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FOREWORD

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

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

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

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

The first Digest was issued in 1951 under the present title and with the new method of presentation. Since then, the usefulness of the series has continued to elicit favourable comment from the aeronautical world. It is hoped that States will co-operate to the fullest extent permitted by their national laws in the submission of material for inclusion in future issues of this Digest. It is recognized that investigations take a diversity of forms under the variety of constitutional and juridical systems that exist throughout the membership of ICAO and that, for this reason, accident investigation presents one of the most difficult problems of standardization in international civil aviation. At the same time it is a most fruitful source of material for the attainment of the objectives of the Chicago Convention.

The usefulness of such a publication as this is directly proportional to the

* Provisional International Civil Aviation Organization.

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

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

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. An example of such action is Summary No. 1 (TWA accident of February 1955 on Mount Sandia, New Mexico). The report was first released in Digest No. 7, then as a result of further studies it was revised in Digest No. 8. There have been still further developments since that revision, and a supplement was released in 1960 which appears at Summary No. 1 of this edition of 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. This edition contains approximately seventeen pages of such illustrations.

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 237).

Part III refers to the general subject "Hazards of the Wake". It includes recent excerpts from Flight Safety Foundation Bulletins as well as a brief reference list of other known sources of information regarding this subject.

Part IV is the most recent list of laws and regulations available relating to aircraft accident investigation, incorporating all amendments received by ICAO up to 31 December 1960.

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.

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COMMENTS ON ACCIDENT SUMMARIES AND CLASSIFICATION TABLES - 1959

Three hundred and ninety-nine* reports on aircraft accidents occurring during 1959 have been received by ICAO from twenty-five Contracting States and one non-Contracting State. The form of the original reports has ranged from a brief statement of the facts to a comprehensive account of the investigation. Selection of fifty-two accident reports for inclusion, in summary form, in this Digest has been made on the following basis:

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.

Six reports have been carried over from 1958 and have been inserted at the beginning of Part I. These 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.

For various reasons the supplementary lists of accidents known to have occurred in 1959 but not received to date have been omitted from this Digest. The general listing of smaller accident reports by country has also been omitted.

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. Less than half of the total number of accidents investigated by States are released for general publication or sent to ICAO, and of these a selection, as described above, has been made. No effort has been made in this publication to classify according to the type of operation being conducted, for instance, whether public transport (scheduled or non-scheduled), commercial, business, or training; 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 figures are not significant for statistical purposes and readers are warned not to place too much reliance on the trends indicated without comparison with other figures, 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.

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

* Of this total, three hundred and twenty-eight were Canadian reports many of which concerned private aircraft.

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.

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TABLE A:- ACCIDENT CLASSIFICATION - 1959 (based on phase of operation)

Phase of Operation	No.	Type of Accident	No.	Description	ICAO Ref.	Type ** of Operation	Page
Take-off (25%) *	13	Emergency condition - engine failed, take-off	5	Failure of a connecting rod. Burning breather discharge and abnormal exhaust flame caused an uncontrollable fire.	AR/600	S	67
				Undetermined.	AR/589	S	99
				Incorrect fuel system management.	AR/649	S	187
				Deformed ring cowl of left engine caused buffeting and a drag condition.	AR/642	S	195
				The right engine failed following take-off.	AR/646	S	233
		Emergency condition - precautionary landing	1	Failure of the forward truck beam of the left landing gear.	AR/620	S	156
		Emergency condition - forced landing	1	Port propeller oversped and starboard engine failure followed.	AR/617	T	217
		Ground Loop	1	Strong cross-wind with gusts.	AR/626	NS	74
		Collision - water	1	The aircraft crashed into the sea at night during a turn following take-off.	AR/619	S	127
		Collision - ground	1	Undetermined.	REP/GEN/8	S	181
		Collision - rising terrain	1	Navigation error and possible engine fire.	AR/611	S	213
		Engine tearaway - ground	1	Fatigue failure of propeller blade.	AR/604	S	131
		Wheels-up landing	1	Gust lock had not been placed in the fully secured position to unlock the controls prior to take-off.	AR/605	NS	189
En route (48.1%) *	25	Collision - rising terrain	7	Attempted VFR flight over mountainous terrain in restricted visibility.	AR/560	NS	51
				Attempted to clear high terrain under poor visibility conditions.	AR/615	C	101
				The aircraft drifted north of its normal track and hit a mountain.	AR/624	NS	114

* Percentages are based on the total number of 1959 accidents summarized in this Digest, i.e. 52

** S = Scheduled, NS = Non-scheduled, TR = Training, T = Test, C = Commercial, M = Military, P = Private
B = Business, D = Demonstration

TABLE A:- ACCIDENT CLASSIFICATION - 1959 (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)		Collision - rising terrain (cont'd)		Deviated from planned route.	AR/592	S	116
				Insufficient altitude during climb at normal power.	AR/593	NS	117
				Entered clouds unaware that a mountain lay ahead.	AR/594	NS	167
				Did not maintain flight in accordance with VFR rules.	AR/641	S	182
		Collision - ground	1	Embarked on a flight, which necessitated instrument flying, when not certificated.	AR/602	C	82
		Collision - water	1	Undetermined.	AR/612	NS	224
		Collision - aircraft - both airborne	2	The crews of the two aircraft did not see one another.	AR/643	TR & TR	209
				Jet formation leader did not see Beechcraft and his wingman collided.	AR/644	P & M	227
		Loss of control	6	Co-pilot's inattention to progress of flight following involuntary disengagement of autopilot.	AR/609	S	84
				Inexperienced pilot attempted to restart engine following asymmetric flight.	AR/631	P	118
				Possibility of control difficulty while passing through a line of thunderstorms.	AR/650	B	153
				Loss of control while flying under IFR conditions.	AR/645	C	170
				Pilot may have become suddenly indisposed.	AR/608	D	179
				Breaking of the gudgeon pin bearing of No.6 piston of the left engine.	AR/613	S	197
				Structural failure due to sudden overloading beyond the design strength of port wing while flying through a thunderstorm.	AR/614	S	109
		Airframe - Air	3	Loss of control in extreme turbulence. The aerodynamic loads exceeded the design strength of the aircraft.	AR/603	S	120
				Separation of improperly glued wood joint caused inflight structural failure.	AR/633	TR	177

* Percentages are based on the total number of 1959 accidents summarized in this Digest, i.e. 52

** S = Scheduled, NS = Non-scheduled, TR = Training, T = Test, C = Commercial, M = Military, P = Private
B = Business, D = Demonstration

TABLE A:- ACCIDENT CLASSIFICATION - 1959 (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)		Fire in flight	2	Cargo ignited due to contact with an unguarded light bulb.	AR/591	S	112
				Fire of undetermined origin in No.2 engine nacelle.	REP/GEN/1	NS	204
		Explosion in flight	1	Explosion in fuel vapours in tank No.7, ignited by static electricity discharges.	AR/657	S	132
		Stall	1	Navigation error.	AR/655	NS	159
		Engine tearaway	1	Structural failures during improper recovery from a "Dutch Roll".	AR/635	D	190
Landing (26.9%) *	14	Collision - rising terrain	2	Failed to identify Gray intersection properly and continued ILS approach contrary to company and regulatory procedures.	AR/597	S	53
				Failed to execute a timely abandoned approach.	AR/654	S	219
		Collision - ground	1	Attempted flight beyond ability and experience.	REP/GEN/1	C	65
		Collision - water	2	Flew below minimum altitude on final approach.	REP/GEN/8	S	59
				Attempted to continue visual flight by night in unfavourable weather conditions.	AR/628	S	60
		Collision - object - tower	1	Descended below allowable minimum altitude, inattention to flight instruments.	AR/601	NS	106
		Undershoot	1	Premature descent below landing minima, neglected flight instruments.	AR/610	S	87
		Loss of control	1	A strong gust of wind tilted the aircraft to the right during final approach.	AR/656	S	104
		Emergency condition - forced landing	2	Continued into known and dangerous icing conditions.	AR/607	NS	79
				Improperly secured bolt worked loose and loss of elevator control resulted.	AR/622	S	173
		Overshoot	3	Landed too fast on wet runway under conditions conducive to aquaplaning.	AR/636	S	124
				Ineffective brakes on wet runway.	AR/623	S	164
				Fuel contamination damaged fuel pump.	REP/GEN/12	S	232
		Ground Loop	1	Loss of directional control following a poorly executed landing.	AR/621	S	168

* Percentages are based on the total number of 1959 accidents summarized in this Digest, i.e. 52
** S = Scheduled, NS = Non-scheduled, TR = Training, T = Test, C = Commercial, M = Military, P = Private
B = Business, D = Demonstration

TABLE B:- ACCIDENT CLASSIFICATION - 1959 (based on accident causes)

Causal Factor	No.	Description	No.
Pilot (50%) *	26	- continued VFR into unfavourable weather	5
		- improper IFR operation	7
		- continued IFR below minimum	1
		- exceeded ability - experience	3
		- continued into known unfavourable conditions	2
		- became lost VFR	1
		- misuse, brakes	1
		- improper use of fuel valves	1
		- exceeded stress limits, aircraft	1
		- failed to observe aircraft	2
		- other	1
		- undetermined - possible indisposition of pilot	1
Other personnel (5.8%)	3	- co-pilot	1
		- flight mechanic	1
		- inadequate maintenance inspection	1
Power plant (17.3%)	9	- engine structure	3
		- propeller	2
		- fuel system	2
		- undetermined	2
Airframe (3.9%)	2	- wing	1
		- flight control system	1
Landing gear (1.9%)	1	- main gear	1
Weather (7.7%)	4	- unfavourable wind conditions - take-off	1
		- unfavourable wind conditions - landing	1
		- winds aloft	1
		- turbulence	1
Airport terrain (1.9%)	1	- wet runway	1
Miscellaneous (1.9%)	1	- unguarded light bulb	1
Undetermined (9.6%)	5	-	5

* the percentages are based on the total number of 1959 accidents classified (52)

PART I

No. 1

Trans World Airlines, Inc., Martin 404 aircraft, N 40416, crashed on Sandia Mountain, near Albuquerque, New Mexico, on 19 February 1955. Civil Aeronautics Board (USA) Accident Investigation Report No. SA-303, File No. 1-0063.

The final report on this accident was released on 12 October 1955 and appeared in summary form in Accident Digest No. 7. Because of controversy over certain elements in the report, further study followed and an amended report, dated 26 August 1957, was issued by the CAB. These revisions were published in Digest No. 8. Owing to further developments, the CAB, on 15 June 1960, released this supplement to its revised report of August 1957.

Circumstances

(as they appeared in Digest No. 8)

Having received the following instrument flight rules clearance by radio from the tower at 0703 hours mountain standard time - "ATC clears TWA 260 for approach at the Santa Fe Airport via Victor 19 cruise 9 000 ft, report leaving 9 000, climb northbound on the back course of the ILS localizer", the flight departed Albuquerque, New Mexico, at 0705 hours, its destination, Baltimore, Maryland, carrying a crew of 3 and 13 passengers. The tower requested the flight to report over the Weiler Intersection* (formerly the Alameda Intersection), however, after taking off at 0705 hours there were no further radio contacts with the flight. The aircraft was last seen at an estimated altitude of 3 000 ft (8 300 ft mean sea level) in a high speed shallow climb continuing its heading towards Sandia Ridge, the upper portion of which was obscured by clouds. The wreckage was sighted the following morning at 9 243 ft mean sea level, just below the crest of Sandia Mountain, approximately 13 miles northeast of the Albuquerque Airport and almost directly on a straight line course of 30 degrees magnetic from that airport (elevation 5 340 ft mean sea level) to the Santa Fe Airport (elevation 6 344 ft mean sea level). There were no survivors.

Supplemental Analysis

Co-pilot Experience

The Board's amended report of August 1957 gave the co-pilot's experience over the Albuquerque-Santa Fe route only for the month of the accident and for the previous month. It did not mention his flying that route during previous years. He had flown the Albuquerque-Kansas City route a total of 32 trips and the Albuquerque-Santa Fe route a total of 24 trips. Obviously,

* The Weiler Intersection is the intersection of the 026 radial from the Albuquerque Omni Range and the back course of the Albuquerque ILS localizer. It is 13 miles north of the centre of the Albuquerque Airport.

he was familiar with the route and the adjacent terrain, as was the captain.

Airplane Heading

During the third visit to the crash site, on 24 November 1958, the heading at the time of impact was determined to be 249° magnetic. This direction was determined by a sun compass not subject to magnetic forces or their local variations. Previously the direction was believed to be 320° as determined by a magnetic compass.

From this it was evident that the aircraft must have been turned to the left from about 35° magnetic, the direction in which it approached the mountain, through some 145°, when it struck. This is nearly a reversal of course and must have been brought about by the pilot's sudden realization of proximity to the high land. This realization could have come from a glimpse of the ground, from warning by the terrain warning indicator, or from sudden awareness of course error by reference to the flight instruments and the indications of radio navigational aids.

Weather

A detailed review of the official weather observations as taken at Kirtland Field, Albuquerque, and the observations of ground witnesses indicated that weather conditions directly over Kirtland Field and throughout the western semicircle (from Kirtland) were good. The 0708 weather observation showed scattered clouds at 4 000 ft with thin broken clouds above based at 7 000 ft and a prevailing visibility of 40 miles. The Sandia Mountains were obscured by clouds during virtually the entire duration of the flight. Various ground witnesses described the cloud conditions over and near the mountains as covering all but the bases or foothills of the mountains with slightly more of the mountain bases visible along the extreme northern end of the Sandias. The cloud bases adjacent to the mountains were further characterized as ragged, and there were snow showers present near the mountains, further restricting visibility in this quadrant. In summary, the only weather of any consequence near Albuquerque was the clouds and snow showers, which had developed owing to orographic effect over and in the immediate vicinity of the Sandia Mountains.

Fluxgate Compass System

The Air Line Pilots' Association suggested several theories which it believed could account for the flight path of the aircraft, all of which were based fundamentally on a malfunction of the fluxgate compass system.

Upon take-off from Albuquerque, a right turn was made which carried the aircraft around the airport until it reached a position in the vicinity of the northwest corner of the airport at which time the aircraft took up a heading towards the mountains. The aircraft was observed flying on this heading until lost from view upon entering the clouds that concealed the mountains.

Since deviation from the prescribed route occurred at the beginning of the flight, while the aircraft was in the immediate vicinity of the airport of departure, attention must be focused on this segment of flight to determine the most probable condition or set of conditions present at the time that could cause the crew to continue the turn after take-off beyond the proper point and assume and maintain a heading that resulted in a course leading to the mountains.

Clearly, the crux of the matter lies in the reason for the initial departure heading. Since the crew received heading information through two fluxgate compass systems, consideration must be given to the possibility of the crew's having responded to erroneous information from these systems. Also, in view of the clear weather in the

immediate vicinity of the airport, consideration must also be given to the possibility of the crew's having taken up the initial heading visually by rolling out of the turn after take-off on a course approximately parallel to what was mistakenly thought to be the north-south runway, but was the northeast-southwest runway. This proposition presupposes a considerable period of visual reference with the airport during the turn after take-off. Whether this be continuous or intermittent observation, it would provide an opportunity for the crew to detect its error through reference to familiar landmarks on the airport and sections of the city adjacent to it. Further, if valid heading information was being furnished by the compass systems, the substantial disparity between desired heading and indicated heading would serve to alert the crew to the error when they subsequently checked the aircraft heading by reference to the radio magnetic indicator (RMI), or the master direction indicator (MDI).

Considering the first possibility, that of erroneous heading information from the aircraft's compass systems, a more plausible explanation was found for the assumption of an erroneous heading as well as the failure to detect the error quickly. Further, as will be detailed, erroneous information from but one of the two compass systems need be assumed.

The misinformation envisioned is of the type produced as the result of a tilted fluxgate transmitter gyro. Proper heading information is dependent upon the sensing element being held at all times in a horizontal plane. Stability of the element is obtained through the use of a small gyro within the fluxgate transmitter. The gyro is of the self-erecting type and an additional quick erection feature is provided in the form of a caging mechanism electrically operated and controlled by a switch in the cockpit. This latter mechanism, employed prior to take-off, erects the gyro to the nearly vertical position, leaving its final position to the self-erection feature.

Although malfunctioning of a fluxgate transmitter can produce a gyro tilt condition, the operating conditions of the transmitter assemblies on the subject aircraft remain unknown since only parts of one assembly were recovered.

It has been demonstrated that it is possible that when first energized the gyro can assume a tilt angle that will produce correct heading information when the aircraft is on the take-off runway, but will indicate erroneously as the aircraft assumes other headings. Thus, failure to erect the gyro by means of its caging system before take-off can result in varying degrees of indicated heading error dependent upon actual aircraft heading, relative strengths of horizontal and vertical components of the earth's local magnetic field, and upon the degree and direction of gyro tilt. Eventually, these errors diminish in magnitude until they become non-existent as the gyro responds to its self-erection mechanism. However, at the relatively low self-erection rate of the gyro, (averaging approximately two degrees per minute), it is possible that an aircraft could become airborne before the gyro was fully erected.

Also to be considered is the possibility of gyro tilt as the result of a caging cycle taking place while the aircraft was banked. Had such an action occurred during the period that the aircraft was in its turn after take-off, either as the result of crew action or system malfunction, erroneous heading information would be displayed until the gyro had again been erected by its self-erection feature. Further, the error produced under these circumstances is one that would necessitate the aircraft being flown on a northeasterly heading in order for the compass system to indicate a northerly heading.

Heading information from the fluxgate compass systems is supplied by four instruments; an MDI and an RMI on each pilot's instrument panel. The MDI's receive heading intelligence from separate fluxgate transmitters located in the left wing tip.

The RMI is a slave instrument which receives its heading intelligence from an MDI. In the subject aircraft both RMI's were normally slaved to the co-pilot's MDI which in turn received heading intelligence from the inboard (No. 2) fluxgate transmitter. A selector switch was provided for emergency transfer of the RMI's to the captain's MDI, which receives its intelligence from the outboard (No. 1) fluxgate transmitter.

It is apparent that the aforementioned transmitter-indicator relationship would, in the event of a tilted gyro in No. 2 fluxgate transmitter, permit the display of erroneous but identical heading indications on three of the four heading indicators, the co-pilot's MDI and RMI, and the captain's RMI. The captain's MDI would, however, show a heading which was different from these three instruments.

The front end housing of one RMI was recovered at the accident site. Although its glass and pointers were missing, the bezel, mask, and dial were still in place. Careful study of these damaged parts indicated that the dial reading was approximately 272° at the time of impact. This reading is 23° from the recorded impact heading of the aircraft which, as previously mentioned, was measured as approximately 249° magnetic. Considering such unknown factors as the amount of aircraft heading change after destruction of the RMI, and the accuracy of the aircraft centreline as established within the wreckage area, it may be concluded that the RMI heading indication was substantially correct at the time of impact.

This finding does not preclude the possibility that erroneous compass information due to gyro tilt caused the crew to take up a course toward the crash site. Such initial error could have been considerably reduced in magnitude by action of the self-erection feature of the gyro as the aircraft proceeded toward the mountains, or it could have been completely removed through operation of the caging mechanism. This latter might well have occurred if the captain noted a disparity between heading indications displayed on his MDI and RMI. It would be entirely reasonable to expect that he would, under these circumstances, actuate the caging mechanisms of both compass systems to determine which system was in error.

Use of Available Navigational Aids

The Board believed that the crew intended to follow the route prescribed in the ATC clearance. This is confirmed by their care in verifying the location of the Weiler intersection, a reporting point in their clearance, by the airplane's radio receivers being found set properly for this route of flight and because the crash occurred at about 9 000 ft, the planned cruising altitude. Further, it is inconceivable that a crew familiar with the terrain features in the Albuquerque area, as was this crew, would have taken a direct route to Santa Fe at an altitude of 9 000 ft.

Each RMI is fitted with two rotatable pointers that may be used to display either ADF or VOR bearings.

Two ADF and two VHF navigation receivers were installed in the aircraft and were designated No. 1 (captain's) and No. 2 (co-pilot's). Each RMI was provided with a selector consisting of two toggle switches, one for each pointer. The single pointer indicated either No. 1 ADF or No. 1 VOR bearings depending upon the position of its toggle switch. Similarly, the double pointer could be used for either No. 2 ADF or No. 2 VOR.

Mounted directly below each RMI was a flight path deviation indicator (FPDI) the vertical needle of which responded to course displacement information derived from either the No. 1 or No. 2 VHF navigation receiver as selected by a toggle switch mounted adjacent to the instrument.

One omni bearing selector (OBS) was mounted on each pilot's panel; the one on the captain's side was used in conjunction with No. 1 VHF navigation receiver, and that on the co-pilot's side was used in conjunction with the No. 2 VHF navigation receiver.

Although the settings of the RMI and the FPDI selector switches are not known, some understanding of the technique used by the crew in this departure and of the navigation aids available to them may be deduced from a study of the factual information obtained during the investigation.

The No. 2 navigation receiver was tuned to the frequency of the Albuquerque ILS localizer and the No. 1 VHF receiver was tuned to the frequency of the Albuquerque VOR. Since the FPDI selector switches are typically positioned so as to connect the instruments to their respective receivers (captain's to the No. 1 and co-pilot's to No. 2) it may be assumed that the co-pilot was flying the aircraft with the en-route information displayed on his panel while the captain's panel was set to display the crossing of the 026-degree radial of the ABQ VOR (Weiler intersection). This latter assumption is further strengthened by finding the captain's OBS set to either 026 degrees or its reciprocal 206 degrees.

In addition to course deviation information, each crew member could display on the single pointer of his RMI the magnetic bearing to the Albuquerque omni station.

The No. 1 ADF receiver was found tuned to the frequency of the compass locator at the outer marker of the Albuquerque ILS. Its function switch was in ADF position. No. 2 ADF receiver was tuned to the frequency of the Albuquerque low frequency range station; however, its function switch and sensitivity selector were both found in the "off" position.

This indicates that the crew was using No. 1 ADF during the flight and therefore that at least one of the crew members had selected his RMI single pointer to display the bearing to the outer marker. It is probable that the co-pilot would want such information displayed on his RMI to assist in his en-route navigation while the captain would probably select No. 1 VHF navigation receiver for his single pointer to provide continuous relative bearing indication to the Albuquerque omni to assist in his identification of the Weiler intersection.

Any error in magntic heading information received from the fluxgate compass system due to gyro tilt would also be introduced into the RMI pointer when selected to VOR. This would result in the pointer following the compass card so as to indicate the magnetic bearing to the station. Under such circumstances it would not point to the station. As a result, the crew would not initially see an incongruous presentation on the RMI despite the magnetic heading error. However, if the pointer were selected to ADF position, it would point to the station regardless of compass system error and should serve to alert the crew of any substantial heading error.

In summary, the aircraft's radio navigational receivers were determined to have been set as follows:

a) The co-pilot's VHF receiver was set to the Albuquerque ILS frequency. This would enable the pilot to utilize the back course of the ILS localizer.

b) The captain's VHF receiver was set to the Albuquerque omni station and his OBS was set at either 026, or 206 degrees, the reciprocal. This would enable a check to be made of the Weiler intersection as specified in the IFR clearance.

c) The No. 1 ADF receiver was tuned to the outer marker of the ILS. This would permit use of a tail bearing to determine when the aircraft was on the proper departure course.

The Board recognized that the theory of the fluxgate compass error advanced by ALPA could not be disproven. Such error may account for the initial directional error of the flight, heading the aircraft

toward the Sandia Mountains. However, it could not account for the continued flight long past the time the crew should have noticed the error.

Several other factors must be considered along with this error to account for the continuance of this flight on the erroneous heading:

First: The magnetic compass could have been used as a cross-check for heading information.

Second: Terrain features such as the appearance of the city area, the river bed more or less paralleling the correct course, and the railroad track to the right of the correct course, could have been noted. The weather was quite clear for an ample period of time to alert the crew they were off course had they referred to ground features. In addition, it may be pointed out that this type of initial check immediately after departure might well be most pertinent inasmuch as the precipitous Sandia Mountains, then hidden by clouds, lie adjacent to the correct course and are, as a matter of fact, the highest terrain between Albuquerque and Santa Fe.

Third: The MDI on the captain's instrument panel would indicate a different heading from that of the RMI and could have been noted and should have alerted the crew that an error was present in one of the systems.

Fourth: The FPDI on the co-pilot's panel would have moved from the full fly-right position to the full fly-left position as the aircraft crossed through the localizer course north of the airport. This should have alerted the crew that they were proceeding away from the heading of the localizer and that it would be necessary to turn back to the left in order to arrive at the Weiler intersection in accordance with their clearance.

Again, in order to accept the theory offered, the Board had to conclude that both crew members were completely oblivious to all these indications, that their attention was focused entirely on the RMI, and that they did not cross-check any other flight instruments.

One other possibility, advanced by ALPA, remains which the Board also considered in this study. It is the possibility that the pilot became confused with respect to the proper sensing of the FPDI during a back course departure on the ILS. On a back course approach the FPDI would indicate a reverse reading from the normal approach. However, in departing on the back course the indications received in the FPDI would be exactly the same as an approach made normally on the front course. Even if this confusion did exist, the normal cross-checks outlined above were still available and should have alerted the crew, providing they were conducting the flight according to prescribed procedures and accepted good operating practices.

In view of the foregoing discussion the Board believed that the former report did not accurately reflect all the circumstances of this accident. It is believed that insufficient evidence exists to substantiate the reason for the deviation from the prescribed flight path. The probable cause, therefore, has been changed accordingly.

Probable Cause

The Board determined that the probable cause of this accident was a deviation from the prescribed flight path for reasons unknown.

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Scheduled
Take-off
Collision - rising terrain
Undetermined

ICAO Ref: AR/392

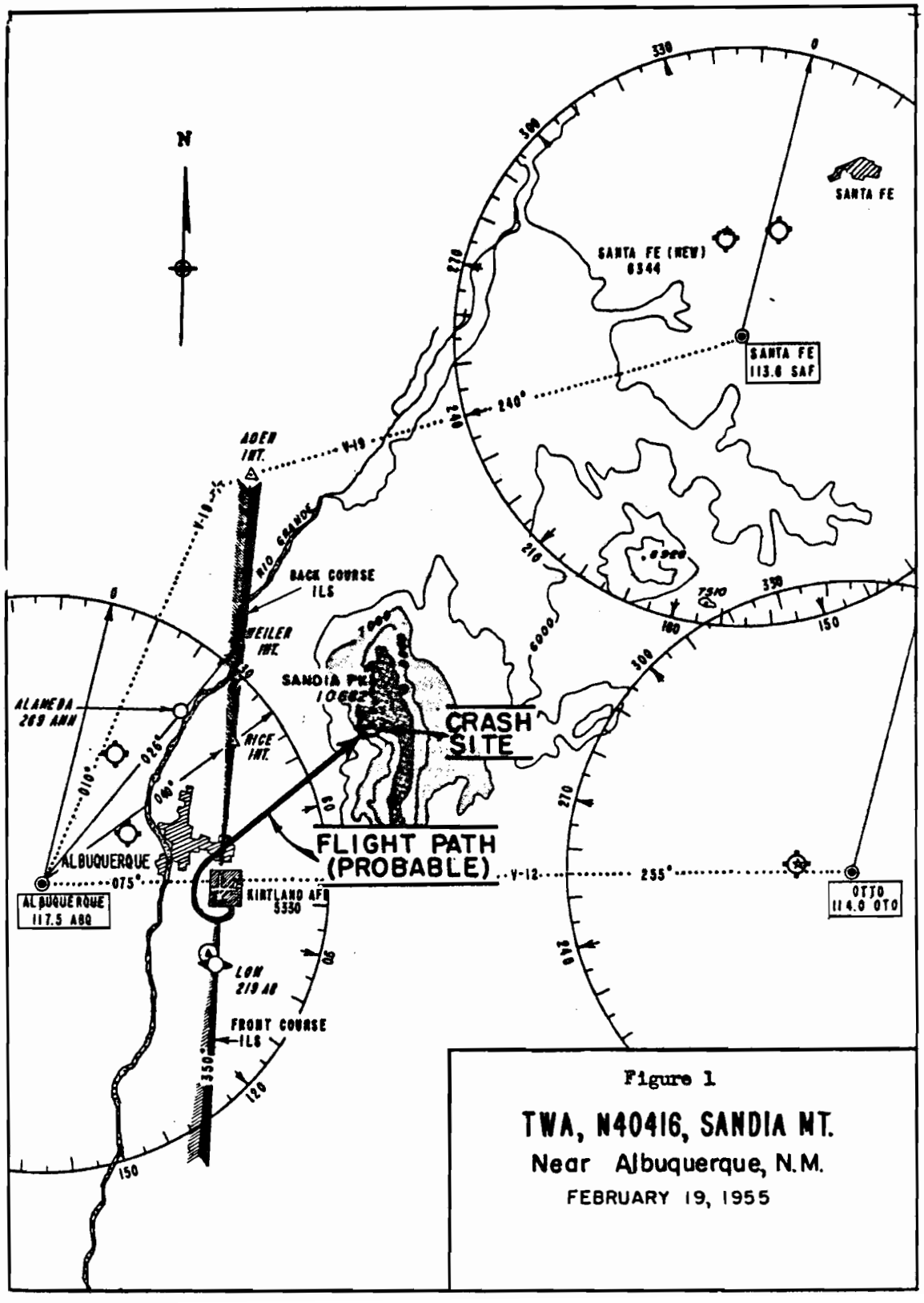

Figure 1

TWA, N40416, SANDIA MT.

Near Albuquerque, N.M.

FEBRUARY 19, 1955

No. 2

Swiss Aero Club, de Havilland Leopard Moth, HB-OKO, accident east of the terminal building, Kloten Airport, Switzerland, on 13 March 1957. Report No. 64, dated 8 January 1960, released by the Federal Air Office, Switzerland.

A summary of this 1957 accident has been included in the Digest in order that special attention may be drawn to its cause - tip vortex. Further information is available in Part III of this Digest and in Summary No. 6.

Circumstances

When coming in to land in a south-north direction on runway 28 at Kloten after a sightseeing tour of Zurich, HB-OKO's landing was delayed as a Super Constellation aircraft had priority to land on the same runway. On emerging from a left bank the aircraft suddenly entered a right bank. The right wing dropped rapidly and the nose of the aircraft sank. The pilot was unable to pull out, and the aircraft crashed from a low altitude. It turned once again slightly to the right during the crash and hit the ground with the right wing tip. Then the aircraft made a 3/4 turn and came to rest following a skid over a distance of about 20 metres. The pilot and one passenger were killed; a second passenger was seriously injured.

Investigation and Evidence

The Wreckage

The wings were torn off from their attachments at the upper part of the fuselage. The rear part of the fuselage and the control surfaces remained intact. The engine and propellers were torn free from the attachments to the engine mounting. The engine mounting itself was considerably deformed and fractured in places.

A detailed investigation of the wreckage was made at the site of the accident. Its results revealed that neither had the engine malfunctioned nor had any part of the airframe failed.

The Flight

When coming in to land on runway 28, the pilot of HB-OKO received the "landing prohibited" signal because of the landing priority which had been given to a Super Constellation coming in from the west on the same runway. HB-OKO then proceeded to the holding pattern at an altitude of 200 metres. In the meantime the Constellation was flying the downwind leg in the direction of Kloten. It completed the landing turn over Kloten and touched down a short distance from the approach end of the runway. While the Super Constellation was approximately in the middle of the landing turn over Kloten village, the runway attendant removed the "landing prohibited" signal, which consisted of a red circle. At that moment HB-OKO had already completed its holding pattern and also entered the downwind leg. The air traffic controller at Kloten Airport observed HB-OKO for the first time coming from the holding pattern at an altitude of about 200 metres on the downwind leg while it was flying towards Kloten village. He followed the aircraft until shortly before it entered the landing turn and noticed nothing unusual. Other witnesses confirmed that the approach, the holding pattern and the downwind leg manoeuvres were performed correctly with respect to altitude, speed and flight procedure. It may be assumed that the pilot noticed the Super Constellation's preparations to land while in the holding pattern or on the downwind leg at the latest. Thereupon he initiated the landing turn over Kloten at

the procedural and normal altitude for this type of aircraft. Eyewitnesses' statements led to the conclusion that the landing turn was carried out normally as regards flight safety and air traffic regulations.

The mean airspeed during the flight period between the completion of the holding pattern and the crash can be estimated with considerable accurary on the basis of the time indications registered on the control tower tape recorder. According to these indications, 80 seconds elapsed from the time the "landing prohibited" signal was removed until the crash. The distance corresponding to the phase of the flight between the completion of the holding pattern and the crash amounts to about 2 700 metres, requiring an average speed somewhat in excess of 120 km/hr to cover it. No exact conclusions could be reached with respect to the actual speed in the final phase of the landing turn - however, it remains unlikely that the aircraft flew below the authorized speed shortly before the crash. An inspection report of the Federal Air Office of 5 and 12 May 1956 gives the minimum authorized speed with a load of two persons and 3/4 fuel capacity as 78 km/hr. This load approximately corresponds to the aircraft's weight at the time of the accident. Since one of the witnesses stated that HB-OKO flew rather fast at the beginning of the landing turn, it is hardly likely that the pilot reduced speed to below the critical value during the landing turn, all the more so because for safety reasons the red mark (minimum mark) on the speed indicator for that particular type of flight has been placed at 110 km/hr. In view of the pilot's excellent record it would appear hardly likely that he would have committed such a major error. In addition, reconstruction flights proved that the radius of the turn was normal and in no way led to a dangerous attitude.

Probable Cause

In approaching to land the aircraft entered an area of great turbulence, caused by the landing 1-1/2 minutes earlier of a Super Constellation. The pilot lost control of the aircraft, which, because of the low altitude, crashed before he could regain control.

Effect of tip vortex on other aircraft

Although, in the development of aerodynamics, the tip vortex phenomenon has been known for a long time, it is only in recent years that attention has been drawn to the danger it involves for following aircraft. The reason for this is that during the war and the post-war years, aircraft of increasing wing loadings have been developed. Moreover, for some time, tip vortex incidents were attributed to other causes such as propeller or jet turbulence or gusts of wind.

As a result of various accidents or near-misses, and by means of laboratory and flight experiments, it has been established that an aircraft flying into this kind of tip vortex can be forced into a position in which it is unable to counteract the movement. According to whether it flies parallel or perpendicular to the path of the aircraft producing the vortex, it is subjected to a movement around the longitudinal axis (rolling) or around the transversal axis (pitching). If this occurs near the ground, the low altitude may be insufficient for normal flying position to be restored before contact with the ground. The violence of the vortex gusts may also impose structural overloading on the aircraft.

Experience has shown that this influence is greatest at a certain distance from the aircraft producing the vortex. Immediately behind it the effect is still small, since the vortex is in process of formation: at a greater distance it decreases again as the vortex fades owing to friction with the air. This fading depends, apart from the size of the vortex, on the condition of the surrounding air. While, normally, the vortex from a large aircraft fades 30 - 60 seconds after the passage of the aircraft (i.e. 1 - 5 km behind it), in calm air it can remain much longer.

Incidents caused by tip vortex in Switzerland and abroad

Since, before the HB-OKO accident, very little was known about incidents due to tip vortex in Switzerland, the investigator decided to inquire about such accidents at the Zurich and Geneva airports. It was revealed that in the years 1951 - 57 at least one accident and six near-misses were presumably due to tip vortex effects on these airports. Some of these occurrences were originally attributed to propeller turbulence. Subsequent findings gave the very probable conclusion that they were caused by tip vortex effects.

Some accidents in the Swiss air force also seem to have been caused in this way. The competent military authorities, therefore, performed extensive tests in 1958, confirming the information given in the section above on the effect of tip vortex. In view of the definitely established danger involved in tip vortices, detailed investigations of the problem have been made in other countries. (The original report refers to a study undertaken by the Beech Aircraft Corporation, a publication of the Douglas Aircraft Company in December 1954, and an official American investigation on a tip vortex accident which occurred on 23 August 1957 to a P-38L, N 69902, of Hycon Aerial Surveys. This accident report appears as Summary No. 36 in ICAO Aircraft Accident Digest No. 9 .)

Recommendations issued by the Federal Air Office, Switzerland, with regard to tip vortex effects

On the basis of the investigations conducted in other countries, the Federal Air Office issued Technical Notice No. 344 on 10 March 1956, pointing out the danger of tip vortex formation and containing recommendations to pilots based on available knowledge at that time. This Notice was issued to flying instructors, flying schools, airport managements, Radio Switzerland etc. In the course of the investigation, however, it became apparent that this Technical Notice had not in all cases reached the pilots. It could not be ascertained whether the pilot of HB-OKO was informed of the occurrence of tip vortex and in particular of Technical Notice 344.

After this accident the Federal Air Office issued a supplement to this Technical Notice with a more exact description of the extent of the tip vortex and the areas of danger. In the September issue of the Aero-Revue 1957 there was also an article on the tip vortex problem, based mainly on the Technical Notice of the Federal Air Office.

Further tip vortex incidents in Switzerland since the subject accident

Since the accident of 13 March 1957, i.e. during a period of more than two years, no further cases of this kind have been reported. This is no doubt due to the information issued by the Federal Air Office and published in the Aero Revue and passed on to pilots through the Swiss Aero Club. At the time of the accident the pilots had little information on the tip vortex problem but now the majority of them are well informed and know that in certain circumstances - i.e. still air or a wide angle of incidence of the aircraft producing the vortex, a following aircraft may be endangered. They have also been advised of the measures to be taken in the event of entering a tip vortex.

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Private
Landing
Loss of control
Miscellaneous - aircraft turbulence

ICAO Ref: AIG/ACC/REP/GEN/No. 15 - Switzerland

No. 3

Bristol Aircraft Limited, Britannia 301, G-ANCA, accident at Downend, Bristol, on 6 November 1957. Civil Accident Report (U.K.) No. C. 667, dated 29 February 1960. C.A.P. No. 162.

Circumstances

The aircraft was making a development flight from Filton Aerodrome, Bristol, carrying 4 crew and 11 technicians. After a flight of approximately 1 hour 40 minutes the aircraft approached Filton from the west then made a complete left-hand circuit of the aerodrome followed by the downwind leg of a second circuit. When it was at about 1 500 feet and after having commenced a left turn on to base leg, the aircraft banked steeply to the right and turned some 270° losing height in the turn until it struck the ground. All the occupants of the aircraft were killed.

Investigation and Evidence

The Aircraft

G-ANCA, owned by the Ministry of Supply and operated by Bristol Aircraft Limited, was built by the latter for the development of the 300 Series Britannia. On 19 November 1956 it had been granted a Certificate of Airworthiness in the "Special" category for research or experimental and demonstration purposes. It was equipped with the Smiths Integrated Flight System. The airframe was maintained in accordance with a Bristol Aircraft Ltd. maintenance schedule and was subject to constant modification and development. One such modification included the installation of a solid forged duralumin bladed propeller on No. 2 engine in place of the normal hollow steel bladed propeller.

At 0730 hours on the day of the accident a Flight Clearance Certificate was issued, which stated that the aircraft was airworthy.

The purpose of this flight was to carry out a test programme, which included strain-gauge measurements on the non-standard propeller of No. 2 engine, high speed upset manoeuvre recovery tests in connection with the American certification, and the making of both a ciné film and still photographic record of flight compartment instruments for use in the building of a Britannia flight simulator.

The Crew

The captain was the Assistant Chief Test Pilot of Bristol Aircraft Limited and held a Commercial Pilot's Licence endorsed for Britannia aircraft in Group I. His total flying experience amounted to 6 647 hours of which 697 were acquired in Britannia aircraft. He had been engaged in Britannia development and production flying since January 1954.

The co-pilot was a qualified Royal Air Force pilot with a total flying experience of over 3 400 hours. He had flown 16 hours as co-pilot in Britannia aircraft and had completed a course on the airframe and engines. He held no valid civil pilot's licence.

The flight engineer held no licence to fly in that capacity but was adequately trained to carry out a flight engineer's duties. This flight was his first acting as flight engineer-in-charge in this type of aircraft.

The Final Flight

Returning to Filton, the aircraft entered the aerodrome circuit and partial extensions of the undercarriage occurred for unknown

reasons. Attempts may have been made to complete undercarriage free fall tests as these had failed the previous day, however, such tests were not on the programme for this flight. At an altitude of approximately 1 500 feet, a turn to the left on to base leg was commenced, but before the aircraft had made any substantial change of direction, the right wing dipped, and the aircraft went into a right-hand turn in a very steeply banked attitude. There was a substantial recovery from the steep bank, and at about this time the call "Mayday" was sent out. The aircraft then banked steeply and lost height. Two hundred feet above the ground the angle of bank decreased momentarily, but when the aircraft struck the ground it was again steeply banked to the right.

Wreckage Examination

Inspection at the scene of the accident showed that the aircraft had struck the ground in a wood near a residential area. The main force of impact was taken by a rising bank within the wood, and complete disintegration of the aircraft resulted.

An extensive technical inspection was then carried out by the Accidents Investigation Branch. This failed to reveal any pre-crash failure or defect in the structure or the flying control circuits. The flaps were retracted on impact, and no asymmetric operation had taken place prior to their last retraction. The undercarriage was locked in the "up" position. Indications were that all the engines were running under some degree of power when the aircraft struck the ground. Strip examinations of the engines revealed nothing of an unsatisfactory nature with regard to either their mechanical or operational state.

Examination of the propellers by the manufacturers failed to reveal any evidence to indicate that each assembly was other than at a positive pitch within the constant speed range.

After consultation it was decided to move the wreckage to the Structures Department of the Royal Aircraft Establishment, Farnborough, where a partial reconstructio and a detailed examination could best take place. The examination was concerned in the first instance with the aircraft structure and primary control systems. The fact tha the aircraft had exceeded its speed limitations on the subject flight was particularly borne in mind.

The extensive disintegration of the aircraft necessitated partial reconstruction of the wings, their respective ailerons and flaps, and the tailplanes. No attempt was made to reconstruct the fuselage. The conclusions drawn from the examination were that the starboard wing had been disrupted progressively from tip to root by forces upward and backward. The port wing had been crushed by spanwise forces from tip to root, and the port and starboard tailplanes had been damaged in a manner simila to their respective wings.

The main control surfaces, their tabs and trimming circuits, were near to the neutral position at the time of impact, and there was no evidence that any hydraulic control lock had inadvertently operated in flight.

The examination was then extended to include the electrical and autopilot systems. It was established that the autopilot power switch was in the "off" position at the moment of impact but closer examination of individual components indicated that the gyro rotors and another associated motor were rotating though not under electrical power at that moment. This suggests that they were 'running down' after having been switched off a short time before the accident occurred. No direct evidence was found to indicate that the aileron servomotor clutch had remained engaged after the autopilot had been switched off.

The conclusions of the Structures Department on their examination of the wreckage were as follows:

> ".... evidence shows that the autopilot aileron channel had been damaged before the crash in a manner consistent with failure of the channel clutch to

disengage although the appropriate switches had been operated.

"It is considered that the lack of disengagement of the aileron channel could have seriously hampered the pilot's actions and led ultimately to a loss of control of the aircraft.

"There was no direct evidence as to the cause of the clutch failing to disengage, but it was most likely due to some undiscovered fault acting in conjunction with a known design fault in the electrical circuits of the autopilot/flight system."

Incident to another Britannia - G-AOVG

This aircraft was equipped with the Smiths Integrated Flight System similar to that of the subject aircraft.

During its first flight which took place on 10 January 1958 and whilst descending from 6 000 feet in instrument meteorological conditions with heavy rain and turbulence, dangerous aileron control difficulties were encountered shortly after disengagement of the autopilot by means of the cut-out button on the pilot's control column. The emergency lasted several minutes, and at times the combined efforts of the pilot and the engineer were required to maintain lateral control.

Although the autopilot cut-out buttons on both control columns had been operated, it was not until the power supply to the autopilot was cut off by switching off the appropriate inverter that the emergency was resolved.

Investigations into this incident revealed that a design fault was incorporated in the electrical circuitry of the autopilot/flight system. This resulted in single pole instead of the intended double pole operation of the aileron servomotor clutch. The fault was such that in conjunction with a stray positive feed, malfunctioning of the autopilot could occur to a degree consistent with the conditions experienced during the emergency. A stray positive feed due to defective soldering, was, in fact, ultimately located. Component inspection showed that the shaft of the force limiting link in the aileron circuit was not marked by ball indentations neither was the aileron servomotor shaft shear neck fractured despite the combined force of two men having been applied to the aileron controls.

The design fault in the electrical circuitry of the autopilot/flight system which was detected in G-AOVG was also present in the subject aircraft G-ANCA.

The Britannia - Speed Limitations

The following are the limitations for this aircraft with regard to speeds:

Normal Operating Limit Speed
250 kt indicated airspeed and 0.60 Mach

Demonstrated Flight Diving Speed
304 kt equivalent airspeed and 0.70 Mach

Following the accident to G-ANCA, a piece of paper identified as part of the Flight Test Observer's handwritten log and concerning the subject flight was recovered from the accident site. The second line of writing ".... SE at 300 kt", probably refers to a single exposure of the automatic observer panel camera. The third line indicates that very severe buffeting was experienced and a Mach number greater than .75 was registered. This line may be a continuation of the second line, and the buffeting and Mach reading may have been registered at the same time as the speed of 300 kt. If, however, it is a separate item there is the possibility that a speed higher than 300 kt registered when the Mach reading was greater than 0.75.

Observations

Numerous hypotheses as to the cause of the accident were considered before finally being rejected. Two of them are worth noting:

1. a photographic flash bulb might have burst in the cockpit and incapacitated the crew.

Glass particles extracted from the flying helmets of the crew and from the cockpit area were the subject of careful analysis. The report concluded that none of the glass extracted could have originated from the type of flash bulb used.

2. the possibility that the manoeuvrability of the aircraft may have been influenced by radio coupling to the Greenham Common VOR.

Radio flight tests were conducted in the area flown by G-ANCA, and it was found that at an altitude of 2 200 feet the VOR signals commenced to fade, and they were lost completely at 2 000 feet and below.

The final manoeuvres of the aircraft indicate that the pilot was unable to prevent it from making a steeply banked descending turn to the right.

It was the view of the Structures Department, R.A.E. Farnborough, that the evidence of the pattern of ball indentations on the aileron force limiting link and the time at which the torsion failure of the shaft of the aileron servomotor occurred suggest that the aileron channel clutch remained engaged after the appropriate disengagement switches had been operated in flight. In support of this, it was held that only slight movement of the shaft of the force limiting link should be necessary to cause the ball to enter the housing and break the electrical circuit to the clutch. During this process the ball was not intended to leave the confines of the shaft ramp and bouncing, which is necessary to make the indentations, could not occur.

The manufacturers of the autopilot argued that the servomotor shaft can be sheared and ball indentations on the force limiting link shaft can result from crash impact damage with the clutch disengaged. To support this they carried out tests which sheared the servomotor shaft in a manner similar to that of the accident aircraft and which produced representative ball indentations.

Their report on the tests carried out concludes as follows:

"The tests as carried out, have shown that the Servomotor Mounting Output Shaft can be sheared and ball indentations can be produced on the Force Limiting Link shaft, due to impact damage in either compression or extension with the Servomotor electrica clutch disengaged."

Flight Recording Equipment

On the flight of 6 November, G-ANCA carried some flight recording equipment, but this was destroyed by the force of impact, and no useful information could be obtained from any of the recordings made.

The equipment is not intended to withstand the type of shock loading to which it was subjected, but a suitably designed crash recorder might well have remained intact. The aircraft was not fitted with one.

Probable Cause

The accident was the result of the aircraft developing a very steep descending turn to the right which the pilot was unable to control. The reason for this could not be determined, but the possibility that it occurred as the result of malfunctioning of the autopilot cannot be dismissed.

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Development
Landing
Loss of control
Untermined - autopilot may have malfunctioned

ICAO Ref: AR/618

No. 4

Aviación y Comercio S.A., D.H. 114, Heron, EC-ANJ, accident near Barcelona Airport, Spain on 4 April 1958. The report, dated September 1960, was released by the Directorate General of Civil Aviation, Spain.

Circumstances

The aircraft departed Zaragoza, Spain at 1919 hours GMT on a scheduled flight to Barcelona, carrying 2 crew and 14 passengers. At 1956 it reported over Reus and was descending at that time to flight level 30 as instructed. At 2005 it commenced its descent to land. One minute later it reported that it was on a wide base leg and asked for visibility data. At this time another aircraft, EC-AEJ, requested permission to take-off but was refused. However, when EC-ANJ advised that it was five minutes away take-off authorization was then granted. Shortly thereafter, when the two aircraft were flying intersecting tracks at an altitude of 150 m, EC-ANJ, with its flaps and landing gear extended and its engine running at reduced speed was compelled to make a sudden avoidance manoeuvre. Loss of control resulted and the aircraft fell into the sea, at 2007:30 hours, killing all those aboard.

Investigation and Evidence

The Aircraft

It had a Certificate of Airworthiness valid until 7 October 1958.

The Crew

The pilot had a total of 2 361 flying hours to his credit; 1 600 with the Air Force, 253 as second pilot with Aviación y Comercio and 508 as pilot-in-command on Heron aircraft.

The radio operator had flown a total of 1 585 hours.

Both crew members held the required licences.

Weather Conditions

At the time of the accident the conditions were as follows: visibility 6 km; wind 30°/2 kt; cloud 4/8 stratocumulus at 450 m and 8/8 altostratus at 2 100 m; QNH 1003 mb.

Description of the Flight

Contact was maintained with EC-ANJ after it had reported over Reus. At 2005 it started its descent and the visibility data was confirmed. This would seem to indicate that it was then flying over the sea since according to statements of the pilot of another aircraft, EC-ABL, which was flying from Palma to Barcelona and coming in on a lower level, contact was not made until flight level 20 was reached, from which it was deduced that EC-ANJ was at that time descending from flight level 30 to flight level 20. Once EC-ANJ had reported that it was "five minutes away" control cleared EC-AEJ to take off from runway 17, indicating a course of 219°. A few minutes later EC-AEJ reported crossing the path of an aircraft at about 150m, just as it initiated a right turn to get onto the given course, making it force the turn. The other aircraft must have been EC-ANJ, which was on a base leg. It also was probably forced to make a sudden manoeuvre to avoid collision and as it had its undercarriage and flaps extended, was at a low power setting,

and its load margin was very small (about 180 kg), it lost altitude. The pilot could not recover control of the aircraft, and it crashed into the sea.

Examination of the Wreckage

It was found at a depth of approximately 60 m.

Persons who saw the wreckage before it was towed away, stated that it was located parallel to the coast, the nose towards Castelldefels and the tail towards Barcelona.

Although information supplied concerning the wreckage was uncertain and even contradictory, this was only natural because of the depth at which it was located and the darkness was accentuated by the mud which had been stirred up by the movements near the bottom of the sea. It appeared, however, that the left wing of the aircraft was torn free close to the fuselage and inner port engine, and all or a large part of it was located about 5 m from the fuselage. This wing retained the two engines and their propellers. The right wing was not found, and it was, therefore, concluded that it was torn off more violently than the left one, since there was a hole in the fuselage at the juncture with the right wing, opening rearwards into the larger hole made by the destruction of the crew's cabin and giving access to the passenger cabin.

All that could be deduced from the wreckage was that the landing gear was definitely extended at the time the aircraft struck the water. Judging from statements of those who saw and described the initial shape and condition of the wreckage and assuming their description to be correct, it was presumed that the aircraft entered the water at a steep angle, inclined toward the right.

Discussion

EC-AEJ was given permission to take-off on the strength of EC-ANJ's message "five minutes away". This was confirmed by the pilot and radio operator of another aircraft (EC-ABL) in the area. It should, however, be noted that this phra can give rise to errors since it might be taken to mean that the aircraft was five minutes from the airport on its route, or that it was five minutes from touchdown, fully engaged in the landing operation.

Control followed the first of these interpretations and authorized EC-AEJ to take-off. On the basis of "Article 20051 AN ICAO"*, when an arriving aircraft is making a straight-in approach, a departing aircraft may take off in any direction until five minutes before the arriving aircraft is over the airport. In spite of this, contrc should never have permitted EC-AEJ to depart without knowing the exact position of EC-ANJ, since the latter aircraft had sent two contradictory messages within a short space of time - "wide base leg" and "five minutes away". The situation should have been clarified by questioning the aircraft or from the VHF direction finder from which the position of EC-ANJ could have been ascertained. Then permission for EC-AEJ to take off on runway 17 should have been refused, to avoid sending it in a direction which lay only 180° from the track of EC-ANJ, which was coming in to land on runway 35, and to avoid the risk of the two aircraft meeting as they actually did.

* It corresponds to para. 12.2(a), part IV of the ICAO PANS-RAC

Probable Cause

The probable cause of the accident was the fact that EC-AEJ was permitted to take-off without the exact position of EC-ANJ being known. During avoidance action taken by EC-ANJ, loss of control occurred, and the aircraft fell into the sea.

The accident was recorded in accordance with section d) of the Decree of 12 March 1948 under "Deficiencies in Air Navigational Aids."

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Scheduled
Landing
Loss of control
Other personnel - improperly cleared second aircraft for take-off

ICAO Ref: AR/647

No. 5

SABENA, DC-7C, 00-SFA, accident at Cazes Aerodrome, Casablanca on 18 May 1958 Report released by the Minister of Foreign Affairs, Morocco.

Circumstances

During a flight from Lisbon, Portugal to Leopoldville, Belgian Congo, the pilot advised Casablanca area control centre that he intended to make an emergency landing having cut off engine No. 1 which was vibrating considerably. He was cleared to jettison fuel and subsequently arrived over Cazes. At 0419 an approach procedure to land on Runway 21 was initiated. Five minutes later while in level flight 600 m past the runway threshold at a height of 5 m, full throttles were re-applied. The aircraft began to deviate from the runway centreline, rose a few metres and started an increasingly sharp left turn. On reaching 25 m it stalled, crashed into buildings, and burned. Nine crew and fifty-two passengers were killed, and the aircraft was destroyed.

Investigation and Evidence

The Aircraft

00-SFA was airworthy at the time of the accident and had been serviced at the required intervals.

The Captain

He had flown a total of 12 820 hours. On DC-7C aircraft he had flown approximately 374 hours of which 240 had been at night. He had not been on duty during the 48 hours preceding the final flight.

Weather

The 0405 weather at Cazes was reported as:"clear skies, surface wind calm, visibility 4 km to the south of the airfield and 6 km to the north".

The Accident Site

The aircraft crashed 250 m east of Runway 21. Il hit buildings in a steep nose-dive and sharp left bank on a heading of 090° which represented a 120° change of direction in relation to the flight over the runway. The wreckage was spread over 80 m.

Results of the Technical Investigation

The following conclusions were reached after examination of the wreckage

1. the landing gear was retracted at the time of the accident;
2. the flap actuating cylinders were extended (100% - 50°);
3. No. 1 propeller was feathered;
4. propellers No. 2, 3 and 4 were at an angle of 34° at time of impact;
5. the four propeller governors (CSU) were salvaged and the position of the rack-bar corresponded to the "fine pitch" position.

The following points were also brought out -

1. the pilot's altimeter was set on 1010 mb (QFE at Cazes is 1010 mb);
2. the co-pilot's altimeter was set on 1012 mb;

3. the automatic pilot was in the "off" position;

4. the Sperry horizon and zero reader were jammed at a left bank between 30° and 45°.

Examination of the Engines

No. 1

The damage, which had led to the propeller being feathered, was located in cylinder No. 2. It had probably been caused by a loosening of the exhaust valve regulating screw which resulted in undue over-heating around that valve and its seat. The metal melted and pierced the cylinder head between the seat of the valve and spark plug socket.

No. 2 and 3

Nothing unusual was observed.

No. 4

All the blades of one of the turbines were broken off at their base and the metal had started to melt. This defect could not have occurred in flight, since normally four blades would break off at their attachment in case of overspeeding. The defect appeared to have been caused by the crushing of the cap on impact.

Discussion

The defects of No. 1 engine, which made the pilot decide to turn back, were not considered the primary cause of the accident.

The pilot chose to land on Runway 21, i. e. heading south, despite better visibility to the north. Landing in the opposite direction would have necessitated a very short landing immediately beyond 350 m of unserviceable runway, and it is possible that the pilot feared a touchdown before reaching the serviceable portion of the runway (1 450 m in length).

Under the circumstances, it is probable that the pilot wished to save the unserviceable 350 m as a stopway in case of a long landing. Alternatively, the fog formations visible to the south may have influenced the pilot's choice of Runway 21.

At 0411 hours, 13 minutes prior to the accident, the white lights along the last 300 m of the runway were out of order. At 0419 the tower controller informed the crew that the landing would take place with sodium lights and repeated that the last 350 m were out of commission. While on the downwind leg, before the last turn, the crew requested confirmation of the length of the usable runway and repeated: 1 450 m.

At 0423 the aircraft, weighing 109 000 lb, entered a short final leg at a speed of 115 kt. The pilot lowered the flaps to 50° (100%) implying a decision to land. After 10 to 12 seconds of level flight over the runway, however, the throttles were re-opened.

Reasons for such action were examined and, finally, it would seem that it was the last minute decrease in visibility towards the south of the runway that led the pilot to proceed in that manner.

The aircraft had in fact reached the critical phase in a landing at which the throttles can safely be re-opened only by observing a strict procedure; full throttle gradually applied; attaining V_2 speed; retracting the landing gear; and, at 115 kt, retracting the flaps from 50° to 20°.

Taking into account the decrease in speed of the aircraft during the 10 to 12 seconds of level flight in the landing configuration, it was certainly at less than Vmc (one propeller feathered: 102 kt) that the throttles of the three remaining engines were opened. That assumption was confirmed by the fact that the flaps were not brought back to the take-off position.

The aircraft, therefore, under these circumstances immediately turned on the side of the stopped engine, headed toward obstacles and was unable to manoeuvre normally and efficiently.

Probable Cause

The accident was caused by an error of judgement in re-application of power when the aircraft was neither in the appropriate configuration nor at a sufficient speed to carry out the attempted safety manoeuvre.

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Scheduled
Landing
Loss of control
Pilot - other - attempted overshoot after committal to land

ICAO Ref: AR/637

No. 6

Piper PA-22, N 2945P, accident near Dover, Delaware on 23 September 1958. Civil Aeronautics Board (U.S.A), Aircraft Accident Report, File No. 2-0124, released on 10 October 1959.

(another "tip vortex" accident)

Background Information on this Investigation

The Board's investigation of this accident was not started until several months after its occurrence on 23 September 1958. At that time the investigation of accidents to U.S. civil aircraft weighing less than 12 500 lb had been delegated to the Administrator of Civil Aeronautics by the Civil Aeronautics Board. Accordingly, the CAA performed an investigation; however, no formal report or finding of probable cause was issued. On 22 December 1958, the estate of the deceased pilot petitioned the Civil Aeronautics Board to investigate this accident and to make public its findings of facts and probable cause. The Board granted this petition and began its investigation of the accident to N 2945P on 30 March 1959.

Circumstances

The pilot (and owner) of N 2945P took off from Zahn's Airport, Amityville, Long Island, New York at 1240 hours eastern standard time on a trip to Charlottesville, Virginia. The aircraft had enough fuel to fly non-stop a distance of about 350 miles, and weather over the entire route was ideal for visual flight. While at an altitude believed to be about 2 000 ft, during excellent weather, the aircraft was subjected to aerodynamic overloads which caused failure of its primary structure, and it crashed near Dover at about 1400 hours, killing the pilot.

Evidence strongly indicated that the overload was caused by the destructively energetic vortex in the wake of a large aircraft.

Investigation and Evidence

No record exists of the filing of any flight plan, although the flight planning of the route was witnessed. It was to be south from New York, east of McGuire Air Force Base, and then by Victor Airways to Charlottesville, Virginia. Victor 16 airway is nearly straight from the Coyle VOR, about 50 miles southeast of New York to the Gordonsville VOR, 15 miles east of the University of Virginia Airport, the destination. The accident site was on this course.

The pilot had a reputation for planning his flights carefully and most probably chose an altitude in consideration of the winds. These were light and variable offering the most assistance at an altitude of 2 000 ft over most of the route, including the accident area. This is based upon the winds aloft information for the Philadelphia area which the pilot most probably received. Above 3 000 ft he would have had to fly in accordance with the hemispherical provisions of the air traffic rules which would have made it necessary to fly at 4 500 or 6 500 ft or higher. It is customary for pilots of such aircraft to fly under 3 000 ft in good weather over such flat and relatively open country. Thus, it is likely that the pilot was flying at approximately 2 000 ft.

The proposed time en route was 3 hours and 15 minutes, making a groundspeed of about 115 mph for the 350 miles. From Zahn's Airport to the Kenton VOR, about one mile north of the crash site, is approximately 160 miles. As the accident occurred about 1 hour and 20 minutes

after take-off, the groundspeed was calculated to be about 120 mph. He must have been navigating by the Kenton VOR as his omni receiver was found tuned to that frequency. Major parts of the aircraft were found within 100 yd of the wreckage. This also indicates that the aircraft was relatively low at the time of disintegration.

A careful search of the accident area yielded only five lay witnesses. One had immediately called police, establishing the time of the accident as 1400. All had seen the aircraft falling and shedding parts after some had heard a loud noise. None had seen the aircraft prior to that time and none witnessed the actual failure. All thought that the fall was "straight down". One witness stated that only one wing appeared to be still attached, and it seemed to be folded back. Three witnesses saw no other aircraft in flight at the time and place. However, the two remaining witnesses did see another aircraft which they described as "large". One of these two said, "... I then saw a large airplane so close I thought the larger airplane was towing a target and that was what was falling ..." No smoke or fire was seen with the falling wreckage. Visibility was excellent with a light ground wind.

Most of the wreckage was some 300 ft west of Delaware State Route 9 in Muddy Branch Swamp. This site is six miles northeast of Dover Air Force Base, on the edge of the Dover control zone, as stated and about one mile south of the Kenton VOR. The badly broken fuselage was embedded in mud in such a way that initial ground contact must have been nearly vertical.

The right wing and right lift struts were found with the fuselage. The left wing structure with the left front lift strut and a section of the fuselage still attached, the left aileron, right aileron, right gasoline tank, pieces of wing fabric, and the left rear lift strut were found in a markedly localized area close to the main wreckage.

The propeller and engine were attached and deeply buried. All four lift strut clevis fork ends were still attached to the fuselage and broken from their lift struts. Some fuel remained in the left wing tank. The right landing gear was buried about one foot in the swampy ground, and the left landing gear was just at the surface. There was no evidence of fire or explosion either before or after impact with the ground.

Examination of the wreckage revealed:

1. There was no evidence of air collision with aircraft, bird, or any object. (A thorough check disclosed that no civil or military aircraft had reported a collision or a near collision that could be related to this accident.)

2. The power plant exhibited nothing to suggest that it was not operating normally.

3. The aircraft's control system, although extensively damaged by bending, breaking and stretching, at time of impact and during salvage, appeared to have been normally operable at the time of structural failure.

4. Failure of the aircraft's primary structure was from downward acting airloads.

5. Damage to both wing panels, to their lift struts and to other associated components, was markedly bilateral.

6. There was no evidence of fatigue or of faulty or questionable construction.

Dover Air Park is a civil airport two miles southwest of the accident site. Persons there saw numerous military aircraft in the Kenton VOR area the afternoon of the accident, but none saw the

Piper. They stated that considerable and frequent turbulence near the Kenton VOR caused local pilots generally to avoid that area.

Dover Air Force Base, six miles southwest of the crash site, is headquarters for an Air Transport Group using C-130's and C-124's. Only C-124's were in use the day of this accident. Proficiency flights on local flight plans from the Dover Base often use the Kenton VOR as a navigational and letdown aid. By agreement with the New York Air Route Traffic Control Centre, flights in this area departing or returning to Dover AFB, cross airways Green 5 and Victor 16, from the Hartley intersection to a point 20 miles northeast of the intersection, at 2 000 ft or below unless otherwise cleared. The Kenton VOR is on Victor 16, 11 miles from the Hartley intersection, and 7 miles from Dover AFB on a bearing of 346°.

During September 1958, there were 7 000 operations and 1 777 practice instrument approaches, including those using the Kenton VOR. The number of total flights at Dover AFB for 23 September, was not learned although there were 45 local flights. Flight plans filed with the New York Air Route Traffic Control Centre did not indicate other aircraft in the vicinity of Dover, on the heading as reported by a witness, at the time of the accident. At 1400 runway 01 (010 degrees) was in use, but it was not possible to relate any particular aircraft, as reported by two witnesses, to the time and place of this accident.

The C-124 transport has four reciprocating engines and a wing span of 174 ft. Its empty gross weight is approximately 107 000 lb; the maximum gross weight is 185 000 lb. The rate of climb when light is approximately 1 100 ft per minute; at full gross it is approximately half that. Normal climb speed is 115 kt, normal cruise speed is 175 kt, and letdown speed is 145 kt with 10 degree flap.

A C-124 departing Dover AFB on runway 01 will cover the 7.6 miles to the Kenton VOR in about 2 minutes and 30 seconds. Loaded C-124's reach the Kenton VOR at altitudes ranging from 1 300 ft to 2 000 ft depending on their gross weights. Their course will be approximately 90° to Victor 16 and an aircraft on that airway could encounter their wake at approximately a right angle.

Practice and actual approaches to Dover AFB are made using the Kenton VOR. An approach may be initiated at 1 500 ft, the minimum en route altitude for Victor 16, or at the cruising altitude of the aircraft, whichever is higher. This is an established procedure for military pilots and would be generally unknown to pilots of the type represented by the pilot of N 2945P. Practice approaches can be initiated at 2 000 ft or less by military aircraft operating from Dover AFB by merely contacting the Dover Tower. The outbound heading is 20° and the procedure turn is at 1 500 ft within 10 miles of the station. The inbound heading is 200° with a descent to not less than 1 000 ft, with a turn over the station to a heading of 166°. Vortex turbulence would be increased by any turn because of the increase in 'g' loads in the turn. The missed approach procedure calls for a climbing turn to the east, and a return to the Kenton omni at 1 500 ft.

As the Piper did not enter the Dover control zone, radio contact between the pilot and the Dover tower was neither required nor made.

Official weather reports bracketing both the time and the place of the accident show that there should not have been any appreciable natural turbulence near Dover during the afternoon of 23 September 1958.

An autopsy disclosed nothing that might have impaired the pilot's flying ability.

Analysis

On the basis of all available evidence the Board believed that the aircraft was airworthy and was being flown normally and competently in clear weather and smooth air when it was suddenly subjected to airloads greater than those it was designed to withstand. The specific gross weight of the aircraft could not be determined; however, evidence showed it was less than the maximum permissible and that the centre of gravity of the aircraft was within limits. The overloads which caused structural failure were downward and not consistent with loads normally imposed by any acrobatic manoeuvre, including unduly abrupt recovery from a spin. Moreover, this aircraft was placarded against acrobatics. The pilot, who was known to fly conservatively, was transporting fragile and expensive phonograph equipment. These factors allow ruling out the possibility of intentional acrobatics. The possibility of collision may safely be dismissed as there is no evidence of it.

Thus, violent artificial turbulence produced by aircraft having high span loading is the only plausible explanation. First, the accident area was being traversed repeatedly by large military aircraft at the Piper's altitude. The wind was light, allowing longer life to the wakes of those aircraft. Second, the nature of the failure - its remarkable similarity on right and left sides - can only be explained by violent downloads to both wings applied simultaneously, causing simultaneous failures.

Turbulence lies in the wake of all aircraft and its severity and its persistence depend upon several factors. The dangers of wake or vortex turbulence are still unknown to many pilots. Engineering studies clearly indicate that vortex turbulence can be great enough to cause structural failure of light aircraft; however, vortices of such destructive magnitude are generally associated with aircraft of the larger civil or military types.

Reports by Douglas Aircraft Company and a National Advisory Committee for Aeronautics Technical Note (No. 3377)** discount the effect of the "prop wash" or the wake due to jet exhaust, at a distance of 1 000 ft. Both assert that severe turbulence is created predominantly by wing tip vortices. The NACA study states: "The velocity distributions show no indication of a disturbance other than that produced by trailing vortices." It can be seen, therefore, that the energy produced does not depend on the type of power plant.

A paper on this subject issued by the Beech Aircraft Corporation ("A Preliminary Study of Effects of Jet Blast or Wake on Other Aircraft") points out that a light aircraft at 100 mph penetrating the vortices of a large jet aircraft at 90° and one mile behind recorded an acceleration of plus 2.5 g's and minus 3.5 g's. Other aircraft at greater speeds have measured structural loads as high as 9 g's in the wake of a large jet aircraft. The Beech paper states:

> "1. If a small plane, flying at cruising speed, observes a jet aircraft and executes an evasive manoeuvre which increases the load factor to approximately its design limit, then penetration of the wake area could produce load factors in excess of the design values, with structural failure resulting."

* Report No. SM-18647, "Theoretical Analysis of Light Plane Landing and Take-off Accidents Due to Encountering Wake of Large Aircraft."

** "Flight Measurements of the Velocity Distribution and Persistence of the Trailing Vortices of an Airplane."

"2. If two or more aircraft are flying in formation, or close proximity, the combined effect of the wake could produce structural failures in the small aircraft."

The NACA experimented with aircraft with smoke generators at the wing tips. Using an F-51 as the vortex generator and an F-80 as the receiver, it was determined that the energy of the vortex does not lessen appreciably for 35 seconds. The highest velocity within the vortices occurred 33 seconds after their origin. Velocities then gradually decreased for 60 seconds, the longest interval measured, but the vortex still retained a relatively large amount of circulation. From this it can be seen that peak velocity can be approximately 1-1/2 miles behind an aircraft cruising at 180 mph. Also, that a relatively large amount of velocity will persist for 3 miles astern.

When a large jet aircraft climbs at approximately 420 mph, the peak turbulence is 3-1/2 miles in back and a relatively high degree of turbulence will exist for 7 miles. In relatively still air the turbulence can persist for several minutes or long after the aircraft is out of sight. The study indicates that vortices can persist, theoretically, for as long as 30 minutes. The energy of the vortices depends on the ratio of aircraft weight to the wing span and the speed, being directly proportional to the former and inversely proportional to the latter.

A paper on this subject published on 1 January 1957 by the Beech Aircraft Corporation is "Evaluation Report - Effect of Wing Tip Vortices and Sonic Shock on Army Aircraft in Flight." Beech participated in tests at Eglin Air Force Base, Florida. The report is based on observations, comments of military personnel, and oscillograph test data. Its conclusion carries the following:

"Negative load factors higher than the minimum ultimate design requirements for Normal Category personal aircraft can reasonably be expected...."

In summary, all tests and theory to date indicate that structural failure can be anticipated in light aircraft upon penetration of the vortices behind larger civil transports and military aircraft.

The variations and reversals of forces encountered when traversing a pair of vortices is of great scientific interest. The forces are both large and sudden.

When an airplane runs squarely through a pair of vortices at their diameters the loads imposed are up, down, down and up, in that order. The total distance from entering one vortex to leaving its mate is short and would be traversed by a 120 mph airplane in less than two seconds. The initial abrupt and powerful up-current might normally be met by down elevator. Then, within a fraction of a second a sharp reversal of load occurs, then again in the same brief interval, another reversal.

Pilot reaction during this short period can only be surmised. But if the elevator control were moved forward upon hitting the first up-draught, as it might be, the following forces would be greatly intensified. This secondary shock, under these conditions, can be enough to destroy civil aircraft which are designed to accepted standards for normal category aircraft.

The Piper PA-22 is certificated under Part 3 of the Civil Air Regulations. It is designed to an ultimate manoeuvring load factor of 5.7 g's and in conformance with Part 3 has a negative ultimate manoeuvring load factor of 2.28 g's. This model aircraft has not been tested to destruction and the actual negative load limits of all components have not been determined.

Authoritative computations show that the loads that could be encountered in the wake of a large aircraft such as the C-124 are of a magnitude just approaching the limit manoeuvring load factors, positive and negative, and under certain conditions, may reach or exceed the negative ultimate manoeuvring load factors of normal category aircraft. These certain conditions include any appreciable attempt by a pilot to hold constant altitude upon encountering the vortex.

Conclusion

The Board concluded that the pilot of N 2945P was cruising on course at an altitude of 2 000 ft or less in the vicinity of the Kenton VOR; that a large aircraft, probably a C-124, was leaving or approaching Dover Air Force Base utilizing the Kenton VOR; that the pilot may or may not have seen the aircraft; that if he did, being unfamiliar with the potentially destructive forces of vortex turbulence, he may well have considered his crossing point to be safely behind it; that the pilots of the other aircraft did not see the Piper or saw it at an apparently safe distance; that the Piper penetrated a wing tip vortex of the large aircraft and was destroyed.

Probable Cause

The probable cause of this accident was structural failure of N 2945P resulting from excessive airloads created by wing tip vortices behind a large aircraft.

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Private
En route
Airframe - Air
Miscellaneous - aircraft turbulence

ICAO Ref: AR/599

"A SAFETY MESSAGE FOR PILOTS"

"It is unfortunate that vortices are invisible. If they could be seen they would look like a pair of horizontal tornadoes stretching back from each wing tip. For miles astern these compact and fast-spinning air masses stay close together and parallel, sometimes undulating slightly, as a pair. They gradually weaken and die but can remain dangerous until their birthplace is far out of sight. Because the real hazard can be many miles astern and since it is not thick nor wide, the probability or running into this insidious danger by chance is extremely slim. However, the result is sure to be startling and may be lethal."

