-examined.

Other factors of this investigation are being studied, one of which is the evacuation of an aircraft when upside down.

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ICAO Ref: AR/686

No. 55

World Airways, Inc., Douglas DC-6AB, N 90779, accident at Agana Naval Air Station, Guam, Mariana Islands, on 19 September 1960. Civil Aeronautics Board (USA), Aircraft Accident Report File No. 1-0029, released on 18 July 1962.

Circumstances

The aircraft was making a passenger flight (Flight 830) from The Philippines to the United States, provided pursuant to contract between the Military Air Transport Service of the United States and World Airways, Inc., of Oakland, California. The flight originated at Clark Air Force Base, The Philippines for Guam; the segment on which the accident occurred was a continuation of Flight 830 to Wake Island, Honolulu, Hawaii, and Travis Air Force Base, California.

The flight took off from Agana Naval Air Station (Guam) into night VFR weather conditions. It made a right turn after take-off and although making a continuous climb over the distance flown, it struck Mt. Barrigada at a point about 2 NM from the departure end of runway 6L and approximately 300 ft above the elevation of the airport. Of the 94 occupants on board, 7 crew members and 73 passengers received fatal injuries; one crew member and 13 passengers survived. Damage and injury were more attributable to fire than to impact forces.

Investigation and Evidence

The Aircraft

N 90779 was a Douglas DC-6AB manufactured in January 1956. A No. 4 block overhaul was completed at aircraft total time of 10 398 hours on 4 October 1959, at Tulsa, Oklahoma, prior to the aircraft's sale to World Airways by American Airlines. It was converted from a DC-6A (cargo) to a DC-6AB (passenger/cargo) by Air Research Aviation Corporation, Los Angeles, California, in April 1960, at an aircraft total time of 11 631 hours. Certification of the aircraft was accomplished at this time. At the time of the accident it had accumulated a total of approximately 12 746 hours. The engines and propellers had all been overhauled within the prescribed time limits.

The aircraft was reported to be in good condition by the incoming crew at Guam and, as best as could be determined, there were no discrepancies entered on the aircraft log. However, upon inspection at Guam, a hole was discovered in the aluminum skin on the left side of the vertical stabilizer to the rear of the HF antenna bracket. Upon closer inspection, an additional "L" shaped fatigue crack was observed below the hole in the skin. The HF antenna was removed, and the hole was enlarged and trimmed. The "L" shaped fatigue area was cut out and trimmed, and a temporary fabric patch about 18 inches square was installed, covering both holes. This repair work was performed under the supervision of the outgoing flight engineer, completed at his insistence, and it met with his approval.

The approximate gross weight of the aircraft was 99 005 lb at time of take-off. The centre of gravity location was 23.5% of the mean aerodynamic chord and well within limits. The allowable gross take-off weight from Agana Naval Air Station for the aircraft was in this case 103 000 lb, using Anti-Detonation Injector (ADI) fluid and with autofeathering on. The landing weight allowable at Wake Island was 86 780 lb.

The Crew

After the flight arrived at Guam, the passengers and incoming crew deplaned and the outgoing crew readied the aircraft for the continuation of the flight. They had been at Agana Naval Air Station since 16 September 1960, awaiting the arrival of Flight 830 from Clark Air Force Base.

The captain possessed an airline transport pilot certificate with a type rating in Douglas DC-6 aircraft. He had a total pilot time of 15 681 hours, of which 2 548 were in the DC-6. He had approximately 713 hours of instrument time and 6 343 hours of night flying time. He held a valid Class I medical certificate with no limitations. The captain, when employed by another airline as a co-pilot, had been at Agana Naval Air Station on 2, 3 and 4 August 1958. It could not be determined if his arrival and departure were conducted during the day or night, or what runway was used. The available records do not indicate that he had been on Guam before or since those dates.

The first officer held a commercial pilot certificate with AMEL, ASEL*, and DC-4 ratings. His total pilot time was 6 317 hours, with 217 in DC-6s. His total instrument time was 266 hours and his total night time 4 617. He held a Class I medical certificate with no limitations.

The flight engineer held all requisite certificates and ratings. The navigator had a total time as navigator of 3 638 hours. There were also three stewardesses and an additional crew member of the FAA aboard the aircraft.

The civil flight operations at Agana Naval Air Station

The civil flight operations at the MATS terminal at Agana Naval Air Station were operated by Pan American World Airways and N 90779's crew used this facility as a base of operations according to existing policy. Passenger manifesting was handled by MATS personnel housed in the same building.

* multi-engine land
single-engine land

The latest radio facility charts, maps and other aids to pilots were available there to the crews. A folder containing weather information prepared by the U.S. Navy forecaster on duty was issued to the crew by Pan American World Airways during the dispatching process.

A poster, printed in large lettering, lay under the glass on top of the dispatch counter. It read as follows: "ATTENTION PILOTS! REF: Radio Facility Charts page 72 - Directory of Airdromes: Aircraft departing runway 6L will not make a right turn until a minimum of 1 000 ft has been attained". This poster was on display at the time the subject crew was using the dispatch office. It should be noted, however, that the notice referred to by the poster did not appear in Radio Facility Charts, page 72, as advertised. That publication had been re-entitled "USAF/USN Flight Information Publication En Route Low Altitude Pacific and Far East" and the referenced notice appeared on page 78 of that document. Furthermore, there is no indication that the obsolescence, or even the existence, of the poster was known to the captain of Flight 830.

The Weather

The local weather existing at Agana Naval Air Station at 0606 was 1 400 scattered; 14 000 scattered; high overcast; visibility 15 miles; temperature 77°; dewpoint 75°; wind east-southeast 5 kt; altimeter 29.80. Civil twilight began that morning at 0649, and official sunrise was at 0710.

The Accident

The flight's radio transmissions to Agana Tower were not recorded; however, the transmissions of the tower were recorded, and the transmission regarding ATC route and departure clearances was given to the flight as follows: "ATC clears World Airways seven seven niner to the Wake Island Airport, rhumb line track; maintain one thousand; read back." "Roger, seven seven niner, clearance correct as read: call one minute prior to take-off." "Roger, seven seven niner, we are getting your climbout instructions at this time." "Seven seven niner, I have your climbout instructions." "Roger, right turn after take-off, climb one zero zero degrees, contact center on one three five point nine after take-off." "Roger, clearance correct as read, seven seven niner, you are cleared for take-off." The flight then began its take-off roll at 0600. The take-off as observed by several witnesses appeared and sounded normal. The aircraft became airborne at approximately the 5 000-foot point on the 7 986 foot runway. As the aircraft passed over a brightly lighted construction area at the end of the runway, it was observed to make an immediate shallow right turn and take up a climb heading.

Approximately 50 seconds after take-off the aircraft first struck trees on Mt. Barrigada at an elevation of 580 ft msl, or 300 ft higher than the elevation of the take-off runway, and at a bearing of 087° magnetic from the end of the runway. After cutting a slightly curved swath 975 ft in length in a direction averaging 120° magnetic, the aircraft came to rest. According to survivors, the first portion of the impact with the trees was slight but the forces then increased in severity and fire broke out just before the aircraft came to rest. The fire seemed to come forward through the cabin from behind. The survivors left the aircraft through a hole in the left side of the cabin, an escape hatch on the right side over the wing, and the co-pilot's window. According to the navigator, the sole surviving crew member, nothing unusual occurred in the cockpit and to the best of his memory all check-lists were called out and followed, and nothing was indicated by the crew's actions or by their voices which reflected anything but a normal condition.

The manner in which the aircraft struck trees prior to ground contact indicated that the aircraft had been in a slight right turn with an almost level longitudinal attitude. Investigation revealed that all the aircraft wreckage was confined within the impact area. Contact with trees punctured the fuel tanks, and the ground fire consumed the majority of the aircraft structure.

Reconstruction of the Flight

A Navy helicopter and a U.S. Air Force C-54 were used by the Board in an attempt to determine the approximate flight path of N 90779. A course of 280° magnetic (reciprocal of 100°) was flown in the helicopter from the point of impact to a point on a straight line projected from the centre line of runway 6L. The purpose of this was to determine the approximate location of the spot where N 90779 made the right turn after take-off. Later, using these data, the C-54 was employed to determine the flight path and to develop a time envelope. By simulating the V_2 speed of a DC-6 and timing from the estimated point of take-off, it was determined that the flight time envelope was 50 seconds. A probable flight path was determined by climbing straight ahead to the point determined by the helicopter to be where N 90779 commenced its right turn, and a right turn with a bank of 15° was made in the C-54 at this point and continued until a heading of 100° magnetic was attained. This aligned the aircraft exactly with the swath made where N 90779 crashed. A witness, whose house is located on the flight path, stated that the aircraft which crashed had flown directly over his home, which confirmed the flight path as flown by the C-54.

Technical Investigation

A thorough examination was made of the engines, propellers, fuel system, and ADI system of the aircraft. The power units were damaged in varying degrees by the impact and the fire that followed. An extensive teardown inspection was made of the power units over a period of a week. Nothing was revealed that cast any doubt on their capability of normal operation prior to impact. All propeller blade fractures were examined for evidence of fatigue, but none was found.

There was no evidence of any failure of the structures, flight controls or related systems prior to impact. The wing flaps and landing gear were fully retracted prior to impact.

The section of the vertical stabilizer of N 90779 which had been repaired prior to the flight's departure was sent to the manufacturer for examination. Search for the fabric patch that had been placed over the two holes was made, but the patch was not found. The Douglas Aircraft Company reported that neither the flight characteristics nor ultimate design-load strength would have been significantly affected in the airspeed envelope at which the aircraft was operated during this flight.

There was no evidence of fire prior to initial contact with ground objects.

Samples of the fuel and ADI used by the aircraft were analysed. Laboratory tests showed that the fuel and ADI fluid were within required specifications and uncontaminated.

A number of cowl flap screwjacks were measured to be 1.53 to 1.58 ft. A comparison of this screwjack length with comparable measurements of both a sister aircraft and a built-up engine showed the extension of the screwjacks to represent a "cowl flap full open" position. The World Airways DC-6 Technique Manual states that the cowl flaps will be set at four degrees after take-off clearance has been received and the aircraft is positioned on the runway. The setting of four degrees was the streamlined or trail position for N 90779, since it did not have propeller spinners. The full open setting was 22°.

Mt. Barrigada Beacon

Inasmuch as the flight had made a predawn take-off, much consideration was given to the question of the adequacy of the flashing red beacon light upon the summit of Mt. Barrigada. It was determined that the beacon was in operation during the take-off and short flight. It, however, operated on acetylene gas and was of much lower intensity than the electric beacons on top of several radio antennae which were situated slightly to the right of the flight path but lined abreast with the acetylene beacon and about 200 ft lower in altitude.

Conclusions

Since the take-off was made during the hours of darkness it may be assumed that the outline of Mt. Barrigada was not visible to the captain. However, the location of the mountain was well-known to most pilots and the procedure to avoid it was clearly posted in the dispatch office.

In addition, World Airways operations manual stated that radio facility charts, current flight information manuals, and other documents which indicated the correct departure procedure for runway 6L, must be carried in the airplane. These documents advise pilots when taking-off in this direction to climb to an altitude of 1 000 ft before turning to the east. It is, therefore, difficult to understand why this procedure was not followed. Owing to the low intensity of the single red flashing beacon on the summit of the mountain and the likelihood of early morning mountain haze, it is questionable whether the beacon would have been visible to the crew, thus alerting them to their precarious position in sufficient time for evasive action to be taken.

Although information concerning the climb restriction was available in publication form, a more effective procedure for dissemination of this information would have been the inclusion of the restriction in the departure instructions issued by the ARTC.

The rate of acceleration and rate of climb of the aircraft would have been increased had the cowl flaps been properly set at 4° instead of 22°. However, the increase would not have been sufficient in itself to cause the aircraft to clear the obstructing terrain.

The Board believed the aircraft power units were capable of producing required power and were, in fact, delivering approximately 1 900 BHP each at impact. Because of a slight variance in the rpm of the engines, it is believed that the first power reduction to METO had just been completed prior to impact, and the engines had not yet completely stabilized.

All of the evidence conclusively indicated that the aircraft did not collide with any object (other than the mountain), nor was there any in-flight fire or structural disintegration prior to initial impact.

Probable Cause

The Board determined that the probable cause of this accident was the failure of the pilot to comply with published departure procedures applicable to runways 6 left and 6 right.

Follow-up Action

Immediately following the accident, Agana Naval Air Station instituted the practice of having the tower advise pilots prior to take-off on runway 6L to climb straight ahead to 1 000 ft before turning.

Also, since the accident, the acetylene beacon on Mt. Barrigada has been replaced by a red electric obstruction beacon containing two 600-watt bulbs, which combine to produce 2 000 candle power. This beacon flashes 32 times per minute and is actuated by a photoelectric cell.

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ICAO Ref: AR/718

No. 56

Austrian Airlines, Vickers Viscount 837, OE-LAF, accident 11 km west of Sheremetevo Airport (Moscow), on 26 September 1960. Report, dated 5 October 1960, of the Russian Board of Inquiry as received from the Director of Civil Aviation, Republic of Austria.

Circumstances

Flight OS 901 from Vienna to Moscow via Warsaw was carrying 6 crew and 31 passengers when it crashed at approximately 1840 hours GMT, 11 km from Sheremetevo Airport along the approach corridor to runway 07. The aircraft was completely destroyed. Five crew and 26 passengers were killed in the accident or died in hospital as a result of severe injuries.

Investigation and Evidence

The aircraft had a Certificate of Airworthiness valid until 4 March 1961. At the time of take-off on the day of the accident the aircraft had flown a total of about 1 273 hours, including test time, and had made 872 landings. The airframe had not sustained any damage up to the time of the accident.

The crew were properly certificated and both the captain and co-pilot had flown over 2 000 hours. On Viscount aircraft the pilot-in-command and co-pilot had flown 1 752 and 459 hours respectively.

The Flight

The first portion of the flight from Vienna to Warsaw was routine, and no difficulties were reported. The aircraft then departed Warsaw at 1554 hours GMT and expected to arrive at Moscow at 1849 hours. This arrival time was subsequently corrected to 1840 hours GMT. The aircraft was in constant contact by radio with the appropriate flight security stations and did not report any irregularities.

The actual approach procedure was reconstructed on the basis of a tape recording of radio communications between the aircraft and approach control centre as well as from interrogation of the approach controller and radar observer.

OE-LAF flew over NDB "MR" at 1828 hours 30 seconds. Approach control directed the aircraft to curve in at 338°. According to the radar observation the aircraft did take this bearing a short time later. After the aircraft had aligned itself almost exactly along the indicated approach plan and had reported the prescribed altitude, ground control gave no further instructions for flight correction to the aircraft.

The approach controller, who was observing the PPI (plan position indicator) at the same time, recalled that OE-LAF had effected the last turn before the final approach as well as the final approach to NDB "MR" deviating somewhat to the left of the approach ground line. However, this deviation was not considered as unusually great and, consequently, no corrective measures were taken in this approach phase. The message transmitted from OE-LAF at 1836 hours 30 seconds advising that the final approach would be made at 400 m altitude was considered by the controller as normal.

The landing radar controller then expected to localize the aircraft on his screen at a distance of approximately 13 km. When the approach controller inquired at 1838 hours 45 seconds about the position of the aircraft, it appeared a single time in the approach path radar at a distance of 12 km from the beginning of runway 07.

After this single time its movement towards the approach ground line could not be ascertained satisfactorily. The aforementioned distance was transmitted to OE-LAF and upon request of the crew it was repeated and acknowledged with thanks by the latter at 1838 hours 58 seconds. The conclusion can be drawn on the basis of the foregoing facts and the technical characteristics of the radar apparatus and also from the fact that OE-LAF did not appear at all on the glide path radar, that, at this time, the aircraft was at a height of 100 m above ground. This altitude also appears to be confirmed by the testimony of witnesses. However, according to the approach procedure, the aircraft should have maintained an altitude of at least 200 m above ground until overflight of the NDB "MR". Beginning at 1840 hours 50 seconds the aircraft was repeatedly called by approach control with no reply. It is, therefore, assumed that the time of the accident was between 1838 hours 58 seconds and 1840 hours 50 seconds.

The accident occurred in a wood the highest trees of which reached a height of 20 - 25 m. The aircraft had made initial contact with the trees approximately 380 m before the crash point, about 20 m above the ground. The trees along the full wing span were broken off 4 m from the tops. The initial contact with the trees did not cause any bank. Parts of the left landing flap were found at this point. Approximately 150 m beyond, a second point of contact with the trees was observed. A compass bearing taken from the point of initial contact to the main crash point yielded a reading of approximately 85°.

From the investigation conducted at the accident site it was deduced that: during the interval between its localization on radar and the crash, the aircraft was evidently moving in normal sinking flight. In view of the distance from the point of initial contact with the trees to the point of impact, the average slope of the descent path can be estimated as 1:15. The fact that the trees at the point of initial contact with the trees were lopped off along the entire wing span of the aircraft and at a uniform height, seems to indicate that, at this moment, the aircraft must have been flying without any lateral inclination. Only after the loss of the left landing flap did it begin to turn gradually to the left along its longitudinal axis. Immediately thereafter, at a distance of 300 m from the point of initial contact with the trees, the left wing struck the ground at an inclination of approximately 60°. The left wing was presumably ripped off at this point and the left (external) slipper tank at the same time burst into flames. At this stage, the aircraft then turned along its normal axis until the fuselage reached an angle of approximately 90° to the direction of flight, and the pilot's cockpit lay at an angle of about 150°. The testimony of witnesses confirmed that shortly before impact, the aircraft, although flying low, was not in an unusual flight attitude.

Aids available to the flight

Non-directional long wave radio beacons were available as navigation aids for the flight from Vienna to Moscow. It was not known whether any of these aids failed to operate on the day of the accident.

The following landing aids were available for landing approaches at Moscow-Sheremetevo:

non-directional radio beacon "MR" 700 kHz
non-directional radio beacon "M" 338 kHz

It was not known whether any of these landing aids failed to operate.

Conclusions

The investigations revealed that there were no technical deficiencies in the aircraft itself or any meteorological phenomenon involved in the accident.

The Austrian observers participating in the investigation of the accident were of the opinion that the accident was related to altitude measurement, inasmuch as it was apparent from radio communications as well as from the examination of the wreckage that the crew believed they were flying at the normal approach altitude.

The erroneous altitude measurement may be attributed to:-

a) a technical deficiency of either of the two altimeters;

b) the divergent settings of the altimeters; or

c) omission of altimeter reading or erroneous reading of altimeters.

The internal mechanism of both altimeters was so heavily damaged that it could no longer be ascertained whether, at the time of the accident, the altimeters were functioning accurately. Both altimeters were set to the correct atmospheric pressure but their settings differed, namely: the left altimeter was set at QFE 0990 mb and the right altimeter at 1013 mb, which in view of the prevailing atmospheric pressure conditions, could have corresponded both to QNH and to the standard pressure setting. Such divergent settings are at variance with the usual procedure of Austrian Airlines. The reasons prompting the flight captain to depart from the usual practice could not be ascertained.

It was not possible to reach a categorical conclusion as to which of the three causes was responsible for an approach below the minimum flying altitude.

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ICAO Ref: AR/662

No. 57

United Arab Airlines, Vickers Viscount 739B, SU-AKW, lost at sea in the vicinity of the Island of Elba, Italy, 29 September 1960. Report released by the Director General of Civil Aviation, United Arab Republic.

Circumstances

SU-AKW was on a scheduled international flight (No. 738) from Geneva to Rome, Athens and Cairo. Following departure from Geneva for Rome at 1005 hours GMT the aircraft was to follow Airway A3. Near the Island of Elba, at flight level 210, the pilot notified Rome ATC that he would change his heading to the west to avoid some unfavourable weather. Rome ATC cleared the aircraft to do so. This was the last contact with the aircraft.

Search and rescue procedures were begun at 1305 hours. Very little wreckage of the aircraft was found. It was believed that it crashed at about 1115 hours into the Tyrrhenian Sea, 17 miles north of the Island of Elba, killing the 4 crew and 17 passengers aboard.

Investigation and Evidence

The aircraft's certificate of airworthiness was valid up to 3 April 1961. SU-AKW was owned by Misrair.

Both the pilot-in-command and co-pilot held airline transport pilot licences valid until 30 September and 25 October 1960 respectively. The pilot had flown a total of 10 888 hours, 897 of which had been as pilot-in-command on Viscount aircraft. The co-pilot had flown a total of 2 630 hours.

Weather Conditions

There was a deep depression lying to the southwest of Ireland with a trough including a complex system of depressions extending to the southeast to Italy. On 28 September another low existed over the Tyrrhenian Sea which deepened over the Genoa Gulf giving rise to turbulence and unstable conditions over the northern and northwestern parts of Italy. This low was associated with an active cold front moving eastward at a speed of 40 kt. At 0500 hours on 29 September the cold front was lying over Mont Blanc and extended to La Spezia. At 1100 hours on the same day the cold front was passing over Turin, Genoa and Elba.

The weather was cloudy with rain south of the Alps and cloudy with thunderstorms and local showers to Elba. Along the route from south of the Alps to Elba, the clouds were as follows:

6/8 to 8/8 medium cloud, base 2 400 m, tops 5 000 m.
3/8 to 5/8 cumulonimbus cloud, base 600 m, tops 9 500 m.

There was also turbulence - moderate to severe between Genoa and Elba with moderate to severe icing within the clouds from 3 000 m to 6 00 m, and light to moderate icing from 6 000 to 7 000 m.

Search and Rescue Action Taken

The distress phase was entered at 1435 hours GMT (the limit of estimated possible flying time based on a take-off fuel load of 1 600 imperial gallons) - i.e. 4 hours 30 minutes after take-off. Radio contact with the aircraft was lost at 1115 hours GMT, and the search was begun at 1305 hours.

On 29 September the radar at Vigna di Valle recorded an echo considered to be Viscount, SU-AKW. The echo was watched from a position over Genoa on Airway Amber 3 until it was approximately

5 miles south of Elba. It was last recorded at this position at 1118 hours GMT, and then disappeared from the screen and was not recorded again.

An intensive search was carried out on 29 and 30 September, 1 October and up to 1110 hours GMT on 2 October when it was discontinued.

Wreckage

The only identifiable wreckage found was as follows:

1. an aircraft wheel was picked up from the sea on 2 October at a point 4 miles north-northeast of Marciana Marina, which was identified as a spare main undercarriage wheel carried on SU-AKW;

2. a tin of coffee was picked up at the same time and was identified as being part of a consignment purchased by Misrair and used in the galley service of SU-AKW;

3. a patch of oil was found on the sea during the later afternoon of 3 October at a point 12-1/2 miles due west of San Vincenzo and 17-1/2 miles north-northeast of Portoferraio;

4. on 11 October, a mail bag containing mail and a package of gold coin known to have been on the aircraft was picked up on the beach of Follonica on the mainland east of the Island of Elba;

5. two uninflated life jackets were picked up on the beach 3 miles south of San Vincenzo on 11 October - a third life jacket was picked up in the same area on 12 October;

6. on 13 October an aircraft cushion, marked Misrair, was found on the beach south of Bastia, Corsica.

Attempts were made to locate the aircraft's wreckage at the bottom of the sea without success.

The Flight

Prior to departure the captain was briefed on the meteorological situation and then filed an IFR flight plan which indicated he would be following the route - Geneva, Mont Blanc, Turin, Genoa, Pisa, Elba, Giglio, Bolsena, Rome. The flight was established to take 3:02 hours; fuel on board was sufficient for 4:30 hours and Naples was selected as the alternate. Flight level 190 requested for the flight was 210.

Flight 738 left Geneva at 1005 hours GMT on 29 September. At 1017 it was flying at 13 000 ft over Geneva beacon - PY - and requested clearance to climb VMC to flight level 210. Geneva cleared it to do so. At 1022 it was over Mont Blanc and was cleared to change over to Milan ATC giving its ETA over Turin as 1042. The aircraft contacted Milan ATC at 1026 and then reported that its ETA over Turin was 1038 and it was still climbing to reach flight level 210. At 1027 the aircraft informed Milan that there was rough weather with cumulus to the right of the airway. It reported at flight level 210 at 1030 and asked for clearance to change to flight level 230, but Milan instructed the aircraft to maintain flight level 210. The aircraft reported over Turin at 1038, giving its ETA over Genoa as 1055 maintaining the same flight level. At 1054.5 Flight 738 informed Milan it was over Genoa at 1045 and that its ETA abeam Pisa would be 1110 hours, maintaining the same flight level. It reported as being abeam Pisa at 1110 and that its ETA over Elba would be 1121. Milan ATC requested the aircraft to change over to Rome ATC. At 1115 hours the aircraft informed Rome ATC that it was going to avoid some weather ahead of it. Rome acknowledged the message. This was the last contact with the aircraft. All successive attempts to contact the aircraft were to no avail.

Findings

The flight was normal as of the last contact, and no difficulties were reported by the captain. It was not believed that the aircraft had exploded in mid-air as no scattered parts of the aircraft were located, nor were any victims of the accident found. The aircraft had dived into the sea at a point most probably 17 NM to the north-northeast of Portoferraio, Elba.

Probable Cause

The accident was attributed to the entry of the aircraft into a severe thunderstorm which resulted in loss of control of the aircraft or one of its main parts had sheared off or was completely damaged.

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ICAO Ref: AR/689

No. 58

Eastern Air Lines, Inc., Lockheed Electra L-188, N 5533, crashed into Winthrop Bay following take-off from Logan International Airport, Boston, Massachusetts, on 4 October 1960. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 1-0043, released 31 July 1962.

Circumstances

A few seconds after taking-off from runway 9 at Logan International Airport, Boston, the aircraft struck a flock of starlings, a number of which were ingested in engines Nos. 1, 2 and 4. Engine No. 1 was auto feathered. Nos. 2 and 4 experienced a substantial momentary loss of power. This abrupt and intermittent loss and recovery of power resulted in the aircraft yawing to the left and decelerating to the stall speed. As speed decayed during the continued yaw and skidding left turn, the stall speed was reached; the left wing dropped, the nose pitched up, and the aircraft rolled left into a spin and fell almost vertically into the water. An altitude of less than 150 ft precluded recovery. Fifty-nine passengers and 3 crew sustained fatal injuries*, and 9 of the 10 survivors were seriously injured. Calculations revealed that the time of the accident was 1740 hours eastern daylight time i.e. 47.5 seconds after the take-off was commenced.

Investigation and Evidence

Flight Personnel

Five crew members were aboard the flight.

The captain held a valid airline transport pilot's certificate with ratings for the Martin 202, 404, Convair 240, 340, 440, DC-4, DC-6, DC-7, Lockheed Constellation and L-188. He had flown 1 053 hours on the L-188 out of a total of 23 195 hours.

The co-pilot and flight engineer were also well-qualified and experienced crew members.

Description of take-off based on eyewitnesses' statements (See Figure 16)

Following completion of the routine preparations for the flight to Philadelphia, Pennsylvania; Charlotte, North Carolina; Greenville, South Carolina and Atlanta, Georgia, the aircraft was issued an instrument flight rules clearance in accordance with its flight plan. It was instructed to cross Natick Intersection at 3 000 ft and to maintain runway heading for two minutes after take-off.

Take-off was commenced from runway 9 at 1739 hours. The aircraft lifted off the runway after a ground roll of about 2 500 ft and attained a height of 30 to 40 ft. It continued at this height in nearly level flight for several hundred feet before establishing a normal climb attitude. During this time the landing gear was retracted after which the airplane climbed straight ahead for a short interval. While it was in this initial climb several witnesses saw an unusual puff of grey smoke from engine No. 1 - other saw a ball of fire from engine No. 2.

During the climb the aircraft was described as veering to the left and then returning to its original course; its speed was said to be very slow. After reaching an altitude of 100 to 200 ft the aircraft made a flat left turn from the runway heading of 090° magnetic to a heading of about 030°. While on this heading it maintained its nose-high attitude but appeared to settle approximately one-half the height it had attained.

* The two stewardesses survived the accident.

Two witnesses adjacent to the take-off area of runway 9 took photographs of the aircraft at this point. The first picture confirmed that the aircraft was on a heading of 030° magnetic, at an altitude of 121 ft msl and had reached a position about 7 000 ft down the runway but was displaced about 1 350 ft to the north. The deck angle at the time also appeared to be about 9° above the horizontal, and the aircraft was at an angle of bank of 8.5° to the left.

The second photograph, taken about one second later, was also assessed. It showed the aircraft at an altitude of 121 ft msl, on a heading of 030° magnetic as before; however, at this time the deck angle had increased to 14° and the angle of bank to 14°. The aircraft was then seen to execute a manoeuvre most closely described as a wing-over. During this manoeuvre the nose came up higher while the left wing dropped to near vertical. The nose then fell through rapidly and the aircraft descended, striking the water almost vertically and while still rotating to the left. The impact area was in Winthrop Bay approximately 2 000 ft to the left of the centreline of runway 9 and approximately 7 000 ft from the point where take-off was started.

Three persons, all experienced pilots, aboard an Aero Commander approaching runway 15 for landing had an excellent view of the Electra's take-off. They first observed the departing aircraft, already airborne, at about the time it passed the intersection of runways 9 - 15. They noted that the Electra appeared to be starting a left turn well before crossing the end of the runway and assuming a nose-up angle which they considered excessive. Thus, their attention was concentrated on the Electra until its contact with the water. The altitude of the Aero Commander was approximately 400 ft when its occupants first observed N 5533, and thereafter decreased normally, commensurate with a landing approach. These three men stated that N 5533 never attained an altitude equal to that of their aircraft. The co-pilot stated that he saw either a puff of smoke or flame come from the No. 2 nacelle shortly after the Electra passed runway 15. The passenger also saw this emission but described it as a white puff of smoke.

