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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 ICAO 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 ICAO 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 accidents 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 ICAO 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 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.

The ICAO Manual of Aircraft Accident Investigation (Doc 6920-AN/855), Second Edition) has proved to be a valuable guide in securing the information required for accident prevention measures, and, whether available facilities and resources permit of the fullest investigation or not, if the Manual is followed to the greatest practicable extent, uniformity of findings and their usefulness for the Digest will be enhanced. Briefly, information should include:

1) Aircraft Type;
2) State of Registry;

3) Date and Place of Accident;
4) Résumé of the Accident;
5) Result of the Technical Investigation;
6) Conclusions and Recommendations (if any).

Note. - Names of persons involved may 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 may also be submitted for inclusion in the Digest.

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.

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

Part II of this issue dealing with Aircraft Accident Statistics mainly for the year 1955, has been based on material derived for the most part from the Air Transport Reporting Forms G submitted by States. (For further review of material included refer to the Introduction, page 223). The tables for 1955 are presented in the same manner as those appearing in Digest No. 6 for the years 1952-1954 inclusive, and it is to be noted that revised tables for 1954 have been issued with this Digest.

Part III consists of two Pilots Safety Exchange Bulletins, put out by Flight Safety Foundation Inc., dealing with the subjects of "Windshear" and "Flicker Vertigo". Due to the great number of reports included in this issue it has been necessary to limit the amount of material printed in this Part.

Part IV is a complete list of laws and regulations relating to Aircraft Accident Investigation and incorporates all amendments to the list presented in Digest No. 5.

Whenever possible, photos and diagrams have been obtained for illustration purposes in order to give a clearer over-all 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.

COMMENTS ON ACCIDENT CLASSIFICATION TABLES AND SUMMARY OF REPORTED ACCIDENT CAUSES - 1955

This issue of the Digest contains 52 reports of aircraft accidents occurring in 1955 prepared from reports received from States.

The Digest contains for the first time two accident classification tables. The first (Table A) is based primarily on the phase of operation and the second (Table B) on the causes of the accidents. These tables are intended to provide a comparative picture of reported accidents and to indicate any change in trends in operations, accident types, causes etc. The stage of operation or flight shown in the tables is that in which lay the apparent cause of the accident but not necessarily the accident itself. For example, in the case of engine failure while en route and resultant inability to maintain height with a subsequent crash while executing a forced landing, the accident is classified as "en route".

The term "undetermined" includes all accidents concerning the nature of which so little evidence is available that a definite classification could not be made.

These classifications closely follow the suggestions contained in the ICAO Manual of Aircraft Accident Investigation (Doc 6920-AN/855). 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. The reason for this is that the classifications have been based on accident reports which have been founded on a variety of reporting and analyzing techniques. Also the accidents reported in 1955, and included in these classifications, do not include all accidents that occurred and that were investigated during the year; only approximately 50% of those investigated by States are included in published reports or sent to ICAO. No effort has been made in this publication to classify according to the type of operations being conducted, for instance whether scheduled, non-scheduled, airwork, or non-revenue operations such as testing, training or positioning. However, a notation on the type of operation being conducted, where known, is included in Table A.

Although considerable care has been taken in drawing up the tables to ensure that the information contained therein in no way alters 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, invited always to refer to the report in the Digest.

A survey of the accident reports for 1955 suggests that the following features are worthy of attention:

Table A

(i) Of the 45 accidents classified, the largest percentages occurred during the following phases of operation:-

en route	29%	- 2% less than the 1954 percentage
climb after take-off	18%	- 50% due to pilot error
final approach	18%	- 50% due to 'other collisions'

(ii) 22% of all the accidents were due to 'collision with terrain' and a further 22% were due to 'other collisions'.

Table B

(i) 51% of all accidents were caused by pilot error - 9% less than the 1954 percentage

(ii) 18% were due to material failure - 50% due to engine trouble

(iii) the breakdown for the remaining 31% was as follows:-

errors of other personnel	11%
weather	9%
miscellaneous	11%

An increasing number of reports on helicopter accidents are being sent in to ICAO. At present helicopter accidents are not included in the classification tables but are included in the Digest for their technical information only.

Report No. 46 mentions vertigo as a contributing factor to the accident. An article received from the Air Transport Division of the Flight Safety Foundation is included in Part III and gives further information on the subject of "flicker vertigo", based on actual experiences.

Included in the 1955 accident reports in this Digest are those dealing with two mid-air collisions, one airliner which was shot down and two cases of sabotage.

TABLE A:- ACCIDENT CLASSIFICATION - 1955 (based on phase of operation)

Phase of Operation	No.	Type of Accident	No.	Apparent Cause	No.	Description	No.	ICAO Ref.*	Type of Operation*	Page
Take-off Run	5	Ground loop	1	Pilot error	1	Loss of directional control and inability to regain it.	1	AR/384	S	35
		Collision with terrain	1	Miscellaneous	1	For undetermined reasons propeller feathered on take-off.	1	A/B No.4 p.46	NS	114
		Other collisions	3	Pilot error	2	Selected unsuitable runway for take-off.	1	AR/405	S	44
						Took off under poor weather and in overload conditions.	1	AR/414	NS	116
				Errors of other personnel	1	Used spark plugs inappropriate to engine type.	1	A/B No.4 p.51	NS	77
Initial Climb	2	Emergency condition (immediate forced landing)	1	Material failure	1	Overheating of right engine's rear master rod led to engine failure after take-off.	1	AR/415	NS	177
		Stall	1	Material failure	1	Failure of front bearing of propeller shaft led to sudden stoppage of left engine.	1	PR 13-C-55	NS	213
Climb after Take-off	8	Emergency condition (immediate forced landing)	1	Errors of other personnel	1	Omissions by maintenance personnel caused an almost complete loss of elevator control in flight.	1	AR/391	S	58
		Collision with terrain	2	Pilot error	2	Badly executed steep turn to port carried out at night at a low altitude.	1	AR/404	S	65
						Unintentional movement of No. 4 throttle into reverse range and aircraft became uncontrollable.	1	AR/385	C	98
		Stall	1	Pilot error	1	Loss of control at low altitude - aircraft was overloaded.	1	AR/407	T	118
		Collision with other aircraft	1	Pilot error	1	Failure of DC-3 crew to observe other aircraft and to comply with prescribed airport traffic pattern.	1	AR/410	C & (TR)	125
		Airframe failure in flight	1	Pilot error	1	Loss of control during which design strength of aircraft was exceeded. Vertigo was a contributing factor.	1	AR/419	NS	194
		Explosion in flight	1	Miscellaneous	1	A dynamite bomb exploded in No. 4 baggage compartment.	1	AR/425	S	201
		Other collisions	1	Errors of other personnel	1	Improperly indexed propeller blades.	1	AR/426	NS	204
En Route	13	Collision with other aircraft	1	Pilot error	1	Operation of DC-3 in control zone as unknown traffic without clearance.	1	AR/375	NS & (S)	39
		Collision with terrain	3	Pilot error	2	Deviation from normal procedures and from airways at an altitude too low to clear obstructions ahead.	1	AR/392	S	74
						Improper operation on authorized instrument flight.	1	PR 3-C-55	S	172
				Weather	1	While climbing to better visibility conditions aircraft was caught in adverse weather and struck a mountain.	1	AR/378	NS	110
		Emergency procedure (immediate forced landing)	2	Material failure	1	Failure of No. 3 propeller and loss of No. 3 power plant.	1	AR/400	S	92
				Pilot error	1	Fuel exhaustion due to inadequate flight planning.	1	AR/429	NS	170
		Explosion and/or fire in flight	3	Miscellaneous	2	Explosion of timed infernal machine in starboard wheel well punctured No. 3 fuel tank and a fire followed.	1	AR/397	NS	108
						Loss of empennage due to inflight fuel explosion.	1	AR/416	NS	188
				Material failure	1	Failure of No. 3 propeller governor drive shaft.	1	AR/435	S	221

* S = Scheduled NS = Non-scheduled C = Check flight TR = Training T = Test flight F = Filming flight A/B = Argentine Bulletin PR = Pr[illegible]guese Report

TABLE A:- ACCIDENT CLASSIFICATION - 1955 (based on phase of operation) (cont'd)

Phase of Operation	No.	Type of Accident	No.	Apparent Cause	No.	Description	No.	ICAO Ref.★	Type of Operation★	Page
En Route (cont'd)		Undershoot	1	Material failure	1	Fatigue failure of crankshaft in starboard engine.	1	AR/422	F	122
		Other collisions	1	Material failure	1	Starboard engine failed due to fracture of the crankshaft at No. 3 crankpin.	1	AR/424	S	[illegible]
		Miscellaneous	1	Miscellaneous	1	Aircraft was shot at by jet fighter planes.	1	AR/389	S	[illegible]
		Wing tip landing	1	Material failure	1	For undetermined reasons the starboard engine failed.	1	AR/409	NS	[illegible]
Landing Procedure	3	Other collisions	1	Pilot error	1	Premature descent of the aircraft due to the pilot's being unaware of his correct altitude when entering fog.	1	AR/403	S	[illegible]
		Collision with terrain	2	Pilot error	2	Navigation was conducted without making use of all radio aids available for checking and correcting drift.	1	AR/434	S	[illegible]
						Aircraft was flown too long on outbound track and descended below prescribed minimum altitude.	1	AR/413	S	[illegible]
Final Approach	8	Collision with terrain	2	Weather	1	Due to a sudden downpour of rain while landing.	1	AR/388	S	[illegible]
				Pilot error	1	Inattention to flight instruments.	1	AR/382	S	[illegible]
		Other collisions	4	Pilot error	2	Misjudged approach due to an error in timing. ø	1	AR/398	S	[illegible]
						Failed to make adequate reference to instruments.	1	AR/420	S	[illegible]
				Weather	2	Momentary disorientation due to loss of visual reference.	1	AR/381	S	[illegible]
						Encountered fog and restricted visibility.	1	AR/438	S	215
		Emergency condition (immediate forced landing)	1	Errors of other personnel	1	Installation of an unairworthy engine cylinder.	1	AR/402	S	[illegible]
		Collision with other aircraft	1	Pilot error	1	Each pilot failed to observe other aircraft. Pilot (Piper) did not conform completely with approved traffic pattern.	1	AR/412	NS & (S)	173
Landing Run	5	Ground loop	2	Pilot error	2	Deviated from normal landing procedure.	1	AR/363	S	[illegible]
						Made a full flap landing in a strong crosswind.	1	AR/364	NS	105
		Collapse or retraction of landing gear	1	Material failure	1	Undercarriage failed to retract on take-off and selector switch was left in 'up' position. Undercarriage retracted on landing.	1	AR/393	TR	[illegible]
		Overshoot	2	Pilot error	1	Too high and too fast approach together with ineffective braking action on wet runway.	1	AR/390	S	117
				Errors of other personnel	1	Improper position of reversing circuit breakers.	1	AR/411	S	166
Missed Landing	1	Other collisions	1	Pilot error	1	Throttles were closed on attempted go-around and aircraft struck a powerline pole.	1	AR/401	S	135

★ S = Scheduled NS = Non-scheduled C = Check flight TR = Training T = Test flight F = Filming flight A/B = Argentine Bulletin PR = Portuguese Report

ø See Report No. 27 for Brazilian comments.

TABLE B:- ACCIDENT CLASSIFICATION - 1955 (based on accident causes)

Cause	No.	Description	No.
Pilot error	23	- misused brakes and/or flight controls on the ground	1
		- continued VFR into unfavourable weather	1
		- selected unsuitable terrain or runway for landing or take-off	1
		- misjudged distance	5
		- improper operation on authorized instrument flight	4
		- failed to compensate for wind conditions	3
		- misused power plant or power plant controls	2
		- exceeded operating limitation	2
		- failed to observe other aircraft	2
		- inadequate flight preparations	1
		- attempted flight beyond ability or experience	1
Errors of other personnel	5	- aircraft inadequately maintained	5
Weather	4	- thunderstorm	1
		- low ceiling	1
		- fog	2
Material failure	8	- power plant - propeller	3
		- landing gear - main landing gear	1
		- power plant - engine	4
Miscellaneous	5	- (explosion of timed infernal machine)	2
		- undetermined	1
		- (aircraft was attacked by jet fighters)	1
		- (inflight fuel explosion)	1

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PART I

No. 1

Northwest Airlines, Douglas DC-4 aircraft crashed at Sandspit, British Columbia, Canada, on 19 January 1952, Civil Aeronautics Board (USA) Accident Investigation Report No. SA-255, File No. 1-0017.

(Secretariat Note: The following is a supplement to the Civil Aeronautics Board's accident investigation report released 15 September 1952 - see ICAO Circular 31-AN/26 - Aircraft Accident Digest No. 3, report No. 33.)

In accordance with the Board's policy of keeping accident investigations open for consideration of new evidence, continuing study was carried out by the Bureau of Safety Investigation subsequent to release of the original report. This study resulted in the disclosure of nose gear malfunctions by review of service difficulties on DC-4 aircraft for a considerable period subsequent to the accident, the development of additional facts by detailed examination of the nose gear wreckage of the subject aircraft, and the submittal of supplemental information relative to the handling characteristics of the DC-4 during take-off with three engines operating. Thus, adoption was necessary of a revised report, released 14 November 1955, containing a new probable cause.

Circumstances

The flight crashed in Hecate Strait less than a mile offshore following an attempted precautionary landing at approximately 0138 hours at the Sandspit, British Columbia airstrip. Of the 40 passengers and 3 crew members, only seven passengers survived. The aircraft was substantially damaged upon impact an' subsequently was destroyed by action of tides.

Investigation and Evidence

The nose gear of the aircraft washed up on the beach shortly after the accident and was later transported to Seattle for certain examinations; following this, it was forwarded to Washington for detailed examination by Board engineers. This latter examination disclosed that the nose gear was retracted when torn from the airframe. Normally, the nose wheel retracts before the main landing gear on this type aircraft, however, in the event of malfunction, it can retract only partially.

Review of service difficulties which were experienced on Northwest Airlines DC-4's for a considerable period after this accident disclosed a number of instances in which the nose gear failed to retract fully. All of the malfunctions occurred in cold weather operations and mainly during crosswind take-offs which require nose wheel steering as do three engine take-offs. (The subject take-off was crosswind.) Reasons for these malfunctions included broken steering cables, excessive steering paddle clearances, rapid gear retraction due to defective nose gear orifices, and slow shock strut extensions due to over-tight packings or rough centering cams. In this case, the centering cams were found to be satisfactory but the other possibilities remain indeterminable.

Runway length and condition at Sandspit were satisfactory to accommodate the DC-4, and the captain's decision to land there was, therefore, in conformance with good operating procedures. Under the circumstances of load, speed, and braking conditions at the time, the distance remaining on the runway from point of touchdown might be considered marginal, and a successful stop may or may not have been possible; the attempted go-around, therefore, may have been necessary.

Subsequent to this accident, changes relative to survival equipment and procedures were made in the Civil Air Regulations.

Pilots would normally retract flaps to 15 degrees for a go-around. The diver's estimate that the flaps appeared to be down about 40 degrees might be correct; however, the flap position may have shifted due to tide action or towing the aircraft backward. The flap handle was found in the neutral position which suggests that the pilot moved it from the full down position and retracted flaps during acceleration. None of the evidence on this matter is conclusive, but if the flaps were at 15 degrees, climb performance would have been considerably better than at a 40-45 degree position.

At the request of the Board, the Douglas Aircraft Company furnished a series of curves plotting air speed versus rate of climb for a DC-4 operating on three engines at rated take-off power and with the propeller feathered on the inoperative engine. Without consideration of ground effect, these curves were computed for sea level at a gross weight of 62 479 pounds, the estimated weight of the flight at the time of the accident. They show that the best rate of climb with 45 degree flaps and landing gear down would be 15 feet per minute at approximately 98 miles per hour; however, ground effect for approximately the first fifty feet of altitude would increase the rate of climb appreciably. With 45 degree flaps, gear up, the best rate of climb would be 200 feet per minute at about 108 miles per hour; 420 feet per minute could be realized with 30 degree flaps, gear up, at an airspeed of about 118 miles per hour. Thus, from the time the aircraft first broke ground to the time that the landing gear was fully retracted the rate of climb would have been low. At airspeeds both below and above those noted, the rate of climb curves fall off rapidly. In considering the flight characteristics of the aircraft at the applicable weight, a climb would have been possible with flaps extended 40 to 45 degrees if proper airspeeds were maintained, three engines continuously developed rated take-off power, the aircraft was free of ice, and the landing gear retracted without malfunction.

If malfunctioning of the nose gear retraction system occurred during the attempted go-around it is likely to have caused failure of the rods actuating the nose wheel well doors. The doors then could have caused the buffeting which one survivor noticed. A partially retracted nose gear would also cause deterioration of the climb performance. The evidence that the nose gear was torn from the aircraft while in the up and locked position does not preclude the possibility of malfunction. Service experience indicates that extension of the landing gear after nose gear malfunction, followed by a second retraction, usually results in completion of the retraction cycle. The time interval between the take-off and the crash was probably sufficient for the above sequence of events.

The directional controllability of the DC-4 during three-engine take-offs is such that the effect of a fully deflected rudder is insufficient to counteract the turning moment due to the unsymmetrical thrust at any speed appreciably below the safe take-off speed. As a result, pulling the nose wheel off the ground in an attempt to take off at these lower speeds results in the aircraft veering off the runway. Since, in this case, the aircraft did not strike the snow banks lining the runway, it is apparent that the take-off was not made at any speed appreciably lower than the recommended take-off and climb speed.

Probable Cause

The probable cause of this accident was a nose gear retraction difficulty in connection with an icing condition or a power loss, which made the aircraft incapable of maintaining flight.

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ICAO Ref: AR/194 and 215

No. 2

KLM Royal Dutch Airlines, Douglas DC-6B aircraft, PH-DFO, crashed into the North Sea, 10 nautical miles west of Egmond, The Netherlands, on 23 August 1954. Report of Accident Investigation Bureau, Department of Civil Aviation of The Netherlands, adopted 14 November 1955.

(This report was received too late for inclusion in Digest No. 6 /1954 accidents/. Due to a 15-month period of intensive investigation it was not adopted until 14 November 1955.)

Circumstances

The flight departed New York on 22 August 1954 for Schiphol Airport, Amsterdam, with a stop at Shannon. On board were a crew of 9 and 12 passengers. At Shannon, following a briefing on the expected en route weather conditions, the crew filed an IFR flight plan, which indicated that the flight was cleared at a cruising altitude of 11 500 feet in Airway "Green 2" at a true airspeed of 256 knots. Take-off from Shannon was at 0929 hours Greenwich Mean Time. Permission was granted to fly direct from Tulsa to Rush-beacon by which the roundabout way via Athlone was cut. At 1122 the aircraft advised that the boundary of the Netherlands flight information region had been crossed. At 1125 the flight informed the area control centre at Schiphol that it was leaving the cruising altitude and descending to approach the beacon "Spijkerboor" (PHA) with an estimated time of arrival at 1137. The flight was then cleared to approach this beacon at 5 500 feet or above, later amended to 4 500 feet or above and then to 3 500 feet or above. Everything up to this point seemed to be quite normal and there was no indication of any difficulty on board. At 1135 the area control centre at Schiphol cleared the aircraft to descend to 2 500 feet but no answer was received. Half an hour later the alerting phase was declared by Schiphol followed by the emergency phase. An extensive search(hampered by low clouds, showers and heavy seas) was then started. Searching aircraft reported a big oil spot on the sea off Bergen on the Sea and at 1610 floating debris was reported, some of it showing the initials KLM. There were no survivors.

Investigation and Evidence

Weather conditions were not as favourable as expected before take-off from Shannon, but certainly not unfavourable for a flight on instruments. During the flight over the North Sea area the weather was as follows:

> extensive formations of clouds produced an 8/8 cover with its base at some hundred metres, and there were many showers below this level. Above this layer, which extended at a height of 1 600 - 1 800 metres (5 200 - 5 900 feet), many clouds existed and it is possible that there was a more or less solid cover up to some 3 500 metres (11 500 feet). Freezing level was at an altitude of 2 400 - 2 600 metres (7 900 - 8 500 feet).

Based upon observations of captains of other scheduled aircraft it is known that, in spite of these comprehensive formations of clouds, turbulence was only slight to nil, and almost no static in radio communication was experienced. Ice accretion was negligible. A study of the weather conditions led also to the conclusion that the presence of thunderstorms was highly unlikely. Wind at sea level was 260 - 290/14-18. At 14 500 feet the wind encountered was 320/15

Some people near the small town of Egmond, where airway "Green 2" crosses the coast of the Netherlands, informed the local police, that they had observed a four-engined passenger aircraft flying extremely low between 11 and 12 o'clock. A thorough investigation disclosed that this aircraft must have been PH-DFO. One witness could give a very accurate time check as his observation closely followed the end of a certain radio program to which he had been listening. He must have observed the aircraft at 1134 or 1135, which fits perfectly well with the time at which PH-DFO should have crossed the coast at that place. However, one witness, whose statement also seemed to be trustworthy had seen the aircraft flying in a direction which did not fit in the assumed pattern. Therefore, it was considered to be possible that the flight path had been more complicated and an extensive search for more witnesses, which took several weeks, was initiated, resulting in some ninety dependable statements. Based upon these observations the path of PH-DFO over the northern part of Holland could be reconstructed approximately up to the time of 1201. At this time two quite independent witnesses made the same observation at the same time, which could be exactly established by comparison with the radio program. Then the aircraft flew in the direction of the sea, and no other witnesses are available for this part of the flight.

According to the statements, the plane flew at a height varying from about 100 to 1 200 feet and except for the low altitude no abnormalities were observed. The flight pattern, as performed by the aircraft, could only have been flown if the controls were more or less fully usable and if the aircraft was flown by hand.

On 24 August attempts to recover the wreckage of the aircraft were commenced. An area of 150 square miles was thoroughly and systematically explored by Navy ships and fishing boats. Sonor sweeps to locate the wreckage proved to be unsuccessful due to the great number of metal obstructions of wrecked ships and also of aircraft from the war. The best results were obtained by trawlers with reinforced fishing nets. In spite of the relatively shallow sea (approximately 60 feet), salvage action was hampered by rough seas throughout the autumn of that year, in which weather in general had an unsettled character. The last months of search activities were almost without result, and as by then the favourable season was over, the salvage action was stopped on 25 November 1954 when 45 to 50% of the aircraft had been brought ashore.

The aircraft had been broken into many thousands of pieces, of which the cabin door was the second biggest. All recovered parts were transported to Schiphol Airport where a detailed inspection of each fragment was carried out. Furthermore, a mock up of the fuselage was made by means of a framework, the tail and wing constructions being carefully laid out in their relative positions.

As fragments of nearly all main parts of the ship were available, the conclusion was reached that at the moment of impact the aircraft must have been complete and that no vital elements had been lost in flight. On the right hand main spar it was found that deformation was caused by forces in an upward and aft direction, the left hand wing failed in forward direction. Main parts of the engines No. 3 and 4 and some parts of engines No. 1 and 2 were found. The lower cylinders of the right hand engines were torn off, obviously by impact. Investigation revealed that engines 2, 3, and 4 must have been running at the moment of impact and that engine No. 1 might possibly have run. It was impossible to determine at what power they were running, there are indications that this was at low power or perhaps the power developed with closed throttles. From the propellers only separate blades could be recovered, two of these originating from propeller No. 4. The tips were missing and the blades were broken off in a backward direction near the hub.

The deformation of the wreckage indicated that the aircraft contacted the water with the nose slightly down and slightly banking to the right. Due to the fact that only minor parts of the systems could be recovered no conclusion about their function prior to the impact could be drawn. None of the parts showed any indication of fire. As no watch or boardclock was found the time of impact remained unknown.

The examination of the recovered bodies and personal properties of the victims gave no indication as to the cause of the accident. No traces of fire were found. The blood did not contain CO_2 and no particles of soot were found in the bronchial tubes. The injuries were considered to be partly vital and partly post-mortal, but no conclusion about the minimum time elapsed between the vital injuries and the deaths could be drawn. Possibly both types of injury originated during the impact with the water.

The aircraft passed the Netherlands coast at the time expected, however, at a very low altitude. This leads to the conclusion that very shortly after the last radio contact the rate of descent, intentional or not, had been increased considerably. No clearance was requested for this descent and for flying under IFR conditions at such an altitude. It is obvious, that there must have been a reasonable ground for this action and it is believed that this part of the flight contains the key to the mystery. Furthermore, it has not been possible to find a reasonable explanation for the half-an-hour's flight over land without any radio contact, after the fast descent was made.

In the evidence available no indication could be found as to the cause of the accident. In the opinion of the Investigator of Accidents it is highly unlikely that the disaster was due to:

a) the weather conditions, including ice accretion and lightning;

b) any type of collision;

c) ground-air firing;

d) failure of a powerplant, including blade failure;

e) failure of main structural parts in flight.

There are no indications that the sudden descent was due to passengers, crew condition or loading. A failure in one of the systems (control, hydraulic, electric, oxygen, fuel, cabin pressure, emergency equipment) cannot be excluded, but due to the fact that only about 10% of the systems were available for inspection, it is impossible to base any conclusion upon the evidence.

A number of hypotheses as to the cause of the accident were developed. Some possibilities considered were: overheating of the electric system with heavy smoke development, explosion of one of the high pressure bottles, failure of a cockpit window, failure of the automatic pilot. However, no hypothesis could be formulated in which all occurrences and evidence could be made reasonably acceptable. Therefore, in November 1955, after a 15-months' period of intensive investigation, the conclusion had to be drawn that the cause of the accident could not be established.

Probable Cause

The Investigator of Accidents was unable to determine the probable cause of the accident.

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No. 3

KLM Royal Dutch Airlines, Lockheed Super Constellation, crashed in the estuary of the River Shannon, Ireland, on 5 September 1954. Department of Industry and Commerce, Ireland, Accident Investigation Report, released 31 January 1955.

(This report was not included in Digest No. 6 [1954 accidents] as ICAO was awaiting any comments on the Irish report that the Netherlands Government might wish to make. These have been added at the end of the report.)

Circumstances

The aircraft engaged on a scheduled flight from Amsterdam to New York took off from Shannon, after a scheduled stop, at 0230 hours with a crew of ten and forty-six passengers. The take-off from Runway 14/32 to the southeast appeared to be normal up to lift-off speed. Thirty-five to forty seconds later an inadvertent but almost perfect ditching was made in the River Shannon, 8 170 feet from the departure end of the runway used. Twenty-eight lives were lost and the aircraft eventually became a total loss through a combination of ditching, exposure and salvage operations.

Investigation and Evidence

The flight left Shannon Terminal Building at 0230 hours. It was properly loaded with fuel and load distribution was correct, placing the centre of gravity within acceptable limits. It was properly dispatched. The gross load was 131 930 pounds, well within the maximum allowable take-off weight.

The before take-off run-up was completed in take-off position on the active runway, No. 14, 5 643 feet long.

Take-off was made at 0238. V.1 speed was reached at 3 500 feet and lift-off at 125 knots was made just over the V.2 speed at approximately 4 000 feet from threshold. The flight then passed over the remaining 1 600 feet of runway in a shallow climb, retracting its landing gear; approached the 17 foot high embankment 850 feet further on and passed over it at a height variously estimated at 20/80 feet. Acceptable evidence tended to indicate that passage was very low, having in mind a heavily loaded aircraft in darkness. A somewhat steeper climb was initiated almost coincidentally with this passage. One ground witness whose evidence could not be shaken in any way was so concerned that he was instrumental in initiating a call to the Security Forces when he felt that the aircraft had "gone into the Shannon". This witness, a customs officer, with three and a half years' service at Shannon, was attracted, justifiably or otherwise, by what he considered unusual engine sound and exhaust flame as the aircraft gathered speed during take-off. He, therefore, particularly observed the take-off, initial shallow climb and passage over the embankment. The initiation of a somewhat steeper climb was followed almost immediately by a shallow descent (in his own words: "A gradual glide") to a point where the flight disappeared behind the Fire Station, which interrupted his line of sight.

Up to this point observation had been made from a vantage point just inside the Terminal Building. Such concern was felt that the witness went outside, accompanied by another customs officer, to see if the flight would reappear. It did not and it was then that the previously mentioned call was initiated. As no action of an emergency nature followed at the Fire Station (the Airport Rescue Headquarters) the witness assumed he had been mistaken.

The duration of the flight was about 31 seconds from the time it passed over the end of the runway until the aircraft first contacted the water in a tail-down slightly right-wing-low attitude. It then covered a certain distance to a point 7 350 feet from the runway, where it shed its Nos. 3 and 4 propellers, coming to rest on the Middle Ground, a shallow mudbank, losing Nos. 3 and 4 engines approximately 200 and 100 feet before doing so, at a total distance of 8 170 feet from the end of Runway 14. The aircraft was in complete darkness almost immediately, as the flight engineer switched off the master electrical switch. The cockpit emergency lighting failed as the battery "drowned". The flight could not have exceeded at any stage a true height of 170 feet.

Total flight time has been variously estimated at 32-42 seconds. Thirty-nine seconds appear from reconstruction to be reasonable. In this 39 seconds a number of commands affecting changing flight configuration were given:

a) command gear up at 125 knots;

b) command first reduction (METO power) at 140 knots;

c) command flaps up at 150 knots;

d) command climb power at 160 knots.

Seconds after command climb power, first contact with the water, described as a "shiver" or a "shudder", and lasting 3-5 seconds, was made. This was followed by several heavy bumps, which appear to have been the first indication of trouble to all crew members except the captain, who had detected difficulty very shortly before the "shiver", apparently more from instinct than otherwise.

The captain's and first officer's evidence, relative to the various commands and speeds connected with this flight, coincide fairly well. Their statements on altitude, however, cannot be reconciled. The captain stated a last observed top altitude of 250 feet and climbing (acceptable only on the basis of a possible 100 foot altimeter error), prior to seeing, just before the crash, an altimeter reading of 100 feet and rate of climb indicator showing a descent passing through 1 000 feet per minute. The first officer stated normal flight climbing, at a last observed altitude of 600 feet. This was his last instrument reading prior to (he stated) placing the landing gear lever from "up" position to "neutral", and picking up his check list preparatory to calling the after take-off check. No reconstruction is possible with such a height (600 feet) between lift-off and touchdown. For this reason, considerable evidence was required in connection with flight instrument static and pressure "plumbing". It was impossible to reconcile the stated position of the landing gear lever. On first inspection of the wrecked aircraft it was found in the "up" position. It was generally agreed that owing to design features of this lever, it could not be moved by accident from the "neutral" position.