"The intensity of the vortex is directly related to span loading and inversely related to airspeed; however, it is a safe and practical generalization that the bigger the ship the more violent and long-lived will be the vortex disturbance. Technically, the faster the plane is moving the less energy it casts off. The more it weighs in relation to its span, the greater will be its trailing danger. Also, the blows (the airloads) felt on piercing a vortex depend on the speed of entry. At half the speed the shock would be only one-fourth as great."

"Don't pass close behind any other aircraft: the bigger it is the more time it should be given. Two minutes should suffice as a working rule. Avoid, when possible, places and altitudes frequented by large aircraft. Areas near high-density airports, whether civil or military, should always be suspect. If you are to pass behind a crossing aircraft, change altitude so that you will be at least 100 feet higher or lower, preferably higher, and slow down. If you do get into a bad vortex, your best procedure is to ignore altitude changes and use no elevator control."

See also Summary No. 2 and Part III for additional information on this subject.

No. 7

Seaboard and Western, Constellation, L-1049D, N-6503C, and Trans-Canada Airlines, Viscount, CF-TGL, collided on the ground at New York International Airport, New York, on 10 November 1958. Civil Aeronautics Board (U.S.A.) Aircraft Accident Report, File No. 1-0116, released 25 March 1960

Circumstances

The Constellation began its take-off run, prior to a training flight, on Runway 31R at 1100 hours eastern standard time. When an airspeed of 117 kt (V_2) was reached, the aircraft became airborne and climbed to approximately 25 ft. A muffled explosion was heard and control difficulty occurred which caused the aircraft to veer suddenly to the left and the left wing lowered 20 to 30 degrees. This wing then struck the runway and directional control was lost. The aircraft skidded in a westerly direction into a temporary terminal area and came to rest after striking the Viscount, which was preparing to board passengers. Both aircraft were destroyed by fire after impact. One member of the Constellation's crew and a TCA stewardess received minor injuries.

Investigation and Evidence

Various pieces of the aircraft structure and its components were found along the 2 700 ft groundpath from the point of impact.

There was no indication that either a structural failure or fire occurred prior to impact with the ground. All flight controls and their actuating systems when checked showed no signs of having failed or malfunctioned during flight.

The four engines were carefully examined and although they had been considerably damaged, there was no evidence to indicate that either an in-flight failure or fire had occurred. There were also no indications of overspeeding, combustion chamber distress, or foreign material in the lubricating systems.

The four electric propellers were examined in detail. Because of crew statements describing the yaw condition that occurred just after take-off, the possibility of one or more of the propellers having experienced an unwanted reversal was highly suspect. Propellers No. 2, 3 and 4 showed no evidence that this had happened.

However, examination of No. 1 propeller clearly confirmed the reversal suspicic The positions of the blades in relation to the hub index indicated a full reverse pitch position of minus 11.7 degrees. The hub interior was adequately packed with grease and the hub retaining nut and all safeties were in place and secure. The front and rear cones bore no evidence of abnormal wear or galling. There was no evidence either of arcing or burning at the hub switch connector pins.

Lubrication of the spline assemblies of this propeller consists of packing the sleeve assembly with lubriplate and molybdenum disulfide which is retained by a seal. When examined, the seal assembly on the reducer sleeve was very brittle because of its subjection to intense heat, and, therefore, positive determination of its condition prior to the accident could not be determined. In this case, however, no charred deposits of lubricant were found and this is contrary to what would be expected if the seal had been in normal condition before the accident.

Statements were taken from a number of persons from whom it was thought pertinent information could be obtained - among them were representatives of the manufacturer of the propellers involved - Curtiss-Wright Corporation, which also overhauls them for Seaboard and Western.

They testified that based on tests made, the pitch-change rate with a disengaged power unit could be in excess of 40 degrees per second. This is subject to functional torque of the blades and the inertia effect of the speed reducer which has a reduction rate of 6 000 to 1. They further testified that in this instance when the aircraft reached 120 kt and 3 250 bhp during the climbout, the blade angle would have been 27 degrees, and that because of the worn armature spline condition the pitch-change motor could then become disengaged from the propeller and speed reducer. Once disengaged the blades could move to the full reverse position in approximately one second.

Several facts were apparent when the No. 1 propeller and assembly were examined. The wear of the rotor spline and mating speed reducer sleeve was of sufficient magnitude to cause complete disengagement between the power unit motor assembly and the speed reducer, thus preventing electrical control of the propeller. These conditions would permit the centrifugal forces on the blades to move them to the flat pitch position and beyond.

It was evident that the condition of the rear motor bearings was not caused by impact forces or heat, and that it contributed materially to the wear and cupping of the associated parts. In addition, this was not an isolated case; in fact, there had been six other cases of excessive spline wear and/or lubricating seal failures. Although portions of the reverse electrical circuits could not be examined because of fire, it is believed that an electrical malfunction did not cause the reversal.

With respect to the controllability of the aircraft in flight with an outboard propeller in full reverse pitch, full power applied and full forward power on the other three engines, it was determined that if a sudden application of negative thrust on the left side occurred, there would be a drag on that side which would cause a yaw and bank to the left. If would be extremely critical for this to occur at an airspeed as low as 112 kt at low altitude since a sacrifice of altitude is necessary to regain sufficient speed for restoring control.

The pilots could do little more than they did to prevent this accident. During the time the aircraft travelled from the initial ground contact point to the collision with the parked aircraft, the pilots had only partial control. The events which occurred in rapid succession, such as the initial impact of the left wing with the ground, the resultant bounces on first one gear and then the other, the loss of the left wing and the two engines on that side, and the additional unwanted thrust gained when the throttles again jumped forward, bear evidence to this fact. Intermittent ground marks which were found throughout a large portion of this travel indicate that brakes were being applied.

Probable Cause

The probable cause of this accident was an unwanted propeller reversal at a low altitude occurring immediately after take-off. A contributing factor was the inadequate overhaul procedure employed by the propeller manufacturer.

Recommendations

As a result of this accident the Board recommended to the Administrator of the Federal Aviation Agency that the inspection and overhaul procedures of the propeller division of the Curtiss-Wright Corporation be reviewed to ensure that high standards of airworthiness be maintained; also, that the recently developed and then available power unit, incorporating low-pitch stops designed to prevent propeller blade travel into the reverse pitch range if certain type failures occur, be required as soon as possible on certain model Curtiss electric propellers. As an interim safeguard, it was recommended that immediate inspections and shorter periods of time between the lubrication of these propellers be effected.

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Training
Take-off
Collision - aircraft
- one airborne
Power plant - propeller

ICAO Ref: AR/616

No. 8

Johnson and Johnson, Learstar, N 37500, accident near Woonsocket, Rhode Island, on 15 December 1958. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 2-0107, released 20 February 1961.

Background Information

The Civil Aeronautics Board was notified of this accident on 15 December 1958, and an investigation was immediately initiated. Depositions were taken on this matter commencing 5 February 1959, and the Board issued an accident report on 11 September 1959.* In view of new and pertinent evidence which came to light after the issuance of the original report, the Board determined that it would be in the interest of the public to hold a public hearing on this accident which commenced 29 June 1960 in Providence, Rhode Island.

Circumstances

The flight was a nonstop business trip from Linden Airport, New Jersey to Logan Airport, Boston, Massachusetts. It departed Linden Airport at 0834 hours eastern standard time and proceeded in accordance with its instrument clearance. It passed over Poughkeepsie VOR at 0901 hours at 5 000 ft, and its next position report indicated it was over Hartford VOR at 0913 estimating Sterling Intersection** at 0922. At approximately 0919 the captain advised that the right engine was inoperative, the propeller was feathered and he declared an emergency. He also indicated that he would continue in accordance with his instrument flight plan to Logan Airport. The flight was cleared to Boston to maintain 5 000 ft until another altitude was available. At approximately 0926 the captain advised the Boston Centre that he was experiencing a loss of power on the left engine. The aircraft was instructed to contact Boston Approach Control immediately on 126.5 Mc/s. However, no word was received by Boston from the aircaft, and other attempts to contact it were unsuccessful. N 37500 crashed during a snowstorm at approximately 0930 hours in a wooded area about 5 miles southwest of Woonsocket, i.e. about 35 miles (approximately 12 minutes) southwest of Logan Airport. The two crew and five passengers aboard were all fatally injured.

Investigation and Evidence

The Aircraft

N 37500 had been manufactured as a Lodestar Model 18 in 1942 and had been converted to a Learstar in 1955. It had flown a total of 5 258 hours, 1 706 of which had been flown since its conversion. Since overhaul the left engine had flown 606 hours and the right engine 364 hours.

The aircraft was last refuelled on 12 December at Fort Lauderdale, Florida and following the flight to Linden, NewJersey, four hours of fuel (440 gallons) remained

* It was not summarized in Digest No. 10 (1958 accidents) because of limited space available.

** This reporting point is located at the junction of Victor 167 and Victor 16 Airways and is approximately 53 nautical miles southwest of the flight's destination - Boston, Massachusetts.

in the tanks. The subject flight which followed on 15 December was expected to last about one hour's flying time.

At time of take-off from Linden the aircraft's computed gross weight (20 732 lb) was well below the maximum allowable (24 000 lb), and the aircraft was loaded within the centre of gravity limits.

Crew Information

The pilot held a currently effective airman's certificate with airline transport and flight instructor ratings. He also held a ground instructor's (power plants) certificate and a mechanic's certificate with airframe and power plant ratings. He had flown a total of 5 877 hours, 503 of which were in N 37500.

He was aware of the company procedures for the use of carburettor air preheat and carburettor alcohol, which were substantially in accord with the recommendations of both the engine and aircraft manufacturers.

The co-pilot held an airman's certificate with commercial privileges, single and multi-engine land, and instrument ratings. His total piloting time was 1 798 hours, of which 145 hours were in Lockheed L-18 type aircraft.

The Wreckage

The aircraft struck the ground in a marshy section in a very steep attitude while inverted, and the direction of travel at impact was approximately 80 degrees magnetic. Most of the wreckage was confined to an area not much longer than the aircraft. The nose section and cockpit were demolished and the aft section of the fuselage and the empennage came to rest on its left side.

The main landing gear, flaps, and the tail wheel were all in the up position at impact. There was no evidence of any inflight or ground fire.

Because of the severe disintegration of the cockpit area, readings from instruments and the position of controls could not be accurately established.

Examination of the structures and power plant of N 37500 revealed no evidence of inflight failure, or malfunction of the aircraft, or of its systems or components. It was evident that the No. 2 engine was not turning at impact and its propeller was feathered. The No. 1 engine was rotating at impact and its propeller was not feathered. Both left and right engine carburettor heat doors were in the "full hot" position. The cowl flaps on the left and right engines were both found in the closed position.

Both propellers were examined and no evidence was found of any malfunction or failure prior to ground impact.

Weather Briefing

Between 0700 and 0730 hours on the day of the accident the captain was briefed by telephone on en-route and terminal weather conditions, by the chief meteorologist of the National Weather Forecasting Corporation, Newark, (a private forecasting firm). The conditions were as follows: "Boston at arrival - ceiling 2 000 ft overcast, visibility 3 miles in snow showers, cloud tops at Boston 9 000 ft; Newark - broken clouds based at 2 500 ft with tops at 4 000 ft; probable light icing in clouds en route; winds at 5 000 ft - 250°, 20 kt, 7 000 ft - 250°, 30 kt, 9 000 ft - 250°, 40kt. During the briefing the meteorologist gave the captain the 0700 sequence weather for Boston. He stated further that he may have given him the 0700 weather for Providence and others, as well as Newark.

Flying at 5 000 ft the aircraft would have been on instruments commencing in western Connecticut and would have remained on instruments during the remainder of the flight. During that portion of the flight from central or eastern Connecticut to the crash site, moderate to heavy snow would have been encountered. Available meteorological data indicated that the temperature

at the flignt altitude would have been in the minus 10 to minus 8 degrees centigrade range through Connecticut, and in the minus 5 to minus 3 degrees centigrade range through Rhode Island. The latter range of temperature is considered particularly favourable for ice formation. The data also revealed that temperatures were at or below freezing at all levels over most of southern New England and that the air was near saturation at the flight altitude. With such a combination of temperature and moisture the aircraft would have encountered heavy icing conditions from eastern Connecticut to Rhode Island.

Icing of this magnitude was not anticipated in the pertinent U.S. Weather Bureau forecasts, nor was it anticipated by the National Weather Forecasting Corporation. The failure to adequately predict the intensity of icing conditions was a deficiency on the part of the forecasters concerned at both the U.S. Weather Bureau Airport Station (Boston) and the National Weather Forecasting Corporation (Newark).

The pattern of three hourly pressure falls along the coast, warming aloft indicated by snow grains and snow pellets reported at various southern New England stations, as well as rapidly deteriorating ceilings and visibilities should have alerted both the Weather Bureau and the National Weather Forecasting Corporation to the likelihood that the low pressure centre was intensifying and moving northward more rapidly than was anticipated and that the centre was nearer to the coast than indicated on the early morning charts.

Weather Bureau forecasts, particularly the flash advisories, including those issued before the captain's departure, did warn of ceilings below 1 000 ft and visibilities below 3 miles in snow over New England. Nevertheless, these advisories were not brought to the captain's attention by the National Weather Forecasting Corporation and the failure to do so also represents a deficiency in the briefing service provided.

While these flash advisories did call attention to low ceilings and visibilities, there was no mention of moderate or heavy icing conditions even though these conditions were reported by pilots prior to 0900 and did meet the criteria for issuance of, or inclusion in, a flash advisory.

At 0720 the Weather Bureau Office (Boston) issued an amended forecast for Boston, Providence, and other terminals reflecting a more rapid deterioration of conditions than originally anticipated and at 0940 again amended a considerable number of forecasts for terminals in its area of responsibility.

The National Weather Forecasting Corporation made no effort to contact the captain prior to take-off with weather information additional to that given in his briefing despite the fact that before 0800 and within just a few minutes after 0800 there were available by teletype numerous indications of deteriorating conditions which were especially significant owing to the known presence of the northward moving low pressure system off the coast.

Icing - General

New evidence which came to light after the issuance of the Board's report on 11 September 1959 indicated that considerable stratification existed in the Learstar carburettor air induction system. Subsequent official tests conducted by the Federal Aviation Agency showed that the degree of stratification in the Learstar carburettor air induction system was unacceptable.

The controllability of carburettor air temperature (CAT) in order to prevent carburettor icing in the Learstar is accomplished by maintaining a temperature of up to 38°C on the cockpit carburettor air temperature instrument. A maximum limit of 38°C for continuous operation is specified by the engine manufacturer. "Continuous operation" is defined by one major aircraft manufacturer as being not over 30 seconds. If this temperature is

exceeded, detonation may occur which can lead to rapid failure of the engine. There is no indication in the cockpit of the carburettor air heat door position on the Learstar. The indicated CAT is the only information available to the pilot. This results in a partially open/closed door position, which under the official and unofficial tests conducted on the Learstar indicated that carburettor icing could occur with indicated carburettor air temperatures of 38°C.

Ice accumulation in the impact tubes and automatic mixture control needle will cause leanness of the fuel mixture. This generally will occur at near or below freezing temperatures over quite a wide range of temperatures with atmospheric ice or snow. Snow can collect around the automatic mixture control needle and screen under conditions where icing is not normally suspected. Its location requires a fairly high heat rise for a prolonged period of time in order to bring casting temperatures above freezing. Alcohol is relatively ineffective in removing this type of accumulation. When power loss is experienced, the heat necessary is not available.

The problem will be further aggravated if ice which has accumulated in dead areas in the duct or behind the heater doors is released by movement of the heater doors, or by a temperature rise in the air inlet duct. The block of snow or ice thus released may break loose and move to a position where it can seriously restrict air flow to the engine. The resulting loss of power reduces still further the heat available for curative purposes, and can lead to complete power loss.

It should be noted that the aircraft log showed an outside air temperature rise from -10°C in the vicinity of Poughkeepsie to -2°C at Sterling. When this outside air temperature rise is coupled with the free temperature rise of 24.6°F in the carburettor air inlet duct (as determined during type certification tests), the release of duct ice becomes a distinct possibility in contributing to the failure of the engine on N 37500.

Icing - En Route

Considering the pilot's experience, it is reasonable to assume that the crew was utilizing carburettor air preheat to prevent induction icing from the vicinity of Poughkeepsie, since it was in this area that the overcast and associated precipitation would be entered. It is not possible to state whether the pilot had any appreciable advance warning of severe induction icing difficulties since power loss from induction icing can occur virtually instantaneously, or may be progressive over a period of time depending on the atmospheric conditions encountered and the type of carburettor icing being experienced. In this connection it should be noted that induction system icing, while utilizing partial carburettor air preheat, was not uncommon in the Learstar. The chief pilot of Johnson and Johnson stated that this was a situation that had been previously encountered, and was the reason for detailed procedures for the use of carburettor alcohol if carburettor icing was experienced while utilizing preventive preheat. He further stated that while they considered the heat rise inadequate, and had made several modifications to the carburettor air inlet system to overcome this supposed deficiency, they had never considered the lack of heat rise to be critical since the aircraft was also equipped with carburettor alcohol. Carburettor alcohol was not a required item under the certification of this aircraft, but when incorporated in the system provided an additional means of eliminating carburettor and carburettor screen ice.

The procedures used by the crew of N 37500 had been adequate in previous encounters with carburettor icing conditions, and up to the point of failure the crew would have little reason to believe that they would not be effective in this instance. The use or nonuse of the alcohol system, or whether it did or did not function could not

be determined, since the solenoid valves return to the "closed" position when de-energized.

Upon failure of the right engine to produce power, the pilot was faced with the decision of continuing to Boston in accordance with his flight plan, or selecting a suitable alternate airport. He chose to continue to Boston. In making the decision he would consider, among other factors, the icing conditions he had just passed through, the icing condition he was in, and the probable icing conditions ahead. The severity of the carburettor icing conditions ahead were unknown to the pilot. However, to reverse course, in order to proceed to an area to the west would require that the flight return through or remain in, known icing conditions which had produced failure of one engine. At reduced speed on single engine and faced with an apparent 25 kt headwind, the aircraft would remain in this area of icing conditions for a period of time approximately twice as long as had been sufficient to produce failure of the right engine. A rapid estimate by the pilot of the time to continue to Boston, as compared to proceeding to another suitable airport, would indicate that there was little choice. (Logan Airport is served by an ILS, has radar service, and the approach could be made straight into a 10 000-foot runway.) The flight log showed that the flight was in receipt of the 0900 Boston weather which was 1 000 overcast, 1/2 mile visibility in light snow and smoke. This information had been secured within a matter of minutes before the pilot declared his emergency. Upon declaring the emergency and stating his desires, he was cleared by Boston ARTCC direct to the Boston ILS outer marker and advised, "We'll have a further altitude for you shortly." In view of the short time the pilot had in which to assess the various factors, the Board believed that there was little basis upon which to criticize the pilot for his decision to continue to Boston.

Assuming that the ground speed was considerably less after the power loss of the right engine, it is logical to conclude that the flight was proceeding in a northeasterly direction on course from Sterling Intersection, and was approximately 10 nautical miles northeast of Sterling at 0926 when the crew reported intermittent power loss on the left engine. The flight continued on course for approximately another 8 miles where it crashed.

There is no doubt that the right engine ceased to develop power and the propeller was feathered. Subsequent to the shut down of the right engine, the crew advised of power less on the left engine, and intermittent operation of this engine is confirmed by several ground witnesses. There was no physical failure of the engines, propellers, or accessories. Both carburettor air heat doors were found in the "full hot" position. The facts indicate induction system icing, and it is concluded that this was the cause of the failure of both engines to produce power.

Probable Cause

The Board determined that the probable cause of this accident was the failure of the anti-icing and deicing systems to prevent and remove carburettor ice under the atmospheric conditions encountered.

Preventive Measures

Since the accident the Weather Bureau has taken the following action:

A Weather Bureau-FAA cooperative PIREP (pilot report) programme was started in January 1960. Three new positions were established at each aviation forecast centre to assist in flash advisory and related aviation forecasting work.

Attempts are being made to develop effective procedures for assuring positive notification to IFR flights of pertinent flash advisory information.

The Board, on 7 January 1959, recommended to the Federal Aviation Agency that the adequacy of the carburettor induction heat system of this aircraft be re-evaluated and more specific instructions regarding its use be provided. The FAA subsequently advised that portions of the flight manual pertaining to deicing procedures were to be clarified. They also advised that an alternate fuel source arrangement had been certificated which would enable engines to operate even though the carburettor boost venturi and impact tubes were iced over.

The FAA, however, did not propose to make this a mandatory modification since the information available to them indicated that the Learstar had sufficient carburettor anti-icing and deicing provisions if proper operating techniques were employed.

On 16 January 1960 the Board forwarded to the Administrator new information indicating the presence of severe carburettor air induction system stratification in the Learstar aircraft and recommended that the Administrator conduct further evaluation of the Learstar induction heat system.

As a result of additional testing, the Federal Aviation Agency issued an airworthiness directive applicable to all Lockheed Model 18 aircraft which have been converted to the Learstar configuration. The airworthiness directive restricts such aircraft against flying into known icing conditions until the carburettor air preheat system has been modified and appropriate revisions to the Learstar Flight Manual have been accomplished. This modification results in a more accurate carburettor air temperature indication for the prevention of ice formation on the carburettor screen and engine induction system at all preheat positions. Such modification will also permit operation with preheat under varying power and ambient temperature conditions without resulting in excessive carburettor air temperature.

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Business
En route
Emergency condition - engines failed
- normal cruise
Weather - icing conditions

ICAO Ref: AR/596

No. 9

B.O.A.C., Britannia, Series 312, G-AOVD, accident at Sopley Park, Christchurch, Hants., on 24 December 1958. The report, dated April 1960, was released by the Ministry of Aviation as C.A.P. 164 - Civil Accident Report No. C.693.

Circumstances

The aircraft took off from London Airport at 1010 hours GMT on a test flight in connection with the renewal of its Certificate of Airworthiness. During the climbs which followed it reached an altitude of approximately 18 000 ft. Further tests were carried out and at 1153 the captain requested permission to descend from 12 000 to 3 000 ft. Three minutes after commencement of the descent, the aircraft struck the ground, which was obscured by fog. The accident occurred at 1158 hours within the area of controlled airspace near Hurn. Two of the five crew and the seven passengers, all B.O.A.C. personnel, were killed.

Investigation and Evidence

The Aircraft

It received its first Certificate of Airworthiness in December 1957, and it was renewed for another year on 3 December 1958. A Check 4 inspection in conjunction with Group D of the progressive overhaul programme was carried out on the aircraft between 14 and 23 December 1958. Part of this work involved the calibration of the pilots' altimeters, airspeed indicators and rate of climb indicators. The aircraft was serviceable for the test flight.

The Crew

The captain was a Senior Captain First Class and the Officer-in-Charge of Training for Britannia 312 aircraft in B.O.A.C. He had a valid Airline Transport Pilot's Licence, endorsed in Group I for Britannia 100 and 300 aircraft, which included current instrument and instructor ratings. He was considered to be a reliable and competent captain with exceptional ability, and had flown 9 000 hours of which 909 had been in Britannia aircraft.

The first officer also held a valid Airline Transport Pilot's Licence endorsed in Group I for Britannia 100 and 300 aircraft and a current instrument rating. He had flown a total of 4 127 hours, 550 of which had been in Britannia 312's as first officer.

Three engineer officers made up the remainder of the crew. One of them, who was acting as Flight Engineer on the subject flight, held the appointment of Chief Engineer Officer Instructor in the Britannia 312 fleet. The other two, also qualified flight engineers and experienced in Britannia 312 aircraft, were to record the details of the flight.

Weather - General

The weather forecast for the area of the flight for the period 0800 hours to 1800 hours drew attention to extensive areas of fog especially in the west and north. 6/8 to 8/8 stratocumulus clouds were forecast for the east of the area and spreading very slowly west. The height of the base of the cloud was estimated to be 1 500 ft to 2 500 ft with tops at 3 000 ft. Variable amounts of altocumulus and cumulus were forecast for heights of less than 10 000 ft.

In the London-Bristol-Hurn vicinity between 1000 and 1200 hours the conditions were as follows:

> extensive fog or mist; cloud - extensive areas of low stratus, base surface 400 ft, tops approximately 1 500 ft amsl, patches of stratocumulus base 2 000 - 3 000 ft, tops about 4 000 ft in the east of the area; visibility - generally 100 - 300 yd, but 500 - 1 500 yd inland in the east at first and 1 - 3 NM in coastal areas east of the Isle of Wight; freezing level - 4 000 to 4 500 ft.

In the Hurn vicinity there would be complete coverage of fog and low stratus with tops about 1 500 ft.

The Flight

Following take-off, the aircraft climbed towards Woodley, levelling off at 3 000 ft where the altimeters were cross-checked by the first officer. Passing Woodley at 1015, it left the Airways and climbed southwest to 5 000 ft.... the pilots' altimeters were again cross-checked. For test purposes the propeller of No. 4 engine was feathered, and a three-engined climb at take-off power was made to just over 9 000 ft. The aircraft was then climbed to 18 000 ft. Records of altitude, speed and temperature were recorded every 30 seconds. During the later stages of the climb, differences were noticed among the airspeed indicators. All engines at completion of the climb were running normally. The first officer stated that he considered it superfluous to carry out the prescribed spoken cross-check of pilots' altimeters during the climb as so many readings were being taken. Handling tests, including a high speed dive and stalls in various configurations, were then commenced. During the stall tests the first officer's airspeed indicator read 80 kt and the captain's read 100. Rate of roll checks followed. On their completion it was noticed that the first officer's altimeter read what was believed to be 13 000 ft. When the flap and undercarriage functioning tests had been made, the captain asked the first officer to get clearance to descend from 13 000 to 3 000 ft and also wanted to know the heights of the tops of the lowest cloud layer at Hurn. To the information requested, Hurn replied..... "haven't got an estimate here, understand in the Southampton area they are VMC (visual meteorological conditions) at 2 000 ft." At 1135 the aircraft requested permission to descend to 3 000 ft - it was VMC on top at 13 000 ft just above a cloud layer - and stated that they would come over the top of Hurn and would like clearance from there. For 18 minutes a course was steered towards Hurn during which period the first officer thought they were approximately 3 000 ft above a cloud layer. At 1153 he reported they were overhead Hurn at 12 000, VMC on top and requesting descent clearance to 3 000 ft. He also stated that descent could not be made VMC as there was a cloud layer at 10 000 ft. Hurn advised the aircraft to contact London Airways if overhead or if to the west to contact Flight Information Region. The flight contacted FIR and requested an IMC (instrument meteorological conditions) descent to 3 000 ft. It was asked to advise when at 3 000 ft. The message ended at 1155 hours. The aircraft descended at an airspeed of 180 kt and entered haze. On passing through it the ground suddenly appeared, and the aircraft struck it with its starboard wing while flying approximately longitudinally level.

Discussion

Between 1135 and 1153 hours the aircraft descended from 13 000 to 12 000 and flew towards Hurn approximately 3 000 ft above a cloud layer. In view of the meteorological conditions, however, it would seem that the only cloud layer which existed in the Hurn vicinity was on or near the surface.

The final descent was commenced some time after 1155 hours with the inboard engines at "flight idle" power and

at an airspeed of 180 kt. The fuel dump chutes were in the extended position. Under these conditions the associated rate of descent would be about 750 ft per minute. It was established that the aircraft struck the ground at 1158 hours. It would seem, therefore, that at 1153 hours the aircraft was at approximately 2 000 ft and not 12 000 ft as reported and that, consequently, some 10 000 ft were lost prior to 1135 hours, without either pilot appreciating it. It may be significant that when the climb to 18 000 ft was concluded the subsequent air tests were not of a kind which required the crew to focus attention on the altimeters.

The Wreckage

Examination of the wreckage revealed that at the time of impact the flaps and undercarriage were retracted and the engines were running under power. No pre-crash defect in the airframe or engines was found.

The manufacturers examined and tested the flying instruments and found:

a) the captain's altimeter functioned normally within its specified accuracy tolerance and his airspeed indicator had a consistent error of -6 kt..... but this was due to impact damage;

b) the altimeter and airspeed indicator of the first officer were damaged by impact, and no positive assessment of their pre-accident condition could be made.

The Static System

Two separate systems provide air at atmospheric pressure to a number of instruments including the airspeed indicators and altimeters. The first officer's and the navigator's instruments are supplied from a common source not connected with that which provides pressure to the captain's instruments.

Discrepancies were noted during the flight between the airspeed indications of the captain's and first officer's instruments. They were consistent with a pressure leak found subsequently in the static system of the first officer's instruments... this would, however, have no effect on the captain's altimeter. Also, the effect on the first officer's altimeter would be small. Calculations showed that the effect would be approximately 300 ft too low at 20 000 ft and decreasing with descent. They also showed that if an altimeter indication of 10 000 ft too high did result from a defective static pressure system when flying at an altitude of 3 000 ft then an associated airspeed indicator would register a speed of 465 kt when flying at 200 kt EAS (equivalent air speed).

Altimeters

As a result of Comet I experience of operating over a wide range of altitudes, B.O.A.C. introduced, in 1952, a modified type of altimeter. At the time of the subject accident all Britannia aircraft were equipped with this type. It had a 10 000 ft pointer which extended to the outside scale and could not become totally obscured by the other pointers.

Following an incident involving the misreading of an altimeter during flight an order was issued in May 1958, part of which read:-

> ".....during climbs and descents the captain and the co-pilot are to cross-check their altimeters at 20 000 ft and 10 000 ft.....to avoid the possibility of misreading the altimeters by 10 000 ft....."

In 1958 the first accident due to an error of this type, as far as is known, occurred.

This resulted in action being taken to ascertain the practicability of -

a) modifying the three-pointer altimeter so as to eliminate as far as possible the chance of a 10 000 ft reading error, and

b) developing an instrument more suited to current operational needs.

Various modifications were assessed and then in February 1959 the Air Registration Board issued a notice that Britannia, Comet and Viscount aircraft must be equipped with approved altimeters having a presentation where the probability of a 10 000 ft reading error was removed.

Subsequently, also in February 1959, a Civil Aviation Information Circular was issued on the subject, "Flight Safety Warning - Reading the 3-Pointer Sensitive Altimeter". Part of the Circular reads as follows:

"Pilots of aircraft which operate in the range of altitudes where reference to the 10 000 ft pointer on the instrument is necessary are reminded of the need for care in reading this type of altimeter, particularly:-

1) prior to starting any stage of descent,

2) at times when monitoring of the flight instruments has been, or is being, interrupted."

On 26 February 1959 the United Kingdom Altimeter Committee was set up to investigate, inter alia, the design of altimeter faces and mechanisms.

Probable Cause

The accident resulted when the aircraft flew into the ground which was obscured by fog. Both the captain and first officer failed to establish the altitude of the aircraft before and during the final descent.

Representations made on behalf of the captain and first officer were carefully considered and as a result the following was added to the opinion on the accident:

The height presentation afforded by the type of three-pointer altimeter fitted to the subject aircraft was such that a higher degree of attention was required to interpret it accurately than is desirable in so vital an instrument. This, when taken in conjunction with the nature of the flight on which the aircraft was engaged, was a contributing factor.

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Test
En route
Collision - ground
Pilot - improper IFR operation

ICAO Ref: AR/632

No. 10

Air France, Lockheed Constellation 749A, F-BAZX, accident near Vienna/Schwechat Airport, Austria, on 24 December 1958. Report released by the Aircraft Accident Commission, Austria.

Circumstances

The flight was scheduled from Paris to Vienna via Munich. The aircraft departed Munich at 1958 hours GMT estimating its arrival at Vienna at 2053. Following an ILS let-down at Vienna the pilot elected (at 2056) to make a visual circuit of the airfield. Three minutes later, the aircraft crashed in the base leg turn and burned 2 200 m from the threshold of runway 30. The pilot-in-command and the flight mechanic were seriously injured; the passengers and other crew members escaped with only minor injuries.

Investigation and Evidence

The pilot-in-command held a valid French Airline Transport Pilot's Licence with an L 749 rating. He had completed a total of 10 027 flying hours, of which 552 were in L 749 aircraft. He had made 11 landings at Vienna/Schwechat Airport.

Weather

A weak cold front reached Vienna shortly after 2 000 hours with a slight northwest wind which increased to 9 kt by 2 100 hours. Visibility increased from 1 800 m to 6 km, and the ceiling increased from 400 to 600 feet, although rainfall from the rising clouds continued.

The following actual weather was reported at Vienna:

2018 340/05 kt, 1 800 m, rain	8 st 400 ft 5 st 200 ft		
2035 330/05 kt, 2 000 m, rain	8 st 300 ft 3 st 200 ft	7°	QNH 1004, 9 mb
2045 320/07 kt, 4,0 km, rain	8 st 400 ft 4 st 300 ft		
2100 310/09 kt, 6 km, rain	8 st 600 ft 2 st 400 ft	6°	1005, 2 mb
2135 310/06 kt, 6 km, rain	8 st 900 ft 1 st 500 ft	5°	1005, 0 mb

The Flight

Departure from Paris was delayed from 1430 to 1630 hours. The flight was normal as far as Munich. There was a slight snowfall during the approach to Munich, which slightly reduced the braking effect. During the approach, icing occurred but was overcome by the de-icing system. The departure from Munich was somewhat later than planned, since another Air France aircraft on the ground had to be de-iced. From Munich to Vienna the flight proceeded at a cruising level of 7 000 feet and only slight icing occurred, causing no difficulties. The flight to Vienna was normal and after reporting over the OEC beacon the aircraft was transferred to Vienna approach control. Time of arrival over Steinhof was reported by the aircraft as 2049, and probable altitude was then 4 000 feet. At 2048 it was instructed by Vienna Approach to maintain 4 000 feet and to report over radio beacon OEB. The following weather report was also given: 4/8 stratus at 300 feet and 8/8 stratus at 400 feet wind 310°, 10 kt, QNH 1005 mb, QFE 984 mb. The pilot then requested clearance for an ILS approach. Clearance was given for direct approach to runway 12 with instructions to report over the radio beacon Steinhof and the outer marker. The aircraft reported over Steinhof at 2052 and over the outer marker 4 minutes later, whereupon Control passed the following message: "Cleared to land, wind 310° 10 kt. Report when landing lights are in sight for further wind information." The pilot acknowledged this and at 2056 reported, "Runway in sight." He stated that he would report over the runway and thus indicated his intention of landing on runway 30. At this point the pilot reported that the ceiling was 8 000 feet but this was later corrected to 800 feet. The controller in the tower saw the aircraft's landing lights at the moment when the pilot reported "runway in sight". The pilot then received clearance for a visual approach and was instructed to report in the base leg turn. At 2057 hours the aircraft crossed the aerodrome in a southeasterly

direction at an estimated height of 600 to 700 feet above the ground descending slightly. The approach appeared to be normal. At 2058 the aircraft was observed from the tower entering the base leg turn. According to the crew there was visual contact with the ground at 800 feet. After discontinuation of the ILS approach the co-pilot carried out checks and switched on the landing lights. A few small clouds could then be seen at the same height as the aircraft. There was a normal setting of 2 300 rpm during the approach. The landing flaps were 60% out and the base leg turn was initiated with a 30° bank at an altitude between 700 and 450 feet. The speed was 145 kt.

The aircraft crashed from this base leg turn and burned out about 2 200 m from the southeastern end of the runway.

Examination of the Wreckage

The wreckage was scattered over 250 m. The final crash is assumed to have taken place about 130 m beyond the place of first contact with the ground. At this place propellers and engine parts were found. All the engines were torn free as the aircraft skidded forwards. The undercarriage wheels were found 200 m from the first ground traces. The left main gear was forced backwards through the left wing, which remained joined to the fuselage. The right wing was torn free, but the landing gear remained attached to the wing and withstood the heavy strain. The propeller blades were at a normal angle; none of the propellers was in feathered pitch. The landing flaps were about 20° out at the time of the accident. The cockpit was totally burnt out, only an air speed indicator from the right instrument panel was found with a mark burnt in it at 50 mph, and the left altimeter which was set as follows: QFE 985 mb: the small pointer showed 500 feet, the large one 900 feet. The main wreckage was completely burnt out. Examination of the airframe was, therefore, not possible. The fire was clearly due to the impact.

Medical Aspects

Five hours after the accident, after treatment for injuries and while still under anaesthesia, the pilot-in-command was subjected to a blood test; this revealed no alcoholic content.

One week after the accident the pilot-in-command was questioned by a medical expert. The pilot's memory was clear, and he did not appear to have suffered from amnesia which can usually be observed following brain concussion. He reported that he had been well rested before the subject flight. During the flight he felt physically and mentally alert and experience no headache or signs of fatigue. The pilot-in-command was at the controls throughout the flight from Munich to Vienna.

Both the pilot and the flight engineer rejected the possibility of their being affected by exhaust gas or fuel vapours in the cabin. The reported cabin pressure equivalent of 1 350 m (4 500 feet) altitude is certainly too low to cause direct lack of oxygen.

The medical expert concluded that it was improbable that the pilot's faculties were affected by insufficient rest before the flight, excessive meals, particularly tiring weather conditions, or by lack of oxygen.

Findings and Conclusions

The Investigation Commission concluded that the flight was normal up to the initiation of the base leg turn and that technical malfunction as a causal factor could be excluded

As regards the visual approach-to-land at Vienna, the pilot stated that the runway lighting and the control tower were clearly visible, both in flight along the southern end of the runway and while turning towards the north. The radio communications at the time were carried out by the co-pilot. The turn towards the north was performed without any particular centrifugal acceleration. Then the pilot reports having entered

a cloud, not previously noticed, followed by a total loss of visibility of the ground. The instruments, however, were clearly readable and the pilot claims that he immediately changed to instrument flight. He also remembers having feared the possibility of airframe icing on entering the cloud, and at that moment the aircraft apparently pitched forward along its axis - when questioned, the pilot repeated: pitched and not rolled - and he contends he pulled the control column but felt great resistance and ordered the co-pilot also to pull. The pilot claims that, in the circumstances, in view of the strong pulling, the aircraft should have pulled out. The possibility exists that the control column was deflected to its limit and, therefore, could not move any further. It was not stated whether the engine revolutions were simultaneously increased. The pilot then felt a first impact, and as he was not strapped to his seat his head hit a hard object; he cannot remember what happened immediately following the crash.

The Commission concluded that the pilots lost sight of the ground during the base leg turn. Subsequently, a variety of circumstances, such as wrong altimeter readings, failure to watch the instruments, loss of airspeed or a slide in the turn could have resulted in the crash. It could only be assumed that the crash was attributable to an abnormal flight attitude during the base leg turn.

Probable Cause

It is possible to establish that there was no question of a technical malfunction, and that the flight crew lost sight of the ground in the base leg turn, at which time the aircraft adopted an abnormal attitude for this manoeuvre which led to the crash.

Presumably the accident could have been avoided through immediate discontinuation of the approach procedure (immediate changeover to climb - heading for radio beacon OEW) following loss of visibility.

Recommendations

Both training and air transport agencies should be instructed to prepare pilots who engage in instrument flight for the hazards which may occur in the changeover from visual to instrument flight and vice versa, and train them accordingly.

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Scheduled
Landing
Collision - ground
Weather - low cloud patches

ICAO Ref: AR/638

No. 11

Servicio Aéreo de Honduras, S.A., DC-3C, XH-SAA, accident at Peña Blanca, Republic of Guatemala on 6 January 1959. Report by the Board appointed by the Director General, Civil Aeronautics, Honduras.

Circumstances

The aircraft was on a special flight from San Pedro Sula to Copán Ruinas and return on a VFR flight plan. It landed at Copán Ruinas at 1033 hours following a flight of 1 hr 38 min, which was somewhat longer than expected. Nothing unusual, however, was reported by the crew. The aircraft was then cleared to proceed to Nueva Ocotepeque (an 18-minute flight) in order to take on additional fuel, and departed from Copán Ruinas at 1113 hours, carrying 3 crew and 2 passengers. As the aircraft had not reached its destination by 1145 hours, the first search aircraft was sent out at 1155 hours. The wreckage of XH-SAA was located shortly after 1900 hours on Peña Blanca mountain. All aboard the aircraft were dead, and it was demolished by impact and the ensuing fire. The accident occurred at approximately 1120 hours.

Investigation and Evidence

The Aircraft

The aircraft's Certificate of Airworthiness was valid until 30 April 1959. It had completed 15 840 hours of flying, 1 286 of which had been since the aircraft's last 1 500-hour overhaul. It had undergone regular 150 and 300-hour overhauls as required.

Crew Information

The pilot-in-command was one of the most experienced pilots in Honduras as well as check pilot for the Directorate General of Civil Aeronautics. He had flown a total of 13 000 hours, 8 000 of which were on DC-3 equipment. At take-off from Copán Ruinas he was occupying the co-pilot's seat.

The co-pilot had completed a total of 2 027 flying hours, 1 089 of which were on DC-3 equipment. The fact that he was occupying the control seat during the flight was not considered to be a contributing factor to the accident.

Weather

The weather at Copán Ruinas and Nueva Ocotepeque was within the limits required under VFR.

> Copán Ruinas - 0845 - 10/10, wind calm, ceiling: from 2 000 to 2 500 ft, visibility: 3 to 4 miles, drizzle over hills to the west, height of the cloud layer above the ceiling: unlimited, better approach to the west, breaks in the clouds ...

> Nueva Ocotepeque - 1100 - 6/10, NNW wind at 20 to 25 mph, visibility-east 5 miles, west and south unlimited, ceiling 5 000 ft, better approach from south, no rain ...

The weather at the accident site, however, was below VFR minima since the latter require at least 3 miles visibility and that it should be possible to keep the aircraft at a vertical distance of 500 ft and a horizontal distance of 2 000 ft from the clouds.

Aircraft over the search area reported the weather as follows:-

> "overcast with occasional breaks, drizzle, low ceilings over hills and mountains ..."

Peña Blanca mountain, where the accident occurred, was covered with low cloud.

Residents of San Isidro (a village located at the foot of Peña Blanca mountain) stated that the weather on the day of the accident was cloudy with drizzle and poor visibility. Those living in houses on a straight line from the wreckage area saw the aircraft fly over them at a low altitude a few seconds before the accident and stated the aircraft was slightly within fog. However, other witnesses (of houses approximately 1 mile from the first group), who did not actually see the aircraft but heard it, stated it was fairly close. This village is at an elevation of 4 200 ft and from data available it was gathered that the aircraft was approximately 150 to 250 ft above the ground. It was inferred from the above that the pilots could see below but that their forward or lateral visibility was nil - they did not notice the mountain when flying over the houses from which the aircraft was seen although the houses are not further than 1/4 of a mile from the mountain in a straight flight line.

Examination of the Wreckage

The site of the accident was inaccessible except by helicopter, and the investigation committee was not able to visit it until 24 hours after the accident - in the meantime villagers had carried off the unburned parts of the aircraft.

The central section was inverted, the wings were pushed back into the fuselage after hitting trees (100 ft high), and the cockpit was torn from the fuselage.

Tree tops had been cut off by the aircraft approximately 150 ft below the spot where the wreckage was found - from this it was concluded that upon sighting the mountain the pilot had immediately attempted an emergency climb. However, he was unable to clear the mountain and the aircraft had crashed at an elevation of 4 750 ft at an angle of approximately 30 degrees. The aircraft had risen 350 to 400 ft from the height at which it had been seen from the houses.

Probable Cause

The accident was caused by the pilot's attempt to fly over mountainous terrain by visual reference to the ground under weather conditions severely restricting visibility ahead of the aircraft, which forced him to descend to a dangerous altitude.

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No. 12

Southeast Airlines, DC-3, N 18941, struck a mountain while approaching Tri-City Airport, Bristol, Tennessee on 8 January 1959. Civil Aeronautics Board (U.S.A.) Aircraft Accident Report File No. 1-0021 released 11 September 1959.

Circumstances

N-18941 departed Memphis at 1630 hours on a regular flight to Tri-City Airport, Bristol, Tennessee with stops at Nashville and Knoxville. Following departure from Knoxville at 1946 it was cleared to the Gray intersection* via Green Airway 5 to maintain 5 000 ft and requested to contact Tri-City approach control when over the Bulls Gap marker beacon. It did so at 2010 and was cleared to make an approach to the airport on runway 27. The flight then switched to company frequency at Tri-City and estimated its arrival time at 2026. At 2024 it reported to approach control that it was over Gray intersection, (from which an ILS approach was to be continued), leaving 5 000 ft making an outer marker approach and was advised to report leaving the outer marker inbound. At 2032 the flight was asked its position - the captain then inquired as to whether or not the glide slope was operating. He was advised that it was. The captain stated his ADF was acting up, that he did not pick up the outer marker aurally or visually and that they were making a procedure turn. The controller aknowledged and asked for the flight's altitude. No further word was received. The aircraft crashed (at approximately 2032 hours), immediately after its final transmission, fatally injuring the 7 passengers and 3 crew aboard.

Investigation and Evidence

The wreckage was found the next day on the northwest side of the Holston mountain range, 18.75 NM east of Tri-City Airport and 1.25 NM north of the ILS localizer path.

The aircraft, while on a 235° course first struck several trees which severed the left wing 21 ft from the tip and destroyed a portion of the horizontal stabilizer. It could be seen from the initial impact marks that the aircraft was in level flight longitudinally with an angle of bank to the right of less than 10 degrees when it struck the trees growing on the 35° slope, at an elevation of 3 140 ft near the crest of the mountain. As it continued into the trees, parts separated and finally the outer right wing panel was severed by another tree. The remainder of the aircraft continued over the crest of the hill without hitting the ground. Its forward motion was then stopped by contact with several large trees, and it fell to the ground in an upright position. The cabin section of fuselage with the empennage attached then rolled 180 degrees to the right and came to rest inverted across the stub of the right wing. An intense fire ensued in the main wreckage.

* the intersection of the southwest leg of Tri-City low frequency radio range and the 275-degree radial of the Tri-City VOR - 3 miles southwest of the airport.

Maintenance records indicated that both the airframe and power plants had been maintained in accordance with all applicable regulations. There were no outstanding discrepancies and no maintenance carryover items which might have affected the airworthiness of the aircraft.

Analysis

From evidence it was clear that no structural or mechanical failure or malfunction occurred which in any way contributed to the cause of the accident.

The components of the instrument landing system and the compass locators at Tri-City were functioning properly on the night of the accident.

Examination of the radio equipment of N 18941 indicated that the crew was not utilizing all the facilities available. The No. 2 navigation receiver was not tuned to a frequency of any facility in the area, and it was, therefore, presumed that the No. 2 navigation receiver was not in use. Normally this receiver would be tuned to the TRI VOR (117.7 Mc/s) and utilized to determine the backup radials which define the safe easternmost limit of the procedure turn area.

As near as could be determined the low frequency receiver was tuned between 325 kc and 349 kc. Again, this frequency is unrelated to that of any facility in this area which could be utilized by this receiver. Normally the low frequency receiver is tuned to the TRI low frequency radio range, 221 kc, and used as another aid in determining the aircraft position in relation to the radio range legs. It is clear this receiver was not being used on the TRI-LFR because it is extremely improbable that impact forces could move the frequency over 100 kc.

The ADF was tuned to 221 kc, the Tri-City low frequency radio range. While en route from Knoxville to Tri-City it would be used to follow the airway. However, after the aircraft had reached the vicinity of the airport and an approach on the ILS was started, the crew would normally tune the ADF to the non-directional compass locator associated with the middle or outer marker. These frequencies are: 201 kc and 239 kc respectively.

Another alternative would be to tune the ADF to the Emmett "H" facility (320 kc) for assistance in establishing the safe easternmost limit of the procedure turn area.

Two inferences arise because the radio compass was not tuned to the frequency of a facility which would assist in determining position along the localizer. The first is that the automatic direction finding feature was not functioning or was not being used. The second is that the radio compass was entirely inoperative and neither the visual presentation nor the audio signals could be received.

During the last transmission from the flight, the pilot stated that "... his ADF was acting up." In addition, the captain who had flown the first segment of the trip (Memphis to Nashville) testified that he was unable to receive either visual or aural signals on the ADF prior to landing at Nashville. The evidence also indicates that he informed the next captain, who was to fly the aircraft from Nashville to Tri-City, of the malfunction at Nashville but that no maintenance was performed there or at Knoxville, nor was any entry made in the log. It is, therefore, reasonable to presume that the ADF was completely inoperative and further that the crew was aware of the situation prior to take-off from Nashville.

There is a remote possibility that a sightseer at the crash site could have altered the setting found on the No. 2 navigation receiver frequency selector; it is also possible that the frequency selector was moved as a result of heavy inertia forces. If this were true and the receiver was being used on the TRI VOR, the pilot should have been acutely aware of his position. As for the ADF, because of the fire markings on the dial and exposed gears, investigators determined that the frequency setting had not been altered. It was clear that this receiver was tuned to 221 kc.

The flight reported as being over Gray intersection at 2024. About 2032, the conversation with the tower took place. Before completion of that conversation the aircraft crashed. This would place the accident time at approximately 2032.

A study was made to determine the airspeed which would have been required for the aircraft to traverse the distance from Gray to the crash site in eight minutes. It was calculated that N 18941 would have had to have had an airspeed of 180 kt or a groundspeed of 191 kt to travel this distance in such a length of time. This speed is much too high for a DC-3, especially while manoeuvring prior to an ILS approach. From the calculations it was evident that the aircraft could not have been over Gray at 2024, as it reported.

The Board, therefore, selected two airspeeds, 130 kt and 110 kt, as representative manoeuvring speeds at which an ILS procedure would be flown. Substituting each of these speeds in the computations, and starting at the crash site working back toward Gray, it was possible to determine two lines of position along one of which N 18941 had to be located eight minutes before the crash. (See Figure 2). It was immediately discerned that the 110 kt line of position could not, in all probability, be correct because it was impossible to correlate the en-route reporting times to it. However, the 130 kt line of position appears to be consistent with all the known facts.

From a position report over Piedmont at 1958 and the report over Bulls Gap, which is 30.5 miles from Piedmont, at 2010, it can be seen that the groundspeed of the aircraft was 152 kt. The next position report was over Gray, 32 miles from Bulls Gap. At a groundspeed of 152 kt, this segment should have taken 12.5 minutes. However, the flight did not report over Gray until 2024, 14 minutes after passing Bulls Gap. At this same groundspeed the airplane would have travelled 35.5 miles, or at least 3.5 miles closer to the accident site than Gray. In other words, when the flight reported over Gray it was actually 3.5 miles or 1.5 minutes beyond Gray. By plotting this distance (35.5 miles from Bulls Gap) on a chart, it was found to cross the 275-degree radial of the Tri-City omni at the same approximate point as the line of position calculated for a manoeuvring speed of 130 kt. Again referring to Figure 2, it can be seen that a course from Bulls Gap to this point would pass approximately two miles east of Gray.

As stated before, the Board believed that the ADF was inoperative as reported by the captain. It further believed that the flight from Knoxville to Tri-City was made in instrument weather conditions without using the low frequency radio aids which define Green Airway 5. There was evidence at the public hearing that in some instances pilots were using the intersection of the 65-degree radial of Knoxville VOR and the 275-degree radial of the Tri-City VOR as Gray intersection. The intersection of these radials is very indefinite because of the distance from Knoxville and it is possible to receive an indication which could place it several miles east of Gray.

On the basis of all evidence the Board believed that the crew of N 18941 flew from Knoxville to Tri-City, utilizing the Knoxville VOR, and attempted to locate Gray without the aid of the low frequency radio. The winds aloft were reported to be from the north-northwest at approximately 20 kt* and would tend to drift the aircraft east of its course. All these factors combined to cause the airplane to arrive at the position which was reported as Gray intersection.

Had the aircraft been at Gray the correct procedure would have been to continue on the same heading as the low frequency range leg (65 degrees) to intersect the localizer at the middle marker and then to turn to a 90-degree heading to track outbound past the outer marker. It is probable that the crew, thinking they were in the vicinity of Gray, followed the normal procedure for intercepting the localizer.

* the captain of another flight in the area at the time of the accident estimated winds which he encountered at 5 000 ft were from the west-northwest at 25-30 kt.

From the position it has been shown the aircraft was over when it reported at Gray, a course of 65 degrees to the localizer would pass south and east of the outer marker. Thereafter, without receiving the outer marker and without the use of the low frequency receivers or the No. 2 navigation receiver, the flight would be unable to determine its position along the localizer.

From calculations, the time interval from the Gray report to the beginning of the procedure turn was found to be 5 minutes 45 seconds. Normally, a procedure turn would have been started approximately 3 minutes and 30 seconds after passing Gray. Even if the flight had been over Gray, as it reported, to continue 2 minutes and 15 seconds beyond the normal flying time to the outer marker would place the procedure turn well beyond the authorized 5-mile limit and probably beyond the 5-mile buffer area which is provided as a safety zone east of the procedure turn area. Actually the flight flew for a period of 5 minutes and 45 seconds from the position, which was erroneously reported as Gray, before starting its procedure turn. Had a procedure turn been started 3 minutes and 30 seconds after this report, as is normal, it is probable the accident would have been avoided.

Both crew members were familiar with the Tri-City Airport and facilities, and both must have been well aware of the terrain variations in the area. When they realized they were east of the outer marker an unknown distance, the first and only proper action was to execute a missed-approach procedure, climbing to 5 500 ft on the west course of the localizer.

It is assumed that the flight did receive the localizer indications. However, it did not receive an indication of the outer marker. The transmission from the flight asking if the glide slope was operating indicates that this instrument was not operating properly or that they could not rationalize the indication from it with their supposed geographic location. If the localizer had been intercepted to the west of the outer marker, the glide slope indicator would have been at a full fly-down deflection because the aircraft would have been above the glide slope. It would have changed from full fly-down to full fly-up as the aircraft proceeded eastward on the localizer past the outer marker.

It is possible that either the glide slope indicator or the outer marker beacon did not function properly. It may be that the crew concluded they were inoperative. In this event they were wrong in continuing the approach.

Actually, the aircraft intercepted the localizer east of the outer marker. At this point, the glide slope indicator would have been at a full fly-up deflection because the glide slope was above the aircraft. It may be that the crew was confused when, thinking they were west of the outer marker, they received an indication opposite to that expected. It is also possible that high terrain intervening between the transmitter and the aircraft may have blocked the signal (which is VHF and line-of-sight) from being received by the aircraft, causing a flag to appear in the deviation indicator of the aircraft. In either case the Board believed that the crew had a clear duty to discontinue the procedure immediately and execute the approved missed approach.

One of the provisions in the operations specifications issued to the company by the Federal Aviation Agency clearly establishes the conditions under which an ILS approach can be executed. Those specifications make it clear that an ILS approach may not be commenced if more than one component of the ILS is inoperative or the signals cannot be received. N 18941 could

not receive the compass locators and did not receive the outer marker. Although it may have received the glide slope signal it is obvious the crew did not or could not understand the indications.

All the radio aids in the Tri-City area are maintained by the Federal Government for the use of all pilots. While the use of all radios may not be mandatory for IFR flight, good operating practices dictate a maximum crosscheck of all available facilities. If this flight had utilized either the low frequency receiver on the Tri-City range or the No. 2 navigation receiver on the VOR, this accident would in all probability have been avoided.

Probable Cause

The probable cause of this accident was the failure of the pilot to identify Gray intersection properly and his decision to continue an ILS approach contrary to company and regulatory procedures.

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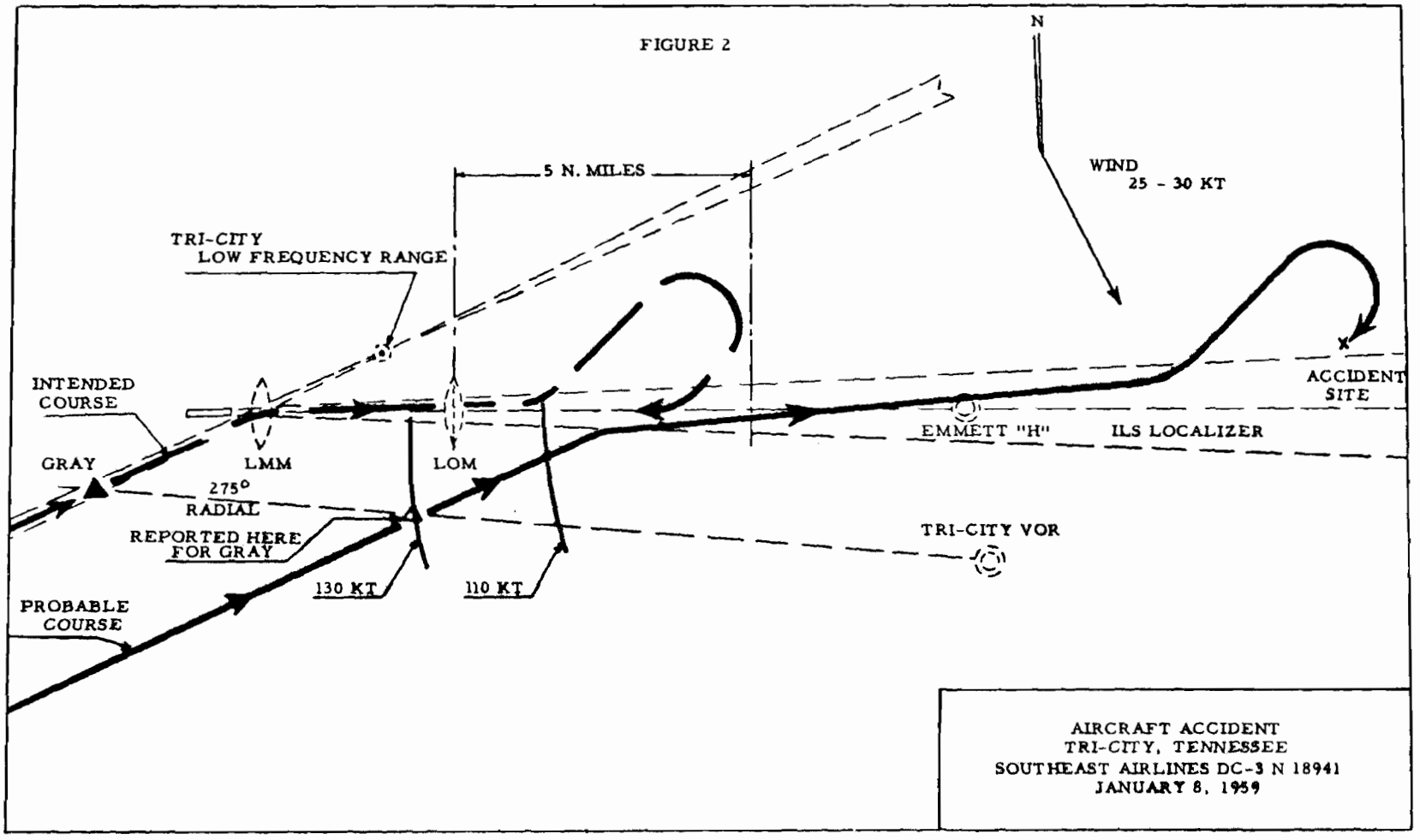
ICAO Ref: AR/597

FIGURE 2


N
WIND
25 - 30 KT
5 N. MILES
TRI-CITY
LOW FREQUENCY RANGE
INTENDED
COURSE
GRAY
LMM
LOM
275°
RADIAL
REPORTED HERE
FOR GRAY
130 KT
110 KT
PROBABLE
COURSE
EMMETT "H"
ILS LOCALIZER
ACCIDENT
SITE
TRI-CITY VOR
AIRCRAFT ACCIDENT
TRI-CITY, TENNESSEE
SOUTHEAST AIRLINES DC-3 N 18941
JANUARY 8, 1959

No. 13

Lufthansa, L-1049, D-ALAK, accident at Flecheiras Beach, Galeão, Rio de Janeiro, Brazil, on 11 January 1959. Summary report released by the Ministry of Aeronautics, Brazil.

Circumstances

The flight was scheduled between Hamburg, Germany and Rio de Janeiro. After reporting 20 minutes out from Rio de Janeiro under IFR conditions the aircraft was authorized to descend from 4 200 m to 3 000 m and to maintain this altitude to NDB KX. Over KX it was authorized to descend to 900 m and to transfer to Galeão Tower for approach instructions. These instructions, together with receipt of the meteorological conditions on the final approach sector were acknowledged; normal position reports including final approach were transmitted.

The aircraft descended over Guanabara Bay under rainy conditions and hit the water with its nose wheel. After this impact it is assumed that the pilot tried to continue the approach but the aircraft undershot the aerodrome and caught fire. The aircraft was destroyed. All 29 passengers and 7 crew died in the accident. Three other crew members were seriously injured.

The crew's duty and flight time immediately before the accident exceeded the limitations established in Brazil, although they did not exceed those established by the State of Registry.

Probable Cause

In spite of an exhaustive investigation it was not possible to determine the actual cause. However, the probable cause was considered to be pilot error in descending below the minimum altitude on final approach.

Aircrew fatigue was considered to be a contributing factor.

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ICAO Ref: AIG/ACC/REP/GEN/No. 8 (Brazil)

No. 14

Empresa Austral, S.A. I. y C., C-46, LV-GED, accident 1 200 m off the coast, opposite Camet Park, Mar del Plata, Argentina on 16 January 1959. Report No. 1191 dated 28 October 1959 released by the National Director of Civil Aviation, Argentina.

Circumstances

After a 35 minute delay (for meteorological information from Mar del Plata) LV-GED took off from Aeroparque Airport, Buenos Aires, at 1950 hours on a scheduled IFR flight to Mar del Plata and Bahía Blanca; it was to cruise at 2 400 m to Mar del Plata within airways. The flight was normal until the final approach at Mar del Plata. The aircraft arrived over the threshold of runway 12 at an estimated height of 85 m and attempted a landing. However, it overshot and without touching the ground did a missed approach procedure and flew out to sea. Approximately 1 200 m from the shore and while in a cruising configuration it descended gradually into the sea (at 2140 hours) killing all 5 crew members and 46 of the 47 passengers aboard.

Investigation and Evidence

The Aircraft

It had a Certificate of Airworthiness issued by the competent authority valid until 3 March 1959.

The Crew

Both the pilot and co-pilot held valid Airline Transport Pilot Licences.

While working for Empresa Austral the pilot had flown about 1 120 hours all as pilot-in-command and on C-46 aircraft. Of this total, 749 hours were night flying and 341 were instrument flying. In all he had flown a total of about 6 846 hours - 2 181 of which were as pilot-in-command, 836 during night flying, and 341 on instruments. As co-pilot he had flown about 4 666 hours - night flying 1 451 hours, instrument flying 1 003 hours and in ground trainers 117 hours. During the previous 90 days he had exceeded by 22 hours the flight time limitations stated in Resolution No. 678 of 27 June 1957.

The co-pilot had flown a total of 982 hours. During the previous 90 days he had exceeded by 3:50 hours the maximum flight time allowed by the aforementioned Resolution.

The radio operator and the two hostesses were properly certificated.

Mar del Plata Airport

The airport's height above sea level is 18 m. The landing area consists of a concrete runway 1 750 m long and 60 m wide, with the ends oriented 120 - 300° magnetic. It is equipped with control tower, radio beacon (NDB) and, at the approach end of runway 12, an inner marker beacon (LI) which was not serviceable on the day of the accident. The airport has a portable lighting system. There are trees at both ends, which are 10 m high, 200 m from the threshold of runway 12, and 14 m high, 200 m from the threshold of runway 30.

Taking the runway centreline towards the sea and following the track of the aircraft, the terrain is covered with forest of an estimated maximum height of 14 m ending about 600 m from the end of runway 30.

The distance between the threshold of runway 30 and the shore is 2 650 m. Parallel to the coast and 15 m from the shore there is a power line whose cables, 12 m high, were cleared by the aircraft. The coastal zone consists of a cliff, approximately 14 m above sea level, which drops steeply to the sea.

Weather

An excerpt from the route weather forecast, which the pilot received prior to his departure from Aeroparque, read as follows:

Aeroparque - Mar del Plata - Bahía Blanca

"altitude: 1000 m, wind direction 210°, speed 35 km/h; altitude: 2 000 m, wind direction 210°, speed 40 km/h; altitude: 3 000 m, wind direction 330°, speed 40 km/h, turbulence moderate - severe with heavy cumulus and cumulonimbus"

Actual weather at Mar del Plata

2115 visibility 4 km; ceiling 150 - 200 m; QFE 1 009.4 mb (pilot then stated there was visual contact at 450 m)

2118 (descent was authorized to 750 m) - visibility 3/5 km; ceiling 100 - 150 m reduced by light rain; surface wind, 20 kt from 180°

2140 (time of final approach)

weather had deteriorated considerably. Visibility poor; heavy drizzle; gusts of wind 40 km/h.

The Final Approach

At 2140 hours, witnesses, all familiar with aviation, observed the aircraft begin its final approach in line with the axis of runway 12, reaching the threshold at 80 - 100 m altitude. The aircraft was off the longitudinal axis of the runway manoeuvring to the left and then the right in an attempt to correct its course. Half way along the runway the pilot tried to force the landing, descending steeply at an angle of 45°. The tower operator got the impression that the aircraft was going to overshoot, and he warned the pilot three times. When he saw that the pilot was persisting in his intention to land after passing over more than 1/2 the runway and had arrived within about 200 m of its end, he warned him two or three times to pull out because of the trees 14 m high. The aircraft then initiated a missed approach procedure, continued its flight climbing on full power, and passed over the trees and out to sea, without replying to repeated calls of the tower operator.

Two witnesses, who were in a wooden hut located 150 m inland from the point on the shore nearest to where the aircraft fell into the water, followed its path out to sea. The flight was reconstructed from their reports as well as from the statements of the sole survivor. The loud noise of the engines, which were functioning normally, attracted the attention of the witnesses on the ground. When they saw the aircraft it was at a height of about 40 - 60 m and descending gradually it went into the sea. An explosion followed.

Since the accident occurred at night and in unfavourable weather, the evidence of those who observed the plane at the time it fell into the water does not, technically, shed much light on how it struck the water, although they related, like the passenger, that the impact occurred in normal flight. The inquiry was, therefore, conducted on the basis of the technical investigation of the recovered material.

From this it was concluded that -

a) The aircraft entered the water at an angle of about 5°, at an angle of bank to the right of about 7°. The landing gear and the flaps were retracted; the forward speed was estimated at about cruising speed; both engines were operating normally.

b) The aircraft struck the water first with the lower half of No. 2 engine, which broke loose, causing a rotating movement through the aircraft and giving rise to forces of inertia leading to the breaking-off of engine No. 1 and both wings.

From analysis of the fractures of recovered parts of the aircraft it was deduced that the movement of the aircraft was transformed into a combination of parallel displacement and rotation, the latter around a plane very near the floor of the aircraft.

General Observations

Following investigation the following points were brought out:-

1) the engines were functioning normally at the time of impact, and the controls were not jammed;

2) there were no signs of fire or explosion;

3) effects of mechanical and thermal turbulence were considered insufficient to suggest the aircraft had been drawn into the sea by a descending wind effect. Studies showed that the impacts of the wind (cyclone) were directed on the surface towards the interior by the general wind flow and the ascending influences were greater than the descending ones.

4) the possibility of the aircraft having struck a very high wave was also discounted.

Discussion

Having carried out the "escape manoeuvre", the pilot should then have proceeded to gain height and adhered to the instrument missed approach procedure in order to make a new approach.

He continued visual flight in a descent, uncontrolled or unnoticed by the pilots. If he conformed to the procedure indicated on the instrument approach chart, then following the missed approach, the pilot must have performed the "escape operation" with initial climb on course 123° up to QNH 600 m, requesting instructions from the control tower. During the technical inspection of the aircraft following the accident, it was found that the configuration of the aircraft at the moment of touching the water (landing gear and flaps retracted, approximate cruising speed and slight turn to the right) inferred that the pilot, because of the critical situation, his lack of familiarity with the aerodrome and his emotional state at the moment, sought visual referenc points, (and the only ones to be seen were situated to the right of his course, the light of Mar del Plata), in order to reorientate himself for a new approach. At that partic ular time the city was fully illuminated and was visible, in the investigator's opinion, from the accident site, even though the weather conditions were unfavourable. (Visibility was 4 - 10 km, and the distance between the accident site and the coastline nearest the city is 3/4 km). Added to this the fact that the pilot lost a horizon when he turned towards the sea, it is clear that he was seeking this visual reference. Moreover, his direction coincides with the track he would follow in order to find his bearing and make a new approach towards runway 1 first flying over the city.

Lack of Familiarity with Mar del Plata Airport

While formerly employed with Aerolineas Argentinas the pilot had never flown this route. The Mar del Plata Airport staff did not know the pilot and could not remember having seen him operate there.

Empresa Austral stated that on 22, 23 and 24 February 1958 the pilot flew between Aeroparque and Mar del Plata on aircraft, LV-PEV. The Directorate General of Commercial Aviation had no knowledge of these flights. Aeroparque has records of all these flights but with another aircraft, PEU, and the subject pilot is not included on the records. Mar del Plata stated that the flights were with PEU and that on 22 February only the pilot was on three VFR flights as co-pilot and was not a member of the crew on 23 and 24 February. He had only made one VFR landing at night as co-pilot on 22 February and had not operated on this runway for a year. He had never flown this route IFR or as pilot-in-command.

The Empresa Austral dispatcher at Aeroparque stated that before departure from Aeroparque, the pilot had asked to see the approach chart for Mar del Plata.

The flight radio operator of Aerolineas Argentinas aircraft, LV-ADM, departing on the same route to the same destination stated that the pilot asked him for information on the position of the radio beacon with respect to the runway to be used (since the inner radio beacon was not in use) and also on the night marking, since it was only the second time he was on a flight of this kind. It was concluded from the foregoing that the pilot of LV-GED was not familiar with Mar del Plata Airport or radio navigation aids available.

Factors affecting the pilot's state of mind

The following factors were considered to have affected the pilot's capability and skill when landing at Mar del Plata:

1. lack of familiarity with the airport;

2. prior to departure from Aeroparque he knew that existing conditions prohibited landing at Mar del Plata - these continued to exist during the greater part of his flight there;

3. indecision when the landing problem arose (i.e. difficult weather conditions, slippery runway, excessive height and speed, and the tower operator insistently warning of overshooting).

All these factors must have confused him and contributed to his making an error of judgement during the missed approach - i.e. he tried to fly visually, seeking reference points, rather than go back on instruments.

Inadequate dispatching

This was the first flight of a service commenced on that day. Austral should have selected a crew familiar with the route and the airport. In view of the prevailing weather conditions, this pilot was ineligible.

Dispatching was adequate with regard to regulations for the flight plan and the departure. At the time that LV-GED took off from Aeroparque, landing at Mar del Plata was prohibited due to existing conditions. However, the flight was feasible since the alternates were in operation.

The operator assigned a pilot for this flight without observing the requirements of Regulation No. 854/55 of the competent authority, the National Directorate of Air Transport. The pilot in question had never been assigned to this route as pilot-in-command nor on IFR flights.

Probable Cause

The pilot failed during a missed approach procedure to observe the instrument flight procedure and attempted to continue visual flight by night in unfavourable weather conditions. The aircraft then lost altitude and descended into the sea.

Contributing factors were:

1. as the pilot was not familiar with the airport in this type of operation, he miscalculated during the instrument approach procedure;

2. the pilot's temporarily confused mental state, when he found himself in this critical situation, affected his capability and skill;

3. the radio beacon was out of service and the lighting was poor because of the weather conditions at the time of the approach;

4. unsatisfactory dispatching of the aircraft by the operator.

Observations

The investigation revealed the following irregularities:

1. The operator used meteorological minima below those established by the

Directorate General of Air Traffic and Aerodromes for the Mar del Plata Airport.

2. The operator infringed upon the regulations contained in Resolution No. 678/57 by allowing the pilot and co-pilot to exceed the maximum flying hours allowed in the previous 90 days.

3. The operator employed a pilot who did not satisfy the conditions required under Nos. 5, 6 and 7 of Regulation No. 854/55 of the National Directorate of Air Transport.

4. The control tower operator of the Directorate General of Air Transport and Aerodromes was not familiar with the meteorological minima fixed by the aeronautical authorities nor with the existence of the airline's own minima.

Recommendations

The Board advised the aeronautical authority to adopt appropriate measures in order to avoid the recurrence of similar situations and submitted for consideration, by the authorities governing air traffic in the country, a proposal for the study of ways of improving the lighting of Mar del Plata Airport, or in default of that, to contemplate the possibility of establishing meteorological minima higher than those at present in force at that airport.

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ICAO Ref: AR/628

No. 15

Piper PA-24 Comanche, D-ELAC, accident 5-1/2 miles southwest of Sydney Airport, Nova Scotia, Canada, on 16 January 1959. Report Serial No. F-180, released by the Department of Transport, Canada.

Circumstances

The aircraft was being delivered to West Germany. The pilot, the sole occupant of the aircraft, was en route to Moncton, New Brunswick from Gander, Newfoundland when he received a weather report indicating that his destination was already below the safe limits for landing under instrument conditions. He elected to fly to Sydney and was attempting to let down on instruments through low clouds for a visual landing when the aircraft collided with the ground, killing the pilot and destroying the aircraft.

Investigation and Evidence

Aircraft - General

A Certificate of Airworthiness for Export had been issued for the aircraft by the United States of America.

The aircraft was not fitted with de-icing equipment.

Two galvanized iron tanks had been installed on the rear seats as part of an unapproved auxiliary fuel system designed to give the extra range necessary for the trans-Atlantic flight. There was no record of a compass swing after this tank installation.