Engines - Bird Ingestion

Shortly after the accident, Board Investigators received a report that a number of bird carcasses had been found on the runway. Bodies and pieces of bodies representing approximately 75 birds, identified as starlings, were scattered predominantly on the left side of runway 9 between the intersections of taxiway 33 and runway 33. The remains were strewn over an area roughly 400 ft long by 200 ft wide, the midpoint of which was about 3 800 ft from the approach end of runway 9. After autopsies of the birds, several ornithologists as well as personnel from the U.S. Fish and Wildlife Service concluded that they had been killed during the late afternoon of 4 October.

Bird remains extracted from the engines and the carcasses which were found on the runway provided evidence that during take-off starlings were ingested by engines Nos. 1, 2 and 4. The Board concluded that engine No. 3 did not ingest any birds, because detailed examination of material specimens from its interior revealed no traces of bird remains. The possibility that sea life may have destroyed the bird remains in No. 3 engine was considered and discarded. All engines were removed from the water within a few hours, with No. 3 being first; consequently the exposure of all the engines to sea life was about the same.

Several eyewitnesses reported seeing smoke or fire emitted from the engines. This evidence, together with that of the bird remains found in the engines during teardown, indicated a need for more information concerning engine operation after bird ingestion.

Engine Tests

A series of tests was conducted by the Allison Division of General Motors, the engine manufacturer, in which starlings were introduced into an operating engine in varying numbers and sequences. In view of its immediate availability, a static test stand was utilized. Although the test was limited in simulating the in-flight engine response to ingesting birds, much valuable information was obtained. The tests demonstrated that substantial power interruptions and emissions of flame from the tailpipe would occur when starlings were ingested; however, quantitative information was lacking with respect to the engine behaviour under flight conditions.

Subsequently, another test programme was incorporated in the study of the broad problem of turbine engine bird ingestion being conducted under the auspices of the Federal Aviation Agency. In cooperation with Board personnel, the test programme was planned to provide information pertinent to the circumstances which prevailed at the time of the accident. These tests were conducted in the Lockheed Aircraft Corporation wind tunnel in Burbank, California. An electra QEC (Quick Engine Change*) was installed with modifications in the inlet duct to permit controlled introduction of birds. Various numbers of starlings were ingested into the engine at different power settings and tunnel speeds. Pertinent operating parameters were recorded during each test. Besides substantiating the results of the static test stand programme, these tests afforded the following information:

1. The Allison model 501-D13 engine demonstrated excellent resistance to structural damage from starling ingestions.

2. Single-starling ingestion at cruise and take-off conditions revealed negligible power interruption and approximately 90% of pre-test power was recovered.

3. Two-starling ingestion at cruise power decreased shaft horsepower approximately 15% after recovery; at take-off power, approximately 10%. In both cases, at least 50% power was always available.

4. Four-starling ingestion at take-off power decreased shaft horsepower approximately 15% after recovery. Power fell to approximately 500 SHP and was below 50% rated from one to three seconds. An autofeathering signal occurred in one of the three tests conducted.

5. Six-starling ingestion at take-off power decreased shaft horsepower approximately 23% after recovery. In one instance, the engine failed to recover. In another test less than 50% power was available for four seconds. In the last test the engine flamed out, relighted and produced 50% or more power after seven seconds. All tests indicated that autofeathering would occur.

6. Eight-starling ingestion at take-off power produced an autofeather signal in all three tests. The engine failed to recover in two of the tests. In the remaining instance the engine flamed out, relighted and partially recovered when surging and overtemperature necessitated shutdown.

7. Ingestion of eight starlings in time-sequenced groups of four each critically complicated the recoverability of the engine. One test terminated in shutdown because of surging and overtemperature. In the other test, the engine flamed out, relighted and recovered steady 50% or more power after a 10-second interruption. In both instances the propeller would have autofeathered.

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* Allison 501-D13 engine, equipped in this case with an Aeroproducts 606 propeller, mounted in the forward detachable section of the nacelle.

The Board extracted information from reports of bird strikes experienced by commercial air carriers. During the period, 25 February 1961 to 13 September 1961, fourteen bona fide bird strikes were reported on the 501-D13 engine. In all instances, the damage proved to be minor. The most critical flight regime was take-off. The majority of bird strikes (57%) including three multiple strikes occurred at this power setting. In a multiple strike involving all four engines, only one engine experienced a slight decrease in horse-power; however, the other multiple strikes, each involving two engines, auto-feathered a propeller in both instances. Most of the bird ingestions at take-off power (62%) resulted in an engine shut-down in which the propeller was usually autofeathered (80%); engines which recovered after ingestion experienced 100 to 250 HP deterioration in rated power. The nature of inflight ingestion precluded any accurate determination of bird number and/or weight required to cause an engine shutdown. In flight regimes other than take-off, the bird ingestions caused neither an engine shutdown nor a reported loss in power.

Test Result Evaluation

Evaluation of the results of the bird ingestion tests indicated that these tests reasonably simulated engine behaviour in flight. Apart from possible structural damage, birds ingested into the engine affect power output by blocking airflow, decreasing compressor airfoil efficiency with surface debris, distorting gaspath, etc. Component efficiency may deteriorate until the engine is unable to provide external power or is even incapable of surge-free steady operation. It also appears that ingestion of more than three starlings can actuate the autofeather system, cause engine flameout, or reduce the power substantially for several seconds. Engine recovery after ingesting eight or more starlings simultaneously appears very improbable. Post-test inspections indicate that bird debris lodges within the engines after an ingestion.

Engines of N5533

No. 1 propeller was feathered, most probably by a thrust sensitive signal, generally known as autofeather. The thrust sensitive signal is produced when the power lever is advanced beyond 75°, the system is armed by a switch in the cockpit, and propeller thrust decays below 500 lb. Autofeathering of any one propeller disarms this feature from the remaining propeller systems, which would account for a like action not occurring to any of the remaining propellers. Auto-feathering of No. 1 propeller further suggests that its engine was the first to be materially affected by bird ingestion and that at least four birds were ingested.

It is believed that No. 2 engine ingested about six birds; consequently, its power was the most adversely affected of all the engines, excluding the autofeather action of No. 1 propeller. As no direct method is available to determine the number of birds ingested by an engine, this conclusion is reached following the consideration of several factors. The obviously critical and rapid deterioration of airplane performance and the initial yaw to the left after penetrating the flock of starlings indicated a prolonged substantial power interruption on the left side. In addition, witnesses observed flames emitting from an engine on the left wing and several specified the No. 2 engine. This is further substantiated by recalling that the No. 1 engine was shut down in conjunction with the autofeather action. The flames emitted from the tailpipe of No. 2 engine indicate a torching relight after a flame-out. The flames emitted during engine surges observed in tests appear to be too short to extend through the long exhaust duct in the Electra installation. The only conclusion compatible with all the circumstances of this accident is that No. 2 engine ingested about six birds, flamed out, relighted and recovered substantial power within several seconds. Tests indicate that less than 50% rated power would be available for 6 to 7 seconds, following which a recovery to stable operation would occur with some semi-permanent power loss.

There was no evidence that No. 3 engine ingested any birds, and it was concluded that it operated normally until impact.

No. 4 engine probably ingested fewer birds than engines Nos. 1 and 2; consequently, its power transients were least severe with substantial decrease most likely not exceeding two or three seconds. This belief is based on the indications that the starling flock was concentrated more on the left side of the airplane and lack of observations of flames on the right side of the airplane as contrasted with observations of flames on the left side. Furthermore, the path of the aircraft suggests considerable power asymmetry with the most power being on the right side.

Except for No. 1, the engines were producing near take-off power at impact. This somewhat limits the number of birds that may have been ingested. Wind tunnel tests indicate that power recovery is improbable when eight or more birds are ingested, and it is obvious that there was recovery of No. 2 and No. 4 engines before impact.

Shaft horsepower readings obtained from the instruments are not compatible with the semi-permanent power losses that the wind tunnel tests indicated would occur following bird ingestion. Assuming the semi-permanent power losses occur as indicated by the wind tunnel tests, the instrument readings also are not compatible with the bird ingestion pattern that is known to have occurred, i.e. the SHP (shaft horsepower) reading of No. 3 engine which did not ingest birds was about the same as No. 2 and less than No. 4, both of which ingested birds. Consequently, it is concluded that the instrument readings obtained are not valid criteria by which to determine the number of birds ingested by the individual engines.

Systems

It was concluded, following examination of the aircraft's primary hydraulic and electrical systems components, that they experienced no in-service failures prior to impact.

Since No. 3 engine showed no evidence of power loss during its flight, its generator would be supplying electrical power for essential system units throughout. Even if generators Nos. 1, 2 and 4 were initially lost due to engine power loss because of the ingestion of birds, the No. 3 generator would automatically supply electric power to Priority Bus A; hydraulic pumps 1A and 2 would have electrical power available to them and consequently both hydraulic power systems would be available for flight control booster operation.

Using an arbitrary 3 seconds delay between lift-off and the selection of gear up, and the nominal 9.5 seconds for landing gear retraction time, a period of hydraulic and electrical capability is shown to cover approximately the first 12.5 seconds of flight following lift-off.

Six seconds after take-off the aircraft struck a flock of birds and the No. 1 propeller was feathered. The time required to feather the propeller is approximately 8 to 9 seconds when the engine is at take-off power. The feathering operation confirms the availability of generator power, and covers the first 15 seconds of the flight after lift-off.

During the feathering operation or a short time later, the No. 1 engine shutdown handle was actuated. One function of this control is to close the fuel cutoff and engine oil shutoff valves electrically. These valves receive their power from the Essential DC Bus and, since they were found fully closed, this condition verifies the existence of power. The Essential DC Bus is also the power source for the emergency inverter.

Had all generator capability been lost more than four to five seconds prior to impact, the emergency inverter would have started operation at the time of the electrical power loss and would have shut down automatically upon any restoration of power. Since the rundown time of the emergency inverter is approximately 13 seconds and examination of the recovered inverter disclosed clear evidence that its armature was not rotating at impact, it can be concluded that there was no interruption of electrical power from the time of feathering the propeller to the time of impact. Hence, it can also be concluded that hydraulic boost assist to the primary flight controls was available throughout the flight.

Flight tests - Lockheed

Lockheed Aircraft Corporation undertook a series of flight tests to study the controllability of the Electra L-188 under conditions of multiple powerplant failures and operating under circumstances considerably more critical than those required for certification. Specifically, the tests determined the minimum control speed (V_{mc})* of the aircraft while in various bank angles, and with one or two engines inoperative. In addition, the tests defines the maximum asymetric power at which the aircraft heading could be maintained at a constant low airspeed.

It was found that with the No. 1 propeller feathered and the other three engines developing 3 800 hp, V_{mc} ranged from 110 kt with 5° of right bank to 136 kt with 5° of left bank.

In similar tests with the No. 1 propeller feathered, No. 2 propeller windmilling, and engines Nos. 3 and 4 each developing 3 800 hp, V_{mc} was found to be 125 kt with 5° of right bank and up to 154 kt with 5° of left bank.

Another group of tests was conducted with the No. 1 propeller feathered, No. 2 propeller windmilling and various power combinations on engines No. 3 and No. 4. The aircraft was flown at bank angles of 5° left and right. Under these conditions it was demonstrated that in order to maintain directional control of the aircraft with two engines inoperative on the left side, the total power output of both engines on the right side could not exceed the maximum power output of a single engine.

The results derived from these tests provided the Board with valuable information concerning the capabilities of the Electra under predetermined adverse conditions and also formed a basis for evaluating the operating limits which may have prevailed at the time of the accident.

The test flights did not exactly duplicate the conditions under which N 5533 was operating, in that they were conducted at constant, rather than fluctuating, engine power conditions. The aircraft at Boston, after striking the birds, experienced a power loss on the No. 1 engine which resulted in the feathering of its propeller. The Nos. 2 and 4 engines experienced an abrupt loss and nonsimultaneous recovery of power while the No. 3 engine remained at full power throughout the flight.

It was brought out during the Board's public hearing that after striking the birds and with No. 1 propeller feathered and No. 2 engine power output interrupted, it would require 3 500 total hp to place the aircraft at the observed points in space; more or less horsepower would have produced a different flight profile. The flight test, wherein it was demonstrated that an Electra, similarly configured, could not be controlled with more than 3 800 hp on its right side, tended to corroborate this.

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* V_{mc} as used in this report differs from V_{mc} as defined in Civil Air Regulations. In this case it refers to the minimum speed at which a constant heading can be maintained under any prescribed power configuration and angle of bank.

Further study of Electra under adverse conditions

Following the hearing, further study was made of the performance and control of the Electra under critically adverse conditions, particularly the drag aspects of large yaw angles. It was determined that the previous information on required horsepower can only be applied if the aircraft does not have a high drag count over and above that produced by interrupted power output. The excessive yaw angle associated with a flat turn of small radius produces drag to the extent that abnormally high power is required to maintain flying speed or, in fact, to prevent rapid deterioration of airspeed to the stalling point. Inspection of a plot of power required versus turning radius reveals that, at 110 kt and 10° bank angle, the power-required curve becomes asymptotic at a turning radius of 2 000 ft.

The Board recognized that N 5533 was not at precisely this speed and bank angle throughout the final stages of flight, but it was near enough to make the data applicable. It is known that the radius of the flat turn from an easterly heading to northeasterly was less than 2 000 ft. It logically follows that if the drag, which is related to power required, is many times higher than the total thrust available under any engine condition, additional thrust is available only by assuming a steep nose-down attitude; otherwise the aircraft will rapidly lose airspeed.

Calculations based on the Electra lift curve and on the deck angles reflected in the two photographs taken by witnesses produce an airspeed of 118 kt at the time of the first photograph and 103 kt at the time of the second. During the approximately 1-second interval between the first and second photograph the aircraft was approaching the stall at the rapid rate of about 15 kt per second, and at the time of the second photograph was well below the stall speed which, for the weight, flap position, and attitude of the subject aircraft, was 108 kt.

Extreme yaw angles also cause the fuselage to partially shield one wing from the airflow. The skidding turn reduces the lift on the shielded wing. These two phenomena, together with, in this case, the additional lift due to slipstream on the unshielded wing, produce a condition commonly referred to as roll due to yaw. This condition is normally countered by aileron and rudder application to the opposite side, but becomes uncontrollable at low airspeeds where control surface effectiveness is low. There is, then, a point where the induced rolling moment is higher than the countering moment produced by control surface deflections.

Flight simulator tests

In an effort to explore all facets of control difficulties that may have been encountered by the crew of N 5533, the Civil Aeronautics Board devised and observed a series of tests utilizing an Electra L-188 flight simulator owned by National Airlines and certificated by the Federal Aviation Agency. While recognizing the limitations of the trainer, the tests were designed to simulate the conditions of airspeed, altitude, and, insofar as possible, various power interruptions which might have affected the subject flight. These tests provided the Board, through qualitative observation, with a more thorough understanding of the complex problems confronting the crew of N 5533 during the fatal emergency. The results of the tests made by qualified Electra pilots, who flew the trainer under conditions simulating those that prevailed at Boston, demonstrated that control of the aircraft, under such conditions, could have been an insurmountable task.

Reconstruction of the flight

The total time from the start of take-off until the crash was 47.5 seconds. It is believed that the take-off roll and lift-off were normal. The time required to the lift-off point was 20 seconds. The speed would have been approximately 121 kt, which was V_2 for the existing conditions. It is, therefore, evident that the airplane was in the air approximately 27.5 seconds.

Based on the relative locations of the bird carcasses and the point of lift-off, it is concluded that the aircraft struck the birds approximately six seconds after lift-off. Assuming a reasonable acceleration of 2 kt per second, the speed at this point would have been about 133 kt. Allowing 1 second for ingestion to occur, it would then require an estimated additional 6 seconds for total power recovery excluding the No. 1 engine. There would then be a period of 14.5 seconds remaining during which the aircraft was in the air. This 14.5 seconds would be further reduced by a 3-second interval allowed for the aircraft to plunge uncontrolled into the bay. It is recognized that these times are estimated, but it is believed they are sufficiently accurate to emphasize the extremely short period of time (approximately 11 to 12 seconds) that was available to the pilot to take effective corrective action.

From all the evidence available, the Board concludes that about 27 seconds after take-off roll commenced and 7 seconds after lift-off, engines Nos. 1, 2, and 4 ingested sufficient numbers of birds to cause losses of power on these engines and that Nos. 2 and 4 recovered in the manner previously described.

More important, however, the Board believes that the key to the severity, and probably to the occurrence of the accident, lies in the unique and critical sequence of a rapidly occurring chain of events.

First, the more complete loss of power on the left side than on the right started the aircraft turning to the left while its airspeed was decaying as a result of the overall power loss. The fact that the No. 1 propeller rather than an inboard propeller autofeathered, while not critical in itself, was more undesirable in that it increased the degree of asymmetry of any power combinations on the right side.

The No. 2 engine flameout, coupled with only a partial loss of power on No. 4, placed the aircraft in a condition of having no power on the left side and substantial power on the right. This produced a severe yaw to the left which was further aggravated by No. 4 engine recovering full power prior to the relight and recovery of No. 2.

The high yaw angle, as earlier described, produced a drag of such magnitude that the subsequent recovery of No. 2 engine could not arrest the rapid decrease in speed before the aircraft stalled. The recovery of No. 2 engine, while it reduced the degree of asymmetry, could not compensate for the high-power condition on the right side. With some degree of asymmetric power still producing left yaw and roll, coupled with the effects of roll due to yaw, and with the aircraft rapidly entering a stall regime, roll control effectiveness degenerated and the aircraft rolled farther to the left, stalled, and entered a spin. The only recovery from such a situation prior to the spin would have been to reduce power and lower the nose to regain control and airspeed. Recovery in this case was impossible since the 100 to 150 foot altitude was insufficient in an aircraft of the Electra's dimensions and speed requirements.

It is not unreasonable to assume that birds may have struck the windshield and may also have plugged one or both pitot heads. The startling effect of the noise generated by the bird strike and impairment of forward visibility, in conjunction with a possible loss of airspeed indication, would certainly be disturbing elements in an already critical situation. Neither the outer windshield panels nor the pitot heads were recovered; therefore, no proof can be offered.

Conclusions

The Board concludes that emergency conditions of great complexity were thrust upon the crew in an increasingly deleterious environment, and that human capabilities of perception, recognition, analysis, and reaction were insufficient in the time and space restrictions of this accident to accomplish restoration of positive performance control.

It was also determined that there was no structural failure or mechanical malfunction of the aircraft, other than has already been discussed, which contributed to the cause of the accident.

Probable Cause

The probable cause of this accident was the unique and critical sequence of the loss and recovery of engine power following bird ingestion, resulting in loss of airspeed and control during take-off.

Follow-up Action

Research programme - birds

As a result of this accident and pursuant to section 701(a)(3) of the Federal Aviation Act of 1958, the Civil Aeronautics Board recommended on 5 December 1960, to the Administrator of the Federal Aviation Agency, that a basic research programme be initiated by the FAA aimed at improving the tolerance of all turbine engines to bird ingestion. It was also recommended that a study be made of the means of precluding bird entry into turbine engines. A comprehensive programme of research into turbine engine bird ingestion has since been initiated by the FAA. Information obtained as a result of various tests which have been conducted thus far is being analysed and should prove significant in preventing accidents of this type in the future.

Safety aspects

The investigation disclosed the first failure points of the seat and seat belt attachments and also pinpointed injury-producing environment within the cabin. In view of these findings, recommendations were made by the Board soon after the accident with the objective of enhancing passenger safety aspects of the Electra L-188 aircraft. Based on these recommendations, considerable research was engendered which it is hoped will result in an overall improvement in passenger safety.

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ICAO Ref: AR/722

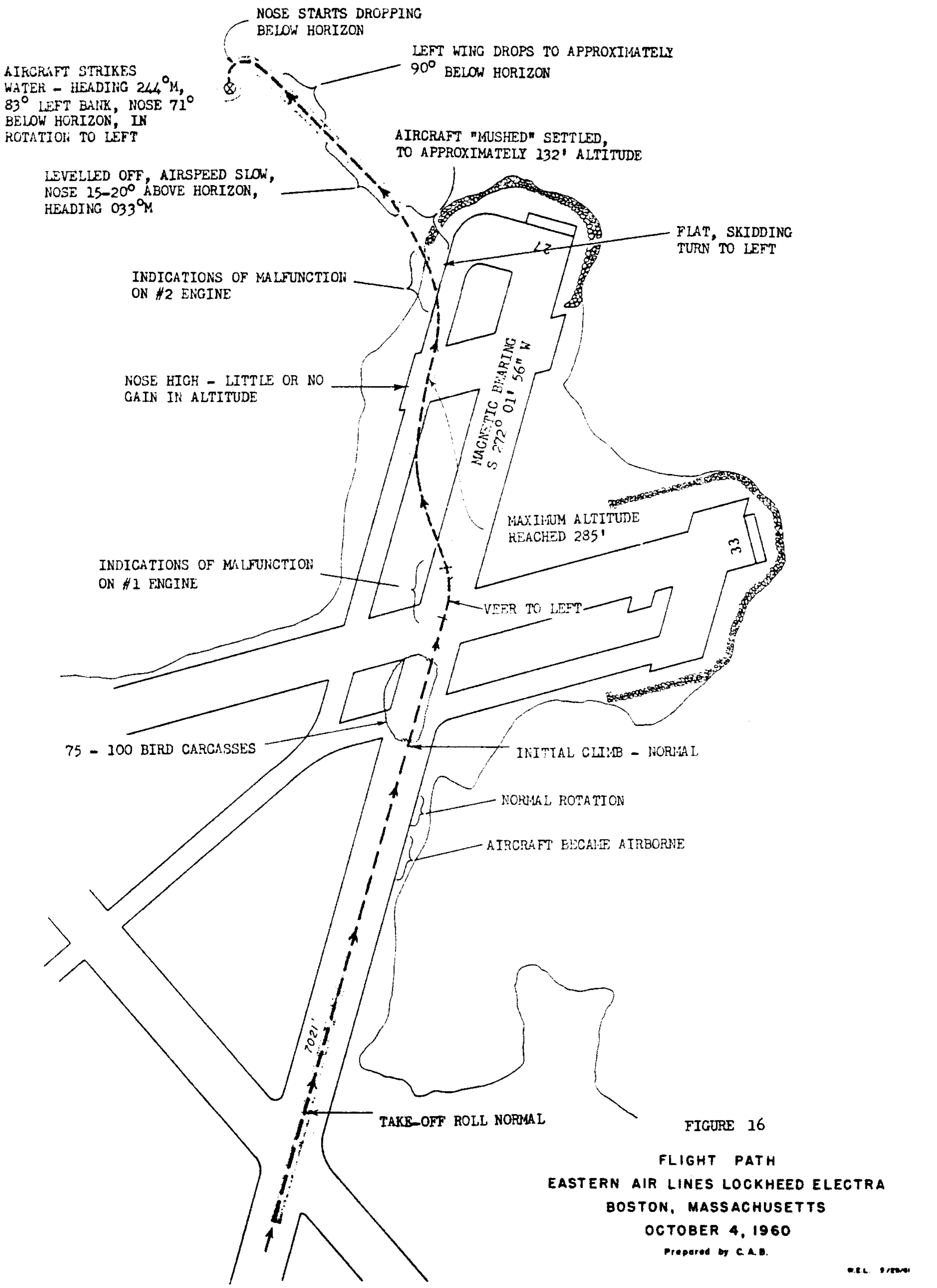

FIGURE 16

FLIGHT PATH
EASTERN AIR LINES LOCKHEED ELECTRA
BOSTON, MASSACHUSETTS
OCTOBER 4, 1960
Prepared by C.A.B.

No. 59

Falcon Airways Ltd., Handley Page 81 Hermes 4, G-ALDC, accident on the railway line and the eastern boundary of Southend Municipal Airport, England, on 9 October 1960. C.A.P. 172, Civil Accident Report No. C.722 released by the Ministry of Aviation (U.K.)

Circumstances

The aircraft was engaged on a charter flight from Southend to Son San Juan Airport, Palma, Majorca, Barcelona, Spain, and return to Southend. The flight was uneventful until after landing at Southend when the aircraft failed to stop within the runway distance available. It overran the runway and struck an earth bank adjacent to the Airport boundary. Contact with this bank broke the nosewheel strut from its upper attachment, and the aircraft came to rest in a steep nose-down attitude on an adjoining railway track. There were no fatalities among the 5 crew members and 71 passengers aboard the aircraft when the accident occurred at 1247 hours GMT. There was no fire.

Investigation and Evidence

The Aircraft

It held a certificate of airworthiness valid until 17 December 1960 and had been maintained in accordance with an approved maintenance schedule. It had flown 17 183 hours in all. The centre of gravity was within limits, and at the time of landing the aircraft weighed 74 600 lb. *

The Crew

Both the captain and first officer held valid airline transport pilot licences. The captain had flown 12 500 hours, of which over 5 000 were in command of Hermes aircraft. This was his first landing at Southend in a Hermes, but he had landed there previously on numerous occasions in other types of aircraft.

Weather

The weather observation made at Southend Airport three minutes after the accident (i.e. at 1250 hours) was as follows:

surface wind	calm
visibility	2 NM
weather	continuous slight rain
cloud	5/8 stratus at 600 ft
	6/8 stratus at 1 500 ft
	8/8 nimbostratus at 4 000 ft

Although this report and the one of 1220 hours refer to continuous slight rain, there was evidence that the rain was moderate to heavy at the time the aircraft landed.

The Flight

The aircraft took off from Barcelona for Southend at 0910 hours with 71 passengers. No difficulties were encountered until the final portion of the flight as the aircraft was landing at Southend.

At 1238 hours the pilot called Southend radar who identified the aircraft 5-1/2 NM west of the Airport, and the aircraft was then positioned for a "step down" radar approach to runway 06. The approach proceeded normally and at 1243 hours the aircraft was established on the approach centre line 3 NM from touchdown.

* Maximum landing weight = about 78 000 lb.

The captain subsequently stated that at this distance his speed was about 135 kt, the wheels were down and locked and 20° of flap had been applied. The approach and landing checks had included a check of the brake pressure system which was satisfactory. The runway approach lighting was sighted by the first officer when the aircraft was about 2 NM from touchdown. Full flap was then applied and the approach continued by visual reference. Witnesses who saw the aircraft at this time stated that the approach appeared normal for an aircraft landing on that runway and that the rain was moderate to very heavy. The captain estimated that he crossed the runway threshold markings at a height of about 15 ft and that the speed was 115 kt. At about this point the throttles were closed.

The aircraft touched down about 600 ft beyond the threshold markings at a speed estimated by the captain to be between 105 and 110 kt. The nosewheel was lowered onto the runway about 4 to 5 seconds later. The wheel brakes were then applied but after about 6 or 7 seconds the captain realized that they were having little effect. To preclude the possibility of his having inadvertently locked the wheels by applying too high a pressure, he released the brakes and applied them again using light pressure at first then increasing to the maximum. Although the pressure gauge indications were normal there was no noticeable braking effect on the aircraft.

By this time the aircraft was about halfway along the runway and although the captain thought he would have difficulty in stopping before reaching the end he considered that it was then too late to take off again. He continued to use maximum brake pressure and as the aircraft approached the end of the runway he tried to turn it to the right by using nosewheel steering and so keep within the confines of the aerodrome. However, the speed was too high and although the heading was changed the direction of travel was only slightly altered and the aircraft skidded off the runway. After crossing soft ground it struck an earth bank near the Airport boundary at a speed estimated by the pilots to be about 30 kt.

As the aircraft left the runway the captain ordered "All engines and electrics off" and at the same time switched off the magnetos. By the time the aircraft struck the bank the propellers were rotating only slowly.

Injuries to occupants

No passenger was injured as a result of decelerative forces or structural damage during the crash. All the passenger seats were rearward facing and remained intact and undamaged. Some passengers received slight injuries from loose bottles and other articles flung from the overhead luggage racks and others sustained cuts and bruises as they were leaving the aircraft owing to the steep angle of the fuselage (tilted forward at 28°) and awkwardness of the descent onto the side of the railway track. (The passengers had to leave the aircraft through the crew door as the rear door was too high for the use of the escape chute). The steward and stewardess were injured having been thrown forward against the step immediately behind the pilots' seats. They were both in the vicinity of the flight deck entrance to the galley when the impact with the bank occurred.

The Accident Site

Inspection of the scene of the accident showed that the aircraft had started to swing to the right when 560 ft from the eastern end of the runway. At this point the tire marks of the aircraft became visible. They started in the centre of the runway and gradually converged with the right-hand edge crossing it 240 ft from the end at an angle of about 30°. The marks made by the two nosewheels gradually closed with those of the right main wheels until they coincided where the aircraft left the runway, indicating that the aircraft was skidding with its nose to the right. The aircraft then crossed grassland in the corner formed by the runway and the perimeter track, then the perimeter track itself and 170 ft of soft ground before striking an earth bank immediately inside the Airport boundary.

Damage to the Aircraft

Structural damage, confined to the front fuselage and nose landing gear, was sustained when the aircraft ran through the bank. The underside of the fuselage had been crushed displacing the floor of the flight deck, jamming the rudder pedals and damaging the pressure, static and pneumatic system pipe lines.

Braking System of the Hermes

The Hermes aircraft has twin wheels on each main landing gear and each wheel has 2 Dunlop bag type brake units. The brakes are operated by a duplicated pneumatic system feeding double air bags within the brake units. No. 1 pneumatic system serves the outer bags and No. 2 system the inner bags. Each system is provided with a triple pressure gauge indicating supply pressure and port and starboard brake line pressures. The normal supply pressure is 450 psi and the maximum brake line pressure is 190 psi ($\pm$ 5 psi). No anti-skid device is fitted.