The initial investigation of the wrecked aircraft tended to indicate that the landing gear had been up and locked at the time of ditching and that although the left main wheel remained in its up-lock, the nose wheel and right wheel had, at some later time, come out of their up-lock condition. Close examination of the up-locks on the Super Constellation will show that once the up-locks are engaged, severe damage would occur to the up-lock mechanism if forcibly released. They could be released hydraulically, or through severe deceleration forces acting on the hydraulic piston of the up-lock. Owing to the type of system involved this appeared to have been impossible in this case. The up-locks for nose and right main wheels were, practically speaking, undamaged. It was concluded that the left wheel was up and locked and that for all practical purposes the nose and right main wheels were up but had not been locked when the hydraulic system failed to function as Nos. 3 and 4 engines tore loose from the right wing, at the time of ditching.

Note.- The landing gear and flaps operated from the secondary hydraulic system supplied by hydraulic pumps driven from Nos. 3 and 4 engines.

The wing flaps were up at time of ditching. The landing gear should be up and locked prior to initiation of flap retraction. The fact that the aircraft was not found in this configuration called for explanation and considerable investigation as follows:

a) Was the take-off made with flaps up rather than in the take-off position? It has been established from flight test data that the time for landing gear retraction varies from a minimum of 9 to a maximum of 25 seconds. It is apparent that on a flight totalling 32 to 42 seconds there was ample time for the landing gear alone to be retracted if the flaps had not been in take-off position. This confirms crew evidence that flaps were in the proper take-off configuration.

b) Were the flaps selected to "up" by mistake at command "gear up"? If this mistake was made and landing gear selected "up" shortly after the error was noted, the aircraft, having been lifted off the ground at 125 knots would have passed the embankment low and accelerating and lost lift approximately 10 seconds after lift-off, as the flaps were in the final stages of retraction. It would then have touched down in a nose-up attitude as the landing gear was finally retracting, quite beyond the control ability of the captain.

The Court, aware that this type of mishandling has occurred on other type aircraft in the past, considered the possibility should not go unquestioned. The crew evidence denying such mishandling was accepted.

c) Were the flaps selected "up" inadvertently prior to completion of landing gear retraction? The red light which indicates that the landing gear is unlocked and/or in a transient condition was removed from the aircraft, tested and found burned out. Although not wholly satisfied with the method of removal and checking of the bulb in question, the Court accepts that it had burned out during landing gear retraction giving a false indication of landing gear "up".

Under such a condition during take-off, and while the landing gear was retracting, acceleration to flap-up speed would have been made and the "flaps up" order given.

It was found from test flight data that when flaps are selected while the landing gear is in the retracting stage the flaps will first retract delaying the landing gear and, in some cases, allow re-extension. The joint operation - flaps up, landing gear up - takes 34-38 seconds. It is quite possible that this did occur, thereby causing unexpected drag, creating a condition wholly unexpected by the captain. Performance of the Super Constellation, loaded to full gross weight, is such, that this situation could reasonably have been handled with adequate safety. Consequently the Court can only consider the condition referred to as contributing to but not the cause of the accident.

Reconstruction of the most probable flight path of the aircraft, based on facts and submissions accepted and inferences drawn by the Court, with accompanying comments and consideration is as follows.

Point of unstick; speed of unstick; point of contact with the water; speeds at various commands have been taken as stated ante.

The wreckage was found about 650 feet to the left of a projection of the centreline of Runway 14/32. The aircraft, after take-off, probably followed a slightly more easterly course than the centreline of the runway and the bank, referred to earlier, was originated only a short time before the ditching.

The direction of the fuselage was at an angle of about 60° east of the course of the aircraft.

While it is clear that the aircraft must have hit the water, with some starboard bank, in a southeasterly course, the Court rejects the opinion that it made a 270 degree turn before coming to rest, as such a turn would have affected passengers and crew much more than they were in fact affected. It has been taken, therefore, that the aircraft came to rest in a more or less southerly direction, partially resting on the mud and partially floating, and that the tide movement at the time of the disaster caused the aircraft to turn through about 90 degrees to its final position. A rough calculation shows that, assuming the aircraft made first contact with the water at an airspeed of 170 knots (ground speed of about 158 knots), approximately at the point some 300 feet before the propellers were found, the time elapsed between this point and reaching the final position of the wreck would have been about 9 seconds. This is justified by the time observations made by several witnesses on the sequence of shudder, bumps and so-called impact and final coming to rest. The average deceleration must then have been .9g.

The Court considered that the aircraft followed a flight path somewhat as reconstructed in Fig. 1. This is based on the calculations (these are set out in the original Report as Appendix V) taken from the appropriate evidence accepted by the Court and taking into account the following factors.

Instrument Errors: As rough calculations showed the impossibility of the aircraft having ever reached the height of 250 feet (as observed by the captain) the possible error of this instrument was examined. Several errors - all aggregable - were found. They were as follows:

a) According to check sheets submitted by KLM an altimeter check was made at Schiphol on 4 September, when the aircraft was prepared for the flight. The captain's altimeter then showed a setting of 1013.8 mb at a barometric pressure of 1014.8 mb. This instrument error could thus account for a possible reading of 1 mb (28 feet) too high.

b) The captain's altimeter before the take-off at Shannon appeared to be set at 1010.3 mb whilst the official setting (QNH) passed to PH-LKY before take-off was 1009.6 and the actual barometric pressure eight minutes before take-off (0230 hours) appeared to have been 1009.3 mb.

This difference between actual barometric pressure and the captain's altimeter setting could have accounted for a possible reading of 1 mb (28 feet) too high.

c) According to Document 193* measurements made by the National Aeronautical Research Institute, Amsterdam, on the so-called "position errors" of the static system of L. 1049 aircraft show that at speeds from about 120 knots to 150 knots, flaps in take-off position (irrespective of landing gear position) and at speeds of about 160 knots, flaps "up", a position error of about 30 to 50 feet, altimeter reading too high, can be expected. This is different from the previously existing data which showed that in this range of speeds, errors of about 10 feet only might be expected. However, taking into account that the tests in Amsterdam have been made carefully, it was accepted that an error of 30 to 50 feet (altimeter too high) due to position error might be possible.

The errors mentioned under a), b) and c) above, which all have to be added, result in a possible total error of about 90 to 100 feet in the captain's altimeter, reading too high, during the take-off. Thus it is considered that about 160 feet was the greatest true altitude actually reached.

Performance Characteristics: Assuming that the gear might not in fact have been in the "up" position when flap retraction was ordered, it followed that the aircraft would have had a slowly retracting landing gear. A possibility existed that the performance of the aircraft, climbing at METO power, was not fully up to L. 1049 standard. Therefore, in making calculations for the flight path, slightly lower performance has been allowed for.

The Climb: It was considered that the evidence can fairly be interpreted by an estimate of an average rate of initial climb of 150 ft./min., a height of 36 feet passing the embankment, and a speed of 140 knots at 12-13 seconds after unstick. During that initial climb, say three seconds after unstick, landing gear retraction would have been ordered. At about the time of crossing the embankment a much steeper climb was set up and METO power was ordered. Assuming that around 3-4 seconds later METO power was set and the speed increased to 144 knots 15-16 seconds after unstick, a more or less steady climb would probably then have taken place, which is estimated at 530 ft./min. and this is reasonably justified by the evidence of a rate of between 500 and 600 feet per minute. The true indicated speed of 149 knots (which according to Lockheed data could have been shown on the airspeed indicator as 150 knots) would have been reached at a true height of 140 feet conforming to a probable altimeter reading, as it appeared to the captain, of around 230 feet. From then on some more climb (say about 30 feet) would have been performed but this would have been coupled with a flap retraction and is dealt with later.

The Transition between Ascent and Descent and the Flap Retraction; The Descent: There was a gradually curved path between climb and descent (no sudden vertical accelerations or other irregularities were noticed by any crew member between airspeeds of 150 to 160 knots). During this period flap retraction was initiated.

On the basis of a re-extension of the landing gear, as described earlier, having occurred, the results of the tests submitted in Doc. 227** were used to estimate the flight path between ascent and descent.

From a point, where during climb a speed of 150 knots was reached, it was assumed that a flight path, according to the tests of Doc. 227, was followed, which path then gradually proceeded to the descending flight path. Flap retraction would then, according to the tests mentioned, have been initiated about two seconds before the true indicated airspeed of 150 knots, i.e., at a speed of 149 knots (which could, however, as stated earlier, have been shown on the captain's airspeed indicator as 150 knots).

* Report on Lockheed L. 1049 C Super Constellation. Pitot-Static Pressure Deviations in Take-off and Initial Climb by F.E. Douwes Dekker - Report V. 1749, National Aeronautical Research Institute, Amsterdam.

** Observations on the Influence of Flap Retraction on Gear Retraction Time - KLM Research Department. ILS/MVM/Dec. 16, 1954.

The rate of descent of an average of 1 200 ft./min., conforms with the captain's evidence of an indicated rate, passing through 1 000 ft./min. (which with the known appreciable lag in the rate of climb indicator, denoted a higher true rate of descent). The airspeed of 160-165 knots likewise agrees with the evidence of indicated airspeeds.

A surface headwind of 12 knots reported at time of take-off was allowed for. The usual variation of wind with height, as well as momentary deviations from the reported value of the surface headwind could well account for a shortening of this flight path by some hundreds of feet. The final part of the flight path, therefore, could well have been somewhat more flattened out, thus allowing for a point of first contact some hundreds of feet before the point actually shown in Fig. 1.

In regard to the descent, the Court considered the possibility of a lift disturbing action during this part of the flight. No evidence, however, could be found to support such a disturbance. Examination of the wreck did not reveal any condition which could have caused it. Nor was there any evidence of the vibrations or buffeting which would be expected at an earlier stage of the flight from such a condition.

If a re-extension of the landing gear took place, after flap selection, the landing gear must normally have had a retraction time of around 25 seconds, which is fairly long but not inconsistent with evidence on retraction times of other aircraft of the same type (Doc. 231*) showing cases of 23 and 25 seconds. Furthermore, flap retraction time must have been around 12 seconds which is fairly short but again not inconsistent with data given in the same document, showing some cases of 12 and 13 seconds flap retraction time. Moreover, the conclusion that in this case flap retraction was fairly quick is corroborated by evidence from the co-pilot.

* Report on Retraction Times of Gear and Flaps on KLM Super Constellations departed from Schiphol during the period from Dec. 25, 1954 until Jan. 3, 1955 - F.H. van Weydom Claterbos. Schiphol. Jan. 3, 1955.

From the data of this flight path, the approximate instrument indications, available to the captain, from flap retraction onwards, were computed.

It was observed that the airspeed indicator indicated a gradual increase in speed, which, in general, is not uncommon during flap retraction. The rate at which speed was increasing, as far as it can be judged from the airspeed indicator, would certainly not have shown anything abnormal to the captain for about the first 10 seconds after flap retraction.

The altimeter would have shown him for about the first 9 seconds from flap retraction an indication nearly at, or slightly above, 250 feet "several times" and after that a gradual decrease of altitude.

The rate of climb indicator should have been indicating for about the first 9 seconds a rate of climb, at first staying around 500 feet per minute and later on decreasing gradually, until about the eleventh second after "flap up" selection, when it should have shown about level flight and from then on a descent at an ever increasing rate. To the captain, who was not aware that a descent of considerable rate had already begun and thus had no reason to suspect an increasing degree of lag in the rate of climb indication, this instrument, in the first 9 seconds after flap retraction, could have conveyed the erroneous impression of a gradually flattening flight path, to be followed by a more or less horizontal flight at the end of flap retraction.

The artificial horizon should have shown him at the initiation of flap retraction a certain nose-up attitude conforming with the climb he had been performing before flap retraction started. A nose-up attitude change from this moment on for about 4 seconds should have been apparent in conformity with the action taken by the captain to correct the aircraft's attitude for flap retraction.

However, at about 6 seconds after flap retraction started the horizon indication should have begun to show an aircraft attitude lower than the nose-up position during the climb preceding the flap selection.

This nose-down movement of the indication should have continued for about 3 more seconds until it more or less settled to a condition conforming to about 4 degrees of attitude lower than the attitude in the climb preceding flap selection. (This attitude corresponds with a still slightly nose-up or about level position of the fuselage reference line, certainly not with a marked nose-down attitude.)

It may have been about the eleventh second after flap selection that Climb Power was ordered. The altimeter may then have shown about 200 feet and the rate of climb indicator may have been moving through about zero. In the next one or two seconds, however, the rate of climb indicator ought to have been showing an appreciable rate of descent whilst the altimeter should have continued to show the downward movement at an ever increasing rate. The true descent was then about fully developed and it must have been at this moment that the captain, according to his statement, realized that there was something entirely wrong. He then took decisive recovery action pulling the control column very firmly, which gave him probably the impression of a pronounced "stiffening up" of the elevator control. It is quite clear that apart from a nose-up movement on his horizon, none of the normal flight instruments could have given him, in the few seconds that remained before the contact with the water, any indication of a response of the aircraft to his control movement.

The Report then considered what explanation could be given for the above described events and for the actions of the captain.

In this respect, in the first place, attention was drawn to the fact that the events which had an immediate and direct bearing on the final disaster began to develop at the moment of flap retraction, that is only about 15 seconds before the moment of contact with the water.

The first indication of the necessity for corrective action on his part should have been given by his horizon displaying a definite lowering of the nose, though not indicating a nose-down attitude.

The occurrence of this attitude change, notwithstanding a positive nose-up correcting action for flap retraction taken by him several seconds earlier, must very probably have been promoted by the fact that the landing gear was in the course of re-extension, which, as was brought forward in evidence, is likely to cause the aircraft to have a tendency to lower the nose, and possibly by the fact that the captain did not retrim the aircraft for flap retraction.

Even if the change of attitude to a more or less level position had not been noticed immediately by the captain, the first indications of a descent could have been noticed about 3 seconds later on the altimeter. The fact that at that moment a scan of his instruments had not yet revealed to him an undesirable flight condition must be attributed to one or both of the following causes:

a) After the first 5 or 6 seconds of climb, when he is accustomed to scan his instruments less continuously, the captain's observations of the horizon and (particularly after 250 feet indicated) the altimeter movements were inadequate; he placed too much reliance on the rate of climb indicator.

b) He did not, to the full extent, appreciate the anticipating character of the horizon indication, in that a change of the horizon bar position indicates a change of flight conditions which will not become apparent from the other instruments until some seconds later. The fact that some pilots, in this respect, fail to gain the fullest profit of the observation of the horizon was brought forward in evidence.

The captain ordered climb power at a speed of 160 knots and immediately afterwards felt that there was something entirely wrong. He was later convinced the descent had already begun, before he gave this order. This conveyed to the Court that he did not observe his altimeter for some seconds before ordering climb power.

When he detected the fatal flying condition he took decisive action immediately but nothing then could have prevented the accident. The action taken was fortunately just in time to prevent a heavier impact.

Other factors contributed to the accident. In the first place a proper setting of the captain's altimeter before take-off would have reduced the error of his instrument by about 20 feet. Secondly, the climb performance of this aircraft was not utilized by the captain to the extent possible.

If the captain had concentrated less on building up speed and more on gaining height in take-off, he would have had a better opportunity for coping with unexpected incidents. He was at a further disadvantage in dealing with unexpected hazards, in his stated assumption that 250 feet indicated altitude placed him in a position of sufficient safety against all known take-off risks.

There is no question of individual or collective experience. Evidence during the investigation, and the very nature of the accident, focused attention on a number of items and actions which a) appeared at variance with the Manufacturer's and Company's instructions and b) appeared to be at variance with basic requirements of an operator of Scheduled International Air Services.

1) The captain agreed that the flight engineer could abandon take-off, up to V.1 speed, on his own initiative.

2) The chief flight engineer stated that it was normal practice to switch in generators individually, as each engine was started.

3) The flight engineer stated that it was his practice to switch off automatic feathering, immediately after reduction to METO power, (i.e. at very low altitude on initial climb).

4) The captain's altimeter, as found, was not set at the official barometric pressure, current at take-off.

5) The landing lights were found "off" but in the "extended" position. Neither pilot could state if they were used during take-off. (Evidence indicated no definite practice.)

6) Though not necessarily at variance with Company policy, the Court was impressed with the captain's emphasis on the desire for speed rather than climb, particularly in the early stages after take-off. This technique, coupled with a stated concern in connection with the use of take-off power, "with these highly strung engines", could have an adverse effect on the course of events during the take-off of heavily loaded aircraft.

7) The second pilot had initial difficulty opening the forward entrance door until the third pilot remembered that it was necessary to press a device to unlock the handle. One of the survivors (a passenger who gave evidence) stated that the cabin crew had difficulty with the rear main entrance door. In his own words: "The stewardess said to us that we should keep quiet and everything is all right, and then they were hammering on the door to open it; they were pushing with their shoulder against the door and that is the last I heard." (It is significant that on Super Constellation aircraft this door opens inwards.)

8) The flight radio operator's last emergency ditching drill was 31 March 1954. He had not had any type of "dry run" ditching, or emergency drill in Super Constellations. Written instructions only had been available.

9) The instrument rating renewal of KLM pilots is accomplished within Netherlands regulations by a combination of

a) An instrument check which is accomplished in a Link Trainer;

b) Conducting a periodic proficiency check which is acccomplished on a regular en route flight;

c) Indicating to the licensing authority that the applicant for rating renewal is currently in fact exercising the rights of his licence (i.e. doing sufficient actual flying).

10) The captain, on 31 July 1953, completed a conversion course on Lockheed Super Constellation aircraft, consisting of six hours flying and certain technical ground school subjects. Between that date and 5 September 1954 a periodic proficiency check was conducted on 25 January 1954 by a check pilot while en route Amsterdam/New York. An instrument check (in the Link Trainer) was completed on 25 March 1954.

11) The first officer completed co-pilot conversion training on Super Constellation aircraft on 14 July 1953 consisting of 1 hour 30 minutes flying and certain technical ground school subjects. Previous to this, on 27 June 1950, co-pilot conversion training had been completed on the smaller Constellation, Model L 749, consisting of 7 hours 03 minutes flying. There is no record of any recurring flight training or checking between these dates. An instrument check (in a Link Trainer) was completed on 12 February 1954 for licensing purposes. A captain's transition training course on Convair 240 and Convair 340 type aircraft was completed on 27 May 1954 consisting of 4 hours 25 minutes flying.

The first officer, however, is a captain in his own right and had apparently, from 18 September 1949, been flying DC-3 aircraft in that capacity. He had not had any periodic proficiency checks in this period.

During the three months previous to this accident the first officer had flown either as captain and/or first officer on five different types of aircraft.

In connection with any consideration of crew competency, respecting a Scheduled Air Carrier, it is considered relevant to quote from ICAO Anne 6:

"The present edition of Annex 6 contains Standards and Recommended Practices adopted by the International Civil Aviation Organization as the <u>minimum Standards</u> applicable to the operation of aircraft in scheduled international air services, etc."

"4.2.7.2.S. An operator shall ensure that piloting technique and the ability to execute emergency procedures is checked in such a way as to demonstrate the competence of his pilots. Such checks shall be performed twice within any period of one year. Any two such checks which are similar and which occur within a period of four consecutive months shall not alone satisfy this requirement.

"4.2.7.5 An operator shall ensure that all crew members are instructed and periodically examined in the use of the emergency and life-saving equipment required to be carried and that they are drilled in emergency evacuation of the aircraft used."

<u>Pilots</u>: The Court is of the opinion that the amount of checking done, though formally complying with the Operators' Licensing Authority's requirements, for instrument rating renewal:

a) Does not fully satisfy the intention of the applicable portions of Annex 6 of the ICAO.

b) Does not represent the amount of recurring training and/or checking required, for the many and varied procedures that pilots of modern transport aircraft are involved with.

<u>Flight Engineers</u>: There is apparently no formal requirement to ensure maintenance of flight engineer competency. The applicable crew station on modern aircraft is important and involves complex procedures. It was the Court's opinion that there is a necessity for periodic inflight checking of a supervisory nature in order to maintain competency. (This recommendation is not intended to imply that the flight engineer on this flight had any responsibility for the accident).

<u>Crew (General)</u>: Making due allowances for the effects of "after-casting", the evidence nevertheless suggested insufficiency of drill "in emergency evacuation of the aircraft used."

Probable Cause

The probable cause of the accident was as follows:

1) Failure of the captain to correlate and interpret his instrument indications properly during flap retraction, resulting in necessary action not being taken in sufficient time.

This failure was partially accounted for by the effect on instrument indications of inadvertent and unexpected landing gear re-extension.

2) Loss of aircraft performance due to inadvertent landing gear re-extension.

3) The captain failed to maintain sufficient climb to give him an opportunity of meeting unexpected occurrences.

RECOMMENDATIONS

It is recommended:

1) That warning or signal lights, indicating an unlocked or transient condition of the landing gear, as on the Lockheed 1049 Super Constellation, be duplicated.

2) That self-sufficient emergency lighting be provided in passenger accommodation of transport category aircraft.

3) Respectfully that regulations be adopted at the earliest date specifying "Standards for ensuring that holders of the instrument rating maintain their competency". (See: Note to ICAO, 3rd Edition, April 1953, Annex 1, Para. 2.11.1.3).

4) That flashlights for use of flight crew personnel be so designed that they may be functional while leaving the hands free.

5) That flight personnel be made aware of the danger that a power-on ditching may remove power plants from the wings, in turn causing damage to the wings and possible loss of dinghies stowed therein.

6) That flight personnel and all other services concerned, be made aware of the extreme danger of fumes in a confined space, such as the cabin of an aircraft, resulting from ingress (or in-flow) of petrol.

7) That portable oxygen equipment for emergency use by more than one crew member be available on transport category aircraft.

Search and Rescue

The Court was satisfied that after the aircraft had become airborne at 0238 hours and had passed out over the embankment, the Air Traffic Control Service were under the impression that the aircraft was still flying but had developed a complete radio failure, an impression strengthened by the erroneous report of identification by the GCA Director. Their main task, therefore, became one of trying to re-establish radio communication for Control purposes. But for unawareness of the report that a witness had suspected that the aircraft was in danger after take-off, and the later erroneous report from the GCA Director, the control officer in the tower undoubtedly would have investigated the possibility of the aircraft being down. On the other hand, the Section Leader of the Security Force was satisfied that nothing was amiss, when, upon receipt of the telephone report, he looked out over the river and saw or heard nothing to arouse his suspicions. In the result - the air traffic control officer was unaware of the message received by the Security Force concerning the aircraft's take-off, while the Section Leader was unaware that the aircraft was out of radio communication with the control tower. If the information received by the Security Force had been immediately available to the nerve centre of the airport, (i.e., the control tower) no doubt the suspicion that a disaster might have occurred in the vicinity of the airport would have set in motion the Rescue Services before the GCA report had been received and would probably also have influenced the GCA Director to be more guarded in his identification of a "blip" which showed for a very short time on his radar screen.

Rescue operations were delayed because no one at the airport realized, or even suspected, the need for rescue. A crash was not associated with the lack of radio communication wholly or to a less extent by reason of the cumulative effect and misleading influence of the circumstances next mentioned and commented on:

a) Any fears entertained by the Security Force from the alarm given by the Customs officials were allayed by the absence of fire, or any other indication of danger and the Customs officials' own fears were set at rest by their seeing no unusual activity at the Fire Station.

b) The non-observance by the officer on duty in the air traffic control tower of the aircraft after it ceased to climb.

This officer was alone on duty in the tower. While it was unfortunate that he failed to observe the aircraft longer, when he might have noticed its descent, he cannot be blamed for ceasing to watch it when he did.

c) The security officer on duty in the Fire Station Watch Room kept the flight under observation only until it passed over the embankment and did not further see it.

It is not clear from paragraph 1.1 of the Shannon Airport Crash Orders whether the stand-to period ends when the departing aircraft can be no longer seen or heard by the Duty Crew, or when it can no longer be seen or heard by the Look-out. This should be clarified.

The Court accepted the explanation given by the officer who was in the Watch Room, that reflections of airport lights on the windows of the Watch Room could prevent his picking out again the aircraft's lights when he resumed his watch after making his log entry.

d) No distress signal emitted from the aircraft.

The crew of the aircraft had no time to send out a radio distress signal before ditching and they were unable to use the radio after the accident owing to the lack of electric power and the immersion of the aerials. Petrol on the water and in the vicinity of the aircraft and dinghies precluded the lighting of distress flares near the scene of the accident and no Verey pistol equipment was carried in the aircraft.

e) The Security Force did not pass on to the control tower the observations of the Customs officers.

Although there are no written instructions regarding the passing of suspected flight incident reports by the Security Force to the air traffic control, it should be the normal practice for all such reports to be passed to the control tower so that any necessary coordination of action can be undertaken by a central body on the airport. The recognition of the air traffic control tower as the nerve centre of the airport, through its knowledge of minute to minute aircraft movements, should be impressed on all airport personnel.

f) The GCA Director passed to area control and tower a radar identification of the KLM Constellation in flight, outward bound.

The Court considers that a grave error of judgment was committed by the GCA Director in positively identifying the aircraft "blip" as the KLM Constellation without qualifying the report that the path of the aircraft had not been followed from the vicinity of the airport and had, in fact, only been on the screen for some ten seconds' duration.

g) Failure of Launch - Tower Intercommunication.

The unfortunate failure in obtaining HF/RT communication between the rescue launch and the control tower when the launch first set out, caused by the tower receiver being off tune, resulted in a delay of some 35/40 minutes before the launch arrived at the scene of the disaster It was not considered necessary for the Court to investigate fully the reason for the receiver being off tune but the Court considered that, apart from the high noise level in the control tower, the type of radio installation in use for this important means of communication, open as it is to the possibility of the receiver becoming off tune, calls for criticism.

No blame was attached to either the launch crew or the air traffic control officer in the tower.

Note: The Court was unaware of any vehicles superior to those presently in use at Shannon for negotiating the mudflats, but understood that this question is constantly under review by the airport authorities.

RECOMMENDATIONS

It is recommended:

1) That an assistant to the air traffic control officer in the tower at Shannon Airport be provided at all times.

2) That the stand-to period of the Security Force at the Fire Station be more clearly defined in the Shannon Airport Crash Orders.

3) That instructions be issued to all sections and services employed at the airport to communicate suspected flight abnormalities to the air traffic control tower and that the importance of this requirement be stressed.

4) That GCA crews be instructed not to report identifications of aircraft to other agencies without giving appropriate identifying facts.

5) That the noise level in the control tower be reduced to a minimum, while at the same time adequately monitoring required radio frequencies.

6) That radio communication installations fitted to the rescue launches, or any other airport service equipment be such that effective instantaneous inter-communication is ensured at all times.

Note: The Court was gratified to learn of the work in progress (prior to 5 September 1954) for construction of a Rescue Launch Station at the airport. When this work is completed, a launch will be more readily available for emergency.

Subject to this, the rescue facilities and services at Shannon Airport were considered adequate and no recommendation was made in this regard.

Comments of the Netherlands Government on the Irish Report

"Aeronautical Council
The Hague - The Netherlands.

DECISION

The Commission formed from the "Aeronautical Council" referred to in Article 6 of the "Act, regulating the Investigation of Accidents to Civil Aircraft;"

Considering the documents relating to the preliminary investigation made by the Preliminary Inquirer into the causes of an accident which occurred to the aircraft PH-LKY (Triton) on September 5, 1954, in the vicinity of Shannon airport, Ireland;

Considering the recommendation made by the Preliminary Inquirer on October 10, 1955, No. BVO-3/8, to the effect that no further investigation will be made by the Aeronautical Council;

Taking into account that the Commission from the documents pertaining to the preliminary investigation found the following:

a) Progress of the flight.

Although the aircraft was heavily loaded, the take-off weight was approximately 500 kgs below the maximum take-off weight. The aircraft was airworthy. With the exception of a few parts to which reference will be made below, the inspection of the wreck showed no evidence of technical deficiencies. The engines functioned normally

The Commission is in agreement with a reconstruction of the take-off path prepared by the Irish Court of Inquiry.

During the first 25 seconds after leaving the ground the climb was normal. During this period take-off power was reduced to METO power (maximum except take-off power) after approximately 15 to 20 seconds. At the end of this period a height was reached of approximately 40 metres. At that moment the captain considered the undercarriage to be fully retracted, and he gave the order to retract the wing flaps which at the time were in the take-off position. During this manoeuvre the take-off condition began to develop unfavourably. After the aircraft had reached a height of 50 metres (according to the indication of the altimeter 80 metres), the flight path gradually changed from a climb into a descent. The descent continued during the later part of the flight, for a period of approximately 10 seconds.

The descent could have been apparent to the captain from the indications of various instruments, in particular from the indications of the artificial horizon and the altimeter. A few moments later this descent would also have been apparent from the indication of the vertical speed indicator which reacts with a certain delay. However, the captain paid insufficient attention to these instruments since he was of the opinion that with a normally functioning aircraft no special alertness in respect of the continuation of the take-off was required after reaching a height of approximately 75 metres.

As soon as the flaps were fully retracted he gave the order to reduce the power of the engines to climb power without first reading the altimeter. This must have taken place approximately four seconds before the aircraft came into contact with the water. A few seconds later the captain realized that the aircraft was descending. He took action with the elevator control. Due to the small distance between the aircraft and the water the only favourable result of this action was that upon contact with the water a heavy impact was avoided.

b) After considering this course of events the Commission agrees with the conclusions of the Irish Court that, in the first place, the accident must be attributed to the captain failing to pay sufficient attention to the indications of the instruments, in particular those of the artificial horizon and the altimeter.

Some attending circumstances, which contributed to the accident were:

1. Prior to take-off the captain failed to adjust the altimeter according to the latest barometric pressure communicated to him; as a result the altimeter overread by six metres.

2. In addition, instrument errors of the altimeter and the change of barometric pressure, which occurred after the last weather report communicated to the aircraft, resulted in an overreading of 20 to 25 metres.

3. In all probability the warning light, which should be on when the undercarriage is not retracted and locked, was unserviceable. This may have led the captain to the conclusion that the undercarriage was retracted and locked while this was actually not the case. Investigation of the wreck revealed that the nose wheel and the starboard main gear could not have been locked up. If the undercarriage is not locked in the "up" position, retraction of the wing flaps may result in the landing gear moving down again. The resulting increase in drag considerably affects the climb performance of the aircraft. When METO power is applied, such need not necessarily result in a descent. However, when insufficient attention is paid to the indications of the instruments the flight path may easily change from a climb into a descent. This possibility is further enhanced by an apparent tendency to pay more attention to the increase in speed than to the maintaining of a sufficient rate of climb (shallow take-off).

Consequently, as a result of the unserviceability of the warning light the captain did not realize that the condition of the aircraft had become such that the climb performance was unfavourably affected. This again resulted in the fact that the actions which the captain normally took during take-off did not lead to a normal continuation of the climb.

The consideration which prompted the Commission to view the above factor as only a secondary cause of the accident is that during a night take-off the captain should pay considerable attention to the indication of the instruments. If the captain had paid this attention, he would have been able to take the necessary action in time.

4. That a dangerous situation should arise is also to be attributed to the tempo in which the various actions followed each other, such as the retraction of the undercarriage, power reduction to METO power, flap retraction, and power reduction to climb power. As a result the captain did not fully utilize the favourable performance possibilities of the aircraft, and thereby it happened that, as explained under 3, the flap retracting system started to operate before the undercarriage was locked.