The Pilot

He held a German Commercial Pilot's Licence and a Special Purpose Pilot's Certificate issued by the U.S.A. According to his log book he had flown 399 hours and 37 minutes of which 33 hours and 51 minutes had been flown in the Piper PA-24 Comanche. He had approximately 90 hours of training for instrument flying, but his licence did not have an instrument rating endorsement. His log book indicated that he had made a successful ILS approach in this aircraft under IFR conditions four days prior to the accident. However, on the subject flight he did not carry any of the let-down procedure charts necessary for a pilot to navigate his aircraft down through clouds to the minimum safe limits for a landing at any airport along the route. The lack of such a chart for Sydney was the only apparent reason for the pilot's failure to attempt the approved standard type of approach to the airport.

Loading of the Aircraft

At take-off from Gander the aircraft was overloaded by 16% of its authorized maximum gross weight. At the time of the accident it was overloaded approximately 8%. The centre of gravity was within the approved limits on take-off from Gander and at the time of the accident, 1604 hours, was slightly beyond the rear limit.

The Flight

The aircraft took off from Gander at 1303 hours Atlantic standard time having been briefed on the weather situation. Ten minutes after passing over Sydney it was cleared by ATC to return to Sydney having been advised that Moncton, its destination, and Charlottetown, the alternate, were reporting weather conditions below the IFR limits for landing.

At 1557 Sydney gave the pilot landing instructions and the weather report... indefinite ceiling at 200 ft, sky obscured, visibility 3/8 mile in light freezing drizzle and fog... and as the weather was below the minimum IFR limits for landing he indicated that he would proceed to the November radio beacon where he would descend through clouds until visual contact was made with the ground and then would proceed to the airport for the landing.

Having reported over the November beacon at 1603 the aircraft was not heard from again.

Conclusions following technical investigation

It was determined that the aircraft had struck the ground in a left spiral dive. Ice had accumulated on the aircraft during the latter portion of the flight. About 15 hours of fuel remained at the time of the accident, but it was not possible to determine how much was in the particular tank selected, as all tanks had been ruptured. It was concluded that considerable power was being delivered by the engine when the propeller cut down a tree near the point of impact.

It appeared that the pilot did not encounter any difficulty during the descent, but became distracted at a very low altitude when the engine power fluctuated, and inadvertently allowed the aircraft to come into contact with the ground. The cause of intermittent engine power, as heard by witnesses, could have been caused by either carburettor icing or by some difficulty in the unorthodox fuel system. The overloaded condition of the aircraft would have been aggravated by the additional weight of ice forming on various portions of the structure, which would also affect the flying characteristics of the aircraft.

Probable Cause

The pilot attempted a flight beyond his ability and experience when he continued into unfavourable weather. Contributing factors were the overload, icing and lack of proper airport charts.

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No. 16

Eastern Air Lines, Inc., Lockheed 1049G, N 6240G, made an emergency landing at Miami International Airport, Miami, Florida, on 17 January 1959. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 1-0024 released 20 September 1959.

Circumstances

Flight 704 was a daily non-stop flight from Miami, Florida to Detroit, Michigan. It carried 5 crew and 12 passengers. Immediately after take-off from Miami, No. 3 engine failed following an initial failure of a connecting rod, and an uncontrollable fire in the same nacelle ensued. It was believed that during the engine failure progression an abnormal exhaust flame occurred, which ignited a flammable discharge from the outboard breather exit of the engine. The resulting flame then penetrated the aluminum wheel well doors igniting a fire in zone 3-A of the nacelle. An emergency landing was carried out on runway 9R at the Miami International Airport during which the right main gear collapsed. One passenger received minor injuries. The aircraft was badly damaged by inflight and ground fire and by impact.

Investigation and Evidence

The flight engineer stated that his pre-flight inspection of the aircraft was complete, and he was satisfied that there were no leaks.

The aircraft was cleared to taxi to runway 27R at 1559 for take-off. However, its departure was delayed because of heavy traffic for 20 minutes. While in runup position a thorough and satisfactory pre-take-off check was made. Take-off was at 1621. All crew members said that power plant response was normal, and the aircraft accelerated properly. When airborne the landing gear control was positioned to "gear up", and while the gear was in transit maximum continuous power was established. About 150 ft above the runway and about the time the gear was retracted the captain saw a fluctuation of the No. 3 engine tachometer. The rpm dropped from 2 600 to 2 300 and returned. The engine was shut down. At the time the engine failure procedure was in progress Miami tower personnel saw smoke, then flames trailing the aircraft from the No. 3 engine nacelle area. The local controller informed the flight and cleared it to land using any runway. At the same time the airport emergency equipment was alerted.

Before the aircraft was over the west end of the runway and when the last steps in the engine-out procedure were taken the master fire-warning bell sounded, and the No. 3 engine zone 1 fire-warning light came on. The flight engineer positioned the fire extinguisher selector to the No. 3 engine, and the first of two Freon* bottles was discharged. The warnings continued, and the second bottle was discharged. The action was ineffective.

* The aircraft's fire extinguishing system is a dibromodifluoromethane (commonly referred to as Freon) type, which, as it pertains to the No. 3 nacelle consisted of two Freon bottles located in the upper section of zone 3-A from which the extinguishant is routed to zones 1, 2 and 3. The system does not route the extinguishant to zone 3-A, and thus would not be available to this area with the landing gear up and the wheel well doors closed.

At this time fire was known to exist and extinguishing action had been taken. Therefore, the company's emergency procedure required that the emergency firewall shutoff valve be pulled and the cowl flaps be opened. This was not done. Also, emergency steps taken were not checked against the cockpit checklist as there was little opportunity for such action in the short time available.

In the aircraft the captain turned left as soon as possible to establish a base leg for landing on runway 9R, the parallel runway to 27R in the opposite direction of take-off. He stated that the pattern speed did not exceed 140 kt, the altitude did not exceed 400 ft, and the pattern was as close as possible. He also estimated the first Freon discharge was before the first leg turn and the second was shortly after this turn. The landing gear was extended during the left turn to final approach and landing flaps were extended shortly thereafter. Both operations were accomplished normally. The captain said the touchdown was smooth and very close to the approach end of the runway. He said that during the rollout normal system braking rapidly "faded out" and became ineffective. All four throttles were pulled into reverse range, at which time the aircraft yawed to the left. About this time it was learned the No. 4 engine had stopped and nose wheel steering was inoperative. Secondary braking was initiated but also quickly faded out although the auxiliary hydraulic pump and manual pump were operated. It was also noted the primary and secondary hydraulic quantity indications were zero.

With the partial braking available, some reverse thrust and normal rolling deceleration, the aircraft slowed appreciably but did not stop until it overran the east end of the runway about 75 ft. Then the right main landing gear collapsed.

Examination of the aircraft and the crew statements established that the inflight fire was confined to the No. 3 nacelle and adjacent areas aft of the nacelle. The other power plants and structure did not cause or contribute to the cause of the accident. Despite this advantage the severity of the fire in the areas most important to the investigation destroyed much valuable evidence and the ground fire damage made it most difficult to ascertain and trace the inflight fire patterns with certainty.

On the L-1049-series aircraft the No. 3 engine nacelle installation is divided into four zones. Zone 1 is the engine power section which is located forward of the engine fire seal; zone 2 is the engine accessory section located between the fire seal and the stainless steel fire wall; zone 3 is the area from the firewall rearward to the auxiliary fire shield (some fluid-carrying lines are routed through this zone and it houses the right main gear wheels and the lower portion of the gear strut when the gear is retracted); zone 3-A is the area aft of the auxiliary fire shield, located just in front of the front wing spar rearward to the rear wing spar. The right main landing gear strut is hinged to the rear spar.

Testimony of a Lockheed representative at the public hearing was that the auxiliary fire shield which divides zone 3 and 3-A in the No. 3 nacelle of the L-1049 was for the purpose of additional safety beyond regulatory requirements. The installation, he said, was not dictated by any adverse operational experience. He stated that with the landing gear up and wheel well doors closed a fire seal was formed between the two zones; however, with the landing gear down both zones were open to the atmosphere and to each other.

Following the accident, examination revealed the fire detector system even though badly burned was capable of functioning satisfactorily.

Because of considerable probative evidence found during the investigation of the accident, the investigators were aware of the possibility that an abnormal exhaust flame may have occurred in conjunction with the engine failure. It was further thought that this flame then entered the nacelle igniting flammables causing the fire. Therefore, during the public hearing the Board sought technical information and experience data from highly qualified personnel of the engine manufacturer, the airframe manufacturer and the operator. This possibility was also discussed by a highly recognized and experienced witness in the field of flammables and conditions under which flammables can be ignited in flight.

An incident occurred 25 March 1959 which is significant and has an important bearing on this accident. It involved Flight 134, an Eastern Air Lines Constellation and a model which has identical engine and nacelle installations to N 6240G. Shortly after take-off, Flight 134 experienced a failure of the No. 2 engine which, upon examination, showed nearly identical internal damage to the engine involved in the accident under consideration, except the damage involved the rear row of the power section instead of the front row.

A CAB investigator who witnessed this incident stated that after the engine was shut down and the propeller feathered, he observed a flame which emanated in the area of the exhaust and breather exits and trailed rearward at least to the trailing edge of the wing and continued to burn for nearly a minute while the flight made a pattern around the airport (Miami International) to land.

Examination of the front and rear outboard wheel well doors revealed heat damage coincident with the exhaust stains on the doors. Heat blisters and heat damage existed on the outside surface of the front door, and oil coating and charring were found on the leading edge of this door. Similar coking was found on the inside of the rear door in the area adjacent to the opening between the front and rear doors. The seal between the doors was undamaged. Examination also disclosed that the entire outside surface of the fire damaged doors was coated with engine oil and there was an abnormal accumulation of oil on the inside of the doors. Further, oil was dripping from the No. 1 power recovery turbine and the breather exit on the same side.

Examination of the engine in this incident revealed no leaks, and there was no release of exhaust flame and gases except through the normal exhaust system exits. It was evident that an exhaust flame during the type failure involved did impinge against the wheel well doors. The incident also proved that such exhaust flame can and did enter the nacelle between the front and rear doors with sufficient heat to coke oil deposits on the inside of the rear door as far rearward as a point just aft of the leading edge.

To determine and show the effect of oil forced into the exhaust system, the Curtiss-Wright Corporation ran tests for the Board. Although they indicated that the introduction of oil into the exhaust system would not produce an abnormal flame, the 25 March incident and verbal pilot reports prove conclusively that under certain circumstances an abnormal flame will occur. Compared to the tests, some differences were present in the incident. These, the Board believed, may have been the introduction of a fuel-air mixture, the slipstream effect not present in the tests, and the ignition of such a combustible mixture from the engine breather. Because more pistons were out of the cylinders in the accident situation an even more combustible fuel-air mixture would have been present.

It also appears significant that the No. 1 power recovery turbine exhaust is angled downward slightly with the opening just outboard, forward and above the outboard breather. Also, examination of the oil breather pattern and exhaust stain shows they cross at the forward edge of the right front door. Thus, after consideration of all the aforestated conditions, the Board was of the opinion that although ignition of the breather mixture is not probable, under certain conditions, it is possible that it did occur in this accident.

Analysis

Analysis of the damage and damage patterns found in the No. 3 engine strongly indicated that the initial failure was a connecting rod. Because the No. 10 rod showed a splitting-type failure while all others showed clean overload breaks, it is logical to believe that this rod most probably failed first.

Failure of the No. 10 rod would add reciprocating loads on the front master rod, therefore, it most likely failed next. Similarly, with one or more rod failures the remaining pistons would begin to overtravel permitting the bottom rings to pass below the cylinder skirts progressively failing the piston rings, pistons, and connecting rods as indicated by damage found. The unbalanced loads would produce flaring of the master rod until it failed. During the flaring, which was clearly shown on the front master rod, cocking of the connecting rods and pistons could take place which would reasonably account for the heavy wear patterns found on the top land of one side of the pistons and on the piston skirt on the opposite side.

Initial failure of the connecting rod was also evident by the damage to the front main bearing itself. All of the failures in the bearing assembly were overload as the result of jamming and restricting the normal bearing function. The only parts and pieces which would have jammed the bearing were those found in the assembly and these were from the front row pistons, connecting rods, and rings. In addition, parts of the bearing found in the oil sumps were free of the heat indications that are normally characteristic of a bearing failure. Had bearing failure been the initial occurrence, damage should have been found to the centre and rear main bearings as well as to the reciprocating assemblies of the rear row; no such damage was found.

After a careful study of all available evidence the Board believed that the engine failure shortly after take-off and the uncontrollable fire in the same nacelle were related and could not be accepted as two isolated events that happened at nearly the same time in the same nacelle. Also, there was no evidence which could account for the fire having been started from a source of ignition within the nacelle. It was, therefore, believed that the fire resulted from conditions and events relating to the engine failure. There was no physical evidence found to show that the source of ignition came from zones 1 and 2 or from within the nacelle. Thus, it was believed the ignition source for the nacelle fire must have been an abnormal exhaust which ignited a flammable substance outside of the nacelle. The resulting flame penetrated the nacelle through the aluminum wheel well doors. Evidence and expert testimony were available to support this opinion.

During such an engine failure, hot, highly agitated, engine oil and oil vapours would be forced into the airstream through the exhaust system and from the engine breathers. Even more so in this instance because two lower pistons had failed in a manner allowing them to fall into the crankcase where they had tumbled for some time as evidenced by the fact they were pounded into balls. This circumstance would permit crankcase oil to drain freely into the lower exhaust system. Similarly, from back pressure, oil and oil vapours would be forced from the crankcase breathers. In addition, as long as the engine controls remained at rated power, high airflow and fuel flow would be delivered to all combustion chambers since both cam drive assemblies were

intact and operating. Although many of the front row pistons became incapable of compressing the mixture, it was free to pass into the exhaust and also to enter the crankcase and then into the slipstream through the engine breathers. This process probably began during the take-off roll, as evidenced by unusual gray-white smoke observed at this time. It would also continue and increase with the engine failure progression until the reciprocating action of the engine was stopped which, according to many eyewitnesses, was well after a major fire existed in the nacelle.

Because the normal discharge of breather oil enters the nacelle in considerable amounts it is most reasonable to believe a flame from the same source would enter the interior of the nacelle while the wheel well doors were open. Also, it is believed that such flame would impinge the doors while they were closed and, if of sufficient intensity, could burn through the aluminum structure in a few seconds. Considerable probative evidence exists leading the Board to believe the latter occurred in this instance. This opinion is supported by the layered pattern of nonferrous metal which was impinged rearward and inward on the vertical outboard forward door member. This could have occurred only in flight by a fire source outside the nacelle which burned through the aluminum doors to supply the molten metal. Although other metal splatter patterns found in zone 3 of the nacelle, were in accordance with the in-flight swirl patterns with the wheel well doors open, it is believed such a pattern would exist with portions of the doors burned away. Further supporting the opinion that the doors were closed is the fact that fire warnings did not occur until well after gear retraction when the gear doors would have been closed. Finally, a photograph of the aircraft during the landing roll showed a major portion of the right front door burned away although the existing fire at that time was well behind this area. Again, this burnout, together with the impingement pattern of molten aluminum, must have been caused by a sustained flame which originated outside the nacelle earlier in the sequence of events. Thus, by this evidence and the elimination of other fire sources, the Board is of the opinion the source of the fire must have been the ignition of breather discharge which then burned through the wheel well doors.

It was also apparent that the flame penetrated zones 3 and 3-A before the engine was stopped. This was evident by the ingestion of molten metal by the engine-driven vacuum pump. It was considered probable that rotation of the propeller occurred or continued after the vacuum line, which supplied the metal, was melted. With such propeller rotation a continuation of the supply of flammables from the exhaust and power recovery turbine would exist for a longer period of time.

Even after the fire was extinguished the lines in zone 3 were intact; therefore, there could have been no continuing source of flammables in this zone which could have sustained a fire of the magnitude that occurred. Relatively light damage in zone 3 also indicated this. In view of this evidence and because there was no way for the fire to enter zone 3-A from zone 3 with the gear up and the fire shield intact, the major fire must have been ignited in zone 3-A. It is considered most probable therefore that the breather flame, after burning through the wheel well doors, entered zone 3-A travelling upward and forward behind the auxiliary fire shield to the area of several flammable fluid-carrying lines and the No. 3 fuel filter.

Because of the extensive burnout that occurred in zone 3-A it is extremely difficult, if not impossible, to determine the precise source of flammable material where the uncontrollable fire began or if a pre-existing leak was present in the zone which, when ignited, sustained the flame until fire damage released the large quantities of flammable fluids. From the fire pattern and apparent airflow it is possible that the breather flame impinged upon the heat-split B nut, creating a spray

of hydraulic fluid, and/or impinged upon the light aluminum alloy cover of the No. 3 fuel filter creating a spray of fuel. Considering the fire-resistant quality of the lines in zone 3-A, the rapidity with which the fire began, and the lack of precedence for such fire, the Board could discount the possibility of a pre-existing leak.

Believing the raging fire was principally in zone 3-A, it is immediately apparent that because this zone is not serviced with fire extinguishing agent outlets, the fire could not be put out when the crew discharged the Freon. Also, since the source of the flammable which ignited is unknown, the effect of the flight engineer's failure to actuate the emergency fire-wall shutoff valve cannot be determined.

On the basis of all available evidence the Board concluded that in this instance during an engine failure an abnormal exhaust flame occurred. It is concluded that this flame did, in fact, ignite an abnormal discharge of oil and fuel vapours from the outboard No. 3 engine breather exit. The resulting flame from the breather then impinged upon and burned through the right wheel well doors and entered the interior of the No. 3 nacelle. The Board concluded that although fire damage occurred in zone 3, the principal fire in the nacelle was ignited from a source of flammables in zone 3-A although the precise source and conditions surrounding how the flammables were released cannot be determined.

As a result of the accident the Board submitted recommendations to the Federal Aviation Agency stating that it believed it necessary, in the interest of safety, that consideration be given to a requirement that zone 3-A of Constellation aircraft be serviced with fire-detection and fire extinguishing equipment. Also, that action is necessary which will, through directional control of the exhaust flame, ensure that an abnormal exhaust flame will not ignite a breather discharge or impinge upon the wheel well doors when they are either open or closed. Also it was recommended that wheel well doors should be replaced with those of fireproof materials.

Firefighting

The Dade County Port Authority airport emergency rescue and firefighting equipment intercepted the aircraft from a crossing runway (17-35) before it stopped. The fire was not extinguished for approximately 30 minutes and not until assistance was received from off-airport fire departments from Miami, Miami Springs, Hialeah, and Dade County.

It was learned that foam was used as the principal extinguishing agent and the total capacity of the four pieces of equipment manned at the accident was about 2 150 gallons of water-foam mixed in a 10 to 1 ratio. This total capacity could be discharged in about five minutes. Additional foam concentrate was not carried to the accident scene and other than hand extinguishers the department had no extinguishing agent to supplement the foam. Water, however, was available to any part of the airport through a system of wells and hydrants.

Compared to National Fire Protection Association suggestions, which, in this field, are widely accepted in the absence of any regulatory matter, the amount of foam available at the scene was well below the amount suggested. As indicated, the suggested amount of supplementary extinguishing agent, such as dry chemical or carbon dioxide, was not possessed. The discharge rate capacity of the equipment was about one-half that of the NFPA suggested rate. In addition, the Port Authority lacked such important rescue equipment as power saws and escape stairs.

During the investigation comparisons were also made between the Miami International Airport rescue and fire-fighting equipment and equipment capabilities and those of other airports of similar size and generating comparable traffic factors. The comparison showed Miami was far below New York, Los Angeles, San Francisco, and Chicago.

The equipment reached the aircraft before it stopped and the prime piece of equipment was positioned at the cabin door to carry out the protection and assistance of evacuating occupants. When this was assured, the equipment was moved in front of the burning wing, close to the fuselage. Another foam truck was positioned behind the wing and at the same time hose lines were laid to water sources. Both foam trucks laid foam on the fire according to accepted techniques. According to nearly all observers, in a few minutes the fire, then being fed by about 1 700 gallons of fuel from the right wing fuel cells, was under control and nearly out. At this time the foam supply at the scene was exhausted. Two flashbacks of the fire then occurred and it rekindled to its original intensity. The lieutenant in charge of the airport equipment at the scene stated, in essence, that, when the fire was nearly out and despite the flashbacks only a small amount of additional foam would have enabled his personnel to have put out the fire. Without it, extinguishment took the combined efforts of his equipment and the off-airport equipment that reached the scene about the time the fire rekindled. The fire was finally extinguished by using several thousand gallons of water.

It was the Board's conclusion that a lack of equipment and equipment capability was the principal reason the aircraft fire was not extinguished more promptly. The record shows that the Airport Authority initiated action to increase its firefighting capability through procurement of new equipment.

Probable Cause

The probable cause of this accident was an uncontrollable fire ignited in zone 3-A by a burning breather discharge which was ignited by and combined with an abnormal exhaust flame during engine failure.

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No. 17

Air Charter Limited, Avro 688 Super Trader, G-AGRG, ran off the edge of the runway and burned during take-off run from Brindisi Airport, Italy on 27 January 1959. Report released by the Ministry of Defence and Aviation, Italy.

Circumstances

G-AGRG was on a charter flight from Australia to England, landing en route at Brindisi, Italy. The aircraft began its take-off run at 0609 hours on runway 32; after a normal run of 550 m it suddenly swerved to the left, ran off the runway and after 160 m lost its left landing gear because of the rough terrain. It continued for 110 m and came to rest after turning 90° to the left. A violent fire broke out immediately in the left wing. Of the six crew members aboard, two died in the fire. The aircraft and its cargo were destroyed.

Investigation and Evidence

The Aircraft

The aircraft had undergone normal overhaul and inspection and was airworthy at the time of the accident. The load was properly distributed and secured, and the centre of gravity was within the allowed limits. After the accident the engines were thoroughly checked by the manufacturers and the fuel used was analysed. No evidence was found which suggested that there had been any malfunctioning of the aircraft or engines prior to the accident.

The Crew

All crew members held valid licences and were properly qualified to carry out their specific duties. Information and medical data available indicated that the crew's mental and physical conditions were entirely normal. However, during the 12 days prior to the accident the crew had flown 98 hours, of which 22 were during the last 48 hours. The crew showed remarkable control after the accident. It can, therefore, be assumed that their mental and physical conditions were excellent.

Wind conditions

The only weather element which had any bearing on the accident was the wind which was between 030° and 050° gusting between 30 and 42 kt.

The direction and intensity of the surface wind were such that they gave a crosswind component ranging from a minimum of 23.5 to a maximum of 42 kt, which was, therefore, above the maximum crosswind from starboard (22 kt) permitted by the flight limitations contained in the Operational Manual of the airline. The gust pattern was such that an adequate period of reduced wind condition permitting take-off could not reasonably be expected.

The Runway and Surroundings

The runway was in excellent condition and no factor was revealed during the investigation that may have had an adverse effect on the take-off manoeuvre. The runway had no safety shoulders and the adjoining terrain was irregular, with dips, ruts and mounds of earth, the latter resulting from ground levelling work that was being undertaken at the time. These conditions aggravated the consequences of the accident after the aircraft had left the runway.

The Wreckage

The wreckage was 40 m beyond the southwest edge of runway 32-14, approximately 1 000 m from the southeast end of the runway.

The tire marks on the runway surface ran straight initially and oriented approximately 30° to the left in relation to the runway centreline. Then they made a wide curve to the left and there were signs of braking, especially on the right wheel, followed by a straight line. The ground marks continued beyond the runway, but the tire tread patterns were offset 20° - 30° from the centre line of the ground marks. The distance between the two marks decreased from 7 m to 6 m and the marks then ran parallel to the runway while the tire tread marks on the ground became larger. Off the runway the marks were still visible over the rough terrain which included a dip approximately 50 cm wide and 30 cm deep along the path followed by the left wheel. The wheel bounced over this dip and fell back on the ground some 40 m further where it sank in a patch of fresh earthwork softened by recent rainfalls. The work had been recently completed to connect the open land with a crossroad leading from the runway to the control tower. As a result of this dip and bounce the left wheel struck the side of the roadbed, raised approximately 40 cm above the level of the surrounding terrain, causing the failure of the supporting structure of the left landing gear, already weakened by the earlier impact. The left wing then sagged and the blade tips of propeller No. 1 began to cut into the ground approximately 50 m from the point at which the landing gear had collapsed, leaving slash marks at intervals of approximately 30 cm (or 90 cm for each turn of the propeller). Assuming that the speed of the aircraft was already below that mentioned by the crew, namely 50 kt (i.e. 26 m/s), this gives an rpm of approximately 1 700, indicating that the engine was at low speed.

Firefighting

The fire broke out a few seconds before the aircraft came to a full stop. The airborne fire fighting equipment was not used. However, because of the rapid sequence of events it probably would not have been effective.

The ground fire fighting equipment reached the scene of the accident 30 seconds after the accident. CO_2 and water foam vehicles were used but the wind evaporated and dispersed the jet as it left the nozzle. The extent and violence of the fire, the strong wind, and the orientation of the aircraft in relation to the wind indicated that the effectiveness of the fire fighting means, which corresponded to those prescribed, could not have been used with any better results under the circumstances. Two members of the fire fighting squad, wearing protective clothing and protected by the vapourized water, managed to enter the door of the fuselage but were unable to go any further because of lack of visibility and dense smoke.

Actions of the crew during take-off and after the accident

The take-off manoeuvre was performed by the pilot-in-command assisted by the flight engineer. The two inboard engines were throttled up to 30" while the aircraft was at rest and braked. The brakes were then released and full power applied to the inboards, the throttles being held there by the flight engineer on instructions from the pilot.

The aircraft started its run and the pilot, by juggling the two outboard throttles, managed to keep it on a "reasonably" straight course. However, because of the crosswind from starboard and the consequent tendency of the aircraft to swing to the right, full power was applied at a certain moment to the right outboard engine. As the aircraft gathered speed, the tail began to rise and the aerodynamic

forces increased; the pilot then increased the power on the left outboard engine.

When the aircraft had reached a forward speed of 60 - 70 kt it began to ease off the ground without, however, becoming airborne (normal unstick speed 90 kt). The ground marks indicated that the aircraft at this speed was skidding towards the left edge of the runway. The track of the aircraft then curved sharply towards the left, pointing towards the tower; this sudden rotation surprised the pilot, who was then giving full power to engine No. 1 and who immediately gave full right rudder. The marks on the runway indicated that there was also a sharp braking on the right wheel.

In spite of the wind direction, the aircraft skidded and ran off the runway to the left; while the pilot was able initially to check the tendency of the aircraft to veer to the right, he was probably taken by surprise at the very instant when the aircraft, which had become lighter on the ground because of the increased speed and the thrust of the right outboard engine put on full power - offered its entire surface to the effect of the wind during the critical phase immediately prior to becoming airborne and was caught by a more violent gust. When the gust dropped, the corrective measures became excessive and caused the aircraft to skid to the left.

The aircraft suddenly ran off the runway, and at the very same moment the flight engineer pulled all the throttles back, presumably because he believed that it was dangerous to continue the take-off manoeuvre once the aircraft had gone off the runway, and not because he had observed any sudden engine failure. The flight engineer's action in cutting the engines took place when the aircraft had practically run off the runway; it is not believed, therefore, that his intervention could have had any effect on the accident or aggravated it. After the accident the flight engineer opened the roof escape hatch but invited the other members of the crew to go out first, which they did in the following order: first, the flight navigator, second, the pilot-in-command, third, the first officer. The flight engineer then tried to get clear of the aircraft, but it was too late to escape the flames.

The second flight engineer left the aircraft by the tail exit after crossing the fuselage and climbing over the last large box attached close to the exit door.

The radio operator was the only crew member who was unable to abandon the aircraft.

Summary of evidence

The following items of evidence were directly related to the accident:

1. the strong gusting wind giving a crosswind component above the maximum value permitted in the Operations Manual of the aircraft should have discouraged the pilot from attempting take-off;

2. the condition of the ground bordering the runway was an aggravating factor - however, the pilot must have been aware of its condition;

3. the actions of the crew during the take-off manoeuvre;

4. the behaviour of the aircraft as a consequence of the three above factors.

Probable Cause

The primary causes of the accident were the strong crosswind with gusts and the ground condition on the edge of the runway.

Recommendations

It was recommended that:

1. pilots of aircraft and their crews should comply thoroughly with the rules contained in the aircraft operating manual and carefully observe at all times the safety regulations for the normal operation of air transport;

2. the possibility of urgent action to level the safety shoulders of runway 14/32 at Brindisi Airport should be investigated;

3. the capacity of Brindisi Airport to handle traffic should be increased by making runway 05/23, which is better oriented to northerly winds, serviceable once again.

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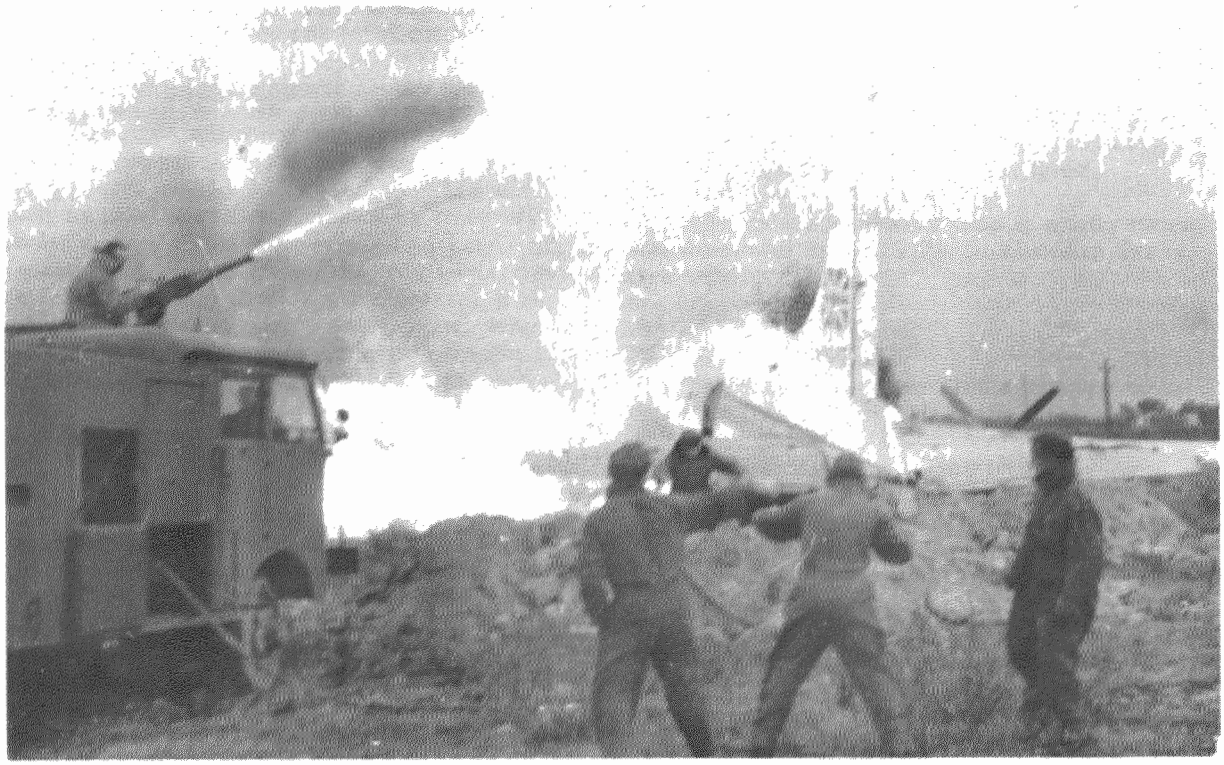
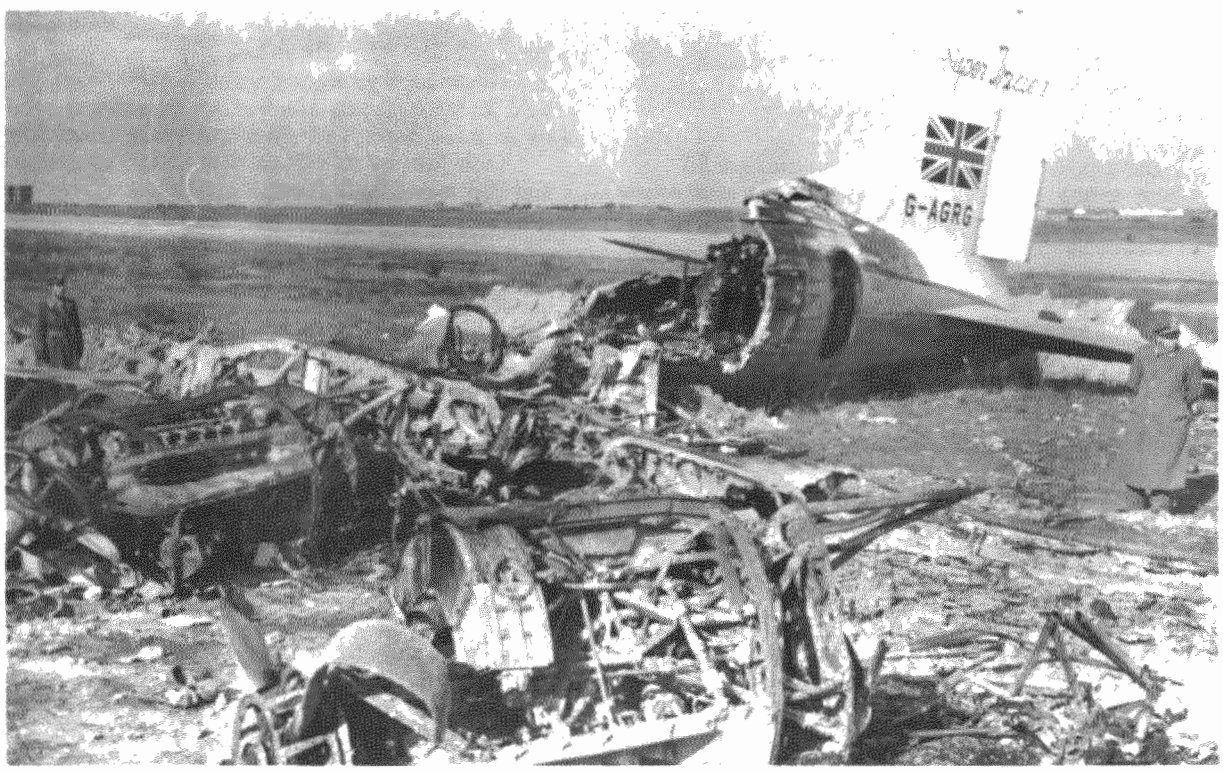
ICAO Ref: AR/626

FIGURE 3



FIGHTING THE FIRE WHICH BROKE OUT IN THE LEFT WING OF AVRO 688 SUPER TRADER, G-AGRG, AFTER A TAKE-OFF ACCIDENT AT BRINDISI AIRPORT, ITALY - 27 JANUARY 1959

FIGURE 4



GENERAL VIEW OF THE WRECKAGE OF G-AGRG

No. 18

General Airways, Inc., DC-3, N 17314, crashed near Kerrville, Texas, on 1 February 1959. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 1-0056, released 24 November 1959.

Circumstances

The DC-3 was on the final segment (Pueblo, Colorado to San Antonio, Texas) of a civil air movement flight from Boise, Idaho to Lackland Air Force Base, San Antonio, Texas. Twenty-eight occupants were aboard including the captain, a reserve captain and a co-pilot. Take-off from Pueblo was at 1800 hours central standard time and at 1916 the flight requested to change altitude from 9 000 to 7 000 ft, reporting light icing. This request was granted at 1945. Ice accretion became worse, critical and then incapacitating. The aircraft attempted a landing at a privately used airport at Kerrville, Texas, but failed and was then crash-landed nearby. Three occupants were killed - the captain, the reserve captain, who was acting as co-pilot, and one passenger. Four others were seriously injured.

Investigation and Evidence

Take-off Weights

At take-off from Boise there was a 104 gal discrepancy in the amount of fuel on board. The actual gross weight of the aircraft on take-off was 26 117 lb instead of the 25 493 lb indicated on the weight and balance form. Following computations from data in the operating manual approved for the carrier's use by the CAA (now FAA), it was concluded that on leaving Boise (elevation 2 858 ft), the aircraft was approximately 517 lb over the permissible take-off weight.

A further discrepancy of 242 gal was noted in the amount of fuel on board on the Pueblo to Lackland Air Force Base portion of the flight. On the weight and balance form the gross weight at take-off was 24 870 lb., the actual being 26 322 lb. The maximum allowable take-off weight from Pueblo (elevation 4 725 ft) was 24 950 lb, therefore, at take-off from Pueblo the aircraft was overweight by a computed 1 372 lb.

Weather

The briefing from the Weather Bureau at Pueblo was by field interphone between 1635 and 1650. It consisted of a reading of 1600 hourly weather reports for 13 stations along the route to San Antonio, the terminal forecast for San Antonio, pertinent excerpts from the area forecasts issued by Denver, Fort Worth, and New Orleans, plus a flash advisory issued by Albuquerque. The briefing concluded with the Winds Aloft Analyses for Pueblo, Amarillo, Abilene, and San Antonio. All of the weather data utilized in this briefing clearly indicated widespread low ceilings, restricted visibilities, snow, freezing precipitation and icing conditions existing along the route. Weather Bureau Forecast Offices at Denver, Albuquerque, Fort Worth, El Paso and San Antonio had covered the conditions accurately and exhaustively in area forecasts, terminal forecasts, and even in flash advisories which had been issued throughout the day by each forecast office.

Fatigue

At the time of this accident the crew, having been on continuous duty for more than 40 hours of which more than 32 hours had been in flight, were in violation of Section 42.48, Part 42, of the Civil Air Regulations. This violation existed at the time of departure from Boise, and at the times of arrival at and departure from Pueblo.

Pilot fatigue, which may engender a decrease in competence and diligence, could have been a factor in an overweight take-off from Boise.

The time on the ground at Pueblo was relatively short, and it may reasonably be expected that an increased level of pilot fatigue prevailed upon departing Pueblo. The reason for the overload upon departing Pueblo may have been an anticipation of added and unforeseeable flight time because of the questionable weather ahead or an indifference to regulations.

Economic Factors

Crews are frequently away from their base at Portland, Oregon for extended periods. While away, the captain functions not only as captain but becomes his own dispatcher, his own chief of operations and the carrier's fiscal agent carrying a sizable amount of cash. He is not required to clear operational or other matters with his home office and did not do so during the series of flights culminating in this accident. He is almost entirely on his own even to the extent of paying all en route expenses of fuel, maintenance, housing and feeding of passengers (on CAM flights), and all other operating costs. Less than 90 days prior to this accident General Airways had entered into bankruptcy proceedings in the Oregon courts. At the time of the accident the company's staff and operation had been sharply curtailed.

Economics could have been a factor in departing Pueblo in the face of a critical weather picture rather than remaining overnight. Laying over would have obligated the carrier to furnish lodging and two additional meals to 25 persons. The total cost of this has been estimated at about $250.

The action of the captain in getting so far into a bad situation could be attributable to indifference to elementary rules of flight safety, coupled with severe economic compulsion.

Crew Information

The captain was highly experienced with 15 000 hours of piloting, 9 000 of it in DC-3's. This, combined with weather briefings he obtained, should have alerted him to the fact that by decreasing altitude as he did he would be staying in clouds, with below freezing temperatures and severe icing conditions. The changing of altitude from 9 000 ft to 7 000 ft early in the flight because of icing appears to have been the start of his trouble. He could safely have gone elsewhere: landing in the panhandle section of Texas (at Amarillo) or a diversion to the east (Fort Worth-Dallas) would have been an understandable and safe course of action.

Testimony of the Co-pilot

The only member of the crew to survive was the co-pilot who was not on pilot duty during the Pueblo-Kerrville portion of the flight. The following are excerpts from his testimony:

"I did not awaken until I heard the sound of the engines revving which was approximately 45 minutes before the accident... The captain explained that we had been picking up ice for about an hour previous to that... When we first went forward we were holding an approximate air speed of 120 kt with cruise power 29 inches and 2 050 rpm."

"In a few short minutes the airspeed slipped from 20 kt to 115, to 110 and finally 100 at which time as nearly as I can recall the pilot added power to 35 inches and 2 250 rpm which brought the airspeed up to around 115 to 120 kt. The icer boots were engaged and ice on the leading edge of the wings came off which further increased the air speed..."

"At this time the captain knew that the fuel supply was getting to be critical... The ice and extra drag had used more fuel... he called for weather reports from several airports closest to us... I gathered more of the area was reporting freezing rain and low visibility... As San Antonio was the first station that had

an on course that was reporting above freezing temperatures, he decided to continue on to San Antonio and look for emergency airports on the route. The only emergency airport available seemed to be Kerrville which was some 50 miles short of our destination... The decision to attempt to land at Kerrville was made since the fuel supply was getting real critical by this time... flying at 4 000 ft presumably to have been cleared to that altitude..... approximately 2 000 ft above the terrain. We went to the homer at that altitude and then took an outbound heading for a normal descent and approach; completed the procedure turn, returned to the homer and from there to the airport descending continuously... I don't believe anyone in the cockpit saw the airport though we must have been close. Ice was covering the front windshield entirely and the only visibility was from the side window which the pilot was able to open and could look out from; although unable to see the airport, we had at this time contact conditions and could see the ground."

"The pilot decided to make a second attempt at an approach but rather than follow recommended approach altitude maintained his contact with the ground rather than climb back into the overcast. Somewhere during the second approach attempt the pilot made his decision to bring the plane in for a wheels-up belly landing rather than risk the possibility of the fuel running out during blind conditions in the overcast the re-entry of which would be necessary if we were to go through a normal approach procedure. ... I went to the rear to warn the passengers... I returned forward and the pilot was still searching for a spot to set down. About this point one of the engines sputtered and was out of fuel. A few seconds later we were making our forced landing."

Crash Site

The crash site was at an elevation of 1 535 ft msl in moderately hilly, wooded terrain 6.8 statute miles bearing 123° T. from the Kerrville Airport, and 4.4 statute miles bearing 118°T. from the Kerrville radio beacon. It is in the approximate area where a procedure turn from an outbound heading to an inbound heading would normally be made for a prescribed DF approach to Kerrville Airport.

Probable Cause

The probable cause of this accident was the captain's poor judgement in continuing into known and dangerous icing conditions.

General Airways surrendered its FAA operating certificate shortly after the accident pending FAA re-evaluation of the carrier's operations. The FAA later restored the certificate.

The FAA imposed civil penalties against General Airways on 3 April 1959 for violation of CAR 42.48 (c) 1, 2 and 3, (duty time) and CAR 42.71 (b) (take-off weight).

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No. 19

Beech Bonanza, N 3794N, crashed northwest of Mason City Municipal Airport, Iowa, on 3 February 1959. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 2-0001, released 23 September 1959.

Circumstances

The chartered aircraft took off from Mason City at 0055 hours to fly three entertainers to Fargo, North Dakota. Following a normal take-off to the south, the aircraft made a 180° turn and climbed to approximately 800 ft then heading northwest. Five miles from the airport the tail light of the aircraft was seen to descend gradually until it disappeared. There were no further contacts made. All four persons aboard were killed, and the aircraft was demolished.

Investigation and Evidence

The Aircraft

N 3794N's engine had a total of 40 hours since major overhaul. The aircraft had been properly maintained since its purchase in 1958 by the Dwyer Flying Service. It was equipped with high and low frequency radio transmitters and receivers, a Narco omnigator, Lear autopilot (only recently installed and not operable), all the necessary engine and navigational instruments, and a full panel of instruments used for instrument flying including a Sperry F3 Attitude Gyro.

The Pilot

He was 21 years of age, was regularly employed by the Dwyer Flying Service as a commercial pilot and flight instructor and had been with them about one year. He had been flying since October 1954 and had accumulated 711 flying hours, of which 128 were in Bonanza aircraft. He had approximately 52 hours of dual instrument training and had passed his instrument written examination. He had failed an instrument flight check on 21 March 1958, nine months earlier. When his instrument training was taken, several aircraft were used, and these were all equipped with the conventional type artificial horizon and none with the Sperry Attitude Gyro such as was installed in N 3794N.

The conventional artificial horizon provides a direct reading indication of the bank and pitch attitude of the aircraft which is accurately indicated by a miniature aircraft pictorially displayed against a horizon bar and as if observed from the rear. The Sperry F3 gyro also provides a direct reading indication of the bank and pitch attitude of the aircraft, but its pictorial presentation is achieved by using a stabilized sphere whose free-floating movement behind a miniature aircraft present pitch information with a sensing exactly opposite from that depicted by the conventional artificial horizon.

Weather

The local weather at time of take-off was - precipitation ceiling 3 000 ft, sky obscured; visibility 6 miles; light snow; wind south 20 kt, gusts to 30 kt; altimeter setting 29.85 inches.

The weather briefing consisted solely of the reading of current weather at en route terminals and terminal forecasts for the destination. Flash advisories issued by the U.S. Weather Bureau (Minneapolis) at 2335 on 2 February and by the Bureau (Kansas City, Missouri) at 0015 on 3 February were not brought to the pilot's attention. This could have led the pilot to underestimate the severity of the weather situation. The owner of the Bonanza went

with the pilot to the Air Traffic Communications Station prior to the flight to obtain weather information and none was given to them indicating that instrument flying weather would be encountered along the route.

At time of take-off the barometer was falling, the ceiling and visibility were lowering, light snow had begun to fall and the surface winds and winds aloft were so high one could reasonably have expected to encounter adverse weather during the estimated two-hour flight.

It was already snowing at Minneapolis, and the general forecast for the area along the intended route indicated deteriorating weather conditions. Considering all these facts and the fact that the company was certificated to fly in accordance with visual flight rules only, both day and night, together with the pilot's unproven ability to fly by instrument, the decision to go seemed most imprudent.

It was believed that shortly after take-off the pilot entered an area of complete darkness and one in which there was no definite horizon; that the snow conditions and the lack of horizon required him to rely solely on flight instruments for aircraft attitude and orientation.

The high gusty winds and the attendant turbulence which existed that night would have caused the rate of climb indicator and the turn and bank indicator to fluctuate to such an extent that an interpretation of these instruments so far as attitude control was concerned would have been difficult to a pilot as inexperienced as this one. The airspeed and altimeter alone would not have provided him with sufficient reference to maintain control of the pitch attitude. With his limited experience the pilot would tend to rely on the attitude gyro which is relatively stable under these conditions. As the pitch display on this instrument is the reverse of the instrument he was accustomed to he could have become confused and thought that he was making a climbing turn when in reality he was making a descending turn. The aircraft struck the ground in a steep turn but with the nose lowered only slightly, an indication that some control was being effected at the time.

The directional gyro was found caged, and it is possible that it was never used during the short flight. If the directional gyro were caged throughout the flight this could only have added to the pilot's confusion.

Probable Cause

The pilot unwisely decided to embark on a flight which would necessitate flying solely on instruments when he was not properly certificated or qualified to do so. Contributing factors were serious deficiencies in the weather briefing, and the pilot's unfamiliarity with the instrument which determines the attitude of the aircraft.

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ICAO Ref: AR/602

No. 20

Pan American World Airways, Boeing 707, N 712PA, made an uncontrolled descent over the Atlantic Ocean between London, England and Gander, Newfoundland, on 3 February 1959. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 1-0001, released 3 November 1959.

Circumstances

The flight was en route from Paris, France to New York, N.Y. carrying 119 passengers and 10 crew. At approximately 2205 GMT while flying at 35000 ft in smooth air the autopilot disengaged, and the aircraft gradually entered a steep descending spiral. Recovery was finally made at an altitude of approximately 6 000 ft, and the aircraft was flown to Gander, Newfoundland, where a safe landing was carried out. A few of those aboard sustained minor injuries. The aircraft received extensive structural damage.

Investigation and Evidence

Crew Information

The captain had a total of 11 185 flying hours of which 350 were in B-707 aircraft, and the co-pilot had 14 952 flying hours - 269 of which were in B-707 aircraft. Both were supervisory personnel and qualified as pilots-in-command of Boeing 707 aircraft.

The Flight

Flight 115 departed London at 1845 GMT on an IFR flight plan. Owing to the aircraft's encountering turbulence and light icing en route while flying through the tops of heavy thunderstorms, the aircraft obtained clearance to climb to and cruise at 35 000 ft where it was on top with all stars visible.

At 2150 the captain went to the main cabin, leaving the co-pilot in the cockpit strapped in the co-pilot's seat with easy access to the controls. The aircraft was in maximum cruise configuration flying at Mach 0.82 in smooth air; the autopilot was engaged in the manual mode, the altitude hold was on and the comparison unit was in operation. At approximately 2200 a change in heading of 20° was made, and the co-pilot observed the autopilot was holding the new heading normally. He then turned his attention to making various computations and did not observe the instrument panel during this time. Shortly thereafter buffeting occurred, his instrument panel lights went out, and he saw from the captain's instrument panel that the captain's artificial horizon had tumbled. The aircraft was in a nosedown right spiral about to roll over on its back. The co-pilot pushed the autopilot release button and applied left aileron and rudder. The captain then managed to return to the cockpit, pulled the power levers to idle position and pulled himself into his seat. The airspeed needle was in the vacant area to the right near the zero mark, and the altimeter passing throug 17 000 ft. He could not see the Mach meter because it was hidden by the control wheel, and he could not lift his head. The stabilizer was in the full nosedown position and the electric trim button failed to function. Visual reference was impossible as they were in cloud. The captain then rolled the wings level and the G forces were relieved. The flight engineer pulled the circuit breaker which deactivated the stabilizer system and then straddled the console and

began rolling both stabilizer wheels toward the up position by hand. On passing through 8 000 ft the captain pulled the yoke back with a steady pull and at 6 000 ft, following violent buffeting, the aircraft ceased to descend and began a fairly steep climb. At about 9 000 ft the wings were level, the aircraft was in a moderate climb, and positive control had been regained. Gander was then advised of the difficulty, and the aircraft cruised at 31 000 ft for the rest of the trip.

Damage to the Aircraft

The damage consisted mainly of buckles in the lower surface skin of the right and left horizontal stabilizers and buckles in the centre section web and upper surface doubler, and both wing panels were damaged including shear wrinkles in the rear spar webs and damage to the outboard ailerons and aileron control rods. The wing-to-fuselage fairings were damaged and a three-foot section of the right fairing separated in flight. Both wing panels suffered a small amount of permanent set. All four wing-to-strut fairing sections of the engine nacelle struts were buckled. Nos. 2 and 3 nacelle shear bolts partially failed in shear and the fitting holes in all front spar-to-wing bushings were elongated.

Technical Investigation

Owing to the nature of this accident, certain systems and components of the aircraft were definitely suspect; these were the autopilot, Mach trim systems and their warning systems.

The functional checks conducted on the autopilot system and its components disclosed certain minor discrepancies. In several instances the autopilot disengage warning light did not function properly after disengagement of the autopilot. Also, the pitch trim potentiometer did not recentre after autopilot disengagement. The mechanical centring of this potentiometer is necessary for the autopilot upon re-engagement to have available full noseup or nosedown trim. Under the conditions of flight, at approximately 2150, the pitch trim potentiometer irregularity would remain unnoticed, and it would have no tendency to cause the aircraft to depart from the established cruise condition.

Testing of the vertical gyro transmitter disclosed that the rate switch was inoperative. This transmitter is an electrically driven gyro that provides the vertical reference for the automatic pilot. Incorporated in the assembly is a rate-of-turn control consisting of a hermetically sealed rate gyro and switch. At pre-set turn rates the switch turns off the vertical gyro erection system, thereby preventing erection of the vertical gyro to a false (dynamic) vertical during turns. Examination revealed that the rate gyro motor windings were open; the rate switch was, therefore, unable to respond to turns and would have permitted the erection system to remain on at all times. However, during the slight turn and subsequent continuation of the straight flight path, this malfunction would not have manifested itself. Subsequent to the examining group's inspection, Boeing engineering personnel observed that the rate switch would occasionally stick when closed manually.

Tests of the comparison unit disclosed some irregularities in the pitchup attitude condition. One involved intermittent disengagement at a 10-degree noseup attitude; however, this attitude is not pertinent to the level attitude of the aircraft in this instance. It was also slightly out of tolerance in response to a step change in pitchup attitude; however, this would have made it less sensitive and therefore less likely to disengage the autopilot in response to a pitchup of the aircraft.

These were the only discrepancies involving components capable through malfunctioning of causing the autopilot to alter the established flight condition or cause autopilot disengagement.

In analysing the autopilot irregularities found, it is apparent that they were both minor in character and unable to have caused

this disengagement. Although such disengagements are by no means common occurrences, some may be expected of an autopilot of this type incorporating a comparison monitor designed to disengage the autopilot quickly should it sense any number of undesirable behaviours or responses. In achieving the desired sensitivity of the monitor system it is conceivable that nuisance disengagements can occur as the result of transitory spurious signals. In this instance, the disengagement also could have been the result of either the accidental operation by the co-pilot of the stabilizer trim switch or the autopilot disconnect button, both of which are on the control wheel; or by operating the autopilot engage (on-off) switch located on the pedestal.

Functional tests performed on the Mach trim system disclosed that it was capable of normal operation. It must be concluded that it had not been turned on by the crew, otherwise it would have provided increasingly more noseup stabilizer trim action with increase in Mach number.

The crew reported a change in stabilizer trim to full nosedown. This did not result from a malfunction of the Mach trim system but could have resulted from inadvertent pressure upon the electric stabilizer trim switch located on the control wheel. Although the co-pilot testified that he was quite certain that his hand did not touch the switch, it remains, after careful consideration, the only logical explanation for the trim system behaviour. It is not definitely known what caused the captain's electric stabilizer switch not to function when he attempted to use it after returning to his seat. It may have been caused by clutch slippage induced by high aerodynamic loads. It functioned normally when tested later.

Laxity in the inspection of the flight recorder aboard the aircraft caused a shorter than normal tape to be used. This error resulted in the loss of valuable information because of improper recording.

Probable Cause

The probable cause of the accident was the inattention of the co-pilot to the progress of the flight during the absence of the captain from the cockpit, following the involuntary disengagement of the autopilot. Contributing factors were the autopilot disengage warning light in the dim position and the Mach trim switch in the "off" position.

Corrective Action

As a result of this accident the company took the following corrective action:

1. Issued a directive that one pilot give continuous attention to the attitude and flight of the aircraft during autopilot operation.

2. Re-emphasized in pilot training the narrow speed margins between Mach 0.82 and M_{ne} and the brief interval of time it takes the aircraft to accelerate into critical speed ranges.

As a part of the investigation of this accident depositions were taken of the crew, personnel of the company, the manufacturer of the aircraft, manufacturers of various components, and the Federal Aviation Agency.

Following the taking of these depositions, the FAA, citing failure to comply with Part 41.62 (Pilots at Controls) of the Civil Air Regulations, levied a civil penalty against the captain. The co-pilot received a six-months' suspension of his Air Transport Rating.

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ICAO Ref: AR/609

No. 21

American Airlines, Inc., Lockheed Electra, N 6101A, accident in the East River, near La Guardia Airport, N.Y. on 3 February 1959. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 1-0038, released 10 January 1960.

Circumstances

Flight 320 departed Chicago at 2154 hours for La Guardia Airport, New York. Between 2339 and 2349 the flight was vectored to the back course of the ILS while descending from 8 000 to 1 500 ft and then at 2344 was given the 2338 La Guardia weather. At 2352 it reported that it had passed New Rochelle and approach control requested the flight to contact the La Guardia tower on 118.7 Mc/s for a straight-in approach to runway 22.* Two minutes later Flight 320 reported over the La Guardia range (2.8 NM from the threshold of runway 22 and 4.8 NM from New Rochelle). It was cleared to continue its approach to runway 22 and at 2355:20 was cleared to land straight in on runway 22. At 2355:27 the flight acknowledged by saying "320". Nothing further was heard from the aircraft. It crashed 7 seconds after the final transmission, killing 63 of the 68 passengers and 2 of the 5 crew members.

Investigation and Evidence

Weather

The 2352 weather observation was the last one taken at La Guardia prior to the crash - "ceiling 400 ft variable, sky overcast; visibility 2 miles in light rain and fog; temperature 37; dewpoint 35; wind south-southwest 6 kt; altimeter setting 29.76. The ceiling was indicated as 400 variable to 300 ft, and the pressure was indicated as falling rapidly.

Some witnesses described very restricted visibility conditions above the surface of the river and over the land areas north of the river.

Other aircraft approaching La Guardia shortly before and after the accident did not report icing difficulties. The rapid influx of warm air aloft was causing a temperature inversion of increasing proportions.

The Airport and Facilities

All required airport, boundary and runway lights at La Guardia were on at the time of the accident.

Following its occurrence an immediate ground check of all navigation facilities serving La Guardia was conducted by the FAA. The following day these facilities were also flight checked and found to be operating normally.

The Aircraft

The aircraft had been flown a total of approximately 302 hours. The required maintenance had been performed on it, and complaint entries of an airworthiness nature had been corrected and properly signed off.

* Initial approach procedure prescribed an altitude of 1 500 ft asl 10 miles northeast of New Rochelle inbound for runway 22, to pass New Rochelle at minimum of 1 000 ft afl (above field level), descend to a minimum of 800 afl over the La Guardia range station, and continue descent to 400 ft afl altitude. If contact is established at this point, a landing may be effected. (Day and night company minima for runway 22 are 400 ft and one mile.)

The Wreckage

More than 90 percent of the primary structural components of the aircraft and the majority of the systems ' components were recovered.

Most of the wreckage was found submerged within a 200-foot radius circle, the centre of which was located approximately 4 891 ft short of the threshold and 610 ft to the right of the extended centreline of runway 22. It was determined that the horizon director indicator and course deviation indicator would indicate full-scale deflections if any aircraft were approximately 300 ft to the right of the localizer centreline and approximately 5 000 ft from the localizer shack. The lateral displacement of this aircraft from the localizer course is excessive and indicates that the pilot might not have been maintaining proper alignment with the localizer course during the latter portion of the approach.

Power plants and Propellers

The lengthy submersion of the wreckage in the East River resulted in corrosion and contamination throughout the engines, propellers and accessories. However, accurate determination of the condition of the parts and components prior to impact was readily accomplished.

According to the testimony of the surviving crew members all power plants were functioning normally until impact. The engine and propeller oil systems were free of significant contaminants. There was no pre-impact damage, foreign object damage or evidence of over-temperature. Examination of detailed parts including bearings, accessory drives, oil pumps and components of the reduction gear assemblies, did not show any to have failed during engine operation.

The propeller blade angles were relatively uniform and averaged approximately 36°. This blade angle when related to power is consistent with power readings obtained from the recovered aircraft instruments, and the crew's testimony concerning horse-power being used during the approach.

Flight Instruments (see Figure 6)

All recovered instrument and instrument system components were inoperative with the following exceptions: the captain's horizon direction indicator, the two directional gyros, the autopilot control panel, the two static selectors, the three-axis trim indicator, the two fluxgate transmitters, and the clock on the captain's instrument panel.

The two instantaneous vertical speed indicator instrument casings were still attached to their respective panels and relatively intact, but the instrument mechanisms were missing and were not recovered.

The altimeters installed on the instrument panels of N 6101A were Kollsman, type A-28586-10-001, pressure drum type, having a range of from minus 2 000 ft to 50 000 ft altitude. The pointer makes one revolution for each 1 000 ft of altitude change, and two concentric drums measure the number of turns of the pointer and accordingly indicate the 1 000-foot flight levels. Provision is made for barometric setting to correlate altitude indication with the prevailing atmospheric pressure in a manner similar to that employed in conventional three-pointer altimeters except that the numerical values of the setting appear in reverse order.

N 6101A had approximately 302 hours of flight time since manufactured during all of which the drum type altimeters installed had operated satisfactorily.

Prior to departure from Chicago the altimeters were checked by the crew and were reported operating satisfactorily; also, during the flight they appeared

to be operating satisfactorily. During let-down on approach to runway 22, both altimeters were reportedly cross-checked at 900 ft and again at 600 ft.

Examination and testing of these altimeters subsequent to the accident did not reveal any mechanical failures other than those attributable to impact, shock and immersion in salt water.

When the wreckage was recovered, the captain's altimeter read minus 1 500 ft, with a pressure altitude setting of plus 85 ft (barometric setting 29.83). The first officer's altimeter read minus 1 650 ft, with a barometric setting of 29.79.

Internal inspection of the altimeters revealed considerable corrosion within each of the instruments. A broken link pin was found in the captain's altimeter, and a rocking shaft pivot was found broken in the first officer's altimeter. The corrosion was removed to permit a detailed inspection of the moving parts. The broken components were replaced, after which both instruments were checked for mechanical freedom and were found to operate without significant restriction over a range of minus 1 000 ft to 12 000 ft.

Since the diaphragms of both altimeters were overstressed due to submersion, it was impossible to establish a calibration curve which would be representative of the calibration of the altimeter before the crash.

As a result of this accident and in connection with its investigation, the Board arranged extensive tests of the altimeter systems and components of the Electra. In addition, tests were carried out by Lockheed Aircraft Corporation.

Also, an exhaustive review was accomplished of all maintenance records including pilot complaints of all operators, civil and military, utilizing this type of altimeter. On the basis of the available evidence, several possible equipment malfunctions and operational errors were examined critically with a view to determining the most probable cause of the accident.

Dual Altimeter Failure

From the testimony of the first officer and flight engineer it was apparent that any error in the two drum altimeters must have been in the nature of a lag rather than pointer sticking. As required by the Civil Air Regulations, the altimeters installed on the pilot's and co-pilot's flight instrument panels have separate static sources. The static lines leading to the instruments from normal source are completely independent. Since there exists no common element of the instruments or any of their related static system and sources, an identical and simultaneous malfunction of these instruments and associated systems of the magnitude suggested by the crew testimony would involve such an extreme mathematical improbability that the Board was compelled to reject it.

In rejecting the possibility of dual and simultaneous altimeter error the Board had to reject portions of the testimony of one or both flight crew members. On the basis of other evidence the Board was compelled to reject this testimony to the extent that it would require dual and simultaneous failure of the altimeters in the order of a 500-foot lag.

Single Altimeter Failure

So far as this accident is concerned, any single altimeter failure must have involved the captain's altimeter since it was clear that the captain was at the controls of the aircraft during the approach. The Board could not, however, conclude that a single altimeter failure had occurred.

Although the first officer had testified concerning his observation of altimeter indications down to an altitude of 600 ft, he had no recollection of a lower altitude indication. It was his impression that the impact occurred shortly following his 600-foot observation; however, the Board

believed that his subsequent judgement of this time interval may be incorrect. While approaching an altitude of 500 ft it would have been expected that, in addition to monitoring the instrument panel, the first officer would be scanning the approach area for lights and handling radio communications. Considering the sparseness of lights on the approach over the East River, there could well have been greater concentration or attention than is usual since it is always difficult at night to judge attitude and altitude over the water. While the aircraft was in instrument conditions, it is also not at all unlikely that the co-pilot was giving careful attention to the captain's efforts to maintain the localizer path, especially in view of the apparent difficulties being experienced by the captain in maintaining a precise course. Although preoccupation with this or any of the several elements of a new cockpit environment could reasonably explain the failure of the first officer to follow the procedure required in the Operations Manual with respect to monitoring and calling out altitude and airspeed below 600 ft, the Board believed it more likely that he was anticipating breaking out beneath the overcast and, thereafter, having seen lights on the ground or water, was focusing particularly on visual identification of the airport and was no longer monitoring the flight instruments.

At and prior to reaching 600 ft the flight crew members were clear as to their testimony of cross-checking altimeters. With respect to the possibility that the captain's altimeter had failed it was believed that such a failure did not occur before reaching 600 ft. During the examination of the wreckage no evidence of instrument failure was discovered.

The sole evidence of a malfunction of the captain's altimeter was the flight engineer's testimony. His observation of the captain's altimeter was 500 ft at impact. This was after the first officer had called out 600 ft.

To substantiate further a single failure on the captain's altimeter one must assume a premature descent and discount the first officer's testimony that he called out 900 ft over the La Guardia Range Station. This is necessary in order to rationalize approximately a 300-foot per minute descent as testified to by him.

The captain's altimeter was set at 29.83. The actual pressure at the time of the accident was 29.75, and La Guardia tower was reporting a setting of 29.77. This error in setting of the captain's altimeter would account for 80 ft of erroneous altimeter indication. Since an additional minus 30 to 45 ft of error due to static air correction must be made to the captain's altimeter, one can readily rationalize an accumulative error in which the altimeter indicated from 110 to 125 ft higher than the actual altitude near sea level.

Misreading the Altimeter

Because of the novel presentation components of the altimeter, serious consideration was given to the possibility that the pilot misread the altitude indication and thereby permitted or caused the aircraft to deviate vertically from the desired flight path. While some incidents have been reported in which a pilot had misread the 1 000-foot scale on the small drum, no such error could conceivably be involved here. The altitude presentation below 1 000 ft is accomplished by a pointer the indications and appearance of which are, for all practical purposes, identical to those used by the crew in other aircraft types and the interpretation of which calls for no new or different evaluations on the part of the pilot.

The reversed sensing of the altimeter setting numerals was also considered. While an erroneous setting might result from this condition, the possible order of error would be very small. Unlike the primary instrument flight reference which is frequently "generalized" by approximate positions of pointers or indicators, the altimeter setting scale must be read in order to permit any

substantial correction to be made. Furthermore, the altimeter setting positions which were found in the altimeters installed in this airplane are very reliable indications of the settings existing at the time of the accident. The Board did not believe that the 80-foot error resulting from the setting of the captain's instrument was chargeable to misreading of the instrument.

One other peculiarity of this instrument, however, has raised some question as to susceptibility of misinterpretation. On the right side of the instrument face a cutout is provided through which may be seen the drum which indicates 1 000-foot levels. On both sides of this cutout there has been printed a luminous triangular shaped index against which the 1 000-foot calibrations are read. In a darkened cockpit, the index which appears on the left side of the drum assembly cutout has at times been mistaken for the small 1 000-foot pointer which is installed on the older altimeters. Such an error would leave the impression that a small hand was indicating an altitude of 2 500 ft. This fact had been brought to the attention of the company prior to the accident and it had been agreed that the left index should be removed in order to prevent such a confusion; one of the company's fleet of six Electras had had this index removed at the time of the accident. The altimeters installed in the aircraft all contained indices on both sides of the cutout.

The Board was of the opinion that confusion is also possible in mistaking the right index for the 100-foot pointer. Although this may appear remote because of the distinctiveness of shape of the 1 000-foot altitude index as compared with the 100-foot pointer, these distinctions lose most of their significance at night, especially where hurried references to flight instruments are required in critical flight situations. If, in a hurried glance, the right index were to be mistaken for the large 100-foot pointer, the pilot would have the impression of being at 250 ft when, in fact, the aircraft might be considerably below this altitude.

As a part of the Electra training programme, the company gave special attention to the need for training in the Bendix Flight Director System which was installed in the Electra and was otherwise new to the line pilots. The ground trainer in which the captain received approximately five hours of initial training on the Bendix Flight Director System had installed the conventional three-pointer altimeter and not the drum-type altimeter which was actually installed in the Electra.

Misreading the Vertical Speed Indicator

The instantaneous vertical speed indicator installed in the Electra does not possess the lag typical of older instruments which rely solely upon a calibrated flow from the diaphragm for the initial indication of climb or descent. This type of vertical speed indicator possesses characteristics which are definitely superior to those of older types. In at least one respect, however, the difference in presentation must be regarded as significant so far as this accident is concerned. This instrument installed in the Electra is calibrated in such a manner that a given displacement of the needle represents a rate of climb or descent almost three times as great as that shown on former designs. For instance, were the needle of the older instrument displaced 90 degrees downward from its normally horizontal position, it would signify a rate of descent of approximately 750 ft per minute. This same relative position in the case of the Electra instrument would signify a rate of descent of approximately 2 300 ft per minute.

For the experienced pilot it is common to rely upon approximate pointer position rather than consciously to read the numerical indications associated with each pointer position. Such a tendency is heightened at night when precise reading of instruments is more difficult even with optimum instrument lighting. Accordingly there is a strong suggestion that a pilot with limited exposure to this particular instrument might be led to accept an

excessive rate of descent because of a general appearance of instrument indication being within a range normal for an instrument approach when using the older instrument.

A computation of the times reported over New Rochelle and the La Guardia Range Station indicates that the ground speed of Flight 320 on the approach between these fixes was approximately 129 kt. A computation of the times reported over New Rochelle and the La Guardia Range Station by the five flights preceding Flight 320, and an analysis of the winds aloft reports at Idlewild International Airport and surrounding areas taken at 1900, 3 February, and 0100, 4 February, indicates that Flight 320 would be making its approach into a mean wind of approximately 25 kt from about 210°. The indicated airspeed between New Rochelle and the La Guardia Range Station appears, therefore, to have been in the order of 150 kt. At this indicated airspeed and at the power settings which the flight crew were using, a rate of descent higher than that necessary for this portion of the approach procedure appears to be likely.

The ground trainer in which the captain received initial training on the Bendix Flight Director System had installed the conventional vertical speed indicator and not the instrument which was actually installed in the Electra.

Pilot Preoccupation with the Instrument Approach

The Eclipse-Pioneer autopilot, model PB-20E, used by American Airlines on its Electra airplanes is designed to permit completely automatic control of the airplane from initial climb through an ILS approach. An automatic ILS approach utilizing the PB-20E is possible only where a glide path is suitably paired with a localizer course. Since no glide path is available, an automatic approach could not be made on the backcourse of the La Guardia ILS.

Testimony of the first officer and the flight engineer indicated that the captai was making a "heading mode" autopilot approach and that the autopilot was still engaged at impact. In this method, the pilot uses the autopilot as an intermediate system to operate the flight controls instead of operating them directly through the control wheel and rudder pedals in the conventional manner. The airplane is steered by selecting a desired heading on the course deviation indicator; the autopilot then directs the airplane to this heading. The captain had been using this procedure during the entire flight after the take-off climb. According to testimony, he was actuating the pitch trim wheel, whic is mounted in the autopilot controller on the pedestal to his right and slightly aft, with his right hand and was leaning forward in his seat to reach around the control wheel with his left hand to rotate the CDI cursor just prior to impact. Since no glide slope is available, proper altitude over fixes must be checked solely by reference to the altimeter.

The FAA-approved portion of the Electra Airplane Operating Manual contains no limitations as to the type of approach for which the autopilot may be used; nor does it establish any minimum altitude limitations for use of the autopilot. While it is recognized that the autopilot system installe in the Electra is capable of complete automatic control of descent path and direction in an ILS approach, the Electra Airplane Operating Manual specifies that the autopilot must be off before leaving a holding point for final approach.

The Board could find no instance where the captain had made a previous backcourse ILS approach to La Guardia Airport in an Electra under actual instrument conditions. Records were not available to determine how much previous experience the captain had in making simulated or actual instrument approaches in the Electra using the "heading mode" autopilot setting.

The captain's and first officer's radio magnetic direction indicators, when removed from the water, read 205° and 219°, respectively. Although the heading indications of the two RMDI's reasonably agree with the instrument approach heading to be flown, neither reading is necessarily that of the aircraft heading at impact.

The captain was using the ILS localizer for direction in conjunction with the ADF's to determine precisely the aircraft's position over the navigation fixes. His No. 1 ADF was tuned to the La Guardia compass locator: the No. 2 ADF was tuned to the La Guardia Range. In order for ADF information to be displayed visually on the RMDI, the selector on this instrument must be placed in the ADF position.

Investigation disclosed the selector switch for the captain's No. 1 ADF needle was selected to the ADF position; however, the No. 2 selector was in the VOR position. Under these conditions the single needle would be displaying the position of the La Guardia middle marker which is southwest of the airport and, therefore, would be approximately straight ahead of the flight throughout the final approach to the moment of impact; however, the No. 2 or double needle would be inactive, eliminating its use in displaying the position of the La Guardia Range. Testimony also indicated difficulty in receiving the range station, although station passage was observed by the first officer on his RMDI. The No. 2 ADF control settings were 10 kc/s above the La Guardia range frequency and in the loop position, this suggesting a possible manipulation of the ADF controls to confirm station passage.

The landing gear was extended while passing over New Rochelle at 1 500 ft and the pilot established a rate of descent which he believed to be in the order of 350 ft per minute. Because of the different calibration of the vertical speed indicator as compared with the instruments used by the captain during almost all of his previous 29 000 flying hours, the actual rate of descent was between 900 to 1 000 ft per minute until checked by the captain. His altimeter indicated an altitude approximately 125 ft higher than the actual altitude. Since the captain was utilizing the autopilot, his corrections of altitude and direction were somewhat slower than would normally be expected in a manual approach. Because of the excessive rate of descent, the aircraft descended below the minimum altitude prescribed for station passage.

Crew Information

The captain had a total of 48 hours in Electra aircraft at the time of the accident.

He received training in a Link trainer equipped with the flight director system similar to that installed in the Electra but not having drum-type altimeters or instantaneous vertical speed indicators. An Electra simulator was not available.

Operations Specifications issued to American Airlines on 23 January 1959 require that the ceiling and visibility landing minima prescribed in the Operations Specifications be increased by 100-foot ceiling and one-half mile visibility whenever the captain in scheduled operation has not served for 100 hours as pilot-in-command on the equipment, or until such time as the captain is certified by his Regional Superintendent of Flying as qualified to operate at the landing minima prescribed. If these restrictions are to serve any purpose other than to give the appearance of a conservative flight operations policy, the Board questions the wisdom of the company in exempting the captain when he had but 12:32 hours of flying the Electra in scheduled operations. This occurred nine days before the accident.