When examined on the evening of the accident the No. 1 system supply pressure gauge showed zero and the No. 2 system supply pressure gauge showed 350 psi. This pressure was maintained in the system until 11 October when functioning tests were carried out.

Examination of the pneumatic system showed that all lines from the No. 1 system triple gauge and the brake line pressure pipes from the No. 2 system triple gauge were broken immediately below the cockpit floor where the fuselage skin had been crushed on impact. For test purposes these lines were repaired by the insertion of short lengths of flexible hose. The pneumatic system cross feed valve was found correctly set in the OFF position.

Both pneumatic systems were then charged to 450 psi from an external source, and as the toe operated brake pedals were jammed, the maximum pressure was applied to all brakes in turn by operating the relay valves manually. The pressure available at the brake bags was checked by inserting a gauge at the point where the supply line entered the brake unit. In each case the maximum pressure was fed to and held by the brake unit until released.

The brake units were then removed from the aircraft for detailed examination and performance tests in conjunction with the manufacturers. A physical examination showed that they were in a satisfactory and serviceable condition. Dynamic tests were then carried out to compare their performance with that recorded during the type tests in July 1948. Three units were selected for this test including those most worn. The results showed that the brakes tested were capable of developing dynamic torques within the limits permitted by British Civil Airworthiness Requirements. The remaining units were considered to be capable of developing dynamic torques of the same order.

The Main Wheel Tires

The main wheel tires were subjected to a detailed examination by the manufacturers. On each tire there was one local area of scalding (blistering of the rubber) and one local area of scoring. (See Figure 17). The markings in the scalds of the two port tires indicate that the aircraft was travelling in a straight line when the scalding occurred. The scalding on the two starboard tires was much more severe and heavy scoring within the scalds due to cutting by stones was inclined at an angle of about 20° to the direction of rotation of the wheels. Apart from the scalding and scoring of the tread surface the tires were sound and in good condition.

The Pressure and Static Systems

The pipe lines of the pressure and static systems had been broken in the front fuselage area as a result of impact damage. Consequently, they could only be checked from the pitot and static heads to a point at the forward end of the nose-wheel bay. They were found to be free from leaks.

Both air speed indicators were removed and subjected to a calibration check. They were within normal tolerances.

Runway 06

Runway 06 is 5 265 ft long and 120 ft wide. The surface is hot-rolled gravel asphalt and with a camber of 1 in 80. There is a down gradient of approximately 0.2% (11 ft in 5 265 ft). The runway threshold markings are displaced 125 ft from the beginning of the runway for operational considerations, leaving an available landing distance of 5 140 ft. During a visual inspection of the runway on the day following the accident in conditions of moderate rain there did not appear to be an abnormal amount of surface water.

Measurement of Braking Force Coefficient on Runway 06

As the question of runway friction appeared to be a possible factor in the accident, the Road Research Laboratory of the Department of Scientific and Industrial Research was asked to carry out certain tests. These tests were made with a small braking force trailer and measurements of the braking force coefficient of the runway were obtained. At the time of the tests the surface of the runway was wet after heavy mist and rain and a 600 ft section was kept in this condition by a water tanker fitted with a spray bar. Measurements made during the tests showed that this achieved an average water depth of 0.05 inches.

Several runs were made with the trailer over this section at speeds from 10 to 80 mph. This latter speed was the maximum that could be achieved with safety. On each run the brake of the trailer was applied so as to lock the wheel for a period of 2 to 3 seconds. The braking force exerted by the runway surface on the locked wheel was measured and recorded on a moving chart. (Details of the system and the trailer are given in the Road Research Note RN/2431).

The braking force coefficients obtained at 80 mph were 0.17 and 0.14 for a smooth and a patterned tire respectively. Detailed results follow:

Test Tire	Estimated Skidding Distance from 100 mph (ft)	Values of braking force coefficient from smooth curves, drawn through plotted points at the following speeds (mph)							
		10	20	30	40	50	60	70	80
Smooth	1665	0.63	0.47	0.38	0.30	0.25	0.22	0.19	0.17
Patterned	1580	0.70	0.59	0.49	0.39	0.30	0.24	0.19	0.14

These values are comparable with those which have been obtained with the same braking force trailer on runways where skidding incidents are known to have taken place in wet weather. On such surfaces the range of values recorded during a number of tests with a smooth tire at 80 mph is 0.04 to 0.21 with a mean of 0.14. On runway surfaces where there is no knowledge of trouble caused by slipperiness in wet weather the range of values of braking force coefficients with a smooth tire at 80 mph is 0.10 to 0.66 with a mean of 0.33. The Hermes' tires were of the "ribbed" type and can be considered smooth in this context.

Observations

Aircraft Performance

Hermes aircraft have no "performance group classification" in their Certificates of Airworthiness. They therefore have to meet the requirements with respect to performance contained in the Schedule to Regulation 6 of the Air Navigation (General) Regulations, 1960. Paragraph (9) of the Schedule states that the distance required by the aeroplane to land from a height of 50 ft must not exceed 70% of the landing distance available. The assessment of the ability to comply with this requirement has under Regulation (5) to be based on the information contained in the Flight Manual. The relevant data extracted from the Flight Manual of Hermes G-ALDC shows that the landing distance required by the aircraft on this occasion was almost exactly 70% of that available.

The landing distance from 50 ft scheduled in the Hermes Flight Manual was derived from data obtained in flight tests and is associated with an approach speed of 1.2 times the stalling speed in the landing configuration with power off (Vso) and an approach gradient of 7%. The measurements were carried out on a dry runway which has been the normal practice. The approach speed used in the test measurements, 1.2 Vso, is below that used for the measurement of landing distances with other aircraft, where in general a speed of 1.3 Vso has been used. However, because of the technique employed during the Hermes tests the resulting landing distance is comparable with that achieved during the tests with the other aircraft. At the estimated landing weight of 74 600 lb, 1.2 Vso is 115 kt which was the threshold speed estimated by the captain.

The object of the landing distance performance requirements is to ensure that landing distances are adequate for the anticipated operating conditions when normal landing techniques are used. On an aircraft like the Hermes the normal technique involves a target threshold height of about 30 ft and a speed of 1.3 Vso. It is also the intention that the landing distance required should have sufficient margin to permit reasonable departure from this speed and height.

An examination of the figures for landing distance of the Hermes on wet surfaces indicates that the distance required under the Performance Regulations is adequate if reasonably normal braking action on the wet surface is available. However, in the light of research work with another type of aircraft into the effect of wet runway surfaces on braking friction and the analysis of the tests carried out by the Road Research Laboratory of the available braking friction on the actual runway at Southend, it would appear that the landing distance required under the Regulations for the Hermes can be inadequate on wet surfaces when abnormally low runway friction occurs. In the present state of knowledge it is difficult to predict when such abnormally low friction will be experienced, but it is almost certainly associated with water depth.

The Hermes aircraft is particularly sensitive to braking conditions because of the relatively large contribution of its brakes to the total decelerative force during the landing run.

The mandatory landing distance requirements for the Hermes were amended in March 1960. Up to this date the landing distance from 50 ft had to be within 80% of the available landing distance if a visual approach and landing could be made. This "requirement" was amended to 70% in order to tighten up the performance requirements for aeroplanes not having a performance group classification. It is worthy of note that the more modern types of transport aeroplanes over 12 500 lb, many of which have means of retardation in addition to wheel brakes, have more stringent landing distance requirements.

Runway Friction

The effectiveness of the aircraft brakes is limited by the coefficient of friction between the tires and the runway. In dry conditions this value may be as high as 0.8 and shows no significant reduction with speed. However, recent aircraft tests have shown that in a relatively small amount of water this value may fall to between 0.075 and 0.22 at 100 kt, depending amongst other things on tire pressure, tread pattern and the braking system used. Tests by the Road Research Laboratory indicate a similar trend.

The aircraft tests have also shown that the coefficient of friction falls with increase of forward speed, for example from 0.5 at 10 kt to 0.1 at 100 kt with a tendency to remain constant thereafter. It is thought likely that the large decrease to 0.1 could be due to the tires becoming increasingly supported on a film of water. At the higher speeds less water is removed from the tire contact area due to the shorter time that the pressure exerted by the tire is maintained at any single point on the water film. A condition can then be reached when the tire is no longer in contact with the runway and can be said to be aquaplaning.

Data available indicates that the coefficient of friction may drop from 0.125 to 0.05 at 100 kt during very heavy rain when approximately 0.25 inches of water is on the runway. As the value reaches a minimum at about 100 kt and thereafter shows no significant change it can be argued that at this speed the tire is fully aquaplaning, but present knowledge of this phenomenon is limited.

From the frictional values measured by the Road Research Laboratory an attempt was made to assess the values for the Hermes. Although the figures resulting from this must be considered approximate, calculations based on them show that the aircraft should have stopped on the runway but with little margin to spare. It would appear therefore that unusual conditions existed which resulted in abnormally low frictional values at high speed. At the time of the landing, witnesses have described the rain falling as "moderate", "heavy" and "very heavy"; the conditions conducive to aquaplaning. In addition, inspection of the mainwheel tires has shown patches of scalding which can only occur when the wheels have been locked with a film of moisture between the tire and the runway.

Probable Cause

The accident was due to the aircraft aquaplaning during part of the landing run. The low frictional values during this condition prevented the captain from obtaining effective braking.

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ICAO Ref: AR/682

FIGURE 17

THE MAIN WHEEL TIRES

PORT OUTER | PORT INNER | STARBOARD INNER | STARBOARD OUTER

HERMES ACCIDENT AT SOUTHEND

9 OCTOBER 1960

No. 60

Trans-Canada Airlines, Canadair DC-4 M2 (North Star), CF-TFK, accident at Sydney Airport, Nova Scotia, Canada, 24 October 1960. Report No. 1161 released by The Department of Transport, Canada.

Circumstances

During the landing roll at Sydney Airport at the conclusion of a scheduled flight from Stephenville, Newfoundland, the nose landing gear suddenly retracted. The aircraft skidded on its nose then came to rest. None of the 4 crew and 26 passengers aboard the aircraft was injured, but the aircraft was substantially damaged. The accident occurred at 1726 hours (Newfoundland standard time.)

Investigation and Evidence

The Aircraft

A certificate of airworthiness had been issued for the aircraft, and the date of the last log-book certification was 23 October 1960, in accordance with Trans-Canada Airlines approved maintenance system. There was no evidence of any fault in the airframe, engine, propellers or controls prior to the accident.

The Crew

The pilot-in-command holds an airline transport pilot's licence, and his total flying experience is approximately 6 000 hours. He has flown 900 hours on the North Star aircraft, including 240 hours during the 90 days preceding the accident.

To co-pilot holds a commercial pilot's licence, and his total flying experience amounts to 6 000 hours. He has flown 2 000 hours on this aircraft type, 240 hours of which were completed in the 90 days prior to the accident.

The Flight

The aircraft had departed Stephenville at 1640 hours (Newfoundland standard time) for an instrument flight rules flight to Sydney. The flight was uneventful until after the aircraft had made its approach for the landing at its destination. At this time the first officer was at the controls and in the right-hand seat while the captain occupied the left-hand seat.

After touchdown on the runway the captain decided to raise the flaps to allow the aircraft to settle onto the runway more firmly to improve the braking action, but raised the undercarriage lever by mistake. The horn blew, and the undercarriage warning lights turned red; the undercarriage was immediately re-selected to the wheels-down position. The rapid re-selection of the lever to the 'down' position was quick enough to prevent the main undercarriage from retracting but not to prevent the nose gear from completing its upward cycle. The nose gear usually retracts faster than the main undercarriage.

The nose of the aircraft began to sink. Both pilots pulled on the control column to raise it, but their efforts were in vain, and the nose scraped along the runway surface. The aircraft came to rest in a nose-down attitude in the centre of runway 14 near the junction of runways 14-32 and 01-19.

The nose-wheel doors, the up-lock mechanism and a segment of the nose-wheel door operating yoke were damaged. The propellers of both inboard engines were bent rearwards.

The Runway

The runway on which the accident occurred is 200 ft wide, 5 200 ft long, has a hard surface and is considered suitable for North Star aircraft.

Wind condition

At the time of the accident the wind was reported to be east-southeast at 25 mph gusting to 38 mph.

Undercarriage tests following the the accident

Retraction and extension tests were repeated several times on the undercarriage which was found to function normally; the warning system was also in good working order.

Statement of the captain

Following the accident the captain stated that he had inadvertently raised the undercarriage lever. This was possible because at the time the wrong selection was made the aircraft was still partially airborne, and the right main undercarriage was not compressed sufficiently for the safety device to lock the undercarriage lever.

Probable Cause

The accident was attributed to the inadvertent retraction of the undercarriage during the landing roll.

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No. 61

Northwest Airlines, Inc., Douglas C-54A-DC, N 48762, accident near Missoula, Montana, Airport, 28 October 1960. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 1-0045, released 1 March 1962.

Circumstances

Flight 104 was a scheduled passenger flight from Portland, Oregon, to Minneapolis, Minnesota with various intermediate stops including Spokane, Washington and Missoula, Montana. It departed Spokane at 1056 hours mountain standard time on an instrument flight plan and was to fly to Missoula via Victor 2, maintaining 9 000 ft. At 1136, Great Falls Centre contacted the flight and cleared it for an approach to Missoula. The aircraft acknowledged. No difficulties were reported at this time. Three minutes later, at 1139 Flight 104 crashed at the foot of Cayuse Mountain, 13 NM northwest of the Missoula Airport, at an elevation of 3 140 ft msl. All 4 crew members and 8 passengers died in the crash.

Investigation and Evidence

Accident Area

The area within 1 NM radius of the crash site is where the Clark Fork Valley intersects the southeast end of Nine-Mile Valley. The latter extends northwestward from the crash site about 14 NM, and its floor rises only 321 ft in that distance. The valley is open also at the northwest end. The intersection of the two valleys forms a bowl, and Flight 104 entered the bowl from the west, flying about 500 ft above the valley floor on a heading of approximately 060°M. This heading forms an approximate 90° angle with a heading up the Nine-Mile Valley. Between the bowl and Missoula, the Clark Fork Valley makes an "S" turn, and between the bowl and Missoula lay snow showers or wall of dark clouds which would have necessitated instrument flight.

Instrument approach procedure to Missoula Airport

The approved instrument approach procedure allows a straight-in approach from the west providing the aircraft remains at 9 000 ft msl, until reaching the Alberton Fan Marker, located within 2 NM west of the crash site. After passing the Fan Marker, an aircraft may descend to a minimum of 6 200 ft msl, on a course of 097°, magnetic to the Omni Range, located on the airport, or 096° to the low-frequency range, which is located 1.5 miles from the airport. If the field is not sighted or the landing accomplished by the time the aircraft reaches that point, the missed approach procedure must be followed.

Weather conditions

The 1057 Missoula weather observation, received by Flight 104 after its departure from Spokane was as follows: "measured ceiling 3 900 ft, overcast; 40 miles visibility; temperature 44°, dewpoint 31°; wind east-southeast 7 kt; altimeter 29.87; breaks in overcast; snow showers of unknown intensity in mountains northeast."

Exactly what the conditions were at the Missoula reporting station at 1139 is not known, but the trend was toward improvement.

The pilot of another flight which landed at Missoula at 1144 hours (i.e. 5 minutes after the accident) stated that while his aircraft was in the landing traffic pattern at Missoula he observed the weather conditions to the northwest toward the accident site. There was a line or wall of dark clouds and showers west of the field obscuring the mountains and Nine-Mile Valley.

In comparing the 0957 and 1057 reports of the Missoula weather conditions, the overcast lowered 1 100 ft but the visibility increased 20 miles. During the time the flight was en route the clouds forming the overcast at 3 900 ft began breaking up and raised 400 ft. There was an overcast at 6 500 ft, i. e. 3 500 ft above the minimum approach altitude over the field. This latter conclusion was supported by the 1159 weather observation 20 minutes after the accident.

Ceilings and visibilities usually are considerably lower in the mountains than over the reporting stations and were, in fact, lower in this case.

Light to moderate icing conditions probably existed in clouds and precipitation above the freezing level which was 6 500 ft between Spokane and Missoula. Also, on the route from Spokane to Missoula light to moderate turbulence should have been present from the surface to 9 000 ft. The average cloud bases in the vicinity of the accident site were at or near 5 000 ft msl, with haze and light showers. Tops of the mountains above 5 000 ft msl were obscured by the overcast. Visibility was from 1 to 3 miles with 1 mile in light showers.

The Board was of the opinion that the visibility from the weather station in the direction of the accident site and at the time of the accident was at most about 9 miles - the visibility being in that case obstructed by mountains at ground level and low clouds or showers at a reasonable flight level. From Flight 104's viewpoint, however, as it approached and entered the bowl, formed by the two intersecting valleys, the visibility toward the Missoula Airport at the flight's apparent altitude of 500 ft above the valley floor was blocked not only by the mountains but by the showers or wall of dark clouds. Whether the captain thought, from his knowledge of the weather reports, that he would have 20 or even 40 miles visibility when nearing Missoula, and was therefore under a misconception as to the exact visibility, is a matter of conjecture. Moreover, whether the visibility of less than 40 miles (in the direction from which Flight 104 was expected to approach the Missoula Airport) was of enough operational significance to require reporting, it is noteworthy in the interest of safety in that possible misunderstanding on the part of the captain might have existed.

Final portion of the flight

The aircraft was seen below the clouds and on a heading toward Missoula within 6 to 6-1/2 NM west of the accident site at or near an altitude of 6 700 to 6 800 ft msl and was descending as if on an approach to a landing. This would put the aircraft below 9 000 ft msl, the minimum en route altitude to which it had been assigned by Air Traffic Control, in accordance with his IFR clearance. Whether at this time the flight had received its clearance to the Missoula Airport is not known; but under the assumption that it had received the clearance, it being one omitting a specific type of approach, Flight 104 was free to descend to the approach altitude of 6 200 ft msl after passing the Alberton Fan Marker and proceed on to the airport. Then, if VFR flight conditions were encountered, the flight would be free to proceed in accordance therewith.

The Board believed the captain knew his approximate position and was familiar with the terrain and the general course of the Clark Fork Valley leading on to Missoula, and was also familiar with the intersection of the Clark Fork and Nine-Mile Valleys. It also appears that the flight was attempting to proceed to Missoula under VFR and was descending to stay beneath the ceiling that was lowering as the aircraft approached and entered the bowl. The visibility through the airspace leading around the mountains that had to be circumnavigated in order to continue on to Missoula was reduced, because of the light snow showers, to the extent that instrument flight was required. The hazard involved if the flight had continued VFR around the mountains at low altitude in reduced visibility was obvious, and at that point a sharp left turn of about 90° was necessary in order to proceed up the intersecting Nine-Mile Valley under VFR conditions. In attempting this turn, the aircraft was manoeuvred in a manner wherein control of it was lost. The aircraft nosed downward, rolled to the left to an inverted position and struck the ground.

Examination of the wreckage

Examination of the power plants did not reveal any unsatisfactory condition that could have led to any malfunction. A major portion of the fuselage, from the nose to the point where the empennage had separated, had been destroyed by fire. The control cables were properly attached prior to impact, and there was no evidence of the malfunctioning of any aircraft system.

One altimeter was found set at 29.87 in. Hg, the setting transmitted to Flight 104 by Great Falls Centre just prior to issuing the approach clearance. At the time of the accident the barometer was approximately 29.83 in. Hg at Missoula, however, the difference of .04 inches, the equivalent of about 48 ft of altitude at 8 000 ft msl[1] was not considered significant in this instance.

No other instruments were found that gave any reliable readings.

Certification of The Aircraft and Crew

N 48762 was correctly certificated and loaded within allowable limits.

The crew was also properly certificated, currently qualified in the aircraft and over the Spokane-Missoula route, and had had sufficient off-duty time prior to the subject flight.

Communications facilities and navigation aids

A check following the accident revealed that the Alberton Fan Marker and Missoula Omni Range were operating within prescribed limits.

Consideration of possible causes of the accident

The possibilities of structural failure and mid-air collision were looked into and eliminated. Witnesses, who had definitely seen the aircraft, said it was not trailing smoke or flames and that no items were observed to fall or be hanging from the aircraft prior to impact. Extensive investigation revealed no evidence of collision with another aircraft or any ground object.

Probable Cause

The accident was attributed to the failure of the pilot to continue in accordance with his IFR flight plan and his attempt to carry out a VFR approach during instrument weather conditions.

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ICAO Ref: AR/702

No. 62

Arctic-Pacific, Inc., Curtiss Wright, Super C-46F, N 1244N accident at Toledo Express Airport, Toledo, Ohio on 29 October 1960. Civil Aeronautics Board (USA), Aircraft Accident Report, File No. 1-0047, released 22 January 1962.

Circumstances

N 1444N was chartered to transport the California State Polytechnic College football team from Santa Maria, California to Toledo, Ohio and return. The aircraft took off from Toledo Express Airport on the return flight to San Luis Obispo, California, weighing approximately 2 000 lb more than its maximum certificated gross weight of 47 100 lb. The aircraft crashed approximately 5 800 ft from the threshold of the take-off runway, caught fire and was destroyed. Of the 45 passengers and 3 crew members aboard, 20 passengers and the captain and co-pilot were fatally injured. The accident occurred at 2202 hours eastern standard time.

Investigation and Evidence

The flight was planned as follows:

Oakland - Kansas City, Missouri - (with intermediate stops at Santa Maria, California and Albuquerque, New Mexico) - Toledo, Ohio - ferry flight to Youngstown, Ohio - New Haven, Connecticut - Youngstown, Ohio - ferry to Toledo - Kansas City, Missouri - Santa Maria and Oakland, California.

The accident occurred during one of the last segments of the flight ... Toledo - Kansas City. The aircraft had arrived at Toledo at 1957 hours eastern standard time on 29 October. The pilot checked the weather between 2030 and 2100 hours and at 2115 hours when filing his flight plan was given the 2100 aviation weather sequence for Kansas City. No further weather information was given during this final contact with the pilot.

Fog and/or low stratus were reported all day at Toledo Express Airport with conditions varying from ceiling and visibility zero to ceiling 800 to 1 300 ft and visibility 2-1/2 miles. All observations from 2133 until after the accident showed visibility zero in fog.

The transmissometer on runway 07 at Toledo Express Airport was not functioning properly during the briefing of the captain and therefore the remark "RNVNO" was appended to all subsequent aviation weather sequence reports for the Airport, indicating the nonavailability of runway visibility information.

Following the weather briefing the captain returned to the aircraft, made a walking tour of the ramp in an effort to determine where aircraft were parked, and the co-pilot made a walkaround inspection of the aircraft. The pilot requested take-off on the ILS runway and was recleared to runway 07, to hold short of the runway and to use extreme caution due to the unlighted aircraft parked on the ramp.

The weather at this time was: partial obscuration; zero visibility (less than 1/16 of a mile) in fog; 9/10 of the sky obscured by fog. Arctic-Pacific, Inc., minima for take-off from Toledo were 300 ft ceiling and 1 mile visibility of 400 ft ceiling and 3/4 mile visibility on the sliding scale.

All lights at this time were on at full intensity. Refuelling personnel with flashlights assisted in directing the pilot down the ramp to the entrance of the taxiway.

The pilot asked for the magnetic bearing of the runway and at 2155 a corrected clearance was given to N 1244N as follows: "44 November is cleared to the Kansas City Airport via Victor 92 Joliet, Victor 262, Victor 10. Maintain 8 000. Contact Chicago Centre 127.45; if unable, 128.4 ... Tower release."

At 2201 the aircraft was cleared for take-off with a left turn out of traffic to proceed southwest on the ILS localizer beam to join Victor 92 airway.

The accident occurred one minute later.

Witnesses' Statements re Take-off

Surviving passengers described a swerve to the right followed by a swerve or violent swerve back to the left during the latter part of the take-off run. These swerves were followed by an abrupt or lurching type lift-off which was accomplished before reaching V_2 speed. They also described a shuddering or vibration (characteristic of a stall) just prior to entering a left wing down, nose down attitude. Perceptible changes were heard in the sound of the engine or engines. Witnesses also described a momentary silence prior to the impact noise ... "a dull boom". At no time after the aircraft entered the taxiway had it been seen by any of the personnel on the airport due to heavy fog. It was 21 minutes from the time taxi instructions were requested until the accident occurred. No engine burnouts are known to have been accomplished during this time.

An analysis of the swerves described by the surviving passengers indicates that they were the pilot's efforts to maintain the aircraft on the runway while attempting to accelerate to V_2 speed and that he was experiencing difficulty with directional control. It is believed that the pilot, upon recognizing his inability to maintain the aircraft on the runway, had to elect whether to abort the take-off at this point or make a premature liftoff. The decision was made to continue and a premature liftoff resulted. The ensuing climb to an estimated altitude of 50 to 100 ft was probably made at an airspeed below V_{mc}. Based on witness statements that just prior to the crash there was a moment of silence, the Board believes that the pilot retarded his throttles before striking the ground. This is a normal reaction when a pilot realizes a crash is inevitable.

Impact

The aircraft's left wing struck the taxiway adjacent to runway 07 on a heading of 035° magnetic and while in a left bank of from 60 to 90°. The main impact occurred at the edge of the taxiway after the aircraft's left engine struck the ground and the aircraft cartwheeled on its nose. The impact site was approximately 5 800 ft from the threshold of runway 07 and 400 ft to the left of the centreline of this runway. The two power plant assemblies separated at impact from the nacelles with the firewalls still attached to the engine mounts. The aft portion of the fuselage separated and continued on the impact path, coming to rest inverted on the vertical stabilizer. The forward portion of the fuselage and wings, after cartwheeling, came to rest in an upright position after sliding rearward about 10 ft. Fire engulfed the right wing, cockpit and forward cabin areas.

Technical Examination

Engines

On the basis of statements of witnesses and the flight path of the aircraft prior to final impact, it was obvious that the left engine experienced a power loss of some magnitude, either because of some disorder, or because the throttles were retarded by the crew in an attempt to get back on the airport, or both. Since the engine examination revealed no mechanical failures, the most likely sources of engine maloperation were believed to be ground-fouled spark plugs, disconnected intake pipe gland nut, and the prevailing weather conditions, particularly the moisture content in the air.

Spark plugs

A moderate-to-heavy overlay of black carbon deposits was on the insulator core noses of the spark plugs of both engines. This condition is characteristic of long periods of ground operation at low power. When power is increased rapidly to the take-off setting, the coating of carbon deposits on such plugs causes scattered plug firing with some power loss. These conditions would be evidenced by engine sputtering, roughness, and changes in exhaust rhythm as reported by various witnesses.

The engines were running approximately 24 minutes from the time of starting to take-off. They were ground-operated at low power for a considerable period of time, and this could have caused the ground-fouled condition. It was also obvious from the results of the tests that the majority of the plugs in both engines would have functioned normally had an engine burnout procedure been conducted just prior to take-off.

The prevailing weather conditions at the time of the accident - low temperature and high humidity - could also be conducive to spark plug fouling. Investigation conducted by engine manufacturers on the effects of humidity on power reveal that a portion of the dry air is replaced by water vapour in the atmosphere. This causes the normal fuel-air ratio to be enriched above the normal mixture strength, and, as a result, excessive richness and partial power loss occurs. Tests have indicated that a maximum of 12 to 14% power loss can occur at take-off power with the mixture set at the auto rich position during high humidity conditions. Based on the weather that existed at the time of the accident, a power loss of approximately 2% could have resulted from weather conditions alone.

Intake pipe gland nut

The disconnected intake pipe gland nut could also have caused some power loss. It was obvious that the gland nut did not become disconnected at impact, particularly since it showed no damage, and the surrounding area was sooted. It is difficult to assess the amount of power loss which could result from such a discrepancy. The presence of a moderate coating of soot around the intake pipe and its adjacent areas is indicative of backfiring and partial power loss from cylinders Nos. 8 and 9 of the left engine.

Left Engine - General Background Information

The left engine was a model not currently certificated for use in the C-46 series aircraft but this had no direct bearing on the cause of the accident. However, the circumstances surrounding the installation of the R-2800-79 engine indicated the disregard the management of Arctic-Pacific had for established airworthiness compliance and adherence to the Civil Air Regulations. This is evidenced by the fact that Arctic-Pacific purchased the engine from a dealer in used metals; that Arctic-Pacific requested Newark Air Service to install the engine without furnishing the engine records; and that Arctic-Pacific knowingly permitted Newark Air Service to install and modify the engine knowing that Newark Air Service possessed only Class III Airframe and Limited Airframe repair station certificates.

Newark Air Service installed the engine as verbally requested by Arctic-Pacific's Director of Maintenance. Regardless of Newark Air Service's instructions from Arctic-Pacific, they failed to inspect the engine for airworthiness compliance as required by the Civil Air Regulations. The Chief Inspector of Newark Air Service testified that they were dubious of the airworthiness of the engine, particularly since there were no overhaul records with the engine. Nevertheless, Newark Air Service failed to bring this to the attention of the FAA.

In the investigation of this accident it was disclosed that FAA policy regarding inspections of supplemental air carriers, pursuant to Section 42.8 of Part 42 of the Civil Air Regulations provided, among other things, quarterly en route operations inspections and an annual en route maintenance inspection. However, neither the Operations nor Maintenance FAA Air Carrier Inspectors assigned to Arctic-Pacific conducted any of these inspections during the preceding eleven months of operations because of duties with other assigned carriers. During this eleven month period, the FAA did conduct nine ramp maintenance inspections and seven ramp operations inspections under an FAA policy of conducting at least one ramp inspection each month. In addition, the FAA conducted three main base maintenance inspections, one main base operations inspection, and the full, annual precertification inspection of 11 - 13 October 1960.