Take-off power had only been applied for approximately 50 seconds, whereas 2 minutes' continuous take-off power is allowed without affecting the proper functioning of the engines.

METO power had only been applied during approximately 25 seconds, whereas there is no restriction as to the duration of this power setting. With wing flaps retracted the climb performance of the aircraft exceeds the climb performance with flaps in the take-off position only by a very small margin. Therefore, early retraction of the flaps is not at all necessary.

This fast tempo of successive actions, together with the apparent tendency to pay more attention to the increase of speed than to the maintenance of a sufficient rate of climb, contributed to the beginning of the descent.

In the case under review the take-off procedure is incompatible with the requirements of safe air traffic. In this connection it may be observed that the crew was under the erroneous impression that it would be beneficial to the reliability of the engines if the time during which take-off power is applied were to be reduced to a minimum.

c) Lessons to be derived from the accident.

1. When flying with reduced or zero visibility, or in darkness close to the ground, much attention has to be paid to instruments which give information on the vertical movements of the aircraft.

2. A fast tempo in which during take-off the various actions in relation to engine-, undercarriage- and flap handling are carried out, together with the application of a shallow take-off, reduce the safety margin which is essential in view of unforeseen circumstances. The relative KLM instructions permitted application of a take-off procedure, the safety aspects of which left room for improvement. KLM has derived from this accident, as well as from an accident which happened a short time previously, the lesson that the take-off procedure for its aircraft had to be described in more detail. Revised instructions have been issued to its flying personnel.

3. One of the recommendations made by the Irish Court of Inquiry was to duplicate the undercarriage warning lights. Follow-up action has been taken.

d) Consideration of the need of a further inquiry.

The Preliminary Inquirer proposed not to hold a further inquiry. A very accurate and competent investigation was made by the Irish Court of Inquiry, the result of which, together with all relevant documentation, was kindly put at the disposal of the Department of Civil Aviation and the Aeronautical Council. The Preliminary Inquirer concurs with the viewpoints and the resulting verdict, which is also entirely acceptable to the above mentioned Commission. Under the circumstances taking of disciplinary action against the captain is not urgently required, and it is the task of the Commission to declare that a further investigation need not be held.

According to the Irish Court, it is evident that, by neglecting the indications of the instruments, the captain failed to exercise caution. However, taking into consideration the distress which the accident has caused to the captain and also taking into consideration the fact that this accident brought the very long and distinguished career of the captain to an end, the Commission considers it justifiable that, in this case, the Council does not exercise its authority to take the disciplinary action referred to in article 37 of the Act regulating the investigation of Accidents to Civil Aircraft.

Based on the above considerations, the Commission has decided that no further inquiry will be held by the Aeronautical Council into the causes of the accident."

dated 9 January 1956

KLM Lockheed Super Constellation crash - River Shannon, Ireland - 5 September 1954

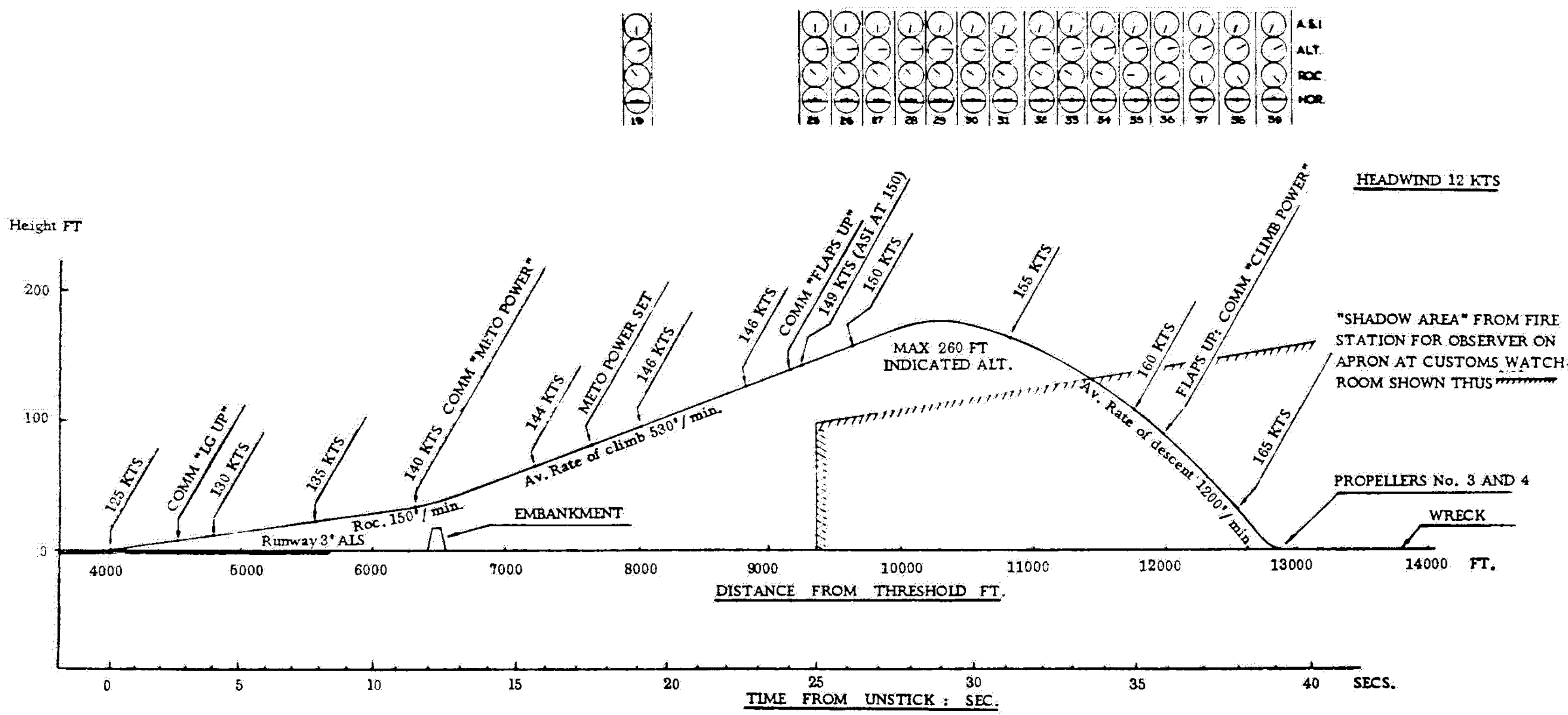

FIGURE 1
FLIGHT PATH AND
RELATED INSTRUMENT
INDICATIONS

KLM Lockheed Super Constellation crash - River Shannon, Ireland - 5 September 1954

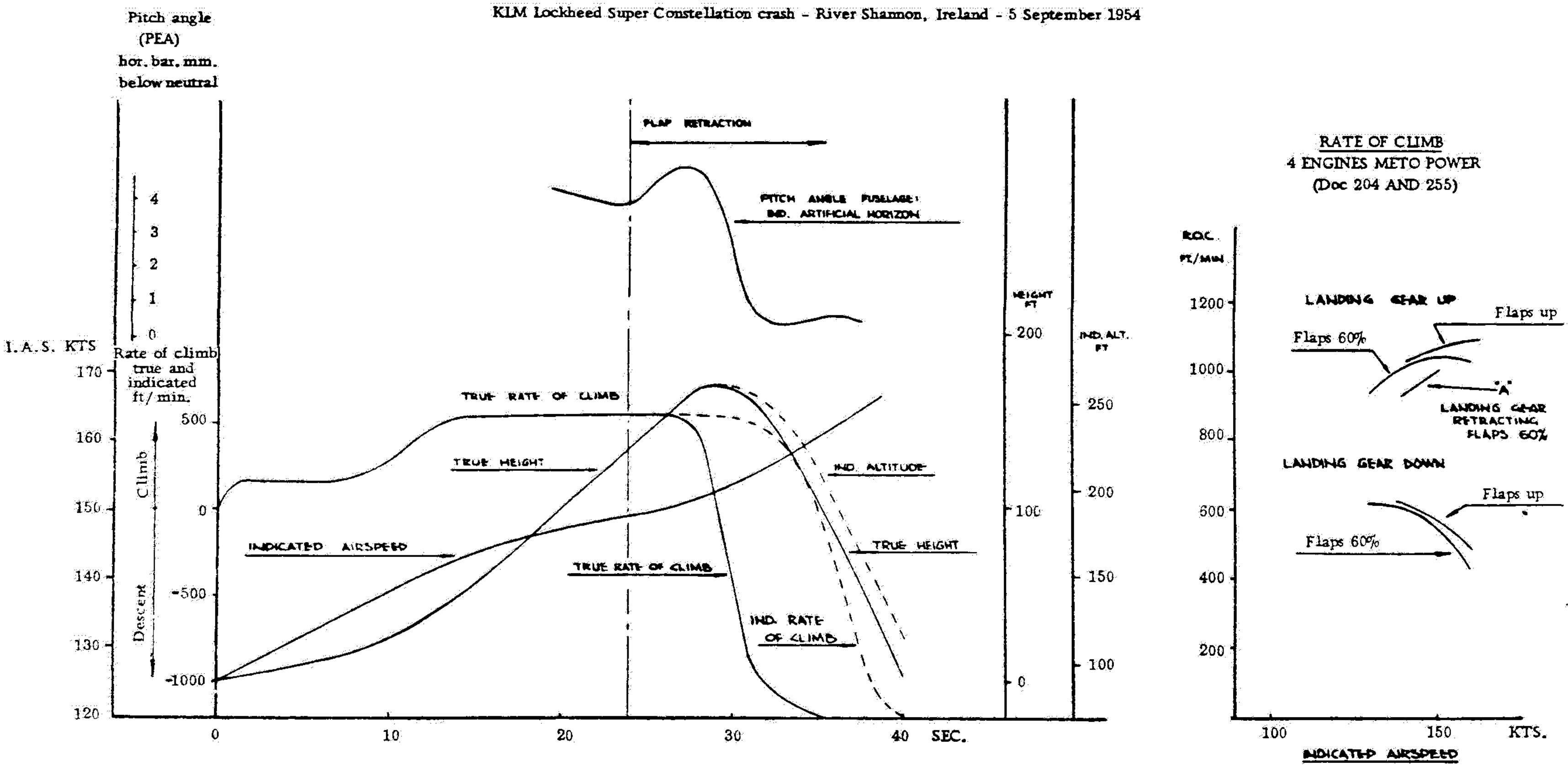

FIGURE 2
TIME HISTORY
AND
INSTRUMENT INDICATIONS

No. 4

National Airlines, Inc., Lockheed Lodestar, Pinellas County International Airport, St. Petersburg, Florida, 10 January 1955. Civil Aeronautics Board (U.S.A.) Accident Investigation Report No. SA-300, File No. 1-0001, released 17 June 1955

Circumstances

The flight originated at Orlando, Florida, destination Miami with intermediate stops at Lakeland, Tampa, St. Petersburg, Sarasota, Fort Meyers and West Palm Beach. The aircraft departed Orlando at 0805 hours Eastern Standard Time with 10 passengers and 3 crew. The flight was routine up to take-off time at St. Petersburg. The captain taxied the aircraft to the run-up position for Runway 9 and then turned the aircraft over to the co-pilot. As the aircraft progressed down the runway it swerved several times, the landing gear collapsed rupturing a fuel tank, and the aircraft came to rest on the sodded area off the runway. Fire broke out immediately. Two crew members received minor injuries.

Investigation and Evidence

After a normal run-up the co-pilot taxied the aircraft to the end of the 5 010 foot runway. The aircraft was then lined up with the runway slightly to the right of the centerline, the tail wheel was locked, and power was applied. As the aircraft progressed down the runway the tail came up and the co-pilot applied forward pressure to the control column. Shortly thereafter the aircraft began to swerve to the left and when this was corrected it went too far to the right. A series of over-corrections followed which resulted in several swerves in both directions. As these manoeuvres began the crew noted a five-inch drop in the manifold pressure of the left engine. At a speed of approximately 80 knots the aircraft again began turning to the left. The captain immediately took over the controls when he noticed a second drop of 25 inches in manifold pressure of the same engine. Both throttles were closed at once and he tried unsuccessfully to stop the turn. The turn developed into a skid and the main landing gear collapsed rupturing the right fuel tank.

The captain and co-pilot stated that soon after the throttles were advanced for both engines to the prescribed 45-1/2 inches of manifold pressure, a drop of 4 to 5 inches was observed on the left manifold pressure gauge. The left throttle was further advanced and this was followed by a second drop in manifold pressure to 20-25 inches. According to the pilots, each drop in manifold pressure was accompanied by a yaw to the left.

The captain testified that he applied full right brake and rudder in an attempt to stop the left turn. This was unsuccessful and he then "stood" on both brake pedals in an effort to stop the aircraft. The co-pilot testified that he did not use the brakes during the take-off run.

The flight crew said that at no time did the aircraft turn to the right after the take-off start was made from a position lined up on the runway. However, the stewardess testified that there was a swerve to the right, then to the left, again to the right, followed by a continuous left turn off the runway. One passenger, with aircraft piloting experience, also said that the aircraft "fishtailed" or made definite swerves both right and left prior to the start of the continuous left turn.

The cockpit was in the area of heavy fire damage and instruments, pedestals and electrical panels were destroyed. All cables coming out of the yoke were burned off. Except for steel parts the right engine was destroyed by fire. The brake discs showed no evidence of having malfunctioned.

On Lockheed Lodestars the method of changing the fore and aft position of the rudder and brake pedals is by manual adjustment of the hanger arm supporting the pedals. The characteristics of the rudder pedal adjustment mechanism are such that attempts to place the pedal in the farthest forward position can result in the projecting tooth on the adjustment pawl passing beyond the end of the ratchet rather than engaging in the last recess of the ratchet. When this occurs, the pedal, on casual inspection, appears to be properly adjusted and the rudder and brake systems are operative. However, in this condition pedal loads are transmitted to the pedal assembly torque tube through mating offsets on the rudder pedal hanger and the torque arm at their attachment to the torque tube. When relatively high pedal loads are applied the aluminum alloy casting at the offset of the pedal arm may tear out causing the loss of rudder and brake control due to the pedal hanger swinging forward.

With reference to the subject accident, during the investigation the captain stated that his pedals were "forward" at the time of leaving the terminal. Fire destroyed the rudder mechanism and it was, therefore, impossible to determine the exact position the rudder pedals were in prior to the accident, or if a failure had occurred.

The Lodestar aircraft has certain ground characteristics which require the pilot to use extra care to maintain directional control during the early stages of the take-off run. Considering this fact, together with the co-pilot's previous flying experience both before and after his employment by the carrier, it is obvious that the captain should have been extremely observant of the co-pilot's technique. The co-pilot had been accustomed to flying large aircraft with tricycle gear which were not in the least susceptible to these peculiar ground characteristics.

There is no doubt that during the initial stages of the take-off run the co-pilot over-controlled the aircraft in an effort to keep straight on the runway. These oscillations both to the left and right were made until the aircraft went into a severe left turn. The forward speed of the aircraft made it light on its wheels and nearly ready to take off, making braking action less effective. The captain then became alarmed and took over. This action of the captain was either too late or a failure occurred which prevented him from being able to control the aircraft effectively. In this respect it is possible that during the captain's efforts to stop the aircraft he exerted sufficient pedal pressure to break the offsets of the torque arm thus preventing braking and rudder action. Since fire destroyed the pedal mechanism, this could not be determined.

Although both the captain and co-pilot stated that the left engine lost power momentarily during the take-off, inspection and test of the engine failed to duplicate this malfunction. Since this engine was found to function in a normal manner, the drop in manifold pressure was not repetitive.

There is no evidence indicating that structural failure or malfunction of controls occurred. However, there exists the indeterminable possibility that during the take-off run there was a failure of the pedal assembly.

Probable Cause

The probable cause of this accident was the co-pilot's loss of directional control during the take-off run and the inability of the captain to regain control of the aircraft, the latter possibly due to failure of the pedal mechanism.

Fire Aspects (from NFPA Special Aircraft Accident Bulletin, Series 1955: No. 5)

While the fire originated near the right engine nacelle, it was needlessly allowed to do extensive damage which seriously complicated investigation into the actual cause of the accident and destroyed more property than was necessary.

The story of the mishandling of the fire should be told so that similar sequences will not occur.

9:38 Aircraft groundlooped, gear collapsed and fire started in area of right engine nacelle.

9:38+ Under supervision of stewardess, all passengers left the aircraft in a rapid orderly manner through the main cabin door (left side). The pilots made egress through cockpit windows. Alarm given to Airport Fire Department by Tower Controller.

9:40 Airport Fire Department reached the scene with a crash truck (capacity 250 gallons of premixed foam) and two 30 lb. dry chemical extinguishers. Fire control could not be achieved with this equipment.

9:46 Telephone call received by St. Petersburg Fire Department.

9:46+ St. Petersburg Fire Department answered call with three tank wagons and one pumper. On arrival, they were told "to let the plane burn" as all passengers had been removed and the plane was "fairly well consumed by fire". No attempt was made by the St. Petersburg Fire Department to extinguish the fire and all equipment was returned to the station.

10:05 U.S. Coast Guard Air Station at St. Petersburg received telephone call from St. Petersburg Fire Department that the aircraft had crashed. Fire truck with crew was dispatched immediately.

10:10 U.S. Coast Guard Duty Officer advised by Pinellas Tower that fire was out and truck would not be needed. Police Department called and fire truck was stopped by them and told to return to base.

10:25 Pinellas Tower advised U.S. Coast Guard that fire had started again. Fire truck and crew were again dispatched.

10:45 U.S. Coast Guard foam truck arrived at scene of crash with 10 men (distance: 18 miles).

10:50 Fire extinguished by foam (100 gallons of foam liquid and 1 000 gallons of water).

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ICAO Ref: AR/384

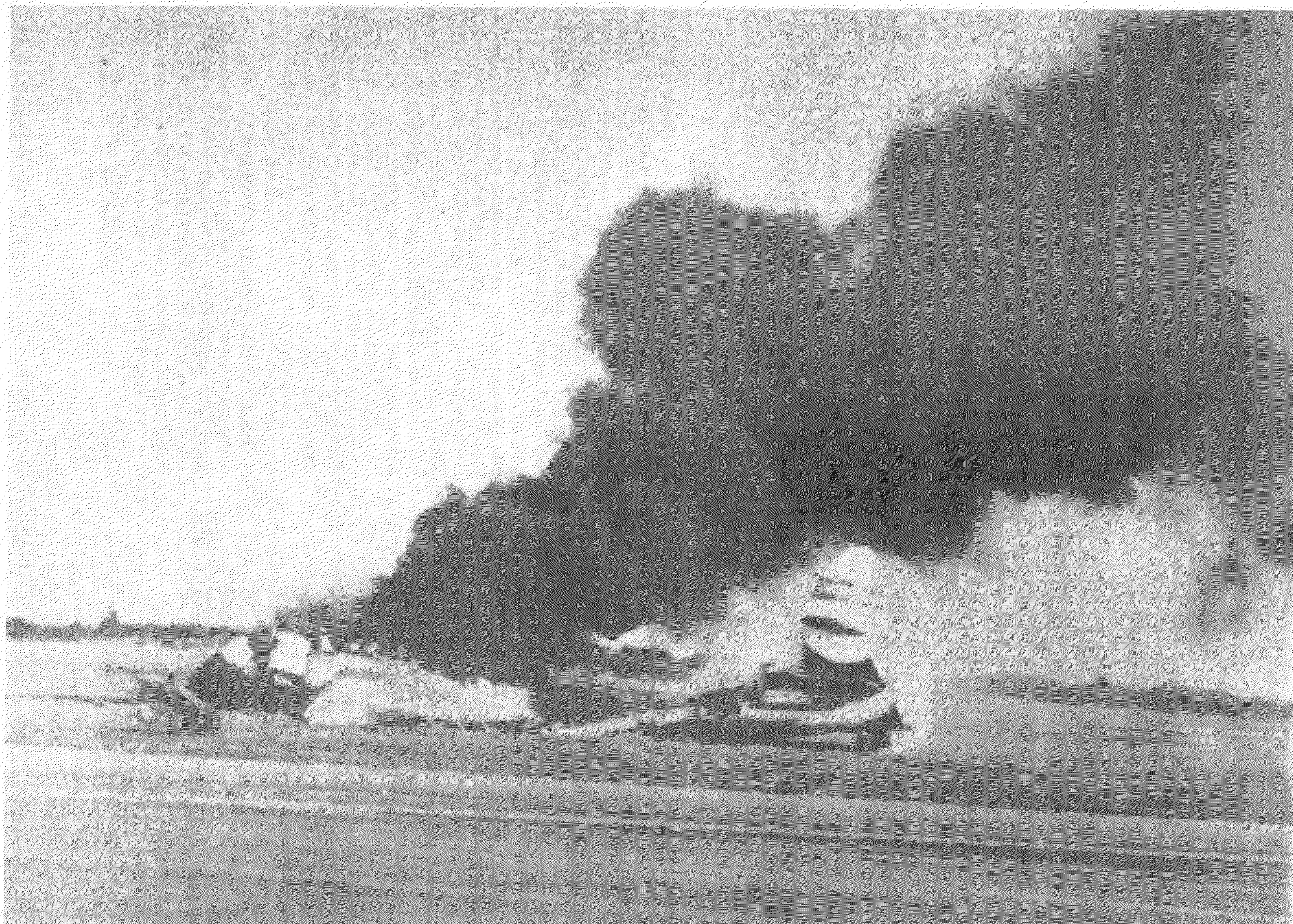

Figure 3 Wide World Photo

Fire originated in right wing of Lockheed Lodestar after gear collapse following loss of control on take-off from Pinellas County International Airport, St. Petersburg, Florida, on 10 January 1955.

No. 5

Trans-World Airlines Inc., Martin 202-A and Castleton, Inc., Douglas DC-3C, collided near Greater Cincinnati Airport, Ohio, on 12 January 1955. Civil Aeronautics Board (U.S.A.) Accident Investigation Report No. 1-0014, released 8 July 1955

Circumstances

The DC-3 aircraft departed Battle Creek, Michigan, at approximately 0733 hours en route to Lexington, Kentucky, and thence to Miami, Florida, carrying two pilots. The flight was proceeding in accordance with Visual Flight Rules to Lexington and if the weather lowered en route the pilot planned to file in flight for an IFR clearance. However, no plan was filed before departure or in the air, nor were radio facilities along the route contacted by the pilot. The Martin 202-A departed Greater Cincinnati Airport at 0902 hours Eastern Standard Time on an Instrument Flight Rules flight plan to Cleveland, Ohio, with 13 persons aboard. While making a right turn after take-off from Runway 22, the Martin 202-A collided with the DC-3 about 2-1/2 miles west of the Greater Cincinnati Airport, in the control zone*, at 0904 hours. Both aircraft went into steep dives, struck the ground, killing all occupants, and were demolished as a result of collision, ground impact and fire.

Investigation and Evidence

Examination of the Martin wreckage (2-1/2 miles west of the airport control tower and approximately the same distance from the southwest end of Runway 22) showed that the right wing was partially severed chordwise at collision about 22 feet from the center line of the fuselage, and wrenched off while the aircraft was still in the air. Due to striking the ground in a fairly steep dive the cockpit and its components disintegrated to such a degree that no information was obtainable on the position of cockpit controls and radio equipment. It was ascertained that both the landing gear and the flaps were retracted when the aircraft struck the ground. Inspection of the propeller domes showed that the pitch of the propeller blades at ground impact was 47 degrees. No evidence was disclosed in examination of the wreckage to indicate any malfunction or failure prior to the collision.

The DC-3 struck the ground in a steep dive (on the stub of the left wing, the nose section and engines) one mile south of the Martin, approximately 2-1/4 miles west-southwest of the control tower. A number of battered and torn sections of the left wing outboard of the flap and portions of the vertical tail were torn off at the time of collision. The cockpit was demolished. Four propeller cuts were found across the top of the fuselage, two in the vertical tail, and one in the left wing. The fin was badly crushed and torn, and the rudder was detached at the hinges. The landing gear was retracted. The flap mechanism was destroyed and, therefore, the position of the flaps at impact could not be ascertained. Examination of the propeller dome assemblies revealed that the pitch on the left propeller at ground impact was 41 degrees, and the right 39 degrees. All radio equipment was so severely damaged that it was impossible to ascertain with any certainty what, if any, equipment was in use, or to which frequency it might have been tuned.

Study of the wreckage of both aircraft disclosed that immediately prior to impact the aircraft approached each other at an angle of about 30 degrees from head on, with the longitudinal axis of the two aircraft crossing to the left of the Martin and to the right of the DC-3. The aircraft were banked relative to one another so that the left wing of the Martin was higher than the right wing of the DC-3, while the right outer wing of the Martin and the left outer wing of the DC-3 were in position to collide. In addition, the collision damage indicates that the Martin was climbing relative to the DC-3.

The first major components to come in contact were the left wing of the DC-3 and the right propeller of the Martin. The right wing of the Martin and the left wing of the other

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* A control zone is an airspace of defined dimensions, extending upward from the surface, to include one or more airports.

aircraft then struck, resulting in disintegration of the DC-3 wing in the contact area, and causing such structural damage to the Martin right wing that it separated from the aircraft before ground impact. While the two wings were tearing through one another, the left propeller of the Martin started its cuts across the top of the DC-3 fuselage and through the vertical fin and rudder while the Martin moved across and to the rear of the other aircraft. Near the end of the contact period, the inboard side of the Martin left nacelle inflicted severe crushing damage on the DC-3 vertical tail, causing portions of the DC-3 fin and rudder to separate in flight.

Several witnesses were found who saw or heard the two aircraft after collision. Witness No. 1* heard the Martin take off. About two or three minutes later he heard a sharp sound to the southeast which resembled a clap of thunder or blasting. Directing his attention toward the source of this unusual sound, he saw nothing except the low overcast for an appreciable time, testifying that it might have been as long as 30 seconds before he saw an aircraft (Martin 202-A) dive out of the clouds and burst into a ball of flame when it struck the ground. At no time did this witness see or hear the DC-3.

Witness No. 2 heard an explosion while at home. Looking out of his west window he saw an aircraft (Martin 202-A) headed north. For an instant it appeared to be in level flight near the base of the clouds, then went out of control, dived to the ground at about a 45-degree angle, and exploded upon impact.

Witness No. 3 "heard a loud noise". Looking up, he saw two aircraft to the northwest, just under the base of the overcast. The DC-3 was in a steep dive and the Martin was apparently trying to pull out of a dive. Although this witness lived near the end of Runway 22, he did not recall hearing the Martin take-off.

Witness No. 4, a teacher in a school about a mile and a half north of the site of the intermingled wreckage, testified that she heard an aircraft west of her position, flying south, shortly before the time of the collision.

One of the students (Witness No. 5) testified that he heard an aircraft and on looking out of the window he saw it pass the end of the building, going west, and it appeared to be flying close to the base of the clouds. His attention was again drawn to the aircraft a few moments later, when he heard a roar of engines, looked up, and almost at the same instant saw an explosion in the air, accompanied by a mushroom of smoke. He said that he saw "two tails" and the wreckage "came down in one heap".

Witness No. 6 who lived near the schoolhouse, heard an aircraft take off from the airport. He then heard an aircraft coming from the north and it passed, going south, west of where he was standing. It seemed to him from the sound that this second aircraft was very low. He searched the sky but never saw either of the two aircraft apparently because of the "hazy condition". On searching the sky he heard a thud and an explosion, followed by a surge of engines from one of the aircraft.

Witness No. 7 was in west Cincinnati when at about 0855 his attention was drawn to an aircraft flying much lower than usual, which he definitely identified as a DC-3. It continued past his position, flying in a southwesterly direction, disappearing and reappearing in the overcast several times.

The presence of the DC-3 in the control area was unknown to CAA Air Route Traffic Control and the Cincinnati tower. Civil Air Regulations specify that aircraft shall not be flown within a control zone beneath the ceiling when it is less than 1 000 feet, unless authorized by air traffic control. If operating on an IFR clearance, a flight would already be under the jurisdiction of air traffic control for flight within a control zone; if on a VFR flight plan, or no flight plan, a clearance to operate within the control zone would have to be requested if weather conditions were IFR (ceiling less than 1 000 feet or visibility less than 3 miles). If the ceiling is less than 1 000 feet, an aircraft, if cleared, may operate within the zone, remaining underneath and clear of clouds. In this instance, the ceiling was less than 1 000 feet and no request was received from the

* Position denoted on Figure 4 by numeral 1; other witness positions are similarly noted by appropriate numbers.

DC-3 for a clearance to operate within the control zone.

The weather reports reviewed by the captain of the DC-3 before departure from Battle Creek showed the existence of an overcast over the entire route, ceilings lowering from 3 100 feet at point of departure area to 1 300 feet at Lexington, visibility lowering from 8 miles at departure point to 2 miles at Lexington, precipitation throughout, icing in the clouds and precipitation areas, and below freezing temperatures existing over the entire route from the surface upwards. Since the flight was conducted without flight plan, in weather conditions which became poorer, and without communicating with any station en route, it is considered that the captain failed to exercise reasonable judgment and conducted this operation contrary to good operating practices. In the light of the weather situation the flight should have been planned and conducted so as to avoid flying at low altitudes in marginal VFR conditions.

At 0907 (3 minutes after the accident) the U.S. Weather Bureau reported the following conditions: ceiling 800 feet variable; overcast; visibility 4 miles; light freezing drizzle; fog (extending from ground to overcast); temperature 28; dewpoint 25; wind southwest 11 knots; altimeter setting 29.99 inches. Remarks - ceiling 700 feet variable to 900 feet, cloud cover between 3 000 to 4 000 feet thick.

It appears that in the collision area, visual reference to the ground was possible up to 900 feet above the surface. It also appears highly probable that visibility progressively decreased with altitude, and that near the cloud base it was considerably less than the surface visibility of four miles. Visibility could have been reduced in either aircraft by windshield icing unless preventive measures were used.

Since the DC-3 was equipped with several transmitters and receivers it is considered remote that total radio failure could have occurred. As there were no radio contacts from the DC-3 it is unknown at what altitudes the flight was made. It would have been possible for the pilot to have conformed with VFR rules between Battle Creek and Cincinnati by flying through areas of low ceiling and visibility at less than 700 feet altitude (below airways) provided the aircraft was operated clear of clouds and visibility was not less than one mile.

The elapsed time from take-off of the Martin 202-A, possible flight paths of both aircraft and the techniques and flying habits of both captains were thoroughly investigated.

TWA flight operations procedures specify that aircraft are to climb straight ahead until reaching an altitude of 500 feet. The flaps are then retracted; power reduced to climb power, and a climbing turn to the desired heading is commenced.