The Board recommended that the Administrator review existing FAA policy to determine whether the waiver provision contained in the Operations Specifications should be deleted.

Conclusions

No one factor was considered to be the probable cause of the accident. On the contrary, the Board found that it was due to an accumulation of several factors or errors,

which, together, compromised the safety of the flight.

After a detailed investigation the Board believed that the flight flew at an average ground speed of 130 kt between New Rochelle and the La Guardia Range Station. Using winds aloft data and time-over-fix data received from aircraft that preceded Flight 320, the Board determined its indicated airspeed over this area to be approximately 150 kt. The aircraft passed over La Guardia Range Station at a low altitude, possibly as low as 300 ft, but probably not higher than 500 ft. The crew had limited visual reference following the range passage; the first officer and flight engineer observed lights just prior to impact. During the instrument approach, the captain's altimeter was indicating at least 80 ft, and possibly as much as 125 ft above the altitude at which the aircraft was flying owing to calibration and setting errors.

Just prior to impact, the aircraft was in a shallow descent, in approach configuration except for landing flaps and landing light extension, and was maintaining approximately 130 kt groundspeed. The captain was flying the aircraft on autopilot "heading mode". Impact occurred within seconds after the crew received and acknowledged clearance to land. The testimony of the first officer and flight engineer concerning the simultaneous misindication of both drum altimeters could not be substantiated by the evidence of record. The possibility of failure of the captain's altimeter was examined. However, the Board believed there was insufficient evidence available to substantiate this.

The Board believed that even though the accident probably resulted from the captain's neglect of certain essential instrument references, it could have been prevented had the first officer followed prescribed operating procedures, and been fully alert and attentive to all his cockpit duties throughout the approach.

As a result of this accident, the Federal Aviation Agency, on 8 February 1959 as a "precautionary measure" raised Electra minima. Upon the installation of the conventional three-pointer type sensitive altimeters, the restrictions were lifted.

During this investigation considerable testimony was presented concerning America Airlines' procedures and techniques employe in the operation of autopilots. The Federal Aviation Agency testified that it had not issued any policy directives with respect to the use of autopilots in the various possible types of instrument approaches for an air carrier.

While the Board considered that fully automatic front course ILS approaches using an autopilot coupler may be basically sound, it was the Board's opinion that autopilot approach criteria and limitations to all air carriers should be established, taking into account the particular autopilot used, the aircraft involved, and the approach facilities utilized. Accordingly, the Board recommended to the FAA that it initiate a study of air carrier policies, procedures, and techniques for employing an autopilot for instrument approaches and take whatever action appears appropriate.

Service Testing of New Equipment

The Board did not believe that altimeter malfunction was a major factor in this accident, however, it was convinced that the searching investigation of the altimeters as a result of this accident disclosed the need for changes in the procedures used to approve such items of equipment and instrumentation.

Units such as the Kollsman drum altimeter, the Eclipse-Pioneer Flight Director System, and the PB-20 autopilot are approved for civil use by the FAA under the Technical Standard Order System. FAA's TSO programme does not require inservice suitability testing of items that are approved, nor does it incorporate specific quality control

standards. Evidence developed during the Board's investigation and public hearing on this accident indicated that FAA had no overall definitive programme for monitoring routine service difficulties on TSO items.

Services testing of novel designs before fleetwise installation is authorized would be very instrumental in uncovering design deficiencies in a product. The incorporation of specific quality control standards in the TSO and/or direct surveillance of the manufacturer's quality control organization by FAA inspectors would ensure only high-quality products getting into service. Closer monitoring by the FAA of minor difficulty reports on newer TSO items would detect trends before a serious failure or malfunctioning occurred.

The Board found it difficult to understand why American Airlines did not at least incorporate the drum altimeter in the Electra cockpit trainer used by the flight crews during their Electra training. Similarly, the new instantaneous vertical speed indicator would have been a desirable instrument to incorporate in the cockpit trainer. In addition, added emphasis should have been placed on the difference between these new instruments and the older types during the crew training programme until such time as it was evident that the various crews were experiencing no unusual amount of difficulty in effecting transition to the newer types.

Aircraft Simulator

The carrier introduced an aircraft containing the many novel systems and characteristics of the Electra without having previously established a comprehensive aircraft simulator programme. The carrier has not yet procured an approved Electra simulator.

The Board was of the opinion that almost all adverse operational aspects of new and substantially different equipment, systems, and procedures, could have been avoided through more comprehensive training in an aircraft simulator.

The Board recommended that the FAA give immediate consideration to the adoption of a requirement that any air carrier planning to introduce into service an aircraft type containing equipment, systems, or characteristics significantly different from those of predecessor aircraft, shall be required to institute an approved aircraft simulator programme the completion of which shall be required before any pilot may be assigned as pilot-in-command in air transportation.

Flight Recorder

In 1957 the Civil Aeronautics Board adopted an amendment to the Civil Air Regulations which required the installation of a device on certain aircraft used in air transportation for the purpose of recording continuously during flight, time, airspeed, altitude, vertical acceleration, and heading. This requirement met with considerable opposition in the aviation industry and serious consideration was given by the Board to the question whether the potential value of this device justified the cost of procurement, installation, and maintenance. The Board finally concluded that only the larger turbine-engine aircraft intended for operation in completely new environments would justify the expense of providing flight recorders. To define such aircraft types the Board relied upon a simple criterion - such recorders would be required in aircraft certificated for flight above 25 000 ft. Although the Electra is capable of flight above 25 000 ft, the carrier chose to request certification below 25 000 ft under which limitation it is unnecessary to install flight recorders. The probability that this would be done was known to the Board at the time the regulation was written. However, the Board concluded that the regulation, then promulgated, represented the most demanding requirement which could be justified on the basis of the then existing state of the art.

Clearly, a flight recorder in this aircraft would have enabled the Board to

identify the causal factors involved in this accident with far greater precision than is now possible. The Board was of the view that the quality of flight recording systems which are available to the industry warrants the conclusion that no large aircraft introduced into air carrier service should be without a recorder. Accordingly, the Board recommended that the FAA initiate action to amend the appropriate regulations to require that all large turbine-engine aircraft used in air transportation be equipped with flight recorders.

Probable Cause

The probable cause of this accident was premature descent below landing minima which was the result of preoccupation of the crew on particular aspects of the aircraft and its environment to the neglect of essential flight instrument references for attitude and height above the approach surface.

Contributing factors were:

1. Limited experience of the crew with the aircraft type;
2. Faulty approach technique in which the autopilot was used in the headin mode to or almost to the surface;
3. Erroneous setting of the captain's altimeter;
4. Marginal weather in the approach area;
5. Possible misinterpretation of altimeter and rate of descent indicator; and
6. Sensory illusion with respect to height and attitude resulting from visual reference to the few lights existing in the approach area.

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ICAO Ref: AR/610

FIGURE 5

APPROXIMATE FLIGHT PATH
AAL FLIGHT 320, 3 FEB. 1959

BASED ON TRANSCRIPT OF COMMUNICATIONS BETWEEN FLIGHT AND APPROACH CONTROL AND LA GUARDIA TOWER

CHECKED BY APPROACH CONTROLLER FROM RECOLLECTION OF RADAR TRACK.

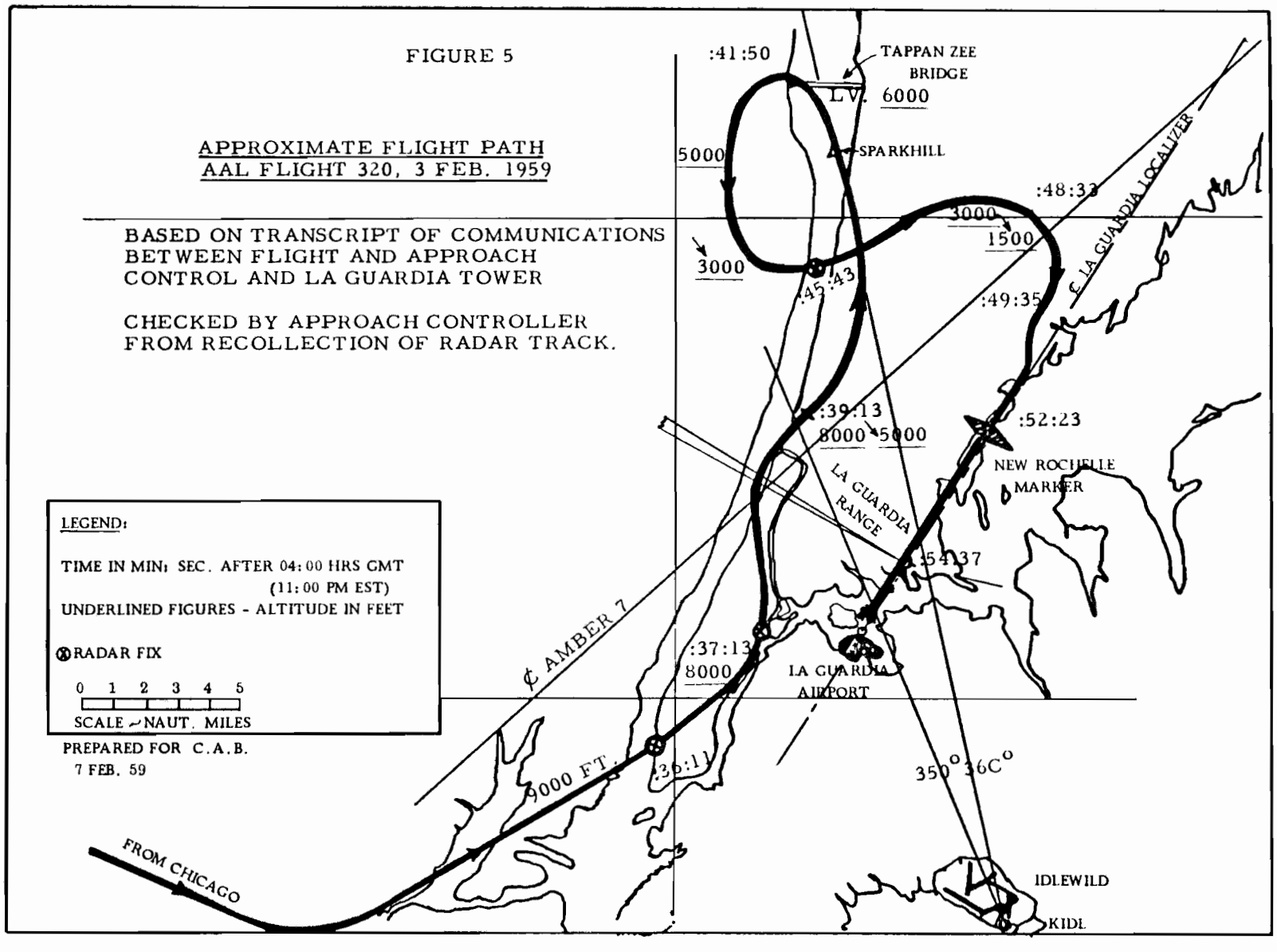
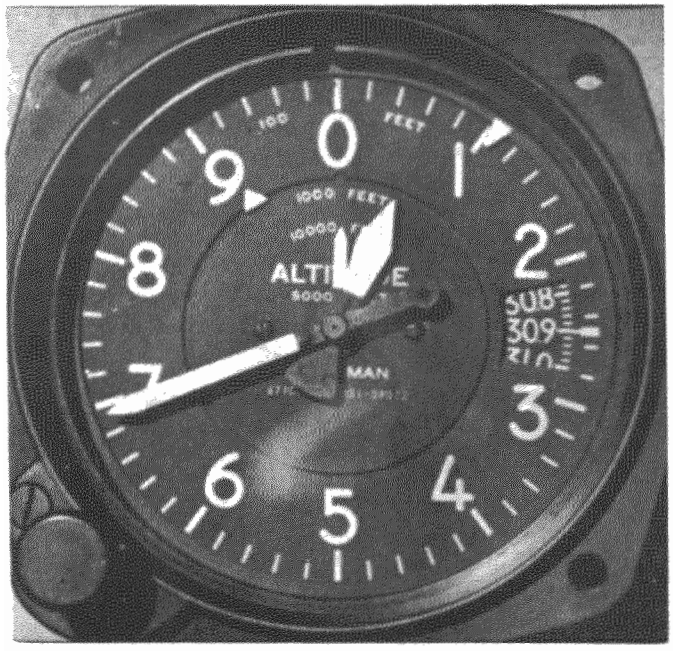
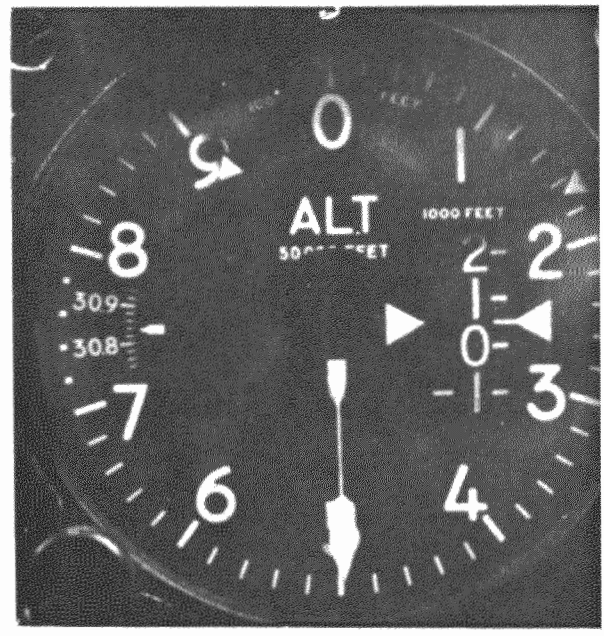


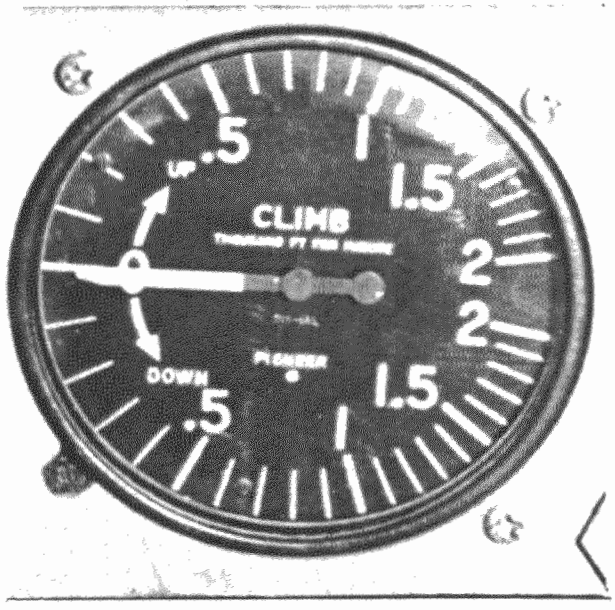
FIGURE 6



CONVENTIONAL THREE POINTER TYPE SENSITIVE ALTIMETER



PRECISION DRUM TYPE ALTIMET



RATE OF CLIMB INDICATOR

INSTANTANEOUS VERTICAL SPEED INDICATOR

(ACCIDENT TO AMERICAN AIRLINES, LOCKHEED ELECTRA, 3/2/59)

No. 22

TACA International Airlines, Viscount 784, YS-09C, accident on take-off from Las Mercedes International Airport, Nicaragua, on 5 March 1959. Report released by the Ministry of War, Navy and Aviation, Nicaragua.

Circumstances

YS-09C, of Salvadorian registry, took off at 1935 GMT on a scheduled flight to Tegucigalpa, San Salvador, Guatemala, Mexico and New Orleans, carrying 4 crew and 15 passengers. The take-off was normal, but the climb-out was not, and eye-witnesses observed that engine No. 1 had stopped. The aircraft started an abrupt left turn, followed by an excessive bank to the left and then it began to lose height, collided with a tree and crashed to the ground inverted. The accident occurred approximately 1-1/2 miles from the north-east end of the landing runway. Two crew and 13 passengers were killed, and the aircraft was destroyed.

Investigation and Evidence

The captain and co-pilot held valid Commercial Transport Licences issued by El Salvador; they had been given Viscount aircraft conversion training at the Capital Airlines Training School in Washington, D. C. and had completed approximately 500 hours and 1 000 hours respectively on the aircraft type.

The aircraft arrived at Managua at 1909 hours GMT after stops at New Orleans, Mexico and San Salvador. The pilot reported everything functioning correctly and requested the refuelling of tanks Nos. 1 and 4. Prior to take-off the captain of the aircraft asked a captain and the Chief of Maintenance of LANICA Airlines (which also operates Viscount aircraft) if they could explain why the red warning lights - normally an indication of icing in the low pressure fuel filters - should illuminate despite tropical air temperatures. The LANICA captain replied that icing must be ruled out and that the probable explanation was the clogging of the fuel filters. There was no indication, during the conversation, as to whether the red lights referred to related to any particular engine.

At the time of take-off the ambient temperature was 32°C, wind east/9 kt, visibility 25 miles.

The weight of the aircraft at take-off was 50 438 lb, 12 562 lb below the maximum authorized. The performance characteristics of this type of aircraft are such that in case of failure of one or two engines on the same side, with the other two engines operating at normal power and in corrected temperature conditions, and with appropriate fuel trimming and injection of methanol for take-off at the ambient temperatures, it would be possible, if the emergency procedures were correctly followed, to continue to fly and to climb the aircraft, particularly under the loading conditions applicable to YS-09C at the time of the accident.

The investigation of the wreckage and propeller marks on the ground indicated that at the time of the accident -

i) engines No. 3 and 4 were operating at high power;

ii) No. 1 propeller blades were in the feathered position;

iii) although it was not possible to establish definitely the pitch angle of No. 2 propeller, the marks indicated that No. 2 engine was operating at a lower rpm than engines No. 3 and 4.

It was also determined that the landing gear was extended and the flaps were lowered approximately 20°.

The four engines, the propellers and other significant components were sent to authorized centres in the United States and Canada for detailed examination under the supervision of the local civil aviation authorities.

Laboratory examination of samples of JP-1 fuel obtained from TACA's various supply bases, including Managua, revealed the presence of foreign bodies in suspension. Corrective action was taken to ensure more efficient filtering of fuel supplies, without implying that fuel contamination was a causal factor of the accident.

Probable Cause

In accordance with the documentation obtained and data collected during the inquiry, the Investigating Board reached the following conclusions:

The accident was caused by the following factors:

1. failure of No. 1 engine at the end of runway 29 during take-off and before reaching V_2 speed;
2. the non-retraction of the landing gear immediately after the aircraft reached V_2 speed; and
3. failure of engine No. 2 a few seconds later, during a climb with insufficient speed to maintain control which resulted in a forced turn to the left that became tighter and tighter; the aircraft finally rolled into an inverted position and hit a tree with its left wing.

Several possible reasons for the failure of engines No. 1 and 2 and the non-retraction of the landing gear were considered, howeve the Board found no substantiating evidence or proof in the various tests carried out on the aircraft's parts to support any one of them. The Board was, therefore, unable positively to attribute the accident to any mechanical or electrical failure or to any piloting error.

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No. 23

Indian Airlines Corporation, DC-3, VT-CYH, accident in the Naga Hills, 10 miles east of Tuensang, India, on 12 March 1959. Report dated 15 May 1959, released by the Director General of Civil Aviation, India.

Circumstances

The aircraft took off from Jorhat at 1305 hours Indian standard time on a supply-dropping sortie to Noklok. It estimated its arrival time over Noklok as 1355 hours and reported it was flying under visual meteorological conditions. It was expected to return to Jorhat by 1445 hours. At 1347 hours, while en route to Noklok, it advised Jorhat Air Traffic Control that it was encountering very poor weather conditions and that it was raining. This was the last contact with the flight. At approximately 1410 hours the aircraft struck trees and crashed in the Naga Hills, fatally injuring the 3 crew members and 2 of the 4 ejection crew.

Investigation and Evidence

The Aircraft

It had been inspected and was issued a Certificate of Safety for Flight by a properly qualified engineer on 11 March 1959. The aircraft had a Certificate of Airworthiness valid until 28 August 1959.

Crew Information

The pilot was adequately certificated and had flown for the first time as pilot-in-command on supply-dropping flights on 7 March 1959. This accident occurred during his first flight to Noklok as commander. At the time of take-off for the flight he was in the right-hand seat and, following the accident, he was still occupying this same position.

His flying experience as of 28 February 1959 was as follows:

Total flying experience	8 939 hours
As commander on DC-3's by day	2 177 "
As commander on DC-3's by night	82 "
Actual instrument flying	587 "

He was involved in an accident on 18 May 1956 when operating a scheduled passenger service. The accident was atributed to the poor technique of the pilot.

The co-pilot had obtained his pilot-in-command endorsement on DC-3 aircraft by day on 19 June 1957 and by night on 19 June 1958. As of 1 March 1959 his flying experience was as follows:

Total flying experience	3 411 hours
As commander on DC-3's by day	819 "
As commander on DC-3's by night	33 "
As co-pilot by day	2 186 "
As co-pilot by night	109 "

His total instrument flying experience as of 18 November 1958 was 194 hours of which 150 hours were actual instrument flying.

His total supply-dropping experience amounted to approximately 257 hours. According to Indian Airlines Corporation regulations, he was not qualified to act as pilot-in-command on these operations. The Corporation permits, however, that

"whenever a Junior Commander flies with another Senior Commander, with the permission of the latter the Junior Commander can log half the flying hours from the place of origin to the dropping zone and back to base i.e. excepting the time spent on actual dropping operations." In this way, the co-pilot had to his credit 113 hours 15 minutes of first pilot (day) hours in supply-dropping operations.

He had not been involved in any previous accident.

A the time of take-off on the final flight of 12 March, he was in the left-hand seat of the cockpit.

The Flight

The flight to Noklok was the third supply-dropping mission carried out by the aircraft on 12 March. At the time of take-off, 1305 hours, the aircraft's all-up weight was 26 905 lb. At 1310 the aircraft advised that it estimated its arrival time over Noklok as 1335 hours and reported flying under visual meteorological conditions. Following a message around 1347 hours regarding poor weather conditions encountered, there was no further contact with the aircraft. At approximately 1400 hours some people at Tobu, about 5 miles northwest of the crash site, saw a Dakota flying overhead. It made two circuits over the dropping zone and was then seen in a climbing attitude heading in a southeasterly direction towards Noklok. A loud report was heard soon after. A message, which had been originated by an Assam Rifles outpost at Chingmei, was subsequently received by Jorhat Air Traffic Control to the effect that the aircraft had crashed 10 miles east of Tuensang, in densely wooded hilly terrain.

Investigation at the Site of the Accident

On reaching the area the Chief Inspector of Accidents observed that the wreckage had been interfered with, and some components had been removed. However, this was not a serious handicap to the investigation.

The aircraft while on a 120° heading had first struck a tree situated on a ridge. This was followed by impact with a trunk of another tree (3 ft in diameter) at a higher elevation. The starboard wing was sheared off just outboard of its attachment with the centre section. In the distance of 60 ft separating these two trees, indications were that the aircraft climbed about 15 ft. The loss of its wing caused the aircraft to roll, and the flight path changed from 120 to 130 degrees. Then descending, the aircraft cleared a 250-foot wide chasm and struck trees on the other side - the rear portion of the fuselage broke away and came to rest in an inverted position.

Impact had first occurred at an elevation of 6 800 ft. The aircraft would have cleared the hill range if it had been 100 ft higher.

The master and individual ignition switches were found to be in the "on" position. The undercarriage and flaps were retracted at the time of impact. Also, the blades of both propellers were in fine pitch, and both propellers were rotating at high speed. There was no evidence of fire prior to the accident.

Weather

All supply-dropping flights in the North East Frontier Agency and Naga Hills and Tuensang Agency areas are conducted under visual meteorological conditions.

Weather conditions in this hilly area change rapidly, and the scanty actual weather data that is available to the forecasting authorities is inadequate to provide route weather briefing to the crews operating on these flights.

The weather at Jorhat at the time of departure of VT-CYH, 1305 hours, was good. Noklok and the surrounding dropping zones reported clear weather on the morning of 12 March and also between

1300 and 1400 hours. However, at 1347 hours the aircraft advised that it was flying through very bad weather en route to Noklok. Witnesses, who saw the aircraft over Tobu a few minutes before the accident stated that visibility was poor due to haze.

Discussion

If the visibility or weather conditions are poor, it is the normal practice for pilots to pin point their position by identifying a dropping zone they may be flying over. For this purpose they descend over the dropping zone. A descent to about 500 ft above the dropping zone enables the dropping zone number to be read even under somewhat poor visibility conditions.

It was considered most likely that the circuits flown over Tobu were for the purpose of identifying the dropping zone. The actual height to which the aircraft descended was not known, however, it was not thought to be much higher than 500 ft. The elevation of Tobu is 4 800 ft. The aircraft flew over it at a height assessed at approximately 5 300 ft. The aircraft should have been climbed to at least 7 000 ft over Tobu before proceeding to Noklok as the direct track to Noklok requires clearing hills higher than those around Tobu.

Load Sheets

During the investigation it was found that the weight of 10 additional gallons of fuel were not listed in the load sheets - this resulted in a technical overloading of the aircraft by a few pounds. It was also noted that there were discrepancies in the listing of the weight of the crew members.

Probable Cause

The aircraft crashed during an attempt by the pilot to clear high terrain under poor visibility conditions. He had previously descended to a low altitude in order to determine his position.

Observations

The present policy of selecting crews for supply-dropping in the NEFA/NHTA area is based on volunteers being posted to that area after they have been assessed as suitable by the Operations Manager of the area concerned and the Officer-in-Charge of the Supply-Dropping Operations at Mohanbari. Previous experience of supply-dropping is not considered to be an essential qualification for their posting.

Visibility in this area generally deteriorates rapidly in the afternoon. It is the opinion of experienced pilots and other persons connected with the supply-dropping operations that it is inadvisable for such operations to be undertaken by crews with little or no previous experience.

It may be desirable to take this matter up with the Indian Airlines Corporation to ascertain whether supply-dropping operations, particularly during the bad weather season, could be undertaken by adequately experienced crews only.

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No. 24

Aviación y Comercio, S.A., Bristol 170, EC-ADH, accident near Mahón Airport, Minorca, on 13 March 1959. Report dated 8 November 1960 released by the Directorate General of Civil Aviation, Spain.

Circumstances

The aircraft was on a scheduled passenger flight from Palma de Majorca to Mahón, Minorca, carrying 3 crew and 15 passengers. On final approach to Mahón Airport, at a height of 120 m the aircraft went into a right banked turn, then hit the ground at 0802 Z killing one passenger and seriously injuring two others.

Investigation and Evidence

The Aircraft

The aircraft had been properly maintained, and held a certificate of airworthiness valid to 12 May 1959.

Its maximum all-up weight was 18 145 kg and at the time of the accident it weighed 16 914 kg. The centre of gravity was within the prescribed limits.

The Crew

The pilot had a valid airline transport pilot's licence and in 1956 had taken a course in instrument flight at the Jerez de la Frontera school. He became a co-pilot with AVIACO in 1957 and then an aircraft commander on Heron aircraft in February 1958. Following his transfer to Bristols in July 1958 he flew them exclusively up to the time of the accident. He had flown a total of 4 350 hours, including 1 050 on Bristol aircraft.

Both the engineer and radio operator held valid licences.

Weather

On the morning of 13 March, before 0800 Z, cloud was about 2/8 at 1 800 m. This was followed by 1/8 cloud appearing at 660 m at 0850 Z. Visibility was 18 to 20 km. Between 0757 Z and 0802 Z, winds were 350°/28 kt with gusts to a maximum of 45 kt.

The angle of wind direction with the landing runway 02 was 30°.

Description of the Flight - Statements of witnesses and the pilot

The Airport Manager at Mahón and the Technical Stop Officer agreed that the aircraft was making its final approach on a normal glide path and that at a height of about 120 m it was observed to turn right. The witnesses on the ground noted the correction to the left and the moment at which power was applied, then, after pitching, the aircraft continued to turn and descend to the right, as though it were about to crash head-on into a building near the end of runway 02. The witnesses also observed the attempt to gain altitude to clear the obstruction, at which time the right wing hit a property boundary wall.

The pilot stated that the flight had been normal, that the aircraft was aligned with the runway and that he had already initiated the landing manoeuvre. Flaps had been partly extended, then extended further. Shortly after this manoeuvre, the right wing tilted and the angle of tilt increased as the aircraft turned right. He tried unsuccessfully to right the plane

by means of the control column and then increased the revolutions of the engines and attempted to right the aircraft by decreasing power in the left engine, again without success. In the final moments he operated the rudder control and was able to deflect the plane from a course which would have caused it to crash straight into a building.

The Wreckage

Examination of the wreckage indicated that impact occurred in a flight direction approximately at right angles to the runway and some 500 m from it. At time of impact the aircraft must have had its right wing sharply tilted. This caused a breaking-off first of the wing tip and then of the aileron.

This impact probably caused the aircraft partly to right itself. Some 20 m further on it brushed against a stone wall, deviated slightly to the right and travelled 50 m further on the ground before stopping.

The fuselage split at the last moment along a line to the rear of the wings and, without separating completely, veered to the right.

Examination of the flaps indicated normal operation of the system. The controls were also believed to be operating normally.

Discussion

The above evidence suggests that after the flaps were completely extended, a gust of wind caused the aircraft to tilt to the right. The aircraft must then have been descending with power off. Possibly, in trying to pull up and maintain flight altitude, the pilot also operated the elevator in order to raise the nose. If the bank angle was great, the elevator would have acted partly as a rudder, combining with the wind to accentuate the turn to the right and increasing the angle of attack on the wings to the point of reducing the effect of the ailerons and causing a stall and the consequent crash.

The application of engine power may have lengthened the landing path, but it was not sufficient to prevent the aircraft from falling, certainly because of lack of altitude.

In addition, to help in pulling up, the flaps may have been retracted to the first position, in which they were found in the wreckage. This would,of course, have further decreased the lift.

In the unlikely case of jamming of the controls, it must be assumed to have occurred after the aircraft tilted laterally. The jamming could have occurred in the aileron system only or also in the elevator system. In the first case, the assumptions are similar to those above. In the latter case, which logically is far less likely, the accident would be due to the pilot's inability to pull the nose up because of lack of elevator control.

Probable Cause

The cause of the accident was probably a strong gust of wind which tilted the aircraft to the right during final approach to land, causing it to crash to the ground.

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ICAO Ref: AR/656

No. 25

American Airlines, Inc., Convair 240, N 94273, crashed during an instrument approach to Chicago (Midway) Airport, Illinois, on 15 March 1959. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 1-0011, released 9 October 1959.

Circumstances

Cargo flight No. 2815 originated at La Guardia Airport, New York for Chicago but because of poor weather at its destination it was only cleared as far as Detroit. On being advised at Detroit that the Chicago weather was not expected to go below minima the flight proceeded to Midway in continuous rain. One approach to runway 31 was missed and the aircraft was again vectored into proper position and started another. Descent continued below 300 ft (prescribed cargo minimum ceiling) until the aircraft struck the top of a 96-foot steel tower, crashed and burned. The crew of 2 were not injured, but the aircraft and cargo were destroyed.

Investigation and Evidence

Because of a change in wind direction the active runway was changed from No. 13 (the ILS runway) to 31 and the flight was advised accordingly. Runway 31 does not have a glide path or approach lights, and the frequency of its localizer is 109.5 Mc/s.

Upon reaching the Surf intersection, 12 miles east of Midway, the tower controller vectored the flight to the Kedzie fan marker, 3.3 miles from the active runway, and the final approach was started. During this period the pilot reported that the localizer indicator in the aircraft was not functioning correctly - he was using 109.9 Mc/s instead of 109.5 Mc/s*. A correction was made. This approach was discontinued at 600 ft above field elevation and the missed approach procedure was started.

During the return to Kedzie the captain studied the runway 31 ILS approach plate while the first officer flew the aircraft. The landing gear was then extended, and the aircraft was trimmed for a rate of descent of 300 ft per minute. Both pilots stated that on this second attempt, according to their altimeters, they were never less than 400 ft above ground level and never more than two dots deflection from the centreline on the ILS indicator. The captain testified that there was turbulence during this second approach and that he was checking power and attitude instruments as well as looking over the glare-shield while making a decision to go around or continue. Directly under and ahead of the aircraft approaching runway 31 was a large railroad yard with well-lighted areas, and a heavily travelled and brightly illuminated highway lay only a short distance to the left of course. The captain stated that he did not see this lighted area but suddenly saw a steel tower through a break in the clouds, attempted to pull up, applied power, and ordered the landing gear up.

The first officer stated that he observed ground lights as the aircraft passed intermittently in and out of cloud bases and suddenly saw a red light on top of a transmission tower. Previously he had called out "minimum altitude" when his altimeter read 1 000 ft (400 ft above airport level) and then directed his attention to looking for the runway. He believed that he started the gear up as ordered. Almost simultaneously the airplane struck the tower and nosed down sharply. Up elevator was applied and

* He later stated that he was using the wrong frequency because he thought that he was making a "back course" approach using ILS runway No. 13 - also the controller, he said, used the words "back course".

descent was lessened somewhat as the aircraft plunged into a railroad yard.

Examination of the engines and propellers showed that they were operating in an approach condition at the time of impact. Both ILS receivers were at the proper frequency. Little could be learned from the remains of the ADF receivers. The captain had been using both of them satisfactorily. Nothing could be learned from the remains of the altimeters nor their static systems.

All ground radio navigational facilities used during the final approach were checked and found to be functioning normally.

The correct altimeter setting was given the flight before the approach to Midway, and the crew set their altimeters accordingly. The ground altimeters from which the setting was given were indicating accurately. Both of the aircraft's altimeters functioned properly and were cross-checked during the flight from La Guardia including the landing in rain at Detroit.

All of the mechanical irregularities pertaining to the aircraft and written up on the log sheets had been corrected; among these were the removal and replacement of three altimeters for reported erroneous indications. Tests of all three of these replaced altimeters showed that they functioned normally and within company and FAA tolerances.

The reporting of the Midway weather to the flight was both accurate and current. There was no frontal passage at the time and place of the accident which could have caused wind changes of sufficient magnitude to have significant effect upon the approach path.

The captain had not been flying regularly into Chicago. His last landing there had been about three weeks before this accident and the preceding one had been six months earlier. He and the first officer had flown together only once, some 16 months earlier. He testified that he was familiar with the Chicago area but had not studied the Chicago approach plate recently nor prior to the Detroit-Midway leg of the flight.

Analysis

According to the approved approach procedure for an ILS/ADF approach to runway 31, the Kedzie fan marker should be crossed at an altitude of 900 ft above airport level, a gradual descent begun, and the descent continued until reaching minimum altitude at or near the middle marker six-tenths of a mile from the approach end of the runway. Upon reaching the middle marker or shortly thereafter, if the pilot does not have at least ceiling and visibility minima, and the lights identifiable with the runway are not in sight, a missed-approach procedure must be started. Evidence indicated that this procedure was not followed.

The captain's inability to execute the first approach properly stems from his failure to study the approach plate and his lack of knowledge of the procedure, even the frequencies involved. As he studied the approach plate between the first and second approach, it is apparent that he must have been aware of the proper procedure during the second approach. A descent to a dangerously low altitude must have been made early in the second approach. Several facts point to this belief. The tower struck was only 96 ft high. It was located more than a mile from the approach end of the runway and it was 3 000 ft to the left of course. At impact the aircraft was in the approach configuration with respect to propeller governors and propeller blade pitch angles, and wing flaps with landing gear down and locked. It is evident that during the approach both the ILS and ADF pointers clearly indicated that the aircraft was off course to the left. In fact, the ILS pointer must have been fully deflected quite some time before impact. Since the captain was a well qualified instrument pilot and would normally easily detect these discrepancies,

this can only mean that he was not referring to his instruments during the final portion of the approach.

With regard to a possible erroneous altitude indication, there was no evidence found to indicate either a failure or a malfunction of the altimeters. The weather conditions at the time and place of the accident could have varied to some extent from those reported at the airport, however, an air carrier aircraft made an uneventful instrument approach and a safe landing to the same runway within a few minutes of the accident. This pilot's landing minima were higher and only moderate weather conditions were encountered.

Probable Cause

The probable cause of the accident was the pilot's descent below his allowable minimum altitude and his inattention to flight instruments while attempting to locate the runway visually.

Following this accident the carrier removed the captain from duty; the first officer was flight-checked and then returned to duty.

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ICAO Ref: AR/601

No. 26

Indian Airlines Corporation, Douglas DC-3, VT-CGI, crashed 15 miles southwest of Hailakandi, India, on 29 March 1959. Report dated 10 September 1959 released by the Ministry of Transport and Communications, India.

Circumstances

The aircraft was flying from Dum Dum (Calcutta) Airport to Imphal via Agartala and Kumbhirgram. Aboard were 20 passengers and 4 crew. Take-off from Agartala was at 1010 hours Indian standard time, and the aircraft was to arrive at Kumbhirgram at 1100 hours. The last contact with the aircraft was at 1045 hours when it informed Kumbhirgram Air Traffic Control on R/T that it was flying through a thunderstorm. Some time later it was learned that the aircraft had crashed at just after 1045 hours on the Agartala - Kumbhirgram track, 35 miles southwest of Kumbhirgram Aerodrome. There were no survivors, and the aircraft was destroyed by impact and the subsequent fire.

Investigation and Evidence

The Aircraft - General

VT-CGI had a valid Certificate of Airworthiness at the time of the accident.

On arrival at Agartala no snags had been reported and a through-flight inspection was carried out.

The all-up weight of the aircraft after loading and refuelling were completed was 25 455 lb, which is below the maximum of 26 200 lb authorized for passenger operations. At the time of the accident it was calculated that the aircraft weighed approximately 25 165 lb.

Crew Information

The captain had a total flying experience of approximately 5 205 hours of which about 1 795 hours had been flown while he was in command. His actual time on instruments was 216 hours, and he was familiar with the route being flown on the subject flight.

The other crew members held valid licences and were qualified to make the flight.

Weather

Prior to his departure from Agartala (at 1010) the captain was advised of the conditions contained in the flight and aerodrome forecasts which were issued at Agartala at 0830 hours on the day of the accident.

While en route to Kumbhirgram, at 1035 hours, the aircraft contacted Kumbhirgram ATC and requested weather information:

It received the following:

> "Weather Kumbhirgram M5 (Danger MET) for thunderstorm. 160°/5 kt; visibility 10 km; weather thunder, rain, 2/8 fractostratus 240 m, 3/8 stratocumulus 750 m, 3/8 cumulonimbus 900 m, 6/8 altostratus 2 700 m."

The aircraft acknowledged this message and added - "I shall try another five minutes. At present passing through thunderstorm, 55 miles out. If not, I shall go back." ATC again contacted the aircraft at 1045 and was advised to standby since the aircraft was still flying through a thunderstorm. There was no further contact with the aircraft.

This last transmission indicates that the captain was experiencing difficulty due to severe turbulence. Shortly thereafter the aircraft suffered a structural failure.

Witnesses stated that bad weather conditions existed at the time and site of the accident. Thunderstorm and strong gusty wind conditions prevailed.

A considerable section of the main wreckage had been destroyed by fire. However, none of the other components in the wreckage trail bore any evidence of fire.

No useful information could be obtained from the instruments as they were all very badly damaged except that the altimeter setting on one of them was 29.92 inches. Similarly, the engine and airframe controls in the cockpit did not give any useful indications. The engines had dug into the ground, and two blades on either side had sheared off at the root end on ground impact.

The Port Wing

Examination in the laboratory confirmed that the initial failure had originated in the port wing. The sudden rolling movement caused excessive airloads which resulted in the subsequent failure of the elevators and rudder. The aircraft, completely out of control, crashed in an inverted nose-down attitude. The location of the wing in relation to the main wreckage indicated that the aircraft was on a southwesterly heading when the structural failure took place and that the failure occurred at a considerably lower height than the 5 000 ft cruising altitude indicated in the flight plan.

The wing was examined at the Technical Centre of the Research and Development Directorate of the Civil Aviation Department. A subsequent report on the nature of the failure of the front port wrap-round skin was also obtained from the Chief of the Test Laboratory, Hindustan Aircraft Limited, Bangalore. As the opinions from the above two sources were conflicting, the failed sections of the front and rear wrap-round skin of the port side of the aircraft was subsequently sent to the Royal Aircraft Establishment at Farnborough. The latter were asked whether in their opinion fatigue of the material was a factor to the failure of the wing. Excerpts from their report are as follows:

> "The fractured wrap-round skin from the lower surface of the port wing centre section has failed largely due to span-wise tensile loads consistent with tip upward bending of the wing. There is some evidence of fatigue at several of the rivet holes aft of the front spar, but at no point does it extend more than .05 inches from the edge of a rivet hole. There is a clear demarcation between the fatigued area and that of the main tension failure. This suggests that there was no gradual progression of a fatigue nature from the fatigued area to that of the main failure and that the latter was probably due to a single heavy loading."

> "The presence of fatigue at the rivet holes possibly influenced the final location of failure, but as the percentage of failed area showing evidence of fatigue is very small (about 1%) we do not think that the failure of the wing can reasonably be attributed to fatigue. In our opinion failure was probably due to an unusually large air-load."

Rework

During March 1953 the aircraft was suspected of having suffered some heat damage due to a torching exhaust from the port engine. The front port centre section wrap-round skin was, therefore, changed. The work was done by Hindustan Aircraft Limited, Barrackpore. At that time the aircraft had completed 13 431 hours.

In March 1954 Indian Airlines Corporation subjected the aircraft to a Certificate of Airworthiness overhaul in Delhi. At that time it was mandatory for all Dakota aircraft having completed 16 000 hrs to comply with the Douglas Drawing No. 5406787 or its approved equivalent, covering the centre section rework.

During the investigation of this accident it was observed that considerable ambiguity existed in the understanding of this requirement concerning the 16 000 hrs rework.

Probable Cause

Structural failure occurred while the aircraft was flying through a thunderstorm. The failure originated in the port centre section and was due to loads which exceeded the ultimate design value for the structure.

It was not possible to establish whether the pilot adopted the correct procedure for flying in turbulence.

Observations

It was noted that the airline's staff responsible for loading of the aircraft did not appear to be very knowledgeable on the technical aspects of the subject. It was felt that more stress should be laid by the operators on loading the aircraft so that it has the proper centre of gravity.

Appropriate x-ray equipment may be introduced for the detection of cracks in the vital structures of DC-3 aircraft.

Recommendations

1. The question of improving the weather forecast facilities for the Assam area could be examined by the appropriate Department. It would appear practicable that the existing facilities could be more properly utilized. At present the W/T watch is open for a very brief period of a few hours a day and even if they do observe any deterioration in the weather that information cannot be passed to the neighbouring airfields. The MET observers stationed at airfields between Agartala and Kumbhirgram should pass their visual observations to the neighbouring airfields.

2. The present procedure for passing weather information to aircraft could be improved. (In the case of this accident, there was an avoidable delay in passing M5 information to VT-CGI.)

3. Comprehensive instructions of the technique of flying through thunderstorms should be incorporated in the Indian Airlines Corporation's Operational Manual.

It should be stressed to pilots that if they have flown through turbulence, they must report the details of the incident in their Storm Report.

4. With regard to the 16 000 hrs rework, it is recommended that a technical committee of a representative nature should go through the subject and lay down an agreed method for the rework mentioning materials to be used and limitation of life to be imposed.

5. The period of the preservation of log books should be extended to the life of the aircraft. (During this investigation it was found that log books prior to 1954 were not available for the aircraft.)

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No. 27

Riddle Airlines, Inc., Curtiss C-46R, N 7840B, had a fire in flight near Alma, Georgia, on 30 March 1959. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 1-0014, released 1 September 1959.

Circumstances

Flight 402 was a regularly scheduled flight from Miami, Florida to Chicago, Illinois. At Orlando, one of the intermediate stops, 9 236 lb of cargo were placed on board, and the aircraft took off at 2235 for Atlanta. It was cleared at 2331 to descend to and maintain 5 000 ft and was requested to report over Alma. At approximately 2340 the aircraft was seen directly over the airport and shortly thereafter it sent the following radio transmission - "Mayday, aircraft on fire, unable to control." After making several left circles the burning aircraft, at 2346, struck the ground inverted at a steep angle and exploded on contact, fatally injuring the pilot and co-pilot, the sole occupants.

Investigation and Evidence

The extensive damage to the heavy components of the control systems, as well as other heavy structural members in the area of the rear wing spar, occurred in a very short period as a result of an intensive hydraulic fluid fire.

The exact cause of the ignition of the hydraulic fluid could not be determined. However, from all the physical evidence the Board believed that the cargo in "G"* compartment (aft lower cargo compartment) was ignited by contact with an unguarded light bulb. The fire smouldered and progressed until it burned through the forward aluminum wall. Any break in the compartment wall would be accompanied by an increase in airflow concentrated at that point. The intensity of the fire increased with the increase in airflow (which is normally forward) and was carried into the area of the rear spar where numerous hydraulic units and lines are located. Fire damage to one of these components resulted in a leak which fed the flames to uncontrollable proportions.

In determining the cause of the fire the Board considered, among other things:

a) previous baggage compartment fires caused by cargo contacting unguarded light bulbs which have been experienced by other airlines;

b) the unguarded light bulbs as installed in N 7840B;

c) the probability that one or more of the mail sacks, containing clothing, pressed against an unguarded and lighted bulb;

d) the probability that the compartment sealing tape had deteriorated permitting an airflow exceeding a rate of 1 500 cu. ft./hr. A flow greater than this rate would supply sufficient oxygen to support combustion within the compartment;

e) the normal airflow in compartment "G" which would carry fire forward to the rear spar.

* The "G" compartment on Riddle C-46R aircraft was certificated by the FAA as a class "D" compartment on the basis of airflow rate tests and engineering specifications submitted by the company.

A second possibility considered by the Board was that of a hydraulic leak in the area of the rear spar. This was considered unlikely as a second element would have had to have been present simultaneously, i.e., an electrical fault of a nature sufficient to generate enough heat to ignite the fluid. Also, had the fire originated in this manner, there would be no accounting for its rearward progress against the normal air flow through the rear cargo compartment.

Probable Cause

The probable cause of this accident was the ignition of cargo in the aft belly compartment caused by contact with an unguarded light bulb.

Corrective Action

As a result of this accident, the following steps have been taken by the company:

1. Guards have been installed on all cargo compartment lights in its C-46R aircraft.
2. The lights have been required, and a switch has been installed on the flight deck.
3. A company procedure has been instituted to require these cargo compartment lights to be off during flight.
4. A programme has been instituted to design and install both fire detection and fire extinguishing equipment in these lower cargo compartments.

Also, the following recommendations were made to the Federal Aviation Agency and the company after the accident:

1. that electrical relays and electrical terminals in the hydraulic compartment area should be protected;
2. that the tape which is used to seal class "D"* cargo compartments be subjected to periodic inspections to ensure that the proper control of airflow is maintained.

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* Excerpt from Civil Air Regulations 4b 383 (d) CLASS D ..... "Cargo and baggage compartments shall be classified as "D" if they are so designed and constructed that a fire occurring therein will be completely confined without endangering the safety of airplane or the occupants ....."

No. 28

British Air Charter Company, Super Trader, G-AGRH, accident on Suphan Mountain, Turkey, on 23 April 1959. Report released by the Department of Civil Aviation, Ministry of Communications, Republic of Turkey.

Circumstances

The aircraft, carrying a crew of 12, was on a flight from Ankara, Turkey to Bahrein via Gemerek, Elazig, Mus, Van and Abadan. It reported at 0814 (at 11 500 ft) over Gemerek, at 0859 (at 13 500 ft) over Elazig and at 0926 over Mus. As it did not report passing over Van as expected at approximately 0952 hours, and as no further contact was established, a search was begun. The aircraft was sighted 6 days later on Suphan Mountain. There were no survivors.

Investigation and Evidence

None of the members of the Turkish and British accident investigation teams were able to climb to the site of the accident for on the spot investigation. However, a Turkish helicopter was able to land (at a height of 14 300 ft) near the aircraft wreckage and the pilot made some observations.

The aircraft had struck 2 metres below one of the peaks of Suphan Mountain. It had hit the west side of this peak in a laterally level slightly nose-up attitude.

Further information was obtained from a pilot member of the British Mountain Rescue Team, which reached the site of the accident:

The wreckage was covered with snow and scattered over an extensive area. The aircraft had hit a small hill northeast of the crater of the Suphan Mountain. There were two headings which the aircraft could have taken in arriving at the point of impact without striking other high ground in the immediate vicinity - 070° and 110°. From observations it appeared that the plane was flying on 070° and was climbing when it struck the hill at considerable speed.

The following indications were noted on the front panel:

1. airspeed indicator - 100 kt;
2. external thermometer .... -20°;
3. altimeter .... 1023 mb at 10 500 ft;
4. either a direction indicator or a repeater compass for the automatic pilot - its glass was broken and the needle was frozen at 070°.

Meteorological conditions

Between Kayseri and Van there was 4 - 5/8 cumulus - stratocumulus, base 2 000 ft with a ceiling of 13 000 to 14 000 ft; at 20 000 ft 4/8 cirrus cloud; high winds from the south-southwest. It was estimated that the mountains facing this direction between Diyarbakir and Van would be covered with rising orographic clouds. The winds were as follows:

	Ankara - Kayseri	Kayseri - Van
10 000 ft	200/20	210/35 kt
12 000 ft	200/25	220/40 kt

Analysis of the flight

Since the speed of the aircraft was shown in the filed flight plan as 190 kt, the plane should have been at Gemerek after 48 min. However, according to the weather report there was, at the flight's altitude between Ankara and Kayseri, a 20 kt wind blowing from the southwest. The aircraft climbed to 9 500 ft between Ankara and

Gemerek and because of the wind actually reached Gemerek after 54 min instead of 48 min.

Gemerek to Elazig

During this portion of the flight the aircraft was flying at 11 500 ft and was subject to a stronger side wind, reported as 200°/25 kt. In the flight plan the estimated time of arrival over Elazig was 0852, however, it was actually 0859.

Elazig to Van

Time between these two points was estimated at 54 min. The aircraft reported at 13 500 ft, encountering winds stronger than forecast; no report was received, however, of its arrival over Van. Another pilot reported turbulence in this area on the same day.

Since the pilot reported normally at 0926 hours it is unlikely that there was any defect in the aircraft or its engines. It would, however, be difficult to fix the position of the aircraft accurately in the vicinity of Mus with the navigational aids available and it may be presumed that the flight from its actual position at 0926 hours to Van was in the direction of Mount Suphan. An altitude of 13 500 ft would give 2 000 ft clearance above the highest points 25 miles on either side of ADR 388, but would not clear the higher mountains to the north. Furthermore, due to temperature error the altimeter would indicate an altitude higher than actual...as a result, the aircraft hit about 10 ft below the peak at an altitude of approximately 14 000 ft.

Probable Cause

The aircraft, flying on instruments, drifted north of its normal track because of strong winds and crashed into the mountain.

Contributing Factors

1. the winds were stronger than forecast;
2. an accurate bearing could not be obtained at Mus, and Van had not been checked;
3. sub-normal temperatures would result in a high indicated altimeter reading;
4. calculations on the flight and contacts with beacons were not co-ordinated and controlled.

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ICAO Ref: AR/624

No. 29

Iberia Airlines, DC-3, EC-ABC, crashed into the Valdemeca (Cuenca) mountain range, Spain, on 29 April 1959. Report released by the Directorate General of Civil Aviation, Spain.

Circumstances

The flight was a scheduled one from Barcelona to Madrid, Spain. Take-off from Barcelona was at 1418Z with 3 crew and 25 passengers aboard. At 1533 a radiogram from Barajas was received at Calamocha reporting that EC-ABC had crossed the FIR boundary as previously estimated at 1513 hours and its estimated arrival time at Calamocha was 1539. The radiogram had been sent through Barajas owing to a severe storm over Calamocha. At 1556 Calamocha heard the aircraft call Barajas and then it called Calamocha requesting a true bearing. Calamocha replied requesting its QSV and QTG. The aircraft transmitted for several minutes as requested and was not heard from thereafter. It crashed at 1600 hours on the east slope of the Sierra de Valdemeca, approximately 60 m from the top of Telegraph Hill, killing all aboard. The aircraft was demolished and fire broke out on impact.

Investigation and Evidence

The accident site was at a height of approximately 1 900 m and 70 km to the left of the normal route.

From the investigation it was deduced that at the time of the accident the aircraft was in level flight with all engines running. There was no evidence of malfunctioning of any equipment, nor were there any indications in communications with the aircraft that it was in any difficulty.

At the time of its last call (1556Z) to Calamocha the aircraft was trying to locate or check its position. It crashed about four minutes later.

Weather conditions

On the entire route thick clouds covered the sky between 1 000 and 1 200 m above sea level. These cumulus and cumulonimbus clouds hid the mountains and produced light to moderate rain. It was, therefore, assumed that the flight encountered isolated storms. Freezing level was at 9 000 ft and, therefore, it was not believed that icing occurred at the flight's level (8 000 ft). There was a strong west-southwest wind. Mountain wave turbulence combined with the characteristics of the air mass over the route may have caused strong downward currents which might explain the aircraft's low altitude.

Conclusions

The fact that the accident occurred 70 km to the left of the normal route, without a crosswind present, would appear to indicate that rather than adhere to the scheduled route the pilot diverted to the left in order to avoid passing through storm clouds.

To explain the crash on a mountain whose height was approximately 600 m lower than the flight level one of the following assumptions must be admitted:

1. rather than adhere to the scheduled flight level, the aircraft was flying much lower, or

2. while adhering to the flight level, severe turbulence was encountered in a storm cloud, which had to be entered, and the aircraft, as a result, had lost altitude following a track correction.

Probable Cause

Due to unfavourable weather conditions it was necessary to deviate from the planned route.

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ICAO Ref: AR/592

No. 30

Austria Flugdienst, DC-3, OE-FDA, struck Alfabía peak, Majorca, on 2 May 1959. Report released by the Directorate General of Civil Aviation, Spain.

Circumstances

The aircraft was on a non-scheduled flight from Vienna, Austria to Palma, Majorca and return. Following a stop of one hour and a half at Palma it took off on the return flight at 2107Z carrying 3 crew and 2 passengers. At 2110Z the flight contacted Palma control and reported it was at 3 000 ft and setting its course. It was instructed to report at flight level 90 or upon leaving the Palma area. Approximately two minutes later it crashed at a height of 3 300 ft on Alfabía peak, killing all aboard.

Investigation and Evidence

Examination of the evidence, the statements of the inhabitants of the over-flown area and the wreckage pattern rule out the possibility of malfunctioning of the aircraft or its engines.

The weather was clear and cloudless over Alfabía at the time of the accident and there was no moon.

In view of the time elapsed between the take-off at 2107Z and the time of the accident at 2112Z it must be assumed that the pilot immediately after take-off set his course on Bagur without having reached the 3 000 ft altitude over the radio beacon or the airport before setting course, an essential condition in order to attain, by the end of the 17 km which separate the airport and the summit of Alfabía, the safety altitude stipulated in the regulations.

Probable Cause

It was concluded that the aircraft crashed as a result of insufficient altitude while flying at normal climb power.

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ICAO Ref: AR/593

No. 31

Lec Refrigeration Ltd., Dove DH 104, G-ALEC, accident on North Road near Maindy Stadium, Cardiff, on 6 May 1959. Report dated May 1960 was released by the Ministry of Aviation (UK) as C.A.P. 163 - (Civil Aviation Report No. C.696)

Circumstances

The aircraft took off at 1320 hours Greenwich Mean Time on a private flight to fly over the opening ceremony of the Welsh Ideal Homes Exhibition being held in Sophia Gardens near the centre of Cardiff. The aircraft passed over the exhibition at least three times. On the last occasion it was at an extremely low altitude with the starboard propeller feathered. After continuing some distance beyond the exhibition, the starboard propeller commenced rotating, and a few seconds later the aircraft dived steeply to the ground. The pilot and three passengers aboard were killed instantly. Following impact, fire broke out which almost entirely destroyed the aircraft.

Investigation and Evidence

The Aircraft

G-ALEC had been properly maintained and was airworthy at the time of the accident. Since renewal of its Certificate of Airworthiness in January 1959 it had flown approximately 33 hours. The all-up-weight of the aircraft at the time of the accident was below the maximum permissible and although it was not possible to calculate the position of the centre of gravity it was considered probable that it was within the prescribed limits.

The Pilot

He had obtained a Commercial Pilot's Licence and Instrument Rating. In April 1959 when being tested for a Group 1 type rating endorsement of his licence he failed to pass the test on the grounds that he was not competent to fly the aircraft under conditions of asymmetric flight,, i.e. with one engine stopped. After returning from his visit to Cardiff he was to receive two hours dual instruction in asymmetric flying.

He had flown 256 hours mainly on single-engined aircraft. Only 28 hours of this total were in Dove aircraft and approximately 3 hours 45 minutes were as pilot in sole command.

Arrangements regarding the flight of 6 May

It had been agreed that the flight, considered as a "fly past", was to be made over the exhibition at 1330 hours, the time of the official opening ceremony. It was also to include a "dip in salute". The Cardiff City Police had been contacted and permission had been requested for the aircraft to fly low over the City. The Cardiff trade agent (of Lec Refrigeration) was informed that the flight must be conducted in accordance with the Air Navigation Order, excerpts of which follow:

> "... an aircraft shall not be operated in a negligent manner or in a reckless manner so as to endanger life or property.."
>
> "... an aircraft other than a helicopter shall not fly over any congested area of a city, town or settlement below -
>
> i) such height as would enable the aircraft to alight clear of the area and without danger to persons or property on the surface, in the event of failure of a power unit; or

ii) a height of 1 500 ft above the highest fixed object within 2 000 ft of the aircraft,

whichever is the higher."

The Senior Pilot of the Company stated that while he may not have given the pilot any specific instructions in respect of height to fly, he had reminded him that the flight was to be carried out at a safe height.

No request had been made to the Minister for a dispensation of the minimum safe altitude regulations.

The Final Flight

The first two runs over the Exhibition were carried out between 200 and 1 000 ft with the engines running normally and no signs of malfunctioning were evident. On the third run the aircraft approached at an altitude of approximately 100 ft and passed over with the starboard propeller feathered at an extremely low altitude. After about half a mile, rotation of the starboard propeller indicated that the pilot was trying to restart the engine. The aircraft then yawed from side to side and climbed to clear some trees. Then it went into a steep right-hand climbing attitude and dived almost vertically to the ground, near a school, houses, business premises and a sports stadium being used at that time by a large number of children.

The Wreckage

Examination of the wreckage revealed that at the time of the accident the flaps and undercarriage were retracted, and there was no evidence that the aircraft had been on fire in the air. The starboard fuel cock was in the "off" position. There was no evidence that the starboard engine was running under power at impact - the port engine was under power. Damage of the pilot's pitch control mechanism of the starboard propeller indicated that the control lever was in the feathering position at impact. Both propellers were in the constant speed pitch range, but the starboard was at a pitch angle nearer to the feathered position.

It was considered probable that during the unfeathering of the starboard propeller the pilot omitted to turn on the fuel. Consequently, the engine did not develop power, and the aircraft lost airspeed due to drag from the windmilling propeller. Under the prevailing conditions, the performance of the aircraft, with a propeller windmilling and with maximum power from the other engine, would permit only a very small rate of climb. The fact that the starboard propeller was not feathered and that the cockpit pitch control lever was in the feathered position indicates that the pilot had initiated refeathering action at the last moment.

Probable Cause

The accident was due to loss of control by an inexperienced pilot during an attempt to restart an engine following asymmetric flight at a very low altitude.

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No. 32

Capital Airlines, Inc., Vickers-Armstrongs Viscount N 7463, disintegrated in flight near Chase, Maryland, on 12 May 1959. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 1-0050, released 23 October 1959.

Circumstances

Flight 75 carried out a normal take-off from La Guardia, New York at 1529 hours headed for Atlanta, Georgia and proceeded to its assigned cruising altitude of 14 000 ft and Victor 3 Airway. Regular position reports were made en route. At 1602 the aircraft contacted Washington Centre, reporting it was over Westchester at 1600 with Herndon next, estimating Westminster at 1617. It also advised that there was a string of thunderstorms along that course and was told that it could stay as requested slightly south of Westminster. At 1610 the flight advised Washington Centre that it had reduced to 170 kt because of rough air. Nothing further was heard from the flight. At approximately 1613 hours eastern standard time the aircraft broke up and crashed, killing the 27 passengers and 4 crew members.

Investigation and Evidence

Weather

At 1600 a cold front existed along a line from Philadelphia to Baltimore to near Gordonsville, Virginia. Regional forecasts issued by the Weather Bureau in Washington at 0700 and 1300 and the area forecast issued at Idlewild at 1400 drew attention to the possibility of locally severe thunderstorms and extreme turbulence associated with the front. The 1400 area forecast also stated there was the possibility of a squall line development in advance of the front.

At 1415 the Idlewild Weather Bureau office issued the following flash advisory - "Line of scattered thunderstorm activity near Martinsburg-Harrisburg-Poughkeepsie northeastward is moving eastward about 20 kt accompanied by severe turbulence and conditions locally below 1 000, visibility 2 miles. This line will move to near Providence-New York City-Philadelphia by 1800 increasing in intensity during afternoon. Valid until 1815."

During the afternoon radar reports were issued hourly from Andrews Air Force Base weather describing the locations of the thunderstorms and indicated they were increasing in intensity during the afternoon along the New York-Washington route of Flight 75.

Although the advisory and the radar reports were both on teletype machines in Capital dispatch, no action was taken to furnish the information to the flight. Dispatch did not know whether the captain had received the advisory prior to departure. It was stated by dispatch personnel that they believed the flash advisory indicated improved conditions over those previously forecast and that all of the weather data indicated the thunderstorms were scattered, thus circumnavigable.

Following the accident a study of the weather conditions prevailing in the accident area was made. Results showed there were large rapidly developing thunderstorms in the vicinity of Martin Airport about 2-1/2 miles southwest of the accident area. It was also determined that extreme turbulence* most probably existed at

* extreme turbulence is defined as a rarely encountered turbulent condition in which the aircraft is violently tossed about and is practically impossible to control. It may cause structural damage.

14 000 ft in the thunderstorm cells and areas around them. It was also shown that extreme turbulence may exist not only in the thunderstorm cell but up to five miles around it.

Because Flight 75 was released at 1435 with 1400 weather attached to the release and because the crew was apparently at the aircraft considerably before flight time, the Board believed that the captain did not receive the 1415 flash advisory. This advisory would have delineated the position and movement of the line of thunderstorms along the route and would have indicated that they were expected to increase in intensity. Radar information could have indicated the individual positions of the thunderstorms. N-7463 carried weather radar equipment, but it was not operative.

Witnesses

More than 100 eyewitnesses to the accident were interviewed and many provided written accounts of their observations. Most were attracted by the inflight breakup itself and comparatively few saw the aircraft both before and during the inflight disintegration. Since most who saw the aircraft break up estimated it was between 3 000 and 7 000 ft when it disintegrated instead of 14 000 ft, the assigned and last reported altitude, a flight test was made to determine the approximate altitude. A Capital Viscount was flown several times along the probable flight course of N 7463 at different altitudes from 3 000 to 14 000 while eleven eyewitnesses watched from their original positions. Each designated the pass on which the altitude of the test plane was closest to that of N 7463 when it disintegrated. The result averaged 5 500 ft.

Certification

The Viscount was built to conform to the British Civil Air Requirements and issued a British airworthiness certificate. The Federal Aviation Agency, then CAA, when satisfied that an adequate standard of airworthiness existed accepted the British certificate and issued the U.S. airworthiness certificate. The strength requirements of each country are substantially the same and the Viscount met or exceeded both.

The recommended rough air penetration speed for the Viscount is about 170 kt, the last airspeed reported by Flight 75. At or near this speed the aircraft's strength is sufficient that extreme manoeuvre and/or gust loading will stall the aircraft rather than cause a structural failure.

Inflight Disintegration

On the basis of all available evidence it was the Board's analysis that the inflight disintegration occurred as the result of loads imposed on the aircraft which exceeded its design strength. The Board believed that the forces were from a high indicated airspeed in turbulence and that this airspeed was generated during an involuntary descent from 14 000 ft, which followed loss of control of the aircraft in extreme turbulence. The Board was convinced that no pre-existing weakness or condition contributed to the breakup and that no malfunction or failure of the aircraft, its systems, or its components led to the circumstances under which the disintegration occurred.

From examination of the major fractures, breakup patterns, and from design considerations, it was believed that the initial failure in the destruction sequence was the nearly simultaneous downward failure and separation of the horizontal stabilizers at the No. 2 hinge points. This was confirmed by the fact that the symmetrical stabilizer failures could only occur with both wings intact. Also, under ultimate loadings on the aircraft the stabilizers would be expected to fail first. Furthermore, the breakup sequence and the nature of the mass of fractures were entirely consistent with this as the initial occurrence.

Following separation of the right and left stabilizers the aircraft pitched down violently so that all four nacelles broke upward from combined inertia and gyroscopic loads. Immediately thereafter both wings were subjected to extreme downloads under which the right separated and the structural integrity of the left wing was destroyed. With the nacelles, right wing, and stabilizers gone, drag induced by the left wing yawed the fuselage violently to the left. Forces to the left tore off the vertical fin with portions of the fuselage attached, the latter already weakened when the left stabilizer stub tore away. During the subsequent gyrations the left wing broke up, its fuel cells were opened, and the flash fire occurred. At the same time the remaining fuselage disintegrated. The Board believed that the major disintegration sequence took less than one second and that during the latter part of the sequence occupants of the plane were exposed in a random manner to the flash fire and attendant high concentration of carbon monoxide.

The high indicated airspeed which the Board believed existed at breakup is suggested by several factors which in their cumulative value and with the overall patterns of evidence, make the existence of excessive speed nearly irrefutable.

Unless an airspeed in excess of cruising is present the strength of the Viscount is such that forces causing the horizontal stabilizer failures which occurred cannot be developed. Below cruising speed the horizontal tailplanes will stall at loadings less than those necessary to cause failure.

The high indicated airspeed was also suggested by the structural damage to the passenger seats, propeller reduction gearing assemblies, the engine mount "W" struts, and possibly by the ante-mortem injuries of two or three passengers. The damage and the injuries resulted from pullup loads which were in the opposite direction to the loads imposed on these subjects by the breakup forces. This damage had to be made prior to the breakup and was compatible with a descent in which high speed was attained, followed by a recovery in rough air in which positive "g" forces had to have occurred.

A further indication of an excessive airspeed and one more definitive of the amount was the blade angle of the No. 3 propeller, 52 degrees. It is believed the indications of blade angle were made during breakup, therefore, airspeed calculated from the blade angle would be valid at that time. From technical data relating to airspeed and propeller blade angles it was shown that with the 52-degree angle there is no throttle position at which true airspeed could be less than 295 kt. Because this airspeed is excessive it is entirely logical to assume the throttles would have been closed to slow the aircraft. With the throttle closed a 52 degree blade angle reflects a true airspeed of 335 kt, which is 15 percent in excess of the Viscount never-exceed speed or about 5 percent in excess of V_D, the maximum speed demonstrated in certification. Loads at such an airspeed, combined with gust and/or manoeuvring load, could easily exceed the strength of the aircraft.

From the evidence of a high airspeed, combined with pullup forces already discussed, it was the Board's opinion that an involuntary descent occurred before the inflight disintegration. The foregoing conclusion is supported by the fact that the breakup occurred at about 5 000 ft and it is not reasonable, under the circumstances, to believe that a voluntary descent would have been made. The configuration of the aircraft at breakup - gear up and flap retracted - is also inconsistent with a voluntary descent under the turbulent conditions known to have existed. Finally, believing that Flight 75 was at 14 000 ft about 1610 and that the aircraft disintegrated some 5 000 ft above the terrain about 1613, a descent of 9 000 ft in three minutes or less is evident. Again, a descent occurring under these factors of time and altitude would not be less than 3 000 ft per minute and not less than V_{ne}.

This evidence confirms the aforementioned speed indicated by the propeller blade angle.

The Board knew of no evidence in this accident from which it could determine the sequence of events and factors immediately attending the situation in which loss of control of the aircraft occurred at 14 000 ft. Such factors may be numerous and varied. The captain may have been attempting to cross the line of thunderstorms to re-establish the flight on V-3 Airway. In doing so he may have selected an opening in the thunderstorms which closed causing loss of visual reference and then entered a thunderstorm which was obscured. It is possible under a similar occurrence that the captain attempted to manoeuvre out of such a situation and placed the aircraft in an unusual attitude and in which control techniques would be more critical. The pilot's technique and psychological approach to thunderstorm penetration are important factors.

Probable Cause

Loss of control of the aircraft in extreme turbulence resulted in an involuntary steep descent following which aerodynamic loads from high airspeed, recovery, and turbulence exceeded the design strength of the aircraft.

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No. 33

Capital Airlines, Lockheed Constellation, L-049, N 2735A, accident at Kanawha County Airport, Charleston, West Virginia, on 12 May 1959. Civil Aeronautics Board (USA), Aircraft Accident Report, File No. 1-0055, released 10 June 1960.

Circumstances

The flight from Washington, D.C. to Atlanta, Georgia, was to make four intermediate stops including Pittsburgh, Pennsylvania and Charleston, West Virginia. It was on an IFR flight plan during the Pittsburgh-Charleston portion of the trip. Aboard were 38 passengers and 6 crew. During a second attempt to land at Kanawha County Airport on a wet runway the aircraft was intentionally groundlooped because of ineffective braking during which it skidded and slid down a steep embankment beyond the airport boundary. A fire followed during which one crew member and one passenger died. The aircraft was destroyed.

Investigation and Evidence

The Aircraft

All overhauls, inspections and maintenance regarding the aircraft had been carried out as required.

Crew Information

The captain was properly certificated and rated for the subject flight. He had a total piloting time of 4 966 hours - 408 as co-pilot on Constellations and 293 as captain on them. During the 30 days preceding the accident he made six landings at Kanawha County Airport.

The first officer was also properly certificated and rated for the subject flight and had 822 hours to his credit as Constellation co-pilot.

Kanawha County Airport - Landing Regulations

The airport is built on the top of a mountain. Runway 32 is 4 750 ft long and runway 23, the ILS runway, is 5 200 ft long. On 12 May, the latter runway was closed for repairs... it was being lengthened 600 ft. Both runways are paved with a surface consisting of an asphalt and concrete mixture. The terrain at the end of the runways slants downward abruptly.

The Civil Air Regulations require that transport category airplanes in scheduled service can be landed within 60% of the effective length of the runway on a dry runway in still air. The effective length of runway 32 is about 3 830 ft, 60% of which is 2 300 ft. According to the Federal Aviation Agency Approved Airplane Flight Manual, the stopping distance for a Lockheed L-049 aircraft weighing 78 700 lb* when landed on this runway is 2 300 ft. The remainder of the effective runway length is intended to provide a safety margin.

* At the time of take-off the aircraft weighed 81 253 lb, which was 4 284 lb under the maximum allowable gross take-off weight at Pittsburgh for an intended landing at Charleston. The maximum allowable gross landing weight for L-049 aircraft for runway 32 at the Kanawha County Airport is 83 000 lb.

Weather

An airport weather observation made at 1530 hours (i.e. one minute after the accident) indicated an estimated ceiling of 4 000 ft with scattered clouds at 600 and 1 500 ft; visibility 6 miles; light rain showers; ground fog; temperature 68°; dewpoint 62°; wind - 4 kt from the east-southeast. Rain was falling during the approach and touchdown and had been for some time previously. The runway was thoroughly wet with localized areas of standing water.

The Landing

Following one ILS approach, which was abandoned, the flight advised that it was in the clear and would cross the airport and would again report on downwind leg. It was again cleared to land on runway 32. The approach appeared normal and the aircraft touched down 800 to 1 000 ft from the approach end of the runway and within the first third of the runway distance. At touchdown or just after the flaps were fully down and during the final portion of the approach, the airspeed was about 105 kt. Although the brakes were immediately applied, and were functioning normally, the aircraft did not decelerate. Early in the landing roll the captain ordered the first officer to raise the flaps to put weight on the wheels and increase traction, however, the first officer did not hear the command. As it was evident that the aircraft could not be stopped within the runway limits or flown out safely, the captain decided to make a left ground loop and called for full power on No. 4 engine. The flight engineer misunderstood this command and applied power to all four engines. Recognizing that all throttles were forward, the captain quickly closed throttles No. 1, 2 and 3. The aircraft then began the left turn which ended in its running over the embankment.

The first tire marks, found 3 450 ft from the approach end of runway 32 indicated that the aircraft was skidding slightly with the nose gear slightly to the left. 3 730 ft down the runway, further tire marks showed a more pronounced skid and the beginning of a left turn. All tire marks were a whitish discolouration on the runway surface and not the dark marks usually found on a dry runway under similar circumstances.

The Wreckage

The main wreckage was 200 ft down the 32° slope. The vertical depth from the surface of the airport to the wreckage was 95 ft.

During the slide down the slope the No. 3 engine was torn from its mounts and reversed its position, resulting in a portion of a broken propeller blade penetrating the left main fuel tank. The fuselage broke open on both sides aft of the forward bulkhead in the forward lounge.

Except for the empennage surfaces, outer wing panels and nose gear, the entire structure was destroyed by fire.

The engines were severely damaged. As the crew stated that they were functioning normally at the time of the accident, no teardown examination was made.