Economic Factor

Because of the weather conditions at Toledo Express Airport, certain economic factors confronted the captain. He had the responsibility for 43 passengers as well as the crew. If the flight did not depart, as planned, the captain, as agent for Arctic-Pacific, would have been obligated to furnish lodging, meals, and transportation for these passengers. It is possible that the economic situation may well have influenced his decision to take off.

The Crew

The positions occupied by the flight crew at the time of the accident were established to be the co-pilot in the left seat and the captain in the right seat. Normally, under adverse weather conditions, it would be expected that the captain would be in the left seat and at the controls during the take-off under the weather conditions which prevailed. The aircraft can, however, be flown from either seat, and there is no possible way of establishing who was actually controlling the aircraft at the time of the accident. Although the co-pilot had over 3 200 flying hours, 1 300 of which were in C-46, held an airline transport pilot certificate, and was qualified as a co-pilot in C-46 aircraft, he did not possess a type rating in C-46 aircraft.

Duty time

Although the accident occurred during the take-off from Toledo Express Airport, which was to be the first flight on the return to Santa Maria, California, the Board made an extensive analysis of the total flying time. en route time, on-duty time, and rest periods from the time the chartered flight departed Oakland Airport, California. Four pilots were aboard the aircraft when it departed Oakland Airport but the second crew flew only the leg from Albuquerque, New Mexico to Kansas City, Missouri and left the flight at Kansas City. The captain of the subject flight was listed as pilot-in-command for the entire flight from Oakland.

Utilizing the arrival and departure times of the stops along the route, it was determined that both the captain and co-pilot were on continuous duty from departure at Oakland Airport to arrival at New Haven, a total of 26:40 hours. During this period, the pilot and co-pilot were actually at the controls of the airplane for 11:15 hours of the total 14:41 hours of flight time to New Haven, Connecticut. The remaining flight time of 3:26 hours was deadhead time between Albuquerque and Kansas City.

The crew had a layover of 29:10 hours in New Haven, Connecticut, prior to beginning the return trip. However, during the morning and afternoon on the day of the accident the co-pilot spent some time at the airport at New Haven attending to servicing and preflight duties.

Since the return portion of the trip from New Haven to Oakland would have been flown under the same conditions, e.g., two-man crew to Kansas City and four-man crew to Oakland, in addition to being a slower westbound flight due to prevailing headwinds, it may be concluded that the entire projected return trip would also have been flown in direct violation of Civil

Air Regulation 42.48, had the accident not occurred*.

Loading

Since no weight and balance information was available, the Board's investigators made an effort to determine what the maximum gross weight was for the departure from Toledo Express Airport.

The weights of the members of the California State Polytechnic College football team were taken from the programme of the game played with Bowling Green on 29 October 1960. The weights, as listed, were verified by college records to be accurate within five pounds.

The maximum allowable Super C-46F take-off weight for the departure from Toledo Express Airport was 46 850 lb. The Board estimated that the actual weight at take-off was 48 859 lb, 1 759 lb over the maximum gross weight of the aircraft and 2 009 lb over the maximum allowable take-off weight at Toledo.

Calculation of the weight and balance of this aircraft and comparison of these calculations with the two filed weight and balance manifests for the Albuquerque and Youngstown departures indicated that in each case the actual weight of the aircraft exceeded the listed weight and allowable take-off weight for these airports.

Take-off run

Examination of C-46 performance data for the take-off distance required with a 5 kt headwind, at an elevation of 684 ft msl, and a take-off weight of 48 859 lb, reveals that 2 750 ft of runway would be required to take off and climb to 50 ft. This is based on a normal take-off under standard conditions.

The Board believed that the loss of power caused by the maloperation of engines not properly runup immediately prior to take-off and the swerving take-off run due to erratic engine performance and poor visibility resulted in a premature liftoff. The pilot was unable to remain airborne due either to a stall condition or a loss of power or both. The wreckage being 5 800 ft down the runway indicates that the above-mentioned conditions caused a longer than normal take-off run.

Concerning Regulations

The Board concluded that the captain and the management of Arctic-Pacific Airlines displayed utter disregard for the regulations set forth as to flight time limitations, minimum weather conditions, proper completion and filing of required paper work, good maintenance and inspection practices, and for compliance with regulations concerned with ensuring operation, including maximum gross take-off weight, in a manner to guarantee safety to the public.

Probable Cause

The accident was due to loss of control during a premature lift-off. Contributing factors were the overweight aircraft, weather conditions, and partial loss of power in the left engine.

Follow-up Action

As a result of this accident, the FAA has published a notice in the Airman's

* CAR 42.48(d) reads as follows:

"Aircraft having a crew of four pilots.

"(1) A pilot shall not be scheduled for duty on the flight deck in excess of 8 hours during any 24-hour period.

"(2) A pilot shall not be scheduled to be aloft for more than 16 hours in any 24-hour period.

"(3) A pilot shall not be on duty for more than 20 hours during any 24-hour period."

guide and has instructed its tower operators to withhold take-off clearance from any air carrier or other commercial aircraft operated for the purpose of carrying passengers or property for compensation or hire when the prevailing visibility for the airport of departure or runway visibility for the departure runway is less than one quarter of a mile, or runway visual range is less than 2 000 ft.

On 31 October 1960 the FAA suspended in accordance with Section 609 of the Federal Aviation Act of 1958, the air carrier operating certificate issued to Arctic-Pacific. Subsequently, the operating certificate, which expired on 14 November 1960 was not renewed.

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ICAO Ref: AR/693

No. 63

Iberia, Lockheed 1049G Super Constellation, N 7125C, accident at Barcelona Airport, Spain, on 8 November 1960. Report released by the Directorate General of Civil Aviation, Spain, June 1961.

Circumstances

The aircraft was on a scheduled passenger flight between Madrid and Barcelona carrying 63 passengers and 8 crew. The flight proceeded normally until during the touchdown manoeuvre, 34 m in front of the approach end of the runway the left landing gear leg struck a small heap of rubbish and the wheels on that side were torn off. The aircraft continued 170 m along the runway, running on the right wheels and the stub of the left leg, then swerved to the left off the runway and caught fire. One passenger was seriously injured.

Investigation and Evidence

The Aircraft

It had flown a total of 14 413 hours of which 1 667 had been since the last 4 000-hour overhaul.

The Crew

The pilot-in-command held a transport pilot's licence valid to 6 January 1961. He had logged a total of 14 000 flying hours of which 600 had been flown on the subject type of aircraft.

The co-pilot had flown 25 000 hours; 3 000 in this aircraft type.

Weather

The conditions at Barcelona Airport at the time of the accident (1448 Z) were as follows:

wind:	150°, 6 kt
visibility:	10 km
cloud:	2/8 cumulus 1 000 ft 1/8 cumulus 10 000 ft
QNH:	1015.8

Reconstruction of the flight

The aircraft departed Madrid at 1342 hours and crossed the FIR boundary at flight level 130 at 1426 hours. At 1438 it was over Reus at level 90, continuing in descent towards Barcelona in accordance with instructions. It was flying over the VOR at level 40, with instructions to report over the VOR or in sight of the field. Before reaching the VOR, the aircraft had reported "field in sight", flying in visual meteorological conditions, and was cleared to change over to the tower which gave the landing instructions and clearance to approach runway 17. It reported on final as instructed and was preparing to touchdown when the accident occurred.

Statements - the pilot

He stated that the flight was normal until the aircraft was over Barcelona Airport at an altitude of 2 000 ft. He started the approach to land on runway 17, entered the downwind leg and commenced landing manoeuvres, extending the flaps and landing gear and maintaining an altitude of 2 000 ft. After turning into final approach he kept the speed at about 145 kt and, with the runway in sight, extended the flaps to 80°; the pre-touchdown checks were completed, everything was normal and at a speed of about 125 kt, the flaps were fully extended, with the aircraft aligned with the runway at an altitude of 500 ft. An indicated airspeed of 120 to 125 kt was maintained, and the pilot was giving his full attention to the touchdown when he felt a violent impact on the left side of the landing gear as though he had struck something in front of the runway threshold. From that moment, the aircraft went into a violent left skid off the runway so that it was impossible to keep control of the aircraft. When it came to rest after swerving around 180° left, he saw that an intense fire had started in the left wing and engine.

The pilot pointed out that the entire landing operation was conducted with the intention of landing as short as possible because he believed the runway was in bad condition, and he wanted to avoid the use of reverse power as far as possible and because, when flying over the aerodrome he had observed a large yellow vehicle crossing runway 17 at its intersection with runway 07 and leaving runway 17 as the aircraft passed over the airport. The need to take every precaution against the possibility of the vehicle recrossing the runway may have influenced him to try to land as short as possible.

- the co-pilot

The co-pilot stated that the flight was normal throughout and confined his detailed testimony to the approach and touchdown made by the pilot-in-command.

The aircraft was at an altitude of about 2 000 ft when it started the approach circuit, and the co-pilot was ordered to extend the flaps to the first position.

The pre-touchdown check was then made, ending with landing gear extension. The flareout and the manoeuvres for approaching the runway were effected at a speed of not less than 140 to 145 kt. After the flareout he received the order to extend the flaps to 80°. The final approach check was made and the co-pilot observed that from that moment, when the pilot ordered the flaps fully extended, the speed gradually decreased to 125 kt. The co-pilot considered that the height was correct and could not explain why before reaching the runway the left landing gear leg struck something. After impact he felt the drag of the left leg and engines on the runway. The aircraft skidded along the runway with a pronounced tilt and came to a stop off the runway facing in the opposite direction to that of its entry.

- the tower controller

He saw the aircraft start its circuit over the VOR, carry out the downwind leg with a left turn, the base leg and final approach and considered the manoeuvre to be correct. The aircraft was completely level and in line with the runway centre-line and from his point of view in the final approach phase.

Following the touchdown at 1448 Z he threw the alarm switch and advised that there was an aircraft on fire at the threshold of runway 17. He believed that it took the vehicles about five minutes to reach the scene of the accident. (The pilot had considered that the fire fighting services had taken longer than they should have to reach the crash site.)

The Wreckage

The aircraft came to rest about 15 m to the left of runway 17 and about 300 m from the threshold.

The fuselage was burnt out except for the radar dome and the portion aft of the entrance door. The left wing had separated. The right landing gear leg was whole although burnt. The left leg had torn off between the wheels and shock absorber rod. The nose leg had a broken axle and one wheel torn off. Engines Nos. 1, 2 and 4 were intact, but No. 3 engine had torn off and was severely damaged by fire.

Discussion

There was no violation of instructions issued by the air traffic control services, although the position on entering final approach may have been rather too short to allow for any major changes in the final manoeuvre with this type of aircraft.

The flight may be considered normal except for the aircraft's actual height.

Thirty-four metres from the runway threshold there was a small pile of rubble fill that had been used to fill in the depression between the runway edge and the cultivated land in the prolongation of the centreline. That pile was struck by the left landing gear leg of the aircraft, which was considerably lower than the right.

Maximum height of pile (point of impact of left landing gear leg): - 0.17 m

Lowest point of contact of left landing gear leg: - 0.97 m

Maximum height of pile (point of contact of right landing gear leg): - 0.37 m

Marks left by pressure of right wheels: - 0.46 m

These heights are measured from the elevation of the edge of the approach end of the runway. Since all the points were below this datum the heights appear as negative.

The left landing gear leg broke on impact. Marks were left by the spilling of a dark oily liquid on the ground, and parallel to these marks was the smooth imprint of the right wheels showing no signs of violent impact.

On the runway, 2.5 m from its edge, was a second contact mark, apparently produced by the stub of the left landing gear leg, as the wheels must have dropped off together with the cylinder at the time of impact, and either the cylinder or the broken stub - it is impossible to determine which - produced the third contact mark before the continuous scoring, certainly caused by the stub, running the whole length of the part of the runway used.

Along the first 200 m, the runway was strewn with a large number of stones torn up by the successive impacts and from the scoring in the runway, which was more than 10 cm deep in some places and with small parts of propellers, landing gear components, pieces of tubing, a screw and the left twin wheels.

Off the runway were found a landing gear door, two pieces of fuel tubing, part of a flap, another landing gear door, the aircraft itself and, about 50 m away, the left nose wheel.

The aircraft appeared to have suffered little damage from the impact and the fire on the left side.

The greatest destruction was caused by the fire which followed the explosion of the central tank. The fire then started on the right side, where the wing sloped downwards toward the fuselage, so that a large amount of fuel flowed out of the tanks.

The fire was finally brought under control when the right wing separated from the fuselage.

The testimony showed that the aircraft had entered its final approach and been laterally levelled before the impact occurred, so that the accident cannot be attributed to a turn too close to the runway and to the surface, from the base leg into final approach.

The very slight lateral inclination to the left at the moment of the impact is attributable to an unexpected movement not connected with the crew, of the lateral shaking type, due to wind effect, inadvertent rolling or some other unknown cause.

The cause of the accident was the pilot's error in estimating the actual height at which he was flying: his argument cannot justify him, as the runway had recently been repaired and its crossing by vehicles or pedestrians was controlled by the light fire truck which was in radio contact with the tower, in accordance with the directives applicable to all work involving movement of personnel or equipment that may affect the runway in use.

If, however, the pilot was not aware of the existence of that control, he should have reported to the tower the crossing of the runway by a vehicle, but if, being busy with other operations, he could not do so or did not consider it important, he may well have had it in mind to land short, at the runway threshold, so to halt the aircraft before reaching the area affected by the crossing.

Probable Cause

The accident was attributed to the pilot's error in estimating the actual height of the aircraft a few moments prior to landing.

ICAO Ref: AR/681

No. 64

Philippine Air Lines, Inc., DC-3C, PI-C133, accident at Mount Baco, Oriental Mindoro, The Philippines, on 23 November 1960. Report released by the Civil Aeronautics Administration, The Republic of The Philippines

Circumstances

The flight (S-26) departed Iloilo for Manila at 1730 hours local time carrying a crew of 4 and 29 passengers. Position reports were received from the aircraft at 1750, 1810 and 1833 hours. From then on no further report was received from the aircraft. When it failed to report over Lipa homer beacon at 1900 hours, as expected, attempts were made by Manila Approach to contact the aircraft on all approach control frequencies. These attemps were unsuccessful. The wreckage of the aircraft was sighted on 30 November on the eastern slope of Mount Baco, approximately 6 000 ft amsl and 10 miles northwest of Wasig, Oriental Mindoro. The accident site was approximately 32 miles west of the airway. All passengers and crew died in the crash, and the aircraft was totally destroyed by the impact and fire which followed. A watch of one of the passengers was found to have stopped at 1845 hours presumably the time of impact.

Investigation and Evidence

The Aircraft

It held a valid certificate issued by the Civil Aeronautics Administration of the Philippines with an expiry date of 12 September 1961. The aircraft was certificated for a maximum gross weight of 26 900 lb and was authorized to operate in instrument meteorological conditions and day and night operations. The maximum allowable take-off gross weight from Iloilo was 26 000 lb. It appears that the total weight was 11 lb less than this maximum.

The aircraft was equipped with two sets of automatic direction finders - one in the captain's position and the other in the co-pilot's; two directional gyros; one magnetic compass; and two sets of altimeters.

Maintenance of the aircraft had been carried out in accordance with the approved schedules of the airline. The maintenance history of the airframe and the engines indicated no discrepancy which might have adversely affected its airworthiness.

The Crew

The pilot-in-command was the holder of an airline transport licence with DC-3 and instrument ratings. He qualified on the Manila-Iloilo-Manila route as captain in May 1954 and had flown flight S-26 five times. He had flown a total of 13 606 hours as of 22 November, of which 10 959 were flown with Philippine Air Lines as DC-3 co-pilot and captain. On the day of the accident he had a total night time of 625 hours to his credit. His last medical certificate (20 June 1960) required that he wear corrective lenses while exercising the privileges of his pilot's licence. CAA records showed that in December 1952 he was designated as one of the CAA special check pilots.

The first officer was the holder of a commercial pilot's licence with DC-3 and instrument ratings. On the day of the accident he had logged a total time of 2 495 hours of which 368 had been flown as DC-3 co-pilot with PAL. He took his flying in the Philippine Air Force and had qualified as a C-47 first pilot.

The second officer was also the holder of a commercial pilot's licence with DC-3 and instrument ratings. He had a total of 1 484 hours to his credit of which approximately 7 were flown with Philippine Air Lines.

Weather conditions

The winds aloft forecast for the route was 80 - 100°, 15-30 kt, at an altitude between 5 000 and 16 000 ft.

The actual winds aloft observation of the Weather Bureau from 1700 to 2000 hours on the day of the accident was 60°, 25 to 35 kt at an altitude from 5 000 to 8 000 ft. Between Mount Baco and Romblon, the prevailing weather conditions were light haze, visibility 15 miles, clouds 2 500 ft, scattered 7 000 ft.

The Wreckage

It was strewn over an area of 50 m radius. The aircraft had struck a big guiho tree 2 m in diameter. Prior to hitting the tree, the aircraft razed several small trees along the flight path. From the marks, it was deduced that the aircraft was heading the normal flight path of 330°, prior to impact. The fuselage was smashed and burned. The left and right engines had been thrown 5 and 4 m respectively from the tree. They were not burned, and there was no indication that fire developed prior to impact. Both left-hand and right-hand propeller blades were badly and symmetrically twisted. The left-hand propeller appeared to be feathered as observed by CAA inspectors, although PAL maintenance crew stated otherwise.

The throttles appeared to be on normal cruise setting, except that both mixture control levers were found to be halfway between the auto-lean and the idle cut-off position. The electrical panel had disintegrated. The VHF control box was found on the 119.7 frequency and the HF radio was on the 6597 kc/s PAL frequency. One of the ADF radio compasses was found and according to the PAL chief pilot (and investigator) it was indicating 110°, while the CAA inspector's report indicated 130.5°. The directional gyro was broken and the reading indicated 250.6° (according to the CAA inspector) and 255° (according to the PAL chief pilot). Two readings were made on the altimeter - 6 080 ft (PAL) and the other 5 800 ft (CAA).

Navigation facilities

On the route Iloilo-Manila, the following ground navigational facilities were available:

Homer beacons - Iloilo, Romblon, Lipa and Rosario

Rotating beacons - Romblon, Lipa

Radio Stations -
- Iloilo Aeronautical Radio Station - operated by PAL
- Roxas Radio Broadcasting Station - used by PAL for position reporting point only
- San Jose Aeronautical Radio Station - operated by PAL
- Romblon Aeronautical Radio Station - operated by CAA.

All these facilities were operating normally.

During the investigation, some PAL pilots testified that the homer beacon at Lipa was unreliable due to interference from other stations, but for record purposes, it can be stated that no report on the matter was received by the CAA prior to this accident.

Discussion

Having received the following clearance: "Manila Airways clears S-26 to the Rosario homer via Amber 1 from Romblon maintain flight level 6 000 ft report 100 miles out", the aircraft took off at 1730 hours from Iloilo.

The three position reports received from the flight were -

at 1750 hours - on VHF - "S-26 abeam Roxas, altitude 6 000, Manila 1925H, fuel 370 gal";

at 1810 hours - on 6597 kc/s - "S-26 penetrating PADIZ* 6 000";

at 1833 hours - on VHF - "S-26 position report at 6:27 p.m., 100 miles out, 6 000 ft, advise airways."

At the time of the third position report, when the captain reported to San Jose PAL Radio, he did not appear to be certain of his position for he asked the radio operator whether he could see an aircraft approximately 7 miles out from the field. The operator replied, "Negative". The contact ended there, and he did not hear anything more from the pilot. The radio operator relayed the report to Roxas Radio and then signed off.

From the location of the crash site, it appeared that the flight deviated approximately 32 miles to the west of the flight clearance given by Manila Airways.

The Board could not understand how a captain of such extensive experience could have deviated from his course, Amber 1, by so many (32) miles. The first and second officers aboard the aircraft were also well trained and experienced pilots in this type of aircraft.

Other pilots who flew PAL flights some minutes behind flight S-26 at 8 000 and 10 000 ft altitudes on Amber 1, stated that the visibility throughout the area was good for many miles around. With good visibility, even if both ADFs of PI-C133 had malfunctioned, the flight could have safely reached its destination by visual reference to the islands which were then identifiable.

* Philippine Air Defence Identification Zone

Ground facilities were functioning normally. However, Lipa homer beacon was allegedly giving unreliable indications due to interference from foreign stations, to such an extent that over Maestro del Campo, an ADF, when tuned to Lipa homer beacon pointed towards Mindoro. The flight did not report over or abeam Romblon, which is a compulsory reporting point.

There was an appreciable crosswind of 25 to 35 kt from the east and the pilots of succeeding flights made 12 - 15° corrections to stay on course.

The Board felt that the flight was on course from Iloilo to a point abeam Roxas, but from that point the flight did not intercept Amber 1, as cleared by the Airways, presumably caused by the pilot's failure to apply the necessary drift correction.

It is difficult to conceive that the captain attempted to make a straight flight from Iloilo to Rosario (Manila) due to hazardous terrain north of Iloilo over which he had to fly. Considering, however, that when he took off it was still daytime he must have flown VMC (visual meteorological conditions) over this terrain until he reached the northern tip of Panay or abeam Roxas.

After Roxas, the flight must have made deviations to the left and drifted with the crosswind to the west which resulted in the aircraft being over Mindoro. While over the southern part of Mindoro the flight encountered poor visibility and bad weather. If the visibility had been good, the crew would have been alarmed by the terrain as by that time they would have been aware that they were supposed to be flying over water. Thus, the flight, without any visual reference, proceeded off-course, towards the heading to Rosario, without any premonition of the dangers ahead.

As stated previously, at 1833 hours the captain appeared to be uncertain of his position. He knew that he was somewhere over Mindoro, but he could not determine his exact position and was proceeding presumably by dead reckoning. With no visual reference the crosswind must have drifted the aircraft further off course to the west.

The possibility of the ADFs malfunctioning was considered at great length. ADFs are known to be usually affected by atmospheric conditions, terrain and twilight effects. With the adverse conditions then existing when the aircraft was already over Mindoro, it is highly probable that one or both ADFs of PI-C133 malfunctioned. The ADF of PI-C133 on the captain's side had malfunctioned in the past, although the log book of the airplane indicated that the previous pilots who flew the aircraft did not complain about it.

The possibility of hi-jacking was considered but was subsequently ruled out by the Board because of a lack of supporting evidence.

As stated, there appeared to be conflicting evidence on the condition of the left propeller - CAA investigators reported that the propeller was in a feathered position, while PAL maintenance men testified otherwise. A possible left engine malfunction could not be discounted but the same could not, however, account for the aircraft being off course by so many miles, for the asymmetric thrust can be easily corrected by the application of the aileron and/or rudder trim. Additionally, the captain would have radioed if he lost an engine. Last contact with the aircraft was at 1833 and no difficulty was reported at that time.

After flying for about 1 hour and 50 minutes the aircraft would have weighed 25 420 lb, having burned approximately 100 gal of fuel. The aircraft at this weight could still maintain an altitude of 6 000 ft and could climb at the rate of about 140 ft/min.

Probable Cause

The probable cause of the accident was a navigational error. Contributing factors were: adverse weather conditions and poor visibility, a 25-35 kt crosswind coming from the east, unreliability of the airborne navigational equipment due to either atmospheric disturbance, night and terrain effects and/or its possible malfunctioning.

Recommendations

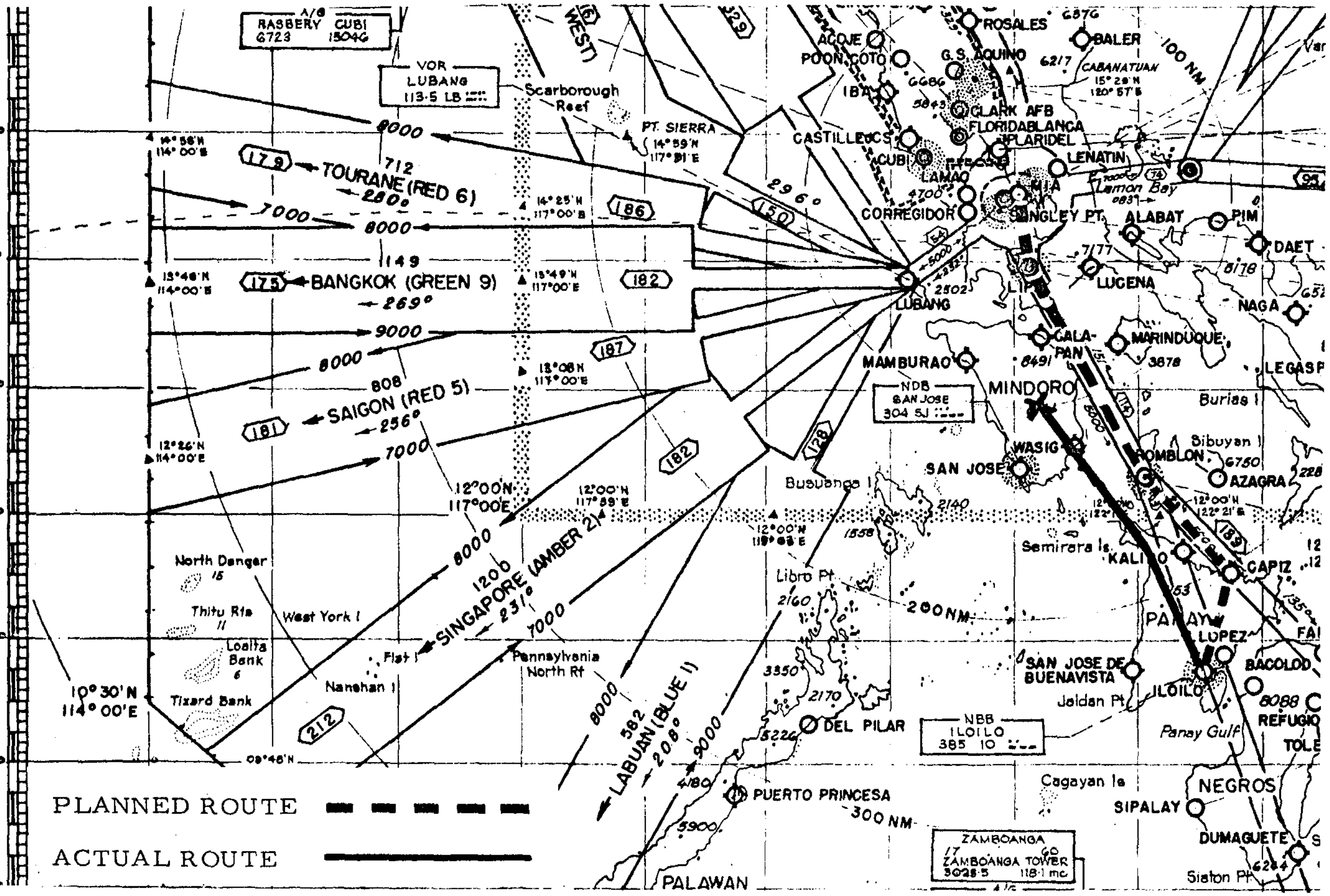
As a result of this accident, the following are recommended:

1. installation of VOR airborne equipment on DC-3s;
2. establishment of more controlled airways;
3. establishment of additional ground navigational facilities; and
4. a request be made to Congress for more appropriations to meet recommendations Nos. 1, 2 and 3 above.

- - - - - - - - - - - - - - -

ICAO Ref: AR/679

FIGURE 18



PHILIPPINE AIR LINES, INC., DC-3C, ACCIDENT AT MOUNT BACO, ORIENTAL MINDORO, THE PHILIPPINES, 23 NOVEMBER 1960

No. 65

United Air Lines, Inc., DC-8, N 8013U and Trans World Airlines, Inc., Constellation 1049A, N 6907C collided near Staten Island, New York, 16 December 1960. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 1-0083, released 18 June 1962.

Circumstances

On 16 December 1960 at 1033 hours eastern standard time a collision between a TWA Constellation and a UAL DC-8 occurred near Miller Army Air Field, Staten Island, New York. All 128 occupants of both aircraft and 6 persons on the ground in Brooklyn were fatally injured. (There were 6 crew and 39 passengers aboard the Constellation and 7 crew and 76 passengers on the DC-8.)

TWA Flight 266 originated at Dayton, Ohio for LaGuardia Airport, New York with one intermediate stop planned at Columbus, Ohio. United Air Lines Flight 826 was a non-stop service originating at O'Hare Airport, Chicago, Illinois with its destination New York International Airport, New York. Both aircraft were operating under instrument flight rules.

Following the collision the Constellation fell on Miller Army Field and the DC-8 continued in a northeasterly direction, crashing 8-1/2 miles NE of Miller Field into Sterling Place near Seventh Avenue in Brooklyn, New York. Both aircraft were totally destroyed by impact and fire. There was considerable property damage due to the prolonged and intense fire in the area where the DC-8 struck the ground.

Investigation and Evidence

Crew Experience

TWA Constellation

The captain held a valid airman certificate with a currently effective airline transport certificate. His ratings included DC-3, Martin 202 and 404 and Lockheed Constellation aircraft. He had flown a total of 14 583 hours of which 267 were in the Constellation. The captain had qualified on this type of equipment in September 1952. He was current in the requirements of proficiency checks, line checks, route qualifications, and recurrent training. His last FAA physical was passed in October 1960.

The two first officers and flight engineer were satisfactorily certificated.