Two test flights were conducted to learn what the altitude and position of the aircraft at various stages would be if standard company procedures during instrument flight were followed. The test pilot had given the captain of the Martin 202 his checks for the past 18 months and it was believed that this pilot could closely duplicate the techniques which the captain probably used. The test runs showed that the aircraft would fly over the intermingled wreckage at an altitude of 1 500 feet above the ground on a heading of 340 to 345 degrees and in an elapsed time of 2-1/2 minutes. Thus, as the captain was a conscientious and conservative pilot who had never been known to deviate from company policy, the collision probably occurred at 1 500 feet.

An aeronautical engineer representing Castleton, Inc. conducted a detailed study of the wreckage and other evidence and submitted a separate report to the Board. He concluded that the point of collision was very near the location of the recovered DC-3 wing tip since this unit fell straight downward after the collision. His value of the closure angle between the two aircraft at the time of collision substantially agreed with the Board's findings. Part of his study was devoted to the calculated trajectory of the DC-3 following collision. From this analysis he concluded that the DC-3 struck the ground 14 seconds after collision, and that it covered a distance of 3 000 feet over the ground and rolled somewhat beyond the vertical in this interval. Based on conservative assumptions he testified that the study further showed the maximum collision altitude as 1 000 feet, and that if the elevator trim, the exact amount of left wing lost, and elevator control displacement (pilot's effort to raise the nose of the aircraft), were more precisely known the collision altitude might be as low as 500 feet. He further stated that his study showed that the DC-3 heading was 170 - 180 degrees and that of the Martin 202-A was 315 - 330 degrees. The Martin heading at time of collision indicated that the TWA pilot started his right turn at the far end of Runway 22, and that the collision occurred 50 seconds later.

It is reasonable to assume that the DC-3 was in level flight on a south heading. Whether it flew over Cincinnati or not could not be absolutely verified. However, the DC-3 seen by Witness No. 7 in West Cincinnati was probably the Castleton DC-3 as no other DC-3's were known to be in the area.

Since the DC-3 was not on an IFR flight plan the pilot could be expected to have tried to remain in visual contact with the ground. Analysis of some witness testimony, however, indicates that it was being operated in the clouds. The controller believed that he lost sight of the TWA aircraft due to its entry into the overcast. Witness No. 1 states that an appreciable period of time elapsed between hearing the collision and the time an aircraft came into view, apparently out of the overcast. Witness No. 5 stated that he saw an explosion in the air which may indicate that the collision occurred at the base of or in the overcast.

During the several seconds it took for the sound of collision to reach the witnesses, the inertia of the two aircraft would tend to make them continue along the same general paths they had immediately prior to the collision. As a result, the two aircraft may have changed altitude very little during the interval until the first witness saw the Martin.

The Martin 202-A is capable of climbing at considerably higher rates than those indicated by the test flight. Results of the test flight indicated that collision occurred in the clouds, several hundred feet above the base of the overcast. However, the results of the study by Castleton indicated that the accident could have occurred between 500 and 1 000 feet. In considering the test flight results, the engineering studies, and all other pertinent evidence, the Board concluded that the accident occurred close to the base of, or in, the overcast.

Probable Cause

The probable cause of this accident was operation of the DC-3 in the control zone as unknown traffic, without clearance, very close to the base of, or in, the overcast.

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ICAO Ref: AR/375

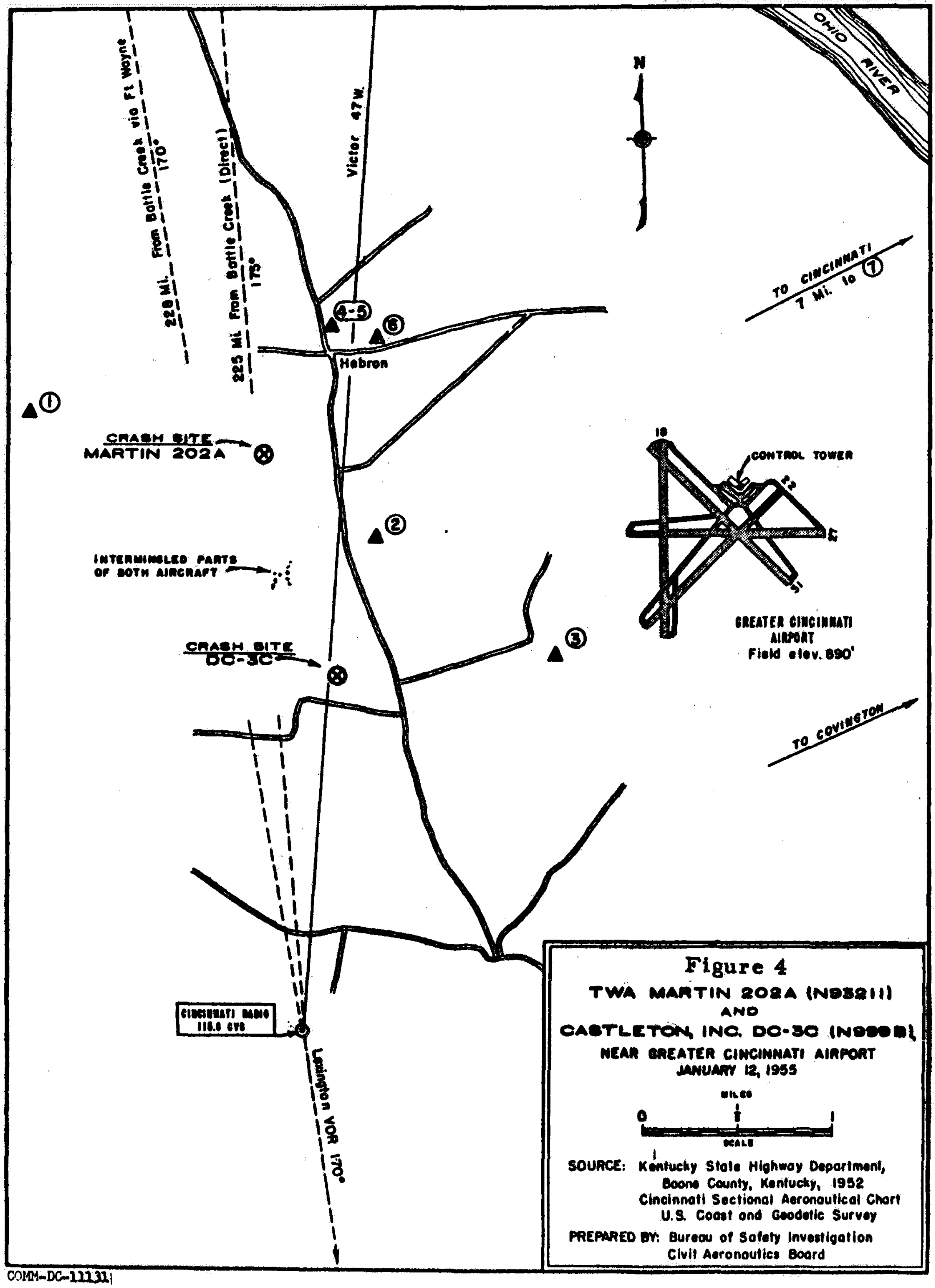

Figure 4
TWA MARTIN 202A (N93211)
AND
CASTLETON, INC. DC-3C (N999B)
NEAR GREATER CINCINNATI AIRPORT
JANUARY 12, 1955

SOURCE: Kentucky State Highway Department, Boone County, Kentucky, 1952
Cincinnati Sectional Aeronautical Chart
U.S. Coast and Geodetic Survey

PREPARED BY: Bureau of Safety Investigation
Civil Aeronautics Board

COMM-DC-11131

No. 6

British European Airways, Viscount aircraft, G-AMOK, crashed into a barrier while taking off from London Airport, England, on 16 January 1955. Report dated 24 August 1955 released by Ministry of Transport and Civil Aviation (U.K.).

Circumstances

At approximately 1150 hours the aircraft, Oboe King, whilst taking off from London Airport for Rome, Athens and Istanbul crashed in conditions of bad visibility due to fog, into a barrier in its path connected with construction work which was then and for some time previously had been taking place in the central area of the airport. The captain and first officer were both convinced before they commenced their take-off that the aircraft was on Runway 6, also known as 15R, and they had received radio-telephone clearance from the airport control authorities to take off. In fact, the aircraft was on a disused runway (hereafter called "the strip"), which had not been used as a runway since June 1949, when building operations in the central area caused it to be closed. Although the aircraft at the time of the crash was almost airborne and suffered considerable damage, there were no casualties, and only the captain and one passenger received minor injuries.

Investigation and Evidence

Layout, Markings and Lighting System of London Airport

The Airport is one of the largest and busiest in the world and consequently there is perhaps both a greater likelihood of a pilot losing his way at London than at most other airports and also a consequentially greater need for clear directions to enable him to find his way. Moreover, the size of the Airport may make methods used at smaller airports inapplicable. A further consideration is that London Airport has been ever since the war in the course of development which is not yet completed. In consequence, there was on the day of the accident a lack of uniformity about marks and direction signs, etc. which was to some extent inevitable in view of the rapid development of the Airport.

It was not until the end of the war that it was decided to adapt the aerodrome for use as the main civil airport for London. At the time when the Airport was taken over for civil aviation there were three runways either completed or in the course of completion forming a triangle with its base running in an east and west direction parallel to and just south of the Bath road (see Figure 5). It was decided

a) to superimpose upon the original triangle of runways a second triangle which would ensure there being two parallel runways running in each of the three directions of the original triangle and

b) to secure a greater length for the runways.

The latter was done by an extension of the runway forming the base of the original triangle and one of the runways forming one of its sides and by building for the third side a new runway considerably further to the west running from northwest to southeast and parallel to the third runway constituting the original triangle. Completion of this new runway and the prolongation of the two remaining runways constituting the original triangle made it unnecessary any longer to use the original northwest/southeast runway. Moreover, development work upon the central area of the Airport involved the obstruction and building upon part of the old runway. Accordingly, it ceased to be used as a runway on 28 June 1949. On the other hand, the building and development work only took place on the centre portion of the old runway and those parts of it to the northwest and southeast of such work were of the same width and composition as runways in use at the Airport and also ran in the same direction as the new runway constructed further to the west.

The six runways in existence at the Airport at the time of the accident were known and referred to in two different ways. One method of distinction was to number the runways from 1 to 7 omitting number 3, which had been the number of the strip at the time when it was in use as a runway. Another method, which is more generally used and particularly for the purpose of giving instructions to pilots either landing or preparing to take off, is designed to distinguish the direction of the particular runway to which reference is being made. Under this nomenclature runways are numbered by a two-figure number which represents the first two figures of the magnetic compass heading of the runway. Thus a runway which runs due east and west magnetic, runs in a compass direction of 270° or 90° and such a runway under this system would be called, if one were proceeding from east to west, Runway 27 and, if proceeding in the opposite direction, Runway 09. Since at London Airport there are two runways in each of the three directions, they have to be distinguished from one another; this is done by calling them Right or Left as seen from an approaching aircraft. The following table demonstrates the two systems of numbering described above.

Numerical Number	Direction	Compass bearing Number
Runway 1	East and West	28R/10L
Runway 2	North-east South-west	05R/23L
Runway 4	North-west South-east	33R/15L
Runway 5	East and West	28L/10R
Runway 6	North-west South-east	33L/15R
Runway 7	North-east South-west	05L/23R

The length of the runways at London is approximately 7 000 ft. and thus affords ample room for the take-off and landing of Viscount aircraft. Each runway is 300 ft. wide (save 2 which are 250 ft.) and is constructed of square concrete slabs. The taxi-ways are similarly constructed of concrete slabs but are only 125 ft. wide. So far as dimensions and construction go "the strip" corresponded to the runways and not to the taxi-ways.

Various methods are employed at London Airport for distinguishing the runways and assisting pilots in finding their way about the Airport. There are in addition certain objects and signs at the Airport not intended for the purpose of giving directions but which nevertheless could in certain circumstances be used to assist in identifying one's position.

Marks on the ground

There were at the time of the accident no painted marks of any kind upon either the strip or any of the taxi-ways. On the other hand there was a variety of marks painted upon some of the runways as follows:-

a) Runway designation marks, also called QDM marks. These marks, consisting only of the compass heading designation of the runway in large figures were painted at the beginning of Runways 10L and 10R/28L.

b) Runway threshold markings, also known as threshold strips. These markings, consisting of a number of parallel white lines 100 ft. long, were only painted at the beginning or thresholds of runways 10R and 28L.

c) Runway centre line markings. A broken centre line of white paint appeared only on the two East/West runways namely 28R/10L and 28L/10R.

d) White crosses. At the time of the accident there were no white crosses painted on the surface of any of the runways or taxi-ways or upon the strip. A white cross had been painted upon the strip just south of its intersection with Runway 28R/10L when the original runway was closed but it had subsequently worn out as a result of contractors' vehicles using the strip and it had never been repainted. The white cross had consisted of arms not less than 20 ft. long and 3 ft. in width.

Notice boards and sign posts

a) Daylight route indicators. These consisted of boards at the side of runways or taxi-ways containing arms indicating various directions open to a pilot passing the board, somewhat similar to the boards which appear on the roads shortly before a junction as an indication to motorists. The appropriate arm on the daylight indicator board is intended to be illuminated so as to indicate to the pilot the direction he is to follow. These daylight route indicator boards are popular with pilots and readily understood by them, but at the time of the accident the completion of the erection of these boards and their electrical equipment was far from complete and none was available to show those in the Viscount the right way to take on the morning of the accident.

b) Position indicator or block number boards. The whole of the operational part of London Airport including taxi-ways as well as runways has been divided up into blocks each of which has been given a number. Small boards at the side of the runway and taxi-ways indicate the boundary between one block and the other by showing on their face the numbers of the two blocks in question. The block number boards are relatively small. The system of dividing the operational part of the Airport into numbered blocks and the use of block number boards is apparently peculiar to London Airport and is an extremely useful way of readily identifying a particular portion of the surface of the Airport.

c) QDM Boards. These are large boards at the side of a runway indicating that one is shortly approaching another runway by showing in large figures the compass heading number of the new runway. At the time of the accident these existed in every case at the side of each runway shortly before the intersection or junction with another, except in the case of the junction of Runway 28R and 15L.

d) Run-up boards. These are notice boards at the side of runways shortly before an intersection or junction with another runway indicating by words such as "Run-up for 15R" in large letters and figures that the position has been reached at which aircraft about to use the runway ahead should stop for the purpose of running-up their engines. At the time of the accident run-up boards bearing clear and consistent words and figures were in position in all appropriate places at the Airport, except at the junction of Runway 28R with 15L where an old run-up board bearing the phrase "Run-up 1" was in existence. In some cases, however, there were run-up boards on both sides of the runway and in some cases only on one side.

Lighting system

For the purposes of this report it is only necessary to deal with three different categories of lighting.

a) Taxi-way lights. These are omnidirectional lights let into the surface of the concrete and were present both in the runways and the strip. Their purpose is to guide aircraft to or from a particular position on the Airport. The lights are 80 ft. apart on straight stretches and more closely together at the curves. So far as the runways are concerned these lights are not placed at the centre of the runway but are closer to that side which is nearer to the central area. The lights are so placed that if an aircraft straddles them it will be able to proceed in safety.

b) Stop bar lights. The division between each of the blocks into which the operational part of the Airport is divided is capable of being illuminated by red stop bars, which are similarly let into the surface of the concrete. In the case of taxi-ways the red lighting proceeds in an unbroken line from one side to the other, but in the case of runways the red lighting is broken towards the centre so as not to interfere in any way with the nose wheels of aircraft landing or taking off. At the time of the accident the taxi-way lighting was fully installed and capable of being used as desired. It provided a clear indication when switched on at night and also in day time during a dark fog. In the case of bright sunshine or fog accompanied by bright light the green taxi-way lighting was not obvious, though it could be seen if specially looked for. The installation of red stop bar lighting had not been completed at the time of the accident and it was only in use at night time. The system is designed so that the green taxi-way lights and the red stop bars can be used in conjunction, the former indicating to a pilot the way he has to go and the latter both protecting his route from others and also serving the secondary purpose of keeping him on the way indicated by the green taxi lights.

c) Runway lights. These are a double row of lights let into the concrete of the runways and shining up and down the runway only. Their use was and is for the assistance of pilots taking off and landing in darkness or in conditions of poor visibility. At the time of the accident all runways were equipped with these lights except Runway 15L/33R. There were no such lights on the strip.

At the beginning of the runways at London Airport and some 70 yards to one side of their edge is a hard standing place for what is called the Runway Controller's caravan. This caravan is moved from the beginning of one runway to another in accordance with the decision of the Airport authorities from time to time as to which runway is to be used.

In addition to the above, information regarding the various runways and taxi-ways at London Airport is published from time to time for the use of aircraft operators and their pilots. The captain and the first officer had available to them in their aircraft a publication issued by International Aeradio Limited (known as "the Aerad"), which on one plan, called the Landing Chart, indicated the direction and compass heading numbers of the runways at London Airport as well as showing the strip and the taxi-ways, and on another plan, called the Traffic Blocks Plan, showed the system of block numbering.

Ground Control System

No aircraft at London Airport is allowed to move along the taxi-ways or runways unless prior approval has been obtained from the appropriate controller. A short description follows of the control exercised on aircraft on the ground by two controllers called the Ground Movement Controller and the Aerodrome Control Officer (Air). They are assisted by information obtained by them from the Runway Controllers at the runways in use at the particular time. The Ground Movement Controller and the Aerodrome Control Officer (Air) at the time in question worked side by side in the old control tower to the north of Runway 1 and just south of the Bath road; they now work in similar proximity in the new control tower. The Ground Movement Controller (subsequently called the "Ground Controller") is responsible for the control of taxying aircraft and also that of directing aircraft and all vehicles on the movement area. His colleague, who is generally known for short as the "Air Controller", has the duty of controlling the take-off and landing of aircraft. When conditions are good he has also more extensive duties in relation to landing aircraft, but on 16 January at the time in question all landings were instrument landings and the Air Controller was in consequence only concerned with approaching aircraft when they had become the next to land.

Each of these two controllers is in radiotelephonic communication with aircraft. Each uses a different radio frequency and is not able to listen in to the frequency of his colleague. In the case of aircraft proceeding to a take-off position it is, in the case of piston-engined aircraft, the duty of the Ground Controller to direct the aircraft and control it during its passage from the parking area to the run-up point for the runway in question. If the approach of the aircraft to the run-up point necessitates the crossing of a runway in use, the Ground Controller will not allow the aircraft to cross such runway until he has received permission from the Air Controller. In the case of piston-engined aircraft, the Ground Controller will normally hand over the aircraft to the Air Controller once it has reached the run-up point. It then becomes the duty of the Air Controller to take the aircraft to the take-off point and in due course give it clearance for take-off.

A difference of practice, of some importance in this Inquiry, obtains in the case of turbine-engined aircraft since these require a much shorter period for running up their engines before taking-off than do piston-engined aircraft and lengthy running of turbine engines on the ground is to be avoided because of the uneconomic consumption of fuel thereby entailed. Accordingly, in the case of turbine-engined aircraft it has been the practice for the Ground Controller to hand such aircraft over to the Air Controller whilst the aircraft in question is approaching what for a piston-engined aircraft would be the run-up position. The object of this difference in practice is to avoid unnecessary delay to turbine-engined aircraft, which will, if at all possible, in consequence not pause at the run-up position, but proceed straight to the take-off point and there do any necessary running up of their engines.

In the case of its being necessary for a taxying aircraft to cross a runway in use, not only is permission sought by the Ground Controller from the Air Controller before crossing is permitted, but once such permission has been given the Air Controller places a strip marked "Runway Obstructed" across the plan of the runway on the board in front of him so as to ensure that he should not by any oversight give clearance to an aircraft to take-off or land before the taxying aircraft has completed the crossing.

Assistance to the Ground and Air Controllers in the control tower was and is provided in certain circumstances by the Runway Controller in his caravan at the beginning of each of the runways in use at any particular time. The Runway Controller's caravan is connected by three radio-telephone loud-speakers to the circuits of the Ground Controller, the Air Controller and the Ground Controlled Approach. He is also connected by telephone to the control tower and to the switchboard of the Airport. His duties are to log the time of aircraft taking-off and landing, to see that runways in use are kept clear and that there is nothing amiss with aircraft passing him to take off or about to land. When visibility is bad the duties of the Runway Controller are increased and also become of much greater importance since, in addition to his duties in clear weather which remain, he has the additional task of calculating the runway visual range by reference either to the marks situated at the sides of the runway or to lights and flares situated at certain fixed distances along the side of the runway in question. The duty of calculating the runway visual range falls upon the Runway Controller whenever visibility falls below 1 200 yards and he has to report any change in runway visual range by telephone to the Control Tower. It is worthy of note that the practice of using Runway Controllers as described above, which is often of value as an additional safeguard, is, it is understood, only followed at United Kingdom airports.

The Accident

Visibility was too bad for Oboe King to attempt to take-off at the scheduled time and it was not until about 1120 hours that there was sufficient visibility on the runways for the captain to consider moving Oboe King from the parking place, which was in block 18 at the extreme east end of Runway No. 1 or 28R. The captain being in radio-telephonic communication with the Ground Controller, heard the periodical statements issued by him of the runway visual range at each of the two runways in use that morning, namely Runway No. 6, or 15R, and Runway No. 5, or 10R. The minimum runway visual range laid down by British European Airways as required for a Viscount to take-off at London Airport was 150 yards, this being considered the minimum necessary to enable a pilot to keep his aircraft on a straight course when moving along a runway to take-off. At 1123 the captain informed the Ground Controller he would like to start if the then runway visual range of 150 yards was maintained and at 1133 the aircraft was given permission to and did start its engines.

Shortly after this the captain informed the Ground Controller that he wished to use Runway 15R and this was approved. He had only once previously taken-off on that runway, but chose it on this occasion since he was late and it was the nearer of the two runways in use. There was also some indication that it had the better visibility. He then received his airways clearance, or initial routing instructions, for Rome and at 1138 hours received permission to taxi west along Runway 28R to the holding position for Runway 15R. The Ground Controller at the same time asked the captain to let the Controller know as a check when Oboe King passed the Control Tower and when it was clear of Runway 23R. The Control Tower would have to be passed to starboard at a distance of some 300 yards, whilst Runway 23R would have to be passed to port some 500 yards beyond the Control Tower.

The captain and the first officer, who had never previously taken off from Runway 15R, consulted the Aerad they had on board in order to ascertain their route to 15R before moving off from their parking place. They observed that they simply had to proceed straight for the full length of 28R in order to arrive at 15R. The pages which they consulted showed the various turnings off 28R in the course of its length, including Runway 23R and the strip. There was no clear indication on the plan that the strip was not in use and none that it was obstructed at any point in its length. The Aerad was kept open between the captain and the first officer in the cockpit whilst the aircraft taxied to its assumed take-off position, but it was never again consulted by either of them. Neither pilot attempted to count from the Aerad the turnings that would have to be passed before the end of Runway 28R was reached so as to be able to check the number as the aircraft passed them.

The first officer at the controls concentrated on keeping the aircraft on the centre line of the runway. The captain also had a close regard to this, but also noticed green taxi lights cross his path from starboard to port and lead off down Runway 23R. He saw no other green taxi-way lights and the first officer noticed none at all. The Board is satisfied that the green taxi-way lights leading to the end of the runway were switched on at the time and could have been seen after the junction with 23R had the captain or first officer been concerned to pick them up. The captain was able to see the Control Tower as he passed it and reported this as requested. He next reported passing Runway 23R as he had also been requested.

The distance from the edge of the concrete at the entrance to 23R to the nearest edge of the concrete at the entrance to the strip is only some 150 yards, whereas the distance from the same edge of 23R to the end of Runway 28R is about 1 100 yards. Notwithstanding this both the captain and the first officer when they came to the junction between the strip and Runway 28R thought they had come to the end of the latter. They both thought they saw ahead of them the end of the concrete, they saw something which so far as width and surface were concerned appeared to be a runway on their port side, and they observed that its magnetic heading was 150°. They both accordingly felt quite sure they had reached 15R and Oboe King was swung round to port so as to be ready to take-off. No steps were taken by either pilot to check their position although they did observe a block number board on their port side, the number on which they could not read as it was edgeways on to them. At the time in question the fog was extremely dark and the conditions were such as the captain had never before experienced. Apart from a military transport operation in wartime the first officer had never taken-off in similar conditions without the aid of lights. There were no lights, whether taxi-way or runway, showing on the strip at the time.

Shortly before reaching its position on the strip Oboe King, pursuant to the practice with turbine-engined aircraft already mentioned, was passed over from the Ground to the Air Controller. At 1143 the pilot reported to the latter as being in the holding position on Runway 15R whereas in truth the aircraft was on the strip. Runway visual range had then deteriorated to 100 yards on 15R so Oboe King had to await an improvement. Whilst taxying to this position the captain had heard conversations between Ground Control and a Trans Canada Constellation which, owing to bad visibility, was returning from Runway 10R to the parking place via Runway 05L, which in the reverse direction is 23R and crosses the strip towards its north-eastern end. At 1145, whilst waiting in position at the strip, the captain thought he saw the Constellation and reported to the Air Controller that he saw it cross the take-off end of 15R and enter 10L, i.e. cross in front of Oboe King and turn to the right in the direction of the parking place from which Oboe King had come. In fact the captain did see the Constellation, but he saw it at the intersection of Runway 23R and the strip and not at the intersection of Runway 23R with Runway 15R at the beginning of which the captain thought he was.

At 1148 runway visual range on 15R was reported as 200 yards and the captain requested clearance to take off which he was given. He was told the runway was clear and that there were no other taxying aircraft. He then commenced his take-off along the strip and when about to become airborne crashed into the barrier. Between starting to move down the strip and the moment of the crash the Air Controller asked him whether he was some distance down 15R and was told that he was "rolling" about 200 yards down 15R. This request by the Air Controller had been prompted by a telephone call to him from the Runway Controller at the beginning of 15R, who could not see Oboe King, but who from the sound of its engines had thought it was some way down Runway 15R, possibly at the intersection with Runway 23R.

The Runway Controller heard the sound of the crash and reported this to the Air Controller at once. The alarm was immediately given, but since no one at the time knew the aircraft had taken off on the strip and vision was obscured by the fog, the rescue teams were originally given inaccurate directions. In consequence they did not reach the scene of the accident until some ten minutes later.

The captain was in command of the aircraft at the time and was, in accordance with the Operations Manual of British European Airways, responsible for exercising operational control of his aircraft. He frankly recognized at the Inquiry that in taking off on the strip he had made a mistake.

No accident would have happened but for the fog. Both the captain and the first officer had no doubt whatever of their position; had they been in doubt there were various methods available to them of checking where they were which they would no doubt have used. The question, however, is whether in the circumstances then prevailing they should have allowed themselves to be so confident of their position that they did not seek any check to make certain that their confidence was well founded.

It can be said that there was no positive mark or sign visible to the pilots to indicate that they were not in the correct position to take-off, that the strip was, so far as width and surface material were concerned, indistinguishable from a runway, that its magnetic heading was correct and that before taking off Oboe King had been specifically informed in answer to an enquiry that the runway was clear.

As against these considerations, however, both pilots appreciated that in proceeding from their parking place along Runway 28R to their assumed take-off position they had been moving in conditions of very poor visibility resulting from a dark fog. In foggy conditions it is difficult to judge distances and easy to imagine things at or near the extreme range of vision which are not in fact what they appear to be. The captain should not have relied, as he did, without any other check upon what he thought he saw in the dark fog to be the end of the concrete of Runway 28R, even though this was coupled with the existence on the right compass heading of the concrete surface of the strip. The conditions for take-off which confronted him when he turned into the strip were such as he had never previously experienced at London Airport in that there was a dark fog and there were no runway lights to assist the take-off. Had he not been over-confident the Commissioner finds it difficult to believe that he could have mistaken the 150 yards distance from the entrance of Runway 23R, which he correctly identified and reported to the Control Tower, with the distance of about 850 yards which he should have traversed after leaving the junction with 23R before reaching his correct position at the beginning of Runway 15R. He did not make a full use of the Aerad Landing Chart. He could, had he been concerned to verify his position, have picked up the green taxi-way lights, at intervals of 80 yards, leading on from the junction with Runway 23R to the correct position for take-off. He could, when he saw no taxi-way lights ahead and no runway lights on the strip, have communicated with the Air Controller and asked for these to be switched on. It is also true that he could, had he been in any doubt, have checked his position accurately by approaching nearer to the side of the strip so as to have been able to read the numbers upon the block number board which he did notice edgeways on at the side of the strip. The Commissioner does not feel, however, that in this respect alone the captain could be criticised if he had in any other way verified his position. These block number boards are small, peculiar to London Airport, and their use does not readily appeal to pilots, who cannot be expected to remember the numbers if read and must check them by reference either to the Control Tower or a detailed plan in their Aerad.

The Commissioner concluded, therefore, that so far as the captain is concerned he made a mistake due to over-confidence. He should have checked his position, and his omission to do so was a cause of the accident.

The first officer was not, of course, in command of Oboe King. He was, however, controlling the aircraft and had the same opportunity for observation as had his captain. The Commissioner considered whether the presence of the captain in command of the aircraft can completely exonerate the first officer, but does not think that such a conclusion would be right. If the argument were accepted that in circumstances similar to this case the first officer could rely exclusively upon his captain taking full responsibility there might be a serious risk of a reduction in the high standard of care at present exercised by, and indeed expected of, first officers. Since the first officer was in physical control of the aircraft he should have satisfied himself that he was in the right position before he took off; the position might be different had he expressed doubts as to his position to his captain and been over-ruled by him. The first officer was as equally over-confident as the captain and like him should have checked his position before taking off. His over-confidence was also a cause of the accident, though his responsibility was less than that of the captain.

In dealing with the above matters the Commissioner did not rely upon or mention the lack, on or near to the entrance to the strip, of any of the various marks on the ground or of the notice boards and sign posts, other than the block number board. He excluded the lack of these various indications, which might have caused doubt to those in the aircraft of their position, because of the lack of uniformity at London Airport at the time of the accident. It was difficult enough when members of the Airport staff were giving evidence for them to remember what particular notice boards or marks were to be found at or about the entrance to any particular runway and no pilot, using London Airport amongst many others, could hope to memorize the various differences. Moreover the lack of uniformity, to which pilots using London Airport have become accustomed during the many changes consequent upon its rapid development, has not unnaturally led them not to place too much reliance upon the absence or presence of any particular marks or notice boards. Nor can those in the aircraft be blamed for not having noticed the absence of the Runway Controller's caravan. In any case this would have been some 70 yards from the side of the runway and, in the conditions of fog prevailing, might not have been visible. Moreover the exact position of the caravan at the beginning of particular runways is subject to some variation.