Braking Effectiveness on Wet Runway Surfaces

Investigation of the accident was extended to the subject of decreased braking effectiveness because of wet runway surfaces. The National Aeronautics and Space Administration furnished the results of data compiled when tests were made using various runway surfaces and with varying degrees of moisture on these surfaces. These tests indicated that it was possible under certain conditions of speed, weight, moisture, etc. for an aircraft to ride on the film of water (aquaplane) and for the aircraft's brakes to be completely ineffective when this occurs.

Analysis

The Board determined that the aircraft did aquaplane throughout a portion of the landing roll. The white tire marks found on the runway are the colour of tire marks definitely associated with aquaplaning. The Board also believed that the approach speed of the aircraft (105 kt) was faster than the recommended approach speed (95 kt) and that this extra speed was partially caused by the lowering of the landing flaps on the final approach. It was further believed that although the aircraft was landed within the first third of the runway, under the conditions which existed, namely a wet runway and without a headwind component, a landing should have been made closer to the approach end, in the interest of safety. Coupling these conditions with the first officer's failure to hear and comply with the captain's order to raise flaps in order to put weight on the wheels, it is easy to understand why an early deceleration was impossible.

Furthermore, at some point in the landing roll the captain realized that something must be done immediately or the speed of the aircraft would take it over the embankment at the end of the runway. At that time he was faced with a real emergency and it does not seem in keeping with the gravity of the situation that he would delegate the handling of the power controls to the flight engineer. Recognizing that the power to delegate is discretionary with the captain, the Board, nevertheless, believed that in this instance this was not the best procedure and that instead the handling of the throttles by the captain may well have resulted in less disastrous results.

Since the accident the company has prohibited the landing of all Constellation aircraft on runway 32 unless the runway is dry and there is a headwind component.

Probable Cause

The probable cause of the accident was the pilot's action of landing the aircraft too fast on the wet runway under conditions conducive to aquaplaning, making early deceleration impossible.

An additional factor was the poor co-ordination of the crew throughout the approach and landing.

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ICAO Ref: AR/636

No. 34

Aerolíneas Argentinas, DC-3, LV-AFW, accident 3 km off the coast, near Mar del Plata, Argentina on 15 May 1959. Accident Investigation Report No. 1219, dated 31 March 1960, released by the National Director of Civil Aviation, Argentina.

Circumstances

The aircraft was on a scheduled flight from Ezeiza to Mar del Plata and Bahía Blanca. The first segment was flown without difficulty and following ground servicing at Mar del Plata the aircraft took off at 2040 hours. Six minutes later it requested permission to leave the control tower frequency and change to communications with the station providing en route service. The frequency change was not recorded, and nothing further was heard from the aircraft. It had crashed into the sea killing the 4 crew and 6 passengers aboard.

Investigation and Evidence

The Aircraft

At the time of the accident, the aircraft had a Certificate of Airworthiness valid until 17 February 1960, which had been issued following a 3 000-hour inspection on 26 March 1959. Its record up to and including 15 May 1959 showed it had flown a total of about 14 748 hours and 3 467 hours since its last overhaul.

The Crew

The pilot-in-command held an Airline Transport Pilot's Licence and fully valid documents. As of the day of the accident he had flown about 2 739 hours. In the airline's service he had flown a total of 2 069 hours, of which 555 were night flying, 504 were on instruments and 44 were on a ground trainer. In the last 363 days he had flown 902 hours.

The co-pilot held a Senior Commercial Pilot's Licence and had a total of 4 219 flying hours to his credit as of 15 May. His flying time during the last 365 days totalled 1 060 hours. During this period he had accumulated an excess of 50 hours flying time in contravention of Resolution No. 678/57.

The radio operator was properly certificated and had flown 1 585 hours for the airline. During the last 365 days he had flown an excess of 181 hours in contravention of the above-mentioned Resolution.

Nothing unusual was mentioned in the medical records of the crew.

Special Circumstances

Although the accident occurred following take-off from Mar del Plata Airport, in view of special circumstances surrounding it, the investigator was compelled to initiate the investigation from the time the aircraft had entered the apron at Ezeiza Airport. He requested the co-operation of the Federal Police and the State Information Service. The circumstances which had to be considered were the announcement of a general strike of airport personnel on 15 May, accusation of an alleged sabotage, and a first impression that the burns had been suffered while the victims were still alive.

Checks were made on the clearance of aircraft passengers and cargo at Ezeiza and it was concluded that operations proceeded normally. At the time of embarkation no person alien to aircraft operations

had been observed to enter the parking apron nor had any packages or parcels other than those inspected been delivered at the last moment. The aircraft contained no object that could be considered suspicious. All waybills of registered cargo were checked and showed that the aircraft did not carry any cargo which at any time might have been considered hazardous to its safety.

The Flight-Ezeiza to Mar del Plata

All passengers on the flight from Ezeiza to Mar del Plata confirmed that the flight was normal and very quiet. A flight engineer aboard, who was also the Airline's Chief of Base at Mar del Plata Airport, stated that there were no signs of engine malfunction or airframe failure.

On approaching Mar del Plata some difficulty arose in the voice communications between the aircraft and the control tower so that a naval aircraft at the end of runway 12 relayed landing information.

On the ground the pilot discussed these deficiencies with the control tower operator, and it was concluded that the communication difficulties were due to the low voltage in the overall electric current network at the airport and, therefore, the control tower lacked sufficient power for the aircraft to be able to hear it in normal conditions.

Mar del Plata to Bahía Blanca

On landing at Mar del Plata all passengers alighted from the parked aircraft and proceeded towards the airport waiting room. It was definitely determined that no outside person had entered or approached the aircraft while at Mar del Plata. Only 240 kg of ballast were placed inside the aft holds of the aircraft.

On this portion of the trip which was expected to take 1 hr 40 min, the aircraft was to fly at 1 200 m. Loading was within the specified authorized limits - take-off weight was 11 043 kg as compared to the maximum authorized take-off weight of 11 895 kg and to the authorized weight of 11 884 kg for the Mar del Plata - Bahía segment.

The weather conditions which existed in the area were favourable.

The co-pilot was in the captain's seat at the time of take-off, 2040 hours. The aircraft climbed normally and a procedure turn to the right, which permits direct on-course alignment, was completed. The control tower operator stated that the aircraft was observed for 6 minutes heading towards Bahía Blanca. At 2046 hours the pilot asked for clearance to change from radiotelephony to radiotelegraphy in order to communicate with the ground station at Mar del Plata. This transfer was authorized, and the pilot advised that from Bahía Blanca he contemplated returning directly to Buenos Aires. This communication was completed, and the tower then lost sight of the aircraft. No radiotelegraphy contact was established. Shortly thereafter, the airline's dispatcher, while in the flight plan office of the airport building, took a telephone call from the fire fighting unit located in the vicinity of the coast of Camet advising that an aircraft had just been seen crashing into the sea.

Search for Wreckage

Shortly after the accident a thorough search was made over one and one-half months in co-operation with the Navy, the Naval Under-Prefecture and the airline to locate the probable site of the crash, bodies of victims and to salvage wreckage. All victims were found except the pilot and one female passenger.

It was not possible to locate the fuselage and engines. Most of the seats of the passenger cabin, the main left gear assembly and a few other components were found.

Examination of the Wreckage

Examination of the fractures resulting from the impact with the water revealed that the aircraft was descending in a steep dive, and the extent of the destruction proved that the left wing touched the water first, followed by the fuselage and then the right wing. The portion of the right wing that was recovered, which consisted of the attachment of the middle section, showed that through pressure on impact the covering gave way over a large area as far as the top part of the wing next to the leading edge. Most of the left wing was destroyed on impact and owing to water pressure on the plating from the inside.

The fractures in the passenger seat frames and safety belts suggested a forward effect of inertia combined with a slight turn to the left. This was confirmed by the aircraft's attitude at the time of the crash as described by witnesses, i.e. steep dive and left spin.

Inspection of the limited number of pieces of fuselage and compartment covering recovered revealed no signs of impact, perforation or tear other than those caused by the impact of the aircraft on the water and its consequent destruction.

The assumption of fire in flight inside the cockpit or passenger cabin could not be substantiated in the absence of burns on the salvaged parts of the wreckage. The supposition even that the alleged burns on passengers had really been caused by fire in the short period of time during which the aircraft remained in flight, the flames, if any, would have been the consequence of an explosion and would have come from inflammable gases or fumes in the air surrounding the aircraft caused either by gasoline or by other spilt liquids. Nor could it be proved that a hydrogen explosion had occurred, as a result of overcharged batteries, since nothing unusual had been observed in flight or on the ground at Mar del Plata Airport.

Medical Examination of Victims

The results of the medical examination revealed that although death had occurred as a result of various fractures, the bodies also showed burns on the arms, thorax and abdomen, but it was interesting to note that the clothes of the victims did not bear traces of burns. Moreover, no discolouration or deterioration was observed that might have been caused by fire or a caustic substance.

Following study it was stated that the above burns might have been produced by some volatile substance or a vesicant type of gas. The report concluded that "while instantaneous death was caused by the violence of the impact, the skin injuries would appear to indicate that they occurred while the victims were still alive and, therefore, should have started before the final crash."

As a result of this report it was decided to carry out a microscopic and spectographic examination of the fibres in the office of the National Police Force in order to determine whether traces of vesicant elements were present on, or had penetrated, the clothes worn by the victims.

The conclusions were as follows:

1. The evidence showed no trace of burns or of extraneous substances or elements, bearing in mind the conditions to which it was subjected.

2. Spectrographic analysis of the evidence failed to reveal any specific indication of remains of any vesicant liquid or gas; the presence of elements found was to be expected normally.

Following the first medical report and in view of the results of the spectrographic analysis, the Board travelled to Mar del Plata to conduct a further examination in order to determine whether in actual fact the bodies of the victims bore traces of burns.

It was concluded that -

1. "The clothes analysed in the Chemistry Department of the National Gendarmerie bore no traces of fire or caustic chemicals.

2. Critical analysis of the results of the histological examinations revealed the following:

   a) The mobilization of cellular elements observed may correspond to intra-mortem (agony and initial stage of death) vital cellular phenomena.

   b) Absence of vasodilatation and liquid exudations in the epidermis and the derm of the supposedly burnt skin, the presence of which would unquestionably prove action by caustics on the skin while the victim was alive.

3. The injuries which at first were taken for burns, as indicated in the report following examination, could equally well have been caused by mechanical action and maceration by sea water, together with other elements, such as gasoline, hydraulic liquids, etc. By mechanical action is meant the traumatism brought about by the aircraft's crash onto the surface of the sea and the friction of clothes, abrasives thrown up from the bottom of the sea, etc., in addition to the influence of the movement of the sea. It must be recorded that the clothes of the bodies recovered from the sea were impregnated with gasoline."

Reconstruction of the Accident

Investigators then focussed their attention on the reconstruction of the accident and it was possible to determine that the actual flight, from the time of take-off until the moment the aircraft was lost from sight by witnesses at the airport, did not coincide with the statements of the control tower operator either in respect of the path or of the time elapsed before the aircraft disappeared. It was also definitely proved that at no time did the aircraft head directly towards Bahía Blanca following the initial turn to the right as stated by the control tower operator.

Four witnesses at the airport followed the aircraft's path from the time power was applied on the runway for take-off up to the moment it was lost sight of in climb. Their statements did not coincide with those of the control tower operator. Four other witnesses near the shore had seen the aircraft approach the sea on a path almost identical with the runway centreline, i.e., heading directly from the airport towards the sea. They saw the aircraft make a wide left turn over the water as though to return to the airport, and it had then lost speed and height and crashed into the sea.

On the basis of the foregoing the flight was reconstructed under similar weather conditions and at the hour of the accident in the presence of all witnesses. Each witness was provided with a portable radio set and was accompanied at his respective observation post by technical aviation personnel. Thus, liaison was established between the aircraft in simulated flight, the control tower and the witnesses, and it was possible to achieve an accurate reconstruction of the flight of the aircraft, LV-AFW.

The time during which the aircraft remained aloft was conclusively proved to be one minute and fifty-seven seconds, rather than six minutes as stated by the control tower operator. This statement had at first misled the investigators. The operator had testified to six minutes so as to preclude admission that immediately following take-off and closing VHF communications he left his post and went to the airport cafeteria where he was seen by witnesses who testified in the investigation.

Probable Cause

For undetermined reasons the aircraft crashed into the sea during a turn following a take-off at night.

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ICAO Ref: AR/619

No. 35

Pan American World Airways, DC-6B, N 5026K, accident at Shannon Airport, Ireland, on the night of 21-22 June 1959. Findings of the investigating officer's report as released by the Department of Transport and Power, Ireland.

Circumstances

The aircraft carried 6 crew, 2 passengers and a mixed cargo. Just after it had started its take-off run a propeller blade failure occurred, which was followed by an engine tearaway and a fire which destroyed the aircraft. There were no injuries to those aboard.

Investigation and Evidence

There was evidence to show that a failure had occurred in No. 1 blade of No. 4 propeller. This resulted in the loss of 50 inches of the length of this blade and an unbalanced condition, which caused the No. 4 engine to be pulled from its mountings. Fire then broke out and combustion was sustained by the petrol flowing from ruptured fuel lines and fuel compartments. The aircraft's fire control system was operated correctly but was ineffective as it is designed to operate within the area enclosed by the cowlings. The cowlings and part of the fire spray rings had fallen away with No. 4 engine. The Fire and Rescue Services went into action approximately 3 minutes after the fire broke out.

Probable Cause

The accident was caused by fatigue failure of No. 1 blade of No. 4 propeller.

Laboratory findings showed that the failure was caused by previous blade bending resulting in the disruption of the compressive stresses in the shot peened area of the propeller blade.

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ICAO Ref: AR/604

No. 36

Trans World Airlines, Lockheed Super Constellation 1649-A, N 7313C, accident in the vicinity of Olgiate Olona, Varese Province, Italy on 26 June 1959. This summary is based on the English translation of the final report of the Board of Inquiry, appointed on instructions from the Ministry of Defence, Republic of Italy, as released in November 1960 as a Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 1-0045.

Circumstances

TWA's scheduled flight No. 891/26 took off from Malpensa Airport, Milan, at 1620 hours GMT for Orly Airport, Paris, with 8 regular crew, one extra member and 59 passengers on board. After 15 minutes of flight and while still climbing on the prescribed route (Malpensa - NDB Saronno - NDB Biella) disintegration of the aircraft occurred and it crashed to the ground, from an altitude of about 11 000 ft, near Olgiate Olona. All persons aboard were killed, and the aircraft was destroyed.

Investigation and Evidence

The Aircraft

As of 26 June it had flown a total of 6 671 hours; 895 hours since its last overhaul and approximately 72 hours since its last Upkeep and Line Inspection. It was considered to be airworthy on the day of the accident.

At the time of take-off from Malpensa, the aircraft's weight (120 175 lb) was well below the maximum authorized (160 000 lb) and the barycentre, at 21% of the mean aerodynamic chord, was within the limits allowed for the weight indicated.

The following are some of the aircraft's operational limits as taken from its Flight Manual:

Maximum permissible weight without fuel - 117 000 lb
- at take-off from Malpensa the aircraft's weight without fuel was 107 175 lb

Design diving speed (V_D) 336 kt (EAS)

Maximum permissible speed (V_{NE}) (up to 13 300 ft) 294 kt (EAS)

Normal operating limit speed (V_{NO}) (up to 18 800 ft) 261 kt (EAS)

Design manoeuvring speed (V_A) 195 kt (EAS)

Design (flap 80% extended) speed (take-off) (V_{FE}) 185 kt (EAS)

Design (flap 100% extended) speed (landing) (V_{FE}) 160 kt (EAS)

Optimum climbing airspeed (V) 156 kt (EAS)

Limit of acceleration: flap up, 2.5 g; flap down 2 g.

Maximum differential pressure in fuselage: 10.92" Hg. Also (from Lockheed's data on structural calculations):

Design speed for maximum gust intensity of 66 ft/sec (V_B) 175 kt (EAS)

The Crew

The captain held a CAA Airline Transport Rating Certificate for DC-3, DC-4 and Lockheed Constellation 049, 749-A, 1049 and 1649-A aircraft. He had his last CAA physical examination in April 1959, his last line check in September 1958 and his last instrument check in April 1959. He had flown a total of 25 514 hours, 682 of which were on 1649-A aircraft.

The co-pilot had been a TWA captain since June 1956 and held a CAA Airline Transport Rating Certificate for Martin and Lockheed Constellation aircraft. His last CAA physical examination was in May 1959, his last line check in June 1958 and his last instrument check in February 1959. He had a total of 12 150 flying hours to his credit, 76 of which were on Lockheed 1649-A's.

The first officer held a CAA Commercial and Instrument Rating Certificate and had flown a total of 3 500 hours, 382 of which had been on Lockheed 1649-A aircraft.

The two flight engineers held Airframe and Engines Mechanic Licences, and each had flown over 9 000 hours including more than 600 hours in Lockheed 1649-A aircraft. Their last line checks were carried out early in 1959.

All these crew members had had a rest period of 12 hours preceding the flight of 26 June.

Weather - General

At 1200 on 26 June, Western Europe was under the influence of a weak westerly influx of Atlantic air slightly cooler than the existing air, advancing from the West behind a relatively weak cold front which, upon reaching the Alps in the morning, settled against them, being held in check by the mountain chain and forming a wave motion along the Franco-Swiss side of the chain. Not until early afternoon did the front succeed in overcoming the obstacle and spreading over the Po Valley. Surface winds were very weak during the entire day over most of Europe. At an altitude of 10 000 ft (700 mb) there was noted a weak gradient wind of about 15 kt pushing the front forward.

It was very difficult to establish the exact surface position of the front in the Po Valley, but its existence was ascertained by an analysis of the general charts at various altitudes. The front was accompanied by vast and imposing formations of cumulus clouds, heavy showers and storm activity.

In view of the small rise in the surface temperature during the day because of dense clouds, the scattered storms hitting the Po Valley on the afternoon of 26 June seem to have been due to phenomena of forced updraft, caused by the infiltration of cold air from the Alps, and by the passage of the front rather than to thermoconvective phenomena.

The calculation of the available energy for the phenomena of forced updraft, as the maximum estimate of the rising vertical currents in the storm cell at the presumed height of the crash, i.e. between 10 000 and 11 000 ft, comes out to about 12 m/s, (approximately 39 ft/sec), a figure which may go up to 19 m/s, (approximately 62 ft/sec), if the thermic instability is also considered as being active.

Because of the aforesaid possible speeds of the rising currents, in contrast with the downward currents which, although weaker, were always present about the storm cell, the existence of turbulence with strong accelerations can be admitted.

Weather - At Time of Take-off from Malpensa

The weather bulletins showed that at 1620 hours, take-off time of the flight from Malpensa, the weather over the airport was not good but neither was it prohibitive,

even though the rumble of thunder, already audible at 1600 hours, announced the approach of a storm. Storm activity of moderate intensity reached the airport at 1650 hours.

Weather - At the Site of the Accident

The aircraft crashed approximately 12.5 km from Malpensa Airport. The weather conditions may be presumed to have been similar to those reported by the weather stations at Malpensa and Linate. In fact, dense cloud formations covered the Milan area at altitudes of from 2 000 - 4 000 to 14 000 - 20 000 ft. At higher altitudes, towering cumulonimbus formations, in large cells, existed at up to 35 000 ft.

Below 2 000 - 4 000 ft the cloud ceiling may for short periods have dropped to 600 - 1 000 ft during the showers. More or less steady rain and shower activities existed over the Alps and in the Po Valley until the system moved on toward the Adriatic Sea, permitting the entry of northerly winds, after which the skies became clear.

Reasonably reliable witnesses stated that at the time of the crash, i.e. 1635 hours, it was raining slightly in the vicinity of Olgiate Olona and the ceiling was estimated at 600 - 700 m. Visibility was approximately 3 - 4 km. There had been a very heavy shower 5 to 10 minutes before the accident, and it rained very hard again, briefly, some time later. Some witnesses heard thunder and saw flashes of lightning just before and after the accident.

As there was no weather station in the vicinity of Saronno, no further data could be ascertained.

Conditions likely to cause disturbances, electric discharges and ice formations

Because of the frequency of strong upward and downward vertical air currents that accompany them, formations of storm clouds are always accompanied by disturbances, even of great violence, and the existence of strong electric charges with wide differences in potential and consequent discharges. Inside these formations, icing will occur at heights above the level of the thermic zero, which according to the soundings made by the Linate station at 1200 hours was in the neighbourhood of 11 500 ft. However, this altitude may vary inside the storm cloud; hence it is permissible to assume that in this case ice might have formed immediately above 10 000 ft.

Navigational Aids

There was no evidence that assistance was requested by the aircraft from the radio aids of the Terminal Area of Milan. From the authorizations issued by the Milan Area Control Centre and the communications exchanged between the aircraft and that control office, it appeared that the aircraft plotted its course by utilizing first the Saronno and then the Biella radio beams which were operating continuously during the flight.

Reconstruction of the Flight

Flight 891/26 began at Athens, Greece at 1015 hours on Lockheed 1649-A aircraft, N 8083H, which stopped at Rome at 1215 hours, where the flight was then resumed on N 7313C. The aircraft departed Rome at 1400 hours, arriving at Milan (Malpensa Airport) at 1536 hours after a normal flight. At Malpensa the captain went to the meteorological and operations offices for clearance regarding the flight to Paris.

The history of the flight from Malpensa Airport up to the time of the crash was reconstructed on the basis of the flight plan, the exchange of messages between the plane and the Malpensa tower, between the plane and Milan Control, and on the basis of the distribution of the wreckage on the ground, and testimony.

At 1617 hours the aircraft was cleared by Milan Control as follows:

> "Malpensa-Paris, via NDB Saronno and Biella. Over Saronno at 4 000 ft. Climb to 10 000 ft or more above Saronno following the waiting circuit. Approach Biella at 18 500 ft and maintain that altitude."

The aircraft then took off at 1620 hours and was asked to report on reaching 4 000 ft and Saronno. At 1623 it reported as being at 2 300 ft. One minute later contact was established between the aircraft and Milan Control (Linate), but the communication was interrupted because of power failure on the recorder. (The storm caused an interruption of the electric current.) By relating that communication with the authorization received and the previous conversations with the Malpensa Control Tower, it was assumed that the captain was reporting that he had reached the altitude of 4 000 ft and was proceeding toward Saronno. At 1626 the aircraft advised that it was on the Saronno circuit at 6 000 ft, then reported at 1632 that it was leaving Saronno NDB at 10 000 ft and proceeding toward Biella NDB. At 1633 the aircraft sent out its last radio signal to Milan Regional Control. The emergency conditions, which arose after this last contact, the disintegration of the aircraft and its crashing to the ground took place within about two minutes. It appears evident that the accident was of a sudden and violent nature and was due to unexpected conditions of abnormality.

Medical Aspects

In so far as the crew was concerned, the autopsies showed no evidence whatsoever of any intrinsic or extrinsic elements in the bodies, such as the presence of pre-existing organic changes, or the presence of carbon monoxide, or a sudden illness of the pilots followed by immediate death, or of the alcoholic factor (intoxication) with resulting erroneous handling of the aircraft etc., which might lead to the belief that there were other causes of death besides complex traumatism.

The Wreckage

The crash area was about 30 km to the northwest of Milan and included the towns of Olgiate Olona, Prospiano, Gorla Minore, Nizzolina, Marnate and Castellanza, all of which are to the northeast of Busto Arsizio in the Province of Varese.

Proceeding into the said area, in an east-west direction corresponding more or less to the aircraft's route, the scattering of the wreckage on the ground extended for about 3 km along a wide and irregular trail which began about 1 km to the northeast of Nizzolina and ended at the town of Olgiate Olona.

Along this path, the following principal parts and pieces of wreckage were found in the order listed below. All parts were brought to a central depot at Gallarate where a detailed examination of every piece was carried out.

1. The upper plate of a fuel tank cap (P.N. 750438-13). It was later ascertained that it belonged to tank No. 6 or No. 7.

2. The upper and lower panels, wing ribs, bulkheads, an inlet pipe (P.N. 478301) and other structural parts belonging to tank No. 6 and the right side of tank No. 7.

   The (right) wing structure from the outer bulkhead of tank No. 6 to the plane's centreline, including tank No. 6 and the right half of tank No. 7, disintegrated in flight into many pieces, which were found scattered over the wreckage trail, but at a distance up-course from the main wreckage and the rest of the right wing as described below in sub-para. 4.

In the area of tank No. 6, between the outer bulkhead and the bulkhead partition between tank No. 6 and tank No. 7, the upper wing structure and the front spar (constituting, with the rear spar and the two bulkhead partitions, tank No. 6) showed clear signs of having been bent outward, manifestly the result of strong pressures.

In particular, the wing panels on both the upper and lower sides, constituting the top and the bottom of tank No. 6, showed a curvature of about 25 cm.

As already stated, the structural pieces of the right side of tank No. 7 were found, together with those of tank No. 6, scattered over the wreckage trail, up-course from the main wreckage and right wing. The partitioning bulkhead between tanks 6 and 7 was found, in pieces of considerable size, at the beginning of the wreckage trail. The structural parts of the left side of tank No. 7 were, however, found in several pieces, damaged by the impact and by fire, under the fuselage at Olgiate Olona.

The intake pipe of tank No. 7 was split open by the obvious effect of great internal pressure. Examination of the ends of the pipe and of the corresponding connexion points on the partition bulkhead between tanks 6 and 7 and on the wing panel constituting the top of tank No. 6, disclosed that the pipe had been subject to outward stress and that, before that stress was exerted, both the partition bulkhead and the wing panel were at their proper places and in a normal position.

All these parts belonging to the area of tank No. 6 and the right side of tank No. 7 were found to be perfectly clean and free from traces or indications of fire. A careful examination did not disclose any trace of electrical discharges.

3. Engines No. 3 and 4 became detached from the right wing in flight, fell some 1 100 m to the southeast of the main wreckage and were considerably damaged. No failures, damage or fire occurred in these engines while the aircraft was still in the air. Subsequent checking (in the U.S.A.) of the calibrations shown by the governors of engines No. 3 and 4 revealed that they were set for the following speeds - 1 949 rev and 2 502 rev respectively, the latter indicative of a climbing speed.

4. The right wing, complete with its cowlings and landing gear assembly, was broken off at a point along the assembly housing. It fell 650 m to the southeast of where the main wreckage fell. Examination of all the areas of breakage showed no evidence of breakages due to stress or metal fatigue. The fire damage incurred took place after the wing had become separated for the aircraft.

5. The main wreckage included the fuselage, the left wing, the left landing gear assembly, the nose landing gear and engine No. 2. It struck the ground almost vertically, and was found with the nose pointing to the southeast in such a position that the axis of the fuselage formed with the north an angle of about 140°. It was badly damaged, twisted and broken

in many places. Engine No. 2 showed no signs of failures or damage in flight. As a result of severe fire damage it was not possible to ascertain whether it had caught fire in the air. As governor No. 2 had been destroyed by fire on the ground, it was not possible to determine its speed setting.

The inspection failed to disclose any concrete and significant evidence which might support the existence or the development during the plane's normal flight of abnormal conditions which would have been either the direct or the indirect cause of the accident.

6. The entire tail assembly became separated from the plane in flight at a point beyond the pressurization bulkhead and fell close by a fencing wall about 450 m south of the main wreckage, and was considerably damaged. Five pieces of the two elevators, the lower part of the left rudder and part of the terminal stern cone and fairing were found distant from the tail assembly, indicating that these parts broke off while the aircraft was still in the air.

   Examination of the breakage area of the tail assembly failed to disclose any trace of metal fatigue and showed that the assembly became separated from the end of the fuselage as a result of static overloads, directed to the left and downwards. Evidence showed that the assembly was structurally in its proper position when, during flight, a fire broke out on the front part of the aircraft and enveloped the tail assembly from its right side.

7. Engine No. 1, which became detached from the left wing in flight, fell about 250 m to the southwest of the main wreckage and was badly damaged. It had not had any failure, damage or fire while the aircraft was in the air. Later examination (in the U.S.A.) showed its governor was set for 2 611 rev, indicating a climbing speed.

Installations and Equipment of the Aircraft

Various factors made the examination of these parts quite difficult. Some conclusions were not so much the result of concrete and specific physical evidence as they were of careful and logical interpretation and of indirect but relevant indications. Some parts were subjected to bench tests and partially or totally disassembled.

The results of the various examinations follow. The term "abnormality" used means any failure or breakdown which, having occurred before or at the time of the accident, might have been the direct or indirect cause of it.

Air conditioning system

No abnormalities were found in pressurization, heating, refrigeration or air circulation.

Automatic pilot system

No abnormality. It was not possible to determine whether the automatic pilot was on at the time of the accident; however, it was not believed to be the case.

The Air Data Sensor's calibration showed the following data:

Altitude: between 2 685 and 7 000 ft

Speed: between 145 and 195 mph.

Communications and navigation

No abnormality. The weather radar was operating.

Fire fighting equipment

No abnormality. It had not been used.

Flight controls

It was concluded that the various controls were in normal operating condition at the time of the accident. The flap controls were in the "retracted" position.

Fuel system

In view of evidence that tanks No. 6 and 7 had disintegrated in flight, this system was examined with extreme care.

With the exception of tank No. 6 and the right side of tank No. 7, all tanks showed signs of damage from fire. All tank caps were recovered. It was established that one of them, of which only the upper plate remained, belonged either to tank No. 6 or No. 7.

The level-indicating rods for tanks No. 1 and 6 were not found. It was believed that they had been removed from the crash site by unauthorized visitors.

All the metallic mesh filters, with which the fuel intake ports on the top surface of the wings were equipped, were found, with the exception of the one belonging to tank No. 5.

The fuel dumping controls were found in the closed position.

The right side vent outlet of the fuel tanks was in place on the right wing; the left side one was found in the main wreckage, crushed and detached from the left wing. These outlets were later subjected to a series of tests intended to ascertain any possible traces of lightning.

The seven submerged pumps of the seven tanks were recovered, identified, and checked by testing and disassembling. They were all in proper working order.

No other parts of the system showed any signs of abnormal conditions.

Hydraulic system

Nothing abnormal was found with the exception of minute bronze residues in the flange and the angle joint of the return pipe of hydraulic pump No. 1. It was disclosed that the residues came from pistons No. 3 and 8; however, the pump was found to be in working condition.

It was deduced from examination of individual parts and kinematic motion tests thereon that the two sides of the landing gear and the nose wheel assembly were in the retracted position when the aircraft disintegrated. The fact that the left portion of the landing gear was found in an extended position, and the right portion in a partly extended position, was ascribed to the inertia forces generated by the breaking off of the right wing and by the impact of the right wing, the fuselage and the left wing with the ground.

About 80% of the accessories of the front compartment of the hydraulic system were recovered. From examination of these parts it could not be established whether fire broke out in this compartment while the aircraft was in flight, however, if there actually was such a fire, it could only have been a small one.

Lubricating oil, oxygen and electrical systems

No abnormalities were found.

Instruments and controls

The Commission could not arrive at any reliable factual deductions from examination of the various flight instruments and installations recovered.

Practically all the instruments were broken, twisted and damaged as a result of the disintegration of the aircraft in flight, the impact of the wreckage with the ground and the fire. The same was true of the engine controls.

It was possible, however, to deduce that the aircraft at the time of the accident was proceeding toward Biella within the prescribed limits of speed, altitude and route and that it did not make use of any emergency measures.

Damage from lightning

No traces or signs of structural damage of any significance due to lightning were found. In particular, the structures of tanks No. 6 and 7 showed no signs of damage of this kind.

No signs of lightning strikes were found on the static dischargers or the areas near them. Likewise, no evidence of lightning strikes was found on the collectors of the fuel tank vent outlets.

Maintenance records of the aircraft and engines

The records were examined to determine whether pre-existing conditions of abnormality might have had a direct or indirect relation to the causes of the accident. It was ascertained that previously the aircraft had made five landings in an overloaded condition and one landing which had been classified as a "hard" landing; however, inspections made after such landings had disclosed nothing abnormal. It was also disclosed that the automatic control of the pressurization system had, in the past, given continuous trouble and was still doing so at the time of the last flight; however, the system's manual control was in good working order. The records also showed a series of minor difficulties, which were taken into account in the examination of the wreckage. Included in these were some leaks in the fuel tanks, which had been promptly repaired as soon as discovered.

Supplementary Inquiries

Along with the afore-mentioned inquiries, a series of other tests was carried out on various accessories, material and parts in the plants of the Alfa Romeo, Secondo Mona and other industrial firms.

The results briefly were as follows:

1. Inspection of the seat of cap P.N. 700438-13 on the wing top of tank No. 6, to ascertain whether a burn mark found had been due to lightning -

   - the mark had been caused by welding during repair work.

2. Tests on samples of metal taken from the wing frame and inspection of the "fracture areas" to ascertain the characteristics of the metal and the type of fractures -

   - the metal conformed to the specifications, and the fractures showed the characteristics of impact fractures.

3. Microscopic examination of the fuel tank vent outlets to ascertain whether traces of blackening and heating found on one of the vents could be ascribed to electric discharges -

   - the traces were due to heat of the fire, and the two vents bore no evidence of lightning strikes.

4. Examination of and bench tests on the submerged pumps of tanks No. 4, 5 and 7 and parts of same to ascertain whether the pumps were in good working order -

   - they were.

5. Examination of a roll of paper found along the wreckage trail

   - the paper was a special wrapping paper having no properties capable of starting or feeding any process of spontaneous combustion.

6. Examination of the technical data supplied by Lockheed Aircraft Corporation pertaining to the plans of the Super Constellation, 1649-A

   - the results of this examination are presented in study No. 1 of the section which follows dealing with principal inquiries in the United States of America.

Principal Inquiries in the United States of America

Other studies were made in the United States of America at industrial plants, maintenance shops, special institutions and laboratories under the direct supervision of the Civil Aeronautics Board.

1. Analysis of the breakage points of the individual pieces of wreckage to ascertain, on the basis of the construction calculations, the results of the breakage tests made on the prototype, and the breaks that occurred in N 7313C, whether disintegration of that aircraft in flight was due to aerodynamic stresses of any kind or to other causes -

   - disintegration of the aircraft was due to explosive forces originating in tank No. 7.

2. Study of the trajectory of fall of some significant parts of the aircraft which became separated in flight from the aircraft after its disintegration to ascertain the height at which the plane disintegrated, by comparing the actual distribution on the ground of som of the significant parts which became detached in flight with the position obtained by calculation:

   - within the framework of the assumptions on which the study was based, the results showed, with the same degr of probability, the following three combinations of altitud and speed (with wind):

560 kt IAS at an altitude of 5 000 ft
290 kt IAS at an altitude of 10 000 ft
125 kt IAS at an altitude of 15 000 ft

Because of the uncertainty existing in the evaluation of certain parameters entering into the calculations, the results of the study must be taken as indicative and not conclusive.

3. Pressure tests on fuel tank caps P.N. 0750438-13 to ascertain whether pressure, and if so how much, could cause the fuel tank cap to separate into its component parts so that one of those parts, namely the upper plate, could appear in the same condition as the one that was found, i.e. clean and undamaged.

   The tests, made on new caps, revealed that the caps in question

   a) can be ejected from the seat onto which they are screwed, following fracture of their lower portion, by pressures ranging between 110 and 136 ps or thereabouts, namely, a pres sure much higher than that which will, in fact, cause the tank structure to collapse and the fuel intake pipe to crack;

   b) cannot be damaged, by stresses deriving from pressures of

various strength, in such a way as to cause a breaking down of the various component parts resulting in the separation of the upper plate only and no other damage.

On the basis of these tests, it was definitely agreed that the cap to which the plate belonged could not have been ejected from its seat, in the upper surface of the wing, as a result of explosive forces.

4. Tests on the vent outlets for the escape of gasoline vapours from the fuel tanks of the Super Constellation, 1649-A to ascertain whether the gasoline vapours, assumed to be flammable, emerging from the vents, can be ignited electrically, and if so, whether the resulting fire, through the outlets, will spread to the interior of the tanks -

   - under the conditions in which the tests were made, it was established that the gasoline vapours will ignite under certain conditions, but the flames will not spread to the tanks.

5. Inspection of the inner surfaces of some pieces of pipe of the vent outlets for the escape of gasoline vapours, belonging to N 7313C to ascertain whether the condition of the surfaces gave physical evidence of the spreading of flames through these pipes -

   - the result was negative.

6. Study of the possibility of sabotage to ascertain whether it is possible to introduce, through the fuelling ports and into the fuel tanks, suitable compounds, properly prepared, which will later ignite the gasoline vapours existing in the tanks and cause them to explode, without leaving any physical evidence -

   - it was concluded that such a possibility existed as some such cases have been known to occur.

7. Inspections and bench tests, made on the premises of specialized firms, on various parts, accessories and equipment belonging to N 7313C -

   - no evidence of abnormal conditions was found.

8. Static tests on fuel tank caps P.N. 750438-13

   - revealed that the breakage of the individual component parts of the caps occurs under loads corresponding to pressures ranging between 126 and 141 psi, namely, pressures far greater than those required to cause the tank structure to give way and the fuel intake pipe of tank No. 7 to burst.

9. Statistical inquiry into the trouble encountered in the practical use of submerged pumps in the fuel tanks to examine the typical defects encountered in pumps of this type and to ascertain whether such defects, if found present in the submerged pumps of N 7313C, might have directly or indirectly caused the gasoline vapours in the tanks to ignite and explode -

   - it was established that the pumps of N 7313C had no such defects.

10. Tests on the highest temperature that the body casing of a submerged pump can attain when the pump is, by mistake, kept operating for a long time in a practically empty tank to ascertain whether, under the conditions in question, the result would be an explosion of the gasoline vapours contained in the tanks -

    - the tests showed that the highest temperature reached under the conditions cited would be about 120° C.

11. Statistical inquiry into the replacing of P.N. 750438-13 caps and P.N. 481742-1 dipsticks on TWA planes at some past time to ascertain from existing records, whether any cases of loss of these accessories in flight had ever occurred in the past -

    - no evidence was found of any cases of this kind.

12. Statistical inquiry into the damage suffered by 193 planes which were struck by lightning in 1958-1959 to obtain factual elements for an evaluation, on the basis of and in accordance with past experience, of the importance to be given to damage caused by lightning to the structure of N 7313C -

    - such damage was no greater than that usually suffered by other planes struck by lightning. Also, it showed that there were no cases on record of vent outlets being struck by lightning.

13. Inspection of all the technical records on former use of N 7313C from the date it was built to the date of the accident to ascertain whether the trouble, the malfunctioning, the stresses from abnormal landings etc., which had occurred during the practical use of the aircraft might have been directly or indirectly related to the causes of the accident -

    - the results of the inquiry were considered during the technical examination of the wreckage.

14. Inquiries as to the origin of a roll of paper found along the wreckage path -

    - it was not possible to ascertain the origin of the paper nor as to whether it was aboard N 7313C.

15. Chemical analyses of the roll of paper -

    - they disclosed only that the roll was a special type of wrapping paper having no particular characteristics of flammability, and that it contained no substance that would aid combustion.

16. Inspection of the vent outlets of N 7313C to ascertain whether the vents showed traces of lightning strikes or of static electric discharges (steamer corona) such as might cause gasoline vapours to ignite -

    - the vents showed no evidence of electric discharges; however, it was decided that this did not exclude the possibility that static discharges

had occurred in the vents that could have ignited the gasoline vapours issuing from them.

17. Microspectrographic examination of the metallic mesh filter of tank No. 7 to ascertain whether the filter might have been, in some way, the starting point of the explosion in that tank and whether it showed anything abnormal -

- the result was negative.

18. Tests on the ignition of gasoline vapours issuing from the vent outlets of Super Constellation, 1649-A, by means of static electrical discharges (streamer corona) -

- they revealed that:

a) On an L-1649-A plane static discharges should occur at the vent outlets if the aircraft is struck anywhere by lightning, or, if it is not struck, when it flies through clouds that are charged with electricity;

b) Static discharges of an intensity comparable to those likely to occur in flight, generated in calm air in a receptacle containing flammable fuel vapours, will ignite these vapours;

c) While the above-mentioned tests, in the present state of knowledge, do not show that static discharges, generated at the vent outlets of an aircraft in flight, will necessarily cause the flammable fuel vapours issuing from these outlets to ignite, they indicate that this hazard cannot be excluded;

d) The tests and observations mentioned in the two preceding paragraphs definitely indicate that adequate precautionary measures should be developed and adopted, particularly the application of anti-flame screens to the vent outlets and the design and construction of these outlets so as to reduce the possibility of the formation of electrical static discharges;

e) Static discharges can, and generally should, develop without leaving on typical aircraft metals, and therefore on the vent outlets, any normally visible evidence.

Discussion

Explosion in fuel tanks No. 6 and 7

Central tank No. 7 is subdivided into two symmetrical parts by a central bulkhead having an ample opening through which the two sections communicate with each other. In the hermetically sealed right bulkhead of tank No. 7, which separates this tank from tank No. 6, there are three holes. The fuel intake pipe (P.N. 478301), which runs through tank No. 6, connects hermetically the said three holes with the fuel intake port recessed below the top surface of the wing at a point where that top surface constitutes the ceiling of tank No. 6. Said fuel intake port is hermetically closed by cap P.N. 750438-13.

The following main accessories are installed in the left section of tank No. 7: submerged booster pumps and respective wiring, electric level-indicator (probe unit), vent valve, and 3-way selector cross-feed valve.

The following main accessories are installed in the right section of tank No. 7: electric level-indicator, vent valve, and 3-way selector cross-feed valve.

Therefore, unlike the other six tanks, which have only one vent valve each, tank No. 7 has two vent valves for the escape of gasoline vapours.

The two vents are symmetrical. They begin at the right and left bulkheads of tank No. 7 and end at two vent outlets situated one on the trailing edge of the right wing and the other on the trailing edge of the left wing, behind engines No. 1 and 4, respectively. To these vent outlets are connected also the vent pipes of tanks No. 3, 4 and 6 (outlet to the right) and of tanks No. 1, 2 and 5 (outlet to the left). The outlets are not equipped with anti-flame wire gauze.

From the description of the damage of the right wing area and taking into account the structural features of tanks No. 6 and 7 described above, it is deduced that:

a) an explosion took place in the right section of tank No. 7;

b) the explosion caused the fuel intake pipe of tank No. 7, which runs through tank No. 6, to split;

c) the splitting of this fuel intake pipe immediately caused an overpressure, or another explosion, in tank No. 6.

Nature of the explosion

The plane took off from Malpensa Airport with the following fuel supply:

Tanks 1, 2, 3 and 4 (capacity of each tank 1 343 - 1 386 gallons)	625 gallons each
Central tank No. 7 (total capacity 1 644 gallons)	22 gallons, excluding the non-usable residual quantity (11 gallons)
Tanks No. 5 and 6 (capacity 1 370 gallons each)	0 gallons each, excluding the non-usable residual quantity (5 gallons)

At the time of the accident the fuel supply conditions had changed as follows:

Tanks No. 1, 2, 3 and 4	550 gallons each

Conditions in central tank No. 7 and tanks No. 5 and 6 had remained the same.

An inspection of the plane's refuelling records showed that:

1) the non-usable residual quantity of gasoline in tanks 5 and 6 had been in the tanks for about 10 hour

2) the residual quantity of gasoline (22 usable and 11 non-usable gallons) in tank No. 7 had been in the tank for about 30 hours;

3) under these conditions, tanks No. 5 6 and 7, at the time of the accident contained gasoline vapours issuing from the residual fuel;

4) the igniting of those vapours in tank No. 7, whatever its cause, resulte in the explosion of tank No. 7, and that in turn immediately either produced an excess of pressure or another explosion in tank No. 6.

Position and altitude at which the disintegration occurred

On the basis of various considerations and taking into account also testimony believed to be reliable, it was estimated that the aircraft disintegrated in the air space above the area bounded by Ravello, Rescaldina and Nizzolina.

With regard to the altitude at which the disintegration took place, it was not possible to arrive at any conclusive and definite findings.

The study of the descent paths of some of the main wreckage parts disclosed that their actual distribution on the ground was in agreement with that obtained from the calculations for three different combinations of speed and altitude (see Inquiries in the U.S.A., No. 2).

Considering that -

a) at 1633, the time of the last radio signal, the aircraft should have been at an altitude slightly below 11 000 ft;

b) the accident occurred suddenly and was over in 2 minutes;

c) the operational procedures, subsequent to the last radio signal, gave as most probable for the aircraft a speed of 170 kt IAS along its flight path and a climbing speed of 800 - 1 000 ft/m;

the afore-mentioned study of the descent paths showed that its results were not completely in conflict with a possible disintegration of the aircraft at a height of 11 000 - 12 000 ft and a speed of about 170 kt IAS. However, other combinations of speed and height are just as possible.

Hypotheses regarding the causes of the explosion

I Structural failure due to aerodynamic stresses of any kind (turbulence, excessive manoeuvre loads, etc.) ensuing explosion of the fuel tanks and, finally, disintegration of the aircraft;

Explosion of the fuel tanks, caused directly or indirectly by:

II Faulty operation and fire in the engines;

III Fires of a different nature;

IV Breakdowns and malfunctioning of the flight instruments and controls in general;

V Foreign bodies of any kind striking the aircraft;

VI Sabotage;

VII Electric discharges from the atmosphere, and consequent disintegration of the aircraft.

I Structural failures due to stresses, ensuing explosion in the fuel tanks and final disintegration of the aircraft

On the strength of technical data supplied by Lockheed, a study was made of the various conditions which might substantiate structural failure as the primary cause of the accident. The inquiry was limited to the wing, because it was believed that its breaking away preceded all other breakages.

The considerations and deductions set forth hereunder are based on the assumption that at the beginning of its last flight, the aircraft was in a normal condition as regards maintenance and structural soundness.

Metal fatigue

The possibility of a collapse of the wing structure as a result of metal fatigue appeared unlikely for the following reasons:

1. no evidence of breakage from this cause was found;

2. the resistance of the main structures to fatigue was positively evidenced by the results of tests made by Lockheed and by the results of the practical use of the L-1649-A aircraft;

3. the wing structure met the U.S.A.'s Fail Safe Requirements; therefore, even in the case of breakdown of a structural element, no collapse of the entire wing structure should have occurred.

Excessive Manoeuvre Stress or Gust

Under the conditions of weight and the position of the aircraft's centre of gravity at the time of the accident and in the presumed climbing trim, with the speed of 170 kt or less indicated on the flight path,

neither intentional manoeuvre nor positive, or negative, gust of any intensity could have caused the breakdown of the wing, because, before the forces necessary to cause the collapse of the structure had appeared, the wing would have gone into a stall.

At speeds higher than that indicated above, the wing could not have broken away except under one of the following conditions:

1. Manoeuvre: Exceeding the positive load factor 4.5 g. This condition appears to be unlikely, because the value 4.5 is very high (180% of the prescribed manoeuvre limit factor) and to reach it would have required a sharp manoeuvre at a very high speed, such as after a prolonged dive, which does not seem likely to have happened in view of the suddenness of the accident, but above all, because the breaking of the wing should have occurred in the outer part and not in the inner part, as actually happened.

2. Gust: At the typical design cruising speed (V_C) and design speed for maximum gust intensity (V_B), that is to say at the plane's speed of 261 and 326 kt (EAS), the wing was capable of standing, without breaking, vertical gust speeds not in excess, respectively, of 100 ft per second (30.5 m/sec) and 75 ft per second (22.7 m/sec).

These figures are very high and give a convincing demonstration of the structure's margin of safety with respect to stresses due to gusts, even if the calculations concerning this inquiry were developed exclusively from the static aspect, without taking into consideration the dynamic effect of the gusts.

However, a further investigation for the evaluation of the dynamic effect of gusts on the wing of the model 1649-A aircraft disclosed that the increase factor of the bending moment on the wing, due to said dynamic effect, is not very great, ranging as it does between 1.06 and 1.2, and that in any case it is no greater than that calculated for the previous models 749 and 1049-C, both of which have been tested extensively. In as much as it is shown by the foregoing that the breakdown of the wing by overstress from gust requires the concomitance of high flight speeds (not admissible in a highly turbulent atmosphere) and gusts of extreme intensity, and in as much as in this case also the breaking of the wing should have occurred, in all probability, in the outer part of the wing as explained above, the hypothesis of the breaking of the wing by stress from gusts is believed to be wholly improbable.

Excessive diving speed

Breakdown from excessive diving speed was considered in the event, which cannot be excluded a priori, that the plane, having gone out of control in rough air exceeded its design diving speed (V_D) = 326 kt EAS.

1. Static overload - Under this condition, the structure that undergoes the greatest stress is not the wing but the fuselage (on the rear area) because of the depressive force exerted on the horizontal tail surface (downward flexion). Actually, the breaking up of the fuselage and separation of the complete tail assembly occurred in flight. However, as the examination of the wreckage disclosed, the separation occurred after and not before the wing broke away. Proof of this is the consideration that, had the tail assembly become separated before, the plane would have dived abruptly, with the result that the wing would have broken off by inverse flexion, which did not happen.

2. Dynamic overload

i) Wing flutter

Data supplied by Lockheed regarding the plans of the 1649-A aircraft showed that the wing is free from self-induced vibration up to the speed of 1.2 V_D (391 kt) and under any condition of fuel load.

Since the worst condition exists when the wing has a fuel load of 7 650 gallons, it follows that with the fuel load the aircraft was carrying at the time of the accident (2 200 gallons), the possibility of flutter was very remote. Flutter would have caused the maximum bending stresses in the area of the nacelles of the outer engines and the maximum torsion stresses in the area between the outer and inner nacelles. Examination revealed no breakage from stresses of this type. Self-induced flutter vibrations would very likely have caused the lead masses fitted on the leading edges of both wing tips to break away during flight - instead, they were recovered very close to their respective wing portions.

ii) Tail flutter

As in the case of the wing, the absence of flutter up to the speed of 1.2 V_D = 391 kt EAS was ascertained also with respect to the tail assembly. Also it was shown that separation of the tail took place after the events causing the accident.

Thus, wing and tail flutter could not be considered primary causes of the accident.

Excessive rolling or excessive yawing

A violent rolling manoeuvre or an excessive rolling speed would have caused signs of torsion on the wing covering in the area of the outer nacelles - such signs were not found - or aileron breakages of a type different to those observed on examination of the wreckage.

As for yawing manoeuvres, the most critical structures are the back portion of the fuselage and the vertical tail surface. Actually, there was evidence that the plane was yawing at a high angle of drift, with strong side stresses, but the traces of fire on the tail assembly and the symmetrical nature of the breakage on the tail indicated that a breakdown from excess of unsymmetrical loads while yawing must likewise be excluded as the primary cause of the accident.

Explosion of the tanks and subsequent disintegration of the plane

II Explosion set off by malfunctioning of, or fire in, the engines

The technical inquiries made into the power plants excluded the possibility that the engines may have broken down or been on fire prior to the explosion and, therefore, may have been the determining cause of the explosion.

This was confirmed by the fact that:

1. neither the flow of air cooling the generators nor the flow of gasoline and oil to the four engines was interrupted;

2. the fire extinguishers of the four engines were not turned on;

3. none of the propellers was feathered.

III Explosion set off by other fires

A fire may have broken out on the plane in flight and set off the explosion, however, such a possibility appeared to be remote and wholly improbable.

Fire damage on the wreckage of the aircraft, however it occurred as a result of the explosion, would hardly have been such as to prevent recognition of any evidence of fire occurring during normal flight. Because of the suddenness of the accident, such a fire would have left very characteristic and easily identifiable marks. No such evidence was found.

IV Malfunctioning of the flight instruments and controls in general

No physical evidence of breakdowns or abnormalities as the direct or indirect cause of the explosion of the tanks was found, which was not attributable to the consequences of the explosion itself.

No evidence of electrical discharges was found in the interior of tanks No. 6 and 7.

As to the upper plate of cap P.N. 750438-13, three hypotheses were considered:

1. The cap, to which said plate belonged, was removed, at the crash site, from the wing panel to which it was attached by some unauthorized person who, after having disassembled the cap into its component parts, kept one or more of them and threw away the others, including the plate.

   This hypothesis was subject to doubt in view of the following -

   i) the plate was found at a distance from the wing panel in the middle of a field about 100 m away from the nearest road;

   ii) not one of the remaining parts of the cap was found in said field and immediate vicinity;

   iii) the plate was found exactly at the beginning of the wreckage trail, where it probably would have fallen if, for any reason whatever, it had become detached from its cap and from the wing as a consequence of the explosion, or just before it.

2. The cap became detached from the wing and then broke up into its component parts as a consequence of the explosion.

   Considering the results of tests, this might be explained, for instance, as the result of some hidden fault in the thread of the central stem onto which the check nut is screwed.

   In fact, if the central stem should break off in that area, the cap would automatically separate into its component parts. In as much as the link chain of the cap was not found in its place on the wing panel, it must either have become detached as a consequence of the explosion or it was removed by unauthorized persons who detached it from the panel.

   Against this hypothesis was the fact that the P.N. 750438-13 caps were subject to periodical inspection and tests.

3. Hidden fault etc. as mentioned, with the variation that the final breaking of the thread of the central stem occurred immediately before the explosion as a consequence of the pre-stress exercised by the check nut, the repeated opening and closing of the cap for refuelling, etc. - that is to say, in the course of the practical use of the P.N. 750438-13 cap.

Of these three hypotheses, the third one, regarding the loss in flight of one of the fuel tank caps, is by far the least probable. There was no record that loss in flight of P.N. 750438-13 caps had ever occurred in the past. However, since such a hypothesis is the only one of the three which is pertinent in so far as the search for the causes of the explosion of tank No. 7 was concerned, it was nevertheless taken into consideration.

V Explosion set off by bodies striking the plane's outer surface, whether such bodies were extraneous to the plane or were parts of the plane which had become detached from it

There were no traces of such an eventuality.

VI Explosion set off by explosive devices as the result of sabotage

No evidence of such a possibility was found.

In view of -

1. the results of investigations regarding the roll of paper;

2. the fact that, after the loss of the right wing and the tail assembly, the fuselage was still a closed body; and

3. the fact that the plane's cargo was found with the main piece of wreckage;

it was considered that even if the roll of paper had been aboard the aircraft, the chemical analyses carried out regarding it excluded the possibility of its having characteristics such as would set off explosions or start fires.

VII Explosions set off by atmospheric electric discharges

In as much as -

1. examination of the structural parts of tanks No. 6 and 7 disclosed no evidence of internal electrical discharges within said tanks;

2. tank No. 7 has two vent outlets;

3. the two vents were not equipped with anti-flame screens;

4. no physical evidence of lightning strikes was found on the two vent outlets; a study was made of the possibility that the explosion might have been set off by ignition of the gasoline vapours issuing from the vent outlets, caused by discharges of static electricity (streamer corona). In fact, discharges of this type would leave no visible traces on the outlets.

This possibility assumes the coexistence of the three following conditions -

a) that the gasoline vapours contained in tank No. 7 formed with the air a mixture that came within the ignition limits;

b) that the flammable vapours issuing from the vent outlets could be ignited by an electric discharge;

c) that after the vapours had been ignited at the vent outlets, the flames could spread to tank No. 7 through the vent pipes.

For each of the three conditions mentioned above, the following observations are made:

a) Taking into account what emerges indirectly from the six hypotheses set forth above, the fact that there was an explosion of the vapours contained in tank No. 7 would in itself indicate that the vapours were capable of being ignited. This may be ascribed to -

   i) an aging process of the gasoline residue contained in tank No. 7;

   ii) a penetration of air in tank No. 7 through one of the two vent outlets, the conditions for such a circumstance having, in some way, been produced by the existence of the two outlets;

   iii) by the possible loss, in flight, of the P.N. 750438-13 cap, taken possibly as a circumstance in conjunction with the two preceding ones.

b) As previously mentioned, the possibility that static and non-static electrical discharges might ignite flammable gasoline vapours issuing from the vent outlets was studied in the United States of America, with positive results.

Tests conducted at a specialized institution confirm that:

In the present state of knowledge, it cannot be stated that static electrical discharges generated at the vent outlets of an aircraft in flight will invariably ignite flammable gasoline vapours issuing from the outlets; the tests, however, indicate that this hazard cannot be ruled out.

The weather conditions at the time of the crash were most appropriate for creating, on the vent outlets of the Super Constellation N 7313C, electrical discharges fully capable of igniting flammable gasoline vapours in the test conditions described.

Other tests were made in a tunnel as follows:

> On only one of the original outlets, placed on the trailing edge of an airfoil, from whose four outlet pipes issued vapours containing a mixture that was within the limits of flammability in the case of tanks No. 6 and 7, and not within those limits in the case of tanks No. 3 and 4;
>
> at a pressure corresponding to an altitude of 1 700 ft;
>
> at an air flow speed of 170 kt IAS;
>
> for an outgoing speed of the vapours, for each individual outlet pipe, corresponding to climbing speeds of 900, 600 and zero feet per minute.

They disclosed that in the presence of non-static electrical discharges of sufficient intensity, said vapours ignite only if the plane is climbing, and that flames will not spread to the interior of the tanks.

In conclusion, if the tests mentioned do not make it possible to state definitely that static electrical discharges occurring at the vent outlets of a Super Constellation in flight can ignite flammable gasoline vapours issuing from these vent outlets, the tests nevertheless indicate that this hazard cannot be excluded and that the vapours would actually ignite if the electrical discharges were non-static and sufficiently intense.

c) With regard to the possibility that, once the gasoline vapours had ignited at the vent outlets, the fire may have spread to tank No. 7 through the pipes, it is observed that the tunnel tests during which such spreading did not take place -

   i) did not reproduce the real vent outlet system of tank No. 7 (existence of two outlet pipes and, therefore, two vent outlets;

   ii) did not bring about the true conditions in which the plane must have found itself at the time of the accident.

In particular, the tests did not take into account the effects generated by the turbulence, by sudden variations in flight trim, etc; such conditions, in concurrence with the existence of two vent outlets in tank No. 7, may have made it possible for the flames to spread to the interior of tank No. 7, causing it to explode.

Similarly, in said tests, no consideration was given to the possibility, however improbable it might be, of the loss in flight of cap P.N. 750438-13, supposedly belonging to tank No. 7, located on the upper surface of the wing. This circumstance may in fact have caused the fire to spread to tank No. 7.

Lastly, the fact that the inspection of the inner surfaces of some sections of the outlet pipes taken from N 7313C showed no traces of the passage of flames does not appear to be sufficient proof that such a circumstance did not actually take place. If flames had actually passed through the outlet pipes, their speed would have been too great to leave any traces on the inner walls of the pipes.

The likelihood of hypothesis VII requires the assumption that in the past, in spite of the continuous operation of Super Constellation 1649-A aircraft, none of this type aircraft was ever involved in that set of circumstances and conditions which, having occurred in the case of N 7313C, caused its destruction.

Such an assumption, although only a possibility, must be regarded as a matter for consideration. In fact, no Super Constellations, Model 1649-A, were equipped, at least up to some time after the N 7313C accident, with an anti-flame screen at the vent outlets and, at least on short or medium-length flights, they flew with tanks 5, 6 and 7 empty.

Therefore, also because of the considerations mentioned above,the hypothesis in question, although based on some factual elements, can be proved only by a suitable series of tests on the ground and in flight.

It can be pointed out that the said hypothesis appears to be, indirectly, in agreement with almost all the statements made by witnesses, regardless of the relative value at which such statements are taken; in fact, in the statements, the crash of the aircraft was closely associated with a lightning strike, with the following succession of events:

1) lightning strike (and, therefore, subsequent formation of static electricity discharges);

2) sound of the explosion, or explosions;

3) fall of the plane's burning wreckage.

Probable Cause

In examining the seven hypotheses dealt with in the report and in determining the degree of probability (plausibility) of these hypotheses, the Commission followed a process of elimination whereby the first six were discussed and discarded, whereas the last was discussed and deemed probable.

The breaking up in flight of the aircraft was due to the explosion of the fuel vapours in tank No. 7, followed immediately by either an excess of pressure or a further explosion in tank No. 6.

In the absence of further significant and concrete evidence, taking into account the stormy weather conditions, with frequent and severe electric discharges. existing in the area at the time of the accident, it may be assumed that the explosion of the fuel vapours contained in tank No. 7 was set off, through the outlet pipes, by the igniting of the gasoline vapours issuing from these pipes as a consequence of static electricity discharges (streamer corona) which developed on the vent outlets.

Recommendations

1. In view of the hypothesis advanced, it was recommended that the manufacturers and organizations concerned undertake a programme of research and tests intended to give deeper insight into the phenomena relating to the possibility of fuel tank explosions caused by electrical discharges.

2. It was suggested that pilots be instructed to avoid, whenever possible, crossing meteorological areas where flying conditions are particularly dangerous.

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ICAO Ref: AR/657

FIGURE 7

Tail assembly of Trans World Airline's, Super Constellation, N 7313C which crashed in Varese Province, Italy, on 26 June 1959.

No. 37

Continental Can Company, Inc., Martin B-26C, N 1502, accident near Marion, Ohio on 1 July 1959. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 2-0545, released 14 October 1960.

Circumstances

The aircraft flown by two company pilots departed Midway Airport, Chicago, at 1644 hours eastern daylight time on an IFR flight plan. The flight was being made to transport eight company executives to Baltimore, Maryland. When near Marion, Ohio, and shortly after the aircraft had traversed an area of pronounced thunderstorm activity, it dived violently and nearly vertically to the ground about 15 miles to one side of the flight's planned course. All persons aboard were killed. The accident occurred at 1752 hours.

Investigation and Evidence

The Aircraft

Examination of the maintenance history and records of the aircraft indicated that maintenance had been satisfactory and in full conformance with Civil Air Regulations.

At the time of the accident the aircraft had flown a total of 2 967 hours. Since its last overhaul it had flown 2 596 hours and 76 hours and 50 minutes since the last regular (quarterly) inspection.

The Crew

The captain had flown 10 577 hours of which 805 hours had been in B-26's. Prior to the final take-off, he had had a rest period of approximately 20 hours. He had been employed by the company since January 1952 and held all FAA certification appropriate for the flight.

The co-pilot had flown a total of 3 766 hours, 1 728 of which had been on B-26's. He too had had a rest period of about 20 hours prior to the final flight.

Weather - Briefing

Personnel of the weather bureau office at Midway Airport were busy during the afternoon of 1 July and could not state definitely that they briefed the crew of this particular flight prior to departure. However, knowing the normal practices of the Continental Can Company crews, they believed that a weather briefing was supplied to this crew. All eastbound briefings that afternoon called attention to the extensiveness and frequency of severe thunderstorm activity expected. Attention was drawn to all pertinent forecasts and flash advisories available. N 1502 was equipped with weather radar which was operable as far as could be determined.

Weather at the Time of the Accident (1752 hours)

According to local persons the weather was substantially as follows:

A thunderstorm had passed through the Marion, Ohio, area about 30 minutes before the accident. Light rain was falling at the time with light winds reported. The ceiling was estimated as 1 500 ft to 4 500 ft. There were no reports of lightning or thunder in the area at the time of the crash.

Weather - General

Radar observations made by the Weather Bureau at Columbus, Ohio and Canton-Akron, Ohio at 1700 showed a 10-mile wide belt of thunderstorms running generally from northeast to southwest just west of Marion, Ohio.

A severe weather warning was issued at 1140 on 1 July by the Weather Bureau's Severe Local Storm Office at Kansas City. It read as follows:

"Line thunderstorms at 1200E from northeastern Indiana southward to western Kentucky and western Tennessee expected to move eastward about 25 kt intensifying during afternoon. Northern portion line more active with a few severe thunderstorms with 1/2 to 3/4 isolated one inch hail aloft, isolated extreme turbulence and surface wind gusts to 50 kt isolated 60 kt expected in area 60 miles either side of a line from 30 miles northwest of Dayton, Ohio, to 25 miles north Bradford, Pennsylvania. Valid 1300E to 2100E. Isolated heavy thunderstorms expected southward along line through southern Ohio central Kentucky and western and central Tennessee as this line moves eastward during afternoon and early evening..."

This warning was amended at 1225 to read as follows:

"Revise severe limits to read 1/2 to 3/4 isolated one inch hail surface and aloft, isolated extreme turbulence and surcace wind gusts to 55 kt isolated 65 kt valid 1330E to 2100E..."

At 1252, the aviation area forecast issued by the Weather Bureau at Chicago read in part as follows:

"Deepening surface low over northern Lake Michigan with cold front southward across extreme western lower Michigan - Goshen, Indiana, with front continuing eastward at 20 kt for next 12 hours. A squall line NNE-SSW across extreme northeastern Indiana with occasional ceiling 1 500 ft, sky obscured, visibility two miles, thunderstorm, rainshower, gusts to 50 kt moving out of northeastern Indiana by 1400C to 1600C."

At 1542 the following flash advisory was issued by the Weather Bureau forecast office at Cincinnati:

"Cold front at 1700E, 50 miles SE of Fort Wayne to near Paducah moving eastward 15 - 20 kt with series of squall lines east of front through southern and central Ohio, northern Kentucky, northwest West Virginia. Locally precipitation ceiling 500 ft sky obscured, visibility 1/2 mile thunderstorm heavy rain shower in front and squall lines with severe turbulence and hail. Valid until 2100E."

FAA procedures, at the time, did not require transmission of the above severe weather information to the flight on ground initiative. It was available on request, however, no such request was made.

The Flight

The aircraft took off from Midway Airport at 1644 hours and was cleared to Baltimore Airport via Peotone, V 144, V 44, to maintain 5 000 ft. It was subsequently cleared to climb to and maintain 9 000 ft. The flight reported over Fort Wayne at 1724 at 9 000 ft and then, as requested, it contacted Cleveland Centre at 1733 hours on 125.8 Mc/s stating that it estimated Findlay omni at 1740 with Appleton omni as the next checkpoint. At approximately 1740 the flight contacted Indianapolis Centre and gave the following position report: "1502 checked Findlay at 39, at nine thousand, estimating Appleton at 56, Zanesville, go head." Indianapolis Centre acknowledged the position report and gave the Columbus altimeter at 29.92. The flight acknowledged. This was its last transmission.

Statements of witnesses indicated the following:

The aircraft was first observed flying over the Marion Municipal Airport on a south-southeast heading at about 4 000 ft altitude. (How and why the aircraft descended from 9 000 ft is not known.) It was next seen over the U.S. Army Engineer Depot, Marion, Ohio, still on a southeast heading. The next positive observance of the aircraft was

when it was turning from an easterly heading to the north. It was seen to make a "short" climb and then continue the turn to a northerly heading. This northerly heading was maintained, and it then entered a vertical dive from an altitude of about 4 000 ft.

Descriptions indicated that maximum or near maximum power was being developed by both engines throughout that portion of the flight when the aircraft altered heading from the south-southeast to the north. Gaining altitude throughout the turn, the aircraft continued to climb after reaching the northerly heading. At this point, power noise became less and the aircraft was observed to enter the reported vertical dive with power again applied, at or near maximum, continuing until impact.

It crashed on a heading of 013° Speed at impact was extremely high as shown by heavy portions of the aircraft imbedding themselves some 8 ft in hard clay. The resulting destruction was so explosive-like that a high degree of disintegration occurred with widespread destruction of the airframe and of the power plants. All major components of the aircraft were found at the crash site, indicating that there had been no inflight loss or separation of parts. There was no physical evidence of structural failure in flight nor of control failure nor of power plant failure, although investigation for these possibilities was thorough.

Analysis and Conclusions

It was apparent that there must have been control difficulty of an undetermined nature. This may have been the breakage of a structural member or possibly a deformation or bending of a part, precipitating the dive. It seems logical that this had its inception while the flight was in severe turbulence only a few minutes earlier. It was not possible to do more than surmise as to the origin of the trouble, because a considerable number of initial malfunctionings could have resulted in the aircraft's turn and final plunge. The nature of the aircraft's manoeuvres prior to the final dive, and their proximity to the Marion Airport, may suggest an intent to land there; there was no tangible evidence of this.

It appears probable that the aircraft's speed was reduced during the thunderstorm activity; this would account for the time of the crash being a few minutes after the aircraft should have passed the vicinity. Being some 15 miles to one side of the planned course may well have been an attempt to avoid the worst of the weather as indicated by airborne radar. There is no explanation as to why this much deviation from the airway was not reported; possibly it was because of stress of the circumstances.

Probable Cause

The Board was unable to determine the probable cause of this accident. However, circumstances suggested control difficulty of an undetermined nature during passage through an active developing line of thunderstorms.

Subsequent Action

This and other seemingly similar air disasters have led the Board to initiate a series of conferences with other government agencies and with industry to better both the currency and accuracy of flash advisories (weather) and to impress their importance on the flying public. These conferences are now in the exploratory stage and are aimed at the development of new procedures designed to assure the reception of severe weather bulletins by those flights which could be affected.

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No. 38

Pan American World Airways, Boeing 707, N 707PA, made an emergency landing at the New York International Airport on 12 July 1959. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 1-0058, released 2 May 1960.

Circumstances

Flight 102 was a regular flight from the New York International Airport to London, England, carrying 102 passengers and a crew of 11. Its departure was delayed 30 minutes because of a wheel change. Shortly after take-off at 2037 hours (11 July), it lost two of the four wheels of its left main gear. At 0029 hours eastern standard time (12 July) it made a successful emergency landing at the New York International Airport (Idlewild). Four of the 102 passengers aboard were injured during deplaning.

Investigation and Evidence

The Flight

Immediately after becoming airborne, one of the Idlewild tower controllers saw what he believed to be wheels separate from the undercarriage and fall into the bay at the end of the runway. He notified the flight and called the office of the Port of New York Authority to have personnel investigate and report the identity of the object - it was two wheels from the aircraft with a portion of the truck beam attached.

The flight circled at low altitude while the captain appraised the situation, and it was decided to land the aircraft at Idlewild with the landing gear extended. The aircraft had enough fuel aboard to enable it to circle for approximately 3 hours at low altitude. As a precautionary measure the last 3 000 ft of the runway were foamed. This operation was completed at 2535 hours. By 0010 the emergency equipment was ready and positioned for the landing.

Flaps were fully extended, and touchdown was made within the first 1 000 ft of the runway with the right main gear. Spoilers were raised immediately and as the left main gear and nose wheels made contact, full reverse thrust was applied. It was possible to hold the aircraft straight using differential reverse thrust until the full weight settled on the left gear and the left strut began to drag on the runway. Right brake was sufficient to maintain directional control, and at 0029 the aircraft came to a stop on the runway about 1 200 ft short of the foamed area.

Although the strut end scraping on the runway generated heavy sparking throughout the landing roll, no fire occurred.

It was estimated that approximately 400 - 600 people surrounded the aircraft after it stopped. Most of these persons were the curious whose presence seriously hampered the efforts of the rescue workers. As there was danger of tires blowing out or the collapse of the damaged landing gear, the sightseers were repeatedly asked to move out of the danger area. These warnings were ignored, and finally a Port Authority fire truck sprayed the crowd and cleared the area.

Forward Section of Truck Beam of Left Landing Gear - Damage

Examination revealed the presence of a flat peen mark on its top face 7-1/2 inches forward of the truck fulcrum. A crack extending longitudinally approximately 1-1/2 inches each way from the peen mark was evident. Although the clamshells and polishing normally associated with metal fatigue were not present,

there were the well-defined end lines of a fatigue-like crack which started at the inside surface of the truck beam. The end lines and the lack of ductility indicated the probability of more than one cycle of loading. A second less well-defined peen mark was found about one-half an inch forward of the above-described peen mark. Although this second mark appeared to have been made by a sharper edge, no evidence of fatigue was present. A peripheral helical fracture originated at this peen mark and ran completely around the truck beam to the left, terminating at the longitudinal crack.

At the forward end of the longitudinal crack, another instantaneous fracture ran helically to the right completely around the beam and beyond to a point on the bottom of the beam three inches to the rear of the front axle centreline. A third instantaneous fracture occurred at the rear of the longitudinal crack and ran peripherally to the left.

The left main gear lower torsion link assembly antirotation bolt was still in place but its nut was missing. Some threads were damaged and the end was slightly bent. The bolt end surface had two peened areas, each the same size and shape as the peen mark on the truck beam. The lower spacer was also peened on the edge of its lower surface.

Landing Gear Truck - Snubber Assembly

During take-off and landing, the landing gear truck may be subjected to extreme and violent vertical oscillation over runway pavement at high speeds. In addition, it has been determined that unequal braking during the retraction cycle may also cause similar violent oscillations. Therefore, the landing gear truck is fitted with a "hydraulic shock absorber" snubber assembly. Its purpose is to dampen these oscillations of the truck beam around its single pivot point at the lower end of the oleo strut. It also serves to limit displacement at the truck beam to a maximum of 10° above the 15° below the horizontal. Without this limiting action by the snubber, the truck beam is free to pivot to an angle at which it will contact the antirotation bolt in the lower torsion link assembly. Investigation disclosed that the position of the peen marks on the truck beam of N 707PA corresponded precisely with the point at which the beam would contact the antirotation bolt during over travel of the truck beam.

Analysis

The Board believed that the landing gear truck beam of N 707PA was damaged on a previous flight by contact with the lower torsion link assembly antirotation bolt.

This damage can occur only if the snubber is removed or is broken from one of its end fittings. The beam could have been peened during a flight from Boston on 7 July after the snubber failed, or on a flight from Santa Maria on 9 July when the snubber had been removed. Since the examination of the fracture indicated multiple loading, the damage may have been done during both of the flights.