UAL DC-8

The captain held a valid airman certificate with a currently effective airline transport certificate. His ratings included: DC-3, B-247, DC-4, DC-6, DC-7 and DC-8 type aircraft. He had a total of 19 100 flying hours of which 344 were in DC-8's and he qualified in the DC-8 type aircraft in June 1960. He was current in the requirements of proficiency checks, and route qualifications and his last FAA physical examination was in September 1960.

The first and second officers were both properly certificated and had flown 8 400 and 8 500 hours respectively.

The Weather

Inflight reports from 51 aircraft which had operated within a 30 NM radius of the accident site within one hour of the time of the accident showed that 45 flights were in clouds at altitudes ranging from 300 ft to 18 000 ft. One pilot reported on top of all clouds at 31 000 ft. Four of the five remaining reports indicated some ground contact up to altitudes ranging from

4 000 to 5 000 ft. One pilot reported between layers from 4 000 to 5 000 ft and from 13 000 to 15 000 ft.

Reconstruction of the flights (see Figure 19)

TWA Flight 266

It departed Port Columbus Airport at 0900 hours eastern standard time and was operating routinely under Air Traffic Control into the New York area. Radar contact was established by the New York Air Route Traffic Control Centre which cleared the flight to the Linden Intersection at 1019. Shortly after passing the Solberg VOR at 1027 control of the flight was transferred to LaGuardia Approach Control who began vectoring the flight by radar from the time when the flight was about over the Linden Intersection to the final approach course for a landing on runway 4 at LaGuardia. The last few minutes of flight were as follows:

1032:20 at 6 000 ft

:22 was cleared to continue descent to 5 000 ft

:37 was advised to turn right to 150°

:47 was advised of traffic at 2:30, six miles northeastbound ...

1033:08 LaGuardia Approach Control asked for the flight's altitude. It was then at 5 500 ft.

:14 was cleared to continue descent to 1 500 ft.

:21 was advised to "turn left now heading 130"

:26 was advised of jet traffic on its right at 3 o'clock at one mile, northeastbound

:33 a noise similar to that of an open microphone was then heard for six seconds duration

:43 LaGuardia Approach Control then requested the flight to "turn further left one zero zero". LaGuardia continued trying to establish contact with the flight until 1036:21 without success.

UAL Flight 826

The flight, operating routinely between Chicago and the New York area, contacted New York Air Route Traffic Control Centre and was then cleared to proceed from the Allentown, Pennsylvania very high frequency omni directional radio range station (VOR) direct to the Robbinsville, New Jersey, VOR and thence to the Preston Intersection (clearance limit) via Victor Airway 123. At 1021 the flight asked Aeronautical Radio, Inc. to advise the company that No. 2 navigation receiver accessory unit was inoperative. Air Traffic Control was not advised. At 1022 New York Centre had radar contact with UAL 826. Shortly after passing over Allentown at 25 000 ft the flight started its descent to 13 000 ft and was recleared to proceed on Victor 30 until intercepting Victor 123. The new routing shortened the distance to Preston by about 11 miles, however, it did not alter the Preston clearance limit.

The New York Centre advised United 826 to maintain present heading from Allentown until intercepting Victor 30, and then cleared it to descend to and maintain 11 000 ft. Subsequently, it was advised by New York Centre that it was crossing the centreline of Victor 30. The flight confirmed its establishment on Victor 30 and requested its distance from Victor 123. The New York Centre advised that the flight was 16 miles from Victor 123 and about 2 miles from crossing Victor 433. This information, showing the proximity to Victor 123 and the

Preston Intersection, should have alerted the United crew of the rapid approach to the clearance limit.

After it was established on Victor 30, the New York Centre cleared the flight to descend to 5 000 ft. United 826 acknowledged and reported leaving 14 000 ft. New York Centre then asked if United 826 could make Preston at 5 000. It indicated it would try. A transfer of control could not be effected to Idlewild Approach Control until United 826 vacated 6 000 ft.

To ensure that United 826 understood the clearance limit, the New York Centre provided holding instructions for the Preston Intersection. The flight was advised at this time that the only delay would be in the descent. It reported leaving 7 000 and 6 000 ft. United's report leaving 6 000 ft was acknowledged by the New York Centre which then instructed the flight to contact Idlewild Approach Control. New York Centre did not furnish radar vectors to United 826. The flight was doing its own navigation and the radar service thus far provided was in the form of advisories. United 826 contacted Idlewild Approach Control and reported approaching Preston at 5 000. When it advised it was approaching Preston it had already passed Preston by several miles.

Summary of Sequence of Events

	TWA Flight 266	UAL Flight 826
1023	Current LaGuardia weather	
1023:33		Over Allentown at 25 000 ft
1027:58	Over Solberg at 9 000 ft	
1028:41		Crossing centreline of Victor 30
1028:54	Leaving 9 000 ft	
1028:56		16 miles west of Victor 123
1029:58	Leaving 8 000 ft	
1030:11		Leaving 14 000 ft
1031:02	Reduce to approach speed	
1032:25		Leaving 7 000 ft
1032:32	Leaving 6 000 ft	
1033:01		Leaving 6 000 ft
1033:20	At 5 500 ft	
1033:28		Approaching Preston at 5 000 ft
	Sound of the open microphone	
1033:33	______	______

The Collision

At the time (1033:28) UAL 826 advised it was approaching Preston it had in fact gone on by this clearance limit several seconds before and was several miles past the point at which it should have turned into the holding pattern. This was confirmed by the data obtained from the flight recorder on the DC-8 as well as by analysis of the communication tapes. At a point approximately 11 miles past the Preston Intersection a collision occurred between the two aircraft.

LaGuardia radar observations indicated that the two targets merged approximately over Miller Army Airfield, New Dorp, Staten Island, New York. After the merged plot one target (the DC-8) broke away to continue northeast until it crashed 8-1/2 miles northeast of Miller Field. The other target (the Constellation) appeared momentarily nearly stationary and then commenced a slow right turn to a southwesterly heading, disappearing from the scope. This aircraft crashed at Miller Field.

Collision Evidence

Examination of the wreckage of the DC-8 and the Constellation substantiated the evidence of an air collision.

The Constellation examination indicated that the impact was from outboard toward the inboard on the right rear quarter at an angle of 110° relative to the course line. The Constellation was in an approximate 22° left bank relative to the DC-8 flight path and maintaining approximately the same altitude.

The DC-8, as indicated by the flight recorder, was in approximately straight and level flight at the moment of impact.

Several pieces of DC-8 engine pod titanium, engine accessory fragments, and cowling material were found in the passenger cabin area of the Constellation. A fragment of fiberglass from the DC-8 tower antenna cover was found embedded in the right stabilizer of the Constellation. Pieces of DC-8 wiring and structure of the No. 4 pylon were found embedded in the Constellation flap panel. DC-8 wing spar fragments were found in the wing of the Constellation.

A portion of the DC-8 left wing leading edge and a section of the right wing we were sheared off and fell in the area of the Constellation wreckage.

Structures

Constellation

The majority of the force of collision impact on the Constellation was centred on the following points:

Upper right section of passenger compartment between fuselage stations 1030 and 1060;

Right vertical fin, rudder, and right outboard portion of the right horizontal stabilizer;

Right wing flap;

Right wing between the engines.

The aircraft broke into three main sections following the collision. The aft section, including the empennage, separated from the forward portion of the aircraft. The centre vertical stabilizer bore evidence of impact force resulting in bending 45° to the left approximately 2 ft from the top. The right vertical rudder and stabilizer and 12 ft of the right horizontal stabilizer were torn free. There was evidence of inflight fire. There were no signs of ground fire about the aft fuselage, but there were of fire in the interior. The right wing and No. 4 engine separated (at wing station 242), and this section showed severe fire and explosion damage. No. 3 engine and nacelle also detached. The forward section of the fuselage and the left wing, including the two engines, fell about 1 100 ft north of the aft fuselage.

Internal examination of the power plants revealed no evidence of frictional overheat, lack of lubrication or internal failure.

DC-8

Six general areas of the DC-8 furnished evidence of a collision:

1. Left wing leading edge
2. Left landing gear door
3. Right landing gear door
4. No. 4 engine, nacelle, and pylon
5. Right wing outboard of the No. 4 engine
6. Belly antenna

Impact and subsequent ground fire consumed the greater part of the passenger cabin structure. The flight deck was also largely consumed by ground fire. Examination of the empennage and fuselage aft of fuselage station 1490 revealed that in addition to the impact damage there was evidence of fire damage. Areas of the empennage were heavily sooted, and the paint was blistered. Soot found on the ground impact fracture areas indicated that some was a result of the ground fire. However, the direction of the soot on the upper and lower skin of the intact left horizontal stabilizer indicated an inflight fire.

Power plants Nos. 1 and 2 were severely damaged by ground impact. No. 3 power plant remained an integral unit, although the low pressure turbine shaft was twisted. No. 4 engine separated at the intermediate and diffuser cases, severing the attaching bolts.

There was no evidence of inflight failure of Nos. 1, 2 and 3 power plants. The damage to No. 4 power plant was attributed to inflight and ground impact forces.

Systems

Constellation

The navigation, communication and flight instrument equipment were closely examined. The first officer's RMI heading indication was 188°; the captain's MDI was 190°. Both of these units receive their inputs from the same fluxgate compass. The captain's RMI heading indication was 062°. No. 2 VOR/ADF pointers on each RMI each indicated 100°. Examination of the selector switch could not determine whether the pointer system was selected to automatic direction finder (ADF) or VHF omni range (VOR). The frequency setting of 232 kc/s was found on the radio control panel of the ADF No. 2 system. The internal receiver mechanism was determined as having been tuned to between 227 kc/s and 233 kc/s. The No. 1 ADF control panel indicated only that the receiver was tuned to between 200 and 410 kc/s. Internal examination of the ADF receiver indicated a frequency of 320 to 326 kc/s. No. 1 ADF loop indicated a relative bearing of 98° and No. 2 ADF loop 77.5°. No. 2 VOR control panel was found to be set to a frequency of 115.9 Mc/s and the internal examination of the receiver indicated frequency of 113.9 or 115.9 Mc/s.

Examination of the VHF communications system indicated that the No. 1 VHF communications system was tuned to 128.9 Mc/s. This frequency was set on the receiver panel, the receiver mechanism, and the transmitter. The No. 2 VHF communications system panel setting was 125.7 Mc/s, the receiver and transmitter mechanisms were also 125.7 or 125.8 Mc/s.

DC-8

The navigational and communication equipment of the DC-8 was also closely examined. Primary navigation equipment of United 826 was a typical DC-8 installation incorporating minor changes in accord with United Air Lines policy. The navigation equipment consisted of the ADF, very high frequency omni directional range (VOR) receivers, and ILS receiver, and a gyro stabilized compass system. Two complete sets of these units form the navigational system, and they are referred to as System No. 1 and System No. 2. The DC-8 was equipped with weather radar for storm monitoring. Components of all navigational systems were found and identified except for components of the weather radar.

United DC-8 aircraft are equipped with two RMI-VOR indicators, and two C-6A gyrosyn compass indicators with pointers for the ADF. The captain's panel has one RMI which presents compass heading and VOR information plus a C-6A indicator for display of ADF and compass information. A similar presentation is displayed on the first officer panel. Each indicator has two pointers and a rotating azimuth card from which the aircraft's heading is read at 12 o'clock position.

The captain's RMI indicator has a single or narrow pointer which operates with inputs from System No. 1. The double or wide pointer operates with inputs from System No. 2. The first officer has an identical display. The display is similar to the V-bar pointers of the No. 1 and No. 2 pictorial deviation indicators. As an example: When the No. 1 VOR unit is tuned to a frequency, the No. 1 pointer of the RMI and the V-bar of the captain's No. 1 PDI present the same data. Two C-6A ADF indicators are independent of the VOR indicators.

The captain's No. 1 VOR receiver was tuned to approximately 109.7 Mc/s. The first officer's No. 2 VOR receiver was tuned to 110.45 Mc/s. The No. 2 accessory unit had been reported as being inoperative prior to the collision. The captain's PDI (pictorial deviation indicator) omni bearing selector was determined to be approximately 039° and that of the first officer was set to approximately 036°. The only ADF equipment recovered was the captain's ADF receiver and the first officer's ADF control head. The captain's ADF receiver was tuned to 293 kc/s. The first officer's ADF control head was set at 103 kc/s.

Navigational Facilities

Pertinent New York area navigational facilities in the vicinity of the Preston Intersection are listed with the charted frequencies in effect at the time of the accident:

Scotland Radio Beacon	294 kc/s
Robbinsville Omni	109.0 Mc/s
Colts Neck Omni	115.1 Mc/s
Solberg Omni	114.7 Mc/s
Idlewild Omni	115.9 Mc/s
Idlewild Localizer (Runway 4 Right)	109.5 Mc/s
Idlewild Glide Slope	332.6 Mc/s
Idlewild Outer Marker Locator	373 kc/s
Idlewild Middle Marker Locator	353 kc/s

The Preston Intersection is defined by the intersection of the 346° radial of the Colts Neck Omni and the 050° radial of the Robbinsville Omni. The 120° radial from the Solberg Omni may be used in conjunction with the Robbinsville radial. These three VOR stations are operated and maintained by the Federal Aviation Agency. VOR stations are located on carefully selected sites and transmit signals in the very high frequency radio spectrum between 108 and 118 Mc/s.

Ground monitor checks on the VOR stations at Colts Neck, Solberg and Robbinsville revealed nothing abnormal.

Flight checks using these three VOR radials composing the Preston Intersection revealed no abnormalities. Preston Intersection as determined by the VOR radials was found to be geographically as plotted on current air navigation charts.

Air Traffic Control

Victor Airway 123, upon which United 826 was proceeding, is utilized and chartered as a one-way, inbound airway serving LaGuardia and Idlewild Airports. Under IFR, aircraft traversing this airway are controlled by the New York Air Route Traffic Control Centre. Under VFR weather conditions, aircraft may traverse this airway without an ATC clearance, in which event ATC would not have knowledge of such aircraft's position, altitude, destination, or identification. Further, air traffic procedures do not provide for the separation of en route IFR and VFR traffic except in designated positive control airspace. In view of the fact that the weather in the New York area on 16 December 1960 during the period 1000 to 1100 was not conducive to VFR operation, it is highly improbable that VFR traffic would have been traversing Victor 123 on approach control radar. On the basis of all available meteorological information, it is concluded that the weather conditions in the New York area were such that between the altitude of 300 ft and 18 000 ft, VFR flights could not have been employed.

The New York Centre records indicate that there were no IFR aircraft over-flying the New York Metropolitan area via Victor 123 during the period 1000 to 1100 on 16 December 1960. Consequently, the aircraft observed on radar by LaGuardia Approach Control could only have been traffic destined for one of the two airports, LaGuardia or Idlewild, or an unidentified aircraft. Since LaGuardia Approach Control did not have a flight progress report on the unidentified traffic, they were aware that the traffic on Victor 123 was not destined for their airport. In order to have been certain of the destination of the unidentified aircraft, the approach controller could have requested this information from the New York Centre. It is doubtful that LaGuardia Approach Control could have established communication with the New York Centre, identified the aircraft, and transmitted effective instruction in approximately 39 seconds. The only immediate alternative action that could have been taken by the LaGuardia Approach Controller would have been to provide evasive radar vectors to TWA 266 on the assumption that the unidentified traffic was conflicting traffic. This provision of evasive vectors to TWA 266 would not be incumbent on the controller inasmuch as the airspace in the area in which TWA 266 was operating had been assigned to LaGuardia Approach Control.

The Idlewild Approach Controllers testified that they did not observe United

826 in the Preston area. In accordance with the information relayed to Idlewild Approach Control by the New York Centre, United 826 would be approaching Preston from the southeast. However, the revised clearance via Victor 123 would have United 826 approaching from the southwest. The purpose of the revised routing was to increase longitudinal separation between United 826 and the succeeding aircraft which were cleared to Preston at higher altitudes than the United flight. The change was not relayed to Idlewild Approach Control nor was it reflected on the Idlewild flight progress strip by way of advancing his expected time of arrival over Preston by approximately five minutes.

The area which would normally be observed by the approach controller on radar in an effort to identify aircraft approaching Preston would have been from a southerly direction. According to the position report transmitted by United 826, and the clearance limit issued by ATC, the approach controller would have normally expected to observe a target approaching Preston. No target was observed.

Aircraft must be positively identified and radar contact established by the controller before radar vectors are commenced. Positive radar contact is accomplished by several means:

1. By the aircraft reporting over a known radio fix which the controller has described on his scope.

2. By ascertaining the heading of an aircraft and requesting a turn to a designated heading for identification.

3. By a coded Beacon transponder response.

A radar handoff would be effected in somewhat the same manner, the only exception being that both facilities, New York Centre and Idlewild Approach Control, would simultaneously observe the aircraft during these procedures and the controlling facility would not relinquish control until the receiving facility had the aircraft positively identified. It was testified that radar handoffs are the exception rather than the rule. Their use is not mandatory in the air traffic control system. Radar handoffs may be used at the discretion of the controller with prior coordination between facilities, or in the event of an emergency. A radar handoff was not used for United Flight 826.

Since United 826 did not advise ATC of a failure of the No. 2 omni receiver or request radar assistance, ATC could only assume that he was capable of providing his own navigation. Therefore, there was no requirement to effect a positive radar handoff procedure between New York Centre and Idlewild Approach Control.

The transmission "No. 2 navigation receiver accessory unit out" has raised the question as to its precise meaning. An inoperative accessory unit is a term which cannot be accurately applied to this DC-8. It appears that the description of the malfunction relates to the VOR instrumentation in earlier aircraft on which the crew had more operating experience. The comparable unit installed on the DC-8 would have been correctly named the VHF navigation No. 2 instrumentation unit; however, the function of the units in both aircraft was basically the same.

The New York Centre Radar Controller's testimony that he observed United 826 on his scope 1 to 3 miles south of Preston at the time the flight reported out of 6 000 ft is inconsistent with the facts concerning the time of collission. It must be concluded that the controller's memory of the position of United 826, or the time of observation, is in error. If he were correct there could not have been a collision at the time and place it occurred. The Board concluded from the foregoing that the controller did not observe 826 at this location.

Flight Recorder Readout

The flight recorder aboard the DC-8 was read out under the supervision of the Civil Aeronautics Board.

The data obtained relative to altitudes, indicated airspeeds, and headings are shown in Figure 20. The flight recorder values between 72 minutes after take-off and the time of collision are plotted as a track profile in Figure 19. This track was plotted in reverse from the point of collision determined by a trajectory study of the DC-8 No. 4 engine and the TWA Constellation No. 3 engine.

The engines were detached in flight upon collision and impacted on Staten Island. Analysis of the trajectory of the DC-8 engine indicated a fall of 5 575 ft on a course of 050° magnetic. Analysis of the Constellation No. 3 engine indicated a 3 470-foot fall on an estimated course of between 110° to 130° magnetic. The intersection of the two trajectories determined the collision area of approximately 1 200 sq. ft., the centre of which is located on a 315° magnetic bearing of 6 555 ft from the centre of Miller Field.

The altitude at the instant of collision was computed to be 5 175 to 5 250 ft AMSL as would be indicated by an altimeter setting of 29.65 in. Hg. The indicated airspeed of the DC-8 at the point of collision was 301 kt, with a reduction in airspeed over a 70-second period prior to collision as illustrated below:

	Time Lapse	Speed	Speed Reduction
1032:22		356 kt	
1032:55	33 seconds	338 kt	18 kt
1033:04	9 seconds	332 kt	6 kt
1033:12	8 seconds	325 kt	7 kt
1033:20	8 seconds	318 kt	7 kt
1033:29	9 seconds	309 kt	9 kt
1033:32	3 seconds	301 kt	8 kt
		Total	55 kt

This was the lowest airspeed subsequent to passing Allentown, Pennsylvania. The elapsed time of Flight 826 between "wheels off" at O'Hare Airport, Chicago, at 0911 and the time of the collision was 82 minutes and 32 seconds. According to this, the time of collision as determined by the flight recorder readout was 1033:32.

Derivation of Flightpaths in Figure 19

Prior to the clearance via Victor 30, United Flight 826 had been cleared Allentown VOR direct Robbinsville VOR. Accordingly, the flightpath after passing the Allentown VOR was projected on the basis of a turn to a direct heading to Robbinsville VOR, and this heading maintained until intercepting Victor 30. The transcriptions indicate that the aircraft was established on Victor 30, and at 1029:02 was given a position by the New York Centre as approximately 2 NM from crossing Victor 433. It was assumed that the aircraft would be flown within the confines of Victor 30 airway until the turnoff to intercept Victor 123. In considering that one VOR receiver may have been inoperative, the turn onto Victor 123 was plotted as a gradual turn to the 050-degree radial of Robbinsville in order not to overshoot the centreline of Victor 123. From the point of interception of Victor 123, the flightpath was projected in a straight line to the collision point computed as approximately 6 555 ft from the centre of Miller Field on a bearing of 315° magnetic. This flightpath was derived independent of the flight recorder information.

TWA Flight 266 had been cleared from Allentown VOR via Victor 6 to the Linden Intersection. It was assumed that the aircraft would be flown along the centreline of Victor 6 until being vectored for an approach to the LaGuardia Airport. At 1030:49 TWA Flight 266 was requested to reduce to approach speed, and subsequently given turns to headings of 130°, 150° and 130°. These turns to headings were properly executed. Accordingly, a ground speed of 160 kt was considered reasonable in projecting the probable path of flight while being vectored, and the path was plotted from the estimated collision point back to Victor 6 on magnetic headings of 310°, 330° and 310°.

The time of collision utilized is not intended to mean that this is the precise time of collision. In order to have a starting point for the purpose of establishing approximate geographical positions at one-minute intervals, 1033:39 was selected as a reasonably within-range figure for the following reasons:

1. It marks a definite point in the transcript of the recordings, i.e. the end of the "open mike" sound.

2. This time point was selected as within reasonable limitations based upon:

   a) at 1033:42 TWA 266 was instructed to turn left to a heading of 100°. This instruction was neither followed nor acknowledged. according to the transcript, and;

   b) at 1033:26 TWA 266 was advised of traffic at 3 o'clock one mile. Assuming the accuracy of the one mile figure and using a ground speed range from 240 kt to 320 kt for the unidentified target, the time to collision is 1033:26 plus 10 seconds equals 1033:36, or 1033:26 plus 15 seconds equals 1033:41.

3. United Flight 826 reported approaching Preston at 1033:28. Detailed landing information to United 826 ending at 1033:54 was given by Idlewild Approach Control, but was not acknowledged, although all previous instructions had been acknowledged in approximately six seconds or less. It was therefore considered that the collision occurred within the time interval 1033:30 - 1034:00.

Since the time of 1033:39 represented a definite time point in the transcribed recording tapes approximately midway between the foregoing time computations, it was selected for the purpose of plotting the approximate geographical positions of the aircraft along the flight path at one-minute intervals.

The flightpath of United 826 as derived from the flight recorder readout was plotted independently of the information obtained from the communications tapes. The two tracks depicted in Figure 19 are similar. The starting point of each track was the point of collision as determined by the trajectory study. The flightpath was then worked out in reverse from this point using the information obtained from the flight recorder readout. The successive points were determined and plotted back along the flight path to Allentown. The data points were then joined in a faired curve.

Flight recorder tapes of selected flights making ILS approaches under instrument weather conditions to New York International Airport from the areas of airways Victor 30 and Victor 123 between 8 December and 16 December 1960, were plotted. Only two of the 31 computed ground tracks included a holding pattern at Preston. Most of the remaining tracks indicated turns at or in the general vicinity of Preston. However, possible track inaccuracies resulting mainly from tolerances in indicated airplane headings and possible differences between actual and reported winds preclude determination of the exact distance from Preston at which these turns were made.

Discussion - VOR Stations ... Route Procedures

United Air Lines Flight 826 did not enter a holding pattern at Preston Intersection but proceeded northeast on Victor 123. Many theories have been advanced to explain how incorrect navigation information could have existed in the vicinity of Preston at the time of the accident. It has been suggested that false radio bearing information existed at Preston and could have been caused by co-channel interference, harmonics, industrial radio noise, reflections, vertical polarization, and a transmitter malfunction.

The theory of co-channel interference suggests the possibility that another VOR station operating on the same frequency as Colts Neck transmitted its signal by some phenomenon into the Preston area. Assuming that such a phenomenon did exist on 16 December, the resultant signal formed by the combination of two different station signals would depend on the quartz crystals being of the same calibration frequency values for each transmitter and on the phasing of the modulated bearing intelligence to form a flyable signal. For such coincidental phenomena to occur over the distance and altitudes flown by Flight 826 as it went through the Preston area is considered highly improbable.

Several industrial processes are known to generate radio signals, harmonics of which fall in the VOR frequency band. The possibility that such signals caused erroneous bearing information to be received by the United flight is extremely unlikely. Two American Airlines flights which followed the United flight over Preston by four and seven minutes respectively reported no interference.

The possibility of interference to the proper reception of VOR signals caused by other strong radio signals was investigated, and no evidence was found of such interference.

A serious condition that can arise once a null or weak signal zone is developed in the VOR pattern is the reflection of a signal of another azimuth into the null. The Colts Neck site was studied for landscape, structure, or device which would act as a reflector and retransmit a signal into a null at or near the Preston Intersection. Two objects, a metal-roofed barn and an amateur radio station antenna, were considered as possible reflectors. A mathematical analysis disclosed that the signal received by any aircraft following the path the United flight is believed to have followed would be unflyable and instrument reaction would certainly alert the crew to unusual conditions. It was suggested that two hills in the area of Colts Neck station may have reflected undesired azimuth signals into the Preston area. The reception of a satisfactory signal by two American Airlines flights over Preston a short time after the passage of Flight 826 indicated that such a condition did not exist at 4 000 or 6 000 ft.

Normally the signal transmitted by a VOR station is predominantly horizontally polarized. However, some vertical polarization exists to a small degree. A review of the flight check data of the Colts Neck station indicates a below-normal level of vertical polarization throughout its history. Such a condition could go undetected by station monitoring equipment, but the lack of such polarization before and after the accident is a strong indication that it did not occur during the period when Flight 826 was near Preston. The two American flights experienced no failure or noticeable signal variation as they followed United 826 up Victor 123.

Investigation was made of the transmitting equipment and station logs of the three stations - Robbinsville, Colts Neck and Solberg. There was no evidence to indicate that any of the three was malfunctioning prior to, at the time of, or subsequent to the accident.

Normal procedure in tracking and determining cross bearings along an airway is to use the pictorial deviation indicator (PDI) and the VOR pointers on the RMI. Two pictorial deviation indicators display an aircraft's position relative to the selected stations by presentation of the VOR information on a V-shaped pointer which rotates with heading changes and points to the selected station. The R-1 (PDI) indicators in the United Air Lines DC-8s are modified in that the indicator always points to the selected radial. There is no provision for a reciprocal switch. Compass heading information is supplied to the rotating mask which revolves with the V-bar pointer. A digital course indicator is located in a window on the upper part of the indicator.

Magnetic bearing to the station is set by the knob on the face of the instrument. A miniature aircraft is attached to the dial representing the relationship of the aircraft to the VOR radial.

The Board believed that the failure to solve the time and distance problem associated with the clearance, in conjunction with the apparent failure of the No. 2 VOR accessory unit and resultant instrument pictorial display, caused the passing of the Preston Intersection to be unobserved by the flight crew. The message to United maintenance personnel that the No. 2 navigation receiver accessory unit was inoperative was to advise that either the cockpit instrumentation, the navigation equipment or both would require attention at Idlewild. However, there was no report that navigation was difficult or impossible.

While flying from Allentown to Robbinsville Flight 826 received an amended clearance via Victor 30 and to intercept Victor 123 with further clearance to be expected at Preston. There was no delay expected. This new clearance necessitated a rapid descent and manoeuvring in order to position the flight at 5 000 ft over Preston. When the clearance was changed, with the subsequent short cut of approximately 11 NM, the crew apparently made no notation of the shortened time and distance from the interception of Victor 123 to the Preston Intersection.

The crew committed a primary error by apparently failing to record and note the time and distance required to comply with their new clearance. It is logical, in view of the rapidity with which the flight was being manoeuvred, to assume that the time and distance from the intersection of Victor 30 and Victor 123 to Preston was not corrected from the original time and distance associated with the Robbinsville/ Preston clearance. This original time and distance was probably embedded in the crew's mind and, time-wise, they would have believed that Preston had not been reached. Since the No. 2 VOR accessory unit and associated instruments were undependable, the captain would be expected to use a substitute method for determining Preston by retuning the No. 1 VOR to Colts Neck or Solberg or by tuning the No. 1 ADF to the Scotland Radio Beacon. If tuned to Scotland, the crew could have observed the pointer for the identification of Preston by reading a magnetic bearing on the No. 1 ADF, but this would have required rapid mental calculation in the interpretation of a display which could easily be misread. The ADF is considered the logical instrument to use inasmuch as the flight would normally proceed toward Scotland after receiving a clearance to depart Preston.

If the crew retuned the operable No. 1 VOR after establishing their position on Victor 123, they could have received the appropriate radial of the Colts Neck omni by selecting 166° in the window and tuning to the Colts Neck frequency. If this were accomplished before passing the intersection at Preston, they would have had an indication of the intersection by the floating pointer when passing Preston. If they had already passed Preston when the selection was completed, the indication on the dial would have been a full deflection of the pointer, at which time they could have taken some action to discontinue further flight in a northeasterly direction.

It is to be noted that the change of routing reduced the time available to the crew to retune the No. 1 VOR to Colts Neck or Solberg or to tune No. 1 ADF to Scotland radio beacon. Normally, with both VOR units operating properly, the No. 2 VOR floating pointer would pass across the centreline when the aircraft passed the Preston Intersection provided that the unit were tuned to Colts Neck and the window setting was 166° to the station. Simultaneously, the No. 2 pointer on the captain's VOR RMI would, when operating correctly, point to 166° on the VOR azimuth at the time of passing Preston. The crew would be accustomed to this instrument display.