So far as the action of the Ground and Air Controllers was concerned, they had available between them information which, if present to one mind, might well have led to action preventing the accident. Thus the Ground Controller, having passed over Oboe King to the Air Controller at about 1142, did not hear the subsequent conversation between the Air Controller and Oboe King regarding the Trans Canada Constellation. On the other hand, the Ground Controller knew, at about the time of such conversations with the Air Controller, of the exact position of the Constellation, which had been verified by a conversation between the Constellation and the Ground Controller himself by reference to a block number board. If the Ground Controller had known that Oboe King, from what was assumed to have been the holding position at the beginning of Runway 15R, had seen the Constellation cross the take-off end of that runway and enter Runway 10L, he would probably have realized that something was wrong. However, the separate knowledge, which each of the two Controllers had, was not by itself sufficient to indicate to either that Oboe King was out of position. The work to be carried out in the Control Tower necessitates a division between the Ground and Air Controllers and it would be impossible to combine their duties. On the other hand, some alteration may well be desirable, in conditions of bad visibility, in the practice mentioned above of the Ground Controller handing over to the Air Controller turbine-engined aircraft at an earlier time than piston-engined aircraft are handed over. This point is dealt with in the recommendations later in this Report. It should be added that the Ministry of Transport and Civil Aviation are in the course of installing at London Airport a radar device, called ASMI, which when in working order will allow the Controllers in the Tower to see on the radar screen any aircraft or vehicle moving upon any of the runways even in conditions of dense fog.

The duties of the Runway Controller have been set out above and it has been pointed out that in conditions of bad visibility these duties are both increased and become of much greater importance. At the time of the accident there was a Runway Controller in his caravan some 70 yards to the east of the edge of Runway 15R and very near its beginning. The Controller in question had three radio-telephonic loud speakers operating at the same time in his caravan, though one of these was toned down, and also had to be constantly estimating the runway visual range and reporting this by telephone to the Control Tower. Had the Controller been able to give unfettered attention to what was being said on the two loud speakers connected to the Ground Controller and the Air Controller, he might have realized that whereas Oboe King had reported that it was at the holding position on Runway 15R, the aircraft was not visible from his caravan nor could its engines be heard. The Controller in question frankly admitted that had he heard Oboe King's report of its position he would immediately have informed the Tower that the aircraft was not where it had reported itself to be and the accident would have been prevented. It is noteworthy that once Oboe King had started its take-off the Controller was the first person to realize that something was amiss. He heard Oboe King receive clearance to take off and expected to see the aircraft turn on to Runway 15R. In fact he did not see the aircraft and heard what sounded like a Viscount's engines coming from a southeasterly direction. He immediately telephoned to the Control Tower as a result of which the Air Controller spoke to Oboe King while it was actually running down the strip, a matter of seconds before the crash but this intervention was then too late.

At the hearing it was argued that in more than one respect the action or inaction of the Ministry of Transport and Civil Aviation, the owners of London Airport, was responsible for and a cause of the accident. In the first place it was suggested that the entrance to the strip should have borne a white painted cross upon the concrete in accordance with Paragraph 51 of the "Rules of the Air and Air Traffic Control" in Schedule II to the Air Navigation Order, 1954. The relevant part of this rule provides that "at an aerodrome which has one or more runways clearly visible white crosses shall be displayed at each extremity of a runway which becomes unfit for use." It was argued that the strip was a runway which had become unfit for use and that accordingly white crosses should have been used at its extremities. It was further pointed out that when the runway was originally closed a white cross had been painted on the concrete at more or less the position occupied by Oboe King when waiting for take-off clearance. The Commissioner does not consider this argument sound since the strip, although it had once been a runway, was not in fact at the material time a "runway" within the meaning of the rule. The word "runway" must, on its true construction, mean something which is normally used for the take-off and landing of aircraft and this was in no sense the use made of the strip at the material time. There is a somewhat similar provision in Annex 14 to the Convention on International Civil Aviation, which, in Part V, Chapter 3 at Paragraphs 3.4.1 and 3.4.4, provides for the use of a white cross to indicate that any part of the movement area of an aerodrome is unfit for the movement of aircraft. The strip was, however, not unfit for the movement of aircraft for the purpose of taxying and was in fact considerably used in this way. It cannot therefore be said that there was any departure from this Standard.

A more serious charge against the Ministry was that there should have been QDM marks, or runway designation markings on each runway at the airport. This is provided for in Part VI, Chapter 2, Paragraph 2.2.2 of the same Annex 14, and is also a Standard. A Standard is a practice which by definition "is recognized as necessary for the safety or regularity of international air navigation and to which the Contracting States will conform in accordance with the Convention; in the event of impossibility of compliance notification to the Council is compulsory under Article 38 of the Convention". The United Kingdom is one of the Contracting States and the Ministry should accordingly have complied with this particular Standard. No notification of the impossibility of compliance had been given, nor was it argued that compliance was in fact impossible. It was admitted before the Commissioner on behalf of the Ministry that there had in fact been a failure to comply with this particular Standard and it was argued on behalf of the captain and the first officer that, had the Standard been complied with, the absence of QDM marks on the strip would have indicated to them that they were not on a runway. QDM marks are intended to assist the pilot in an aircraft about to land and are not used for the purposes of take-off. Whilst it is just possible that, had QDM marks been in position on all the runways in use at London Airport, the absence of such marks on the strip might have caused the captain and the first officer to have had some doubt as to their position, the Commissioner finds it impossible to satisfy himself that such a result would have been probable. Accordingly, he cannot find that the absence of QDM marks was a cause of the accident.

There is a further Recommendation in Annex 14 to the Convention on International Civil Aviation contained in Part VI, Chapter 2, Paragraph 2.6.1 which recommends that a longitudinal marking consisting of a continuous white line six inches wide should be painted along the centre line of all paved taxi-ways. It is suggested that, if this Recommendation had been carried out, such a white line down the centre of the strip would have been a clear indication to those in Oboe King that it was not on a runway and the accident would have been prevented. It is possible that the existence of such a white line would have prevented the accident. The Ministry had given considerable thought to whether or not this Recommendation should be adopted both at London Airport and elsewhere in the United Kingdom and had decided against it for reasons which are discussed later in the section of this report dealing with recommendations. Whatever may be the right conclusion whether or not this Recommendation should on general grounds have been complied with the Commissioner does not think it possible to find that the Ministry and those who are responsible for London Airport can in any way be said to have been lacking in care or foresight in not anticipating that, in the absence of such a continuous white line, an aircraft would, in conditions of bad visibility, have attempted to take off from the strip in mistake for a runway.

Some evidence was given at the Inquiry that on three separate occasions in bad visibility the pilots of aircraft taxying either along Runway 28R or Runway 23R had, on coming to the junction with the strip, momentarily doubted their position and thought that the strip might in fact be a runway. Nothing happened in any of these three cases since the pilot in question was able to make sure of his position, almost as soon as the doubt occurred to him, in one way or another. None of these three incidents, if incidents they can be called, was ever reported to the authorities responsible for the Airport.

The Ministry and Airport authorities are fully conscious of the undesirability of a lack of uniformity in the markings and sign posts and other indications of position in use at the Airport. Some of the lack of uniformity has been due to the development of the Airport since the war which is still not yet completed. But notwithstanding the undesirability of lack of uniformity the Commissioner cannot find that either the Ministry or the authorities at the Airport through what they did or omitted to do as regards the marking or sign posting of runways, taxi-ways and the strip can be held responsible for the most unusual combination of circumstances which led to the present accident, or can be said to have caused such accident within the meaning of the word "cause" in Paragraph 9(17) of the Civil Aviation (Investigation of Accidents) Regulations, 1951.

Probable Cause

The captain and first officer did not check in the conditions of bad visibility obtaining to see that they were in fact lined up on Runway 15R for which they had been cleared for take-off. As a result the aircraft collided with the barrier and other obstacles on the strip consequent upon the aircraft commencing to take off on the strip instead of Runway 15R.

Recommendations

It seems highly improbable that an accident of this type will ever occur again upon the strip since a most unusual set of circumstances is necessary before it can occur. Further, the introduction in due course of ASMI should as long as that apparatus is in working order and properly used render such an accident impossible.

All reasonable steps must be taken to prevent any possibility of such an accident recurring and it will not be satisfactory to rely exclusively on ASMI which may well, even after its introduction in full working order, from time to time become unserviceable.

It is clearly desirable, as was indeed recognized by the Ministry, that appropriate notice boards should be erected at either end of the strip so as to give warning in conditions of bad visibility that the strip is not to be used as a runway. The Commissioner recommends that at the entrance to the strip in blocks 2, 11, 21 and 85 notice boards on each side of the strip at least as large as those used for run-up boards should be set up bearing the words "Taxi-way only". Also that at the entrance to the strip in blocks 2, 11, 21 and 85 the words "Taxi-way only" should be painted in large white letters across the concrete of the strip.

If the information possessed by each of the Controllers in the Control Tower had been available to only one of them, it is possible or even probable that the accident would have been avoided. Such information would have been available to the Ground Controller had he not handed over Oboe King to the Air Controller before it reached the run-up position for Runway 15R in accordance with the practice followed in the case of turbine-engined aircraft. In conditions of bad visibility it seems unwise that the Ground Controller should relinquish control of any aircraft until it is reported as having reached either the run-up or take-off positions. Accordingly, it is recommended that in conditions of bad visibility, by which is meant conditions in which runway visual range is being ascertained and reported, the Ground Controller should not hand over control of turbine-engined aircraft until they have reached either the run-up position or the take-off position for the particular runway to be used.

The Runway Controllers at London Airport clearly have a very useful function to perform in conditions of bad visibility. In such circumstances, however, they have more to do than they can hope always to carry out to their complete satisfaction and in consequence their value is thereby so much reduced. It would be a wise precaution if clearance for take-off was never given in conditions of bad visibility by the Control Tower to any aircraft until the Control Tower had received from the appropriate Runway Controller a telephonic report that the aircraft was in the proper take-off position for the runway in question. It is, accordingly, recommended that this practice be adopted for the future in conditions of bad visibility.

The recommendations in the two foregoing paragraphs are of general application and are not limited to conditions at London Airport.

During the evidence of the captain he was asked whether he was satisfied with the minimum visibility for take-off of 150 yards laid down by British European Airways for London Airport. His answer was that he thought it rather low and that he would prefer the figure of 600 yards, which is the minimum visibility for landing, since 150 yards would in the majority of cases be quite inadequate for a pilot to take avoiding action should there be any obstruction on the runway. He made it clear, however, that he had no fault to find with the minimum of 150 yards, provided that it was possible to be absolutely sure that there was no obstruction in the way, as would be the case for example when ASMI or some similar radar device was in operation.

The minimum visibility for take-off at London Airport laid down by British European Airways for Viscount Aircraft is:-

a) based on the assumption that the runway is free from obstruction;

b) designed to ensure that the pilot can keep his aircraft on a straight course; and

c) always subject to the decision of the captain of the aircraft himself.

In other words, notwithstanding the existence of the minimum visibility, the captain is free to decide whether in all the circumstances he should or should not take off. The course of Oboe King along the strip up to the moment of impact was perfectly straight, as was demonstrated by the wheel marks on the concrete, and accordingly confirmed the suitability of the minimum so far as keeping a straight course is concerned. The Commissioner does not consider that the most unusual facts of this accident are sufficient to justify a recommendation that the minimum should be increased. The concurring factors leading to this accident are most unlikely to be repeated and should be rendered well nigh impossible if the above recommendations are put into effect.

The final question is whether it should be recommended that the Ministry of Transport and Civil Aviation take steps both at London Airport and elsewhere, but particularly at London Airport, to carry into effect the Recommendation as to a continuous thin white line down the centre of taxi-ways contained in Annex 14 to the Convention on International Civil Aviation, Part VI, Chapter 2, Paragraph 2.6.1. One of the problems that has exercised the authorities responsible for London Airport in connection with the strip is to find some mark or indication which would, whilst indicating that the strip was not a runway, also indicate that it was appropriate for use as a taxi-way. The continuous white line device would seem at first glance to satisfy the necessary requirements and has the additional use, which is its main purpose, of assisting taxying aircraft to keep to the centre of the taxi-way in low visibility.

Apart from the weight naturally to be given to a Recommendation of the International Civil Aviation Organization, evidence was given that the continuous white line device was in use at various Continental and Irish airports. It has, however, not been adopted at any United Kingdom airport under the control of the Ministry. The chief witness called on behalf of the Ministry did not consider that as a matter of general application this Recommendation was a useful one, since he thought that taxi-way lights and daylight route indicators were a more valuable indication as to the use of taxi-ways. Furthermore, a continuous white line would involve considerable expense both in its installation and maintenance. In regard to London Airport, in addition to the above disadvantages, the continuous white line would, he thought, give rise to confusion at intersections rather than facilitate the task of pilots finding their way about. Further, he pointed out that at London Airport it is often necessary to use one or more runways as a taxi-way, but it would be clearly impossible to paint the continuous white line down runways. This would at once result in a lack of uniformity in the meaning of a continuous white line down the centre of a concrete paved way.

The Ministry favoured the extensive use of taxi-way lights, stop bars showing red lights and daylight route indicators as the best solution of the problem and there is no doubt that the system of lighting at London Airport, which works in conjunction with the block number system, is one of much ingenuity and has been designed and installed with great care and no inconsiderable expense. The system has the whole-hearted support of the experienced pilots using London Airport who were called to give evidence but they all stressed that it was essential that an intelligent use should be made of the lighting system by those in control. They urged that an aircraft should not be expected, for example, to have to cross any line of green taxi-way lights as was Oboe King on the day of the accident in relation to the lights leading from the direction of the old Control Tower across its path on Runway 28R and down Runway 23R. There is little doubt that, when the completion of the installation of the daylight route indicators and all the taxi-way lights and stop bars has taken place, the control staff of London Airport will make the fullest and most intelligent use of this elaborate and expensive directional apparatus which will be at their disposal. Moreover, experience will, no doubt, indicate its best use. So far as is known, London Airport is the only airport at present installing the ASMI radar apparatus. This fact indicates both the care for the safety of those using London Airport exercised by the responsible authorities and the likely reduction to the barest minimum in the future of any serious consequences of the pilot losing his way should this by some mischance prove possible.

If all runways at London Airport were provided with runway centre line markings of th broken line type, as recommended and describe in Annex 14 to the Convention on International Civil Aviation, Part VI, Chapter 2, Paragraphs 2.2.7 and 2.2.8, then the absence of any longitu dinal markings on the taxi-ways would provide a definite indication to a pilot that, when he was on a concrete strip devoid of longitudinal markings, he was not on a runway.

The Commissioner does not feel able on the basis of the limited evidence available to him of the use of taxi-ways and runways at London Airport, to make a general recommendation that the Ministry should forthwith institute the continuous white line on taxi-ways at all airports under their control in the United Kingdom. There appears to be weight in some of the objections of the Ministry, which the Commissioner has summarized, to such a recommendation. Nor was it at present favoured by British European Airways.

The Commissioner recommends that the Ministry give further study to this problem with a view to choosing a system of marking which will provide a continuous indication to aircraft on the ground whether they are on a taxi-way or on a runway. Among systems at present approved internationally the choice seems to lie between painting longitudinal centre line markings along all taxi-ways in accordance with the Recommendation in Annex 14 to the above Convention, Part VI, Chapter 2, Paragraph 2.6.1, or painting centre line markings of the broken line type described in Paragraph 2.2.8 in accordance with the Recommendation in Paragraph 2.2.7 on all runways, leaving all taxi-ways unmarked by any longitudinal paint markings. In the course of their further study no doubt the Ministry will in particular collect evidence as to the success or otherwise of the use of the longitudinal white line on taxi-ways at large and busy airports in other countries. Such experience will probably in time resolve in one way or another the doubts expressed as to the desirability of adopting the longitudinal white line on taxi-ways in this country in general and at London Airport in particular.

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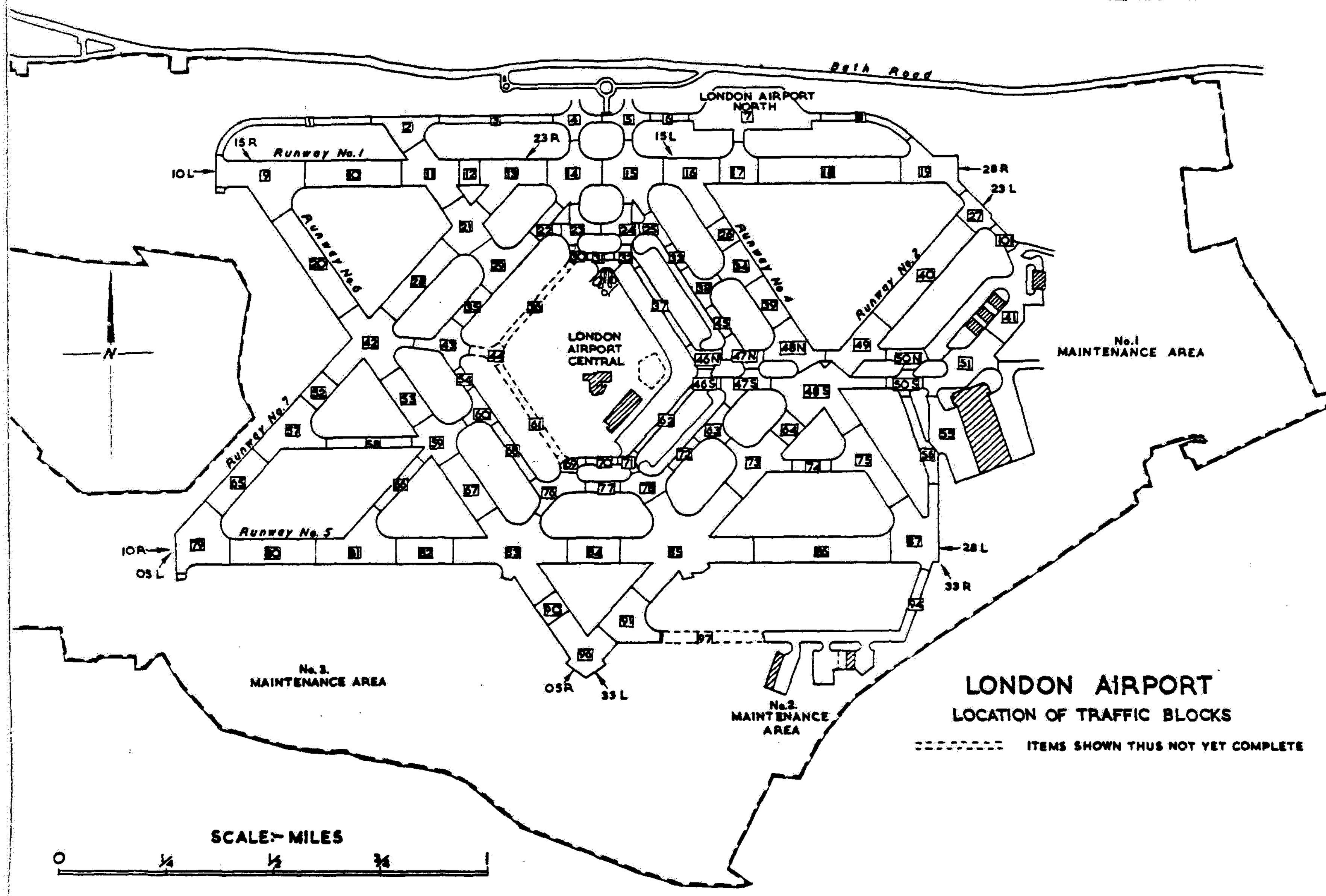
ICAO Ref: AR/405

Figure 5

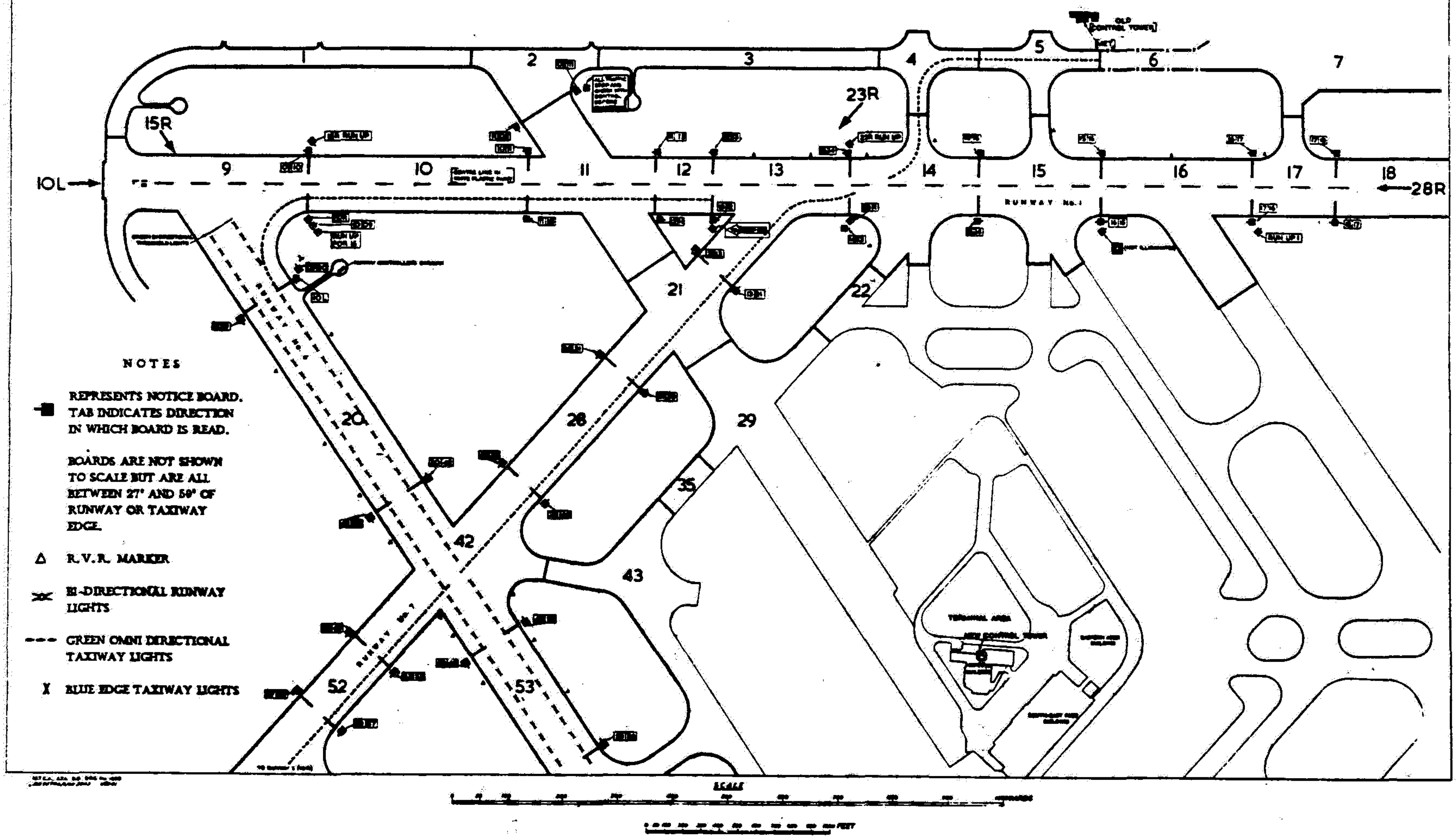


LONDON AIRPORT
LOCATION OF TRAFFIC BLOCKS

M.T.C.A. C.N.4. D.O. Drg. No. 1580

Figure 6

LONDON AIRPORT
ACCIDENT TO B.E.A.C. VISCOUNT G-AMOK ON 16·1·55
PLAN OF N.W. AREA OF AIRPORT



No. 7

United Air Lines, Inc., Convair 340, made a wheels-up emergency landing southeast of Dexter, Iowa, on 19 January 1955. Civil Aeronautics Board (USA) Accident Investigation Report No. SA-302, File No. 1-0026, released 7 September 1955.

Circumstances

The flight departed Newark, New Jersey, at 0703 Central Standard Time en route to Lincoln, Nebraska, with numerous intermediate stops scheduled. Following departure from Des Moines at 1608 on a VFR (Visual Flight Rules) flight plan the aircraft climbed to 5 000 feet whereupon the crew noticed vibration and a slight fore-and-aft movement of the control column. The climb was continued to 6 000 feet where the aircraft was levelled off and power was reduced. The captain attempted to dampen the vibration by engaging the autopilot, however, this proved to be unsuccessful. The first officer lowered the flaps to 15 degrees without any noticeable effect. At this time a sudden failure in the control system was felt and it was extremely difficult to maintain any semblance of elevator control. The buffeting continued to be severe and the crew prepared for an emergency landing. Another failure in the control system was felt and the aircraft went into a steep climb. As it appeared that a stall was imminent the captain moved the propellers to a high r.p.m. and pushed the throttles forward until about 50 inches of manifold pressure was seen on the gauges. The aircraft nosed over and went into a steep dive. During the rapid descent the captain reduced power and headed for open country. At 500 feet he succeeded in flaring the aircraft and made a wheels-up landing on the snow-covered ground. The crew of three were uninjured, however, a few of the 36 passengers received minor injuries.

Investigation and Evidence

Because of the nature of the accident, attention was immediately directed to the empennage and control system of the aircraft. The empennage section was intact and virtually undamaged by ground contact. During the examination of the elevator torque tube assembly it was observed that there was a vertical fracture of the right side. This completely disconnected the right elevator from the main torque tube assembly, and the pilot could no longer operate this elevator by means of the elevator control system. The left elevator was still attached to the torque tube assembly, however, and partial elevator control could still be effected.

The left elevator servo tab was found hanging in the full down (nose-up) position, with the rear terminal of the aft push-pull tube attached to the tab horn. Internal inspection of the servo tab assembly revealed that this push-pull tube had broken transversely about 12 inches forward of its rear terminal. The rear portion of the broken tube showed evidence of abrasion over most of its exterior surface, caused by its rapid and violent movement within the elevator. The interior surface of the elevator skin in the area of the tab push-pull rod was seared and abraided, and the skin was punctured in several places. The inspection doors were opened, and it was found that the servo tab idler was completely detached from its support in the elevator. The 1/4 x 3-1/2 inch close tolerance support bolt was fractured about one inch from the head end and this end of the bolt was found in the lower rear flange of the stabilizer 20 inches outboard of the idler. The remaining portion of the idler rear spar support bolt was found in place in the idler with its fractured end flush with the inboard face of the idler; its broken end was battered. A 1/4 inch castellated nut and two washers of the size and type used with the support bolt were recovered from a fold in the seal balance curtain. No cotter pin was found. The hinge cutouts on the tab were torn rearward, indicating there had been a violent oscillation of the tab resulting in considerable overtravel.

To understand better the chain of events that occurred with respect to work performed on this aircraft, it was advisable to examine the line of command with respect to personnel at the Newark base, and their working hours. The base is headed by a station manager, who has under him a chief mechanic, supervisors of mechanical services (crew chiefs), inspectors, lead mechanics, and mechanics. There are three 8-hour shifts daily beginning at

12 midnight, with personnel reporting for duty 30 minutes before each shift. Top supervisory personnel above the crew chief level are a part of each shift or are available by telephone if needed.

The card system used in the allocation of work comprises a work control record, a routine job card, and a non routine job card. The work control record is a master card that lists all the work to be performed. Routine job cards are distributed among the mechanics according to the number of areas necessary to be covered for each individual inspection. Nonroutine job cards are made out and initialed by mechanics when they encounter work necessary to be done other than that specified on the routine job card.

The aircraft was in the shop ready for a 1500-hour check at the start of the 8:00 a.m. - 4:00 p.m. shift the morning of 18 January. During the inspection of the empennage, which involved a detailed inspection of the horizontal stabilizer, elevator, and related control system components, it was found that there was excessive play in the elevator servo tab. A nonroutine job card was made out by the mechanic but no corrective action was taken because of the proximity of a shift change. The crew chief going off duty briefed the crew chief on the afternoon shift on the required work. The card indicating that repair of the servo tab was necessary was then given to another mechanic.

The idler linkage was disassembled to determine the cause of the play and it was found that the idler support bolt was considerably worn. The mechanic left the bolt with his crew chief for examination and returned to his work. This particular bolt was not in stock and an emergency order was issued requesting that it be sent immediately from the company's base at San Francisco. This emergency order was written up on the nonroutine job card. The mechanic later testified that the worn bolt was returned to him by the lead mechanic with the instruction to put it back in the idler assembly loosely (finger-tight). The worn bolt was then replaced but not safetied. No explanation was written on the nonroutine job card covering this temporary installation. This was contrary to the company's maintenance instructions.

When the midnight shift came on duty there was a heavy workload and the new crew chief (who was the only one assigned on that shift - normally there are two) was not briefed with respect to the worn bolt.

The work on the aircraft continued in a normal manner and when completed the supervisor noticed that the subject nonroutine job card had not been signed off as completed. At this time, however, the mechanic assigned to the job reported to the supervisor that he could not find any excessive play in the servo tab assembly. Accordingly, an inspector was requested to check and determine if this was so. He returned in a short time and said that he also could find none. The supervisor then went to the job with the inspector and from the ground watched while the tab was checked for free play. Observing no excessive play the supervisor initialed the nonroutine card, adding the notation "OK for service."

Correlation of known physical facts with crew testimony indicates the following sequence of failure. The unkeyed castellated nut which fastens the idler assembly support bolt in its brackets backed off because of vibration. This permitted the bolt to come out of the outboard bracket. With the idler supported only by the bolt through the inboard bracket, forces were exerted which broke the bolt one inch from its head. This allowed the idler to drop down and the servo tab began to oscillate, causing a forward and rearward movement of the cockpit control column. Loads were then induced in the rear push-pull tube causing it to fail. With the then unrestrained tab oscillating, the left elevator was also affected so that it, too, oscillated about its hinge line. The resultant loads caused by the left and right elevators being out of phase broke the right side torque tube connector plate, eliminating the right support for the torque tube assembly and preventing cockpit control of the right elevator. Without the right support, forces deformed the torque tube assembly forward about the left support, resulting in almost negligible control of the left elevator from the cockpit.

During the investigation of this accident, a thorough study was made of the company's line maintenance procedures, encompassing its record control system. It was determined that the carrier's maintenance programme and detailed procedures set up to it were adequate. However, the procedures broke down due to the frailties of the human element. The system provided safeguards, one of which required that an explanation of all work performed be written on the respective nonroutine job card; another that the outgoing crew chief at the time of the work shift brief, in as much detail as necessary, the relieving crew chief concerning the work accomplished during the foregoing work period. In this case, these procedures were not followed.

When the final inspection for play in the servo tab was made, no excessive play was found. It was testified to, that if the worn support bolt was replaced and by chance turned from its position when removed, a manual test for play might result in none being found. However, since the nonroutine job card was written up for work to be done and was not signed by the mechanic to indicate that the work had been accomplished, it is believed that the inspector making the final inspection should have gone beyond the normal instructions and actually examined the servo tab system. If this had been done the mistake probably would have been discovered before the mechanic was told to close all inspection covers and doors. The critical omission was the failure to write an explanation on the job card that the bolt had been removed and replaced only finger-tight pending the arrival of a new bolt.

As a result of this accident the company has increased the number of both supervisory personnel and mechanics.