Because the beam and the end of the antirotation bolt are angled 15° from each other at the point of their contact, the end of the bolt must be deformed to that angle to leave a flat mark on the beam surface. If, as PAA claimed, the bolt installed at the time of the accident was damaged during the accident, another bolt would have had to have been installed previously. This bolt would have had to have been flattened as mentioned before in order to peen the truck beam in the manner it did. This previously damaged bolt, if there was one, was either replaced without appropriate notation in the records or was the bolt in place at the time of the accident. Either action indicates improper maintenance practice.

The longitudinal fatigue-like crack originated at this flat peen mark. As the snubber was properly installed at take-off, no contact between the beam and the bolt was possible until the forward truck beam

had separated from the aircraft as a result of forces to which the weakened beam was subjected on take-off.

Results of the investigation indicated that the failure of the truck beam was due to a crack produced by impact loads on its top surface. The initial crack was propagated to complete fracture by additional impact and normal service loads. Some hydrogen embrittlement and an unusually large number of non-metallic inclusions in the area where the fracture started may have contributed to the failure by decreasing the ductility of the steel.

Results following a Study of Snubber Failures

The manufacturer has prepared several changes which it is anticipated will eliminate further difficulty. The size of the orifices in the hydraulic piston of the snubber assembly are to be reduced to increase its load rate, and the pressure relief setting is to be increased from 8 000 psi to 12 500 psi. These modifications will increase the effectiveness of the damping action of the snubber assembly. The automatic wheel braking valve setting is to be reduced from 450 psi to approximately 175 psi. This should decrease the tendency of unequal braking causing the oscillation of the truck beam. In addition, the pressure in the levelling cylinder assembly is to be increased from 925 psi to 1 500 psi.

These changes should prevent excessive oscillation of the truck beam caused by either unequal braking during retraction or by displacement of the truck during taxi or take-off roll.

Broadcasts concerning Emergencies

Public broadcasts about this emergency attracted large crowds of persons to the scene. The resulting traffic completely choked the access highways to the airport boundaries. This could give rise to a serious problem affecting air safety and one which will be given further study by the Board.

Subsequent to this accident, representatives of the National Association of Broadcasters advised that when radio and television coverage of emergency news is being broadcast, a specific request will be made to listeners "to refrain from doing anything that would hamper the efforts of the authorities whose responsibility it is to cope with the emergency."

Probable Cause

The probable cause of this accident was the failure of the forward truck beam of the left landing gear.

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ICAO Ref: AR/620

No. 39

Kalinga Air Lines, DC-3, VT-DGP, accident near Sagong Village, 13 miles south of Along, North East Frontier Agency on 3 August 1959. Report of the Inspector of Accidents, dated 30 October 1959, released as No. 1/42/59/Acc. by the Director General of Civil Aviation, India.

The Government of India examined the report as submitted by the Inspector of Accidents but did not accept it in its entirety. Those portions of the report which were not accepted have been underlined and marked with asterisks. The final decisions of the Indian Government on said points have been added as footnotes.

Circumstances

The aircraft was on a non-scheduled passenger flight from Mohanbari to Along and return. The first segment of the flight was expected to last about twenty minutes, in visual meteorological conditions. VT-DGP's last contact with Mohanbari control tower was at 1028 hours, eleven minutes after take-off. When the aircraft did not return to Mohanbari as expected, search and rescue action was initiated. It was later learned that the aircraft had crashed and was destroyed at approximately 1030 hours Indian standard time, killing all six occupants, i.e. three crew, one freight attendant, and two loaders travelling as passengers.

Investigation and Evidence

The Aircraft

It had a Certificate of Airworthiness valid until 15 August 1959, and had flown approximately 2 725 hours since its last Certificate of Airworthiness Overhaul.

The airframe, engines and propellers were maintained in accordance with the approved maintenance inspection schedules. The last major inspection (100-hour) was carried out on 1 August 1959 at Calcutta by Kalinga Air Lines. On the day of the accident the aircraft was inspected and at 0005 hours was issued a Certificate of Safety for Flight, to cover both the airframe and the engines, by an appropriately licensed aircraft maintenance engineer.

Crew Information

The pilot-in-command had obtained a 'B' licence on Chipmunk aircraft in 1953, and it had later been extended to all conventional types of landplanes subject to a maximum weight of 15 000 lb and DC-3 aircraft. He obtained his pilot-in-command endorsement by day on DC-3's on 12 June 1959, but had not been route checked by the company as commander and, therefore, was not sent out to fly as such. He had, however, flown sometimes as commander with the permission of his senior commanders when they had been on board. His total flying hours as such amounted to approximately 26 hours by day. These had been acquired unknown to the company's chief pilot.

His last route check on the Calcutta-Cooch Behar route, flight check and instrument rating checks, as a co-pilot, were carried out by approved check pilots in July 1959. He had three years experience as co-pilot in the N.E.F.A. including the Along sector.

His total flying experience as of 2 August 1959 was about 4 017 hours.

The flight of 3 August was his first, flying as pilot-in-command, along the Mohanbari-Along route, although the company authorities were not aware of the fact that he was flying as commander on the subject flight.

During the investigation which followed the accident, the company's chief pilot listed this individual as the co-pilot and indicated that all his experience was in the capacity of co-pilot and had no command hours of his own.

It was concluded that no strict vigilance was kept by the company's management over the flying activities of their pilots.

The co-pilot held a 'B' licence valid until 15 November 1959, which had been extended to all conventional types of landplanes up to a maximum weight of 15 000 lb and to DC-3 aircraft. He had held a pilot-in-command endorsement on DC-3 aircraft by day since 19 November 1958 and by night since 28 March 1959. His route check and flight check were carried out by an approved check pilot on 27 March 1959. His total flying experience as of 2 August 1959 amounted to about 2 815 hours.

One of the earlier departure signals from Mohanbari erroneously mentioned that he was the pilot-in-command of VT-DGP on 3 August. The company's chief pilot and relatives of the pilot-in-command were also under the same impression. This was perhaps because the co-pilot was senior to the pilot-in-command. However, the flight plan and the evidence of eye witnesses, who saw the aircraft taxiing out, clearly showed that the pilot-in-command described above was indeed flying the aircraft in that capacity.

The radio officer held a flight radiotelephony officer's licence valid up to 29 September 1959. He had a total flying experience of 5 874 hours as of 2 August 1959.

Weather

The nearest meteorological office to the place of the accident was Mohanbari, 33 miles to the south. Mohanbari is situated in the plains, while the accident site was in hilly country, hence the weather conditions at the site could not be determined by the Mohanbari observations.

Eye witnesses to the accident stated that the weather was fine, and there was no cloud at the time of the accident.

According to the existing procedure, no briefing with regard to the weather en route is given to pilots operating in the N.E.F.A. area.

The Final Flight

After refuelling and loading following the first sortie to Along and back, the captain filed a flight plan on radio-telephony and the aircraft was cleared to taxi out and take off. After take-off it advised, at 1019, that it had departed Mohanbari at 1017 IST and estimated its landing at Along would be about eighteen minutes later. Having tried unsuccessfully to clear this message direct to Calcutta on the same channel for some time, it called Mohanbari at 1028 hours and asked the tower to transmit the message to the flight information centre at Calcutta. This was the aircraft's last message.

Entries in the aircraft's flight log, which was recovered from the wreckage following the accident, indicated that at about 1030 hours the aircraft was flying normally at 4 500 ft.

The aircraft was due to return from Along after off-loading the freight. Normally this complete trip is expected to take about 1-1/2 to 2 hours.

The search and rescue action was begun at 1250 hours as all attempts to locate the aircraft were unsuccessful.

Accident Site and Wreckage Examination

The aircraft crashed on the southern slope of one of the mountain ranges near Sagong Village, at an estimated altitude of 4 300 ft asl. It hit the side of a 70-foot deep gorge. The engines had dug into the ground to a depth of 7 ft, and the fuselage nose had dug into the side of the gorge and slipped into it below. The aircraft had not hit any trees or terrain earlier, and the ground marks clearly indicated that it was in a nose-down attitude at impact.

The port outer wing leading edge had not suffered any direct impact as the ground was lower with respect to the starboard side, but had separated from the centre section outboard of the attach-angle after hitting a tree. The flaps and landing gear were in the 'up' position. Excepting the rear fuselage, tail and the outer wings, the rest of the aircraft was completety burnt.

All the components were found in the wreckage, and there was no sign of any disintegration in the air.

No useful information could be obtained from the instruments and controls as the complete cockpit was disintegrated and burnt. Both altimeters were recovered in a damaged condition. They were set at 29.8" and 29.1". The first setting could not be relied upon due to instrument damage, however, the second, 29.1", corresponded to the QFE (29.13") of Mohanbari Airfield, and might have been used for the landing on the previous sortie. The magnetic compass had also been found in a damaged condition.

Because of extensive fire damage, no strip examination of the engines was carried out. There was ample evidence from the propellers to show that both engines were under power at the time of the accident. Neither propeller had been feathered.

Regular Route for Flights from Mohanbari to Along

Following take-off, flights usually climb to the required height of 7 000 ft, cross the mountains and then descend over the airfield at Along.

It is possible to complete the flight in less time by entering the mountain range through a valley, crossing over the ridge just at minimum height and then following the valley to Along in a descent. In visual meteorological conditions, (in which VT-DGP was flying), some pilots seem to adopt this practice with a view to saving time and fuel.

The terrain in the latter half of the route from Mohanbari (altitude 350 ft) to Along (altitude 700 ft) is hilly and there are many hill tops of the order of 5 000 ft to 6 000 ft.

Reconstruction of the Flight

Considering that the total time of flight was twenty minutes, the position of the aircraft thirteen minutes after take-off, i.e. at 1030 hours, was estimated to be in the valley of the River Simen where it was seen to be flying low in the direction of east to west. This would indicate that the pilots intended to fly through the valleys instead of on a straight course above the hills.

The River Simen flows from west to east very nearly parallel to two other rivers, the Su and the Simi, which flow from east to west and are separated by the mountain range on whose southern slope the aircraft had crashed. The general contour in the valley of Simen rises from east to west and ends with a ridge of about 5 000 ft after Sagong Village. The contours along the valleys of the Su and Simi fall from east to west and these rivers take a turn to the north towards Along. The two rivers Su and Simen are separated by a distance of two miles, which is less than one minute's flight in a Dakota aircraft. It appears, therefore, that the pilot was not fully familiar with the topography of the area and, while flying through the valleys, he entered a wrong valley which led to Sagong instead of Along. After having turned into the valley of the Simen instead of the Su and having flown for about

4 to 5 miles, the pilot must have realized that he was in the wrong valley when he saw a rising contour, and there was no sign of the river turning north. At this stage he would probably have cleared the ridge to the west of the village of Sagong if he had climbed straight ahead, but he appears to have decided to turn back. While attempting to do so, the aircraft inadvertently stalled and crashed in a nose-down attitude.

Loading

An examination of load sheet No. 1 and cargo manifest No. 1, filed by the operator with the control tower at Mohanbari before the departure of the aircraft, showed a total of 8 260 lb of freight and four persons, including the crew, on board. This load sheet was not, however, signed by the captain, although the cargo manifest was signed. Assam Travels, who chartered the aircraft for this flight, submitted a revised load sheet No. 2 and cargo manifest No. 2 the day after the accident and stated that the earlier load sheet No. 1 and cargo manifest No. 1 that were submitted to the control tower before the departure of the aircraft were incorrect. According to the revised load sheets, the total freight on board was 7 260 lb, * four crew and two passengers.

A detailed investigation was carried out to find out which was the correct load sheet.

Considering that load sheet No. 1 had not been signed by the pilot and that the investigation revealed a portion of the freight had been left behind, it was concluded that the revised load sheet could be taken as correct. According to it the all-up weight of the aircraft was within the maximum of 26 200 lb specified for the passenger aircraft. The actual all-up weight was 26 101 lb. **

The pilot had signed two cargo manifests, one for the proposed freight to be carried and the other the actual freight. Obviously, the first one was not destroyed after the second one was prepared. In fact, the pilot or even the traffic officer should not have signed the documents until the loading was finally completed. *** This would indicate that insufficient care was exercised by the pilot while signing the documents.

No evidence was found that the freight was properly lashed. The traffic officer stated that there were a number of tins and loose articles which could not be individually anchored, but the entire load was lashed by three long ropes running along the length of the cabin. Although there was a possibility of some of the loose packages being displaced during abnormal manoeuvres under such imperfect lashing, there was no evidence that this was a factor contributing to the accident.

* 29 tins of wood oil, indo coat and lime were left out as there was no space for them in the lorry going to the airport - they weighed 984 lb and this figure was rounded out to 1 000 lb when the revised load sheet was prepared

Final Conclusions of the Indian Government

** No reliance can be placed on the second load sheet, as the signature of the pilot was allegedly forged. In the circumstances, the inference that could be drawn is that the aircraft at the time of take-off was overloaded by about 920 lb assuming the weight of a loader as 160 lb. The all-up weight of the aircraft was estimated to be 27 120 lb.

*** The pilot had not signed the revised load sheet or the cargo manifest and his signature was allegedly forged on the documents.

There was no trim sheet submitted along with the load sheet and cargo manifest. The traffic officer stated that he did not calculate the position of the centre of gravity as it was not the practice. It is unlikely that the pilot would have used any trim sheet for calculating the position of centre of gravity before take-off, though he would have satisfied himself that the load was properly distributed in the cabin as judged from his experience.

The freight on the aircraft contained, amongst other things, paints, wood oil, indo coat oil and lime, which come under the heading of "inflammable and corrosive articles" and may require a permit for carriage by air. NOTAM No. 7 (1951) specifies that any form of combustible material having a flash point below 73° F should not be carried in the aircraft without such a permit. Data obtained from the manufacturers during the investigation showed that the flash points of the paints and oils in question were higher than the minimum of 73° F specified. The lime was in the unslaked condition. All these articles were packed in tins, and they were not considered to be highly corrosive or highly inflammable and the condition in which they were carried did not affect the safety of the aircraft.

Other facts brought out during the investigation

During a test flight on 25 July 1959, i.e. nine days before the accident, the aircraft suffered a heavy loss of oil after the starboard engine had been changed. It was alleged that the internal condition and performance of the engine was affected as a result of this oil loss. A detailed investigation was subsequently carried out to ascertain the nature and extent of the oil leak. It was observed from the conclusions arrived at, that the oil leak was due to the missing plug on the main oil sump and the performance of the engine was satisfactory over the remaining period (i.e. from 25 July up to the time of the accident) in which no abnormalities or malfunctioning of the engine were reported by the pilots who flew the aircraft or the engineers who carried out the maintenance.

It was also alleged during the investigation that the floor beams of the aircraft had been damaged previously and they had not been repaired. Under the circumstances it was difficult to establish whether the floor beams in question were, in fact, damaged beyond the limits of airworthiness or not.

These two factors, however, were not considered as contributing to the accident.

Probable Cause

The accident was attributed to an error of navigation on the part of the pilot. He entered a wrong valley and without proper assessment of the performance of his fully-loaded aircraft in the space available attempted to make a steep climbing turn during which the aircraft stalled and crashed. The height above the terrain was insufficient to effect a recovery from the stall.

Recommendation

It was recommended, as a result of findings during this investigation, that the company should be asked to reorganize its stores, maintenance and operational set-up so that they come up, in all respects, to the standards laid down by the Director General of Civil Aviation.

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No. 40

Líneas Aéreas Costarricenses S.A., DC-3, TI-1005-C, crashed into a house immediately after landing at San Isidro de El General Airport, Costa Rica, on 15 August 1959. Report released by the Directorate General of Aviation, Costa Rica.

Circumstances

Flight 19-20 took off from La Sabana Airport (San José) at 1211 hours on a trip to San Isidro, San Vito and return. The flight to San Isidro was uneventful until the aircraft touched down at 1238 hours. At this time the landing run was extremely fast because runway 02 was still very wet and slippery from heavy rain which had fallen during the day and previous night. The pilot and co-pilot were unable to stop the aircraft. However, its speed was reduced and the pilot attempted to ground-loop it violently to the left. Skidding slightly to one side the aircraft struck a house, 20 ft beyond the northern boundary of the runway. A baby girl, who was inside the building, was killed. Of the persons aboard the aircraft, only the co-pilot was seriously injured.

Investigation and Evidence

Loading of the Aircraft

Prior to take-off from La Sabana it was found that the total weight of the aircraft was 25 573 lb. This was in excess of 25 500 lb, the maximum authorized for take-off. The airline personnel then removed a total of 85 lb, and the aircraft subsequently took off with a total of 25 488 lb aboard, i.e. 12 lb below the maximum.

During the investigation it was revealed that on landing at San Isidro the aircraft weighed approximately 25128 lb, and the load was properly distributed in relation to the centre of gravity.

Meteorological Conditions

During flight the pilot was advised of the following conditions which existed at San Isidro Airport: southerly wind with a steady velocity of 8 mph, fog (as customary on the south-southeast approach), and a wet runway.

The Landing Runway at San Isidro

Because of obstacles in the approach areas, landings must be carried out only on runway 02 and take-offs on runway 20.

Runway 02 is 1 920 ft asl, 3 600 ft long and 270 ft wide. It has a 20° M orientation and is entirely covered with grass.

The following obstructions are in the approach area:

1. On the northwest side lies the city of San Isidro which begins exactly on the boundary of the runway. This obstruction results in the reduction of the runway's usable length.

2. To the southwest is a hill, approximately 1 000 ft high about 350 m from the end of runway 20. The hill is an obstacle appreciably exceeding the acceptable maxima and imposing a turn to the right immediately after take-off, which is hardly within acceptable safety limits. Flying over the hill after take-off is almost impossible, however, it can be done after a normal take-off when the aircraft carries no load.

The Landing

The investigation revealed that when landing on runway 02 the aircraft tended to overshoot, but in whatever manner the landing was carried out it had to be completed. Otherwise it would have been fatal due to the natural conditions of the airport.

After touching down, the procedures followed by the crew to stop the aircraft were obviously affected by the condition of the ground which was wet and slippery following twelve hours of continuous rain. Braking action reduced the speed of the aircraft but was not sufficiently effective to stop the run of the aircraft. When the speed had been reduced to the point where corrective emergency action could be carried out, the pilot tried to force the aircraft into a violent left turn, opening the throttle of the starboard engine and applying brake on the left wheel. The humid condition of the runway prevented this ground loop to the left. The thrust of the starboard engine brought the aircraft to the left, but, with the left wheel skidding on the grass, the original heading was maintained and the aircraft slipped sideways. The right wheel of the landing gear struck a duct that crossed the end of the runway, breaking the upper struts which pierced the top surface of the starboard wing. The aircraft, then at a 45° angle from the direction of the runway and at an approximate speed of 25 mph, hit and completely destroyed the house.

Technical Investigation

The wreckage was examined at the site of the accident. From the readings and condition of the instruments and other parts it was concluded that the aircraft was operating normally up to the time when it overshot runway 02.

Following information given by the pilot-in-command in his report on the accident, the technical cooperation of "Servicios Aerotécnicos Latino Americanos" was requested and obtained in order to collect evidence regarding the hydraulic equipment of the aircraft. The evidence showed that the equipment, in all its parts, including brakes, was in perfect operating order when the accident occurred.

Probable Cause

The crew could not hold back the aircraft on its landing run because of the ineffectiveness of the brakes on an extremely wet runway. This condition was aggravated by the fact that the aircraft was operating with almost maximum landing weight.

Recommendation

The investigators concluded that the landing runway of San Isidro de El General Airport does not meet the minimum desirable conditions for the operation of DC-3 or similar aircraft.

In view of the foregoing, it is recommended that San Isidro Airport be closed to such aircraft.

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ICAO Ref: AR/623

LINEAS AEREAS COSTARRICENSES S.A., DC-3
ACCIDENT AT SAN ISIDRO DE EL GENERAL AIRPORT,
COSTA RICA ON 15 AUGUST 1959

FIGURE 8

THE AIRCRAFT OVERSHOT THE RUNWAY ON LANDING
AS ITS BRAKES WERE INEFFECTIVE ON THE
EXTREMELY WET RUNWAY

No. 41

Transair Ltd., DC-3, G-AMZD, accident on Montseny peak, Spain, on 19 August 1959. Report released by the Directorate General of Civil Aviation, Spain, and by The Ministry of Aviation (U.K.) as C.A.P. 161.

Circumstances

The aircraft departed Barcelona Airport at 1451 Z on a charter flight to Gatwick, England, with a crew of 3 and 29 passengers. It was cleared on a VFR flight plan and consequently its contact with Barcelona Tower was limited to that required for take-off. The aircraft crashed at 1510 Z, 25 m below the summit of Montseny (1 712 m high). Fire broke out as a result of impact with the ground, and all aboard were killed.

Investigation and Evidence

The weather was good along the route except for the cloud-covered Montseny peak. As the flight was being carried out in accordance with VFR the pilot should have refrained from flying through cloud without an IFR clearance from Area Control. He was also flying at an altitude that did not ensure safe clearance of the mountain. Had he altered course to the right or the left, he would have been able to pass Montseny, since the weather was clear on both sides.

The aircraft was not following the usual route, since, had it followed the IFR flight plan, it would have continued to climb towards Bagur and Cabo Creus and from there would have headed for Gatwick.

It was inferred from examination of the wreckage that the aircraft was climbing slightly at the time of the accident.

The aircraft's total destruction through impact and through the explosions of fuel tanks precluded any conclusions about the performance of its equipment.

Probable Cause

From the foregoing it is to be presumed that the pilot entered clouds unaware that a mountain, 1 712 m in height, lay ahead of him.

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ICAO Ref: AR/594

No. 42

Capital Airlines, DC-3, N 44993, accident at Charleston, West Virginia, on 26 August 1959. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 1-0051, released 11 April 1960.

Circumstances

The flight was a regular one from Pittsburgh, Pennsylvania, to Charleston, West Virginia. Aboard were 15 passengers and 3 crew. Following a routine flight the aircraft veered off the runway and crashed down a steep slope while the co-pilot was attempting a landing at the Kanawha County Airport at Charleston. No one was injured, but the aircraft received major damage.

Investigation and Evidence

The Aircraft

The records concerning N 44993 indicated that it was airworthy at the time of the accident.

Crew Information

The captain had a valid FAA airline transport pilot's certificate and ratings for the DC-3, DC-3S and DC-4. He had flown a total of 7 813 hours of which 4 815 were in DC-3 equipment. He had made nine landings at the Kanawha County Airport in the 30 days preceding the accident.

The co-pilot held a valid FAA commercial pilot's certificate with airplane single-engine land and instrument ratings. He had a total of 2 787 flying hours, of which 741 were in the DC-3. He had made six landings at Kanawha County Airport in the 30 days preceding the accident. His last co-pilot proficiency check and instrument certification was accomplished satisfactorily on 3 June 1959.

Weather

Both pilots stated that the weather was substantially better than had been reported. The visibility was good, there was no turbulence, and no noticeable wind effect on the final approach.

The Landing

On arriving in the Charleston area the co-pilot made a normal practice ILS approach and made the transition from instrument to visual flight after passing the middle marker beacon inbound to the field to complete the landing visually. He described the landing as smooth and slightly tail low but with a slight skip. He said both the captain and he immediately applied forward pressure on the control column and the aircraft appeared to stay on the ground ... the flaps were then raised. The aircraft began an immediate sharp turn to the left and full right rudder was then applied by him and the captain simultaneously. As the left turn continued, full throttle was used on the left engine and the right brake was applied.

The captain also stated that on initial contact the plane veered about 30 degrees to the left and the wings remained level. He said he immediately "reached for the right rudder" to straighten the aircraft on the runway but found that the co-pilot had applied full rudder. He said that as the aircraft touched the second time he eased the flaps up, applied forward pressure on the control column, and applied full right brake. According to the captain, these corrective measures had no effect and he then applied full throttle on the left engine.

Both the captain and co-pilot stated positively that the left brake was not used at any time during the landing.

Analysis

Despite the descriptions by the crew that this was a normal skip-type landing, the Board believed that it was hard and that the airplane bounced. First, the tower operators saw the landing lights appear to tilt upward abruptly ..... it is evident that the movement of the lights was unusual enough to create the impression of a bounce. Second, the passengers' statements described a hard touchdown, a bounce, then a second contact with the runway.

The preponderance of evidence was that the aircraft did not begin to veer off the runway until after the second contact.

A Martin 404 was standing in run-up position near the approach end of runway 23 as Flight 587 was landing. The possibility of propeller wash from this aircraft having caused the DC-3 to veer off the runway was considered and then dismissed. The Martin was parked with the tail and, therefore, the propeller wash, pointing away from the landing runway. Also, the pilot had completed his engine run-up and was waiting for N 44993 to land before taking the runway for departure. Since the landing was toward the southwest and the wind was from the south, any turbulent air mass would have drifted away from the area where control was lost. The slipstream from the Martin would have no effect on the DC-3.

It was evident from the marks on the runway that left brake was applied during the landing. Examination of the brake systems showed that there had been no malfunction in these systems which could have caused a brake to drag or bind and cause this mark. It was, therefore, evident that the left brake pedal was depressed either by the pilot or co-pilot.

From all evidence available, the Board believed that both brakes were applied during an attempted recovery from a poorly executed landing. It seemed clear that the aircraft contacted the runway and bounced. Shortly after the second contact with the runway the crew lost control and the aircraft started to veer off the runway. The effectiveness of the corrective action of right brake and right rudder was greatly reduced by the prior or simultaneous application of left brake. As a result, the rotational forces on the aircraft as it deviated from a straight course could not be overcome until it had veered from the runway.

After the proper corrective action was taken, insufficient distance remained to prevent the airplane from going over the embankment.

Probable Cause

The probable cause of this accident was the loss of directional control following a poorly executed landing.

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ICAO Ref: AR/621

No. 43

Beechcraft, C-18-S, N 57139, crashed near McGrath, Alaska on 1 September 1959. Civil Aeronautics Board (USA), Aircraft Accident Report, File No. 2-1026, released 22 August 1960.

Circumstances

The aircraft departed Kotzebue, Alaska, for McGrath, Alaska at 1315 hours Alaska standard time, with non-refuelling stops at Kiana and Tanana. At Tanana the pilot was briefed on en route weather to McGrath as well as on the route and terminal forecasts. He departed Tanana at 1957 hours, about an hour before sunset, on a VFR flight plan. An emergency distress call from the aircraft was first heard at 2128 hours. There followed several communications between the Beechcraft and the McGrath ground station which issued navigational advice. At or about 2214 hours, approximately 3/4 of an hour after dark and during rain showers, the aircraft struck the ground violently in a steep spiral at a point about 26 miles from McGrath Airport. The pilot and the seven passengers aboard were killed.

Investigation and Evidence

The Aircraft

The last 100-hour and periodic inspection on the aircraft was on 25 March 1959 at which time the aircraft was certificated as airworthy. No further maintenance entries were made in the logbook. As of June 1959 about 19 hours more had been flown and had been entered in the logbook since the inspection, however, several flights flown following the month of June were not entered. Testimony during the investigation revealed that although certified as airworthy there were signs of considerable oil leaks.

The Pilot

He held a valid commercial pilot's certificate with multi-engine land and sea ratings. As of June 1959 when he applied for his last physical examination, he had flown a total of 6 500 hours and more than 100 hours on this model aircraft. Some of his piloting had been of a nature requiring instrument flight, however, he did not have an instrument rating.

Operator

Although this flight was being conducted as a charter operation, no Alaskan air taxi operator's certificate, as required by Part 293 of the Board's Economic Regulations, had been issued to or applied for by the operator, Bailey Enterprises, Inc., an Alaskan corporation.

Fuel

At Kotzebue the aircraft was fuelled to its capacity of 206 gallons of gasoline and 7-1/2 gallons of oil were added. The entire flight of 5 hours and 36 minutes from Kotzebue to the accident site was made on 206 gallons of fuel.

Gross Weight

Upon departure from Kotzebue the gross weight of the aircraft was computed to be approximately 8 600 lb. The maximum certificated gross weight of the aircraft is 7 850. At the time of the crash, however, the aircraft was approximately 450 lb under its maximum gross weight. At that time it was completely, or very nearly, out of fuel.

Weather

Between Tanana and McGrath, during the period from 1900 to 2300 hours, conditions were as follows: broken to overcast cloud layers based at 3 000 to 4 000 ft amsl along the entire route; also patches of broken stratus occasionally forming near 1 500 ft; visibility was at least 10 miles except when briefly restricted to 2 miles in very light rain or drizzle; tops of the cloud layers over Tanana were 14 000 ft amsl, sloping to 6 500 over McGrath; freezing level over Tanana was 5 000 ft amsl, sloping to 3 500 ft over McGrath.

Surface winds along the route were westerly of less than 5 kt, becoming northwesterly 10 kt at 2 000 ft and northerly 10 to 15 kt between 5 000 and 10 000 ft amsl. Over the northern two-thirds of the route occasional light icing would have been experienced in the clouds above the freezing level to 11 000 ft. Turbulence was unlikely except for possible light turbulence near Tanana. Over the remainder of the route and in the McGrath area light icing was present in the clouds and in precipitation above the freezing level.

The Final Flight (see Figure 9)

The series of events leading to the accident could not be definitely established. The last three-quarters of an hour of flight was in darkness, over a wild and uninhabited region completely without lights, and under an overcast. There was no ADF in the aircraft as it had been removed for repairs and the pilot was, therefore, limited to using the low-frequency radio ranges. Under these conditions navigation would have had to be by dead reckoning or by reference to low-frequency ranges. The pilot had nearly 2-1/2 hours of fuel upon leaving Tanana for a flight which he estimated would take about 1-1/2 hours. However, he became lost and consumed considerable time and fuel before reaching the general vicinity of McGrath, which is approximately 166 miles to the southwest of Tanana. Based on conservative consumption figures, the fuel would have been completely or very nearly exhausted at the time of the accident. After receiving terrain altitude information from McGrath the pilot climbed into the overcast to ensure ground clearance. Shortly thereafter he gave the message, "At 5 000 ft, in the soup, ... Radar will have to get me down." He had climbed into adverse weather.

The record indicates he had some practical experience with instrument flight, however, he was not able to cope with the circumstances. The aircraft went into a tight, fast, steep spiral from which, because of his limited instrument experience, the pilot was unable to recover.

All major components of the aircraft were accounted for at the site of the accident which was at an elevation of 1 800 ft asl. Because of the localized wreckage, it was concluded that there was no inflight failure. A brief fire following impact suggests that there was little or no fuel left in the aircraft's tanks.

The pilot had advised that he had seen the lights of McGrath. He may have lost them as he descended and a hilltop have blocked his vision. It is unlikely that he could have mistaken other lights for McGrath as there were no clusters of lights between him and McGrath.

The weather encountered was substantially as forecast. He should not, therefore, have been hampered by unexpected weather conditions when nearing McGrath.

Probable Cause

The pilot lost control of the aircraft while flying under instrument flight conditions and was unable to recover it. Other factors contributing to the accident were poor flight planning, possible fuel exhaustion and the pilot's lack of instrument proficiency.

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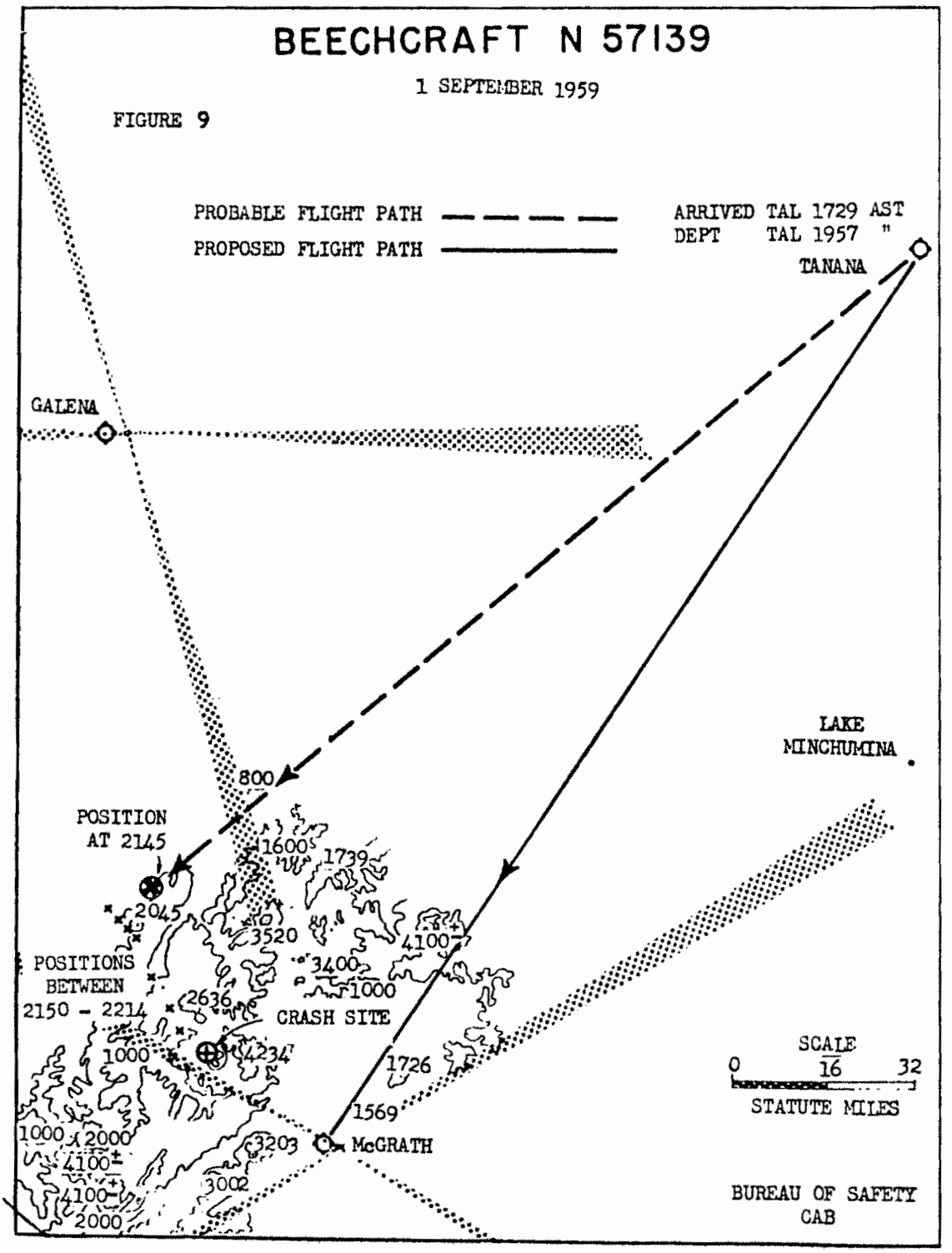
BEECHCRAFT N 57139
1 SEPTEMBER 1959
FIGURE 9
PROBABLE FLIGHT PATH
PROPOSED FLIGHT PATH
ARRIVED TAL 1729 AST
DEPT TAL 1957 "
TANANA
GALENA
LAKE
MINCHUMINA
800
POSITION
AT 2145
1600
1739
2045
3520
4100±
POSITIONS
BETWEEN
2150 - 2214
3400
1000
2636
CRASH SITE
1000
4234
1726
1569
1000
2000
4100±
3203
McGRATH
4100±
3002
2000
SCALE
0 16 32
STATUTE MILES
BUREAU OF SAFETY
CAB

No. 44

AAXICO (American Air Export and Import Company), Curtiss C-46, N 5140B, accident at Dyess Air Force Base, Abilene, Texas, on 2 September 1959. Civil Aeronautics Board (USA), Aircraft Accident Report, File No. 1-0054, released 4 April 1960.

Circumstances

Trip 7002, an air cargo flight, originated at Kelly Air Force Base and was to proceed to Dyess Air Force Base at Abilene and then on to Carswell Air Force Base. At approximately 1631 hours, 20 minutes after taking-off from Dyess on a VFR flight with 2 crew aboard, the flight advised Abilene, Texas, Municipal Tower that it was returning to Dyess because of an emergency - the elevator controls were inoperative, and the aircraft was being flown on autopilot. Shortly thereafter, the captain requested GCA assistance. During the attempted landing at Dyess, the aircraft crashed on runway 16, killing those aboard.

Investigation and Evidence

The Aircraft

A No. 2 maintenance inspection of N5140B had been completed on 2 September 1959 by Associated Airmotive, Inc. of San Antonio, Texas, an approved repair station which performed under contract with Aaxico. Trip 7002 was the aircraft's first flight following that inspection.

The Crew

Both pilots were currently certificated and were experienced C-46 pilots.

The Final Flight

Having contacted Dyess Tower and reported the emergency, the pilot requested GCA assistance and was advised to switch to the GCA frequency. At approximately 1645 GCA had positive radar contact. The captain requested a straight-in approach to runway 16, which is 13 500 feet in length. GCA assisted as requested with regard to alignment, elevation and distance information. A short distance from the runway threshold and about 50 feet above the ground, the approach was discontinued, and the aircraft then proceed several miles north of the base. The captain stated that he was going to try and land the aircraft on elevator tab instead of autopilot as he could get better control by using power and trim.

The flight manoeuvred with GCA assistance for a long final approach - about 9 miles. The position of the aircraft on the glide path was good, a close observer noting that pitch control was better but still jerky and overcontrolled. Touchdown was at 1715. It was a "wheel landing" with the aircraft's speed greater than normal and with considerable power. The wing flaps appeared to be extended between 10 and 20°. The touchdown was considered excellent by all observers. The aircraft rolled on the main wheels for the next 500 - 1 000 feet without an audible power reduction. It then skipped about 1 - 2 feet above the surface and again contacted the runway on the main gear only. This contact caused the tail to rotate downward and the aircraft "porpoised", leaving the runway nose-high. It reached 4 - 6 feet, then descended slightly nose-down and again contacted the runway, this time with greater force on the main gear. The force amplified the downward tail rotation causing a second, more severe, "porpoise". At this time, power, estimated by several observing pilots as full power, was applied. The aircraft climbed in a steep nose-up attitude to 150 - 200 feet above the runway. There it stalled, pitched down violently, and crashed on the runway in a nose-down angle in excess of 45°.

The fuselage forward of the leading edge of the wing was demolished by impact. This section was torn off and moved 425 feet ahead of the remaining aircraft structure when the cargo broke loose and shifted forward with great force. The left wing was sheared off at the attachments to the fuselage, and the right wing remained attached only by control cables. Both engines were torn from the mounts.

Technical Investigation

As the captain had indicated an elevator control failure, the longitudinal control system was immediately examined. It was found that the aft or bearing end of the link assembly was disconnected from the clevis in the elevator control tail section assembly. The bolt (AN 5-12 specification), which normally connects the link assembly and the clevis, was missing. The components which comprise the link assembly-clevis attachment were undamaged. Stress analysis data and tests by the National Bureau of Standards showed that the strength of the AN 5-12 bolt was greater than the strength of several other components which comprise the link assembly-clevis attachment. This conclusively proved that if an AN 5-12 bolt had been in place in the attachment, high impact forces could not have sheared the bolt without badly damaging the components... on this evidence the Board concluded that the AN 5-12 bolt which normally secures the link assembly-clevis attachment was not in place when the aircraft crashed.

During a search of the tail area, a bolt of the same size and specification as the missing one was found on the right side of a shelf of a bracket aft of and above the link assembly and clevis attachment and separated by a bulkhead containing 3-1/2 inch lightening holes. The bolt did not have a washer, castellated nut, or cotter key on it, and no such item which would fit the bolt was recovered. It had been recently used and though unidentifiable with the specific link assembly from N 5140B it had markings which showed that it had been installed in an assembly with the same dimensions as the clevis forks and bearing bore of that link assembly. Rather than believe that this recovered bolt had been left in the tail durin previous maintenance, the Board was of the opinion that this was evidence that the bolt was the one holding the attachment together immediately prior to the accident. In view of inflight jostling, and forward and aft forces at the time of the accident, it was quite possible that the bolt could have reache the location where it was found.

From analysis and conclusions, it was determined that the bolt had not been proper secured nor had this condition been detected during an inspection two hours before the accident. The bolt had, therefore, worked out of the attachment and loss of control followed. The effect of this disconnect condition would be the loss of all longitudinal control except that obtained through use of the elevator trim tab system and that which could be obtained by manipulation of engine power. Under this condition the autopilot could not be used for pitch control; however, both the manual control system and the autopilot system could be used normally to furnish lateral and directional control.

Various radio transmissions of the captain were then discussed as their meaning were not entirely clear. It was finally agree that they were all subject to a single interpretation - the captain had elevator control when the autopilot was engaged. In the light of circumstances and physical evidence the most reasonable interpretation was that all pitch control was lost except that which could have been obtained from power and trim and that this condition was not altered by using the autopilot.

It was clear that the captain did use the autopilot but not that its use restored the lost elevator control which was initially reported. It was believed that the pilot used the autopilot for lateral and directional control in combination with power and trim for pitch control.

The fact that longitudinal control was not provided by the autopilot was clearly

suggested when the captain was using the autopilot and transmitted, "Am going to try dropping my gear pretty soon to see if I can maintain tail trim." Also, when he said, "Have to make a pass or two and get my power and trim figured out on this thing."

Following the first approach the pilot transmitted, "I'm going to try to land on elevator tab instead of autopilot. I get a little better control using power and trim." Out of context this transmission could indicate the pilot had or thought he had pitch control on autopilot. In context with the other transmissions and in consideration of the emergency, it was the Board's judgement that the pilot meant he was discontinuing use of the autopilot and the power and trim combination. It meant he would use manual control for lateral and directional control and power and trim for control in the pitch axis.

Operationally, without normal elevator control, landing the aircraft using power and trim would be a most difficult task. During the approach the pitch control would lack "feel" normally obtained through the yoke. Overcontrol would be unavoidable because of the jerky and lagging response of the aircraft to power and trim. Further, these difficulties would be increased greatly because the manner of control required increased hand movements and would entail a sudden departure from orthodox procedures. Once the aircraft was on the runway the slightest irregularity in the runway or wind gust could cause it to bounce or "porpoise". Considering all the operational circumstances, to prevent the bounce from becoming a "porpoise" or to damp the "porpoise" using power and trim would be extremely difficult. In view of the foregoing, the Board was of the opinion that there were no operational factors that caused or contributed to the cause of this accident."

Probable Cause

The probable cause of the accident was loss of elevator control because of an improperly secured bolt, a condition which was undetected because of an inadequate inspection.

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ICAO Ref: AR/622

AAXICO AIRLINES, INC.
SEPT. 2, 1959
DYESS AFB, ABILENE, TEX.

FIGURE 10

THE BOLT WHICH NORMALLY CONNECTS THE CLEVIS AND LINK ASSEMBLY WAS MISSING

No. 45

Mooney M-18, N 4174, accident near Butler, Pennsylvania, on 7 September 1959. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 2-1027. released 21 June 1960.

Circumstances

The flight was to be a local VFR proficiency flight of approximately 20 minutes. The aircraft took off at 1415 hours eastern daylight time and climbed to 1 500 ft northwest of the airport where several "lazy-eight" manoeuvres* were executed. At about 1430 hours the aircraft was seen in straight and level flight on a southerly heading. A loud crack was heard and parts separated from the aircraft. It then went into a spin and crashed 1-1/2 miles west of the Culmerville Airport near Butler, fatally injuring the pilot.

Investigation and Evidence

The Aircraft

The Mooney aircraft is a single-engined, single-place, low-wing monoplane. Production of the Model 18 ceased in 1956.

N-4174 had a valid airworthiness certificate which had been issued on 5 January 1959. Its last 100-hour inspection was on 26 August 1959 and since that date it had flown only six hours.

The Pilot

He held a valid Federal Aviation Agency commercial pilot's certificate with a rating for single-engined land aircraft and an instrument rating. He had flown a total of 900 hours, 1 hour 40 minutes of which had been on N-4174.

Analysis

Several aircraft parts were found back along the flight path and confirmed the observations that an inflight structural failure had occurred. The right side of the horizontal stabilizer was found 2 600 ft northwest of the main wreckage site; the right elevator was found 1 100 ft northwest; and the fin and rudder, plexiglass, and a piece of right wing plywood were found 550 ft northwest of the wreckage.

Evidence indicated that the initial inflight failure occurred when the glue joint of the No. 2 rib separated allowing the trailing edge member of the right horizontal stabilizer to pull out. Airload bowed the elevator down in the middle, its inboard and outboard hinges remaining intact. As the elevator was bowed downward and the lateral distance between the inboard and outboard hinges decreased, an abnormally high downward loading was consequently imposed on the stabilizer, failing it downward at its attach point. It is probable that as the stabilizer separated from the aircraft the outboard elevator hinge failed and the elevator remained attached to the aircraft momentarily until the inboard hinge also failed. This was indicated by the location of the stabilizer farther from the wreckage than the elevator.

The immediate result of the loss of the stabilizer was a violent nosedown pitching of the aircraft, which failed the right wing spar downward in two places. Following this the aircraft rolled rapidly to the right and the vertical fin separated.

* An advanced flight training manoeuvre which combines the dive, the turn, and the climb.... it does not impose excessive or abnormal loads on the aircraft when properly executed.

The aircraft then fell nearly vertically to the ground.

The generally poor condition of glued wood joints found throughout the aircraft appeared to be a result of poor production techniques. Although deterioration from weathering was noted in some which had failed, it was not believed to have been of such a degree as to cause separation with little or no wood failure. The design practice of using glued butt joints without gussets or the equivalent was considered poor. In the later models 20 and 20A of the aircraft this problem is overcome because the stabilizer and wings are completely covered with plywood and this surface acts as gusset for the structure.

Similarly, poor production techniques were noted in numerous welds throughout the aircraft. Because of poor penetration, several had failed in the weld deposit or at the juncture of the weld deposit and the parent metal. The weld should, if properly made, be the strongest point in the tubular member and loads exceeding design strength of the part should fail it at a point adjacent to the weld rather than through the weld itself.

Probable Cause

The probable cause of the accident was an inflight structural failure brought about by the separation of an improperly glued wood joint.

Corrective Action

As a result of recommendations made by the Board to the Administrator of the Federal Aviation Agency following this investigation, the latter issued an airworthiness directive to correct deficiencies existing in production techniques and design practices.

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No. 46

Danfoss Aviation Division, Tipsy Nipper, OO-DAN, accident at Sønderborg Aerodrome, Denmark, on 12 September 1959. Report released by the Director of Civil Aviation, Denmark.

Circumstances

The pilot took off at 1540 hours in good weather conditions from Sønderborg on a familiarization flight. Several turns of 360° were carried out over and near the aerodrome. The banks were considerable and the aircraft lost height. At a height of approximately 100 m the aircraft overflew the western part of the aerodrome in a south to north direction and made a narrow right turn of 720° which ended in the crash. The pilot was killed, and the aircraft was destroyed. There was no fire.

Investigation and Evidence

A delegation from the Belgian civil aviation authorities and manufacturers and accompanied by representatives from the Danish civil aviation authorities visited the aerodrome on 15 September to look into the circumstances of the accident.

The Aircraft

The aircraft had a valid Certificate of Airworthiness. It had left the factory only two days before the accident and had flown only nine hours. At the time of the accident the weight of the aircraft was less than the maximum permissible and the centre of gravity was within the specified limitations.

The Pilot

The pilot, aged thirty-four years, had commenced flying training in June 1958. He held a valid Danish private pilot's licence - his flying experience totalling about 70 hours.

Prior to the subject flight the pilot had been briefed on the aircraft and its flying characteristics. However, the time allowed for instruction on the aircraft appeared to be comparatively short considering the fact that he until then had only flown K. Z. III aircraft and was not a very experienced pilot.

Reconstruction of the Flight

Following a normal take-off the aircraft climbed to 300 m on heading 140 - 150°. Northeast of the aerodrome the aircraft made one or two 360° turns to the left with a bank of about 45° whereupon it continued the flight to the left of the aerodrome. When right over the public enclosures near the southern boundary of the aerodrome, the aircraft made another one or two left 360° turns under considerable banking, at the same time waving its wings.

This caused the aircraft to lose height but, levelling off at a height of 100 - 150 m, it continued the flight on heading 360° over the western part of the aerodrome. Reaching the northern boundary of the aerodrome, the aircraft banked slightly to the left, as if commencing a turn, but immediately thereupon, turning to the right, the aircraft dropped its nose and the angle of bank was increased to 50 - 60° whereby the aircraft turned into a rather steep right spiral.

When the aircraft in this way had turned 360°, it appeared as though the pilot tried to restore it to normal position but failed to do so, and the steep right spiral was continued until the aircraft struck the ground at an angle of 40 - 45°, on a heading of 360° and under a bank of 10 - 15°.

Medical Aspects

The pilot's latest medical examination with a view to renewal of licence was undertaken on 20 May 1959. This examination revealed inter alia that systolic and diastolic blood pressures were respectively 120 and 80 - 90. The result of the examination was approved without comments by the Danish Directorate of Civil Aviation on 2 June 1959.

A post-mortem certificate showed that the deceased was a very well-fed man, that his heart was rather small in proportion to the weight of his body and in places unusually thin-walled and that he suffered from pronounced arteriosclerosis.

On the basis of the port-mortem certificate and the endorsement on the death certificate by the medical officer, reading: "The cause of death is a rupture in the heart where also changes in the coronary artery were found, wherefore the possibility of a sudden indisposition during the flight cannot be ignored", the Directorate of Civil Aviation calculated the g-forces on the pilot when subject to varying banks.

At a bank of 30° the force is 1.15 g
At a bank of 40° the force is 1.3 g
At a bank of 50° the force is 1.55 g
At a bank of 60° the force is 2.0 g
At a bank of 70° the force is 2.9 g

It was not possible to determine whether the rupture in the heart occurred while the pilot was piloting the aircraft. The possibility of a sudden death from heart attack must, therefore, be left out of consideration. However, the possibility cannot be precluded that the pilot during the flight, having been exposed to g-forces perhaps right up to 2.9, may have been suddenly indisposed.

His very unorthodox flying at a very low height over the aerodrome would seem to suggest that he may have been subject to a sudden indisposition during the turns he made over the public enclosures.

Probable Cause

On the basis of the results of the post-mortem examination it cannot be precluded that the pilot in the course of the flight may have become subject to a sudden indisposition so that the aircraft during the last phase of the flight was partially out of control.

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ICAO Ref: AR/608

No. 47

Viação Aerea São Paulo, Scandia, PP-SQV, accident at Vila Clara City, São Paulo, Brazil, on 23 September 1959. Summary Filing Form dated 15 December 1959 released by The Ministry of Aeronautics, Brazil.

Circumstances

About one and one-half minutes after take-off from the São Paulo Aerodrome on a scheduled flight to Rio de Janeiro the aircraft was seen flying at a low altitude and (at approximately 1849 hrs local time) it finally collided violently with the ground and caught fire. The 4 crew members and all 16 passengers aboard the aircraft were killed, and the aircraft was completely destroyed.

Probable Cause

The cause of the accident could not be determined.

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No. 48

Reeve Aleutian Airways, Inc., Douglas C-54B-DC, N 63396, accident on Great Sitkin Island, Aleutian Chain, Alaska on 24 September 1959. Civil Aeronautics Board (USA), Aircraft Accident Report, File No. 1-0059, released 30 August 1960.

Circumstances

Flight 3, a scheduled flight between Anchorage and Shemya, was to make intermediate stops at Cold Bay and Adak, Alaska. Following a routine trip to Cold Bay it took off from there at 1419 hours Alaska standard time on an IFR flight plan. Five crew and eleven passengers were aboard. At 1650 it reported it was 100 miles northeast of Adak, at 4 500 ft, on top and in the clear, estimating it would be over the Adak low frequency range at 1725. The flight was cleared to the Adak low frequency range, to maintain VFR on top, and to call Adak approach control on 126.18 Mc/s when 30 miles out for landing instructions. It advised the company at 1715 that it was cancelling its IFR flight plan and was proceeding VFR. Two minutes later the flight tried to communicate with Adak approach control... "Adak approach control from Flight 3, 126.18." Approach control's attempts to reach the flight following this message were unsuccessful. It was later learned that the aircraft had crashed at about 1717 hours on Great Sitkin Island, killing all occupants.

Investigation and Evidence

Great Sitkin Island is composed of volcanic rock which rises from the ocean to a height of 5 740 ft.

The wreckage was located on the northeast side of the island at an elevation of 2 100 ft on a 30-degree slope. It was determined that at impact the aircraft was making a right climbing turn and that it struck the mountain when heading 285° magnetic.

All landing gears were retracted when the accident occurred. An examination of the propeller domes of Nos. 1 and 2 propellers showed that the blades of these propellers were positioned 18° and 23°, respectively, from their low-pitch stops. These readings indicated that the engines were developing power at impact.

Readings of all instruments recovered were determined to be unreliable. No evidence was found which indicated that a malfunction of the aircraft or its components had occurred or that fire had occurred prior to impact.

Examination of the company's maintenance records showed the aircraft to be in an airworthy condition for this flight.

It was further determined that the pilot, co-pilot and flight engineer were in their respective seats with their safety belts buckled, and that all passengers were seated with their seat belts fastened at impact.

Weather

Great Sitkin Island was completely obscured by clouds of an orographic formation above the 1 500-foot level. Clouds surrounding the island were in two layers. The upper layer was thin with its top at 7 000 ft and its base somewhat below this level. The lower layer had its top at 4 000 ft and a base at 1 500 ft. Each layer virtually created an overcast condition with very small breaks, if any, in the lower deck. Both layers converged over Great Sitkin Island resulting in a solid cloud condition. There was no fog,

precipitation, or turbulence of any consequence immediately adjacent to the route involved.

The Captain

He held an airline transport pilot's certificate with DC-3, DC-4, Sikorsky S43 and Curtiss C-46 type ratings. His last proficiency check was on 14 September 1958, and his last FAA first-class medical examination was on 26 March 1956. He had flown a total of 12 853 hours of which 1 278 were in DC-4 equipment and had flown this route for several years while employed by Reeve Aleutian Airways.

The captain was also the company's chief pilot and, therefore, had certain company responsibilities which included - proper accomplishment of all pilot en route and proficiency checks when due, the maintaining of all records pertaining to flight, and the maintaining of records pertaining to the currency of pilots' medical certificates.

Examination of the records showed that he and two other captains were overdue for their proficiency checks. Other records in the company files indicated that the captain had taken each succeeding physical examination required after 26 March 1956. However, there were no Federal Aviation Agency or designated medical examiners' records found to substantiate them.

During subsequent inquiries made it was disclosed that the captain suffered from glaucoma and cerebrovascular disease, however, it was not possible to perform an autopsy to find out to what extent he had been affected. This type of disease may lead to total immobilization, partial immobilization and disturbance of memory, judgement and reasoning. Poor judgement, one of the results of this disease, may have caused him to attempt to proceed visually under conditions in which better judgement would have caused him to be more cautious.

A FAA representative testified that periodic spot checks of the company's records had been made and nothing was found to indicate that they were not in order. He further testified that if a pilot was asked if he had a valid medical certificate and he replied "yes", the FAA inspector was not required to actually inspect the certificate for validity. The Board believed that if an FAA inspector had asked for the captain's medical certificate to examine it, during the three years it was not current, the lack of its validity would have been discovered.

The Flight - Discussion

Throughout the flight from Cold Bay to the last reporting point, all reporting points were reached approximately when estimated. From this fact it must be concluded that the captain could have easily computed his position at the time he cancelled the flight plan and should have known approximately how far he was from the only obstacle of any proportion along the course. Since Great Sitkin Island is 5 740 ft in height and at the time was obscured from the pilot's view by converging cloud layers as well as the orographic formation surrounding the mountain, and since the flight was cruising IFR on top at 4 500 ft, it is obvious that a change of course or altitude had to be made to avoid it. If the captain had elected to continue IFR, under the existing weather conditions, he would have had to change course, climb and maintain VFR on top, or request an amended clearance for an altitude assignment of at least 8 000 ft (the minimum en route altitude). To do this would have taken very little extra time and this should not have been a deciding factor because the airplane was to remain overnight in Adak and no other uses were scheduled for it. The captain did not elect to take any of the above courses of action, but instead decided to cancel his IFR flight plan and proceed VFR.

At the time this decision was made, the aircraft was computed to be approximately 35 nautical miles from its destination and about 9 nautical miles from Great

Sitkin Island. Due to the lack of precise information, it is not definitely known what the cloud coverage was where the descent was begun; however, it is believed that it was slightly better than that in close proximity to Great Sitkin Island. It is logical to assume that a pilot with this captain's experience and background would not deliberately descend into a solid cloud condition after stating that he was going to proceed VFR. He must have thought that he could descend to a safe altitude below the clouds in accordance with visual flight rules and proceed in this manner to his destination.

Since the aircraft was apparently in clouds just prior to impact, the Board concluded that the pilot, for reasons unknown, did not continue to maintain visual reference to the extent necessary to navigate successfully through hazardous terrain.

It also concluded that the pilot did not know his exact position when he began the descent and thought he was either to the right or left of course or beyond the mountain.

Probable Cause

The probable cause of the accident was the captain's failure to maintain flight in accordance with visual flight rules during a descent over hazardous terrain.

Corrective Action

As a result of the accident, all approaches into Adak are now to be made in accordance with instrument flight rules. Photographic copies of each pilot's medical certificates are to be made upon the pilot's receipt of the certificate and placed in the file.

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ICAO Ref: AR/641

No. 49

Saudi Arabian Airlines, DC-4, HZ-AAF, made a wheels-up landing at Jedda, Saudi Arabia on 25 September 1959. Report released by the Director General of Civil Aviation, Saudi Arabia.

Circumstances

The aircraft took off at 1404 hours on a special flight from Jedda to Ryiad carrying a crew of 5 and 67 passengers. Following landing gear retraction, the aircraft began to climb rapidly at an abnormal rate, and the crew were unable to force the control column forward to resume a normal flying attitude. Full forward trim was applied and as the aircraft approached a stall, the power was reduced to lower the nose. The aircraft stalled and then descended at almost a 90° angle. Power was reapplied, and the control column was pulled all the way back by all the crew members in the cockpit and the aircraft recovered from the dive at a very low altitude and then began to climb again and approached another stall. Power was again reduced to avert a stall and the aircraft was turned to the left in an attempt to return to the runway. Still another stall was averted by reducing power and as a return to the runway was impossible the captain landed the aircraft with the landing gear retracted in an open spot at the north end of Jedda aerodrome. There were no fatalities, however, the aircraft sustained major damage.

Investigation and Evidence

From statements of the crew and ground observers it was estimated that the aircraft reached a height of 800 - 1 000 ft during the initial climb before it stalled. It recovered from the stall at a height of 100 - 200 ft above the ground. The second climb reached a height of approximately 500 ft before a partial stall occurred and then the aircraft continued at a very low altitude until contact with the ground was made.

Aircraft History

The aircraft received a zero time overhaul early in 1958, was test flown and then returned to Jedda in September to routine airline operation. At 200 hours flying time (2nd maintenance inspection) the gust lock was written up as too stiff to unlock from the floor, or unlock position. The gust lock handle and the latch assembly were checked and signed off as operating normally, and the aircraft returned to airline operation.

In March 1959 on another maintenance inspection the gust lock handle was written up as "hard to lock down". Corrective action was taken.

In September 1959 during a subsequent inspection as the tail skid fairing was rusted around the attached screws and skin washers, it was decided to remove the complete tail skid assembly, and route the assembly and fairing to the shops for repair and back to the aircraft for installation.

Inspection after the Accident

After the accident it was revealed that the elevator would not move past the neutral or nose down elevator position. It was also noted that the control unlock arm was not properly locked down in its respective position, which is flush with the cockpit floor, but raised to an angle of approximately 15°. Further checking revealed that the tail skid fairing, cable and spring assembly was installed on the elevator control locking assembly. With the above conditions there is enough spring action inserted on the elevator locking assembly in the tail section to flip the

elevator control lock assembly to a locked neutral position, and no forward movement of elevators or nose down control of the aircraft is possible. When the control unlock arm was at an angle of 15°, with the incorrect installation of the tail skid fairing spring connected to the elevator locking assembly, the elevator down travel was blocked at the neutral position. Ailerons, rudder and aft movement of neutral position were normal when the tail skid spring was attached to the elevator control lock assembly.

Correct locking procedure for locking flight controls on DC-4 aircraft in neutral position is to unlatch the control lock handle from the locked position on the cockpit floor. When the handle is raised to approximately 60° the ailerons will lock and between 75 - 80° the elevators and rudder will lock almost simultaneously.

Statements of Crew Members

The flight mechanic stated that normally after the run-up was completed and prior to reading off the check list he secured the gust lock in the controls unlocked position by depressing it with his foot until he heard the latch click into position. The captain would grasp the tape from the gust lock control and let it retract slowly into its receptacle above the windshield. He stated that he followed this procedure during this flight and thought he had heard the securing latch click into position. He did not make either a visual or manual check to determine whether the gust lock was fully secured and the securing latch was fully engaged.

During the hearing the captain stated that after securing the tape from the gust lock into its receptacle above the windshield he checked that all controls had full free travel.

Crew Information

All the crew were well qualified in the type of aircraft involved, the only discrepancy noted was that the co-pilot's last physical examination was 7 July 1958.

Probable Cause

The flight mechanic failed to place the gust lock in the fully secured position to unlock the controls prior to take-off, and the spring holding the fairing on the tail skid was incorrectly attached to the elevator control lock mechanism. This spring tension caused the elevator gust lock to lock the elevator from down travel when the gust lock was not in the fully secured control unlock position.

A contributing factor was that neither the captain nor the flight mechanic checked visually or manually to see that the gust lock was in the secured position to unlock the controls prior to take-off.

Recommendation

It was recommended that Saudi Arabian Airlines include in their cockpit procedures, prior to take-off, a visual and/or manual check of the gust lock control to ensure that it is fully secured in the control unlock position.

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ICAO Ref: AR/605

No. 50

U.S. Overseas Airlines, Inc., C-54-G, N 4000A, accident near the U.S. Naval Air Station, Jacksonville, Florida, on 15 October 1959. Civil Aeronautics Board (USA), Aircraft Accident Report, File No. 1-0067, released 20 September 1960.

Circumstances

N 4000A had just taken off from Jacksonville U.S. Naval Air Station on a scheduled U.S. Navy contract cargo flight to the Marine Corps Air Station, Cherry Point, North Carolina, when it advised the FAA Imeson Airport departure control at Jacksonville that it was having trouble with No. 4 engine. Power was then lost on engine No. 3 followed by No. 2. At approximately 2105 hours eastern standard time, i.e. eight minutes after take-off, the aircraft was ditched in a small lake, caught fire and sank in 10 ft of water. The two pilots, the only occupants, were seriously injured.

Investigation and Evidence

Flight Personnel

The captain held a currently effective airman's certificate with airline transport and other appropriate ratings. He had flown a total of 12 166 hours, including 7 303 on C-54 type aircraft of which 6 500 were flown as captain. He had completed 240 flying hours in C-54-B series aircraft and 233 hours in C-54-E and G aircraft. His last previous flight was in a C-54-E series aircraft.

The co-pilot had flown a total of 9 025 hours of which 255 hours were in C-54's. During the previous 30 days he had flown approximately 70 hours in C-54 aircraft. He had flown a total of 209 hours in C-54-B series aircraft and about 47 hours in C-54-E and G series aircraft.

Weather

The recorded weather at the time of the accident was: broken clouds at 2 500 ft, 10 000 ft overcast; visibility three miles in fog and smoke. However, according to statements of the captain following the accident the actual weather was scattered clouds with visibility unlimited and the moon fully visible.

The C-54, Fuel Selector Positions

U.S. Overseas Airlines operates both 6 and 8-fuel-tank C-54's, which have different fuel selector positions. The 6-tank system has a two-position wing tank selector; the main tank positions are forward and the off positions are rearward. The 8-tank fuel system, which N 4000A had, has three tank selector positions; the auxiliary tank positions are forward, the main tank positions are centre, and the off positions are rearward.

The Flight

Following the pre-flight engine start and engine run-up, the aircraft took off at 2057 from runway 090 on an IFR flight plan, having been cleared direct to Jacksonville, Victor 3 to Brunswick, Georgia, to maintain 5 000 ft and climb on runway heading to 1 500 ft until further advised.

The crew stated that following take-off the gear retraction, power reduction, flap retraction and radio communications were routine. Upon reaching about 1 400 ft

the No. 4 engine surged. No. 4 throttle was retarded and again advanced but surging continued and the manifold pressure fell off. A check of the instrument panel revealed that all instruments were normal except the No. 4 fuel pressure and fuel flow which fluctuated. No fuel warning light was observed. The use of carburettor heat and selection of the low and high fuel booster pumps did not improve the conditions.

At 2101, the aircraft advised the FAA Imeson Airport departure control at Jacksonville it was having trouble with No. 4 engine and requested permission, which was approved, to circle east of Jacksonville Naval Air Station at 1 500 ft. The flight then requested a radar vector back to Jacksonville Naval Air Station and the pilot was instructed to turn to a heading of 275°. The following clearance was then given to N 4000A: "cleared to Navy Jacksonville low frequency range, maintain 1 500 ft, stand by this frequency." Neither the clearance nor the radar heading was acknowledged. At 2105 the radar blip of the aircraft disappeared.

Following loss of No. 4 engine, the pilot initiated a left turn toward the 275° heading suggested by departure control. During the turn the No. 4 cylinder head temperature decreased; the cowl flaps were then closed, and the captain had just decided to feather the propeller when the No. 3 engine began to surge. Feathering was then deferred, and the captain called for METO power. This power could not be obtained as No. 3 engine continued to surge. Five seconds later No. 2 engine began surging. During the emergency the co-pilot reached over and checked the position of the fuel selectors, but the captain did not remember whether they were moved from their positions.

The aircraft descended rapidly and hit several trees during the subsequent ditching attempt. It hit the water with wings level and in a tail-low attitude on a 25° heading.

Analysis

Analysis of all evidence indicated that the accident resulted from fuel exhaustion due to positioning the fuel tank selectors to virtually empty tanks prior to take-off. The 25 to 50 gallons of fuel in each auxiliary tank were sufficient to take off and reach the accident site, and the No. 1 fuel tank contained slightly more fuel than the others. It was also obvious that the co-pilot did not move the fuel selectors during the emergency, as considered possible by the captain, but mistakenly considered himself to be in a 6-fuel-tank aircraft and believed, therefore, that the forward fuel selector positions were correct for the main fuel tanks and merely made sure that they were positioned to the forward detents as found.

The flight crew suspected improper or contaminated fuel but that area was thoroughly explored and completely eliminated by the various laboratory analyses of fuel samples and investigation of airport fuel handling and dispensing. The main fuel tanks were filled to a total of 951 gallons, but the four auxiliary fuel tanks were not. Only 25 to 50 gallons of fuel remained in each of these tanks as indicated by the gauges when checked by the previous flight crew.

While it was not unreasonable for the captain to have considered the possibility of improper fuel as a reason for the loss of power, the Board believed it should not have been accepted to the exclusion of fuel starvation. Fluctuation of fuel pressure and fuel flow should have alerted the captain to the actual difficulty, particularly in view of the surging of the engines and the fact that the fuel boost pump did not remedy the condition, and the fact that the low cylinder-head temperatures eliminated the possibility of the presence of jet fuel. Switching fuel selectors to another tank should normally be one of the first acts of a pilot after a sudden decrease of fuel pressure and fuel flow. In addition, the captain had four or more minutes to analyse his problem before impact.

Probable Cause

The probable cause of the accident was incorrect fuel system management, resulting in a power loss in three engines.

Remedial Action

As a result of this accident the company has blocked off the No. 2 and No. 3 tank selectors from the auxiliary positions on all 8-tank aircraft. Also, a large placard has been placed directly in front of the fuel tank selectors in all C-54 aircraft stating whether the aircraft has a 6- or 8-tank fuel system. The C-54 checklist has also been revised to require a response after MAIN TANKS of "Full Forward" on the 6-tank system, and "Centre Position" on the 8-tank system.

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No. 51

Boeing Airplane Company, Boeing 707-227, N 7071, crashed and burned in the Stillaguamish River, 10 miles northeast of Arlington, Washington, on 19 October 1959. Civil Aeronautics Board (USA), Aircraft Accident Report, File No. 2-1754, released 20 June 1960.

Circumstances

The aircraft was on a demonstration and acceptance flight prior to it being delivered to a customer. The flight time was also being used to train airline personnel on the aircraft. While the instructor-pilot was executing a "Dutch Roll", the roll bank angle of the aircraft reached 40 to 60°, which is in excess of the limitations for demonstration of this manoeuvre.* During an improper recovery attempt by the pilot-trainee, structural failures occurred which resulted in violent gyrations of the aircraft. Control was then regained, and it was determined that three engines had separated, and the aircraft was on fire. An emergency landing was attempted, but the aircraft struck trees and landed short of the intended landing area. Of the 4 crew and 4 passengers aboard, all crew members were fatally injured.

Investigation and Evidence

Crew Information

The instructor-pilot, a test pilot, held a FAA airline transport pilot's certificate with a rating in the B-707. Of 5 015 flying hours flown, 369 were in the 707 aircraft. He was fully qualified to act as instructor-pilot on this aircraft.

The pilot-trainee, employed by Braniff Airways in 1936, became a captain in April 1938 and was promoted to check pilot in January 1958. He held a valid FAA airline transport pilot's certificate with ratings in the DC-3, DC-4, DC-6, DC-7 and L-188 aircraft, and had flown a total of 23 563 hours. He had completed the Boeing Airplane Company pilot training ground school course, which consisted of 160 hours of instruction. This was his first training flight in preparation for checkout on the aircraft.

The Aircraft

N 7071 was a new model of the Boeing 707 series aircraft on which FAA type certification flight tests had just been completed. Final certification was awaiting verification of these test results and the aircraft meanwhile was being operated on an experimental certificate of airworthiness.

The "Dutch Roll" - Explanation

The term applies to a wallowing motion characteristic of swept-wing aircraft. During this motion the aircraft rolls right and left around the longitudinal axis while yawing right and left around the vertical axis. Angle of bank and degree of yaw are dependent upon the amount of force applied in initiating the Dutch Roll.

Normally the motion is caused by turbulent air or lateral overcontrol. The low lateral directional damping of swept-wing design allows the motion to continue at slow indicated airspeed.

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* The Boeing Airplane Company's training manual restricts the Dutch Roll manoeuvre to a desired maximum roll-bank angle of 15° and an absolute maximum of 25°.

Compensating for the Dutch Roll may be made by simply keeping the wings level. When the airplane is rolling in one direction or another, the aileron should be used to stop the roll and keep the wings level.

Another method is to apply cross-control. For example, if the aircraft is Dutch Rolling, left rudder and right aileron should be applied when the nose has started to swing from left to right with control forces slowly relieved as the aircraft's yaw angle diminishes.

Rudder application must be applied in the right direction or the Dutch Roll will be further aggravated. If there is uncertainty as to the rudder required, application of aileron only is recommended for recovery.

The damping in the lateral-directional mode is lowest when the angle of attack is high, so that at low indicated airspeeds with flaps up or down, the Dutch Roll will seem to be more pronounced. At high indicated airspeeds the natural yaw-damping forces minimize or tend to zero out any Dutch Roll tendencies.

The purpose of Dutch Roll familiarization is to introduce to the pilots, who are generally not acquainted with swept-wing airplanes, this inherent characteristic peculiar to the design.

The Flight

Shortly before departure, an IFR flight plan for the flight was cancelled, and the flight proceeded according to visual flight rules for approximately 4 hours and 15 minutes. The trainee, who was making his first flight in the aircraft, was in the left-hand seat and the instructor-pilot was in the right-hand one.

Following take-off, a series of manoeuvres were first demonstrated by the instructor, then executed by the trainee - included were Dutch Rolls in a clean configuration. The aircraft was slowed to 155 kt and 40° of flaps were lowered. Recoveries were then made by the trainee from further Dutch Rolls made in this configuration. During these rolls, initiated by the instructor, angles of bank greater than 25° were allowed to develop although the instructor was aware of the bank-angle restrictions and was also reminded of them during the flight. As the recoveries to this point had been made from the left (nose-left position), the instructor suggested that a recovery now be made from the right. He initiated another Dutch Roll in which the angle of bank was quite large. (Survivors estimated the aircraft rolled 40 to 60°.) Before attempting recovery, the trainee allowed the aircraft to complete several oscillations in each of which the roll-bank angle reached 40 to 60°. The trainee initiated recovery while the right bank was still increasing... he applied full right aileron control while the right wing was still moving downward. The aircraft immediately yawed heavily to the right and rolled rapidly right, well beyond a 90° bank. Immediately following application of the right aileron and early in the yaw-roll movement of the aircraft, the instructor took the controls and applied full left aileron. The aircraft's rolling to the right was stopped after the wings had passed the vertical and then rolled back left even more rapidly and violently than to the right. During these rolls the survivors saw the thrust levers snap, the cables go slack, and they heard sounds which could have been the engines separating from the aircraft. Movements described as spins and snap rolls followed. The aircraft rotated left, and the rate of roll finally slowed almost to a stop with the aircraft in an inverted nosedown attitude. The left roll continued and recovery was made to an upright position with the aircraft in a medium dive. A normal pullout was made during which it was noted that there was no thrust on engines Nos. 1, 2 and 4, and the thrust levers and start levers were completely slack. In fact engines No. 1 and No. 4 had broken away, and there was a large fire in the No. 2 engine area. The aircraft

continued its descent on a southeasterly heading down Deer Creek (see Figure 11) and made a gradual right turn to a heading of 230°. It was then almost at treetop level. It continued for about one mile, hit treetops and crashed in the Stillaguamish River bed approximately half a mile short of a large open field, which undoubtedly had been the intended landing area.