If the No. 2 VOR accessory unit were dependable, the captain would use his No. 1 VOR and his PDI on Robbinsville and expect to see the double pointer on his No. 1 VOR pointing to 166° on the rotating azimuth when crossing Preston and at the same time the co-pilot's PDI would be indicating the crossing of Preston. It is believed that since Colts Neck facility was apparently operating normally and that the crew had used this facility while operating the flight on Victor 30, it would have been the logical aid for establishing the Preston fix. Since it is believed that the ADF was used for navigation, it is probable that the captain was transitioning to the ADF and pictorially associated this instrument with the VOR RMI. In such a case he would continue his flight until the No. 1 pointer of the ADF Indicated 166° on the RMI. With the No. 1 ADF tuned to Scotland, the collision occurred when the single pointer was indicating approximately 153° and had not reached the erroneously desired 166°. This, coupled with the facts that the crew had informed approach control that they were coming up on Preston, that the altitude at time of collision was a little over 5 000 ft, that radar service had been terminated, and that the crew had not reported over Preston, all tend to support the conclusion that the crew believed they had not yet reached the Preston Intersection when the collision occurred.

Also, the flight had remained on the 050° radial of Robbinsville while proceeding northeastward and little deviation from course was recorded. The time to point of collision was nearly the same as time normally required to fly from Robbinsville to Preston. The distance from normal interception of Victor 123 via the clearance to Robbinsville to Preston is approximately the same distance that the flight made from intercepting Victor 123 via Victor 30 to the crash site. Therefore, the time to travel from Robbinsville to Preston would approximate the elapsed time from Victor 30 intersection to the crash site.

The Board believed that with the above conditions prevailing the captain would be operating the controls depending upon the co-pilot to tune the navigational equipment, record new clearances, and keep him advised of other operational data. It is further logical to assume that the captain would use his No. 1 VOR pointer and the PDI unit tuned to Robbinsville frequency to maintain his position on Victor 123, and hold if necessary.

The crew had flown this air route many times and were familiar with the time and distance from Robbinsville to Preston. Also, at the Preston Intersection and tuned to Colts Neck the captain, when navigating with both VOR units, was accustomed to seeing the No. 2 VOR pointer in a southeast direction and to reading 166° on the No. 1 or captain's VOR azimuth. The pictorial display by the captain's ADF when tuned to Scotland with the aircraft over the crash site would resemble the VOR display when at Preston with the No. 2 VOR tuned to Colts Neck. The Preston Intersection would be identified while holding the outbound radial of 050° of Robbinsville and by a 100° indication on the RMI tuned to Scotland. It is realized that the New York area charts do not indicate specifically the bearing of Scotland from Preston, but by inspection a very close approximation of the correct bearing could be obtained.

From the foregoing, the Board concluded that the crew of United 826 did not take note of the change of time and distance which would be associated with the new clearance and probably confused the ADF display with the anticipated VOR display, thereby exceeding the clearance limits.

The Board concluded that while with this type aircraft it is possible to navigate with one VOR navigational unit, the high degree of cockpit occupation during the approach to Preston Intersection indicates that a second operable VOR unit would have assisted in a positive identification of the Preston Intersection. The change of clearance from the original "Allentown, direct Robbinsville, Victor 123 to Preston" to the short cut clearance "present heading, to Victor 30, Victor 30 to Victor 123 to Preston" added to the workload of revising and recomputing the navigational problem during a very small interval of time.

The Board further concluded that the New York Centre Controller did not observe United 826 proceeding through the Preston Intersection before he had advised the flight to contact Idlewild Approach Control and prior to the termination of radar service. When radar service was being terminated at 1033:20, Flight 826 had already proceeded eight or nine miles beyond Preston. United 826 acknowledged this transmission at 1033:27, seconds before the collision.

Probable Cause

United Flight 826 proceeded beyond its clearance limit and the confines of the airspace allocated to the flight by Air Traffic Control. A contributing factor was the high rate of speed of the United DC-8 as it approached the Preston Intersection, coupled with the change of clearance which reduced the en route distance along Victor 123 by approximately 11 miles.

Measures taken during the investigation relating to the Air Traffic Control System

Steps taken during the investigation to improve and strengthen the efficiency and effectiveness of the ATC System included the following:

1. A special regulation (SR-445) was issued which requires pilots operating under instrument flight rules to report inflight malfunctions of navigation or communication equipment
2. A program has been established for all turbine-powered aircraft to be equipped with distance-measuring equipment (DME) by 1 January 1963. One year later all aircraft of over 12 500 lb maximum take-off weight must be so equipped.
3. Radar handoff service for arriving and departing aircraft in the New York area is being performed to a much greater extent than was practiced before the accident. On a national basis, full-time radar handoff service has increased to a great extent.
4. Controllers have been instructed to issue an advisory to arriving jet aircraft to "slow to holding pattern airspeed at least 3 minutes before reaching holding fix."
5. The Stroudsbury, Pennsylvania, VOR name and identification signal (SSB) have been changed to Taunersville (TVE) because of potential confusion with Solberg VOR (SBJ).
6. The Agency has issued a speed rule which prohibits aircraft from exceeding 250 kt when within 30 NM of a destination airport and below 10 000 ft except where the safety requirement of tactical military jets dictates a higher minimum speed, which then applies to these aircraft.

- - - - - - - - - - - - - - -

ICAO Ref: AR/713

Figure 19

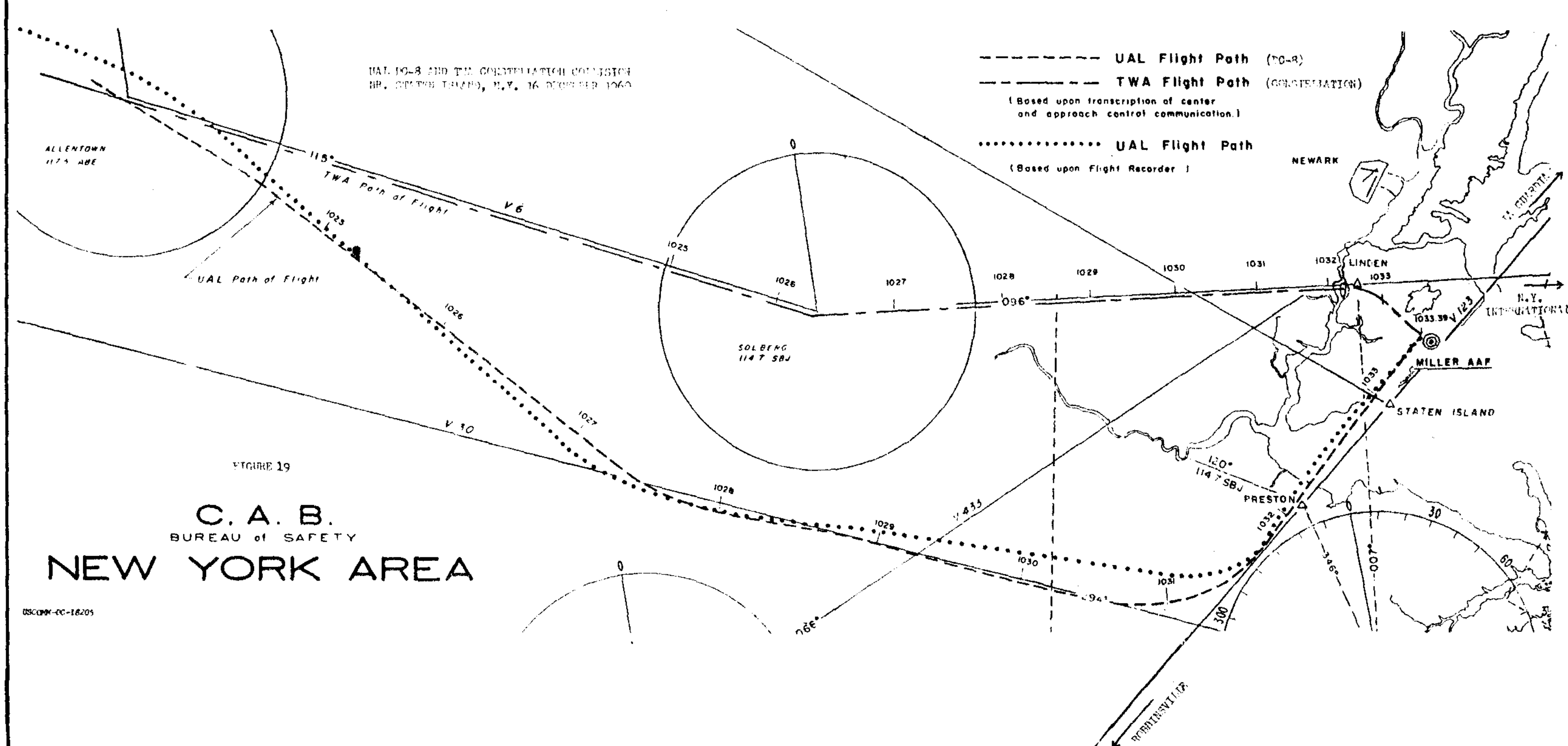
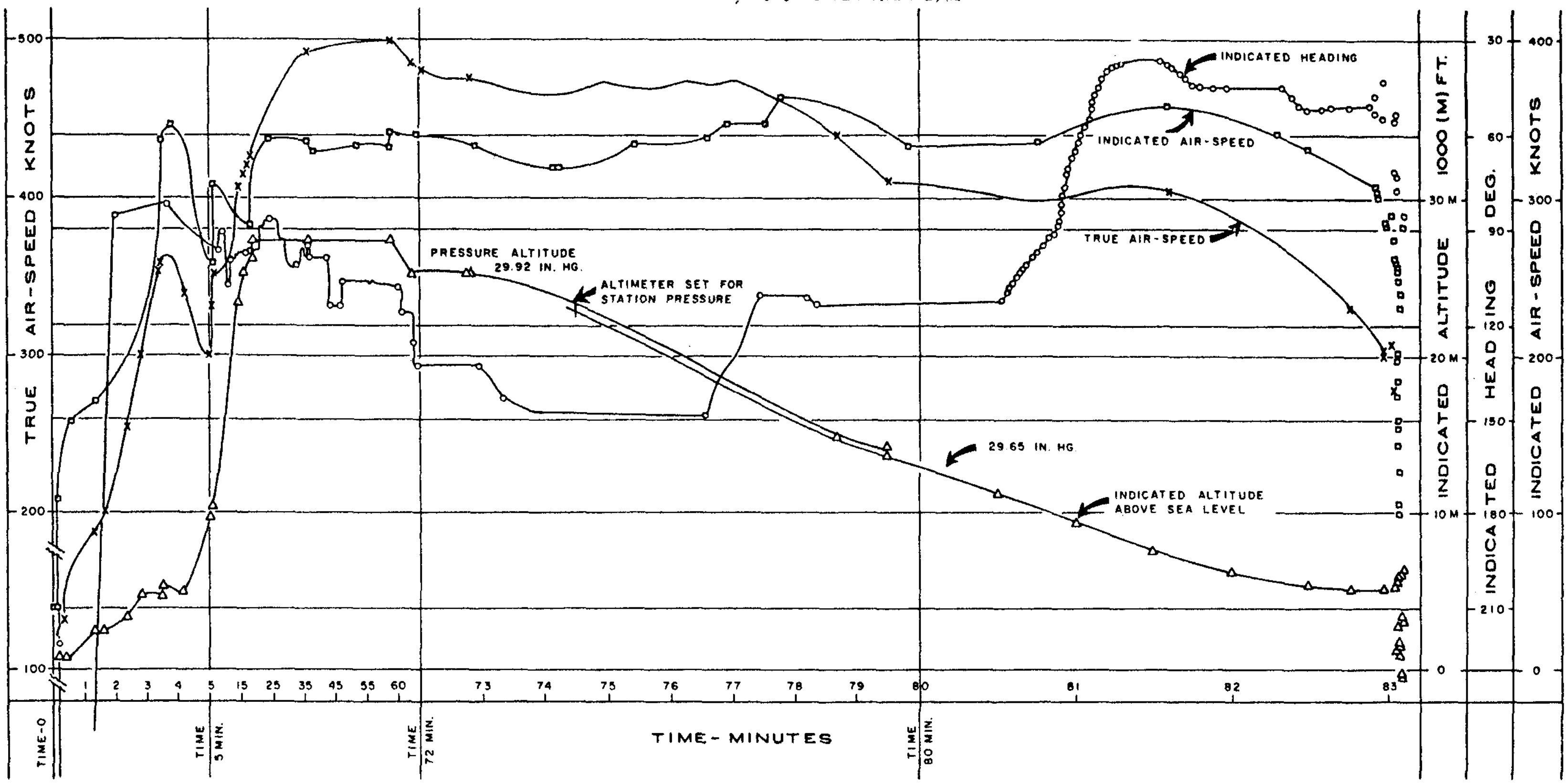

UAL Flight Path
TWA Flight Path
(Based upon transcription of center and approach control communication.)
UAL Flight Path
(Based upon Flight Recorder)
NEWARK
ALLENTOWN
TWA Path of Flight
UAL Path of Flight
V 6
V 30
SOLBERG
LINDEN
MILLER AAF
STATEN ISLAND
PRESTON
N.Y. INTERNATIONAL
1023
1025
1026
1027
1028
1029
1030
1031
1032
1033
096°
115°
120°
300
FIGURE 19
C. A. B.
BUREAU of SAFETY
NEW YORK AREA

Figure 20

FLIGHT RECORDER DATA

UAL DC-8 AND TWA CONSTELLATION COLLISION
NR. STATEN ISLAND, N.Y. 16 DECEMBER 1960



No. 66

Philippine Air Lines, Inc., DC-3C, PI-C126, accident at Talamban, Cebu City, The Philippines on 22 December 1960. Report released by the Civil Aeronautics Administration, The Republic of the Philippines

Circumstances

The aircraft, carrying a crew of 3 and 34 passengers, crashed at 3:31:40 a.m. i.e. one minute and forty seconds after taking-off from Talamban, Cebu City for Davao Airport. The flight, S-85, was part of a scheduled domestic air service.

The crash site was approximately 7 - 8° to the left of the centreline of runway 03 of Cebu (Lahug) Airport and about 2-1/2 miles from the 03 end. The aircraft was destroyed by the impact and fire. There were nine survivors, eight passengers and the flight steward.

Investigation and Evidence

The Aircraft

There was no evidence that the aircraft was not airworthy prior to the flight.

At the time of the accident it had flown a total time of 18 611 hours. It was last overhauled on 3 June 1953 and was last inspected by the CAA on 27 June 1960. It was recently converted from a 26-seater to a 40-seater. The CAA allows PAL a time between overhauls (t.b.o.) of 15 000 hours on DC-3 airframes.

The left engine had a total time of 12 348 hours, and since overhaul a time of 449 hours. It was last overhauled on 7 June 1960.

The right engine had a total time of about 5 064 hours. It was last overhauled on 5 February 1960 and had since operated a total time of 1 128 hours. Philippine Air Lines was authorized a 1 200 flying hours t.b.o. by the CAA on these engines.

The Crew

The crew of three consisted of the captain, the first officer and a steward. The steward was the only crew member to survive the accident.

The captain was the holder of an ATR licence with ratings on DC-3C aircraft and on instruments. He had logged a total time of 8 564 hours of which 7 385 hours were flown with PAL. He had flown 16 S-85 flights and 19 S-86 flights.

The first officer held a commercial pilot's licence and had ratings on L-4 and DC-3 aircraft and on instruments. He was also the holder of a flight instructor's licence with ratings on L-4 aircraft. He had logged 1 822 hours of which 1 462 were flown with PAL as DC-3 co-pilot. He had flown 35 S-85 flights and 36 S-86 flights.

The steward stated subsequent to the accident that at the time of the accident the first officer was occupying the left-hand seat and the captain was seated on the right. Investigation revealed that the first officer was not among those co-pilots authorized by the Chief Pilot of PAL to sit in the left seat position.

Loading of the aircraft

PI-C126 had a total payload of 2 553 kilos, consisting of passengers and cargo. Allegedly included with the 2 553 kilos by the PAL Station Agent at Cebu was an allowance of 52 kilos to compensate for the 14 kilo weight adjustment of the steward and the unmanifested hand-carried baggage of the passengers. The Board was of the opinion that when the aircraft took off from Cebu it weighed a little more than 26 900 lb.

(the maximum allowable). The centre of gravity was within limits.

The Flight

The flight had originated at Manila at 0010 hours and had arrived at Cebu at 0240 on 22 December. The PAL captain who flew the aircraft on this segment of the trip said he found nothing unusual in the functioning of the aircraft's engines or its components.

On its arrival at Lahug Airport the aircraft was visually inspected by the PAL junior maintenance inspector following which the first officer carried out a further visual inspection. The PAL "maintenance plane crew chief" performed the through check of the aircraft and refuelled it.

No maintenance work was done at Cebu prior to take-off. All scheduled inspections and maintenance were accomplished in accordance with the company's approved procedures. There were no findings to indicate that the aircraft was unairworthy prior to departure from Cebu.

Following a crew changeover at Cebu the aircraft took off at 0330 hours for Davao Airport estimating its arrival time there at 0530 hours. The flight was cleared to Davao via Blue 2 "out of control area Buenavista, maintain flight level 9 500 ft, climb on course, report passing Cebu Homer at 1 000 ft or above".

The controller on duty who watched the aircraft's take-off said it appeared to be normal. He waited for the pilot to call up at the Homer, which would take about 2 or 3 minutes. When he saw no aircraft proceeding to the Homer he called PAL and inquired as to whether the pilot had switched to the PAL frequency. He then started calling the pilot of the aircraft but received no answer. At 3:33 he called the Fire Department and then two minutes later he again called the PAL dispatcher. He then saw two flares and flashed a red light in the direction of the CAA fire fighting unit. This was followed by calls to the police and the city fire department to notify them that the aircraft had crashed and was burning at the end of the runway.

The accident site was on a hill top approximately 260 ft high. The tail section and rear portion of the fuselage were turned upside down as a result of the accident.

Technical Investigation

In the preliminary study of the accident the Board found that there were no significant findings and/or indications tending to associate or interrelate the behaviour of the right engine to the probable cause(s) of the accident. Evidence led the Board to believe that the right-hand engine was delivering the normal power before the crash.

On the other hand, the left engine was the subject of a more thorough study. This was based on -

1) the swerving of the airplane to the left immediately after take-off;

2) unsymmetrical bend of the left-hand propeller blades;

3) oblique scratches on the tip of one blade only of the left propeller; and

4) the absence of tip scratches on the tips of the other two blades of the left propeller.

Results of Tests and Analysis of the Findings from Strip Examinations carried out on the Engines and Propellers

The Engine

There were no indications of material failure on the right engine during the strip examination nor was there evidence of malfunctioning of any component parts/assemblies.

Concerning the left engine, the Board further examined the following:

1) the No. 4 exhaust valve, the broken exhaust valve head and the No. 4 cylinder;

2) the punctured diaphragm of the left engine fuel pump.

Additionally, the Board further found out that the fuel pump was subjected to the heat of the fire which might have developed before and/or after the crash.

No. 4 exhaust valve

The exhaust valve was found inside the No. 4 cylinder with the stem broken about 1-1/2 inches from the head. The remaining broken stem with the valve guide together with the exhaust rocker-box assembly and the push-rod were missing.

Broken exhaust valve head

The broken end showed a jagged fracture with hammered uneven surfaces. The break was not clean, but showed a diagonal fracture, elongated with resulting transversal cracks. The hammered surfaces in the broken stem were evidently caused by the reciprocating action of the piston against the broken valve.

The circumferential outline of the valve was rugged and suffered numerous dents. Only a relatively small area in the face appeared free from the pounding.

From all appearances, the valve was repeatedly battered which accounted for the flattening (to some degree) of the head proper. There was the usual amount of carbon deposit in the stem and in the face. The overall diameter of the broken valve head was reduced by about 1/16 of an inch, as a result of the pounding.

No. 4 cylinder

The piston had frozen compression rings with broken oil scraper groove. The scraper ring was also missing. The piston, on the outside faces, had a considerable amount of dried carbonaceous coating and in the upper half, the area after the topmost compression ring, there appeared scales of hardened carbon.

The top of the piston had some 40 marks from the impinging exhaust valve. The marks are elongated, imprinted by the face of the valve and sunk to a depth of about 1/8 of an inch. Prominent marks were also noted as imprinted by the broken stem.

The inside of the cylinder wall appeared to be relatively dry with a circumferential outline at the bottom part, presumably from the piston at its bottom position. The inside of the cylinder head had thick carbon deposit with deep dents on the inner concave surface of the cylinder. The exhaust valve port (valve seat) had dents appearing on its circumferential area. The dents were more pronounced at the centre half of the port.

Fuel pump

The fuel pump from the left engine when bench tested without the booster was found inoperative. There was no pressure registered. Upon disassembly, the diaphragm was found punctured. The left engine fuel pump had some 700 hours of service time. Carrying out the test further, and simulating the fire which the unit was subjected to before and/or after the crash, the Board, after replacing the diaphragm with a serviceable unit (with about the same service time), subjected the assembly to fire for ten minutes with both in and out flow lines open to the atmosphere and bench tested the same after cooling. After the tests, the diaphragm was found intact and serviceable.

Based on the results of the tests, the Board doubted the theory that the diaphragm of the left engine fuel pump was punctured as a result of the heat from the fire after the impact.

The Propellers

One of the findings considered of importance was the fact that there was no material failure to indicate a "runaway" propeller either in the left or right propeller assembly.

In the study and analysis of the bends of the propellers, there was noted a symmetrical bending on all three blades of the right propeller. Whereas, the left propeller blades presented a different picture. The bends in the three blades were considered, as they appeared, unsymmetrical. One blade of the three, had an oblique scratch at the tip, while the remaining two blades bore no scratches. The tips were clean and did not appear to have struck any object while rotating.

Based on the findings of the left propeller blades, the Board was more inclined to believe that the left propeller was probably -

1) in feathered position, or

2) in the process of being feathered, and coming to a stop.

(Tests show that it takes between 6 to 7 seconds to completely feather a propeller).

Simulated Flight

Three findings in this accident were considered very relevant by the Board -

1) the swerving of the airplane to the left by about 8° immediately after take-off;

2) the failure to gain altitude after the take-off; and

3) the statement of one of the survivors that he noted the aircraft in a nose high position went into a level position prior to the crash.

While the 8° deviation is not considered unusual, the Board wanted to further analyse the probable attendant causes thereof, considering that the normal pattern is to execute a right turn immediately after take-off to cross the Cebu NDB. The accident site was about 2-1/2 miles from the end of runway 03 of Cebu Airport from which the aircraft took off and at a 260 ft elevation approximately. The differential height would be (260 - 97 ft, the elevation of Cebu Airport) 163 ft. The Board was at a loss as to why -

1) the aircraft crashed at a location where it should not have been normally;

2) the right turn was not executed; and

3) the aircraft assumed a level position.

In an effort to ascertain the factors related to the afore-mentioned findings, a simulated flight was carried out at Cebu Airport with the CAA's DC-3C. The aircraft was loaded with the near exact weight of PI-C126 when it took off from Cebu with practically the same centre of gravity location and with almost the same temperature which had existed on the morning of 22 December (the temperature at that time was 76°F). The simulated test was carried out at 78°F.

After attaining V_2* (95 mph) the left engine was throttled to 15 in. Hg (manifold pressure) and the following results were noted:

time to reach the crash crash site	1 min 39 sec
rate of climb	150 ft per second
IAS	110 mph
elevation of PI-34 (CAA DC-3 over the crash site)	about 150 ft

The aircraft yawed to the left with heavy right rudder.

* The take-off safety speed.

The Board wished to investigate further the probable factors as to why

1) the aircraft veered 8^{o} to the left, which is considered not unusual insofar as tolerance is concerned, but nevertheless significant, the fact that the scene of the accident was not along the normal flight path after take-off;

2) the aircraft failed to attain the normal climb rate; and

3) the pilot apparently elected to continue flying straight (up to the collision point) instead of executing the right turn.

The right engine, based on the symmetrical bends of the right propeller and from the propeller "bites" on the ground appeared to be developing power when the aircraft struck the ground. Based on the practice of PAL, the power could have been along the first reduction, i.e. with 2 550 rpm and about 41.5 in. Hg. However, the Board was also of the opinion that the right engine could just as well have been on take-off power. The captain might have maintained this setting, or could have added more power on the right engine, assuming that the same had been reduced to the first reduction setting in an effort to assist in the climbout segment with a malfunctioning and/or inoperative left engine, or the pilot could have feathered the left engine. The swerving of the aircraft to the left could be caused by the above.

The Board had reason to believe that the pilot was alarmed by the malfunctioning of the left engine to the point of declaring an emergency. Several reasons could be given to justify his action, some of which are the sudden drop of the left fuel pressure as a result of the rupturing of the diaphragm and/or the vibration from the left engine which could be attributed to extraneous causes which could include the failure of the exhaust valve of the No. 4 cylinder and/or loss of compression on Nos. 2 and 4 cylinders due to frozen rings.

Tests on the fuel pump indicated that with the booster on (which the Board presumed to have been the case), there was only a fuel pressure of 10 psi which should have been about 17 psi with a great quantity of fuel spilling out from the vent. However, tests proved that with 10 psi of fuel pressure, the engine still delivered the normal power under varying rpm. This drop of pressure, together with the other attendant defects, such as the broken exhaust valve in the No. 4 cylinder and the loss of compression of Nos. 2 and 4 cylinders, could have been the reason why presumably the pilot elected to feather the left propeller. The engine malfunction could have been sensed by the pilot through his cockpit instruments and/or he felt the consequential engine vibration ensuing therefrom. The Board would not want to preclude the possibility of fire due to the spilling raw fuel. The Board would wish to advance the theory also that the feathering occurred immediately after the first reduction of power, i.e. after attaining the V_2 speed. This is considered plausible for the pilot could have elected to abandon the take-off, had engine failure occurred before V_2, for there was enough runway left to decelerate.

The aircraft with the load on board, estimated to be a little over 26 900 lb, even on single engine with the prevailing conditions at Cebu Airport at the time could still clear the 260-ft hill. Simulated tests proved this even with the left engine at 15 in. Hg and the propeller not feathered. The Board advanced the theory then that when the emergency (left engine malfunctioning) occurred after V_2 the captain in all probability increased power on the good (right) engine from the first reduction (METO) to take-off power for the climbing assist, or chopped the throttle for the emergency landing, or pushed the yoke forward to gain and/or maintain airspeed without necessarily attaining the rate of climb. It must be recalled that the aircraft at this point was not at a sufficiently high altitude to execute a 180^{o} turn back to the airport.

The above, in the opinion of the Board, explains why the aircraft was found where it was instead of along the radius of the right turn.

The Board also stated that the left engine malfunctioning could have also been caused by other extraneous factors not discussed and analysed here.

Summarizing, the Board adduced the following:

1) left engine malfunctioning which was caused by the afore-mentioned findings and which was probably sensed by the pilot, either through his cockpit instruments and/or by the consequential engine vibration ensuing therefrom;

2) the inability of the aircraft to gain altitude sufficiently to clear the hill, presumably as a result of the pilot intentionally levelling the airplane to gain airspeed, but unknowingly, maintaining an altitude low enough to cause the collision. This is interrelated with No. 1 above. The darkness contributed to the difficulty of the pilot during the emergency.

Evidence further revealed that the first officer was the one sitting in the left seat and the captain was on the right. The Board had no proof, however, that the first officer was the one flying the aircraft. According to company regulations, the first officer is not allowed to sit in the left seat unless authorized by the chief pilot. The first officer of PI-C126 was not among those authorized by the chief pilot.

Post-mortem examinations of the pilots revealed no evidence of alcohol and no appreciable evidence of ante-mortem signs of coronary occlusion.

Probable Cause

The accident was caused by the malfunctioning of the left engine shortly after take-off but after V_2 (the take-off safety speed).

Contributing factors were:

1) the darkness of the night which limited the visibility of the pilot during the emergency; and

2) the inappropriate emergency procedure(s) carried out, or resorted to by the pilot.

Recommendations

1) .. that PAL be required to conduct further study of their progressive maintenance checks and/or inspection procedures especially on the more important component parts of the engine and its accessories, such as the exhaust valves, piston rings, fuel pumps, etc.;

2) .. that in future, PAL should strictly implement their regulations as pertain to the prohibition of the co-pilots sitting in the left seat; and

3) .. that CAA should further study the possibility of installing approach and/or airport obstruction lights on all airports that are used or to be used for night operations.

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ICAO Ref: AR/680

No. 67

British Overseas Airways Corporation, Boeing 707 Series 436, G-APFN, accident at London (Heathrow) Airport, England, on 24 December 1960. Report released by the Ministry of Aviation (United Kingdom) as C.A.P. 178.

Circumstances

The aircraft made a precision approach radar descent to land on Runway 23 Left at London at the conclusion of a scheduled flight from Chicago, Illinois. It then touched down nearly halfway along the runway and as the captain was not able to bring it to a stop on the remaining length of runway it ran onto the grass surface beyond the runway end. The main landing gear units collapsed, and the aircraft was extensively damaged. No injuries resulted to any of the 11 crew members and 95 passengers aboard the flight. The time of the accident was 1138 hours GMT.

Investigation and Evidence

The Aircraft

The aircraft had valid Certificates of Airworthiness and Maintenance at the time of the accident. Its estimated landing weight on this flight was 85 405 kilos, i.e. 8 490 kilos below the maximum permissible of 93 895 kilos, and the load distribution was within the prescribed limits. The aircraft was fuelled with kerosene.