Probable Cause

The probable cause of this accident was a series of omissions made by maintenance personnel during a scheduled inspection which resulted in the release of the aircraft in an unairworthy condition and an almost complete loss of elevator control during flight.

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ICAO Ref: AR/391

No. 8

Indian Airlines Corporation, Douglas DC-3, VT-COZ aircraft, crashed near Gauhati Airport, India, on 21 January 1955. Report dated 23 March 1955 released by Ministry of Communications, Government of India.

Circumstances

The aircraft took off from Calcutta (Dum Dum) on a scheduled freighter service flight at 0546 hours Indian Standard Time and set course for Gauhati, carrying a crew of three. At 0722 hours, the aircraft contacted Air Traffic Control, Gauhati, on radio telephony and reported flying under visual flight rules, 25 miles away from Gauhati Airport at an altitude of 6 000 feet. The Air Traffic Control Officer on duty passed the altimeter setting to the aircraft, cleared it to descend under VFR and instructed it to call when ten miles from the airport. The aircraft asked for a bearing on frequency 119.7 (Homer) at 0725 hours and a bearing of 045° class "A" was given. This was confirmed as correct by the aircraft, which also reported being 15 miles from the airport at a height of 3 000 feet at that time. The next contact with Gauhati Tower was at 0727 hours when it reported being at a distance of 10 miles from the airport. Landing instructions were passed to the aircraft and it was asked to call again on joining circuit. There was no further communication with the aircraft. At approximately 0729 the duty officer at the tower noticed black smoke at the top of a patch of fog to the south of the airport. Repeated calls were made to the aircraft on 118.1 Mc/s and 6 440 Kc/s but no response was received. At about the same time persons in Tarapati village saw the aircraft hit some arecanut trees, crash in a field and burst into flames. The captain and co-pilot died instantly and the radio officer died en route to the hospital. The aircraft was destroyed.

Investigation and Evidence

The crash area was covered by fog at the time of the accident. The exact height of the fog could not be accurately established but was estimated to be about 250 to 300 feet above ground level.

The 0700 weather observation was as follows:

Total amount of cloud	4	Octa
Visibility	0.9 nautical miles	
Present weather	Fog, become thinner	
Past weather	Fog	
Significant cloud	First layer	Second layer
Amount of cloud	1 Octa.	3 Octa.
Type of cloud	St.	Ac.
Height of base	500'	10,000'
QFE	29.89"	
Altimeter setting QNH	30.06"	

A special weather observation was made at 0715 hours at the request of the aerodrome control. Visibility had improved to 1.5 nautical miles.

The aircraft crashed at a distance of 2.9 miles on a bearing of 210° from the 03 end of runway 03/21 at Gauhati airport at an elevation of 162 feet a.m.s.l.

The engine control pedestal was extensively damaged and no reliance could be placed on the position of the levers, which were as follows:-

	Left hand	Right hand
Mixture controls	Auto-lean	Emergency
Throttles	Retarded	Retarded
Propeller Pitch controls	Fully coarse	Fully coarse

The position of the fuel selector and the cross-feed could not be determined, but the positions of the trimmer controls were as follows:-

Elevator trim	1° nose down
Rudder trim	Zero
Aileron	1° right up

The actual settings of the tabs on the elevator and rudder were 1/2" up and full to the left respectively. The aileron trim tab was neutral. The control cables were checked. They showed evidence of tensile failure only as a result of disintegration of the aircraft.

Pilot's altimeter was set at 29.86". The sub-scale of the second altimeter was missing.

The undercarriage of the aircraft was down and locked.

There was no evidence of any mechanical failure of the engines. Both the engines were clear of any sign of fire, external or internal. There was evidence of adequate lubrication. Fuel was recovered from the nacelle filters and injectors. Both the propellers were in the constant speed range and in the same fine pitch.

The air traffic control and communication briefing for the flight was of a routine nature. However, some special significance attaches to the meteorological briefing. The meteorological forecast covering the route along with the terminal forecast for the period 0630 hours to 1030 hours for Gauhati Airport was handed over to the captain, the Commander of the aircraft. The terminal forecast indicated surface visibility of 660 yards in fog, intermittently 110 yards in thick fog, up to 0830 hours and thereafter improving to five nautical miles. It may be pointed out that the weather minima laid down for Gauhati Airport by the Indian Airlines Corporation and approved by the Director General of Civil Aviation require a visibility of 1.5 nautical miles for landing by day. The alternate aerodrome specified in the clearance form was Agartala. Nevertheless, the forecast did not contain the terminal forecast for the alternate. The captain did not ask for this information, nor did the meteorologist volunteer this information during the briefing.

Notice to Airmen No. 29 of 1952 which lays down Meteorological Minima for Aerodromes, requires that "a flight shall not be continued towards the aerodrome of intended landing unless the latest available meteorological information indicates that conditions at that aerodrome, or at least one alternate aerodrome, will, at the expected time of arrival, be at or above the minimum criteria specified for such aerodromes ..." In this case, although the terminal forecast for Gauhati indicated that the conditions of visibility would be lower than the minima for landing by day, and no terminal forecast was available to the pilot for any alternate for the expected time of arrival, the flight took off and continued to Gauhati, contrary to the provisions laid down in the above Notice to Airmen.

It is relevant to add that the weather observation made at 0500 hours at Gauhati indicated a visibility of 550 yards in thickening fog. As a result of this, an M.5 (Danger Met.) for visibility was issued by Gauhati. This message did not reach Air Traffic Control, Calcutta, until 0700 hours and, therefore, was not passed on to the aircraft.

It would seem, therefore, that the aircraft should not have taken off for Gauhati in view of the terminal weather forecast for that airport and that the flight should not have been continued.

The aircraft had its first impact with arecanut trees, 43 feet above the ground. The nature of the cuts on these trees indicated that the aircraft was in a laterally level attitude. The aircraft had its second impact, 100 feet ahead, with a bunch of trees, 40 feet above the ground. This goes to show that within the distance of 100 feet (the distance between the points of the two impacts) the aircraft lost three feet in height. The port wing tip was torn off at the first impact. The second impact caused pieces of landing light glass, cockpit glass, engine nacelle parts, a section of the port elevator with fabric and part of the port aileron to be thrown off from the aircraft. Yet the aircraft continued in the air until it hit the ground at a distance of 830 feet from the point of initial impact. At the time of the crash with the ground, the aircraft was substantially level laterally, though in a nose-down attitude. Heavy disruption of the aircraft took place at this point.

None of the components picked up between the points of the first and second impacts suffered any damage from fire or smoke. Similarly, all the components picked up in the vicinity of the point where the aircraft hit the ground were completely free from any evidence of fire or smoke. In fact, it was not until another 230 feet away from this point that the first burnt component (part of port aileron) was found. This component was laying within 12 yards of the burnt and burst port main fuel tank. Several components, such as the main cargo door, sections of the port elevator and floor board, which had been separated from the aircraft on its disruption, were also clear of any fire or smoke.

Larger pieces of wreckage (the starboard wing centre section and rear fuselage) had suffered damage by fire, but it had affected the top surfaces only. The fabric of the rudder and the elevators, which were still attached to the respective stabilizers, was burnt, but not the sections of the port elevator which had been torn off earlier. There was no evidence of fire on the lower surfaces of the starboard wing or the horizontal stabilizers. There was no smoke trail on either side of the fuselage. There was no soot or fire trail running from the sides of the fuselage to the attachment of the stabilizers. The maximum intensity of the fire had been in the area of the cabin opposite the freight doors. The doors together with the frames had, however, been thrown off earlier and were perfectly clean. Pieces of floor board from this area had also been thrown out. A piece of floor board in the immediate area of the burnt fuselage was charred, and yet the two adjoining pieces of floor boards which were thrown clear of fire were untouched by fire or smoke. The aircraft step-ladder, which is normally placed in this region, but was thrown out on impact, was also clear.

From the foregoing data, it is evident that there was no fire in the aircraft either at the point of its first impact with the arecanut trees or even when the aircraft hit the ground at a distance of 830 feet from this point. The fire obviously started approximately 230 feet from the point where the aircraft hit the ground (approximately 1 060 feet from the point of first impact), as a result of the bursting of the port main fuel tank.

The theory that a fire took place in the aircraft during flight was advanced by some witnesses. This theory was given careful consideration but found to be untenable. The examination of the wreckage definitely revealed that fire broke out in the aircraft after it crashed against the ground. The theory of fire during flight was chiefly built up on a rumour that the aircraft had, just before it crashed, sent an S.O.S. signal. It was established that no S.O.S. signal was sent by the aircraft. The mistake arose because a signal sent by Air Traffic Control, Gauhati, to Air Traffic Control, Calcutta, was misunderstood by the Operations staff of Indian Airlines Corporation to whom it was read out on the telephone. The signal read as follows:-

> "QBM VTGT = LAST QSO VT-COZ 0157 Z (.) SMOKE SEEN THEREAFTER (.) OFFICERS GONE OUT TO ASSESS NEWS (.)"

The word "assess" was misheard for S.O.S.

The CO_2 fire extinguisher bottle as well as two fire extinguishers were recovered from the scene of the wreckage. The head of the CO_2 bottle had broken off and it was empty. The head of one of the extinguishers was also broken and it was partially empty. The second bottle had its handle loose and was empty.

Examination of the wreckage revealed that at the time of the crash the undercarriage of the aircraft was down and locked and both engines were operating. The aircraft was in a laterally level attitude and lined up with the runway. These factors go to show that the aircraft was attempting a controlled descent on the runway at Gauhati Airport and did not come down on account of any distress or emergency. The last communication between the aircraft and the Air Traffic Control, Gauhati, had been exchanged just two minutes prior to the accident. At the time of the crash, considerable fog hung over the area southwest of the airport - the direction from which the aircraft was approaching. The airport itself and an area of about two miles to the southwest were, however, clear. The fog was beginning to form into stratus cloud and the tops were estimated to be approximately 300 feet above ground level. As the sky above the cloud was clear, the pilot must have seen the airport from some distance when still at a height, and apparently he decided to make a straight-in-approach to land, a practice frequently followed by pilots arriving at Gauhati Airport from Calcutta. This is clear from the fact that the aircraft was accurately lined up with the runway with wheels down. There is no doubt that the pilot was making a controlled descent and entered the fog expecting to get out into the clear on the other side which he had earlier seen and known to be clear. Indeed he would have been able to do so, had the aircraft maintained sufficient height.

It was not possible to ascertain the reason why the aircraft was so much lower than it should have been, but it is almost certain that the pilot himself was not aware that he was so low over the ground. The two possible explanations are that either the pilot did not observe the altimeter or the altimeter itself may not have been set correctly and did not indicate correct height. It may be added that the aircraft radio log book was missing even though all other documents were recovered from the wreckage. There was no fire in the area occupied by the radio officer, although considerable disintegration had taken place. This log book would have disclosed what entries had been made therein regarding the altimeter setting.

Probable Cause

The aircraft crashed in the course of a premature descent, during the final approach, as a result of hitting arecanut trees which were obscurred from view by fog in the area.

Recommendation

There are reasons to believe that the premature descent of the aircraft was due to the pilot's being unaware of his correct altitude when entering the fog. Such a situation could easily arise from either an incorrect setting of the altimeter or the pilot's failure to observe it at the time. It is, therefore, recommended that pilots should be warned against the recurrence of such a happening, and should, in order to avoid errors, be required to repeat the altimeter setting to the Air Traffic Control.

Observations

Some other points which call for observations have come out in the course of the evidence and though they do not directly pertain to the cause of this accident are well worth mentioning.

i) Operational control was not exercised for this flight and the operator had not designated a representative for this purpose as required by Notice to Airmen No. 29 of 1952.

ii) The meteorological briefing of the pilot was not complete in as much as the terminal weather forecast for the alternate aerodrome was not obtained by him.

iii) The manuals used by the crew of this aircraft were not complete or up-to-date.

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ICAO Ref: AR/403

No. 9

Indian Airlines Corporation, Douglas DC-3, VT-CVB aircraft, crashed near Nagpur Airport, India, on 2 February 1955. Report dated 1 March 1955 released by Ministry of Communications, Government of India.

Circumstances

The flight, a scheduled night airmail and passenger flight operating on the Nagpur-Delhi sector of the night airmail network, took off from Nagpur Airport at 0348 hours Indian Standard Time carrying six passengers and a crew of four. After the aircraft became airborne it was seen climbing steadily, then it turned to port and disappeared from view. Immediately thereafter, the duty officer, Air Traffic Control, at Nagpur saw a huge flash, followed by a widespread fire in the direction in which the aircraft was last seen. He attempted to establish contact with the aircraft by calling it on radio-telephony but no response was received, so he then sounded the crash siren. At about the same time some persons in the neighbourhood saw the aircraft come down and crash at approximately 0350 hours in a field. It disintegrated, burst into flames and was completely destroyed. There were no survivors.

Investigation and Evidence

At the time of the accident, weather conditions were as follows:

Clouds	Nil
Visibility	5 nautical miles
Wind	050°/4 knots
Aerodrome barometric pressure	974.7 mbs.
Temperature and humidity	63°F. 75%

The aircraft crashed at a distance of 5 650 feet on a bearing of 196° from the 09 end of Runway 27/09 at an elevation of 1 000 feet a.m.s.l. (the elevation of Nagpur Airport is 1 020 feet). The wreckage trail was on a heading of 58 degrees and 672 feet in length. It showed that the aircraft first hit the ground with the port wing tip. Pieces of red glass from the port navigation light were picked up at this point. As a result of the first impact with the ground, and a subsequent impact further inboard on the wing tip, a section of the port wing tip was torn off. The aircraft then levelled laterally, but was in a steep nose down attitude when it hit the ground with the propeller rotating at a considerable speed. The drag occasioned by the impact of the port propeller and port nacelle with the ground caused the aircraft to slew around about 90° and, in that position, be hurled forward by sheer momentum. The distance between the point of major impact and the end of the wreckage trail was 544 feet. This indicates that the aircraft must have hit the ground at a high speed.

The trail of fire commenced at the point of impact of the nose with the ground. The heavy impact disrupted some of the fuel tanks and pipe lines causing fire to break out and general disruption of the aircraft started to take place between 100 and 200 feet of the first heavy impact. The port wing was hurled 140 feet to the left of the wreckage trail and the fuselage, except the nose section, separated itself from the centre section, and then hurtled forward until it hit two trees. Due to hitting the trees its tail was torn off while the remaining section continued to move forward and finally came to rest 530 feet down the trail. The port engine was hurled to a point 672 feet distant from the point of first impact and the starboard engine came to rest 477 feet down the wreckage trail.

The following points emerged after examination of the wreckage:

1) The propeller domes were removed and indicated that they were both in the constant speed range and at a setting of 26°.

2) No reliable settings of the engine controls could be determined.

3) The engine and flight instruments were crushed and destroyed, and the rudder and aileron trimmer settings were unreliable, although the elevator indications showed a 'neutral' trim. The altimeter settings were 28.78" and 29.84". Both the direction gyro and the artificial horizon were destroyed except for the casing with the knobs which were in the caged position. The possibility of the pilot having taken off with these instruments caged cannot be ruled out. The ignition master and individual magneto switches were free to swivel, but were picked up in the "all-on" position.

4) The undercarriage and flaps were both fully retracted.

5) No evidence was found of the aircraft having struck any object prior to its hitting the ground.

6) The control cable runs were satisfactory. Cables had failed in tension following the crash.

7) There was no evidence of any explosion having occurred in the air.

8) The port and starboard engines were torn off from the mountings. The starboard engine was still substantially intact although the accessories suffered damage. The port engine auxiliary section separated from the power section. Neither of the two engines showed any signs of external or internal fire. Partial dismantling of the engines showed evidence of adequate lubrication. Neither of the propellers was feathered and both were at the same fine pitch setting.

9) With the exception of the port wing and its corresponding section of flaps, practically all other components showed evidence of heat. Although there was evidence of a light smoke trail on the lower surface of the centre section directly behind the starboard wheel well, there was marked absence of smoke in the area immediately behind the partially opened inspection panel situated in the very heart of this location. As this inspection panel had evidently opened after the buckling of the skin on impact of the aircraft with the ground, it showed that the trail was formed after the disruption of the fuel tanks and when the aircraft hurtled forward on its own momentum.

10) There was no sign of any control, mechanical or structural failure.

11) There was no sign of any fire having broken out either in the engines or in the airframe before the disruption of the fuel tanks on impact with the ground.

The aircraft had commenced its flight at Madras at 2300 hours on 1 February 1955 and landed at Nagpur at 0230 hours on 2 February 1955. The flight from Madras to Nagpur had been uneventful, however, the smell of battery fumes was noted and the unserviceability of the radio compass. On arrival at Nagpur the batteries were checked and when the radio compass proved to be unserviceable an overhauled unit was obtained and installed.

The commander of the Dakota possessed a total of 5 867 hours 40 minutes flying experience. As day commander he had 2 533 hours to his credit but as night commander his experience amounted to only 245 hours 15 minutes.

The co-pilot had a total flying experience of 3 671 hours 50 minutes and had no experience as a night commander. As night co-pilot he had 268 hours 30 minutes to his credit.

The engines suffered no damage by fire internally or externally. The removal of filters and partial dismantling revealed no evidence of mechanical failure. The port propeller had cut into the ground when rotating at high speed, and the starboard propeller had cut the ground parallel to the wreckage trail after the aircraft slewed at right angles to its direction of motion. These factors coupled with the fact that both propellers were at the same fine pitch setting and neither of them was feathered, indicate that the engines were in operation at the time the aircraft made its first impact with the ground.

One significant feature which emerges from the examination of the location of the wreckage is that the aircraft must have been in a steep turn soon after take-off. The aircraft got the clearance for take-off at 0348 hours and commenced its take-off run immediately. After the aircraft was airborne, it turned to port. There was no direct evidence regarding the nature of the turn, but if one takes into account the time factor, the location of the wreckage and the fact that the wreckage trail was on a heading of 58 degrees, there is no doubt that the aircraft took a steep turn to port at a low altitude. During this manoeuvre, the aircraft lost height and slipped into the ground. This is confirmed by the fact that the aircraft first hit the ground with the port wing tip at an angle of 42 degrees.

No importance need be attached to the fact that the captain took a turn to the left instead of to the right, as is generally done by most of the pilots when taking off for Delhi from Runway 27. We find from the record that it was not unusual for the pilot in question to take a turn to the left but the mistake lay in badly executing a turn.

The reason for such a steep turn is not easy to ascertain. It is possible that the pilot may have done so in order to get on course quickly. It is also possible that he relied on visual reference instead of flying entirely on instruments as he should have done, thereby going into a turn steeper than intended, or it may be that he was misled by the instruments.

Probable Cause

The aircraft crashed as a result of slipping into the ground in the course of a badly executed steep turn to port carried out at night at a low altitude.

Recommendations

1) Although under the present regulations, licensing of commercial pilots includes instrument flying, it is recommended that Instrument Rating according to ICAO standards should be made a compulsory requirement for pilots engaged in commercial air transportation. All flights operated during the night are to be treated as flights under Instrument Flight Rules, as recommended in the Regional Supplementary Procedures issued by ICAO (See Doc. 7030) and referred to in Notice to Airmen No. 23 of 1952.

2) Operators should be required to make comprehensive and up-to-date Operations and Maintenance Manuals available for the use of air crews and other technical personnel engaged in scheduled air transport services.

3) The pamphlet "A Survey of Accidents to Indian Registered Aircraft", which at present is published annually, is a useful document. It is recommended that full details pertaining to the cause of each accident, along with such instructions and advice as may be considered necessary to prevent similar accidents, should be circulated immediately on completion of investigation to all air crews, engineers and others concerned.

No. 10

SABENA (Société Anonyme Belge d'Exploitation de la Navigation Aérienne), DC-6 aircraft, OO-SDB, crashed at Costone dell'Acquasanta, Reatini Mountains, on 13 February 1955. Report by Ministerio Difesa Aeronautica, Italy.

Circumstances

The aircraft departed the Brussels-Haren airport for Rome at 1617 hours Greenwich Mean Time on an IFR flight plan. According to radio communications between the aircraft and the area controls at Zurich, Milan and Rome the flight appears to have been normal. The aircraft was in touch with Rome area control at 1829 hours and the last message from it was received at 1853 hours. At about 1850 GMT the aircraft after overflying the village of Leonessa continued in flight on a heading of 163 degrees until it hit the slope of the Costone dell'Acquasanta at a height of 1 700 metres, after breaking off the tops of trees in a wood in line with the point of impact, near the end of its course. There were no survivors among the 8 crew members and 21 passengers on board.

Investigation and Evidence

The weather situation in general was as follows: anticyclone over the North Atlantic with a large area of low pressure from the Baltic to the Central-Western Mediterranean. The low was over the Gulf of Genoa and extended to the Central Tyrrhenian. In addition, there was a disturbance produced by the influx of cold masses originating in the Atlantic, meeting with pre-existing warm and very humid masses.

At 1800 GMT, the cold front of the above disturbance, which had been detected previously lay along the line from the Strait of Bonifacio to Ortebello and Perugia, and at 2100 GMT, this front must have been on the aircraft's route in the vicinity of Viterbo.

The evidence gathered from the weather charts and from the testimony of the inhabitants of Leonessa (closest inhabited centre to the scene of the crash) indicates that clouds were generally stratified and accompanied by moderate rain and snowfall. Cloud base varied from 400 to 750 metres; cloud top varied from 3 500 to 4 000 metres in the prefrontal zone, but may have been over 5 000 to 5 500 metres (16 500 to 18 100 feet) in the postfrontal zone. No meteorological phenomenon was reported by the stations in Latium and Tuscany or by aircraft in flight, either before or after the time considered. Such an assumption would imply an isolated phenomenon, which is not confirmed by the facts ascertained *in situ*.

The 0° C isotherm in the prefrontal zone was at 2 200 m (Ciampino sounding at 1400 GMT on 13/2/55) and fell in the postfrontal zone to 1 600 - 1 800 m (Ciampino sounding at 0200 GMT on 14/2/55).

Wind analysis by altitude gives the following table:

	Prefrontal zone (Rome - Viterbo)	Postfrontal zone (Viterbo - Florence)
5,000 ft.	240°- 25 kt.	290°- 25 kt.
10,000 ft.	290°- 35 - 40 kt.	290°- 35 kt.
18,000 ft.	270°- 80 - 85 kt.	280°- 75 - 80 kt.

It should be pointed out that the information and forecasts supplied to the pilot are inferred, as regards high altitude winds, from the observations taken at 0200 GMT on 13/2. The chief meteorologist at the aerodrome of departure hastened to communicate later details on high altitude winds, following receipt of information from a crew which had flown the route in the opposite direction a short time before the departure of the aircraft OO-SDB.

Reports from various sources confirm the presence of strong winds at 75 - 90 knots from the West, stronger than forecast. It may further be assumed that on the Apennine crest, i.e., along the aircraft's route, the velocity of crosswind must have increased by Venturi effect.

Position reports relating to the navigation of a USAF-Navy aircraft, which flew the section of advisory route 512 (Brenner - Padua - Lugo - Viterbo - Civitavecchia) involving the Apennine region north of Rome, at about 1930 GMT, indicate a navigation time of 38 m 30 sec. between Viterbo NDB and Civitavecchia NDB.

Such a value is obviously impossible, in view of the small distance between the NDB's involved (26 nautical miles) and one is led to the conclusion that during navigation over the Apennine section, the aircraft must have encountered an unexpected and very strong wind from the western sector, which carried it far to the East of the [1]advisory route and led to an error (probably not picked up) in position estimation over Viterbo NDB, and that this explains the transit time reported.

This deduction supports the conclusions of an analytical study by the Meteorological Service pointing to the existence of a West-East jet stream which must have influenced the navigation of the aircraft, causing a drift of greater extent than that taken into account by the crew on the basis of the flight plan data.

On the basis of analysis of individual thermodynamic soundings and of the presence of an active frontal system, with thick and extensive cloud, it was concluded that there may have been moderate to severe icing in the area between Florence and Rome, particularly at levels between 2 500 and 5 000 metres.

It is not considered, however, that the navigation of the aircraft was influenced by icing, the more so as there is no corroboration for this view in the reports of other aircraft flying the same route about the time of the accident.

Because the flight log and the radio log were not recovered, the investigation concerning the radio aids used by the aircraft had to be restricted to consideration of the communications exchanged between the aircraft and the ACC's at Zurich, Milano (Linate) and Rome (Ciampino) and to examination of the radio equipment salvaged from the wreckage.

It is apparent from the air-ground communications log that the aircraft regularly sent the prescribed position messages over the various beacons on Swiss and Italian MF's, without reporting difficulty or malfunctioning of the aircraft equipment or complaining of lack of effectiveness of the aids used.

The laboratory investigation on the radio compass points to the conclusion that in all probability the two ADF receivers were set to the radio beacons at Civitavecchia (345 Kc/s) and Rome Town (265 Kc/s), while the radio range receiver was set to the Ciampino radio range (255 Kc/s).

It should be observed that weather conditions were particularly unfavourable for the use of medium frequencies.

This is corroborated by the reports filed by the pilots-in-command of aircraft in flight during the same period, which mention difficulties in reception from radio beacons on medium frequencies.

Difficulty in receiving from radio beacons was later confirmed by the navigation report of the USAF-Navy aircraft previously mentioned and by the inquiry by aircraft OO-SDB itself, at 1848 GMT, as to whether the Viterbo radio beacon was operating at full power.

A few small pieces (crew seat cushions) found burnt near the engines indicate a very limited post-crash fire in the vicinity of the engines.

It may be inferred that the fire fighting equipment was not used

a) because the accident must have been unexpected, and,

b) because some of the CO_2 extinguishers found among the wreckage were still charged.

There were no eyewitnesses to the accident. The location of the accident is uninhabited, inaccessible and invisible from any inhabited place or road within a radius of about 15 km in a straight line. At the time of the accident (1853 GMT) night had already fallen, it was windy and raining and there was no fire visible from a distance.

A large part of the wreckage was discovered in the vicinity of Point A in Figure 7. Many parts and fragments were found near the rocky spur (see Figure 7) and in the meadow, not far from the precipitous slope to the right of the fuselage (viewed from the rear).

The state of the wreckage confirms that all forward and under parts of the aircraft struck the rock face violently; to wit:

Translator's Note: In Italian "assisted route". In Italy there are no advisory areas or routes within the ICAO meaning of the terms. There are "assisted routes and areas" the rules applying thereto differing from those for the advisory service. (See Buiatte, Terminologia Aeronautica, page 2, ICAO Library Ref. 453 B-932).

- the lower portion of the fuselage was split open at about the level of the cabin floor;

- the wing and its appendages were reduced to fragments, some of extremely small size, with the exception of about three metres of the right wing tip discovered near the rocky spur;

- the propeller blades were not twisted, but were nearly all broken off at the hub or reduced to broken fragments which bear witness to an impact at full power.

The fuselage broke up into three parts presumably at the very second of impact upon the slope. The engine cradles were torn from their moorings. In the engines some cylinders were wrenched off, casings cracked and in some cases the reduction gear was torn away and the corresponding cowlings were twisted, fragmentary and widely scattered.

The wings were shattered into small pieces, except near the landing gear, to which portions of the spars remained attached, and except the piece of the right wing tip.

The cockpit suffered greater damage than the rest of the fuselage as it is situated in that part of the aircraft which sustained the first and most violent shock. Nevertheless, the instrument panel was in relatively good condition, with all the instruments in place and some with the glass still intact. Many windows were unbroken and the emergency exits in the usual position as apparently no attempt had been made to use them.

The technical examination of the wreckage and the inspection of the surrounding terrain produced no evidence of any defect in the aircraft before the accident.

Technical examination of the radio equipment gave the following results:

- the ADF receiver was tuned to the frequency of 350 Kc/s (corresponding to the Civitavecchia NDB);

- the ADF receiver was tuned to the frequency of 261 Kc/s (corresponding to Rome Town NDB);

- the RNG receiver control box was tuned to 225 Kc/s (corresponding to Ciampino range).

The VHF units had suffered too much damage to allow identification of the frequencies to which they were set at the time of the crash. However, contact with Ciampino control had been regularly established on 119.3 Mc/s.

A study of the radio messages exchanged between the aircraft and the area controls at Zurich, Milan and Rome brings out the following basic points:

Contact with Zurich control

The operator had no VHF contact with Monaco. At 1715 GMT he sent a radio-telegraphy message over the frequency of 3,481.5/3,478.5 Kc/s giving time of departure from Brussels, destination, estimated time over Strasburg, Rottweil and Trasadingen. He requested that the message be relayed to Monaco, as he had not contacted that station, and requested and obtained from Zurich the Monaco QNH. He later communicated with Frankfurt on the same frequency, and still later, again by direct message to Zurich ACC, reported his position over Rottweil and Trasadingen. He then requested to change to telephony on 119.3 Mc/s. Having changed to direct contact with Zurich control on 119.3 Mc/s, he apologized for having been unable to communicate before because of malfunctioning of the VHF. Contacts remained normal up to 17.49.10 GMT.

Contact with Milan control

Contact between the aircraft and Milan control took place on 3,481.5 and 125.3 Kc/s (the Linate thermoionic recorder was out of order between 1703 and 1819 GMT because of a damaged relay. It was, however, possible to gather from the transcribed tapes that the required position reports over the facilities were made in the proper manner and on schedule as estimated in the flight plan.

Contact with Rome control

Contact with Ciampino ACC was initiated according to plan at 1829 GMT, at which time the aircraft had passed over Florence -- or had so estimated -- at 17 500 feet and had sent Ciampino its estimated time over Viterbo as 1847 GMT. Later the aircraft was cleared to descend over Viterbo, first to 11 500 then to 7 500 feet. At 1847, as noted above, the aircraft should have been over Viterbo and have so reported to Ciampino. Not having received this message, at 1848 Ciampino control asked the aircraft whether it had passed over Viterbo. Instead of answering this question directly, the crew inquired whether the Viterbo NDB was on full power. Control replied that another aircraft had overflown the Viterbo NDB shortly before and had found it to be operating properly.

At 1851 GMT the aircraft stated that it had passed over Viterbo NDB one minute previously and requested clearance to descend to 5 500 feet; this was granted. One minute later it inquired whether the Ciampino ILS were operating and received an affirmative reply. At 1853, OO-SDB called Rome control but communication was suddenly cut off.

The history of the aircraft supplied by the Belgian government reveals no element which might have contributed to malfunctioning or deficiencies in its operation. Overhauls of the aircraft throughout its lifetime were performed according to the approved procedure. The weight of the aircraft and its load distribution as it appears on the load sheet were in accordance with the certificate of airworthiness. The possibility of any sudden malfunctioning should be excluded as there is no mention of this by the crew in the last message immediately before the impact.

The weather conditions prevailing along the route were such as are well known to cause great disturbance in receiving from radio beacons on medium frequency; but the crew had other resources for communication in HF and VHF, which would have allowed them to determine their exact position at all times, using the corresponding range-finding networks. It was found that this was not done.