Damage to the Aircraft

Three of the four powerplants, with a major part of their pylons attached, had separated from the aircraft in flight. They were found 1 to 1-1/2 miles northwest of the main wreckage. Engines Nos. 1 and 4, with their nacelles, broke from the airplane in outboard directions. The No. 2 engine, with its nacelle, broke partially outboard but appeared to have rotated downward and rearward during its separation from the aircraft. No. 3 engine remained with the aircraft until impact. There were little or no indications of inflight fire damage to engines Nos. 1, 3 and 4. However, the cowling which fell with the No. 2 engine showed evidence of heavy smoke and sooting prior to impact.

The damage found on all four engines was the result of impact or minor ground fire. No evidence of operational distress or malfunction prior to impact with the ground was found. In addition, indications were that all four were rotating very slowly, if at all, at the time of the accident.

It was determined that the flaps were extended approximately 28° at impact.

The forward portion of the fuselage was almost completely destroyed by impact and the intense ground fire which followed. The aft fuselage, where the survivors were located, broke off just to the rear of the trailing edge of the wing and skidded out into the middle of the river. It was badly damaged by inflight fire and ground impact, but was intact and not subjected to the ground fire which consumed most of the other wreckage.

A section of the left wing tip, 16 ft long, was severed when it contacted trees on the north side of the river and came to rest across the river 50 ft before the first of the gouges which were dug in the ground by the remaining wing structure.

There was extensive inflight fire damage to the left wing in the area of No. 2 engine, to the entire left side of the aft fuselage, and to the left side of the empennage.

Analysis

There was little question that the violent gyrations of N 7071 which followed the improper Dutch Roll recovery attempt resulted in the separation of the three engines and the inflight fire. A safety factor is designed into the nacelle supporting structure so that, in the event of abnormal loading, it will fail before destructive loads are transmitted to the aircraft wing. Separation of engines from the aircraft is, therefore, expected when the aircraft is subjected to high abnormal loadings such as occurred in this case.

It was equally clear that the Dutch Rolls being performed reached angles of bank far in excess of the limitations established by the company. The Board could find no reason for the instructor-pilot's initiating the final Dutch Roll so violently. No training advantage could be gained by conducting these manoeuvres at the extreme angles of bank reached. He certainly should have been aware of this, and he was, admittedly, aware of the company's restrictions. In addition, it was surely less than prudent to permit a pilot with no previous experience in the airplane to attempt a recovery from this extreme manoeuvre.

The severity of the gyrations to which the aircraft was subjected developed loads greater than the design strength of the nacelle pylon structure. After the three engines were lost and while the flaps were still extended 40°, the airplane was

committed to land. The flaps may have been raised to the 28° position intentionally so that full outboard aileron effectiveness would be available during the landing. It is possible that in this configuration, with power available from the No. 3 engine, the airplane could have flown at least long enough to reach a suitable airport for a crash landing. However, the intense fire which is believed to have come from a ruptured fuel line, was threatening the left wing and made an immediate landing mandatory.

Lateral control with flaps down at least 28° is provided by the following: Outboard ailerons, 40%; outboard spoilers, 30%; inboard ailerons, 15%; and inboard spoilers, 15%. The outboard ailerons are moved by means of a cable bus arrangement actuated by movement of the inboard ailerons. As the fire gradually destroyed the inboard left aileron and the flight control components in that area, the outboard ailerons were lost. Loss of electrical power cut out the auxiliary hydraulic system which operates the inboard spoilers and the rudder boost. When the left inboard aileron was consumed the only lateral control remaining to keep the heavily damaged left wing up came from the right inboard aileron (7-1/2%) and possibly the right outboard spoilers (30%). Lift on the left wing was seriously impaired because of the loss of approximately 35 sq ft of upper surface which was burned through, the additional fire damage to the flaps which reduced their effectiveness, the extra drag from the No. 2 pylon stub, and the spoiler effect on the upper wing surface caused by ruptured skin over the fuel vent channels.

This drag, coupled with any appreciable thrust from the No. 3 engine, would force the left wing down. In view of the limited aileron control available, considerable right rudder would be required to induce a yaw to the right to assist in holding the wing up. However, with the rudder boost inoperative, there would not be sufficient rudder control available to induce enough yaw to counteract these forces. It is, therefore, apparent that the No. 3 engine was shut down prior to impact so as to be able to keep the wings level with the minimum amount of control available. This is also supported by the fact that the engine had almost stopped rotating at impact.

When the aircraft hit the trees on the north bank of the river and a 16-foot section of the left wing was severed, the control available was insufficient to maintain the wings level. As it crossed the river, the aircraft rolled rapidly to the left to a bank angle of approximately 55° and crashed on the south bank.

Changes following the Accident

Subsequent to the accident Boeing re-emphasized the roll-bank angle limitations and deleted demonstration of the manoeuvre with flaps down because recovery can be demonstrated equally well in the clean configuration. In addition, the Dutch Roll training has been moved back in the training programme so that trainees will be more familiar with the characteristics of the airplane when the manoeuvre is demonstrated.

The company has incorporated a full-time boosted rudder system in the aircraft. In addition, it has increased the vertical stabilizer area and has added a ventral fin. These changes are anticipated to substantially increase the low speed control characteristics of the aircraft.

Flight Recorder

N 7071 was equipped with a flight recorder, however, it was not in operation during this flight. Civil Air Regulations require the flight recorder to be in use during scheduled passenger operations only.

Probable Cause

The probable cause of this accident was the structural failures induced during an improper recovery attempt from a Dutch Roll which exceeded the angle-of-bank limits prescribed by the company.

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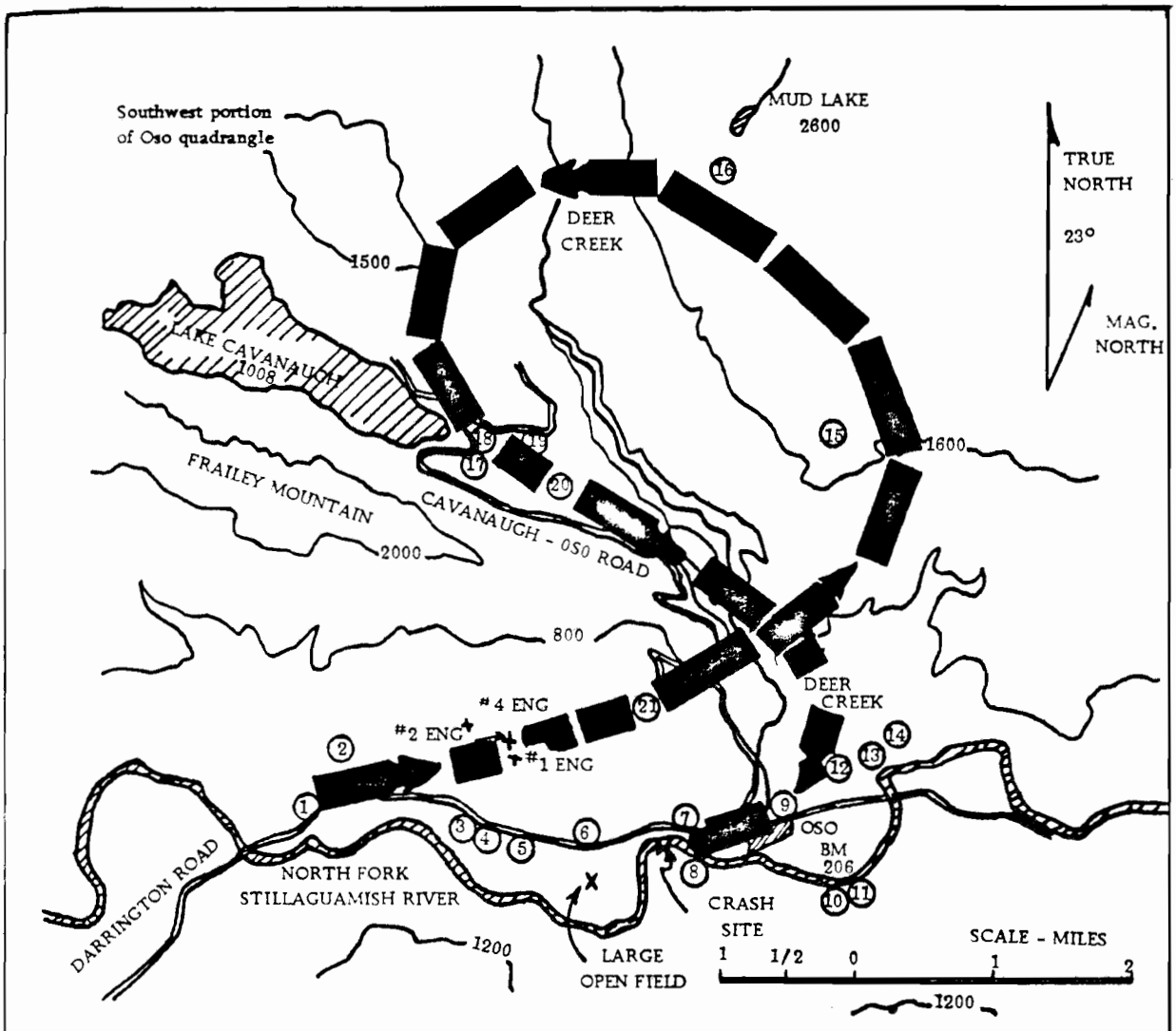
FIGURE 11



CIRCLED NUMBERS INDICATE

LOCATION OF EYE WITNESSES

Accident involving Aircraft N 7071
occurred one mile west of Oso,
Washington, on October 19, 1959

Prepared by
Civil Aeronautics Board
Bureau of Safety

USCOMM-DC-25360

No. 52

Pacific Air Lines, Inc., Douglas DC-3, N 67589, accident at Santa Maria, California, on 26 October 1959. Civil Aeronautics Board (USA), Aircraft Accident Report, File No. 1-0066, released 30 August 1960.

Circumstances

Flight 308 was scheduled between Los Angeles and San Francisco, California with stops at Oxnard, Santa Maria and Paso Robles. While at Santa Maria an oil leak from the left engine was brought to the crew's attention, however, it was not considered sufficient cause to interrupt the flight. The aircraft, therefore, proceeded to take off from runway 30 at 2016 hours with 17 passengers and 3 crew on board. A few seconds after the first power reduction following take-off, a loud explosion was heard and fire was seen in the left engine. The left propeller was feathered, the engine was shut off, and appropriate power was applied to the right engine. The aircraft was at an approximate altitude of 550 feet msl, or 300 feet above the ground. Shortly after this the fire was observed to be out; however, the aircraft began to buffet. The buffeting became so severe that the aircraft lost altitude and the captain had to make an emergency landing (at approximately 2018 hours Pacific standard time) about 1-1/2 miles north of the airport. The co-pilot was killed, the captain was seriously injured, and the passengers received injuries of varying degrees. The aircraft was substantially damaged.

Investigation and Evidence

The aircraft had struck the ground in a left-wing-low attitude and had cart-wheeled to the left on its nose. In so doing the left elevator struck a 12 000-volt power-line.

All of the aircraft structure, power-plants, and propellers were found either near the main wreckage site or on or adjacent to runway 30.

Examination of the wreckage showed that No. 5 cylinder of the left engine had failed and this occurred only seconds after take-off. Proof of the time of the failure lay in the fact that engine and cowl parts belonging to this engine were found on the take-off runway after the accident. The time of the failure was important because it indicated that it occurred very soon after take-off before any appreciable airspeed and/or altitude had been gained, and, therefore, narrowed the field of possible corrective action which could have been taken by the crew. This engine's ring cowl was badly deformed as a result of the failure and a section of it was displaced upward and rearward. The Board believed that the deformation of the cowling disturbed the airflow over the centre section and the empennage sufficiently to cause both severe buffeting and a serious drag condition.

Prior to impact the right engine had been functioning normally.

It was determined that all three blades of the left propeller were positioned at a blade angle of 73° at the time of impact. To be fully feathered the blade angle should have been 88°.

The blade angles of the right propeller were at approximately 23 or 24°, indicating that this engine was delivering power at impact.

Maintenance of the Aircraft

N 67589 was based at Los Angeles and, therefore, was under the supervision of International Flight Service with regard to maintenance. It had been given a 125-hour inspection 25 or 30 hours prior to the subject flight.

Several complaints had been made and were entered on the flight record of this aircraft about oil leaks on its left engine - these extended over the period 19 to 26 October. The owner of International Flight Service testified that his organization had done everything it could to find and stop the oil leaks under the limitations of their contract. The night before the flight was scheduled,the engine was washed down and corrective action taken; the cowling was then left off overnight in order to be able to see any oil which may have leaked during the night. None was found the next morning and the engine was then run until it was hot to see if oil might leak under this condition. Again no leak was found and, accordingly, the cowling was put on and the aircraft was made ready for flight. The engine was considered airworthy by the owner of IFS.

Maintenance facilities of the company in San Francisco were very good. However, in Los Angeles this was not the case. Proper records were not kept (e.g. no recent daily inspection forms were found for this aircraft after the accident), and pilots complained that an inadequate supply of parts was maintained. The owner of IFS testified that although the company did not always furnish them with the required inspection forms, all inspections were made as required and all work was performed by capable certificated mechanics in the same manner it would have been done if they had had the forms.

Analysis

The question arose, should N 67589 have been dispatched as a scheduled flight on the day of the accident in the light of its history of oil leaks?

The company had knowledge of the trouble with this engine from two sources - i.e., engine and aircraft records that are maintained in San Francisco and which should be kept up-to-date daily, and from a message which was sent by International Flight Service to the company from Los Angeles which clearly requested that the aircraft be returned to the main base (at San Francisco) because of an oil leak that could not be stopped. Knowing that oil leaks are often the forerunner of serious engine trouble, the Board believed that both the Service company and the Airline should have taken definite steps to determine that the engine was airworthy before allowing the aircraft to be used on a scheduled flight.

Since this was not done, the Board believed that when the crew found the oil leak at Santa Maria to be of a magnitude sufficient to cause the concern of a fellow company employee, the aircraft should have been delayed until the source of the trouble was determined.

As a result of this accident, the company decided to send its own maintenance personnel to Los Angeles to perform all future work on company aircraft.

Probable Cause

Following the failure of the left engine, the left engine's ring cowl was deformed causing a buffeting and drag condition which made sustained flight impossible. A contributing factor was the scheduling of the aircraft by the company when there should have been reasonable doubt concerning the airworthiness of an engine.

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ICAO Ref: AR/642

No. 53

Olympic Airways, DC-3, SX-BAD, crashed near the village of Avlon Attiki, Greece, on 29 October 1959. Report released by the Minister of Communications and Public Works, Greece.

Circumstances

Flight 214 departed Athens at 1501 hours en route to Thessaloniki, carrying 3 crew and 15 passengers. It was instructed to climb to 3 000 ft on a track of 240° and then to climb on course, having been cleared to fly at 9 000 ft. At approximately 1520 hours it called Tanagra Control and reported reaching flight level 90 over Mount Parnis and in visual meteorological conditions. This was the last contact with the aircraft. It crashed at approximately 1525 hours following loss of control. All aboard were killed.

Investigation and Evidence

The aircraft had been maintained in accordance with the approved systems and procedures and was airworthy at the time of the accident.

The captain had flown a total of 7 294 hours on DC-3 aircraft of which 4 305 had been as captain. The co-pilot had a total flying time of approximately 4 501 hours of which 106 were as co-pilot on DC-3's of Olympic Airways.

The weather conditions in the area at the time of the accident were as follows: surface winds southerly 20 - 30 kt, gusty; upper winds southwest 40 - 65 kt; slight rain on Mount Parnis; visibility was greater than 9 km outside the clouds; clouds - stratocumulus 2 - 3/8; cloud base 3 - 4 000 ft; a small layer of altostratus 6 - 7/8 at 9 000 ft; numerous disturbances below 6 000 ft, weak disturbances in the higher altitudes. The disturbances were in the form of up and downcurrents towards the leeward side. The changes of shape in the currents due to the mountain resulted in an upcurrent movement on the upwind side and downward movement on the leeward side. Reports do not suggest any form of mountain wave. The existing weather conditions were not considered to be a primary cause of the accident.

The Flight - General

It was calculated that the aircraft passed to the west of Mount Parnis peak at approximately 1523:52 hours and at an altitude of 8 100 ft.

The last contact with the ground services should have taken place at approximately 1523:5 hours - the time of 1515 hours reported by Tanagra was considered incorrect as at that time the aircraft was at 3 000 ft southwest of Athenai Central Airport and it was not possible for it to communicate with Tanagra on 119.7, very high frequency, due to the intervening mountain. The time 1520 hours reported by Athenai Approach Control appeared to be more accurate and closer to the most probable hour of 1523:5.

The distance between the point where the aircraft was at the last reporting time and the vertical trajectory from the point at which the aircraft fell could be covered normally within approximately one minute.

It was concluded that the malfunctioning of the aircraft's engine took place between 1523:5 and 1524:5 while it was flying within Tanagra Approach Control at 8 100 - 8 700 ft.

From the evidence available it was found that either the rapidity with which the

engine trouble developed did not allow the captain to feather the propeller before the engine was completely destroyed, or the feathering system did not function properly.

An unusually loud noise attracted the attention of several persons to the aircraft. They saw a part of the left wing and other parts of the aircraft falling. Some of the latter were blown apart by the strong prevailing wind as they fell. Immediately thereafter the aircraft turned 180° and started diving and spinning until it disappeared behind the Armenia hills.

The Wreckage

The main parts of the aircraft were found on the east-northeast side of one of the hills of the Drampalla hill range, which is 2.5 km south-southwest of the village of Avlon and 35.5 km on bearing 353° from Athenai Central Airport (and on the northern side of Mount Parnis.) This area is rocky, bushy and has a 1/2.5 incline.

Examination showed that the aircraft hit the ground at a very steep angle and at a high speed spinning to the left about its longitudinal axis.

None of the parts which became detached from the aircraft in the air and which were found away from the main wreckage bore signs of fire or explosion. These parts were the left wing, a part of the left aileron, part of the right elevator and the left propeller.

The following were found in the area of the main wreckage: the empennage with part of the fuselage, the right wing, the engines, the right propeller and a few parts of the fuselage. The left middle and forward part of the fuselage were completely destroyed by the impact and the fire that followed.

An intense fire started from the point of first impact and spread forward and to the left of this point to a distance of approximately 60 m. The fire was so intense that the majority of parts within the area were destroyed. These included instruments, controls and electrical systems.

Left Wing

The detached part of the left wing represented 60% of the surface of the whole wing. Examination of the spar and stringer broken surfaces indicated that failure occured due to combined bending and torsional loads. There were no signs of fatigue or explosion. On impact with the ground the wing had suffered little damage.

On this portion of the wing there were five cuts approximately parallel to each other and to the longitudinal axis of the wing and going through the upper and lower wing surfaces. Along the cuts all the ribs connecting the beams in areas corresponding to the cuts were sheared. The parts of the sheared ribs attached to the spars were all deflected to the left. Characteristic of the cuts was that the skin presented a classical case of shearing by a fast moving object. The edges of the skin at various parts of the cuts bore traces of black paint similar to that used on the rear surface of the propeller blades.

Left Propeller

It was found intact with its hub, dome and blades. The blades were found at the extreme fine pitch position and the rotating cam was against its fine pitch stops.

On all blade surfaces, from the middle portion to their tips, there were characteristic traces, the centre of curvature of which appeared to be the axis of the propeller.

The forward portion of the propeller shaft, 150 mm long, was found in the propeller hub. Laboratory tests conducted on the shaft portion found on the propeller indicated that the break surfaces bore no sign of fatigue, but failure was due to torsional overstressing. In accordance with the above, the remainder of the propeller shaft on the engine would protrude 70 mm forward of the reduction gear.

From the shape of grooves on the blades of the propeller it was concluded that the rotating propeller, subsequent to its detachment, contacted the protruding part of the propeller shaft which remained with the engine. The appearance and traces of the grooves indicated that the shaft was not rotating.

The part of the propeller shaft which remained with the engine was not found.

Left Engine

It was seriously damaged from impact and the fire that followed. The part of the reduction gear with the constant speed unit and the accessory drives was not found on the engine, nor was it found in the area.

A section of the pistons of No. 6 cylinder with a single gudgeon pin bearing, the gudgeon pin and the small end of the connecting rod, was found detached and near the engine. It was totally deformed with spherical shaping of its surfaces. The clearances of gudgeon pin bearings were in the range of 2 - 3 mm around the whole diameter. It was concluded that following the initial separation of a section of this piston the remainder continued to reciprocate inside the cylinder, hence the spherical shaping of its surfaces.

All the auxiliary connecting rods of the front row of cylinders, except No. 2, which was detached completely from its knuckle pin on the master rod, were broken at various points, between the small and big ends. The big ends of all these auxiliary rods left traces of friction on the surface of the cavity of the master rod bearing on which they were normally connected.

Laboratory examination of the broken surfaces of the master and auxiliary connecting rods did not disclose any signs of fatigue.

The two halves of the forward master rod bearing were found separated inside the crankcase.

The lower part of the forward master rod antifriction bearing bore, at one end, signs of melting due to the ground fire. Lack of lubrication was not apparent.

The crankcase was internally damaged in many parts and bore several signs of detachment of metal due to the contact with the broken connecting rods and other loose parts thrown about by the rotating balance weight. The greatest deformation and failure took place in the area of the twelfth cylinder.

It was concluded that the upper part of the forward master rod bearing was wedged, following a strong impact, between the balance weight and the crankcase in the area of the twelfth cylinder.

The rear master rod bearing did not show any signs of distortion, no trace of over-tightening, overheating or lack of lubrication.

From an examination of all bearing parts of the crankshaft and connecting rods, it was ascertained that the lubrication system was functioning properly.

Examination of the recovered pistons showed that they were not subjected to pre-ignition or detonation.

Measurement of the rear connecting rod lengths and main bearing attach-bolt lengths indicated that they were within the specified limits.

Phases of the engine failure

It appeared most probable that the malfunction originated from the fracture of No. 6 piston.

The configuration of the recovered portion of the piston constituted a typical case of failure originating from the fracture of one of the gudgeon pin bearings and resulting in the splitting of the piston into two large sections.

The two sections of the piston reciprocated for a few moments within the cylinder. Subsequently, the section on which the fractured gudgeon pin bearing was, found its way between the combustion chamber and the remainder of the piston section still attached to the connecting rod, preventing the latter from reaching the top dead centre. Thus, the first piece was pressed against the combustion chamber dome of No. 6 cylinder and created a circular imprint detected during the laboratory examination. Due to the abnormal axial force, No. 6 connecting rod sustained buckling, resulting in permanent deformation.

It is a characteristic of the construction and the adjustment of R 1830 engines that when No. 6 piston is at about the bottom dead centre, the front crankshaft balance weight is adjacent to the piston skirt. The clearance between the two moving parts is approximately 2 mm. The clearance between the inner surface of the balance weight and the body of the connecting rod is about 5 mm. Due to the deformation of No. 6 connecting rod and its consequent shortening, the clearance between the piston and the balance weight, when the piston was at the bottom dead centre, as well as the distance of the inner surface of the balance weight from the main body of the connecting rod became negative. Thus, the balance weight during its rotation struck the piston skirt and the connecting rod and caused permanent deformations or fractures. This correspondingly imposed tension loads on the bearing bolts on the side of No. 6 connecting rod's big end connection.

After the breaking of the retaining bolts the two pieces of the bearing were separated and dropped into the crankcase. From this moment the engine performed another turn or part of a turn until the balance weight swept the upper part of the bearings and wedged it between the balance weight in the area of No. 12 cylinder and caused the abrupt breaking of the engine.

No conclusive evidence was found during the laboratory examination to the effect that fracture of the master connecting rod was the initial cause of failure.

The master connecting rod appeared to have failed last. The possibility that it continued reciprocating for a certain period of time after the fracture of the auxiliary connecting rods was accentuated, judging from the traces of friction of the auxiliary connecting rods on the surface or the recesses around the master rod bearing.

The sequence of the failure might have been the following:

One of the bolts holding the two front master rod bearing half shells may have failed. As a result the bearing assembly would not have the required degree of tightening. On the other hand, the loss of 25% of the retaining bolts probably rendered this unit unable to withstand loads normally applied on the master rod. Consequently, the second bolt on the front master rod bearing failed and created a considerable gap in the bearing, resulting in its opening following operation on an elliptical path. This caused the failure of the master connecting rod together with the auxiliary connecting rods of the front row.

There were no indications to justify the assumption that the initial cause of failure of the missing bearing retaining bolts was prolonged operation of the engines at high power settings, overloading of the master connecting rod bearing due to pre-ignition or detonation, or incorrect torquing of the bolts during assembly.

The Path of the Propeller

The kinetic energy of the propeller could not be completely absorbed by its shaft and was converted to dynamic energy causing the torsional fracture of the shaft. The maximum kinetic energy which the axis could absorb was 175 kgm while that of the propeller with a probable rpm of 1 260 was about 67 000 kgm. Consequently, the kinetic energy of the propeller at the moment of the sudden breaking of the engine was so much higher than the energy the axis could absorb that following the shearing of the shaft the propeller continued to rotate almost with the same number of revolutions as before the separation.

After the separation of the axis the propeller travelled forward due to the same angle of attack which remained unaltered. Then, due to lack of hydraulic pressure, the blades assumed the fine pitch position and the propeller in the form of a disk with considerable aerodynamic resistance was exposed to the relative wind. During a relative motion of the aircraft and the propeller, while the latter fell vertically due to gravity, it approached while rotating, the part of the engine remaining on the propeller shaft. Thus, while it was about 470 mm below the shaft, the rear surface of one blade struck the shaft, followed by a second and a third blade. When the vertical drop reached 584 mm the first blade struck again and at a vertical drop of 854 mm, the second blade struck for a second time.

These successive impacts deviated the propeller to the left and upwards. Mathematical calculation of the path of the propeller was not possible due to many factors. From the results only it was concluded that the centre of the propeller after the successive impacts on the broken propeller shaft ended in a position higher than the left wing. The propeller, rotating at a considerable number of revolutions and proceeding from the leading edge of the left wing backwards, caused five through-cuts from the upper to the lower surface of the wing.

Detachment of the wing

The wing consisted of the covering skin, the spars, the ribs and the stringers, which made up a structure capable of withstanding composite torsional and bending aerodynamic loads.

The ribs prevent the application on the spars of shear loads, which are created as a result of the torsional loading. They assist in the correct distribution of the loads imposed on the spars and covering skins.

Following their destruction, as in the present case, there was no system of torsional resistance, the spars were deformed and consequently their resistance to bending was reduced.

Thus, the wing could not bear the usual loads imposed on it and separated while the aircraft was flying at 8 100 - 8 700 ft.

The aerodynamic condition created after the separation of the wing and the preceding detachment of the propeller resulted in instantaneous rolling of the aircraft to the left about its longitudinal axis. Any correction was beyond the capability of the aircraft's control system.

During this phase of the rolling the left propeller probably struck the right elevator and cut a part of it. The aircraft became uncontrollable, went into a spiral dive and struck the ground.

Overspeeding

Following examination of the engine and propeller it was concluded that there were no indications justifying overspeeding as a primary cause of the accident.

However, it was possible that after the appearance of malfunctioning in the engine small particles of metal may have found their way through the oil into the constant speed unit causing it to lose its ability to control the revolutions of the

propeller and overspeeding may have occurred. If so, the overspeeding should have been of small duration and intensity. However small the overspeeding may have been, the feathering of the propeller would have been more difficult if attempted.

Probable Cause

The accident was caused by the failure of the gudgeon pin bearing of No. 6 piston of the left engine, which resulted in the abrupt breaking of the engine.

Contributing factors

Inertia of the propeller at the moment of the breaking of the engine caused failure of the propeller shaft.

The broken propeller, rotating, caused serious cuts on the left wing. The latter then separated and loss of control followed.

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ICAO Ref: AR/613

PISTON OF NO. 6 CYLINDER

FIGURE 12 OLYMPIC AIRWAYS, DC-3 ACCIDENT, 29/10/59, NEAR AVLON, GREECE

No. 54

Wheeler Airlines, Douglas DC-4, CF-ILI, accident near St. Cleophas, P.Q., on 4 November 1959. Accident report, No. 825, released by the Department of Transport, Canada.

Circumstances

Flight 1658 took off at 2244 hours eastern standard time from Runway 10 at Montreal Airport for Hall Lake, Northwest Territories, and climbed on a heading of 010° to 6 000 ft when it advised that it had changed course to 000°. Subsequently, at 2259 hours the aircraft reported reaching 9 000 ft. Three and a half minutes later the flight contacted Montreal Centre and advised that it was descending on an emergency with a fire in No. 2 engine, which could not be extinguished. At 2307 a final transmission was received stating that the aircraft had lost its left wing, "was in a spin and going straight in." The aircraft broke up in the air and crashed on farm land, forming a wreckage pattern, which covered an area approximately 1-1/4 miles by 3/4 of a mile. The five crew members were all killed in the accident.

Investigation and Evidence

The Aircraft

A Certificate of Airworthiness had been issued for CF-ILI. It had flown a total of 30 357 hours and 10 015 hours since its last major overhaul. All engines were nearing time for major overhauls but were, as far as could be ascertained, operating satisfactorily up to the time of the accident.

At time of take-off the aircraft's weight, reported as 73 594 lb, was approximately 200 lb below the maximum permissible. The centre of gravity was estimated to have been within limits at take-off and also at the time of the accident.

As the return flight was to have carried passengers, seats were installed except where the freight prevented. A large spool of copper cable, which comprised the major item of the freight load, was secured on its side in the forward main cabin by chains to the tie down lugs.

The Crew

The pilot-in-command and first and second officers held valid Airline Transport Licences and had considerable flying experience. The pilot-in-command had flown a total of 15 000 hours. Of this total, 244 hours had been flown in the previous 90 days and of these 137 had been on DC-4 aircraft.

Weather

A warm front lay a short distance south of Montreal. The frontal surface sloped upward over Montreal and the route of the aircraft. Above this surface winds would shift from south to southwest with a considerable increase in velocity. The winds encountered by the aircraft would depend on where it crossed this front on its ascent out of Montreal.

The observed weather at Montreal Airport at 2300 EST was cloud 1 300 ft scattered, 2 500 ft scattered, ceiling 5 000 ft overcast, visibility 4 miles in light rain and fog, wind SSE at 14 mph. Estimated upper winds were:

2 000 ft	170°T	15 kt
4 000 "	210°T	20 "
6 000 "	230°T	30 "
9 000 "	230°T	35 "

The forecast current at the time of the accident was that issued at 1900 hours EST for the Ottawa-Montreal region, valid until 0700 hours EST on 5 November.

Eastern sections: ceiling 4 000 to 7 000 ft overcast, lowering to a ceiling of 800 to 2 000 overcast with patches, 200 - 500 ft overcast in precipitation; visibility from 4 - 8 miles, lowering in precipitation, 1 - 3 miles in light rain and fog, with a chance of 3/4 to 1 mile in light rain, light snow and fog.

Results of Examination of the Wreckage

After considerable investigation in order to eliminate such possibilities as explosion, sabotage, major structural failure, obvious malfunction, error or failure on the part of either the pilot or the aircraft, the following information emerged from an analysis of field data from the ground distribution of wreckage components:

The aircraft was flying on a track 188° true, at an altitude estimated, at the time of breakup, to lie in the lower part of the range 1 750 ft minimum to 4 000 ft maximum.

The left wing and engines separated from the aircraft first, followed almost immediately by separation of the tailplane. Damage and paint markings on the tailplane indicated that it was struck by the wing. The separation of the left wing represented an initial step in the aerial disintegration.

Fire in the No. 2 engine nacelle preceded the loss of the wing, causing primary structural damage, including the complete loss of the front and rear spar caps and top wing skin over a narrow spanwise band behind the engine firewall. This fire spread along the fuel lines within the leading edge of the wing between No. 1 and 2 engines. Structural damage is estimated to have reduced the ultimate strength of the wing (under the actual operating conditions) by about 50%, while reducing the wing bending and torsional stiffness by possibly 20%. However, the main spar of the wing which, because of the loss of other parts of the wing structure would be forced to carry major loads, failed at points remote from any effect of heat damage by the fire. This failure is estimated to have occurred under a minimum load of approximately 1.8g, arising from a manoeuvre of the aircraft and/or a gust loading.

Calculated trajectories of pieces of wreckage suggest that the aircraft was in a slightly nose down attitude at the instant of breakup. It is improbable that failure of the wing could be satisfactorily explained as a gust encounter alone. It is believed, therefore, that the residual wing strength was exceeded by manoeuvre and/or gusts in moderately turbulent air.

It was not possible to say precisely where the fire started, however, the area of initiation could be fairly well-defined as being close to a conjunction of flexible hose lines and an electrical cable; close to and aft of the inner ring behind No. 4 cylinder.

The following facts were determined:

a) A fire of relatively small proportions must have existed prior to the crew being aware of it or taking action to extinguish it. Two points tend to prove this:

   i) Examination of the generator of No. 2 engine indicated that internal insulation must have been burned from an external source which then allowed an electrical short circuit to take place, thus indicating that the fire had reached great intensity prior to the crew shutting down the engine. This they were able to do and fully feather the engine.

ii) A hole was found in the steel braid of one of the flexible hose lines, which was the result of an electrical short and must also have taken place prior to shutting down the engine.

b) The crew made proper selection of the fire extinguishers and activated them.

c) A crack, which was proved metallurgically to have been in existence some time prior to the accident, was found in the exhaust manifold in the area opposite to the No. 4 cylinder exhaust outlet. A hole about 2-1/2 inches by 1-1/2 inches was found in the manifold at this point. The exhaust manifold wall thickness in the area was found to be .009", compared to .035" in its original form. It was not possible to determine when the hole in the manifold had occurred.

d) During the investigation, it was found that Wheeler Airlines were covering electrical cables within the engine nacelle and forward of the firewall with a transparent plastic tubing of a polyethylene type. Another of their aircraft was found to exhibit heat damage on such a covering in an area at one time suspected of being the origin of the fire in CF-ILI. In finding the reason for this condition, it was ascertained that on several Arctic stations it is the practice to prewarm the engines by means of Herman Nelson heaters. These direct a stream of hot air into the engine nacelle and onto the flexible hose lines. It was determined that temperatures encountered with these heaters were sufficient to cause damage to the polyethylene sleeving such as to give all the marks of active burning.

e) It was found that most of the damage to the No. 2 engine by airborne fire was to flexible hose lines.

f) A heat-affected zone on the inner ring assembly was established in the exhaust collector ring fracture area.

g) During the investigation, it was found that Wheeler pilots had on many occasions used METO (maximum power except for that permissible for take-off which is higher) for their climb away from Montreal. The rate of climb of CF-ILI on the day of the accident would seem to indicate this power setting must have been used throughout the climb in order for the aircraft to have obtained the 9 000 ft altitude in something under 15 minutes.

h) It was observed that No. 1 engine had been fully feathered, presumably because the fire prevented fuel from reaching it.

The possibility exists that the fire extinguishers may have put the fire out within the forward engine nacelle, but there is no doubt that it had, by that time, progressed beyond the firewall. Because such late action was taken by the crew, it is possible the fire warning system did not work. Evidence was obtained indicating it had been safisfactorily tested on the three flights previous to the one resulting in the accident, however, a long history of fire warning system troubles was found.

Laboratory Work on Flexible Hose Lines and Polyethylene Sleeving

Considerable experimental work was conducted to determine the flammability characteristics of flexible hose lines and polyethylene sleeving. Tests were made on hose of near the same condition and of the same type as that on CF-ILI. The following conclusions were made as a result of these tests:

1. No change was found in the basic flammability characteristics of these hose lines, compared to new dry hose.

2. Two of the representative assemblies, namely the cowl flap actuator line and the hydraulic pump pressure line, were found to be inadequate for airborne service. The cowl actuator line leaked at a pressure of 750 psi. At 3 000 psi, a steady flow of fluid emanated from one end fitting. (The use of a single wire braid hose for the hydraulic pump pressure line was incorrect for a 3 000 psi application). This assembly leaked fluid through the carcass of the hose at 1 250 psi. The appropriate hydraulic system on this aircraft operates at 3 000 psi.

3. Temperatures higher than 160°F shorten the life of all rubber compounds designed for systems which operate in the range from -65°F to +160°F. Deterioration effects are cumulative and the rate of deterioration increases with temperature. The use of Herman Nelson heaters in the manner practised by the operator would have a deteriorating effect on hose assemblies from the blast of hot air. The rate of deterioration would probably not be known or appreciated by the operator.

4. The use of polyethylene forward of the firewall cannot be entirely dismissed as a contributing cause to conflagration, even though its laboratory ignition temperature was found to be about 1100°F. Sustained temperatures lower than this can cause ignition.

Probable Cause

A fire of undetermined origin started in No. 2 engine nacelle during the climb and developed to the stage where fire extinguishing equipment was inadequate to extinguish it.

The following are considered to be primary contributing factors:

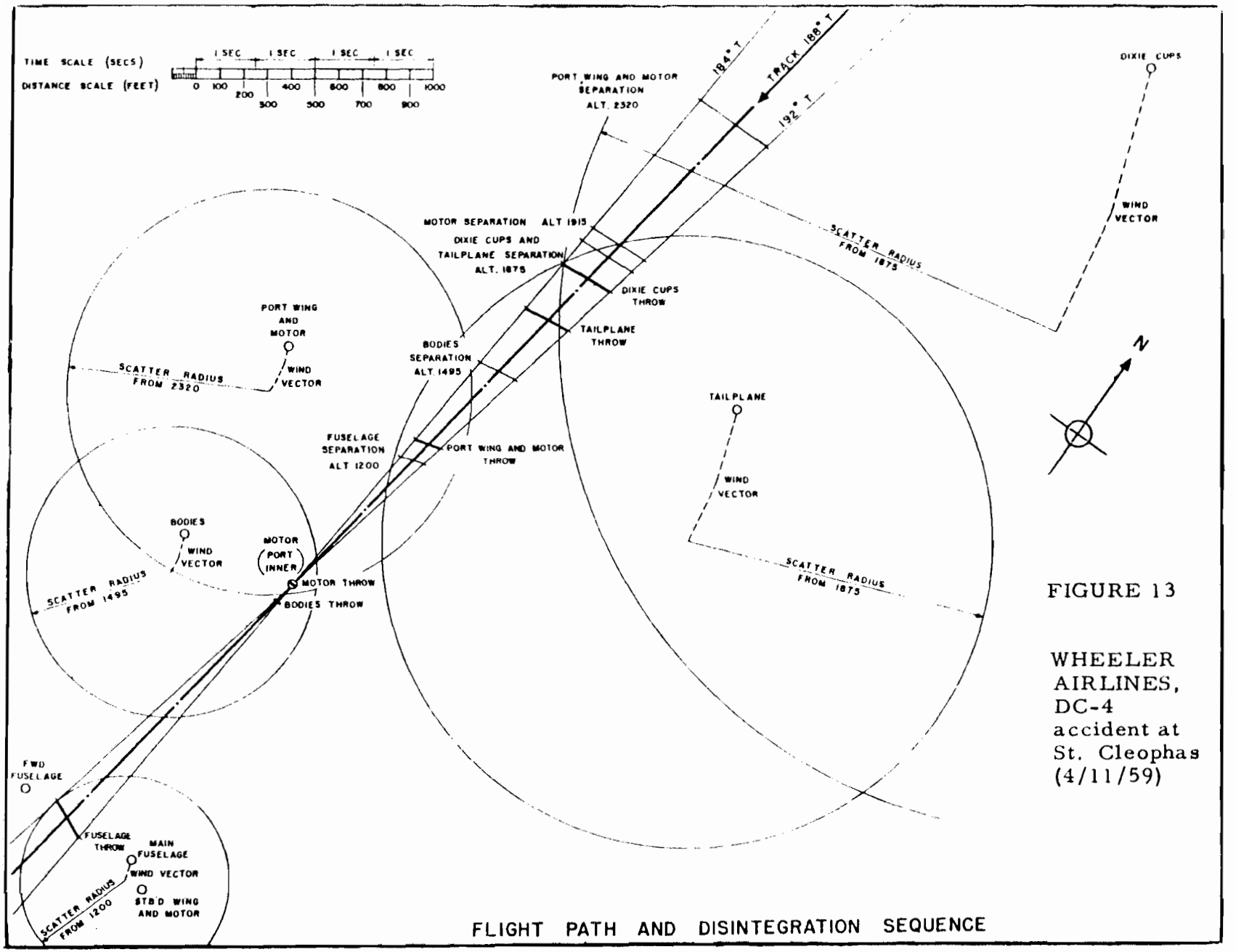
1. The deteriorated condition of the exhaust collector ring;

2. The probable deteriorated condition of the flexible wire braid hose assemblies;

3. The probable use of high power during the climb;

4. The possible failure of the fire detection and warning system to inform the pilot of the existence of a fire before it had penetrated the firewall and ignited the fuel feed system and oil tank to the rear of No. 2 engine.

During the rapid letdown, stresses were imposed on the weakened left wing by manoeuvre and/or gusts which were sufficient to sever the left wing spar. No subsequent action by the pilot could have brought the aircraft safely to the ground; neither was it possible to determine what effect a less rapid letdown would have had.



FLIGHT PATH AND DISINTEGRATION SEQUENCE

FIGURE 13

WHEELER AIRLINES, DC-4 accident at St. Cleophas (4/11/59)

No. 55

Piper PA-22, N 9609D and Ohio Air National Guard, F-84F, 519360, collided in midair near Mansfield, Ohio, on 7 November 1959. Civil Aeronautics Board (USA), Aircraft Accident Report, File No. 2-1753, released 26 August 1960.

Circumstances

The F-84F was the No. 4 aircraft in a flight of four jets making a low-altitude pass in close show formation across the Mansfield Airport from north to south. The Piper was on a cross-country flight from Akron to Mansfield and return nonstop. At the time of the collision it was in the Mansfield control zone proceeding in a northeasterly direction. The pilot of the Piper did not contact the Mansfield tower. The tower controllers cleared the jets for the low pass after scanning the entire area for possible conflicting traffic but failed to see the Piper. The two aircraft collided in the air about 2 miles south-southeast of Mansfield Municipal Airport, Mansfield, Ohio. The two pilots of the Piper received fatal injuries. The pilot of the F-84F ejected from his aircraft and parachuted to the ground uninjured. Both aircraft were totally destroyed.

Investigation and Evidence

The Aircraft

A review of the records of both aircraft indicated that they had been maintained in an airworthy condition. There were no discrepancies or carryover items affecting the airworthiness of either.

The Piper

N 9609D departed Akron at 1345 hours eastern standard time on a VFR cross-country training flight to Mansfield and return nonstop. Thereafter it made no radio contacts with any communications facility.

The F-84F

It was an Ohio Air National Guard single-place jet fighter, one of a four-ship formation training flight.

The formation left Mansfield Airport at approximately 1330 hours, on a local VFR flight plan, to perform various formation tactics and training at high altitude, followed by a formation jet penetration and simulated instrument approach.

The high altitude portion of the training was completed followed by a descent in close show formation. Then the flight flew back towards the field. Ten miles northwest of the field, the leader of the formation flight called Mansfield tower and requested permission to make a low approach across the field with the formation also asking for landing instructions. The reason given for making the low approach was to benefit the pilot flying in No. 2 position. The leader said it was required as a part of the instrument training and this pass was to give said pilot experience in flying close formation at slow speed.

At this time the formation was on a heading of 170° at 3 500 ft. The airspeed was 300 kt, and the four aircraft were in close fingertip formation with the element (aircraft Nos. 3 and 4) on the right.

When permission was granted for the pass, the leader stated that he descended to 2 600 ft. One mile from the field the leader called the tower and was again cleared for the approach. He took the formation across the field at 2 600 ft

(1 300 ft above field elevation), still on the 170° heading and at a speed of 300 kt. The southern boundary of the airport was passed, and he started a gentle climb and left turn to avoid an area of reduced visibility over Mansfield. At this time, the No. 2 man, flying on the left, advised him that No. 4 man had had a collision ... the flight was then at 2 800 ft, indicating 280 kt and in a 30° left bank.

The leader later stated that in formation flight as other members of the flight do not have much opportunity to look around in close formation, they depend on their leader for separation from other aircraft and he looks out for other aircraft.

Tower personnel stated that they recalled only one transmission from the F-84F when that aircraft was 2 miles north of the field. Before clearing it, both controllers scanned the entire area for other traffic.

The minimum altitude for an ADF instrument approach is 1 900 ft (600 ft above the ground.) The controllers said that, based on previous observations of simulated instrument approaches, the flight appeared to be at this minimum altitude but that the speed was considerably faster than normal. The normal ADF instrument approach is on runway 13, heading 130°, but this pass was made from north to south across the airport and not aligned with any runway.

The Collision (see Figure 14)

It occurred at 1416 hours, two miles south of Mansfield Airport within the control zone. At that time the Piper was proceeding in a northeasterly direction and the jet in a southerly direction. The flight paths intersected at an approximate 78° angle. In addition, the F-84F was in an angle of left bank approximately 30° relative to the longitudinal axis of the Piper. These relative angles of impact were determined by evidence of deformation and damage to the Piper's wings, cabin area, engine and engine mounts and the F-84F's right wing, pylon tank, aft fuselage and empennage.

Weather

At the time of the collision the weather conditions were -

> "broken to overcast clouds at 3 500 ft; visibility 12 miles; wind southeast 4 kt."

Analysis

In VFR weather conditions, primary responsibility for collision avoidance rests with each pilot. In addition, it is expected that pilots will exercise extreme caution when operating in a control zone or in the vicinity of an airport. In this instance, the pilot of the Piper should have notified the Mansfield tower of his position in the control zone. While this is not required by Civil Air Regulations, it is, in the exercise of sound judgement, a good operating practice to follow in an area of traffic concentration.

A study of the angle at which these aircraft approached one another revealed that both of the pilots of the Piper and the leader of the F-84F formation had ample opportunity to see and avoid each other. It was assumed that the Piper was on a straight and level course for at least a minute prior to the collision. The sighting angle from the lead F-84F to the Piper was approximately 19° to the right of the nose. The sighting angle from the Piper to the F-84F formation was approximately 74-1/2° to the left of its nose. These computations are based on relative speeds and the angle of impact and the sighting angle from either aircraft would be constant up to approximately five seconds before impact.

The Board could not accept the reasons given for the low pass by the jet formation. It did not believe that practice in slow flight in close formation could be given at speeds of 300 kt. The low pass described by the pilots of the flight could not in any

way be considered simulated instrument approach training. The Board believed that the flight descended to the usual altitude at which a simulated instrument approach is discontinued, i. e. 1 900 ft, and not the 2 600 ft alleged by the F-84F pilots.

Comparison of the relative speeds of the F-84F's and the Piper indicated that approximately one minute prior to the collision the Piper was approximately three miles from the tower in a southwesterly direction. At that time the formation flight was about 3-1/2 miles north of the tower.

The Board concluded that weather conditions were not a factor in the accident. The F-84F flight leader and both pilots of the Piper had a responsibility to maintain a strict lookout for other aircraft. Although closure speed was high, adequate opportunity existed to see and avoid one another. The Board, therefore, concluded that neither pilot was exercising the proper degree of care expected for collision avoidance.

Also, the F-84F's low pass was a close show formation demonstration at excessive speed and was not an essential part of the mission being performed, and, in fact, served no useful purpose in the training curriculum.

Further, it was concluded that National Guard supervisory personnel at least tacitly were aware of and condoned the practice of the low pass - this was evident in that corrective action initiated after this accident did not prohibit the manoeuvre. In fact, part of the corrective action was to require that all low passes across the field be made in the landing direction over the active runway.

The pilot of the Piper should also have informed the tower controller when he penetrated the control zone and operated in the vicinity of an airport where a concentration of traffic should be expected.

Finally, the Board did not believe that the tower controllers conducted a thorough or effective scan of the area for conflicting traffic before they issued a clearance to the formation flight. Had they done so, they could have seen the Piper and would have been able to inform either it, or the formation, or both, of the presence of traffic.

As a result of this accident, the Board recommended to the Administrator of the Federal Aviation Agency that all formation flights, except those involving simulated instrument low approaches and using an observer aircraft, be prohibited in control zones and/or in the vicinity of joint-use civil airports. In addition, it was recommended that all aircraft equipped with two-way radio be required to contact the control tower or other communications facility when entering a control zone.

Probable Cause

The probable cause of this accident was the failure of the jet formation flight leader and the pilots of the Piper to see and avoid one another.

A contributing factor was the failure of the tower personnel to see the Piper and take appropriate action.

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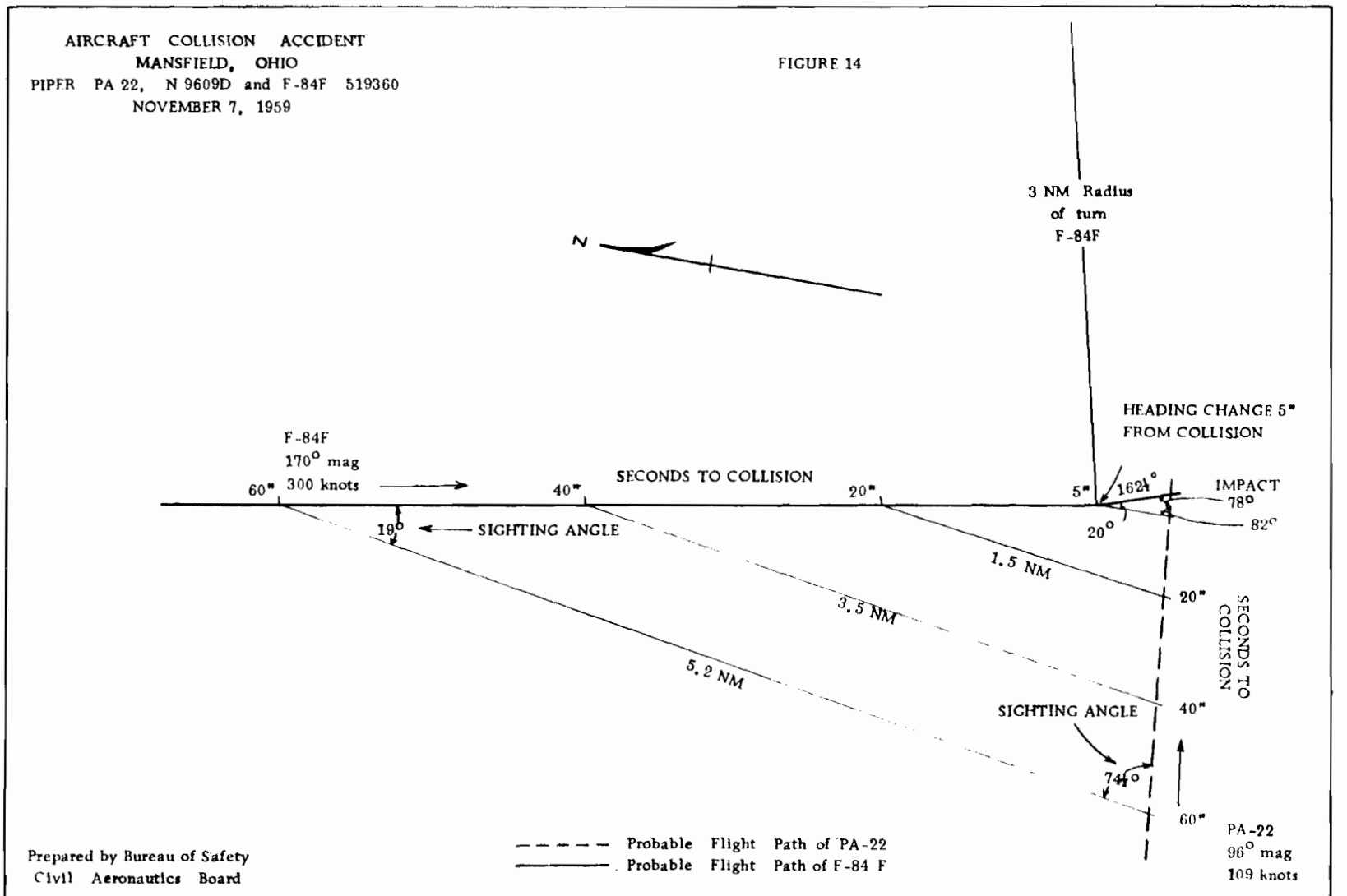
ICAO Ref: AR/643


AIRCRAFT COLLISION ACCIDENT
MANSFIELD, OHIO
PIPER PA 22, N 9609D and F-84F 519360
NOVEMBER 7, 1959
FIGURE 14
3 NM Radius
of turn
F-84F
N
HEADING CHANGE 5°
FROM COLLISION
F-84F
170° mag
60" 300 knots
SECONDS TO COLLISION
40"
20"
5"
162½°
IMPACT
78°
82°
19°
SIGHTING ANGLE
20°
1.5 NM
3.5 NM
5.2 NM
20"
SECONDS TO COLLISION
SIGHTING ANGLE
40"
74°
60"
PA-22
96° mag
109 knots
Prepared by Bureau of Safety
Civil Aeronautics Board
Probable Flight Path of PA-22
Probable Flight Path of F-84 F

No. 56

Ariana Afghan Airways, DC-4, YA-BAG, crashed following take-off from Beirut International Airport, Lebanon, on 21 November 1959. Report released by the Minister of Public Works and Communications, Lebanon. An accredited representative of Afghanistan participated in the Inquiry in accordance with the provisions of ICAO Annex 13.

Circumstances

Flight 202 was a scheduled flight from Frankfurt, Germany to Beirut - Teheran - Kandahar and Kabul. It had arrived at Beirut at 2330 hours GMT (20 November) where technical difficulties which delayed scheduled departure were looked into. The aircraft took off on runway 18 about 20 hours after arrival carrying 22 passengers and 5 crew. Approximately two minutes after take-off, the Beirut tower controller noticed a large fire on the hills of Aramoun south of the airport. The aircraft had crashed about 2-1/2 miles from the end of runway 18, killing 19 of the passengers and all crew members.

Investigation and Evidence

Crew Information

The crew which brought the aircraft from Frankfurt handed over to another crew at Beirut. The operating crew at the time of the accident consisted of two pilots both of whom held valid Afghan pilots' licences with appropriate ratings for DC-4 aircraft. The captain had flown 3 162 hours with Ariana over a three-year period; he had flown 406 hours on DC-4 aircraft (including six flights through Beirut) during the six months prior to the accident. The co-pilot had flown 2 939 hours with Ariana in a 2-1/2 year period, including 185 hours on DC-4 aircraft during the preceding six months. The captain had passed satisfactorily a number of check flights on DC-4 aircraft but there was no record of a night flying check on the type nor a route-check covering Beirut.

Weather

Wind velocity 100° - 8 kt
Visibility 20 miles, no cloud

The accident occurred during the hours of darkness.

The Aircraft

The aircraft was constructed in 1944; its Afghan Certificate of Airworthiness was dated 29 November 1958. The maintenance records covering the period of eight months prior to the accident were investigated; they indicated a programme of regular inspections of airframe and engines.

On arrival at Beirut the captain of the aircraft reported certain defects, one of which was - "No. 1 feathering button will not stay in on check".

The Inspector responsible for defect rectification and between flight inspection made a provisional investigation of this defect. He tried the button twice, one operation of which was a complete feathering. A ground mechanic then continued the investigation during which seven further operations of near feathering were carried out at various engine speeds.

It was believed that the aforementioned handling of the engine may have had the following adverse effects:

- strain on the feathering motor;
- heavy loads on bearings and other engine parts;

- due to vibration, loosening or even shearing of such items as exhaust components, pipes or unions;
- overheating effects on the engine generally due to the use of lean mixture coupled with the lack of sufficient cooling.

On starting up the engines prior to take-off, fumes and smoke were seen to come from the engines, however, on certain DC-4 engines this is not abnormal. Three survivors stated that they heard no run-up of engines during taxying or prior to take-off. Witnesses stated that the engine noise on take-off was unusual. A surviving passenger noticed that from the moment the aircraft left the ground its flight seemed to be unbalanced - the wings were rocking from side to side.

The aircraft's weight at take-off was 32 128 kg which was under the maximum authorized weight of 32 140 kg. There was no record of the position of centre of gravity of the aircraft, but during subsequent examination of the wreckage, the elevator trim tab was found to be in the neutral position.

Wreckage and Technical Investigation

The wreckage was located on the hills of Aramoun, 4 - 5 km south of Beirut International Airport. The wreckage trail was on a heading of 210° and spread over a distance approximately 500 m in length. All items, except for the propellers, were located in a pattern broadly consistent with their respective positions in the aircraft.

Traces found indicated that the aircraft first hit the tops of two groves of trees. Cuts on the trees indicated that No. 1 propeller was revolving without driving power, while No. 2 and 4 were under power. Propeller No. 3 passed over an area where no trees were growing. Areas of fire were noticed at the impact positions of No. 1 and 2 engines.

At the moment of impact with the trees the aircraft had 5° bank to starboard. All indications were that the aircraft was flying horizontally. Because of the impact and subsequent fire the aircraft almost completely disintegrated.

Fire fighting equipment used and its effectiveness

The crash area was not accessible to any type of ground equipment. Helicopters would have been useful. Fire trucks were able to reach the road position nearest to the area in 10 minutes. From there on the trucks left the road and proceeded at slow speed through very rough terrain for another 10 minutes. The fire crew were trying to get their equipment as close as possible to the scene of the crash. However, due to the terrain the crews had to leave their vehicles behind and to proceed on foot for about 3/4 of an hour. The rescue team carried the survivors on their backs to the ambulances. It was impossible to use stretchers over that area.

Technical Observations

The engines were completely destroyed (except for accessory parts) which made the determination of their condition impracticable. All propeller blades were recovered, all blades bent in the same manner, in the same sense of rotation, except No. 3 propeller which was the least damaged and possibly at a higher pitch setting than the other three.

Assuming that the position of the mixture controls, cowl flap selectors, rudder trim tab and handwheel, and tachometers could be considered as good evidence, it appeared that the crew had decided to shut down No. 1 engine. This should be related to the evidence from the cuts in the trees that No. 1 engine was not revolving with driving power.

No. 1 engine may have possibly been overstressed during the repeated feathering

checks; in this case, failure may have occurred after the first reduction of power.

The reading on No. 1 tachometer (zero rpm) can be explained if it is assumed that propeller No. 1 was windmilling and deriving its rotation only through the forward speed of the aircraft. When this propeller struck the trees and the rocks on the ground, its rpm dropped rapidly and the tachometer likewise before major disintegration of the aircraft occurred.

A structural failure in the air was ruled out as a possible cause of the accident - all disintegration was caused by impact.

Findings

1. No emergency occurred prior to 20^h 03' 36" Z.

2. Immediately thereafter (i.e., 1-1/2 minutes after airborne time) a fire indication occurred on No. 1 engine and the crew started engine fire emergency procedure which was interrupted by the crash.

Comments

Normally the first action in engine fire procedure is to feather the propeller. There are three alternative explanations as to why the propeller was not feathered:

1) The pilot pressed the feathering button and went to the next item of his drill, and (unobserved by him) the button jumped out due to a fault in the hold-in mechanism or circuit. Such a fault was reported by the captain who flew the aircraft from Ankara to Beirut. Feathering checks had been carried out by P. A. A. mechanics at Beirut but no corrective action taken since the fault did not recur then.

2) The feathering pump was defective due to maltreatment by the P. A. A. mechanics.

3) Neither of the pilots pressed the feathering button.

A reconstruction of events preceding the accident and the location of the crash (2° west of the extended runway centre line) and the line of the wreckage - 210°T - compared to the runway heading of 177° T indicate that the aircraft had flown in approximately a straight line from take-off until about twenty seconds before the crash. The 33° difference could have been achieved, in a rate one turn, in eleven seconds; but the evidence would suggest that the last 9 seconds of the turn were completed with only 5° - 10° of bank and a rate of turn of only one degree per second. Prior to No. 1 engine being closed with the mixture control it is assumed the aircraft was in a normal rate one turn (3° per second) with 15 - 20° bank to starboard. The likely effect of cutting No. 1 engine in such a turn, assuming the reaction of an average pilot at night, "on instruments", at high power and 125 kt IAS, would be a reduction of bank and rate of turn, for, at any rate a few seconds. On the basis of the foregoing it is estimated that during the 9 seconds before impact the aircraft turned from 201° to 210°, and that during the preceding 11 seconds, it turned from 177° to 201°. The start of the turn, as reconstructed above, coincides with the call from Air Traffic Control giving the airborne time; it seems therefore that this R/T call prompted the pilot to start his turn.

On the basis of tests in a DC-4 cockpit to ascertain the time taken on the

(incompleted) fire drill and calculations based on ground speeds of 118 kt, and 121 kt, the time of the crash was fixed between 51 and 58 seconds after 2003 hours GMT, (i.e., approximately 1-1/2 minutes after airborne time).

There was a choice of two explanations as to why the captain flew straight ahead for more than eighty seconds after becoming airborne, instead of turning after about thirty seconds, at a height of 300 ft. He either

a) forgot the terrain layout, or

b) was distracted by some unusual occurrence.

Probable Cause

The accident was attributed to a combination of

1. a navigation error - in that the pilot did not right turn out as early as he should have, either because he forgot or because he was distracted by some unusual occurrence; and

2. a fire indication (or possibly a fire) in No. 1 engine which induced the pilot to start fire emergency action with a resulting reduction in the rate of turn and the rate of climb.

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No. 57

Linea Aeropostal Venezolana, Douglas DC-3, YV-C-AKU, accident near Maiquetía International Airport, Venezuela on 1 December 1959. The report, dated 15 December 1959, was released by the Directorate of Civil Aviation, Ministry of Communications, Venezuela.

Circumstances

Shortly after taking-off on a test flight from Maiquetía Airport the pilot reported that a state of emergency existed aboard the aircraft. During an attempt to return to the airport, the aircraft crashed at 1111 hours after hitting Playa Grande hilltop, which borders the airport. The 3 crew were killed, and the aircraft was destroyed.

Investigation and Evidence

The pilot and co-pilot had valid licences at the time of the accident, however, it was noted that the flight engineer's licence, which had been issued on 1 December 1958, was only valid until 13 October 1959.

As of 1 December 1959 the aircraft had flown a total of 17 821 hours, 2 758 of which had been flown since its last overhaul.

The Flight

It should be noted that the crew having declared an emergency on board and having spoken with the tower on several occasions, failed to report the specific cause which led to the disaster. Thus, the evidence was merely circumstantial and had to be complemented by appropriate assumptions. One of these assumptions seems to be sufficiently substantiated by reconstructed data and on this basis the following has been evolved.

The aircraft took off normally with take-off power on both engines. During an attempt at initial reduction of power while still on the runway, the port engine started racing, although the overspeed was not extreme enough to cause engine breakdown. The damage was then offset by the pilot's re-application of take-off power to the starboard engine. With power in both engines, a left turn was made, apparently before reaching the runway threshold in a short take-off and the aircraft was able to climb to a height of 700 - 750 ft on a downwind leg westbound. Upon initiation of or during the downwind leg turn, the abnormal flight conditions became more critical. At this time and altitude it would have been impossible to reach the threshold of runway 26 in a glide without power. It was, therefore, essential to keep the starboard engine on a maximum power setting, not only to gain altitude but also to maintain the aircraft on its path. The unequal distribution of power and the parasitic drag made it impossible for the crew to correct the turn made by the aircraft and attempt a ditching. Loss of power in the starboard engine resulted as it was subjected to high power for over 150 seconds while operating on cylinders which were subsequently found to be oversized. The aircraft pancaked at a high rate of descent, with flaps and landing gear retracted.

The site of the accident was 2 km west of the threshold of runway 08. Playa Grande hill is approximately 110 m above sea level and lies 320 m to the north of the site.

The weather conditions did not contribute to the accident, which occurred on a clear and cloudless day.

Inspection of the Wreckage

Following the accident the propellers were dismantled, and it was noted that neither one was in the feathered pitch at the time of impact. A breakdown inspection of the engines revealed no internal malfunction. The records of the last overhaul showed that the cylinders of the port engine were 0.010" oversized and those of the starboard engine 0.020". The left governor was in an unusual condition. Gear teeth were broken, and some pieces were stuck in the rack - this condition may have developed either on initiation of the flight or following the accident. Also, a check of the governor's control record failed to provide any reliable indication of its total hours of service. This led to the suspicion that uncontrolled overspeeding had occurred, and that for this reason, the pilot was unable to feather the propeller.

Discussion

The flight was characterized by lack of control over the aircraft either because of:

1. difficulties with the control surfaces; or

2. loss of power in the engines

Pre-flight checking and take-off operations performed prior to the accident removed any suspicion of malfunction of controls or control surfaces. The aircraft had made several turns, and no control failures were noted by the control tower operators, who followed the flight.

Analysis of the circumstances led the Commission to believe that the aircraft's inability to maintain cruising speed through loss of power, here assumed to have occurred, happened in two stages:

1. the malfunction which caused the emergency originated in the port engine;

2. the power required to keep the aircraft in the air had to be supplied then by the starboard engine.

The latter engine furnished the required power and enabled the aircraft to climb 700 ft at take-off power. However, conditions adversely affecting the flight - parasitic drag, due to the uncontrollable functioning of the port engine, and attempts at gaining altitude - combined with the fact that the starboard engine contained oversized cylinders, gradually drained away the power required to maintain cruising speed.

Probable Cause

The accident was caused by an overspeeding propeller followed by failure of the starboard engine.

Recommendations

It was recommended that an automatic emergency frequency be established and that other frequencies should cease operations while the emergency frequency is in use.

It also was recommended that fresh crews be assigned to test flights.

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ICAO Ref: AR/617

No. 58

Allegheny Airlines, Inc., Martin 202, N 174A, accident near Williamsport, Pennsylvania on 1 December 1959. Civil Aeronautics Board (USA), Aircraft Accident Report, File No. 1-0080, released 8 November 1960.

Circumstances

Flight 371 was scheduled between Philadelphia, Pennsylvania and Cleveland, Ohio with stops at Harrisburg, Williamsport, Bradford and Erie. It proceeded routinely to Williamsport where it was observed in an approach to the airport. While on final approach it made a left turn and disappeared into clouds and snow showers on a southerly heading toward Bald Eagle Mountain, about 1.3 miles south of the Williamsport Airport, where it crashed at approximately 0947 hours eastern standard time, killing the crew of 3, one additional crew member and 21 of the 22 revenue passengers aboard.

Investigation and Evidence

Crew Information

The captain of N 174A had flown 9 790 hours, 1 180 of which were as captain on Martin 202 equipment. Prior to the flight of 1 December he had had a rest period of approximately 9 hours.

The co-pilot had flown 1 153 hours, approximately 93 of which had been as co-pilot on Martin 202 aircraft.

Airport and Ground Facilities

Williamsport Airport has only a low frequency (385 kc) radio range for instrument approach to the field. This low frequency range approach utilizes a low frequency radio beacon (266 kc) and a marker beacon. These facilities were checked on the day following the accident and were found to be operating satisfactorily. Both were determined to have been in operation at the time of the accident.

There was no control tower in operation at the time of the accident. Contact with the airport was through the communicator in the Williamsport (FSS) radio facility. On 5 December, four days after the accident, a control tower at Williamsport Airport commenced operations.

The Approach to Williamsport

At 0923 the flight reported to Williamsport radio that it was making 360° turns five minutes south of the Williamsport low frequency range at an altitude of 3 500 ft, VFR and requested an instrument clearance to the Williamsport Airport. Williamsport radio responded by giving the 0917 Williamsport weather observation followed at 0927 by clearance for the flight direct to the Williamsport low frequency range and to maintain 4 000 ft. One minute later New York Centre instructed Williamsport radio to advise the flight to report north of Victor Airway 232 which it did at 0931. The aircraft was then cleared for an approach to the Williamsport Airport, to report on the ground, or cancelling IFR. The flight had been dispatched IFR but the captain elected to depart VFR because of the existing VFR weather en route. Allegheny company policy is to dispatch all flights IFR unless load conditions or navigation facilities require a VFR release. At this time the flight reported over the Williamsport low frequency range, leaving 4 000 ft and commencing an approach. At 0935 the Williamsport 0934 weather observation

was given to the flight as being: 1 000 ft scattered, precipitation obscuration 2 000 ft; visibility 1-1/2 miles in light snow; wind west at 4 kt; altimeter setting 30.26 incles. Allegheny minima for this approach to the Williamsport Airport are 900 ft ceiling and 1-1/2 miles visibility.

At 0941 the flight reported over the low frequency range on final approach. At this time it was advised of the surface wind and altimeter setting and that the runway lights were on high brilliancy on runway 9-27. It acknowledged all these transmissions. At 0942 it reported in range to the company on company frequency. The company advised that its altimeter setting was 30.25 inches and requested the arrival and departure times of the flight at Harrisburg. Flight 371 acknowledged the altimeter setting but did not relay the time information requested.

At about 0945 hours the flight was seen over the airport, too high, however, to effect a landing. After this initial approach to the field the aircraft flew over the field and made a right turn for a circling approach to runway 27. As this circle was completed, the aircraft was seen to roll out of its right turn and into a left turn and proceed in level flight in a southerly direction. It then disappeared into snow showers and clouds. A short while after a loud explosive-type noise was heard. One observer believed that when the aircraft began this left turn it was about 1/4 of a mile from the end of runway 27 and at an altitude of approximately 400 ft above the ground.

At approximately 1120 hours the wreckage of the aircraft was sighted on Bald Eagle Mountain, at an elevation of 1 150 ft msl on a 175° magnetic heading from, and about 1-1/3 miles south of, the approach end of runway 27.

Technical Investigation

Both engines and both propellers were examined at the scene of the accident as the terrain made it impossible to remove them intact for study. Impact damage to both engines was relatively light.

The propeller blade angles at impact and the relatively uniform breakage of the propeller blades were consistent with appreciable power being produced at impact.

There was no evidence to indicate inflight failure of any of the components of the power units.

Examination of the flight controls, wings, tail surfaces and control surfaces failed to show any evidence of inflight malfunction or failure.

The pilot compartment and the instrument panels were subjected to extensive impact damage and subsequent heavy ground fire, and many of the instruments were completely destroyed.

Particular attention was paid to direction-indicating instruments.

The captain's master direction indicator (MDI) was found with the compass card in position and seized in the relatively intact front end housing. The indicated heading was approximately 262°. The repeater indicator from the co-pilot's panel was found in a badly burned condition, but relatively undamaged by impact. Its compass card was held firmly by the heat-distorted front end assembly and indicated a heading of approximately 88°. It has been demonstrated that the compass card of the repeater indicator is subject to random displacement when its electrical power has been removed. An unsuccessful attempt was made to determine the heading information being transmitted electrically to the repeater indicator by the MDI at the time of impact.

The policy that Allegheny Airlines followed on an instrument landing approach such as the one at Williamsport is that the approach will be flown by the captain while occupying the left seat. During such an approach, therefore, the captain in the

left seat and while flying in a right pattern would have the airport to his right, and he would have had some difficulty in keeping it in sight. In addition, the aircraft on the base leg segment of the circling approach was intermittently in snow showers or clouds.

It was believed that during the base leg the captain relied on the MDI of the fluxgate compass owing to the weather and cockpit visibility restrictions that existed. It was believed that the fluxgate compass was functioning, as evidenced by the fact that the captain had successfully completed an instrument approach, and subsequent examination of the fluxgate showed it to be operable after the accident.

The possibility of an inadvertent actuation of the caging switch of the fluxgate compass was explored. The purpose of this caging switch is to rapidly erect the gyro in the transmitter unit located in the left wing. This erection system erects the gyro to a vertical position in respect to the aircraft only, and is independent of the rolling-ball type erection mechanism incorporated into the system which erects the gyro to a vertical position relative to the surface of the earth. The caging of this gyro is normally accomplished on the ground prior to flight and with the aircraft in a level position.

Flight tests conducted showed that the caging switch could be actuated inadvertently by the foot of a person occupying the jump seat and that a serious error could thereby be induced into this system. On this particular flight the jump seat was occupied by an additional member employed as a co-pilot. It was considered likely that this happened since at this segment of the approach the crew members would be attempting to locate the landing runway, and it is probable that the crew member in the jump seat would have been leaning forward in an effort to locate the runway and would thus have made some contact with the rear of the pedestal because of its proximity to the jump seat. Also, no guard was provided for this switch.

Accidental caging of the fluxgate compass with the aircraft on any southeast or southwesterly heading would have induced an error to the right which would have shown up on the MDI by indicating the aircraft was turned to the right in excess of its actual heading.

It was believed that the captain was induced to refer to his instruments on the base leg of the landing approach because of the restrictions to visibility encountered and by cockpit limitations to his field of vision. The captain continued his turn intending to roll out on the runway heading, but reference to the MDI indicated that he had overshot his heading so he immediately turned to the left to an indicated heading of 270°. After rolling out on this heading he was unable to see the field, which was now to his right, and he continued on for a few seconds expecting to see the field momentarily. Owing to the induced error of approximately 30° to the right, the aircraft was now on an actual heading of approximately 190° and the heading for Bald Eagle Mountain. The aircraft then encountered solid instrument conditions. The captain continued his flight on the indicated heading of 270° for approximately 12 to 14 seconds, during which the aircraft was converging with the northern slope of Bald Eagle Mountain. During this time he noted the discrepancy between the MDI and his other directional instruments and caged the fluxgate compass in an effort to determine his correct heading. Upon completion of the caging cycle the MDI turned to a heading of approximately 190°. At this time, just prior to the crash, the aircraft was turned to the right, full throttle was applied, and gear retraction was initiated. Before this turn could be completed the aircraft crashed into the trees and rocky terrain of the mountain.