Braking System

The primary wheel braking system comprises a mechanical linkage of levers and cables which operate hydraulic metering valves situated in the main wheel bays. An electrically operated anti-skid system governs the amount of hydraulic pressure applied to the disc brake assemblies in order to prevent wheel locking. The system is designed to relieve brake pressure automatically, and when this occurs a slight kick-back can be felt on the brake pedals. An extract from the BOAC B.707 Operations Flying Manual regarding the use of brakes is as follows:-

> "Maximum braking is obtained when the wheels are braked without severe skidding. This is accomplished with the anti-skid system which relieves brake pressure automatically when a skid develops. When this happens a slight kick can be felt in the brake pedals. The proper technique is to use the brakes as on any other aircraft not equipped with anti-skid but when enough pressure is applied to cause rapid kick-backs in the pedals, release the brake pressure slightly to reduce the amount of skid cycling. In this manner the maximum braking effectiveness is being attained. Keep enough brake pressure on so that an occasional kick is felt. The above technique is applicable on any type runway surface".

The anti-skid system may be selected "on" or "off" by a switch which is located above the captain's position in the cockpit. The aircraft is also equipped with an emergency braking system which is actuated by compressed air from a cylinder normally charged to 1 200 psi. This system is completely independent of the hydraulic system and is operated by means of a hand lever at the top of the captain's instrument panel. Differential braking and anti-skid control do not function when the emergency system is used.

The Crew

Both the captain and first officer hold valid airline transport pilot licences endorsed for Boeing 707 aircraft. The captain's flying experience amounts to 15 805 hours of which 202 hours were flown in this type aircraft. The first officer has a total of 4 550 flying hours.

Runway 23 Left

This runway is 7 734 ft long, and there is no slope. The precision approach radar glide path angle for the runway is 3-1/2°, and the touchdown point is 900 ft from the outer boundary of the perimeter track or 800 ft from the runway threshold. The angle of the glide path is dictated by the presence on the approach of the Southall gasometer, which projects to a height of 327 ft above aerodrome level and is 2-1/2 miles from the touchdown point, practically on the extended centreline of the runway. This glide path angle of 3-1/2° has been in use since the introduction of precision approach radar in 1947. Up to the time of the accident no complaints concerning the angle of the glide path had been received by the Ministry from any operator.

Landing Distances

The scheduled landing distances required for the subject aircraft at a landing weight of 85 405 kilos applying the relevant operating regulations were as follows:

7 080 ft with anti-skid brake control operative and
8 580 ft with anti-skid brake control inoperative.

Applying the ambient conditions at the time of landing, the scheduled landing distances required were:

6 825 ft with anti-skid brake control operative and
8 250 ft with anti-skid brake control inoperative.

These distances include a safety factor of 1.67. The retardation effect of reverse thrust on the distances is not taken into account.

Reconstruction of the flight (See Figure 21)

The accident occurred while the aircraft was landing when on the final sector of a flight Chicago - London via Detroit, Montreal and Prestwick. It had taken off from Prestwick at 1042 hours, climbed to flight level 340 and in due course commenced its descent. As it approached Watford the approach check was carried out during which 30°flap was selected. A descent was made from flight levels 180 to 60 in the Watford holding pattern after which the aircraft was positioned for a precision approach radar talkdown on to Runway 23 Left. The London weather, broadcast at this time (1125 hours) by approach control, was - surface wind 260° at 5 kt; visibility 1.5 NM in mist; 6/8 cloud at 500 ft; 8/8 cloud at 1 500 ft.

When the aircraft had descended to 2 000 ft the landing check was completed and 40° flap selected. The airspeed index setting pointers were set to the correct V ref. figure of 132 kt, and both pilots' altimeters were set to the appropriate QNH value. Upon interception of the 3-1/2° glide path the talkdown was commenced. The captain was advised that the wind was westerly at 5 kt. According to the captain the aircraft broke cloud at about 1 500 ft, and the approach lighting came into view. During the talkdown the flight path deviations were of normal proportions, the greatest being 100 ft above the glide path when at a distance of 2 miles from touchdown. The captain stated that he maintained an airspeed of 142 kt between the time of breaking cloud and being at a height of 300 ft. At 300 ft full flap was selected and, according to the captain, the speed was gradually reduced to 132 kt over the runway threshold. The first officer believed that the speed when passing over the threshold was about 142 kt. The aircraft crossed the threshold between 35 and 59 ft above the surface, and tire marks on the runway indicated that it touched down when it was nearly halfway along the runway. There was no bounce, and the captain closed the throttles. The spoilers were then fully extended and reverse thrust on all four engines was applied at about 50% power. Just before the first officer called out "100 kt" the captain commenced to apply the brakes. Cancellation of reverse thrust was initiated at 100 kt, and the wheel braking was then progressively increased. According to the captain, the landing had appeared normal to him up to this stage, and he had no doubt that the aircraft would stop within the remaining runway length. He said he continued to increase pressure on the brakes until the pedals were at full travel, but the braking effect appeared to be far less than normal. The brakes were released and re-applied several times but with no appreciable effect. He did not detect the normal brake pedal kick-back so he switched off the anti-skid device and re-applied the brakes. By this time it was evident to the captain that the aircraft would not stop before reaching the end of the runway so he attempted to steer the aircraft through a right-hand turn of about 100° on to Runway 33 Left, which has its beginning at the end of Runway 23 Left. After an initial change in direction the aircraft commenced to skid to the left and crossed the end of the runway on a heading approximately at right angles to its original direction. After skidding a short distance on the grass surface the main landing gear units collapsed, and the aircraft came to a standstill. At no stage during the landing run was the brake hydraulic pressure observed by any of the operating crew nor were the emergency brakes operated. The crew immediately shut off engine power, the fuel supply and the electrical services. The aircraft sustained substantial damage, and fuel leakage occurred. Fire did not break out.

The Runway - after the accident

Three and a half hours after the accident, inspection of the runway revealed that its surface was moist to the extent that a squeegee effect was discernible in the tracks made by heavy aircraft, but there were no pools of standing water.

The first touchdown marks made by G-APFN were about 3 500 ft from the runway threshold and were astride the centreline. These marks showed the characteristics of wheel spin-up which included light fresh rubber smears. The wheel tracks were traced to the end of the runway. Fresh rubber smears 15 - 20 ft in length indicated that the anti-skid system was inoperative during the latter part of the landing run.

Examination of the aircraft

It came to rest on a heading of 350° M, about 50 ft beyond the end of the runway. The two main landing gear units had collapsed sideways to starboard causing associated damage in the wheel-bays and at the side-strut attachments. The port engines had become detached from their mountings. Three small punctures were present in the underside of No. 1 (port wing) tank which were made when No. 1 engine was torn away and rolled under the mainplane. It was noted that a considerable amount of fuel had drained out. The emergency air brake selector was wire-locked to the "off" position and the emergency air brake pressure was 1 100 psi. The anti-skid switch was at the "off" position.

Later examination of the aircraft did not reveal any defects which could be associated with any reduction in the braking effectiveness.

Final approach and landing - speeds

The target threshold speed for the aircraft at the landing weight of 85 405 kilos was 140 kt, and the maximum threshold speed was 155 kt.

A profile reconstruction of the aircraft's descent during the precision approach radar is shown at Figure 21. Calculations made on a basis of the time taken between the radar ranges show that the average groundspeed of the aircraft between the 4-1/2 and 1/2 mile ranges was approximately 160 kt. Bearing in mind that the wind at 2 000 ft and 1 000 ft was 230°/10 kt and the surface wind was 240°/ 4 kt it would appear likely that the aircraft's airspeed was about 10 kt higher than the groundspeed during most of the approach.

The captain's evidence that the airspeed of the aircraft during the approach was 142 kt is not consistent with the analysis of the precision approach radar talk-down, nor is it possible to reconcile the aircraft's touchdown position, nearly half-way down the runway, with the captain's belief that he crossed the threshold at 35 - 40 ft at an airspeed of 132 kt.

A post-accident calibration of the precision approach radar carried out on the day of the accident showed that the equipment was working within the prescribed accuracy tolerances.

Approach technique

In considering a possible reason why the approach and threshold speeds were too high it is necessary to examine the relationship between the glide path angle and the approach speed in light wind conditions. If the glide path angle is steeper than normal the resultant rate-of-descent will be greater than normal; also in conditions of no wind the rate-of-descent will be greater than when there is a strong headwind. When these factors are acting in combination, higher rates-of-descent will result.

To flare the aircraft from a given height an increment of lift coefficient (CL) is required which is proportional to the square of the rate-of-descent. It is therefore essential to ensure that an adequate margin of lift capability is available to achieve the flare successfully, subsequent to a high rate-of-descent. One method of doing this is by approaching the flare at an airspeed higher than the target threshold speed. It is probable that the experienced pilot will instinctively adjust the airspeed in relation to the rate-of-descent but as the amount of the increment of speed is a matter of fine judgement and the consequences of underestimating it can be more dangerous than the consequences of overestimating it, the pilot may tend to err on the safe side and select a speed that is too fast rather than too slow.

Braking technique

The instructions contained in both the Flight Manual and the BOAC Operations Manual state that upon touchdown the spoilers should be fully extended, then the wheel brakes should be applied at the same time as the nose wheel is being lowered on to the runway.

On the subject flight, reverse thrust was applied at about 50% power and its cancellation was initiated when the first officer called "100 kt". Full advantage was not taken, therefore, of the available retardation effect resulting from reverse thrust.

Maximum reverse thrust should have been used and maintained until an airspeed of 90 kt was reached whereupon the reverse thrust should have been regulated to prevent engine surge and controllability difficulties. At a speed of 60 kt reverse thrust should have been cancelled. When it became clear that the aircraft would not stop before reaching the end of the runway, it is considered that reverse thrust should have been re-applied regardless of the airspeed limitations.

The wheel brakes were operated after reverse thrust had been applied, and the speed was just above 100 kt. They were applied and released several times both with and without anti-skid control selected. There is no evidence from the runway marks, the tires or from the strip examination of the brake assemblies that the brakes did not operate normally during the landing run. It is probable that less efficient braking resulted from the captain's action of switching "off" the anti-skid switch. When he had the impression that there was no retardation from braking effort it is considered that the emergency brakes should have been used although it seems unlikely that this would have prevented the aircraft overrunning.

Probable Cause

The captain carried out the final stage of the approach to land at too high an airspeed. As a result the aircraft touched down too far along the runway and failed to stop within the remaining length.

ICAO Ref: AR/707

B.O.A.C., BOEING 707, G-APFN,
ACCIDENT AT LONDON, ENGLAND,
24 DECEMBER 1960

RECONSTRUCTION OF P.A.R. TALKDOWN OF BOEING 707 G-APFN
(Side Elevation)

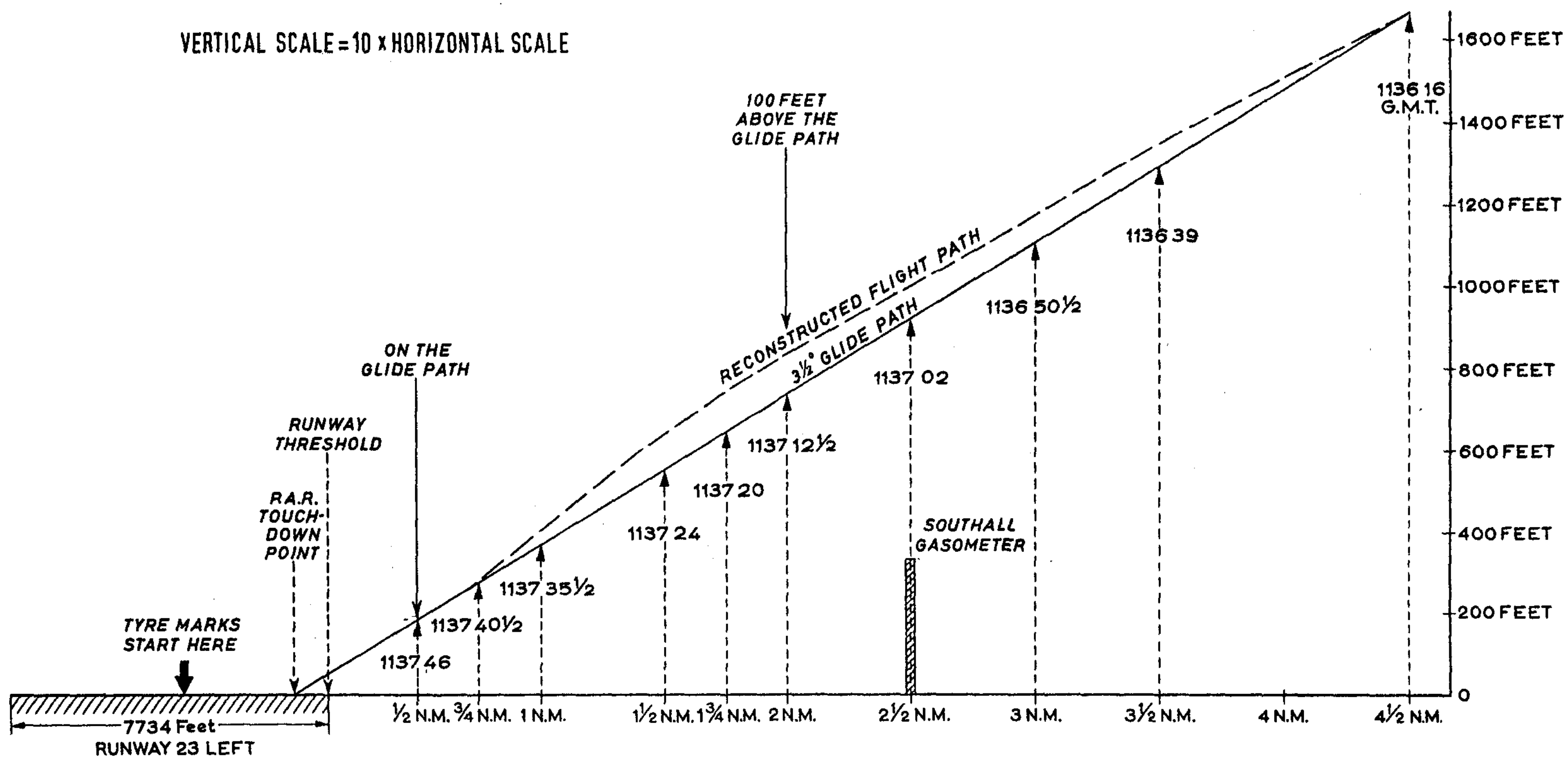


FIGURE 21

M.O.A. C.N.O.12. O.O. DRG. No. 3239 15-5-61

PART II

AIRCRAFT ACCIDENT STATISTICS 1960

INTRODUCTION

GENERAL COMMENTS

1. This section of the Aircraft Accident Digest No. 12 contains a detailed analysis of the statistics for the year 1960, as well as selected data for the years 1925 to 1961 inclusive. Figures for the years subsequent to 1951 were obtained largely from the ICAO Air Transport Reporting Forms G (Aircraft Accidents; see pages 347 and 348) 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 - 1961.

TABLE A Number of fatal accidents and passenger fatalities on scheduled air services 1925 - 1961.

4. Three tables are given for the year 1960. 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

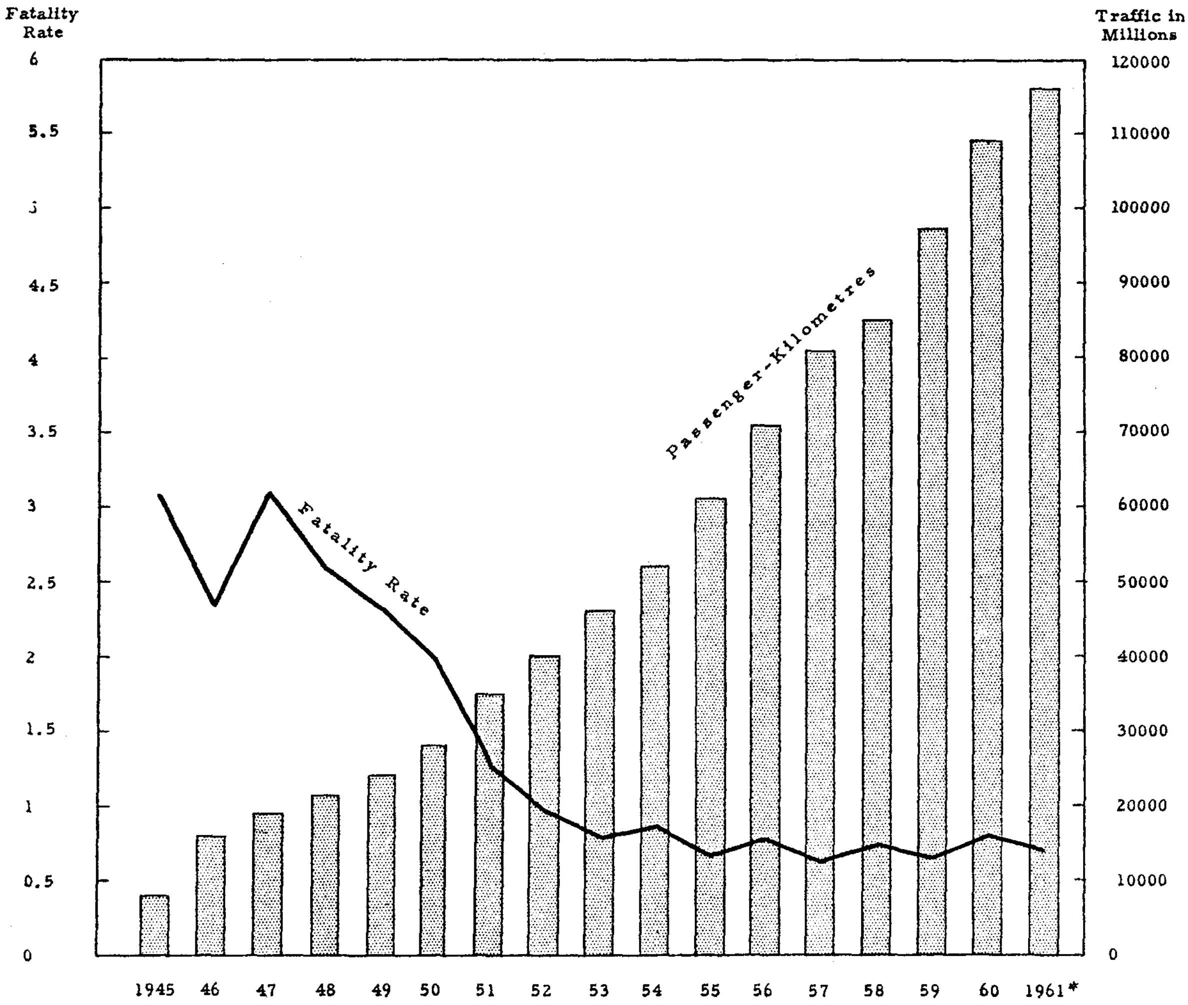
5. There has been a remarkable downward trend in passenger fatality rates since 1945, indicating a steady improvement in safety of commercial flying over the past fifteen years. The increase of speeds, weights, traffic density on airways, etc., during the last decade, has not increased the risk of accident occurrence; in fact, technological development resulted in increased safety.

6. It is to be noted that all accident data prior to 1952 are to be regarded as the best available data only, because of the fact that accidents were not so widely or fully recorded in those years. The figures show that the average fatality rate per 100 million passenger-kilometres has dropped from 12 in the 1925-1939 period to 0.95 in the 1946-1961 period.

7. From a perusal of the chart and table shown on the following pages, it will be observed that preliminary reports so far received on accidents in world air transport in the year 1961 suggest that the safety record on scheduled air services as a whole (international and domestic) was slightly better than in 1960. The accident rate for passengers, measured in fatalities per 100 million passenger-kilometres, was reduced from 0.78 in 1960 to 0.68 in 1961. It will be noted that 1960 was not a particularly good year: however, a reduction of this order (about 12%) may be considered within the annual variation to be expected from chance factors, now that over a hundred fatalities may well occur in a single accident. On the whole, therefore, 1961 can be regarded as a year in which the safety record on world scheduled air services was relatively satisfactory and it is an encouraging sign that the number of accidents in which fatalities occurred decreased by about 30% (from 32 to 22), bringing it to the lowest figure since 1952.

PASSENGER FATALITY RATE AND TRAFFIC

SCHEDULED AIR SERVICES 1945 - 1961



NOTES: Fatality rate equals number of passengers killed per 100 million passenger-kilometres flown.

* Preliminary

TABLE A

NUMBER OF FATAL ACCIDENTS AND PASSENGER FATALITIES

ON

SCHEDULED AIR SERVICES 1925 - 1961

YEARS	Accidents in which Passengers were Killed: Number of Accidents	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	27	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	8.7	0.34
1959	28	611	97 000	0.63	159	8.9	0.31
1960	32	847	109 000	0.78	129	8.6	0.37
1961 (preliminary)	22	794	116 000	0.68	146	8.2	0.27

Exclusions: The People's Republic of China and USSR.

1960

TABLE B

CONTRACTING STATES OF ICAO
PASSENGER FATALITIES OCCURRING ON
SCHEDULED INTERNATIONAL AND DOMESTIC OPERATIONS
YEAR 1960

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	101	1	26	990		
Australia	280	1	25	3 008		
Austria	9	1	26	66		
Bolivia	16+	1	55	47+		
Brasil	400*	3	79	2 817		
Colombia	147+	2	57	777+		
Costa Rica	12	1	1	55		
Denmark	38	1	35	602		
Ecuador	23*	1	34	42*		
France	334+	2	56	5 267+		
Italy	92	2	30	1 339		
Japan	89	1	2	1 051		
Mexico	200*	1	2	1 177*		
Nicaragua	4	1	1	12		
Philippines	60	2	55	286		
United Arab Republic	32+	1	17	241+		
United States	4 089+	9a/	336	62 542+		
Venezuela	88	1	10	386		
All other States	2 570	-	-	28 203		
Total	8 584	32a/	847	108 908	0.78	129
International Scheduled Operations						
Argentina	28	1	26	563		
Austria	9	1	26	66		
Colombia	21+	2	57	208+		
Denmark	34	1	35	571		
France	138+	1	55	2 933+		
Italy	66	1	23	1 145		
United Arab Republic	18	1	17	167		
United States	556+	2	10	13 367+		
All other States	1 665	-	-	23 199		
Total	2 535	10	249	42 219	0.59	170
Domestic Scheduled Operations						
Australia	239	1	25	1 932		
Bolivia	15*	1	55	44*		
Brazil	359*	3	79	2 280		
Costa Rica	4	1	1	18		
Ecuador	19*	1	34	24*		
France	196+	1	1	2 333+		
Italy	26	1	7	194		
Japan	61	1	2	569		
Mexico	153*	1	2	778*		
Nicaragua	2	1	1	5		
Philippines	58	2	55	253		
United States	3 533+	7a/	326	49 175+		
Venezuela	66	1	10	247		
All other States	1 318	-	-	8 837		
Total	6 049	22a/	598	66 689	0.90	112

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.
* Estimated data.
a/ Includes a mid-air collision, counted as one accident.

CONTRACTING STATES OF ICAO
AIRCRAFT ACCIDENT SUMMARY FOR 1960
OF ALL OPERATORS ENGAGED IN PUBLIC AIR TRANSPORT

1960

TABLE C

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	-													
∅ Argentina	3	1	26	-	26	6	9	5	-	-	39 680	64 745		
∅ Australia	4	2	25	-	69	7	-	13	-	-	nca	245 580	280 719	nca
∅ Austria	1	1	26	5	-	5	1	-	-	-	5 610	9 141	9 141	5 610
∅ Belgium	-													
Bolivia	1	1	55	-	-	4	-	-	-	-				
∅ Brazil	7	5	81	-	10	22	-	6	-	-				
Burma	-													
∅ Cambodia	-													
Cameroun	-													
∅ Canada	19	4	5	1	146	3	-	29	-	-	395 367	468 103	468 103	395 367
Ceylon	-													
Chile	-													
China (Rep. of)	-													
∅ Colombia	3	2	57	16	8	5	6	1	-	-	84 615	109 210	151 060	232 111
Costa Rica	1	1	1	-	12	-	-	1	-	-				
Cuba	-													
Czechoslovakia	-													
Denmark	1	1	35	-	-	7	-	-	-	-				
Dominican Rep.	-													
Ecuador	1	1	34	-	-	3	-	-	-	-				
El Salvador	-													
Ethiopia	-													
∅ Finland	-												50 354	43 976
∅ France	2	2	56	-	16	8	-	2	-	-	107 000	259 236		
∅ Germany (Fed. Rep.)	5	1	1	3	34	-	2	5	-	-	17 414	8 730	115 198	83 802
Ghana	-													
∅ Greece	-												31 567	21 148
Guatemala	-													
Guinea	nca	nca												
Haiti	-													
Honduras	-													
Iceland	-													
India	-													
∅ Indonesia	-												40 153	18 403
Iran	-													
Iraq	-													
∅ Ireland	-	-	-	-	-	-	-	-	-	-				
∅ Israel	-	-	-	-	-	-	-	-	-	-				
∅ Italy	2	2	30	17	-	15	1	-	-	-	54 967	95 444		
Ivory/Coast	-													
∅ Japan	1	1	2	8	20	1	-	2	-	-	24 672	31 055		
∅ Jordan	-												4 495	2 965
Korea (Rep. of)	-													
Kuwait	-													
Laos	-													
Lebanon	-													
Liberia	-													
Libya	-													
Luxembourg	nca	nca												
∅ Malaya (Fed. of)	-													
Mali	nca	nca												
Mexico	1	1	2	-	13	3	-	-	-	-				
Morocco	-													
Nepal	-													
∅ Netherlands	-	-	-	-	-	-	-	-	-	-				
∅ New Zealand	4	1	-	-	5	1	-	3	-	-	6 610	2 392	89 825	89 548
Nicaragua	1	1	1	-	11	1	-	3	-	-				
Nigeria	-													
Norway	-													
Pakistan	-													
Panama	-													
Paraguay	-													
Peru	-													
∅ Philippines	4	2	55	9	-	6	-	-	-	-	85 933	68 867	71 461	...
∅ Poland	-												19 167	11 164
Portugal	-													
Senegal	nca	nca												
∅ Spain	1	-	-	-	63	-	-	8	-	-	38 735	72 892		
Sudan	-													
∅ Sweden	10	-	-	-	3	-	1	14	-	-	35 964	22 305	145 908a/	
∅ Switzerland	1	1	-	-	37	-	-	4	2	-	49 257	83 558		
Thailand	-													
∅ Tunisia	-												8 527	6 263
∅ Turkey	-												28 184	22 658
∅ Union of S. Africa	14	-	-	-	146	-	-	29	-	-			108 647	78 176
United Arab Rep.	1	1	17	-	-	6	-	-	-	-				
∅ United Kingdom b/	38	2	-	9	759	4	1	119	-	-	323 746	518 830	621 990	414 762
∅ United States c/	100d/	18d/	429	47	2 460	57	8	328	14	1	3 144 938	3 797 453	4 655 228e/	3 931 488f/
Uruguay	-													
∅ Venezuela	17	1	10	-	33	3	-	26	-	-				
∅ Viet-Nam (Rep. of)	-	-	-	-	-	-	-	-	-	-	5 749	7 432	7 432	5 749
Yugoslavia	-													
Total for 83 States	243	53	948	115	3 891	167	29	598	16	1				
TYPE OF OPERATION														
Scheduled International	26	12	249	45	667	53	9	113	3	-	see Table D			
Scheduled Domestic	108	26	598	43	2 753	85	7	324	11	1				
Non-Scheduled International	24	3	74	12	316	10	2	43	-	-				
Non-Scheduled Domestic	61	9	25	13	142	9	2	77	2	-				
Non-Revenue	16	3	2	2	-	10	9	30	-	-				
Scheduled Territorial	4	-	-	-	3	-	-	7	-	-				
Non-Scheduled Territorial	4	-	-	-	10	-	-	4	-	-				
Total Operations	243	53	948	115	3 891	167	29	598	16	1				

NOTES: Source of data: Air Transport Reporting Form C filed by countries indicated with a ∅.
All other country data collected from outside sources.

* Estimated.
nca - No Civil Aviation.
a/ Only the Swedish quota of Scandinavian Airlines System's operations is included.
b/ Data refer to airlines registered in the United Kingdom and its dependencies. Data incomplete for number of landings and hours flown.
c/ 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.
d/ Includes a mid-air collision, counted as one accident.
e/ Certificated route air carrier industry and supplemental air carrier industry.
f/ Certificated route air carrier industry only.