In view of the above-mentioned disturbance in MF communications, the aircraft certainly had difficulty in picking up the Viterbo beacon, as shown by the fact that while the estimated time over Viterbo was given as 1847 GMT, at 1848 the aircraft was still asking whether the Viterbo beacon was on full power. The 1851 message, stating that the aircraft had passed over the Viterbo beacon one minute earlier, when compared with the actual position of the aircraft at the time and with the indication found on its radio-compass, leads to the conclusion that the report was based on a polar pick-up of the Civitavecchia beacon. There is, therefore, good reason to assume that the aircraft never was able to pick up the Viterbo beacon.

It is evident from the investigation of the radio equipment that the crew continued the regular approach procedure, since the units were set on Civitavecchia, Rome City and Rome Ciampino for the routine communications required under Ciampino approach procedures.

The inquiry at 1852 GMT by the aircraft as to whether the ILS was in operation indicates that the crew believed it was already able to pick up the ILS, whereas this was in fact precluded by its true position.

It seems strange, in view of the foregoing, that the crew should not have declared an alert but should on the contrary have continued the descent without availing itself of all the other radio facilities by which it might have gained exact knowledge of its true position.

At the time of the flight the Italian aids also included two VOR facilities usable on the route flown -- one in the Milan FIR and one experimental* in the Rome FIR, -- which could have given much assistance in pick-ups and route indications in the Milan and Rome area.

The airborne VOR facility offered no clue as to its setting.

None of the messages from the aircraft gave the impression that the crew were in any doubt as to their position.

The gradual uncontrolled eastward drift may be assumed to have started along the Alpine route, in view of the atmospheric conditions then prevailing, and particularly because of the jet stream previously mentioned.

The message "passed Viterbo beacon one minute ago" sent by the aircraft at 1851 is certainly an error - actually, the aircraft struck the surface at 1853 at a point more than 60 km east of Viterbo on a heading of 163 degrees.

Probable Cause

The probable cause of the accident was that the navigation was conducted without making use of all such radio aids as would have permitted checking, and consequently correcting the drift of the aircraft, whereas the crew actually remained unaware of the drift. In fact, instead of making sure they were over the Viterbo beacon, they merely held that conviction, and therefore the approach procedure to the Rome terminal area (which prescribes overflight of the Viterbo beacon) was erroneously applied.

* inserted at the request of the Belgian authorities.

The following contributing causes may be taken into consideration:

- crosswind to the route stronger than forecast;

- weather conditions particularly unfavourable to radio reception in MF.

Recommendations

Since one of the causes contributing to the accident was the fact that the crew probably used only the medium frequency radio aids, and since reception of the latter may be considerably influenced by weather conditions and night effect, the Commission makes the following recommendations:

a) that the European medium frequency radio beacon network be replaced at the earliest opportunity by a network of radio aids to navigation offering adequate protection at night and in all weather conditions prevailing in Europe;

b) that, for the Rome terminal area in particular, work on the following projects be expedited - relocation of the Lazio VOR facility from Castel Decima (41° 47' 05" N - 12° 28' 10" E) to Monte Razzano (42° 07'25" N - 12° 22'55"E), and installation of a radar watch;

c) that in all cases of difficulty in navigation, crews be strongly urged to have recourse to the protection of the HF and VHF radio range-finding networks, when available.

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ICAO Ref: AR/434

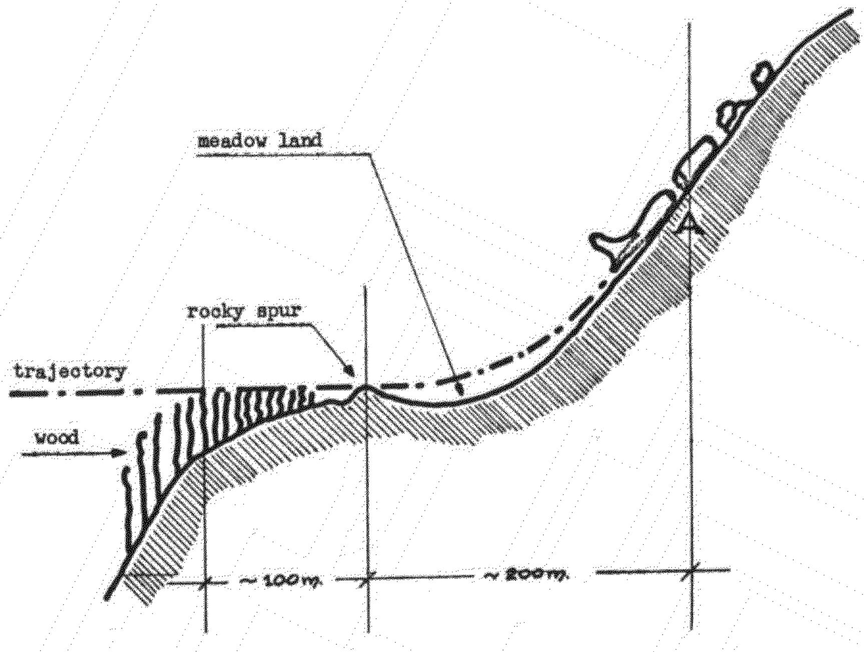

Figure 7

Diagram of territory in which SABENA DC-6 aircraft crashed. Reatini Mountains

Figure 8

General view of crash area.
Costone dell'Acquasanta, Reatini Mountains.

No. 11

Trans World Airlines, Inc., Martin 404 aircraft, 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, released 12 October 1955.

Circumstances

Having received the following IFR (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 feet, 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 there were no further radio contacts with the flight. The aircraft was last seen at an estimated altitude of 3 000 feet (8 300 feet 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 feet 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 feet mean sea level) to the Santa Fe Airport (elevation 6 344 feet mean sea level). There were no survivors.

Investigation and Evidence

The Albuquerque weather five minutes before the crash was: 4 000 feet scattered, 7 000 feet thin broken clouds; visibility 40 miles; wind SSE 6; altimeter 29.82; mountains obscured northeast. Before departure the pilots had been briefed on the weather, which was generally clear and would have permitted visual flight over nearly the entire route, with only short instrument flight probable.

Initial investigation was greatly handicapped and curtailed by deep snow, inclement weather and dangerously unsure footing on the steep, rocky, snow-covered slopes. A later expedition reached the crash site on 3 May and after considerable difficulty and hazard made an exhaustive study of the wreckage and found no evidence of fire or structural failure prior to impact, nor of malfunctioning of either engine or either propeller. A study of recovered radio components disclosed that No. 1 VOR Navigation Receiver was tuned to the frequency of the Albuquerque Omni Range Station; No. 2 VOR Navigation Receiver was tuned to the frequency of the Albuquerque ILS Localizer. However, the flight did not follow this plan.

The aircraft was equipped with a Hughes Terrain Warning Indicator, which simultaneously flashes a light and sounds an alarm when the aircraft is 500 feet, 1 000 feet or 2 000 feet from any obstruction, as set. The obstruction may be anywhere downward from within about 5 degrees of the horizontal in all directions - ahead, astern, or to either side.

The wreckage was strewn in a manner indicating a direction of flight at the moment of impact of about 320 degrees magnetic while in a left climbing turn. This means that the aircraft was turned to its left about 70 degrees from its original heading and climbed just before the crash, as if to evade an obstruction.

The pilot must have suddenly realized that he was practically at the precipitous wall of the mountain and acted quickly. We can only conjecture as to whether this realization was spontaneous with the captain, or the first officer, or induced by a warning from the Hughes Terrain Warning Indicator of an obstruction ahead, below, or both. The realization of the mountain ahead may, of course, have been brought about by something other than the Terrain Warning Indicator, possibly a glimpse of terrain close below, or ahead, or both. Obviously an evasive manoeuvre was started.

It is difficult to conceive of the crew attempting to cross a 10 682 foot ridge at 9 000 feet, especially when the aircraft was capable of climbing to an altitude which would more than clear the ridge. The Martin 404, grossing 40 027 pounds, should , at maximum continuous power, climb at 1 500 feet per minute up to

* The Wieler 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 center of the Albuquerque Airport.

9 000 feet and slightly less than that thereafter. This rate of climb would have brought the aircraft several thousand feet above the ridge starting from Albuquerque, only 13 miles away. Even with much less power the ridge could have been easily topped. There appears to be no plausible explanation of why the aircraft was not climbed, presuming the pilots flew the direct route knowingly.

The course flown was off airways and was neither authorized by the Civil Aeronautics Administration nor sanctioned by TWA. The correct and only permissible course is via Victor 19 airway, which skirts Sandia Mountain to the west by several miles.

Wind velocity over Sandia Mountain was indicated to be too light to produce an important "mountain effect" such as severe turbulence, downdrafts, and erroneous altitude indications. Furthermore, such effects when present are manifest over the crest and lee slopes, whereas this accident occurred on the windward slope.

The captain in command of the flight was well experienced over the route Albuquerque to Santa Fe. The first officer was flying it for the first time that month although he had been over it twice during the previous month. The weather was such that visibility along the airway was good for many miles ahead to the north. The mountains, although partly obscured by clouds, were clearly visible from V-19 airway. The flight took off from Runway 11, circled the airport to the right, and picked up a northeast heading directly toward Sandia Mountain instead of pursuing a course along the airway to the west and north of the mountain. It was contact during the turn around the airport and for approximately five minutes thereafter before entering the clouds obscuring the top of the mountain. Even if all navigational aids and instruments had failed, all the captain had to do was look outside to determine that he was not following the airway. Therefore, from all available evidence, and the lack of any evidence to the contrary, the Board can conclude only that the direct course taken by the flight was intentional.

Probable Cause

The probable cause of this accident was a lack of conformity with prescribed en route procedures and the deviation from airways at an altitude too low to clear obstructions ahead.

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ICAO Ref: AR/392

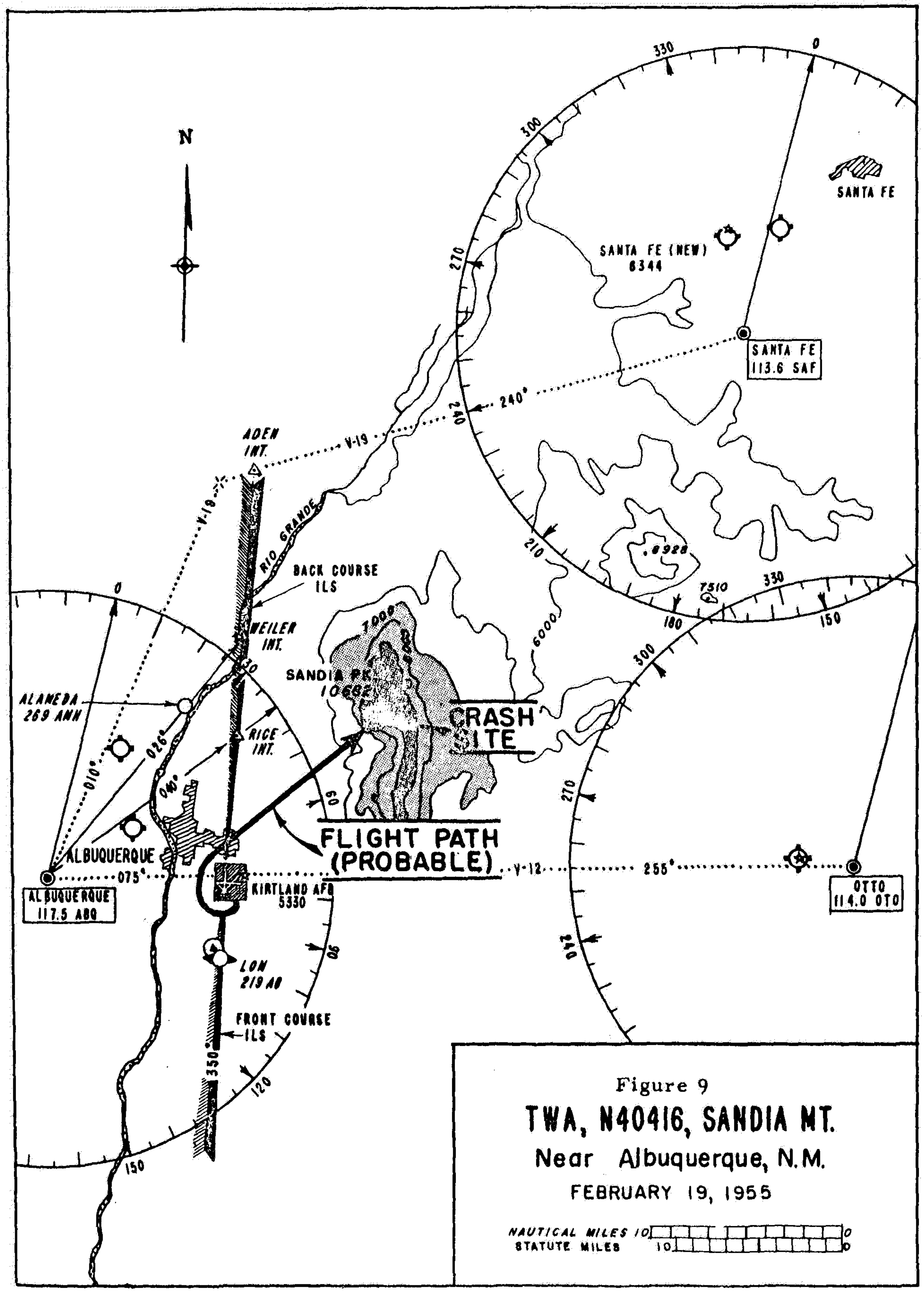

Figure 9

TWA, N40416, SANDIA MT.

Near Albuquerque, N.M.

FEBRUARY 19, 1955

NAUTICAL MILES 10 0
STATUTE MILES 10 0

No.12.

De Havilland 104 "Dove", LQ-XWW, crashed on take-off at Formosa Airport. Territory of Formosa, Argentina, on 26 February 1955. Argentine Accident Investigation Report No 465, released 30 August 1955.

Circumstances

The aircraft on a personnel transfer flight was taking off at approximately 15 50 hours from Formosa Airport with 4 passengers and 3 crew on board. It was observed to run for about 800 metres along the runway, rising only slightly a few metres before the end of the run; it then hit a runway end marker, the wire fence surrounding the aerodrome, and a telephone pole, touching the ground twice; after demolishing another wire fence, it came to rest against a small hill and caught fire. Six of the occupants were killed instantly and the seventh died some months later from burns sustained.

Investigation and Evidence

The meteorological conditions as reported by the local meteorological station, about 5 km from the aerodrome, were as follows:

> sky with 5/8 cumulus with base from 600 to 1 000 metres; wind south at 8 knots; visibility 20 km; pressure at station level 997.6 mb; temperature 32°C; dew point 20°C.

The aircraft had arrived from Córdoba with a stop at Resistencia, landing 25 minutes before the take-off on which the accident occurred.

The ground was carefully inspected and the tracks left by the aircraft on the take-off run were identified. They started 80 metres from the runway threshold, where the surface was muddy. The tracks of the main and front wheels were clearly visible both on the dry surface and in the holes; they disappeared in the central portion of the runway and reappeared on the ground near the end marker.

In the first half of the runway there were some shallow, hard-bottomed holes which were crossed by the wheels during take-off; the tracks left had a maximum depth of 10 cm over 2 metres with gradual slopes. The rest of the runway was hard-surfaced and the only marks upon it were the normal tracks left by the tire treads. The surface of the runway was covered with grass which, even though not properly mown, did not interfere with the take-off.

The total weight of the aircraft was not recorded before the flight.

The authorized weight empty of the aircraft according to its Certificate of Operating Limitations was 2 894 kg, or 289 kg over the normal authorized weight empty; this excess represented extra radio equipment and special facilities, and reduced the disposable load by the same amount. There remained a margin of 1 010 kg instead of 1 299 to reach the maximum authorized take-off weight i.e. 3 859 kg. It was deduced from the tank capacity (772 litres for fuel and 72 litres for oil) that the weight of fuel and oil on board was 621 kg, which, added to the weight empty gave a total of 3 470 kg, thus leaving only 389 kg for crew, passengers, baggage and other transportable items.

At Córdoba, the tanks were replenished with 430 litres of aviation fuel, enough for about 3 hours and 15 minutes' flying time, thus replacing the amount of fuel consumed on the flight from Quilmes.

On departure from Córdoba, the estimated weight of the aircraft was as follows:

Weight empty	2 849 kg
Fuel (772 litres)	556
Oil (72 litres)	65
Baggage and miscellaneous	140
Crew and passengers (6)	480
	4 090 kg
Maximum licensed weight	3 859 kg
Excess	231 kg

The flight from Córdoba to Resistencia required 2 hours and 45 minutes with a consumption of about 260 kg; at Resistencia 230 litres of fuel and 9 litres of oil, totalling 173 kg were taken on board; 80 kg were consumed on the trip to Formosa and an additional passenger was taken on for the return flight, making a total of seven persons on board. In summary, the aircraft took off from Formosa with 4 003 kg, 87 kg less than from Córdoba, but still 144 over the maximum licensed weight of 3 859 kg.

Inspection of the propellers at the site showed that the blades were set on high pitch, except one of those of the left propeller which was facing forward, turned about 100 degrees from the high-pitch position. The other two remained in position, both firmly meshed with the driving gear, although one of them was bent backwards from contact with the ground. The blade found in the inverted position turned freely, overcoming only the normal friction of the packing of the mounting on the hub; the impact caused failure of the screws and locking pins holding the control gear segment. The right propeller blades were also bent back by impact, and one of these had broken free of the gear segment for the same reason.

The propeller controls, having been completely destroyed by fire, could not be checked, and there remains a doubt whether, in the emergency shutting of the throttles, the propeller controls were moved at the same time to the high-pitch position, or whether they slipped during the take-off run and the fact was only noticed at a late stage. The latter would explain the impression of acceleration or increase in rpm gained by witnesses to the departure.

As the right engine had been destroyed in the fire and all its working parts and attachments were melted together, detailed inspection of components was impossible.

The left engine only suffered slight fire damage to its rear attachments, the remaining ones and the engine itself being only heated or smoke-blackened. It was possible to check the distributors, which showed no sign of the internal burns common in such cases; neither did the contact breakers display any abnormal signs.

The spark plugs installed in this engine were of various makes and types, some of them with long, thick, bent electrodes, with excessive wear on the side electrode.

The technical report on the dismantled engine revealed the presence of marks of incomplete detonation on the piston crowns and one exhaust valve seat was burnt and the other pitted.

The presence of spark plugs inappropriate to this type of engine, in which the ambient temperature and that at the cylinder heads are undoubtedly high, as is also the intake pressure required for take-off, caused premature ignition, followed by the detonation revealed by the inspection, in the dismantled engine or in both, thus inevitably producing loss of power and irregular operation.

It was not possible to determine the circumstances in which the propeller blades were switched to high pitch; the very magnitude of such an error seems to rule out the theory that they were in this position at take-off; even if this irregularity had escaped the pilot's attention, it may be assumed that it would have been noticed by the flight mechanic, who usually stands between and slightly behind the seats of the pilots during take-off, or by the co-pilot, who was in the right-hand seat; it is considered possible, however, that the propeller pitch controls could have slipped to the high-pitch position during the take-off run, without this being observed in time.

Weather conditions at the scene of the accident were such that the air density was 8% below normal and the ambient temperature reduced driving power by about 3%. Had the aircraft's engines been operating normally, the meteorological factor would have reduced its forward and vertical speeds, although a run of 800 metres would have given it sufficient speed to climb at a much faster rate than its actual 0.50 m/sec, which was inadequate to clear the first obstruction, 1 metre high.

Probable Cause

The accident was due to the inability of the aircraft to reach its take-off speed after a run of 800 metres on the runway, because of:

1) Insufficient driving power for operation, resulting from:

a) Reduction in power in one or both engines from premature ignition and detonation, originating in the use of spark plugs inappropriate to the engine type.

b) Probable reduction in the rpm rate of the engines during the take-off run; following unnoticed slipping of the propeller controls

2) Overloading of the aircraft in relation to maximum authorized take-off weight.

3) The circumstances in which the operation was carried out indicate that the weather conditions in relation to the characteristics of the runway were a contributing cause of the accident.

ICAO Ref: AIG/ACC/REP/GEN/No. 7
(Arg. Bulletin No. 4, p. 31)

No. 13

Central African Airways, Viking 1B VP-YEX crashed at Belvedere Airport, Salisbury, Southern Rhodesia, on 17 March 1955. Report of Board of Inquiry Ministry of Transport and Communications, Federation of Rhodesia and Nyasaland, released 31 August 1955.

Circumstances

The aircraft departed Jan Smuts Airport at 1115 hours local time on a scheduled flight to Belvedere Airport, Salisbury, under VFR conditions carrying 23 passengers and a crew of 5. At 1427 hours while approaching Runway 09/27 from the east on final approach during a thunderstorm the undercarriage struck the ground a short distance to the north and east of the threshold of Runway 27* causing the starboard tire to burst, the starboard leg of the undercarriage to break and the starboard propeller engine to be severely damaged. The pilot endeavoured to undertake overshoot procedure but as the starboard engine and propeller could not deliver power and the aircraft was at a speed below the minimum required for effective control he was obliged to make a crash landing. No one was injured but the aircraft was extensively damaged.

Investigation and Evidence

The main runway (09/27) is 2 600 yards long of which 1 000 yards at the eastern end is grassed, the remainder of the runway being hardened and so available for use in all weather conditions. At either end of the hardened runway there is a hardened taxiway. The altitude of the airport is 4 780 feet above mean sea level and the distance required for a fully loaded Viking to land at that altitude in standard atmospheric conditions is approximately 1 350 yards.

The two radio aids to navigation at the airport are a non-directional beacon and a VHF direction finder. The former is situated a short distance to the north of the airport buildings and the latter to the south of the main runway. Either may be used for descending through cloud. The procedure in each instance is somewhat the same and is, in outline, that in IFR conditions an aircraft approaches at a height of 1 500 feet over the station (i.e. 6 300 feet above mean sea level) and on a heading of 020°. After passing over it, the aircraft continues on this heading for two minutes. It then effects a procedure turn on to a reciprocal heading of 200°, when a descent is commenced down to a minimum height of 600 feet. On arrival over the station the heading is maintained and the descent continued until the aircraft makes visual contact with the ground or reaches a height of 500 feet, the general critical height laid down for the airport. (In the case of Central African Airways a critical height of 400 feet has been approved.) On making visual contact with the ground an aircraft is travelling approximately at right angles to the runway. The aircraft must then manoeuvre into a position to enable a landing to be made. The usual procedure is to turn to starboard and to land on Runway 09.

There is no instrument at the airport capable of measuring the height of low cloud. This is done by an officer on duty who makes an estimate from a "point" near the airport buildings from which there is good visibility to the south and to the west, enabling the observer to estimate adequately the height of low cloud in those directions, more particularly in the area in which an aircraft intending to come on Runway 09 would be. There is very poor visibility to the east and to the north and from the "point" it is impossible to make any estimate of the height of low cloud in the region in which an aircraft intending to come in on Runway 27 would be or to make the best possible estimate of horizontal visibility. The MET Office informs the air traffic control officer in hourly reports of conditions and these are passed on to approaching aircraft. No log of messages is kept in the control tower as this is considered impracticable because messages are passed to and from the tower by radio-telephony.

The aircraft flew for the greater part of the journey at 11 000 feet above cloud. Amendments to the route weather forecast indicated that active and extensive thunderstorm development was expected at Salisbury. Cloud was given as 1/8 cumulonimbus at 1 000 to 2 000 feet, 1/8 strato-cumulus 1 000 to 2 000 feet, 2/8 cumulus at 1 000 to 2 000 feet, 7/8 altostratus above 8 000 feet.

1404 .. the aircraft announced it was approaching from the southwest at 9 000 feet IFR and was provided with the prevailing QNH and QFE...

* The eastern end of the hardened surface of Runway 09/27 is referred to as the threshold of Runway 27.

1412 .. flying at 6 300 feet and informed that rain was moving in from the northeast ...

1415 .. given clearance to approach right-handed on to Runway 09 ...

1418 .. crossing the Hunyani River at 600 feet flying VFR and indicated joining on right-hand base leg ...

1420 .. told that approach to 09 was obscured and clear to join circuit for Runway 27. At approximately the same time the aircraft reported 09 in sight and requested permission to land on that runway or indicated it intended to land there.

The control tower had advised the aircraft of the storm moving into the aerodrome from the northeast but no mention had been made of a storm covering the Warren Hills. The hills are approximately 200 feet high and some two miles west of the airport, roughly at right angles to Runway 09/27. A gap in these hills is in line with this runway. In conditions of good visibility aircraft coming in on 09 fly over the hills and pass through this gap. On this approach the aircraft was being flown by the first officer from the left-hand seat, the captain being in the right-hand seat. The captain and the first officer were aware of the storm and, therefore, did not permit the aircraft to be flown further west for the usual final approach. Therefore, the aircraft turned inside the hills and tried to come in on 09. After the turn from the base leg it became apparent to the first officer and the captain that the aircraft would not be able to land on the runway without having to make use of the additional thousand yards of grass at the eastern end of the runway. The captain decided on overshoot procedure and took over from the first officer when the aircraft was 50 feet above the runway. The first officer then took over again and was instructed to alter course by flying 20° north of the line of the runway - due to the kopje (hill) to the east of the runway being obscured by another storm. The aircraft climbed to 1 200 feet over the town at which point the captain and first officer changed places, the captain moving to the left-hand seat. A procedure turn over the town was completed which brought the aircraft back on a course approximately reciprocal to that on which it had just left the area of the runway. At about this time there was a storm to the north and northeast of the airport buildings, another storm in the kopje area probably extending even at this stage over part of the grassed portion to the east of the threshold of Runway 27, and clear conditions over the town. The aircraft reported coming "on final to Runway 27", the message was acknowledged by control who did not communicate further with the aircraft.

The captain planned to approach the runway at an angle. This plan necessitated a turn to starboard through some 20° when at a height of about 20 feet above the runway, in order to align the aircraft with the runway. The captain estimated that he would then have touched down 200 to 300 yards from the threshold of the runway leaving 1 300 to 1 400 yards in which to stop. The plan was a bold one and somewhat difficult to execute because it gave him little or no margin for error. The captain was quite confident that he could have carried out this plan, if no circumstances had supervened to interfere. In making this plan there were two crucial limiting factors. The first was the presence of the storm in the area of the kopje and the area covering part of the grassed portion of Runway 27. The effects of this factor were, first, that it was impossible to make a straight approach to Runway 27 without losing sight of the runway and, secondly, that it was impossible to make the turn to align with the runway to the east of the threshold. The other limiting factor was the length of Runway 27. It would have been necessary for the aircraft to touch down within about 300 yards of the threshold in order that it should be able to stop before the western end. In this regard the captain stated that he had previously pulled up a Viking aircraft in similar conditions in under 1 000 yards. This figure would appear to be on the optimistic side even with exceptional application of brakes, but it must be borne in mind that had the captain not been able to touch down at a point giving him sufficient distance in which to stop, he should have had no difficulty in taking overshoot action. His primary duty was to land his aircraft safety at Belvedere; his alternative to making an attempt to land was to go to Lusaka, the recognised alternate airport to Belvedere. A further alternative was to wait in the vicinity of Belvedere in the hope that the weather would improve, but he could not have done so for an unlimited time and he could not know that the weather would improve. The criticisms of the plan are that it involved a turn at the unusually low height of some 20 feet above the ground, that the aircraft would be travelling faster than usual at that height because of the additional speed necessary to compensate for the extra loading imposed by the turn and that there would be difficulty in ensuring alignment of the aircraft with the runway on completion of the turn.

Notwithstanding the existence of the limiting factors already mentioned, and bearing in mind the fact that there would have been ample opportunity to take overshoot procedure if the aircraft had not been able to touch down at about the planned point, the Board finds that the captain acted reasonably in embarking on his plan.

The question remains whether his conduct was at fault in the course of carrying out the plan.

The first impact took place some 10 feet to the east of the taxiway that runs at right angles to the threshold of Runway 27, and about 100 feet to the north of the centre line of the Runway. That the impact was severe is undoubted, for, in addition to the damage caused to the aircraft, some of the marks made by the blades of the starboard propeller in the hardened surface of the taxiway were 2 inches in depth and the distance over which the marks extended was about 140 feet. It was undoubtedly the starboard wheel of the aircraft that first struck the ground. It is clear from the mark made by the starboard wheel, the mark made by the port wheel, and also the line of marks made by the blades of the starboard propeller that the line in which the aircraft was travelling was the line planned by the captain to bring the aircraft over the centre of the runway at about the anticipated point. The fault in the position of the aircraft was its altitude and it is necessary to consider how this loss of altitude was caused.

At or about the time of the first impact there was a great deal of rain about. All the witnesses who spoke of this time said that there was heavy rain but could not say whether or not there was any rain at or about the threshold of Runway 27. The evidence of the captain is that, as he made his approach in accordance with his plan, he could, when the aircraft was at an altitude of about 300 feet, see the whole of Runway 27. He was at this time in rain but not particularly heavy rain and with the aid of the windscreen wipers, which were working at the maximum pace, he was able to see clearly. At this stage there was nothing to suggest to him that he would not be able to carry out his plan. He said that, as he continued his approach, there was a sudden downpour of rain which obscured his view completely in spite of the fact that the windscreen wipers were working at maximum rate. At about the same time, he felt a surge of the aircraft downwards which he sought to correct, and at the same moment started to take overshoot procedure. As he was in the course of opening the throttles the starboard wheel struck the ground. The captain said that the surge was not sudden and would be unlikely to be noticed by anyone other than the pilot. There is thus no evidence to support him on this point. There is no direct evidence to support his statement that there was a sudden fall of rain which obscured his view. The first officer was at the time engaged in setting additional flap that had been called for and was watching the flap indicator. The radio officer was facing forward but because of his position was unable to see what the visibility was through that part of the windscreen covered by the wipers. However, he supports the captain's statement that immediately before impact the latter was in the course of opening the throttles because he saw this happening. The first officer also supports the captain's evidence because, when he looked up after the impact, he was unable to see through the windscreen at all. Observers on the ground, who were at or in the airport buildings, were able to see the aircraft throughout this period, but the evidence showed that very heavy rain completely obscures visibility through the windscreen of a Viking, in spite of the use of windscreen wipers.

The Board accepts it as established that very shortly before the first impact there was a sudden unexpected fall of rain which completely obliterated any view that the captain had and also that the clear view panel was in the circumstances of no assistance to him because of the angle of the aircraft in relation to the runway.

As regards the suggestion by the captain that the surge downwards was caused as a result of a down current produced by the sudden fall of heavy rain, the Board finds that this is a possible explanation for it, but considers that there is another possible explanation for the loss of altitude. It would seem that a sudden loss of vision might well result in a momentary disorientation, of which the pilot would be temporarily oblivious, causing the aircraft to lose height.

The Board can go no further than to say that the loss of height was probably occasioned either by the downdraft suggested by the captain or by the momentary disorientation already referred to, or by a combination of both. It is apparent that the unexpected occurrence was sudden and that as it occurred at a critical height the captain had insufficient time to take effective corrective action. It is clear, moreover, that all this occurred in a very short space of time.