The possibility of accounting for the left turn by the captain having initiated an abandoned approach was also considered. For this to have occurred the induced error in the fluxgate compass would have to be to the left in the order of 80° and

would have been induced by accidental caging of the fluxgate compass while on a northeasterly or northwesterly heading. With such an error and if the captain turned to an approximate heading of 100° to go back to the L/F range, the aircraft would then have been on an actual heading of 180°. This is compatible with the statements of the ground witnesses.

Several facts indicated that this possibility did not occur. The aircraft struck the mountain at approximately the same altitude that it was seen at when departing the airport. The landing gear was in the down position except for the right main gear which was in transit to the up position. The power increase was initiated at the same time the aircraft was turned to the right just prior to hitting the mountain. It was believed that if in fact the captain had initiated an abandoned approach, all of these things would have been started immediately upon encountering instrument conditions and that the captain would also advise by radio that the approach was being abandoned.

Human Factors

The autopsies of the crew members eliminated all but one physiological factor which could have contributed to this accident.

The finding of atherosclerosis in the first officer's coronary arteries required a detailed study of the possibility of an incapacitation of this individual, and possible interference with the operation of the aircraft at a critical segment of its landing approach. However, it was subsequently determined that there was no evidence of incapacitation of the first officer prior to the crash or that incapacitation was a factor in this accident.

Probable Cause

The probable cause of this accident was the captain's failure to execute a timely abandoned approach. The probable accidental caging of the fluxgate compass, which would have resulted in an erroneous heading indication, was considered to be a likely contributing factor.

Resultant Action

Allegheny Airlines, immediately after learning of the possible effect of an accidental caging of the fluxgate compass, installed guards on the four aircraft in its fleet which had similar fluxgate compass caging switch installations.

A recommendation was made by the Board to the Administrator of the Federal Aviation Agency that suitable guards be required on all aircraft that have fluxgate compass caging switches located in a position which would permit inadvertent actuation.

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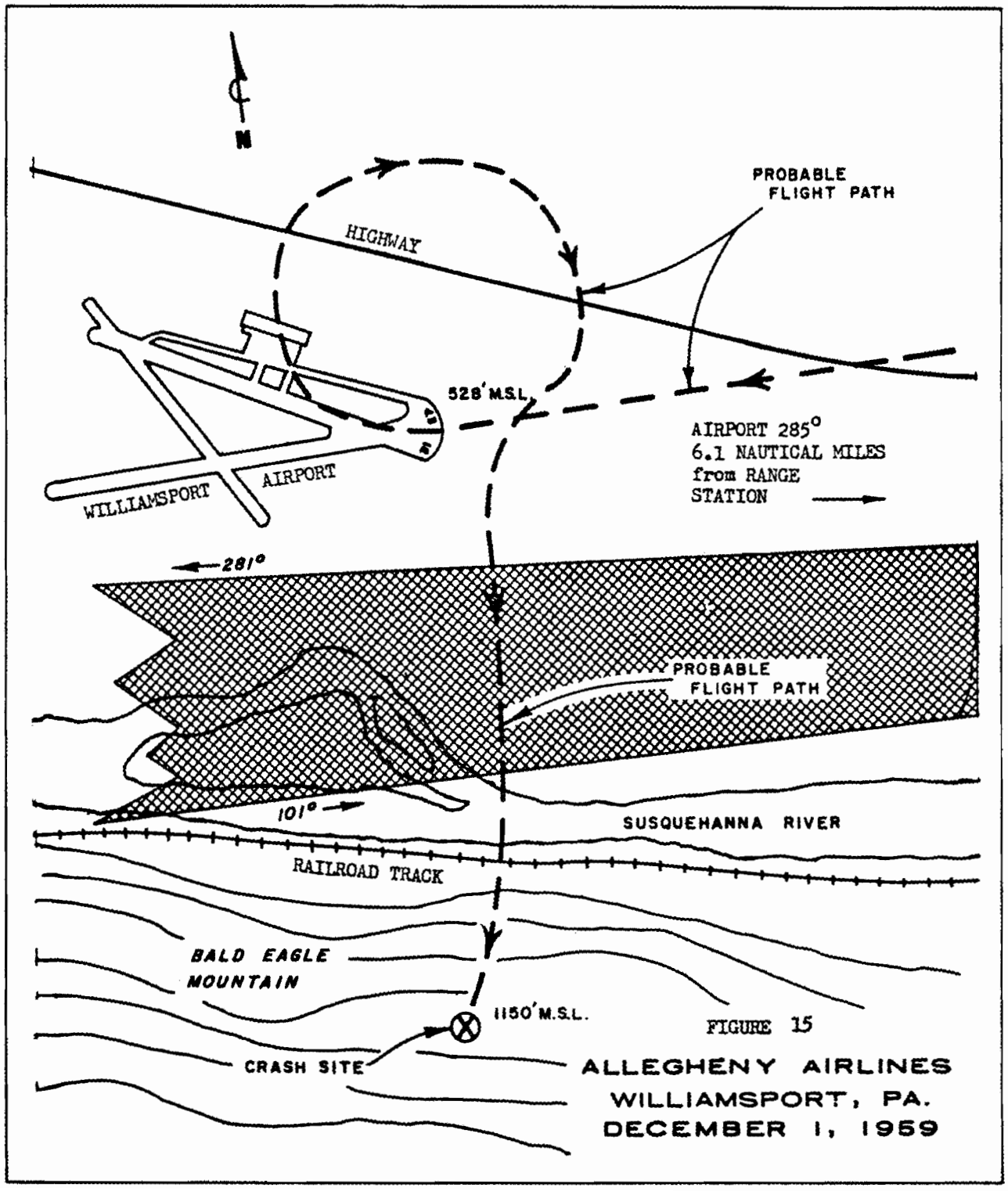
N
PROBABLE
FLIGHT PATH
HIGHWAY
528' M.S.L.
AIRPORT 285°
6.1 NAUTICAL MILES
from RANGE
STATION
WILLIAMSPORT
AIRPORT
281°
PROBABLE
FLIGHT PATH
101°
SUSQUEHANNA RIVER
RAILROAD TRACK
BALD EAGLE
MOUNTAIN
1150' M.S.L.
CRASH SITE
FIGURE 15
ALLEGHENY AIRLINES
WILLIAMSPORT, PA.
DECEMBER 1, 1959

No. 59

Sociedad Aeronáutica Medellín S. A. , C-46A, HK-515, crashed into the sea between San Andrés Island and Cartagena on 8 December 1959. Report released by the Director General of Civil Aviation, Colombia.

Circumstances

HK-515 was cleared at 1600 GMT on an extra flight from San Andrés Island to Medellín with an intermediate stop at Cartagena. Three crew and forty-two passengers were aboard the aircraft. It was to report at points PC-2, PC-1, Tango 2 and Cartagena (see Figure 17). Only the PC-2 report was received at 1657 GMT, and it advised that the aircraft was in visual flight conditions at 9 500 ft. No further contact with the aircraft was established. On 16 December it was learned that the right landing gear wheel assembly of HK-515 had been found near Morón Island, 14 miles east of San Blas, Panamá.

Investigation and Evidence

The Aircraft

At the time of the accident the aircraft was airworthy and had been authorized to undertake mixed transport flights. It had been repaired the day before the accident and had subsequently been tested by the pilot with satisfactory results. No difficulties on the subject flight had been reported.

The aircraft's weight and centre of gravity were within the limits as shown in the Certificate of Airworthiness.

The Crew

The crew held fully validated licences and valid medical certificates.

The captain had a total of 3 512 hours flying on this type of aircraft, 248 hours of which had been flown within the last 90 days. He had made his first solo flight as a pilot on a C-46 aircraft on 15 March 1959.

The co-pilot had flown 7 405 hours on C-46's; 229 of them had been flown during the last 90 days.

Weather

From reports of pilots of other aircraft and weather reports by the different stations, it was possible to establish that fair weather prevailed along the entire route.

The Wreckage

Only the right landing gear wheel assembly and axle of the aircraft and the brake system were recovered. The shaft had failed due to impact with the sea which caused the wheel attachment to break at a right angle at the level of the root.

The search and rescue operations were extended to 24 December, however, as nothing further was found they were suspended .

Statements of Witnesses

Residents of the area where the piece of wreckage was found believed that the accident site lay within an area over 625 sq. mi. from Morón Island northwards.

They stated that there was bad weather in the area where the aircraft crashed. This together with the fact that the aircraft had inadvertently drifted off the airways towards the coast of Panamá points to the

probability of serious malfunction in the aircraft including radio failure - the position reports ceased after PC-2.

Probable Cause

The cause of the accident could not be determined.

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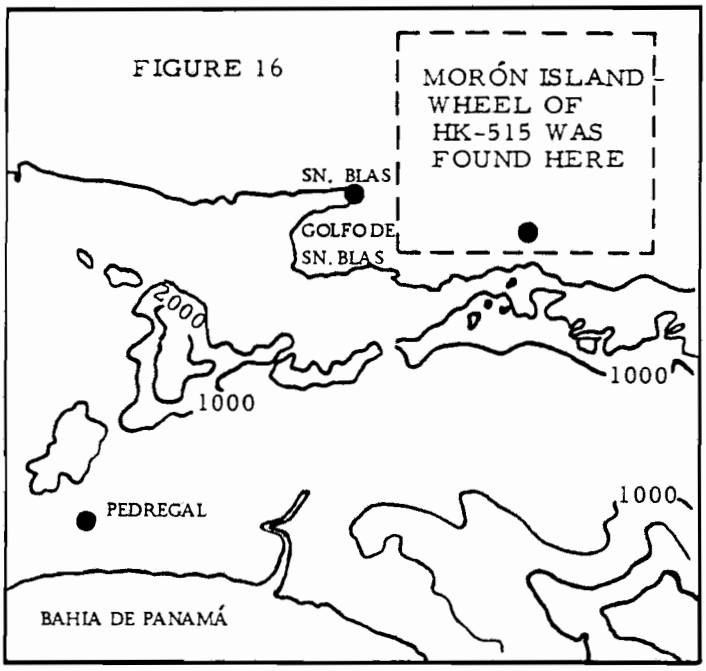
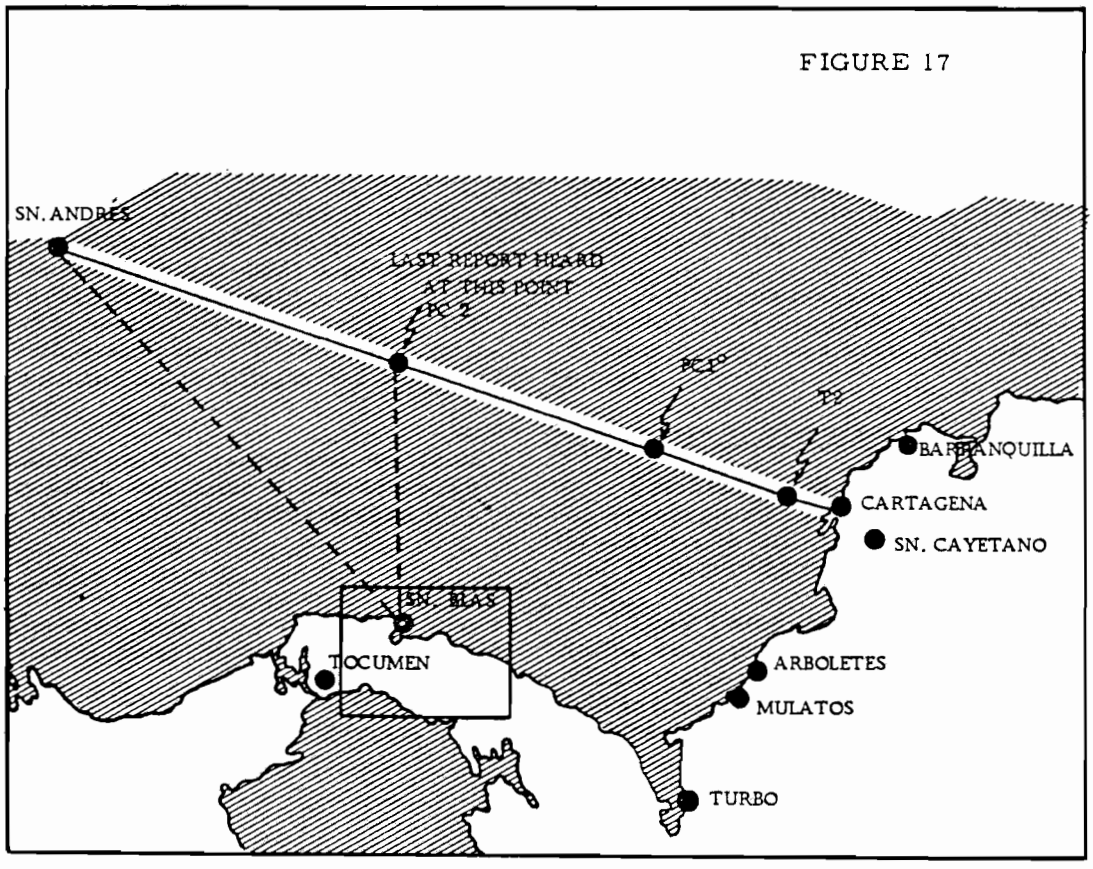
ICAO Ref: AR/612





SOCIEDAD AERONÁUTICA MEDELLÍN, C-46A,
ACCIDENT ON THE SAN ANDRÉS ISLAND - CARTAGENA ROUTE

No. 60

Beechcraft, C-35, N 1839D and Wyoming Air National Guard F-86L, 52-3662, mid-air collision near Cheyenne, Wyoming, Municipal Airport, on 15 December 1959. Civil Aeronautics Board, (USA), Aircraft Accident Report, File No. 2-1774, released 22 August 1960.

Circumstances

On 15 December 1959, at 1520 hours mountain standard time, an F-86L, flown by the wingman in a formation of two Wyoming Air National Guard F-86L's,and a Beechcraft C-35 collided at 9 000 ft msl (2 850 ft above the ground) about 4.5 miles south-southwest of the southern boundary of the Cheyenne Municipal Airport within the airport control zone. The pilot of the F-86L ejected safely; however, the pilot of the Beechcraft was fatally injured.

Investigation and Evidence

The Aircraft and their Crews

The Beechcraft had last been inspected on 24 July 1959, and all airworthiness directives had been complied with.

Its pilot and part owner held a private pilot certificate with single-engine land rating issued by the FAA on 29 June 1959. At the time of the accident the pilot had about 325 hours of flying experience.

F-86L, 55-3662, the one involved in the collision, had received its last line maintenance and pre-flight inspection on 15 December 1959, the day of the accident.

It was being flown by a captain, who was an air training supervisor employed by the 187th Fighter Interceptor Squadron of the Wyoming Air National Guard. Besides being a rated pilot on flying status and possessing a 3-2 (white) instrument card issued by the Air Force, he held a commercial pilot certificate with single-engine land and instrument ratings. Of a total of 2 450 hours that he had flown, 1 250 were in military aircraft. Of these, 160 were in the F-86L.

F-86L, 52-9993 was piloted by a first lieutenant, who was also a part-time reserve officer and a member of the 187th Fighter Interceptor Squadron. He was a squadron pilot and was also employed as a professional pilot. He was a rated pilot on flying status and held a 3-2 (white) instrument card issued by the Air Force as well as a commercial pilot certificate with single-engine, multi-engine and instrument ratings. He had a total of 1 400 hours flying - 800 in civilian aircraft and 600 in military. He had flown 500 jet hours, of which 250 were in the F-86L.

The Flights

The Beechcraft

It was en route to Denver, Colorado from St. Cloud, Minnesota with an en route business and fuelling stop at Dickinson, North Dakota. It took off from Dickinson at 1235 hours, then the pilot filed a VFR flight plan to Denver with the Dickinson FAA communications station. He proposed to fly to Rapid City, South Dakota, direct to Denver at 8 500 ft. At 1343 the pilot contacted Rapid City radio stating he was at 4 500 ft over the city, VFR to Denver. At 1515 he called Cheyenne radio on 122.1 Mc/s requesting the winds aloft and identified his flight. He did not give his position or altitude. The controller gave him the most favourable winds - between 8 and 11 000 ft. The information was repeated as requested, and the pilot acknowledged. Nothing further was heard from the aircraft.

The F-86L's

At 1420 hours that afternoon the F-86L's took off from Cheyenne on a tactical evaluation flight and because of its all-weather nature, following take-off the

lieutenant flew principally by reference to instruments, the captain flying as safety observer and positioning his aircraft behind, slightly below and to the right of the lieutenant's. At this time it was the captain's responsibility as safety pilot for the flight to look out for other aircraft.

After the intercept phase, the lieutenant called Cheyenne tower and requested a practice VFR-VOR jet penetration and ILS low approach.* The aircraft was cleared, was advised to maintain VFR, and to report leaving the VOR outbound at 20 000 ft and when leaving the outer marker inbound to the ILS runway.

The simultated instrument flight portion was carried out, following which the lieutenant returned to visual flight. The captain remained in the safety-observer position as chase pilot. At this time both looked for other aircraft but saw none.

The lieutenant asked for a "simulated flameout pattern**, as the flight crossed the airport above runway 26. The request was approved by the tower, however, the captain informed the lieutenant that he did not have sufficient fuel for the manoeuvre prior to landing. Therefore, it was decided not to make the simulated flameout, but to proceed to the initial point***, enter the initial approach (i.e. that portion along the runway extended centreline) and land. It also meant that the captain would join in close formation. The tower controller overheard the transmission and understood its meaning.

The tower controller watched the low approach and saw the jet flight make about a 30° right turn just past the end of the runway, in conformity with a noise-abatement procedure. The flight then continued outside the traffic pattern limits in a left climbing turn. The controller's attention was then turned to a T-33, in the traffic pattern for landing. The next call from the jet flight would be when it entered the tactical pattern at the initial point for runway 26.

The left turn was continued to 110°, interrupting it once on a heading of about 180° to clear the turn. The captain closed in the turn to close formation. He took position on the lieutenant's right wing with his aircraft slightly below the level of the lieutenant's with 4 to 5 ft wing-tip separation. Fore and aft he flew the "slat line". As the turn progressed, the flight accelerated to 270 kt indicated airspeed.

Because precision, planning and co-ordinated smoothness were important considerations in a satisfactory performance of the evaluation, the lieutenant planned to reach 9 000 ft, 270 kt and the 110° heading simultaneously. This was done, and both pilots estimated that it occurred about 30 seconds before the collision. At this point the lieutenant was the formation leader and the captain was the wingman. As flying formation requires the wingman's undivided attention to the leader, the responsibility to see and avoid other aircraft was entirely that of the formation leader. The lieutenant clearly understood his responsibility and believed that he had kept a careful lookout for other air traffic.

The lieutenant later testified that he recalled stopping the turn about 180° to clear the area, particularly in the direction he intended to continue. During the last 30 seconds he scanned the left quadrant,

* The penetration is an instrument procedure to transition jet fighters from high altitude to the instrument landing system. Low approach meant the plane would not land after the ILS but would go around, passing over the landing runway. The ILS at Cheyenne is from east to west; the runway is 26, 260°.

** A pattern used in the event of a jet power loss, commonly referred to as a "flameout". The pattern is practised by nearly all units using subsonic and trans-sonic fighters.

*** This is a location 5 miles east of runway 26. Jet fighters pass over the location and establish a flight path from it along the runway extended centreline to the end of the landing runway. The landing from this position is a 360° overhead pattern.

then straight ahead and then the right quadrant. At the same time he also checked the captain's position. When he returned his vision forward he saw an aircraft immediately in front of him and made a violent pullup to avoid it. He had no time to warn the captain (in 52-3662) or to identify the aircraft. He had looked in the area where the Beechcraft was located but had not seen it, and except for brief altitude, airspeed and heading checks there were no duties requiring his attention within the cockpit.

The captain testified that his attention was concentrated on the formation formup and thereafter on holding close position. He believed that heading, speed and altitude were as the lieutenant described them. He also believed that these factors were constant for at least the last 30 seconds before collision. He recalled a flash on his windscreen before impact but did not recognize the Bonanza.

Weather

At the time of the collision the weather conditions were: high thin cirrus, visibility 90 miles.

The Collision

Analysis of the factual information and physical evidence led the Board to determine that the in-flight contact sequence began with the Beechcraft on a heading of 154° and the F-86L on a heading of 110°. The Bonanza was flying at a calculated true airspeed of 139 kt and the F-86L at a computed true airspeed of 312 kt. Initial in-flight contact occurred when the F-86L nose structure contacted the fuselage of the Beechcraft just behind the right rear cabin window. The sequence progressed as the nose structure above the wing of the F-86L penetrated and cut through the Beechcraft fuselage at an angle of 110° to the fuselage centreline measured clockwise from the nose. Forces attending the sequence sheared off the Bonanza fuselage aft of the swath line while the right wing of the F-86L most probably passed below the plane of the wings of the Beechcraft.

Because the colliding F-86L was in straight and level flight during the sequence and because the wings of neither aircraft made contact, it was most apparent that the Bonanza was also straight and level. This was substantiated by the lack of any vertical deformation to the structure involved in the collision. These factors caused the Board to believe that no evasive action occurred which would indicate the Bonanza pilot saw the F-86L's during the collision closure.

As part of the Board's analysis a vector diagram (see Figure 18) was prepared, and the probable flight paths of the aircraft were determined for the 60-second period of closure prior to the collision. From the study it was possible to determine the relative position of each aircraft to the other at any given period. Similarly, it was possible to assess the opportunities afforded each pilot to have sighted the other's aircraft in order to avoid the collision.

The study showed that at the beginning of the 60-second period the colliding aircraft were separated 3.48 statute miles. At this time the Beechcraft was located 67° to the left of the nose of the jet formation leader's aircraft. It would have been slightly above the leader and visible to him through the canopy glass, presenting a quartering rear profile. During the first 30 seconds, while the F-86L's were turning, the angular position of the C-35 gradually shifted to a position about 26° to the left of the nose of the leader's aircraft and to approximately eye level. During the final 30 seconds, with formation straight and level, the position of the Beechcraft would remain unchanged.

The study also showed that at the beginning of the 60-second period the F-86L formation was positioned 129° to the right rear of the nose of the Beechcraft, or approximately 40° to the rear of the 90° position. The jets would have been below the level of the Beechcraft. During the first 30 seconds the position of the jet formation would gradually shift forward until it was positioned level at a sighting angle of 110° to the right rear of the nose of the C-35. During the final 30 seconds this position would remain unchanged.

Conclusions

From the available evidence and analytical study of this accident it was the conclusion of the Board that an overtaking situation occurred in which the F-86L formation overtook the Beechcraft from its right rear. The Board concluded that during the 60-second period of closure the Beechcraft was positioned well within the forward visual quadrant of the jet formation leader and that it presented an adequate profile for visual detection within the distance which separated the aircraft. The Board, therefore, concluded that there was an adequate opportunity for the jet formation leader to have seen the Beechcraft in time to have led his wingman off collision course, in accordance with the responsibility of an overtaking pilot.

At all times during the 60-second period before collision the jet formation was positioned well to the right rear of the Beechcraft. This position was as much as 129° and was never less than 110°. It is fundamental that a pilot's primary responsibility is to direct his attention to the most critical area, which is the 180° quadrant ahead of his aircraft. While this is not intended to mean that a pilot should not search all areas available to him, it does mean that his greatest effort should be in the direction of flight with reliance than an overtaking pilot will similarly fulfil the same responsibility. Accordingly, the Board did not believe that the opportunities afforded the pilot of the Beechcraft were sufficiently adequate to have expected him to have seen the jets.

Following this accident, the Air National Guard unit at Cheyenne requires that on missions which require a safety observer, the pilot performing this responsibility will do so throughout the entire mission. This action is to enable all pilots flying as a flight to look for other aircraft. The second action taken was to raise the jet altitude minimum prior to initial approach. This was also done by the Air Guard unit. The Board believed that if there is a concentration of traffic in the Cheyenne Airport area between 3 000 and 4 000 ft, action to utilize a higher altitude by the fighters should also be effective in reducing collision exposure.

Cheyenne Municipal Airport

It has a conventional five-mile radius control zone and utilizes conventional left traffic patterns, one for light aircraft and the other for heavy traffic. The first is close in and the latter is within three miles of the centre of the airport. In addition, the F-86L's use a tactical approach and 360° overhead landing pattern. All of the patterns were published and disseminated locally. The use of the airport by the jet fighters and the fact that they made instrument low approaches was also published in the Airman's Guide according to its publication procedures.

Communications

The F-86L flight utilized UHF (ultra high frequency) communications and the Beechcraft was equipped with VHF (very high frequency) communications. The tower did not, nor does any tower normally, transmit simultaneously on both VHF and UHF communications. The F-86L pilots and the Bonanza pilot, therefore, could not overhear radio communications made with respect to the other.

Probable Cause

The probable cause of this accident was that during an overtaking situation the jet formation leader failed to see the Beechcraft in time to lead his wingman off collision course.

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ICAO Ref: AR/644

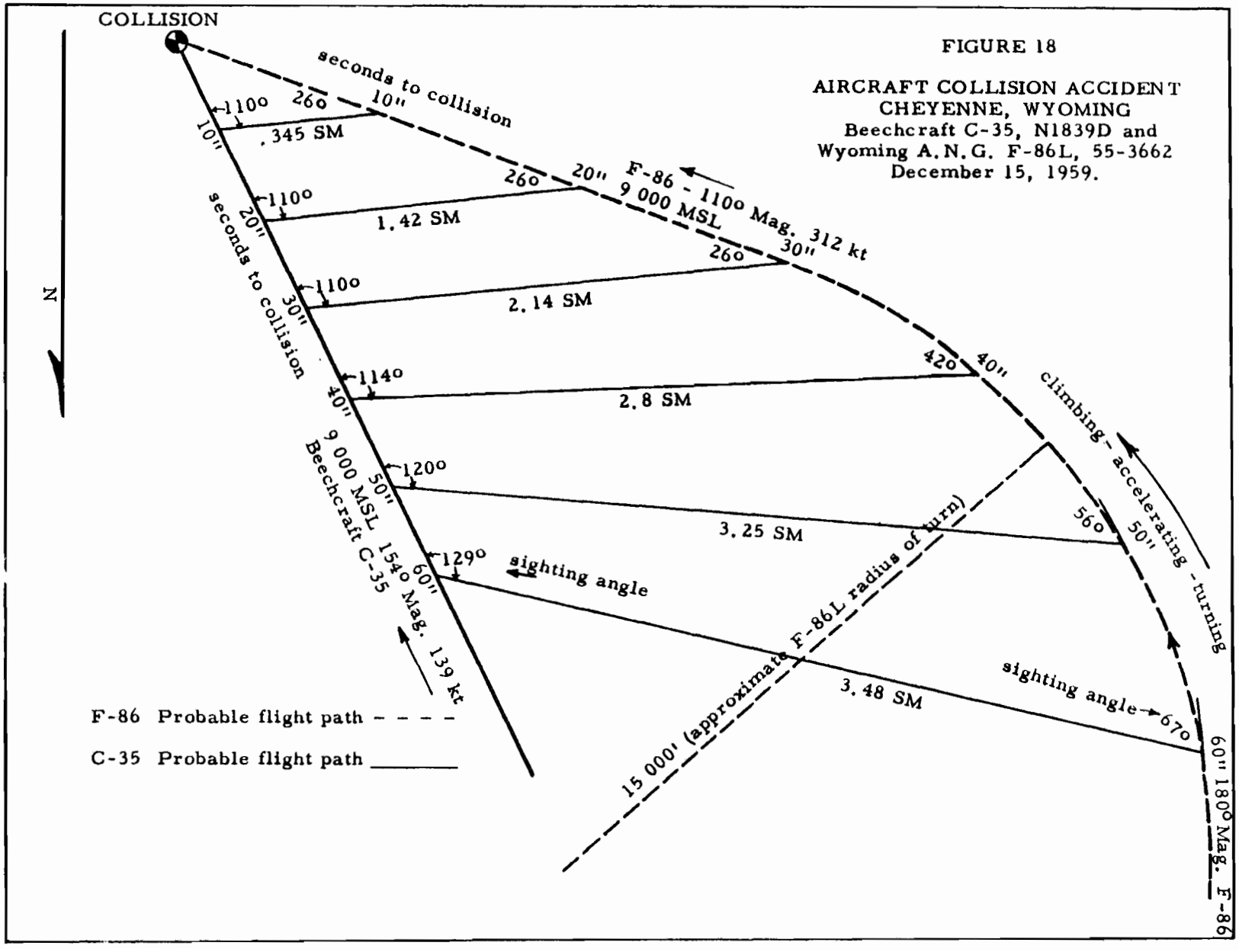

FIGURE 18

AIRCRAFT COLLISION ACCIDENT
CHEYENNE, WYOMING
Beechcraft C-35, N1839D and
Wyoming A.N.G. F-86L, 55-3662
December 15, 1959.

No. 61

Aer Lingus, Friendship aircraft, EI-AKA, accident at Renfrew Airport, Scotland, on 22 December 1959. Conclusions of the Investigating Officer as released by the Department of Transport and Power, Dublin, Ireland - September 1960.

Circumstances

Shortly after take-off the port engine failed, and the aircraft had to return immediately to the airport for an emergency landing. On the landing run the landing gear was retracted to avoid possible overrunning of the airport boundary. Damage was sustained to the under parts of the fuselage, the cabin floor and the starboard propeller. Of the 37 passengers and 3 crew members aboard, only the hostess was slightly injured.

Conclusions of the Investigating Officer

The aircraft was certified as airworthy and had been properly maintained. The loading for this flight was correct and within the permissible limits of weight and balance.

The captain and co-pilot held valid licences and were qualified to undertake the flight.

Preparations for the flight had been completed satisfactorily, and operational requirements had been complied with.

The Flight

On failure of the port engine just after take-off, the pilots carried out correctly the required emergency procedures. The descent was commenced in the final approach at a speed sufficiently in excess of the approach speed demanded by the existing conditions (105 kt) to make attainment of correct height and speed at the runway threshold extremely problematical. The high approach speed resulted in excessive height (100 ft) and excessive speed (probably to the extent of 10 kt) at the runway threshold. These factors, in conjunction with sub-normal deceleration, due to absence of "ground fine pitch" on the failed engine, and low braking efficiency, due to the very wet state of the runway, prevented the aircraft being stopped within runway limits. The captain's decision to raise the landing gear, in order to avert the possibility of a more serious accident, was correct.

Meteorological Conditions

Conditions at the time of the accident were very poor. They added substantially to the difficulties of an asymmetric landing. The effective cloud height was 800 ft, and the surface visibility was 1 300 yd in rain.

Probable Cause

Fuel contamination caused abrasion damage to parts of the fuel pump fitted to the port engine. This led to failure of the pump drive shaft with consequent engine failure.

Due to excessive speed during the final approach on one engine, and the wet state of the runway, the captain was unable to stop the aircraft safely within runway limits.

Follow-up Action

After the accident and pending a detailed examination, which was subsequently made by the fuel company concerned, of the sources of the fuel supplied to Aer Lingus, the overhaul life of fuel pumps in Aer Lingus aircraft was restricted, and a precautionary inspection system was instituted.

The source of fuel contamination has since been discovered, and steps have been taken to prevent a recurrence of this trouble. This contamination was of an unusual type, which could not be detected by the detection methods in use up to that time.

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ICAO Ref: AIG/ACC/REP/GEN/No. 12 - Ireland

No. 62

Garuda Indonesian Airways, DC-3, PK-GDV, accident near Palembang, Sumatra, on 24 December 1959. Report released by the Ministry of Air Communications, Indonesia.

Circumstances

The aircraft departed Talang Betutu Airport, Palembang at 0446 hours GMT as scheduled Flight 330, en route to Pangkal Pinang on an IFR flight plan. Approximately 13 minutes after take-off while still climbing it experienced trouble in its right engine, and an attempt was made to return to Talang Betutu. However, the aircraft crashed in a swamp area about 3 miles from the airfield, killing the pilot and seriously injuring the co-pilot. The aircraft was destroyed.

Investigation and Evidence

As only a narrow path could be seen indicating the flight path of the right wing and right propeller, it was determined that the aircraft had been descending at an angle of approximately 20° in a rather steep right bank. The right wing then hit a tree. Due to this impact the aircraft then made a right-hand swing hitting a cluster of trees. The aircraft completed this swing through a total arc of approximately 180°, lost its speed and dropped down vertically to the ground.

All structural failures, fractures and distortions were due to impact. There was no evidence of any explosion and/or fire nor was there any evidence of faulty assembly or breakdown, which might have caused the accident.

With regard to the fuel system, water in the fuel or fuel contamination could not be determined from actual tank inspection. However, the records were inspected, and the correct procedures had been followed with regard to refuelling and drainage of fuel for water content.

Instrument readings, indicators, handles and switches provided mostly unreliable information.

No evidence was found of any malfunction in the left engine and propeller. The propeller was in fine pitch and only very slightly bent, indicating no power at the time of impact.

The nose section of the right engine had been broken off at impact. Its propeller was also in fine pitch and showing no sign of power at time of impact. The filter inspection showed traces of silver, lead, steel and bronze. Although the quantity found was small and would be negligible under normal circumstances; it could be an indication of an impending internal failure.

The left-hand magneto was found to be in order, however, the right-hand one could not be bench tested. It had been damaged during the accident. Further disassembly of the magnetos and an interview with the co-pilot did not reveal any more information. No other inspection or investigation was possible on the right engine.

The Flight (See Figure 19)

The co-pilot testified that the take-off was normal, and the aircraft climbed to a cruising altitude of 5 000 ft. During climb-out, the co-pilot, who was sitting in the left-hand seat, noticed that the rate of climb was only 300 - 350 ft/min at an indicated airspeed of 115 kt, when it should be 500 ft/min at a gross weight of

27 200 lb, the maximum allowable. (Examination of the loadsheet revealed that at take-off, maximum gross weight was exceeded by 154 lb. The centre of gravity limits were not exceeded.)

When the aircraft reached an altitude of over 4 000 ft, at approximately 13 minutes out, the right-hand engine experienced roughness. It was decided to return to base. METO power was applied on the left engine, and the right engine was still windmilling, but throttle and pitch control were pulled back, and the mixture was in idle cut-off.

The captain took over the controls and the co-pilot set the radio compass and handled the radio. Some time later, during descent, an unsuccessful attempt was made to restart the right engine. Eight to ten minutes after return to base, at an altitude of 500 - 800 ft, the aircraft broke through the clouds but the crew were still unable to see the airfield. The flight continued beneath the overcast.

The co-pilot realized that the aircraft was abnormally low while he was looking out for a suitable place to land in case of a forced landing and also was watching the right engine. He warned the captain of trees and the stick was pulled back and the speed of the aircraft was reduced to 70 - 65 kt. Before the impact the captain closed both throttles.

Some passengers, the radio operator and the stewardess on duty testified that the aircraft was flying at a nose-up attitude first and then down prior to impact.

Weather

Prior to departure from Talang Betutu, the forecast for the route to Bangka was not available. Based on the map available, the captain was told that there was moderate rain and a thunderstorm.

The actual weather conditions at the time of the accident were showery conditions east of the airfield in the direction of Bangka, visibility 3 NM, dark clouds northeast of the airfield moving to the south, cloud bases in the showers estimated at 1 500 ft, and scattered clouds with bases of approximately 500 - 800 ft near the airfield.

Analysis

The fact that the captain had filed for an instrument flight rules flight plan did not prevent him from attempting to make visual contact as soon as possible by descending to a lower altitude. The investigation revealed that the weather was marginal for VFR flight. The crew and passengers testified that the aircraft flew intermittently through showery conditions, and visual contact was made when the aircraft was low.

It was believed that the captain deliberately made the descent to break clouds and did not try to conserve height.

The elapsed time between initial descent at 0500 GMT from 4 000 ft to 500 ft to fly below the clouds, according to the testimony of the co-pilot, was approximately 10 minutes, which means that the aircraft must have descended at a rate of 350 ft/min. This agrees with the testimony of the senior tower operator that at 0510 GMT the aircraft was visual from the tower at an altitude of between 500 - 800 ft. This is a normal rate of descent at the estimated gross weight. Even with a higher overload, the rate of descent would have been less than 350 ft/min with an indicated airspeed of 100 kt, left-hand engine in METO power, right-hand propeller in coarse pitch, windmilling. This was confirmed by a test under simulated conditions.

It might have been either METO power rpm, auto-rich mixture, but less manifold pressure, and windmilling coarse pitch on the right-hand power unit or METO power setting on the left and windmilling fine pitch on the right-hand power unit.

The testimony of the co-pilot regarding the 300 - 350 ft/min rate of climb in

normal climb configuration after take-off with an indicated airspeed of 115 kt might have been a misreading of airspeed on the rate of climb indicator and/or a temporary indication. Assuming a rate of climb of 300 - 350 ft/min at an indicated airspeed of 115 kt in normal climb configuration, the overload would have been more than 2 000 lb. This is very unlikely.

Several possible flight paths were considered by the Committee, but the most likely is shown in Figure 19.

The captain continued to descend to a lower altitude after breaking clouds when he was able to clearly see and identify objects on the ground. This led the Committee to believe that the captain was not aware of the impending serious conditions. The right-hand propeller remained in unfeathered condition; whether this was caused by inability to feather or no attempt had been made to feather, could not be determined. The co-pilot assumed that the captain wanted to preserve power until a later time. It was concluded that the captain of PK-GDV was still confident he would reach the airfield, when at 0511 GMT he was talking to the captain of another aircraft who was flying overhead the field. At this time the conversation was broken off... he then became aware of the situation. However, it was too late to take preventive action.

The Committee concluded that the throttle handle of the left-hand engine was advanced during descent but not up to METO power, or that the statement that the right-hand propeller was on coarse pitch was not true. It also believed that the captain attempted to fly beneath the overcast and expected to reach the airfield with sufficient height to make a straight-in approach to runway 29.

Probable Cause

The probable causes of the accident were failure of the right engine, a lack of precaution on the part of the captain and marginal weather. A contributing factor may have been the overloaded condition of the aircraft, however, not to such an extent that it forced the aircraft to descend to a dangerously low altitude.

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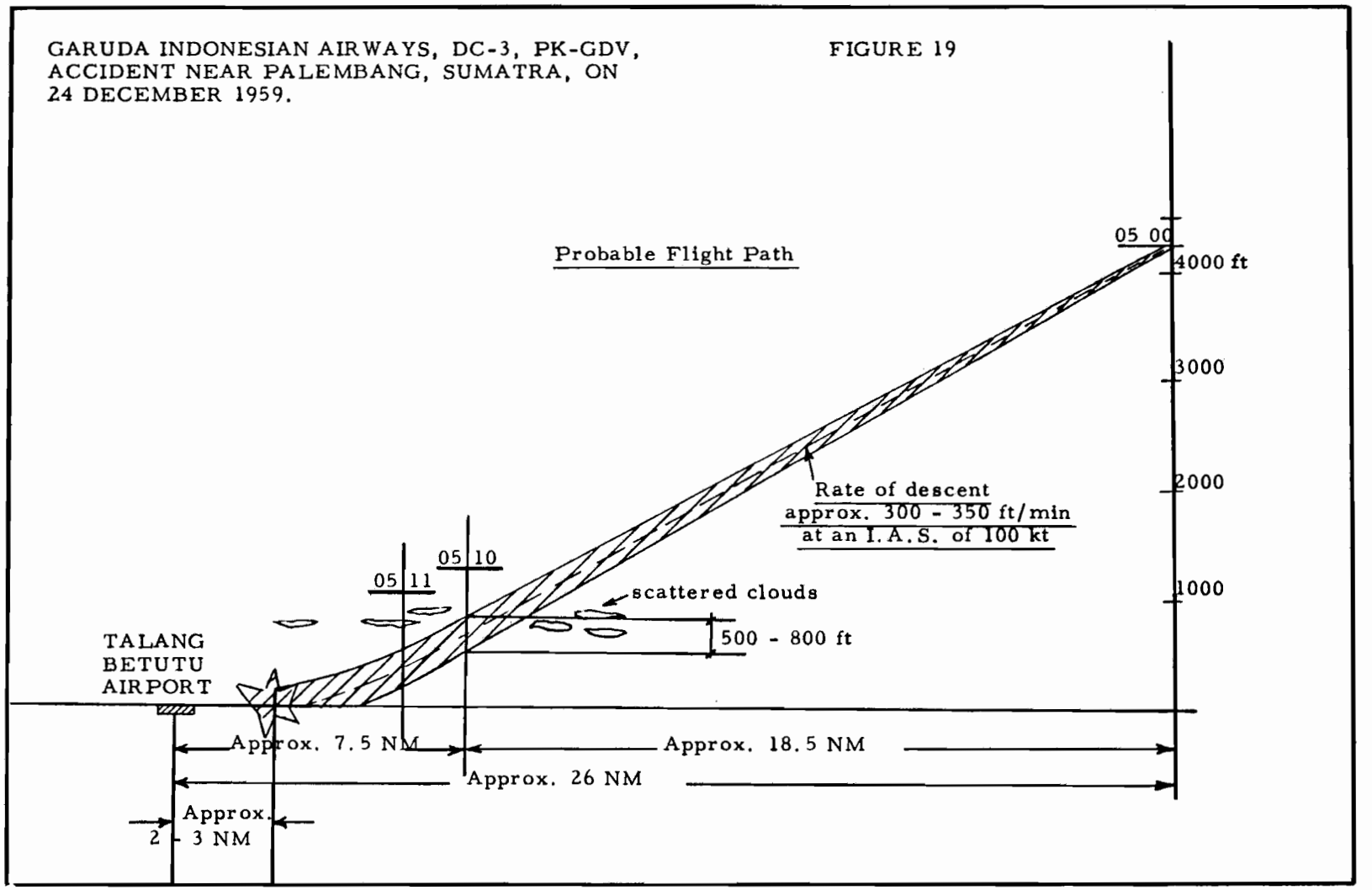
GARUDA INDONESIAN AIRWAYS, DC-3, PK-GDV, ACCIDENT NEAR PALEMBANG, SUMATRA, ON 24 DECEMBER 1959.

FIGURE 19



PART II

AIRCRAFT ACCIDENT STATISTICS 1959

INTRODUCTION

GENERAL COMMENTS

1. This section of the Aircraft Accident Digest No. 11 contains a detailed analysis of the statistics for the year 1959, as well as an historical record of selected data for the years 1925 to 1960 inclusive. Figures for the years subsequent to 1951 were obtained largely from the ICAO Air Transport Reporting Forms G (Aircraft Accidents; see pages 243 and 244) 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 - 1960.

TABLE A Number of passengers killed and passenger fatality rates on scheduled air services 1925 - 1960.

4. Three tables are given for the year 1959. The accident data has been recorded under the country in which the airline which suffered an accident is registered and not under the country where the accident took place. These three tables give the following information:

TABLE B Passenger fatalities occuring 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

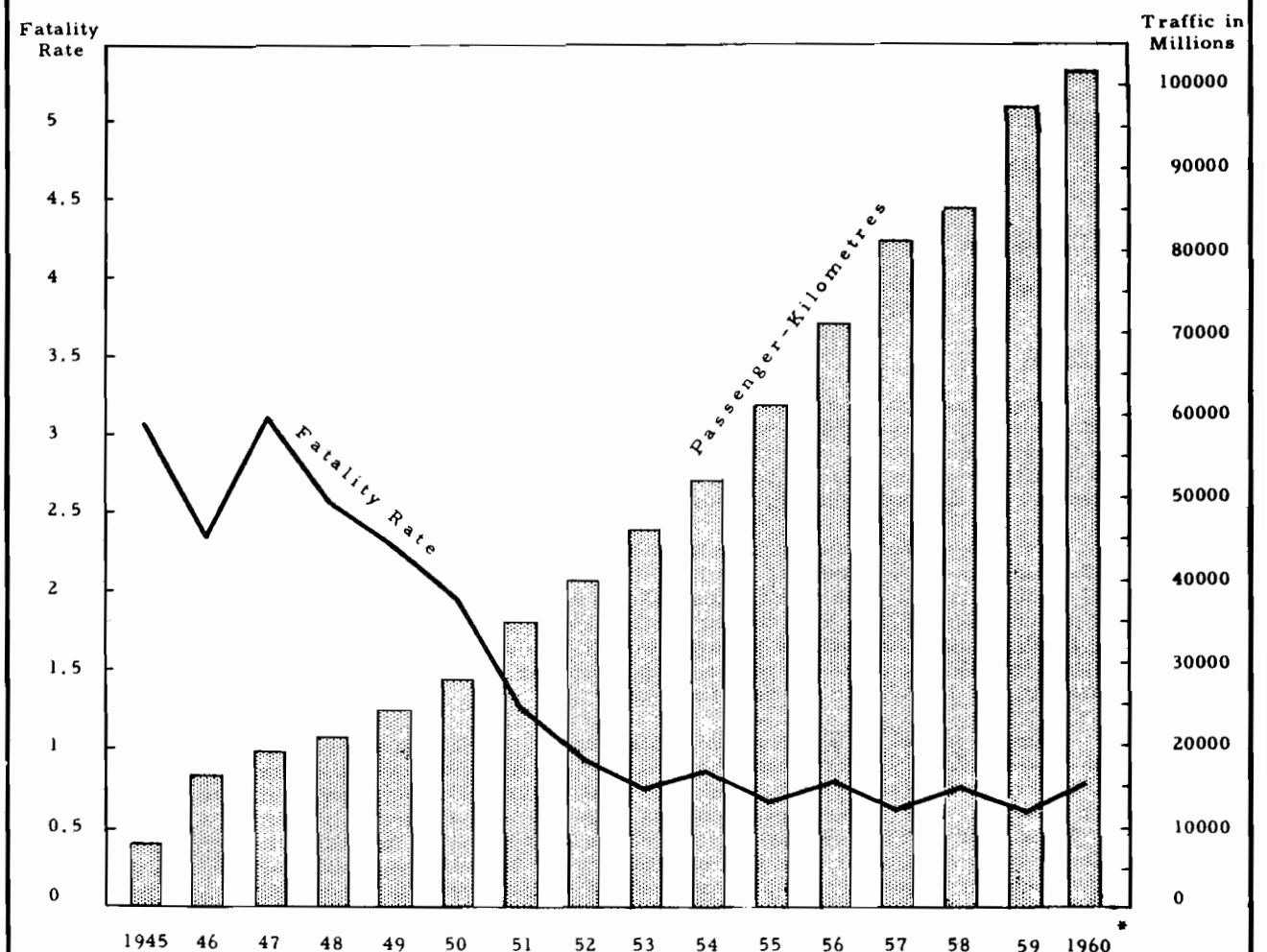
5. There has been a remarkable downward trend in passenger fatality rates since 1945, indicating a steady improvement in safety of commercial flying over the past fourteen years. Despite the increased speeds, weights, range of the aircraft flown today and the increased traffic density on airways as compared with over a decade ago, the risk of accident occurrence has lessened over the period largely through technical changes and improvements in proficiency.

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. With this in mind, if the safety record is extended to compare the pre-war period (1925 - 1939), with the war period (1940 - 1944), and the post-war period (1945 - 1960), it is found that the average fatality rate per 100 million passenger-kilometres has dropped from 12 in the pre-war period, to 3 in the war period, to 2.5 in the first six years after the war, and to 0.76 for the next ten years.

7. From a perusal of the chart and table shown on the following pages, it will be observed that preliminary reports show that the fatality rate per passenger-kilometre on the scheduled services increased from 0.63 for 1959 to 0.77 for 1960. An increase of this kind is not large enough to lead to the conclusion that there has been a reversal of overall downward trend. The rate of 0.77 for 1960 is only 25% of the 3.09 of 1945. For the ninth consecutive year, the rate has remained at less than one fatality per 100 million passenger-kilometres flown. Although the number of passenger killed on scheduled flights over the period 1952 to 1960 ranged from a low of 356 persons in 1953 to a high of 857 persons in 1960, the extent of the increase in passenger traffic has more than offset the change in the level of passengers killed thereby maintaining the fatality rate below the mark of one.

PASSENGER FATALITY RATE AND TRAFFIC

SCHEDULED AIR SERVICES 1945 - 1960 *



NOTES: Fatality rate equals number of passengers killed per 100 million passenger-kilometres flown.

* Preliminary figures.

TABLE A

PASSENGER FATALITIES 1925 - 1960

ON

SCHEDULED AIR SERVICES

YEARS	Number of Passengers Killed	Passenger-Kilometres Flown (millions)	Fatality Rate per 100 million Pass-Kms.	Millions of Passenger-Kilometres per Fatality
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
1946	376	16 000	2.35	43
1947	590	19 000	3.11	32
1948	543	21 000	2.59	39
1949	556	24 000	2.32	43
1950	551	28 000	1.97	51
1951	443	35 000	1.27	79
1952	386	40 000	0.97	104
1953	356	46 000	0.77	129
1954	447	52 000	0.86	116
1955	407	61 000	0.67	150
1956	552	71 000	0.78	129
1957	507	81 000	0.63	160
1958	615	85 000	0.72	138
1959	615 a/	97 000	0.63	158
1960 (preliminary)	857	111 000	0.77	130

Exclusions: The People's Republic of China and USSR.

1959

TABLE B

CONTRACTING STATES OF ICAO

PASSENGER FATALITIES OCCURRING ON

SCHEDULED INTERNATIONAL AND DOMESTIC OPERATIONS

YEAR 1959

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						
Afghanistan	10*	1	19	52*		
Argentina	97	3	53	674		
Brazil	414*	2	42	2 599		
Colombia	163+	2	53	681+		
El Salvador	12*	1	13	53*		
France	355	1	53	4 505		
Germany	80	1	29	842		
Greece	29	1	15	210		
India	131+	1	20	939+		
Peru	34*	1	8	127*		
Spain	74	2	26	662		
Turkey	34	1	9	163		
United States	4 503	10	275	58 532		
All other States	2 949	-	-	27 064		
Total	8 885	27	615	97 103	0.63	158
International Scheduled Operations						
Afghanistan	5*	1	19	34*		
Argentina	25	1	1	354		
Colombia	28+	1	10	191+		
El Salvador	12*	1	13	53*		
France	155	1	53	2 374		
Germany	73	1	29	819		
Turkey	4	1	9	19		
United States	684	1	59	11 369		
All other States	1 631	-	-	19 132		
Total	2 617	8	193	34 345	0.56	178
Domestic Scheduled Operations						
Argentina	72	2	52	320		
Brazil	376*	2	42	2 160		
Colombia	135+	1	43	490+		
Greece	17	1	15	95		
India	89+	1	20	437+		
Peru	32*	1	8	100*		
Spain	45	2	26	333		
United States	3 819	9	216	47 163		
All other States	1 683	-	-	11 660		
Total	6 268	19	422	62 758	0.67	149

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.

CONTRACTING STATES OF ICAO

AIRCRAFT ACCIDENT SUMMARY FOR 1959

OF ALL OPERATORS ENGAGED IN PUBLIC AIR TRANSPORT

1959

TABLE C

Contracting States of ICAO at 31 December	Number of Accidents		Passenger Injury			Crew Injury			Others Injured		By Operators With an Accident		Hours flown 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	
Afghanistan	1	1	19	-	3	5	-	-	-	-			
ø Argentina	10	3	53	-	93	10	-	26	-	-	51 481	87 940	103 835
Australia	-												
Austria	-												
Belgium	-												
Bolivia	-												
ø Brazil	5	5	42	-	-	19	-	-	5	-	42 079	52 367	431 102
Burma	-												
ø Cambodia	-	-	-	-	-	-	-	-	-	-			
ø Canada a/	4	-	-	3	111	-	2	13	-	-	175 704*	279 929*	305 728 b/
ø Ceylon	-	-	-	-	-	-	-	-	-	-			
Chile	-												
ø China (Rep. of)	-	-	-	-	-	-	-	-	-	-			
Colombia	2	2	53	-	-	7	-	-	-	-			
ø Costa Rica	4	3	-	-	25	2	2	2	1	-	87 530		26 333
Cuba	-												
ø Czechoslovakia	-	-	-	-	-	-	-	-	-	-			34 531
Denmark	-												
Dominican Rep.	-												
Ecuador	-												
El Salvador	1	1	13	-	2	2	-	2	-	-			
Ethiopia	-												
Finland	-												
France	1	1	53	-	3	9	-	-	-	-			
ø Germany (Fed. Rep. of)	3	1	29	-	119	7	3	10	-	-	33 214	92 445	114 478
Ghana	-												
ø Greece	1	1	15	-	-	3	-	-	-	-	21 466	29 912	
Guatemala	-												
Guinea	nca	nca											
Haiti	-												
Honduras	-												
Iceland	-												
India	1	1	20	-	-	4	-	-	-	-			
ø Indonesia	1	1	-	-	1	1	1	1	-	-	18 056	38 840	
Iran	-												
Iraq	-												
ø Ireland	2	-	-	-	-	-	-	-	-	-	23 806	28 010	33 550
Israel	-												
ø Italy	1	1	-	-	-	2	-	-	-	-	47 113	95 506	
ø Japan	-	-	-	-	-	-	-	-	-	-			
Jordan	-												
ø Korea (Rep. of)	-	-	-	-	-	-	-	-	-	-			4 454
Laos	-												
Lebanon	-												
Liberia	-												
Libya	-												
Luxembourg	nca	nca											
Malaya (Fed. of)	-												
Mexico	-												
Morocco	-												
ø Netherlands	-	-	-	-	-	-	-	-	-	-			
ø New Zealand	4	-	-	-	13	-	-	5	-	-	3 243	1 119	84 024
Nicaragua	-												
Norway	-												
Pakistan	-												
Paraguay	-												
Peru	1	1	8	-	-	4	-	-	-	-			
ø Philippines	-	-	-	-	-	-	-	-	-	-			
Poland	-												
Portugal	-												
ø Spain	2	2	26	1	3	3	-	2	-	-	44 258	77 292	77 292
Sudan	-												
ø Sweden	14	2	2	-	-	2	-	-	-	-	85 343 c/	121 378 d/	152 462 c/
ø Switzerland	1	1	1	-	-	-	1	-	-	-			101 869
ø Thailand	-	-	-	-	-	-	-	-	-	-			11 955
ø Tunisia	-	-	-	-	-	-	-	-	-	-			
ø Turkey	1	1	9	7	-	5	3	-	-	-	19 348	34 248	34 248
ø Union of S. Africa	23	-	-	-	-	-	-	-	-	-	35 534	36 442	94 490
United Arab Rep.	-												
ø United Kingdom e/	23	3	29	-	388	17	1	76	-	1			426 261 b/
ø United States g/	112	19	278	27	2 341	64	15	324	8	1	3 312 637	4 532 510	5 070 018
Uruguay	-												
ø Venezuela	1	1	-	-	-	3	-	-	-	-			
Viet-Nam (Rep. of)	-												
Total for 74 States	219	51	650	38	3 102	169	28	461	14	2			
TYPE OF OPERATION													
Scheduled International	27	9	193	9	634	45	6	113	-	-	)		
Scheduled Domestic	109	26	422	25	2 064	83	15	259	13	1	(		
Non-Scheduled International	9	3	29	-	188	17	1	19	-	-	) see Table D		
Non-Scheduled Domestic	52	7	5	4	216	7	4	27	1	1	(		
Non-Revenue	22	6	1	-	-	17	2	43	-	-	)		
Total Operations	219	51	650	38	3 102	169	28	461	14	2			

NOTES: Source of data: Air Transport Reporting Form G filed by countries indicated with a ø.
All other country data collected from outside sources.

* Estimated.
nca - No Civil Aviation.
a/ Form G data for scheduled operations only.
b/ Data for total operations of all scheduled operations.
c/ Only the Swedish quota of Scandinavian Airlines System's operations is included.
d/ Includes some hours flown by helicopters whereas landings by the same are excluded.
e/ Data refer to airlines registered in the United Kingdom and its dependencies. Data incomplete for number of landings and hours flown.
f/ Data for airlines registered in the United Kingdom.
g/ Data refer to all public air transport, i.e. scheduled U.S., Alaska airlines and irregular air carriers. Data incomplete for number of landings and hours flown.

1959

TABLE D

CONTRACTING STATES OF ICAO

AIRCRAFT ACCIDENT SUMMARY FOR 1959

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												
Afghanistan	1	1	19	-	3	5	-	-	-	-		
ϕ Argentina	1	1	1	-	53	1	-	10	-	-	7 162	18 140
ϕ Canada a/	1	-	-	-	35	-	-	4	-	-	36 800 b/	70 667
Colombia	1	1	10	-	-	4	-	-	-	-		
El Salvador	1	1	13	-	2	2	-	2	-	-		
France	1	1	53	-	3	9	-	-	-	-		
ϕ Germany	1	1	29	-	-	7	3	-	-	-	24 407	73 112
ϕ Ireland	2	-	-	-	-	-	-	-	-	-	18 889	23 760
ϕ Turkey	1	1	9	7	-	5	3	-	-	-	3 050	4 500
ϕ United Kingdom c/	7	-	-	-	223	-	-	49	-	-	42 553	147 512
ϕ United States d/	10	2	59	2	315	12	-	48	-	-	148 233	492 028
Total for 11 States	27	9	193	9	634	45	6	113	-	-		
SCHEDULED DOMESTIC OPERATIONS												
ϕ Argentina	9	2	52	-	40	9	-	16	-	-	36 580	56 881
ϕ Brazil	3	3	42	-	-	13	-	-	5	-	40 679	47 371
ϕ Canada	3	-	-	3	76	-	2	9	-	-	134 400 b/	180 774
Colombia	1	1	43	-	-	3	-	-	-	-		
ϕ Costa Rica	2	2	-	-	-	2	-	-	-	-	5 508	4 838
ϕ Greece	1	1	15	-	-	3	-	-	-	-	14 918	16 864
India	1	1	20	-	-	4	-	-	-	-		
ϕ Indonesia	1	1	-	-	1	1	1	1	-	-	17 413	28 985
ϕ New Zealand	1	-	-	-	7	-	-	2	-	-	120 b/	87
Peru	1	1	8	-	-	4	-	-	-	-		
ϕ Spain	2	2	26	1	3	3	-	2	-	-	34 253	45 093
ϕ Sweden	1	-	-	-	-	-	-	-	-	-	15 414	21 220
ϕ Union of S. Africa	1	-	-	-	-	-	-	-	-	-	1 207	1 127
ϕ United Kingdom c/	8	-	-	-	133	-	-	19	-	-		
ϕ United States d/	74	12	216	21	1 804	41	12	210	8	1	2 958 006	3 390 828
Total for 15 States	109	26	422	25	2 064	83	15	259	13	1		
NON-SCHEDULED INTERNATIONAL OPERATIONS												
ϕ Germany	2	-	-	-	119	-	-	10	-	-	1 375	6 200
ϕ Sweden	1	-	-	-	-	-	-	-	-	-		5 521
ϕ United Kingdom c/	4	3	29	-	32	17	1	7	-	-		
ϕ United States e/	2	-	-	-	37	-	-	2	-	-	3 528	6 514 f/
Total for 4 States	9	3	29	-	188	17	1	19	-	-		
NON-SCHEDULED DOMESTIC OPERATIONS												
ϕ Costa Rica	1	1	-	-	25	-	-	2	1	-	82 000	30 425
ϕ New Zealand	3	-	-	-	6	-	-	3	-	-	3 043	948
ϕ Sweden	8	1	1	-	-	1	-	-	-	-	13 962	15 410
ϕ Switzerland	1	1	1	-	-	-	1	-	-	-	833	351
ϕ Union of S. Africa	22	-	-	-	-	-	-	-	-	-	32 988	34 160
ϕ United Kingdom c/	3	-	-	-	-	-	-	-	-	1		
ϕ United States e/	14	4	3	4	185	6	3	22	-	-	17 621	71 707
Total for 7 States	52	7	5	4	216	7	4	27	1	1		
NON-REVENUE OPERATIONS												
ϕ Brazil	2	2	-	-	-	6	-	-	-	-		
ϕ Costa Rica	1	-	-	-	-	-	2	-	-	-	22	102
ϕ Italy	1	1	-	-	-	2	-	-	-	-	3 690	921
ϕ Sweden	4	1	1	-	-	1	-	-	-	-	17 963	5 174
ϕ United Kingdom c/	1	-	-	-	-	-	-	1	-	-		
ϕ United States f/	12	1	-	-	-	5	-	42	-	-		52 095
ϕ Venezuela	1	1	-	-	-	3	-	-	-	-		
Total for 7 States	22	6	1	-	-	17	2	43	-	-		

NOTES: Source of Data: Air Transport Reporting Form G filed by countries indicated with a ϕ.
All other country data collected from outside sources.

a/ Includes trans-border.
b/ Estimated.
c/ Data refer to airlines registered in the United Kingdom and its dependencies. Data incomplete for number of landings and hours flown.
d/ Data for all scheduled U.S. and Alaska airlines.
e/ Data for all scheduled U.S. and Alaska airlines as well as irregular air carriers.
f/ Data incomplete for number of landings and hours flown.

FORM G

INTERNATIONAL CIVIL AVIATION ORGANIZATION

AIR TRANSPORT REPORTING FORM

COUNTRY............... **AIRCRAFT ACCIDENTS** YEAR ENDED............

Name of Operator	Type of Operation	Number of Accidents		Passenger Injury			Crew Injury			Others Injured		Number of Landings	Hours Flown
		Total	Fatal	Fatal	Serious	Minor/None	Fatal	Serious	Minor/None	Fatal	Serious		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	Scheduled International												
	Scheduled Domestic												
	Non-Scheduled International												
	Non-Scheduled Domestic												
	Non-Revenue Flights												
	Total Operations	—	—	—	—	—	—	—	—	—	—		
	Scheduled International												
	Scheduled Domestic												
	Non-Scheduled International												
	Non-Scheduled Domestic												
	Non-Revenue Flights												
	Total Operations	—	—	—	—	—	—	—	—	—	—		
	Scheduled International												
	Scheduled Domestic												
	Non-Scheduled International												
	Non-Scheduled Domestic												
	Non-Revenue Flights												
	Total Operations	—	—	—	—	—	—	—	—	—	—		
	Scheduled International												
	Scheduled Domestic												
	Non-Scheduled International												
	Non-Scheduled Domestic												
	Non-Revenue Flights												
	Total Operations	—	—	—	—	—	—	—	—	—	—		

Total hours flown during the year by all operators engaged in public air transport = ...

Remarks:

DOC 7357 - STA/529 - 1/53 The attention of ICAO should be drawn to any unavoidable deviation from the instructions.

INSTRUCTIONS

Reporting Period: This form is to be filed annually by each State in respect of aircraft accidents of operators, registered in the country, which are engaged in public air transport.

Filing Date: This form should be filed not later than 2 months after the end of the year to which it refers.

Notes: 1) Data for individual operators are required only in respect of those operators whose aircraft were involved in an accident - regardless of where the accident took place.
2) The total number of hours flown by all operators (whether involved in accidents or not) should also be inserted in the space provided. The form should be filed giving this information even if there are no accidents to report.

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 received substantial damage (Annex 13).

Notes: 1) An accident resulting in only minor injuries or damages need not be reported.
2) A collision between two or more aircraft should be reported separately for each operator involved, and additional details should be provided under 'Remarks'

Type of Operation:
a) 'Scheduled International', 'Scheduled Domestic', 'Non-Scheduled International' and 'Non-Scheduled Domestic' operations relate to flights operated for the purpose of carrying revenue load.
b) 'Non-Revenue Flights' relate to positioning flights, test flights, training flights, etc..
c) Data should be reported in columns 3 to 12 opposite the type of operation in which the aircraft was engaged at the time of the accident.
d) Data should be reported in columns 13 and 14 relating to the total activities of the operator during the year, subdivided into the types of operation indicated.

Passenger Injury: Include the total number of passengers involved, both revenue and non-revenue.

Crew Injury: Include hostesses, stewards and supernumerary crew in addition to flight crew.

Others Injured: Include all persons injured other than those aboard the aircraft.

Number of Landings: 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.

Hours Flown: Report to nearest number of whole hours. Indicate under 'Remarks' basis used - such as 'block-to-block', 'wheels off-wheels on', etc..

PART III

"HAZARDS OF THE WAKE"

(an excerpt from Accident Prevention Bulletin 60-9,
dated 26 September 1960 of Flight Safety Foundation, Inc., New York.

"Flight Safety Foundation recently received a letter from a business pilot in which he stated his company had established a firm policy to avoid all take-offs and landings when and where there existed the remotest possibility of helicopter prop wash. Having narrowly escaped a serious landing accident when his business transport was caught by the prop wash of a landing commercial helicopter, this pilot had good reason to suggest the establishment of such a policy. He also further suggested that all control tower operators adopt the rule until a research program is initiated to establish better facts, and more realistic control procedures are developed to avoid the hazards of the wake, in this case - helicopter wake."

"In the light of this and many other cases of "unexpected" turbulence from the wake of other aircraft, the FAA was queried concerning the problem. Its reply came in the form of a Circular Letter, which had been sent to all FAA Regional Administrators several months ago. This Circular Letter detailed the cause and effect of thrust stream turbulence and wing tip vortices of other aircraft, and further stated its position, to wit: "We believe it is the pilots' responsibility to be familiar with not only the effect of all types of turbulence on aircraft, but also the various pilot techniques* that can be employed when turbulence is encountered or is suspected to exist .... Also, due to the sometimes unpredictable nature of the occurrences of thrust stream turbulence and wing tip vortices, such turbulence cannot always be anticipated. However, as an advisory service to pilots, controllers should caution them of the possibility of encountering turbulence when it is foreseen." The FAA added that this service does not place a responsibility on the controller to anticipate its need in all cases, and cautioned controllers to be "alert to unexpected pilot action when turbulence of this type is encountered."

Vortex Hazards (from Flight Safety Foundation Bulletin 60-4, dated 22 April 1960)

" We recently heard of two incidents which almost proved fatal. Both occurred on landing; one behind a Viscount, the other behind a DC-8; and in both instances the aircraft were a considerable distance behind the larger aircraft, with a crosswind prevailing which both pilots assumed would dissipate the vortices. Caught by the vortex, one of the "victim" aircraft went into a 45° roll very close to a snowbank. (This snowbank probably prevented the crosswind from sweeping away the vortex.) The second aircraft victimized by a vortex rolled 90°."

"At terminal airports it seems advisable to land down the runway with plenty of speed when there is any danger at all of being affected by the vortex of a preceding airplane. Research indicates it takes at least three minutes for vortices to dissipate."

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* These are available in "Hazards of the Wake" an article originally published by Flight Safety Foundation in January 1956. It includes excerpts from two studies, one by Douglas Aircraft and the other by Beech Aircraft.

"Air traffic control personnel should be reminded that landing or taking-off behind a high performance aircraft can be hazardous, even if there is a crosswind. Flight Safety Foundation will call this to the attention of Air Traffic Control, and, if ATC clears you in or out behind a jet, we suggest you remind the tower of the dangers lurking in a vortex."

JET WAKE (from Business Pilots Safety Bulletin 56-201, dated 27 February 1956)

"Investigation of the turbulence in the wake of a jet aircraft discloses facts of importance to the safe navigation of light aircraft. This study was conducted by the British Ministry of Supply at the Royal Aircraft Establishment at Farnborough."

"Most immediate source of danger is the turbulent and long-lasting vortex created by the wing of a jet aircraft. These vortices impose severe rolling tendencies on tracking aircraft, in some instances so great they cannot be overcome by aileron control."

"This turbulence persists at greater distances behind the jet than generally presumed. AT 8 000 feet behind the aircraft, the strength of its vortices diminishes a bare 50% of its initial value."

"The turbulence created by the engines themselves, either reciprocating, jet or turboprop, is relatively minor. The velocity of the blast from the jet engine drops to a negligible value at a distance of only 200 or 300 feet behind the tailpipe."

Flying the Wake

"When flying a course which would bring your plane across the wake of a jet, cross the jet path at a somewhat higher or lower altitude instead of just well behind the jet itself. Remember, even at a distance of a mile and a half, its vortex turbulence has diminished only 50%."

"An airliner flying at a relatively slow speed, i.e., on approach, also generates extremely turbulent wing vortices. And a temperature inversion near the ground level will extend the length of time during which turbulence is hazardous."

"When landing behind either large or fast aircraft in a crosswind, keep to the upwind side of the runway. The turbulence will tend to drift off the downwind side."

Caution

"Crossing the wake of heavier transport-type aircraft flying slowly in approach and landing stages, or crossing the wake of a jet too closely can be fatal. To a lightplane, the critical danger exists several miles behind the jet."

Additional References:

Accident Digest No. 3 pages 188 - 189
("Turbulence caused by large aircraft" - Ministry of Aviation (UK)
Information Circular No. 177/1952)

Accident Digest No. 4 pages 173 - 175
("U.S. Safety Bulletin No. 187-53")

Accident Digest No. 9 pages 158 - 160
(Hycon Aerial Surveys, P-38L, N 69902, accident south of the Greater Pittsburgh Airport, Pittsburgh, Pennsylvania on 23 August 1957)

Reference is made in this accident report to a study, "Velocity and Persistence of the Trailing Vortices of an Airplane", by Christopher C. Kraft, Jr., Langley Aeronautical Laboratory, NACA conference on some problems of aircraft operation, 17 - 18 November 1954.

This Accident Digest, No. 11, Summary No. 2 - . Swiss Aero Club, de Havilland Leopard Moth, HB-OKO, accident near Kloten Airport, Switzerland, on 13 March 1957.

This Accident Digest, No. 11, Summary No. 6 - Piper PA-22, N 2945P, accident near Dover, Delaware on 23 September 1958.

PART IV

List of Laws and Regulations of the Contracting States containing provisions relating to "Aircraft Accident Investigation"

(Replacing list in Digest No. 10)

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).

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 nº 300 IGAC/SA, concernant les dispositions à prendre en cas d'irrégularité d'incident ou d'accident d'aviation.

GERMANY (FEDERAL REPUBLIC OF)

1936	Aug.	21	Regulations concerning air navigation, as amended: Sections 65 and 66.

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 1 April 1954: 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

1931	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.

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.
1960	avril	1	Ordonnance concernant les enquêtes sur les 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.

UNION OF SOUTH AFRICA

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 22 June 1956: Chapter 29. - Investigation of Accidents (Regs. 29.1 - 29.7).

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
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
Sierra Leone (Colony and Protectorate)
Singapore
Somaliland Protectorate
Swaziland
Tanganyika
Trinidad and Tobago
Uganda Protectorate

UNITED KINGDOM COLONIES (Cont'd)

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.

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).

UNITED KINGDOM COLONIES (Cont'd)

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).

MALTA

1952	Sept.	2	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).

SIERRA LEONE

1953	Dec.	30	Civil Aviation (Investigation of Accidents) Regulations, (P.N. 114/53).

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

1950	Sept.	15	Procedural Regulations - Part 303 - Rules of practice in aircraft accident investigation hearings, (as issued September 15, 1950, 15 F.R. 6440; revised effective February 15, 1957, 22 F.R. 1026; Part revised by Reg. PR-35, effective March 21, 1959, 24 F.R. 2224).
1950	Sept.	15	Procedural Regulations - Part 311 - Disclosure of aircraft accident investigation information.
1955			Procedural Regulations - Part 399 - Statements of General Policy, as issued, effective May 25, 1955; 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).
1958	Aug.	23	The Federal Aviation Act: Title I. - Sec. 103.01 Congressional Committee Report; Title III. - Sec. 313(c) Power to Conduct Hearings and Investigations; Title VII. - Aircraft Accident Investigation.
1959			Safety Investigation Regulations - Part 320 - Notification and Reporting of Aircraft Accidents and Overdue Aircraft (as issued, effective February 28, 1959, 24 F.R. 1508).
1960			Public Notice PN 14 - Statement of Organization and Delegations of Final Authority (as issued, effective January 8, 1960, 25 F.R. 657, revoking Public Notices PN 11 and 12, effective July 18, 1957 and May 1, 1958): Section 1.2 - Functions of the Civil Aeronautics Board - (c) Safety Activities; Bureau of Safety - Sections 5.1 - 5.8; Sec. 7.2 - Functions of the General Counsel; Sec. 7.3 - Delegated authority of the General Counsel - (A); Sec. 7.4 - Redelegation of authority; Sec. 7.6 - Redelegations of authority to Associate General Counsel, Rules and Legislation.
1952			TITLE 22 - Foreign Relations - 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.

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

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

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

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

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

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

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

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

EXTRACT FROM THE CATALOGUE

ICAO SALABLE PUBLICATIONS

ANNEX

Annex 13 — Aircraft accident inquiry.
September 1951. 16 pp. $0.15

MANUAL

Manual of aircraft accident investigation.
(Doc 6920-AN/855/3). 3rd edition, 1959. 257 pp. $2.75

ICAO CIRCULARS

18-AN/15 — Aircraft Accident Digest No. 1.
June 1951. 116 pp. $0.15

24-AN/21 — Aircraft Accident Digest No. 2.
1952. 170 pp. $0.85

31-AN/26 — Aircraft Accident Digest No. 3.
1952. 190 pp. $1.00

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1955. 186 pp. $2.00

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1957. 245 pp. $2.50

54-AN/49 — Aircraft Accident Digest No. 8.
1958. 212 pp. $2.25

56-AN/51 — Aircraft Accident Digest No. 9.
1959. 290 pp. $3.00

59-AN/54 — Aircraft Accident Digest No. 10.
1961. 286 pp. $3.00

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