1960

TABLE D

CONTRACTING STATES OF ICAO
AIRCRAFT ACCIDENT SUMMARY FOR 1960
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	1	1	26	-	-	6	-	-	-	-	9 152	16 263
ø Australia	1	-	-	-	38	-	-	9	-	-	...	52 242
ø Austria	1	1	26	5	-	5	1	-	-	-	5 610	9 141
ø Colombia	2	2	57	16	7	5	6	-	-	-	3 252	14 695
Denmark	1	1	35	-	-	7	-	-	-	-	...	...
ø France	1	1	55	-	-	8	-	-	-	-	...	109 552
ø Italy	1	1	23	17	-	11	1	-	-	-	26 440	66 102
ø New Zealand	1	-	-	-	1	-	-	1	-	-	480	380
ø Switzerland	1	1	-	-	37	-	-	4	2	-	38 551	75 623
ø Union of S. Africa	1	-	-	-	78	-	-	13	-	-	3 918	14 428
United Arab Republic	1	1	17	-	-	6	-	-	-	-	...	...
ø United Kingdom a/	8	-	-	7	307	-	1	57	-	-	109 123	278 723
ø United States	6	3	10	-	199	5	-	29	1	-	110 425 b/	305 873 b/
Total for 13 States	26	12	249	45	667	53	9	113	3	-		
SCHEDULED DOMESTIC OPERATIONS												
ø Argentina	1	-	-	-	26	-	1	5	-	-	28 424	45 412
ø Australia	2	1	25	-	31	4	-	4	-	-	...	169 511
Bolivia	1	1	55	-	-	4	-	-	-	-	...	...
ø Brazil	6	4	79	-	10	19	-	6	-	-	...	...
ø Canada	3	-	-	-	126	-	-	13	-	-	144 039	196 666
Costa Rica	1	1	1	-	12	-	-	1	-	-	...	...
Ecuador	1	1	34	-	-	3	-	-	-	-	...	...
ø France	1	1	1	-	16	-	-	2	-	-	...	...
ø Italy	1	1	7	-	-	4	-	-	-	-	...	...
ø Japan	1	1	2	8	20	1	-	2	-	-	24 225	30 417
Mexico	1	1	2	-	13	3	-	-	-	-	...	...
Nicaragua	1	1	1	-	11	1	-	3	-	-	...	...
ø Philippines	4	2	55	9	-	6	-	-	-	-	85 933	68 867
ø Spain	1	-	-	-	63	-	-	8	-	-	25 289	27 900
ø United Kingdom a/	8	-	-	-	206	-	-	21	-	-	105 328	99 347
ø United States	71	10	326	26	2 186	37	6	253	11	1	2 838 334 b/	2 918 979 b/
ø Venezuela	4	1	10	-	33	3	-	6	-	-	...	...
Total for 17 States	108	26	598	43	2 753	85	7	324	11	1		
NON-SCHEDULED INTERNATIONAL OPERATIONS												
ø Canada	3	-	-	-	6	-	-	1	-	-	c/	c/
ø Germany (Fed. Rep.)	2	1	1	1	29	-	1	4	-	-	8 153	5 721
ø Sweden	1	-	-	-	-	-	-	1	-	-	69	29
ø Union of S. Africa	1	-	-	-	61	-	-	4	-	-	583	3 737
ø United Kingdom a/	8	1	-	-	205	3	-	22	-	-	4 212	4 130
ø United States	1	1	73	11	2	7	1	-	-	-	...	...
ø Venezuela	8	-	-	-	13	-	-	11	-	-	...	...
Total for 7 States	24	3	74	12	316	10	2	43	-	-		
NON-SCHEDULED DOMESTIC												
ø Canada	13	4	5	1	14	3	-	15	-	-	214 213 c/	193 321 c/
ø New Zealand	3	1	-	-	4	1	-	2	-	-	5 887	1 913
ø Sweden	9	-	-	-	3	-	1	13	-	-	26 594 b/	14 281
ø Union of S. Africa	12	-	-	-	7	-	-	12	-	-	45 358	44 616
ø United Kingdom a/	11	1	-	2	41	1	-	7	-	-	18 026	17 862
ø United States	13	3	20	10	73	4	1	28	2	-	...	...
Total for 6 States	61	9	25	13	142	9	2	77	2	-		
NON-REVENUE OPERATIONS												
ø Argentina	1	-	-	-	-	-	8	-	-	-	1 885	2 530
ø Australia	1	1	-	-	-	3	-	-	-	-	...	23 827
ø Brazil	1	1	2	-	-	3	-	-	-	-	...	...
ø Germany (Fed. Rep.)	1	-	-	2	-	-	1	-	-	-	456	374
ø United Kingdom a/	3	-	-	-	-	-	-	12	-	-	...	...
ø United States	9	1	-	-	-	4	-	18	-	-	-	31 466
Total for 6 States	16	3	2	2	-	10	9	30	-	-		
SCHEDULED TERRITORIAL												
ø Colombia	1	-	-	-	1	-	-	1	-	-	618	1 723
ø Venezuela	3	-	-	-	2	-	-	6	-	-	...	...
Total for 2 States	4	-	-	-	3	-	-	7	-	-		
NON-SCHEDULED TERRITORIAL												
ø Germany (Fed. Rep.)	2	-	-	-	5	-	-	1	-	-	9 261	3 009
ø Venezuela	2	-	-	-	5	-	-	3	-	-	...	...
Total for 2 States	4	-	-	-	10	-	-	4	-	-		

NOTES: Source of Data: Air Transport Reporting Form G filed by countries indicated with a ø.
All other country data collected from outside sources. For comparative purposes, the fatal passenger accidents on "Scheduled Territorial" has been included with "Scheduled International" and "Scheduled Domestic" in accordance, as far as possible, with the method of reporting before 1960.

a/ Data refer to airlines registered in the United Kingdom and its dependencies. Data incomplete for number of landings and hours flown.
b/ Data incomplete.
c/ Number of landings and hours flown for non-scheduled international included with non-scheduled domestic operations.

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

"SEEING THE SHEAR"

This article from USAF's "Aerospace Safety" magazine, is an adaptation of an airline technical bulletin, with additional source material from Boeing and Air Force publications. It was also released by the Flight Safety Foundation, Inc., New York, as Pilots Safety Exchange Bulletin 103/104 in April-May 1962 and is here presented with their kind permission.

"Starting his final approach at about 1 500 feet, a pilot finds himself heading into a stiff wind. Because the wind provides a substantial part of the necessary airspeed, he throttles back his engines. Suddenly, a few hundred feet above the ground, the wind dies. Only a fast increase in power prevents the airplane from stalling and crashing."

"Right?"

"Or is this right? Starting final into a stiff wind the pilot finds he has to carry extra power to bring his plane up to the runway. Suddenly, a few hundred feet from the ground, the head wind dies out. Only a fast decrease in power prevents the aircraft from overshooting."

"Or how about this version? Starting final into a stiff wind the pilot finds he has to carry extra power to maintain a normal glide path toward the runway. Suddenly, a few hundred feet from the ground, the wind dies. Only a fast increase in power prevents the airplane from stalling and crashing."

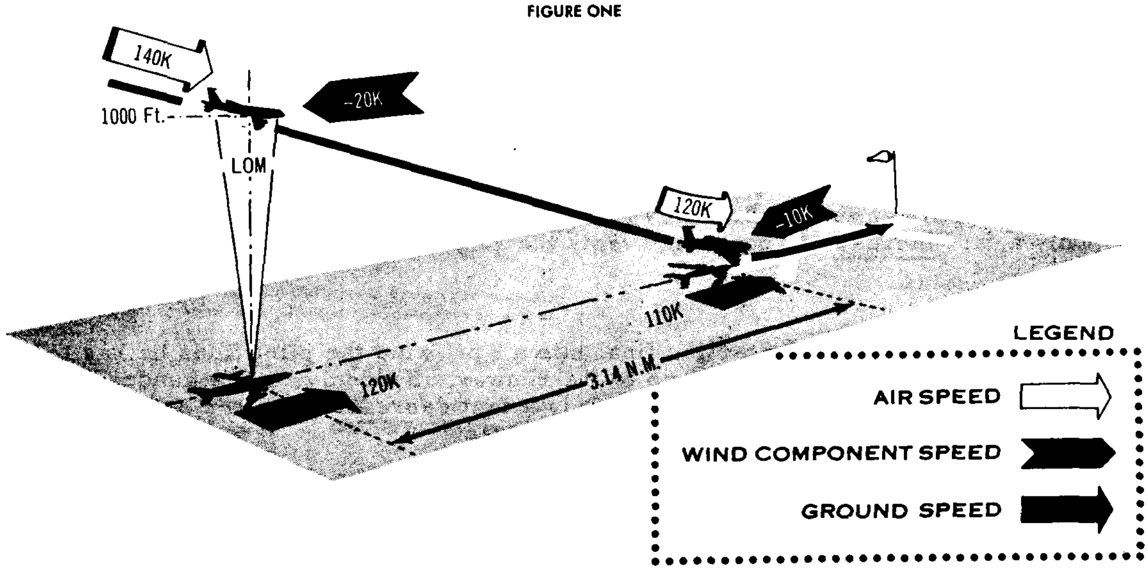
"If there is any doubt in your mind as to which of the three cases above is correct (or if there is no doubt, but you are wrong), read on. There are things you should know about wind shear."

NORMAL GLIDE PATH

"Figure 1 illustrates a normal glide path profile with a 3 degree glide path from the glide slope unit crossing the outer marker at 1 000 feet. This gives a glide slope distance of 3.14 nautical miles from the outer marker to touchdown point. For our typical case we have chosen headwinds of 20 knots at 1 000 feet and 10 knots on the surface. Speed selected is 140 knots over outer marker, tapering to 120 knots at touchdown. These conditions are considered as typical and will be used as standards for analyzing abnormal wind conditions in later examples."

"From Figure 1 we can compute that the elapsed time from outer marker to touchdown in this case is 1.64 minutes, which results in an average ground speed of 115 knots and an average rate of descent of 610 feet per minute. Also, normal airspeed deceleration from outer marker to touchdown is 20 knots and the ground speed deceleration in this case is 10 knots. The change in ground speed becomes a very important consideration when analyzing abnormal wind shear conditions because it involves the problem of rapidly accelerating or decelerating an aircraft mass of up to 150 tons during the landing approach."

FIGURE ONE



TAILWIND APPROACH

"In Figure 2 we consider an abnormal tailwind approach in which a 40-knot tailwind exists at the outer marker with a zero surface wind. As can be computed in this case, the average ground speed from the outer marker to touchdown is 150 knots, which results in an elapsed time of 1.24 minutes and an average rate of descent of 800 feet per minute for a precisely executed approach. Comparing this example with Figure 1, we see that while the airspeed is decelerated 20 knots in both cases the ground speed in the latter case must be decelerated 60 knots in a faster time than the 20 knot deceleration in the normal approach of Figure 1. This is the root of the problem, for whenever the wind environment changes faster than the aircraft mass can be accelerated or decelerated, the wind variations must be reflected by changes in airspeed. In the tailwind situation depected in Figure 2, should the pilot be unable to decelerate his

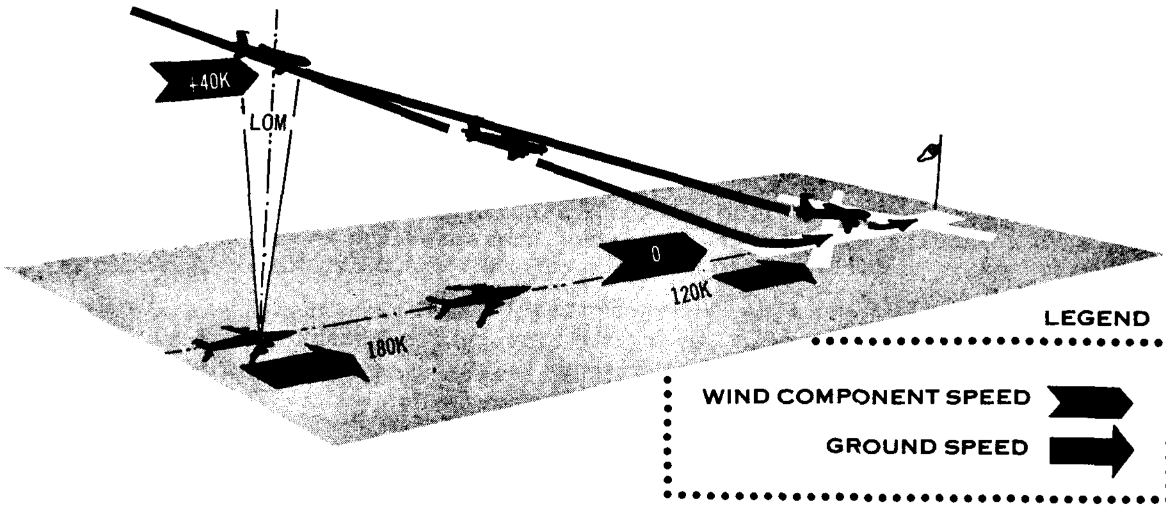


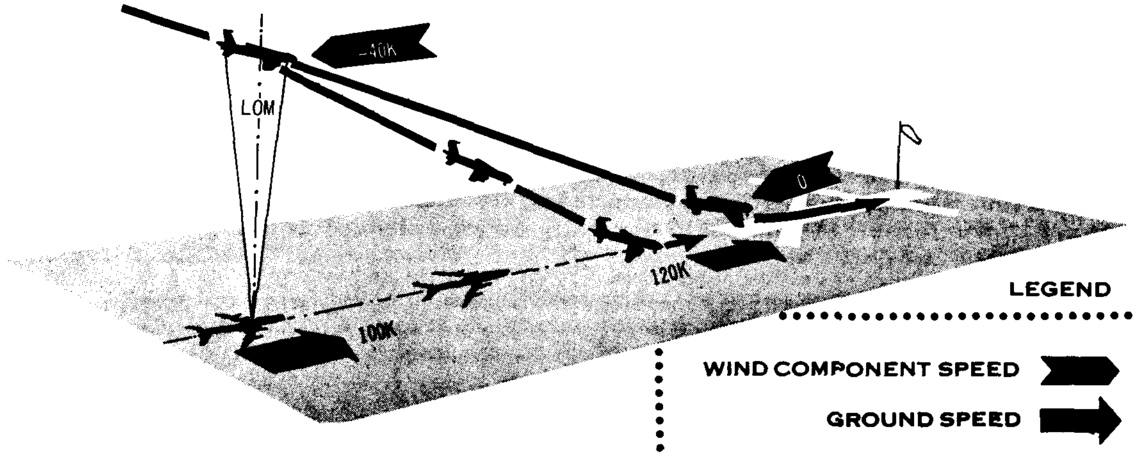
FIGURE TWO

aircraft in the faster time required, he would find his airspeed had increased, very likely he would have gone above glide path in an effort to hold desired airspeed, and he would have to go around. (Assuming, of course, he wisely resists the temptation to land long.) One more point, the more gradual the shear the more likely the pilot is to be able to decelerate to remain on glide path and at desired indicated airspeed."

HEADWIND APPROACH

"In Figure 3 we take up the strong headwind-aloft condition. In this case we have a 40-knot headwind over the outer marker and a zero component on the ground. In this case we find that the average ground speed from outer marker to touchdown is 110 knots, which results in an elapsed time of 1.7 minutes and an average rate of descent

FIGURE THREE



of 580 feet per minute for a precisely executed approach. In comparing this situation with the normal profile approach depicted in Figure 1, we see that in the headwind shear approach the aircraft ground speed must be accelerated by 20 knots during the final approach instead of the normal 10 knot deceleration. Unless this acceleration is accomplished, the aircraft will sink below the glide slope and land short of the runway. Occasionally the shear will not be gradual, but will occur rapidly. If the speed falls below stall speed the aircraft will lose altitude until it crashes or flying speed is recovered. Time required for acceleration to flying speed may exceed that available. To illustrate, following are calculations for a particular aircraft. Conditions are: altitude 1 000 millibars, power setting constant, air speed 100 knots, headwind 20 knots. When the aircraft is instantaneously placed in calm air the times to accelerate to the indicated ground speeds are:

80 knots	-	0. seconds
86 knots	-	39.9 seconds
90 knots	-	77.5 seconds
96 knots	-	175.5 seconds"

"This computation confirms tests run with a Constellation in stabilized flight at constant altitude near the stalling speed in which it was found that nearly half a minute was required before any noticeable acceleration was observed following application of full power."

"It appears that a safe landing speed from a headwind into a calm would be an airspeed equal to at least the stall speed plus the headwind component at approximately 1 000 feet above the surface."

"Aggravating the seriousness of a sudden decrease in headwind component on final approach is increased drag as angle of attack is increased to lower stall speed, with the possibility of entering the backside of the power curve (more power required to fly slower)."

"Pilots of propeller aircraft have a considerable advantage due to faster acceleration and a lowered power on stall speed due to increased airflow over the wings. Jet pilots must rely on increased airspeed alone."

"The sudden loss of headwind component can also be disastrous on takeoff - takeoffs into thunderstorm shear areas have provided several exemples of this."

WIND SHEAR IN TURNS

"The effect of encountering a wind shift during a turn deserves special mention because of the possibility in certain cases of its simultaneous occurrence with other conditions which could compound the hazard. Effects can be: a rapid drop in airspeed; a sudden increase in angle of bank caused by the side component of the new wind environment acting upon the wing dihedral, down drafts. An analysis of meteorological conditions associated with squall lines had led to the conclusion that the simultaneous occurrence of the three hazards could normally be experienced in the Northern Hemisphere only in a left turn."

GUSTY WINDS

"When winds are gusty the airspeed will vary in an amount equal to the difference between the lull and the peak gusts. For this reason it is wise to carry an added airspeed allowance in a gusty wind condition to help prevent experiencing a dangerously low airspeed. This is particularly important during approaches and when circling due to relatively high drag of an aircraft with gear down, particularly when in a banked attitude. Operating procedures manuals spell out allowances to be made, usually on the order of half the value of the gustiness up to a specified figure."

VERTICAL WIND GRADIENT

"Due to reductions in wind speeds at lower levels due to surface friction, wind speed gradually increases from ground level up to the gradient level where surface friction is no longer effective. Another characteristic of wind gradient is the change in wind direction at low levels. In the free atmosphere the wind blows approximately parallel with the isobars, the lower pressure being to the left; but, in addition to reducing the wind speed, surface friction also causes the wind direction below the gradient level to flow somewhat across the isobars toward the lower pressure. As a result, the wind direction usually backs counter-clockwise from about 3 000 feet to 300 feet, the magnitude averaging 20 to 40 degrees but reaching as much as 70 to 90 degrees in isolated cases. A rule which may help in areas where wind flow is not materially affected by terrain features and obstructions is: When the runway wind is from the right and is nearly a crosswind or has a tailwind component, the gradient wind usually has a stronger tailwind component. An extreme situation of this type in a tight pressure gradient could constitute an abnormal tailwind-shear condition for aircraft using this runway. Similarly, the frictional shift of wind direction below the gradient level also increases the wind shear in a headwind approach. In this case, descent below the gradient level magnifies the decrease in headwind component, which tends to also decrease the airspeed unless ground speed is accelerated to correct for this factor."

LOW ALTITUDE WIND GRADIENTS

"Wind gradient effects normally benefit an airplane during take-off, because as the plane climbs into increasing wind velocity the indicated airspeed increases faster than the airplane actually accelerates relative to the ground. Just the opposite occurs on landing. A high level headwind that decreases as the airplane approaches the ground causes a decrease in indicated airspeed that could, under certain conditions, allow the aircraft to touch down earlier than expected. As the airplane descends to the runway some bleed off in airspeed should be expected. During the last portion of the descent, a pilot should be prepared to add considerable thrust to accelerate the airplane in case the airspeed bleed off due to wind gradient is more than expected. A rule of thumb to partially compensate for wind gradient is to add one half the headwind to the approach reference speed, allowing the airspeed to bleed off rather than attempt to hold the approach speed plus the one-half headwind and gust correction factor (maximum of 20 knots total)."

LOW LEVEL JET

"The low level jet is a phenomenon most common over the flat terrain of the Great Plains that reaches a maximum during the middle of the night. In one reported case, at 1700 the wind at 900 feet was 28 mph, at 0300 the next morning it had increased to 67 mph and at the same time the wind speed 30 feet above the ground was 15 mph. Formation of this phenomenon is tied in with nocturnal inversions with wind above the inversion speeding up and giving birth to the jet. This condition, because of its magnitude and occurrence close to the surface, poses a low level shear hazard to aircraft."

"Shear can also be expected from di-urnal cooling. The air close to the ground cools and settles, some fog may form, and about sunrise the upper air starts to move with the result that a low altitude shear - as much as 20 to 30 knots in 200 to 300 feet - results. This shear condition normally dissipates quite rapidly."

CLUES

"Figure 4 provides an indication of clues to wind shear that the pilot can pick up in the pattern. Assuming a calm, or near calm surface wind, if crabbing as depicted in A or B is necessary, lateral shear can be expected on final. If crabbing is required as depicted in C, a tailwind component is present at pattern altitude and over-shoot problems, as discussed in the section on TAILWIND APPROACH, should be anticipated. If crabbing is required as depicted in D, a headwind component is present and a short touchdown potential exists if the gradient is large enough and occurs rapidly during the final approach path."

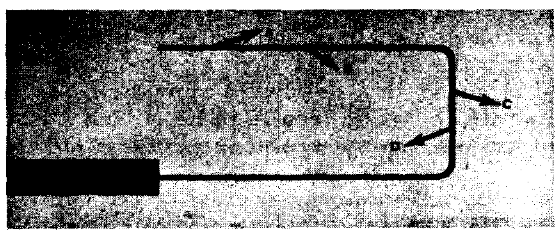


FIGURE FOUR

"Shear can be anticipated whenever there is an inversion (Figure 5). Shear is also a hazard potential with frontal passage and in and near thunderstorms. Severe down drafts associated with thunderstorms warrant delaying take-off or landing when such storms are over or adjacent to the airfield. Shear should be anticipated when taking off or landing over cliffs, water, in hilly terrain and with large buildings or trees adjacent to the runway. Normally, the severity of such low altitude wind shear bears a direct relationship to the surface wind speed. Don't overlook the help you can obtain from the weather forecaster. Check with him before take-off and, when you suspect shear, call him before making your final approach."

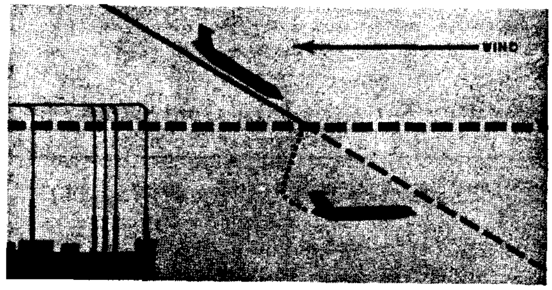


FIGURE FIVE

ANSWERS

"By now we trust you have figured out which of the three conditions posed in the beginning of this article is correct. Also, you may have done some projected thinking and figured out that converse situations could exist. Suppose you have calm air at pattern altitude, but a surface wind. For example, as you start to flare from your calm wind final approach you encounter a 15-knot headwind. Now you have 15 knots more speed to bleed off before reaching normal touchdown speed, and face a go-around or long landing situation. And if the surface wind you encounter is a tailwind . . . you've arrived, ready or not."

"Apply wind shear hazard planning for the aircraft you fly. When you have strong surface headwinds reported, aim a bit farther down the runway. Ground speed will be less and roll out distance will be shortened. If shear is probable, a rather flat approach has been recommended by some in order to transition the shear area more slowly and allow more time for correction. If taking off into suspected shear, accelerate as rapidly as conditions permit until safely above stall speed."

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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. 11)

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, 1957: 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

1951	July	24	Portaria No. 280 - Recommendations relating to aircraft accident investigations.

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 up to 13 March 1956: Part X. - Investigation of Accidents.
1949	August		Notice to Airmen No. 5/49 - Aircraft Accident and Incident Investigations.
1957			Notice to Airmen No. 8/57 - Reporting of accidents and incidents involving aircraft.

CANADA

1960	Dec.	29	The Air Regulations, Order in Council P. C. 1960-1775, (SOR/61-10): 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).

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. II, 17) Investigación de Accidentes.

CZECHOSLOVAKIA

1947			Decree of Ministry of Interior on accident investigation, No. 1600/47.
1956	Sept.	24	Civil Aviation Law: Para. 45. - Investigation of Aircraft Accidents.

DENMARK

1920	Sept.	11	Air Navigation Regulations: Para. 22 - Notifications in case of certain aircraft accidents.

ECUADOR

1954	julio	8	Reglamento de Aeronáutica Civil del Ecuador, Núm. 7: 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.

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.

GERMANY (FEDERAL REPUBLIC OF)

1959	Jan.	1	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.

GHANA

1937	Feb.	17	Aircraft (Accident) Regulations, No. 5/1937.

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.

ITALY

1925	Jan.	11	Decree Law No. 356 - Rules for Air Navigation: 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 up to 15 April 1958: Chap. 9 - Article 132. - Investigation of Accidents.

LEBANON

1949	Jan.	11	Aviation Law: Chap. III. - Sub-Chapter 2 - Landing of Aircraft, (Art. 39).

LIBYA

1956			The Civil Aviation Law No. 47: Part VI. - Accident Inquiry (Annex 13).

MALAYA (FEDERATION OF)

1953	Nov.	1	Air Navigation (Investigation of Accidents) Regulations (L. N. 584/53).

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).

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: Art. 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.

NORWAY

1923	Dec.	7	Civil Aeronautics Act, as amended up to 17 July 1953: Chapter XI.
			Royal Resolution - Regulations on aviation enacted by the Department of Defence, 15 October 1932, in accordance with the Civil Aeronautics Act of 7 December 1923, and the Royal Resolution of 22 April 1932, as amended: VIII. - Aircraft Accidents.
1956	Sept.	21	Regulations (Nr. 68) establishing a Commission for the investigation of accidents.

PAKISTAN

1934	Aug.	19	The Aircraft Act, No. XXII of 1934 (corrected up to 25 October 1950): Para. 7. - Power of Central Government to make rules for investigation of accidents.
1937	March	23	The Aircraft Rules (corrected up to 24 February 1956): Part X. - Investigation of Accidents. (Amended on 7 February 1956).

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 of the Philippines, 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.

RHODESIA AND NYASALAND (FEDERATION OF)

1954	March	26	The Aviation Act, No. 10/1954: Section 13. - Enquiries.
	July	1	The Air Navigation Regulations, F. G. N. No. 246/1954, as amended: Part 18. - Accidents.

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.

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).

SWEDEN

1928	April	20	Royal Proclamation No. 85 regarding application of the Decree of 26 May 1922, (No. 383) on Air Navigation. Amended up to 1953 - (Code of Law 42: 1953): Para. 28. - Notification of aircraft accidents.
			Civil Aviation Regulations (BCL) - Operational Regulations (D): Aircraft Accident Inquiry - ICAO Annex 13.

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.

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.

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. 1653. 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
Bechuanaland Protectorate
Bermuda
British Guiana
British Honduras
British Solomon Islands Protectorate
Central and Southern Line Islands - Malden
Starbuck
Vostock
Caroline
Flint

UNITED KINGDOM COLONIES (Cont'd)

Falkland Islands and Dependencies
Fiji
Gambia (Colony and Protectorate)
Gibraltar
Gilbert and Ellice Islands Colony
Hong Kong
Jamaica (including Turks and Caicos Islands and the Cayman Islands)
Kenya (Colony and Protectorate)
Leeward Islands - Antigua
Montserrat
St. Christopher and Nevis
Virgin Islands
Malta
Mauritius
North Borneo
St. Helena and Ascension
Sarawak
Seychelles
Singapore
Somaliland Protectorate
Swaziland
Trinidad and Tobago
Uganda Protectorate
Windward Islands - Dominica
Grenada
St. Lucia
St. Vincent
Zanzibar Protectorate.

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.

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. 1/1954).

EAST AFRICA

1954-1959			The Civil Aviation (Investigation of Accidents) Regulations.

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).
	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).

JAMAICA

1953	March	24	Air Navigation (Investigation of Accidents) Regulations, (G.N. 37/53).

LEEWARD ISLANDS

1952	July	31	Civil Aviation (Investigation of Accidents) Regulations, (S.R.O. 18/52).

UNITED KINGDOM COLONIES (Cont'd)

MALTA

1956			Civil Aviation (Investigation of Accidents) Regulations.

MAURITIUS

1952	Sept.	4	Civil Aviation (Investigation of Accidents) Regulations, (G.N. 200/52).

NORTH BORNEO AND LABUAN

1950	Jan.	6	Air Navigation (Investigation of Accidents) Regulations, (S. 8/50).

ST. LUCIA

1948	Nov.	27	Air Navigation (Investigation of Accidents) Regulations, (S.R.O. No. 40/48).

ST. VINCENT

1953	Jan.	8	Air Navigation (Investigation of Accidents) Regulations, (S.R.O. No. 6/53).

SARAWAK

1953			The Air Navigation (Investigation of Accidents) Regulations, (G.N. S6/54).

SINGAPORE

1953	Oct.	1	Civil Aviation (Investigation of Accidents) Regulations, (G.N. 301/53).

SOMALILAND

1951	Nov.	7	Civil Aviation (Investigation of Accidents) Regulations, (G.N. 48/1951).

TRINIDAD AND TOBAGO

1954	Nov.	23	Air Navigation (Investigation of Accidents) Regulations, (G.N. 205/54).

UNITED KINGDOM COLONIES (Cont'd)

ZANZIBAR

1937 Sept. 4 Air Navigation (Investigation of Accidents) Regulations, (G.N. 41/1937).

UNITED STATES OF AMERICA

1958 The Federal Aviation Act of 1958, as amended (Public Law 85-726, 85th Cong., 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.

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. P.R. 35, effective March 21, 1959, 24 F.R. 2224).

1950 Sept. 15 Procedural Regulations - Part 311 - Disclosure of aircraft accident investigation information.

1959 (1) Safety Investigation Regulations - Part 320 - Notification and Reporting of Aircraft Accident and Overdue Aircraft (as issued, effective February 28, 1959, 24 F.R. 1508).

1955 Procedural Regulations - Part 399 - Statements of General Policy, as issued, effective May 25, 1955 (20 F.R. 4117); Sec. 399.26 - 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).

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.

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(1) Proposed revision of this Part in 27 F.R. 786, Doc. 62-895, January 25, 1962.

UNITED STATES OF AMERICA (Cont'd)

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	juin	1	Décret gouvernemental relatif à la navigation aérienne, modifié le 19 décembre 1951: IV. Vol (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.

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