Nearly every witness who saw the aircraft approaching the point at which it first struck the ground considered that it did not appear to be coming in as Vikings usually did; some thought that the angle of descent was steeper, and some thought that it was travelling faster than usual. There is no doubt that the aircraft was in an unusual position because at the time it struck the ground it was flying into the ground and was not "flaring out" as it would normally be doing. It was also in the position that its starboard wing was lower than its port wing. It was undoubtedly travelling faster than usual. This was by design because the captain considered that it was advisable to do so having regard to the fact that he was in the course of turning. The explanation for the evidence of these witnesses would appear to be that the approach was from an unusual angle, that it was made on a turn and that there was no "flare-out".

The fact that the starboard engine was damaged was unknown to the captain but he very soon discovered, having opened the throttles and started to climb, that the starboard engine was useless; he therefore took the action necessary to feather the propeller and to close the throttle. It is not established whether the propeller actually feathered, but it seems unlikely that this occurred because of the damage that had been sustained. At this time the speed had dropped to about 85 knots which is less than the minimum speed required for effective control of the aircraft. The drag from the starboard propeller and the power being delivered by the port engine caused the aircraft to yaw uncontrollably to starboard notwithstanding the full application of rudder and aileron to oppose the turn. In these circumstances the captain decided to endeavour to crash land the aircraft. His impression was that he selected the undercarriage up for this purpose. After the aircraft came to rest the lever was, however, in the down position. He is unable to explain this beyond saying that he is certain that he tried to raise the undercarriage but that in the heat of the moment he may not have realised that he had not done so. It is doubtful whether his airspeed at the time exceeded 85 knots, in which case a safety device fitted to the aircraft would not permit the undercarriage to be raised unless a trip switch were operated. The captain is certain that he did not operate the trip switch because that involved the use of two hands, the right hand on the undercarriage operating lever and the left hand on the trip switch. He is quite clear that he did not use both hands for this purpose. In the result he crash landed the aircraft taking all appropriate action to do so. The petrol and oil cut-off levers were thrown out on touching the ground and as the aircraft came to rest the fixed fire extinguishers fitted close to the engines were set off.

Probable Cause

The accident was caused not by mechanical defect of the aircraft nor by the conduct of the pilot but by a combination of unusual and unexpected circumstances. Had the sudden downpour of rain not taken place at the critical moment, it is almost certain that no accident would have occurred.

Observations and Recommendations

There is little margin, when the grass portion of Runway 09/27 is unserviceable for aircraft landing, especially in a westerly direction, since the runway slopes slightly downwards from east to west and there is little over-run at the western end.

The Board recommends that the hardened runway be extended towards the east in order to provide a greater length of all weather surface if this airport is to be used indefinitely for Viking aircraft. The qualification is made because the Board is aware of proposals to use a different airport at or near Salisbury in substitution for Belvedere as the principal airport for the use of the aircraft of airline operators. But this point was not dealt with in the evidence and therefore no accurate details of the position were made known. In these circumstances, the expense of extending the hardened runway may not be justified. The recommendation must therefore be considered in the light of these factors.

Another approach to this problem would be to limit the operational weights of Viking aircraft when the grassed portion of the runway is unserviceable and high atmospheric temperatures prevail.

Whatever may be the ultimate decision in this connection, the question of the serviceability or otherwise of the grassed portion of the runway during wet weather remains. At present, there is no satisfactory means of determining its serviceability and no procedure is laid down as to when and how this is to be done. If it is deemed unserviceable, a radio message to this effect is sent out to aircraft but no visual signs are placed on the ground to indicate the unserviceable parts. It is, therefore, recommended that a proper procedure be laid down for the determination of the condition of the grassed part of the runway and that, if the whole or part be deemed unserviceable, appropriate visual signals be placed on the ground to show this, in addition to the transmission of the information by radio.

Evidence indicated that not all the fire fighting vehicles arrived at the scene of the crashed aircraft, partly due to the unsuitability of the type of some of the vehicles. The evidence also indicated that the replacement of all the present vehicles with vehicles of appropriate type had already been considered and that steps in this direction have already been taken. The Board views with favour these proposals and recommends that this policy be carried out in due course.

There does not appear to be very clear definition of the respective functions of Meteorological Officers and Air Traffic Control Officers in respect of passing meteorological information to aircraft approaching Belvedere when variable weather conditions exist. The Meteorological Officers are mostly on duty inside a building and consequently cannot be expected to be aware of the details of changes in variable weather conditions; the Air Traffic Control Officer, on the other hand, is favourably situated to observe such changes. The Air Traffic Control Officer on duty did not inform the approaching Viking of the existence of the storm over the Warren Hills. This failure to do so probably had no bearing on the events that took place because the storm was seen by both the captain and the first officer. Emphasis must be on the passing of the maximum information about weather to aircraft to enable a planned approach to be made with the greatest possible safety. With this end in view, the Board recommends that the matter of the respective functions of Meteorological Officers and Air traffic Control Officers be investigated and their respective functions be clearly defined.

As has already been indicated the position from which estimates of the base cloud are made is one from which it is impossible to make any proper estimate in the region lying to the east of Runway 27, which is the critical area for aircraft seeking to come in on that runway. Furthermore, estimates of horizontal visibility for use by aircraft so coming in ought to be made from a point nearer the threshold of that runway in order that the observer should have a view comparable with that of the pilot of an aircraft. Accordingly, it is recommended that these observations should be made from a point which will give the observer an opportunity to conform to these criteria.

The evidence indicated that although, strictly speaking, a control zone should have been imposed in the weather conditions which prevailed as the aircraft in question approached the airport, no control zone was imposed by the Air Traffic Control Officer. The absence of the imposition of such a zone had no bearing upon the events that took place because the critical difficulties met by the pilot of the aircraft occurred when the aircraft was less than 400 feet above the aerodrome. Moreover, the Viking in question was the only aircraft approaching Belvedere at the time. Variable weather conditions such as these undoubtedly present great difficulties to those concerned with the control of approaching aircraft.

The question arises whether some provision of a radio aid should not be made which will enable an aircraft approaching in IFR conditions, including "partial IFR", to determine accurately its position in relation to the airport before commencing a descent below the prescribed minimum safety height for the route flown. In the case of this Viking the descent below the route minimum safety height was made on an estimated position. During this descent the aircraft was 3 miles off track when it made a visual fix at Beatrice though, in fact, no danger existed. It is, however, by no means difficult to imagine circumstances in which an aircraft approaching would be uncertain whether it was safe to descend; further, it is not difficult to imagine the danger that might be associated with a descent under those circumstances. This aspect of the matter is put into high relief when it is observed that the minimum safe flight altitude for the route Salisbury/Johannesburg/Salisbury has been laid down by Central African Airways in accordance with section 72(8) (a) (ii) of the Air Navigation Regulations, 1954, as 8 000 feet. The procedure for letting down, using navigation facilities, provides for the let-down to start at "pattern height" of 6 300 feet, that is to say, 1 500 feet above the aerodrome. There is thus no clear definition of the point at which it is safe for an aircraft to descend from 8 000 feet to 6 300 feet, except perhaps that an aircraft could ascertain its position before descending below 8 000 feet by flying at that height over the beacon. This is apparently not as a rule done and, in any event, it would appear to be more desirable that an aircraft should be able to descend to pattern height while approaching the aerodrome. Such a situation would be rectified by the provision of a radio aid to navigation situated in such a way as to enable an aircraft to determine its position accurately in relation to the airport as it approached. This having been done, the aircraft could descend to pattern height without risk. The Board recommends that this matter be investigated, bearing in mind that any aid provided could be designed to be of use in connection with any airport that might in future take the place of Belvedere.

The Board has considered the question whether it would be desirable to provide a radio beacon situated to the west of the runway and aligned with it in order that aircraft coming in on a let-down procedure would be aligned with the runway during the final stages of the let-down and not at approximately right angles to it. The obvious disadvantages of such a procedure are the presence of the Warren Hills and the fact that aircraft would have to come through the gap in bad weather conditions. The provision of such a beacon would involve a complete revision of the existing let-down procedure and a great deal of investigation. If in the fairly near future a new airport is to be substituted for Belvedere it is obvious that such a change is not warranted. On the other hand, the Board recommends that the matter be investigated if Belvedere is to be used indefinitely.

The evidence showed that the New Salisbury Airport which lies within the area of the control zone of Belvedere has a control tower which is not always manned. It would appear that, while there is some co-ordination between the movement of aircraft between the two airports, this co-ordination is somewhat inadequate. It is therefore recommended that this matter should be investigated.

The air traffic control officer on duty at the time of this accident had had considerable experience in his duties and was properly qualified . It emerged, however, that he had been examined to ascertain his capabilities upon a syllabus and by examinations set by the Airport Manager, Belvedere. While it is not suggested that the syllabus and the examination were not completely adequate, it would appear that there should be some uniformity of practice in the matter throughout the Federation, and it is recommended that this should be investigated.

The absence of a complete record of R/T messages passing between Control Tower and Aircraft caused some difficulty in the investigation of the events that led up to the accident now in question because recollections varied as to what was said and the sequence in which messages passed. While it does not appear to be necessary to have a recording device merely because another accident might take place, it is recommended that the question should be investigated whether or not the provision of such a device would be desirable.

MEMORANDUM BY THE MINISTER OF TRANSPORT AND COMMUNICATIONS FEDERATION OF RHODESIA AND NYASALAND

The following are the views of the Government with regard to the recommendations that have been made in this report.

The Airfield

The 1 600 yards of hardened runway at Belvedere are adequate for Viking aircraft, save, perhaps, in the event of take-off in the westerly direction when the 1 000 yards of grass runway at the eastern end of the hardened surface are unserviceable and, at the same time, weather conditons are unfavourable for the take-off. Such a combination of conditions is rare, but when it does occur, the take-off will be deferred or the take-off weight will be restricted. While landing from east to west, the position is that even if the grassed part of the runway is unusable, it is free of obstructions and, therefore, aircraft can land close to the end of the tarmac runway, thus ensuring that the landing run is completed well within the 1 600 yards of tarmac available.

In view of the low incidence of take-offs and landings in the westerly direction at Belvedere, the safety measures applied, and the expected move to the new Salisbury Airport in the near future, the extension of the existing Belvedere hardened runway is not justified. It will be seen that the Board's recommendation in this respect is, in fact, qualified.

No practical method of determining with precision the serviceability of the grass runway is known. Consequently, the practice has been adopted of declaring the entire area unserviceable whenever doubt exists. There is, therefore, no need to display visual signs to distinguish between the serviceable and unserviceable portions.

Meteorological Department

The respective functions of meteorological officers and air traffic control officers are defined under international rules established by the World Meteorological Organization and the International Civil Aviation Organization, and these are implemented in the Federation. Any need for amplification of existing instructions will be examined. In addition, arrangements have been made whereby a meteorological officer will in future be present in all aerodrome control towers when aircraft are approaching in marginal weather conditions.

Radio Aids to Navigation

A radio beacon has been in operation at Norton since January of this year, one purpose of which is to enable aircraft, before commencing a descent, to determine their position accurately whenever this cannot be done by visual reference to the ground. However, a descent to 6 300 feet from an estimated position is perfectly safe at Salisbury where the obstruction level is well below this height.

The life of Belvedere is limited. The present let-down system has been established as perfectly safe and adequate provided aircraft do not attempt to approach in conditions below the approved weather minima of 2 000 yards horizontal visibility, and a 400 foot cloud base. In view of the surrounds of this airport it would be extremely costly, if at all possible, to provide a let-down system which would be an improvement on the present one. Here, too, the Board's recommendation is qualified.

Air Traffic Control

At the present time, the new Salisbury Airport serves purely as a military air station, and whilst it is available for use by civil aircraft in emergencies, normally, only the R.R.A.F. man the Control Tower while their flying operations are in progress. When this military flying is taking place, proper co-ordination is effected with the Control Tower and Flight Information Centre at Belvedere by direct land line communication. Arrangements also exist whereby during non-flying periods, duty staff at the Military Air Station will render assistance in the event of an emergency landing by a civil aircraft.

Belvedere is the training centre for air traffic control officers in the Federation, and the training syllabus and examinations set by the Airport Manager there are based on international requirements in respect of air traffic control procedure. The syllabus is, in fact, compiled in conjunction with other members of the Civil Aviation Department, and is approved by the Director. Training is uniform throughout the Federation.

Tape recording equipment for radio telephone messages will be installed at the new Salisbury Airport, but it is not considered justifiable at the other airports in the Federation at the present time.

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ICAO Ref: AR/388

No. 14

American Airlines, Inc. Convair 240 aircraft, crashed near Springfield, Missouri, on 20 March 1955. Civil Aeronautics Board (USA) Accident Investigation Report No. SA-305, File No. 1-0038, released 22 September 1955

Circumstances

The flight took off from Newark, New Jersey, at 1245 hours Central Standard Time en route to Tulsa, Oklahoma, with several intermediate stops including Chicago, Illinois, and St. Louis and Springfield, Missouri, carrying 32 passengers and 3 crew. Due to low ceiling and visibility forecast for Springfield the flight was delayed over an hour at St. Louis in order that another alternate airport (Gage, Oklahoma) could be selected and additional fuel might be taken on in case Springfield had to be overflown. The IFR (Instrument Flight Rules) clearance issued by ARTC (Air Route Traffic Control) specified in part that the flight was cleared to the Springfield VOR (Visual Omni Range) Station via Victor Airway 14 and was to maintain 4 000 feet mean sea level. At 2218 hours the aircraft contacted Springfield Approach Control and after receiving the weather report advised that its estimated time of arrival at Springfield was 2233 hours. The approach controller transmitted the 2208 weather observation to the flight and it was cleared for a standard range approach and instructed to report when over the range station and also when starting the procedure turn. The flight informed the controller it would make a circling approach to Runway 31 and at 2234 reported "...over the Omni at 34, proceeding to the field." Approximately two minutes later, while proceeding directly from the VOR station toward the airport, not executing the CAA approved VOR instrument approach procedure, the aircraft descended and struck the ground 1-1/4 miles north-northwest of the Municipal Airport. Eleven of the passengers and 2 crew members were fatally injured.

Investigation and Evidence

Impact was in an open muddy field at an altitude of 1 250 feet mean sea level while the aircraft was heading 220 degrees magnetic. Evidence indicated that the aircraft was descending about 1 600 feet per minute prior to impact. The major portion of the aircraft came to rest in an upright position on a heading of 240 degrees. It was determined that the landing gear was fully retracted and the flaps were extended about 19 degrees.

Impact forces were severe and high vertical and fore and aft forces were developed during the initial ground contact. These forces broke the nose section from the fuselage and crushed the lower structure upward to the floor support beams. Vertical compression buckling was induced in areas which did not contact the ground and deflected the sides of the fuselage outward. The right wing was separated and destroyed by the impact and an explosion which occurred in the fuel tank area. The left wing was torn off and came to rest relatively intact in an inverted position several yards ahead of the main wreckage. The passenger seats, with the exception of the last row, were torn free and thrown forward. Examination of this wreckage, although severely damaged, disclosed no evidence of fatigue cracking, structural failure, or malfunctioning controls prior to impact.

Both engines were torn out and broken into several sections by impact. Examination of their combustion chambers, oil pumps, oil screens, front and rear accessory drives and bushings, and interiors of the power sections failed to disclose evidence of malfunction or failure before impact. The propeller blade angles at impact were in the positive pitch range and both were positioned about 40 degrees. This indicated that both engines were developing appreciable power in nearly equal amounts. The amounts were normal for the Convair while circling to land.

The radio and navigational equipment was examined and although damaged failed to disclose evidence of malfunction or failure before impact. Ground navigational facilities, examined immediately after the accident, were operating within accepted tolerances. The aircraft altimeters were found set and indicating correctly.*

* American Airlines' procedure for setting the two aircraft altimeters indicates to the crew the aircraft altitude both above mean sea level and above the airport of next landing. The captain's is set to read altitude above the airport and the first officer's to mean sea level.

Supporting the physical examination of the structure, powerplants, propellers, and controls were the several radio contacts made by the flight, which were normal and indicated no difficulty aboard the aircraft.

Radar impressions of the flight were included on photographs taken by an Air Defense Radar Installation near Springfield while compiling a radar picture of the weather situation and its progress. The radar plotting indicated that the average groundspeed of the aircraft after passing the VOR station was within the normal range for Convair aircraft while approaching an airport before making a circling approach.

There are three CAA approved instrument approach procedures for the Springfield Airport - the low frequency range approach, the VOR approach, and an ADF (Automatic Direction Finder) approach. The VOR facility was being used in this case. The VOR instrument approach procedure associated with a flight from St. Louis requires that the aircraft turn right upon reaching the VOR and establish an outbound track of 13 degrees. It then requires a procedure turn and an inbound track of 193 degrees. This track, if maintained, will pass over the station again and intersect the threshold position of Runway 19, which is 7.8 statute miles from the station. Minimum en route altitude from Vichy is 2 600 feet m.s.l. Minimum altitudes during the approach are 2 600 feet m.s.l. over the station, 2 300 m.s.l. during the procedure turn, and 1 867 m.s.l. (600 feet above the airport) when over the station inbound to the airport. The circling minimum weather conditions for American Airlines' Convair flights are: Ceiling 500 feet and visibility 2 miles. The airport field elevation is 1 267 feet mean sea level.

During the public hearing a company witness stated that under the circumstances he believed the approach path depicted by the radar plots was in accord with the approved VOR instrument approach procedure. He stated that considering the degree of turn to the airport from Airway 14, the distance involved, and the en route altitude compared to the specified minimum altitude for the airport, the approach as executed was a safe and reasonable interpretation of the VOR instrument approach procedure. He believed the approach was within the limitations imposed by the Civil Aeronautics Administration and American Airlines.

A Representative of the CAA, an Air Carrier Safety Agent assigned to the carrier involved, stated that the approach indicated by the radar track of the flight was not consistent with the requirements of the VOR instrument approach procedure. He stated that the full procedure for Springfield, considering the facilities, is expected to be completed when instrument conditions exist. He said that the purpose of the outbound track, the procedure turn, and the inbound track is to permit a flight to descend to a lower safe altitude within a known area. These permit the flight crew to establish a track to the airport with a facility check after that track has been established and also afford the crew more time to complete final cockpit checks before visual contact is made for landing. The testimony of this witness was based upon Civil Air Regulations, Sections 60.46 and 40.364.*

The captain, because of severe injuries, was unable to remember any of the events of the flight. He stated, however, that his interpretation of the instrument approach would not permit eliminating the outbound heading, procedure turn, and the inbound track if instrument conditions prevailed.

During the entire flight and until the instant of impact there was no warning of the crash or indication of an emergency declared in the passenger cabin.

Two passengers stated the flight between St. Louis and Springfield was mostly above or between cloud layers and that during the latter part of the trip the engine power sound lessened, and the aircraft descended and entered the

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* 60.46 Instrument Approach Procedure. When instrument letdown is necessary, a standard instrument approach procedure specifically authorized by the Administrator shall be used, unless:

a) A different instrument approach procedure specifically authorized by the Administrator is used, or

b) A different instrument approach procedure is authorized by Air Traffic Control for the particular approach, provided such authorization is issued in accordance with procedures approved by the Administrator.

40.364 When an instrument approach is necessary, the instrument approach procedures and weather minimum authorized in the operations specifications shall be adhered to.

clouds which at times blotted out their view of the wing light. They said that until the aircraft descended below the clouds they could not see any lights on the ground. Several passengers said they saw widely scattered ground lights through a light mist shortly before the impact. One, seated on the left, stated he saw lights to his left in the general area of the airport one or two minutes before the crash.

Ground witnesses who saw or heard the aircraft believed it was low compared to other flights and all believed the sound of the engines was normal.

After radio contact was established with Springfield Approach Control the flight was given an approach clearance which required it to report upon reaching the VOR station and when it began the procedure turn. Subsequent to this clearance the flight received another which was "cleared for an approach". This clearance, in effect, notified the flight there was no other traffic. It also voided the reporting requirements and permitted the flight to make any approach it desired. The clearance, however, did not permit or intend to permit any other approach except the full instrument approach if instrument conditions prevailed. From the flight's estimate to the VOR station, its report over the station, the time of the accident, and the radar plot it is clear the complete instrument approach was not made.

Weather conditions in the Springfield area strongly indicate the top of the overcast was between 3 000 and 4 000 feet mean sea level and the overcast at the airport was without breaks with its base about 500 feet above the surface. Analysis of the situation also suggests that these conditions prevailed in the area of the VOR station. It is, therefore, believed that the entire prescribed instrument procedures should have been made. The Board nevertheless recognizes the possibility that the flight may have established visual contact with the surface of the VOR station and proceeded visually toward the airport. If the crew did establish visual contact at the minimum en-route altitude before or upon reaching the station it was permissible for the flight to have proceeded visually to the airport without following the instrument approach procedure. This action would also have been permitted under an emergency condition; however, based on all the available evidence it is believed that no emergency occurred.

From the testimony of several eyewitnesses it is apparent that the aircraft was nearly on the 193-degree inbound radial to the airport from the Omni and that it was flown below the overcast for several miles before it struck the ground. During this time the aircraft was in the same relative positions over the ground required by the approved VOR instrument approach procedure. From the evidence available during this segment the aircraft was also apparently in the normal configuration for an approach to the airport before circling to land. The height of the base of the overcast and the distance involved indicate the rate of descent of the aircraft was not high during most of this distance. However, just prior to impact the aircraft was descending about 1 600 feet per minute.

Evidence indicates that the crew was not aware the aircraft was so low and that it was descending. It is probable that at this time the pilots were devoting their attention outside the cockpit and possibly toward the distant airport lights while flying over flat, dark, and sparsely lighted terrain in somewhat restricted visibility. An important psychological factor enters into an approach under these conditions and has been credited a factor in other accidents or near accidents.* The effect of such conditions has given flight crews an erroneous impression of altitude and/or the illusion that the aircraft is flying horizontally with respect to a distant light or group of lights when in reality the nose attitude of the aircraft is up or down.

The likelihood of this situation relative to the flight cannot be positively determined because the primary evidence of it would be provided by the crew's testimony, which was unavailable to the Board. However, the similarity of the circumstances of this and other occurrences lends credence to this explanation.

Probable Cause

The probable cause of this accident was a descent to the ground while approaching the airport caused by the crew's inattention to their flight instruments and a possible sensory illusion giving them an erroneous impression of the attitude of the aircraft.

* 1. Reference "The Sensory Illusion of Pilots," by P.P. Cocquyt. (See ICAO Circular 38-AN/33 - Aircraft Accident Digest No. 4).

2. CAB Accident Investigation Reports, SA-252 and SA-277.

No. 15

British European Airways Corporation, Vickers Viscount, G-AMOL, crashed on landing at Copenhagen Airport, Kastrup, Denmark, on 25 March 1955. Report of Directorate of Civil Aviation, Copenhagen, released 27 May 1955.

Circumstances

The aircraft departed from London at 1518 hours on a scheduled flight - London/Copenhagen/Stockholm - carrying a crew of 5 and 33 passengers. The flight to holding position over the Beacon Saltholm Flak (SF) at Kastrup was carried out according to schedule. During a 15-minute holding period the aircraft was cleared through different heights down to 1 500 feet. The ILS approach to Runway 22 was made by the captain. At 350 - 400 feet he sighted the runway lights and performed the remaining part of the landing procedure with visual reference to the ground. The aircraft was then to the left of the runway and as the captain attempted to manoeuvre it into the centre line of the runway the aircraft drifted, touched down and proceeding in a direction of 240 degrees (runway direction = 223 degrees) wheeled outside the boundary of the runway, collided with a snowbank and finally came to a standstill at the northern edge of the runway. No persons were killed or injured, however, the aircraft was substantially damaged.

Investigation and Evidence

No evidence was found of faulty material or any indication of fatigue fracture.

A thorough examination was not made of the load acting on the nose gear/port main gear, due to which loading they were torn off. It is deemed, however, that the dimensioning of the undercarriage does not permit the heavy side load to which it was subjected.

The chart of the force and direction of the wind for the period in question shows a marked stability.

According to ATC, the noon and afternoon traffic handled on the day in question took place on Runway 12. In the course of the afternoon the wind shifted from 170 to 140 degrees, its force varying between 8 and 12 knots. The weather deteriorated, visibility decreased from 7 km to between 2 and 1.3 km and the height of cloud base from 150 metres to between 90 and 60 metres. Under the prevailing wind conditions it would have been reasonable to make the approach from the northwest on the ILS for Runway 12. Little by little, however, the aircraft due to land changed to Runway 22, the pilots preferring to use Runway 22, even though the wind there was rather unfavourable. The reason for this action must most likely be sought in the fact that the ILS for Runway 12 had only been officially approved on 14 March 1955 so that the majority of the airline companies operating on the Copenhagen Airport had not at the time of the accident entered this facility in their route manuals. Both the ILS for Runway 22 and the ILS for Runway 12 were serviceable on the day of the accident.

According to statements by captains of other approaching aircraft and the MET Office, vertical and horizontal visibility was variable. One captain reported:

> "I estimate the winds to have been 160/35 knots at 1 500 feet backing and decreasing to 110/20 knots at 200 feet, with a sharp change at 500 feet.
>
> The last part of the approach was especially difficult due to the sudden change in wind velocity giving an approximate 9 degree change of drift, and the change from slight headwind to slight tailwind component."

This varying force of the cross wind during the descent from 1 500 feet must be presumed to explain why the aircraft in question was to the left of Runway 22 when the captain got visual reference to the ground, notwithstanding the wind reported from the ground.

For landings with Viscount, BEA accept a maximum cross wind component of 30 knots. The reported wind, 130°/13 knots, was thus well below what was permissible for a landing on Runway 22.

There was no indication that the BEA weather minima had not been observed.

The information available did not reveal anything to indicate that the ILS for Runway 22 was not working satisfactorily. The procedure prescribed for an ILS approach to Runway 22 was to all appearances applied in the normal way. It was not possible to arrive at an exact position-fixing of the aircraft at the time when the pilots in the cockpit got visual reference to the runway. It was established that the aircraft was to the left of the runway (outside of the lights along the left edge of the runway) at the time in question. This caused the aircraft to make a right turn which, according to two of the passengers, was very steep. During this turn, the aircraft, owing to the prevailing wind, was subjected to a drift to starboard which necessitated a correcting turn to port in order to line up the aircraft with the centre line of Runway 22. In the course of this procedure the port main wheels of the aircraft touched the runway at 495 metres from the threshold of the runway and 23,9 metres from the northern edge of the runway.

It was fully established that the aircraft was set down on the runway in a way deviating from normal procedure.

It was not possible on the information available to give any definite opinion as to whether it was justifiable under the prevailing wind conditions to undertake a landing from the point where the captain obtained visual reference to the runway. There was nothing in the facts brought forward to give any cause for disputing the correctness of the captain's judgment and decision to land.

Probable Cause

The pilot deviated from the normal procedure and failed to bring the aircraft into alignment with the runway from its position at the time when he obtained visual reference to the runway.

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ICAO Ref: AR/363

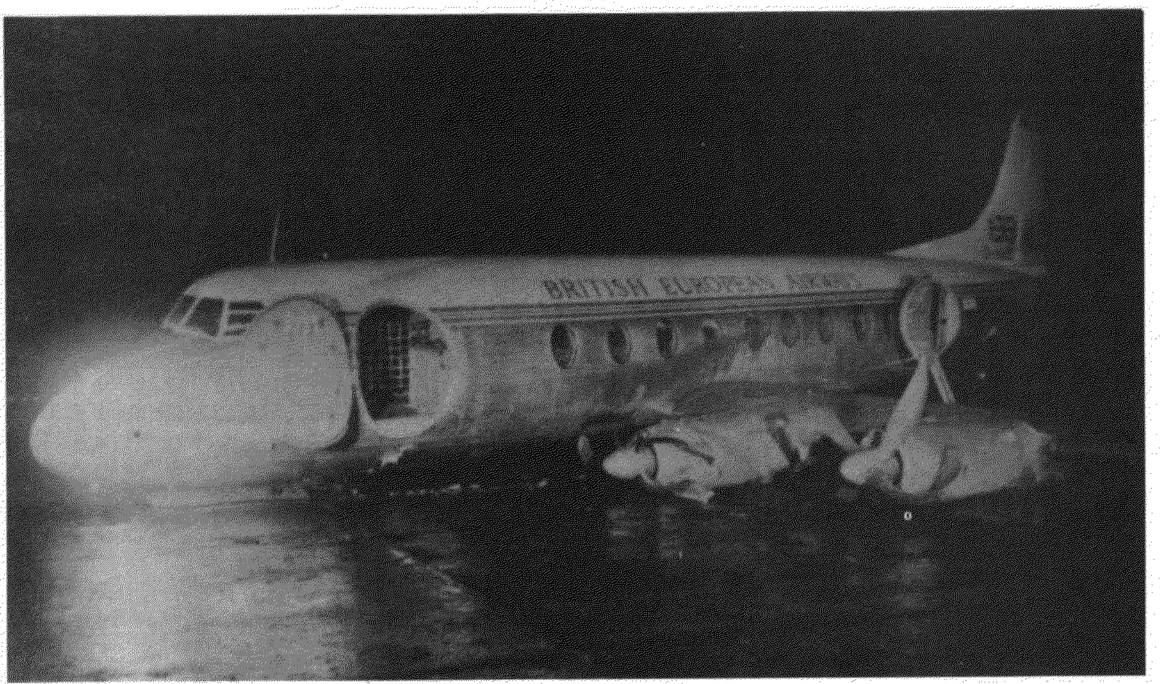

Figure 10

Vickers Viscount G-AMOL at rest on Runway 22 after crash on landing at Copenhagen Airport, Denmark - 25 March 1955.

Figure 11

Impression in snow bank made by nose gear and left main gear wheels.

No. 16

Pan American World Airways, Inc., Boeing 377 aircraft ditched in the Pacific Ocean off the coast of Oregon, on 26 March 1955. Civil Aeronautics Board (U.S.A.) Accident Investigation Report No. SA-304. File No. 1-0039, released 15 November 1955.

Circumstances

The scheduled flight from Seattle-Tacoma, Washington, to Sydney, Australia, departed Seattle-Tacoma Airport at 0815 hours Pacific Standard Time for Portland, Oregon, the first intermediate stop. On board were 13 passengers and 8 crew members and two additional passengers boarded the aircraft at Portland. At 1010 the flight left the ramp at Portland, taking off for Honolulu, Territory of Hawaii at 1021 on an IFR clearance. The flight plan was via Newberg and Newport, Oregon, thence to Honolulu to cruise at 10 000. Forty two minutes after take-off severe vibration occurred while cruising at 10 000 feet under VFR conditions. No. 3 engine and propeller then tore free and fell from the aircraft and control difficulties followed. Effective control was regained after rapid loss of considerable altitude and the aircraft was ditched under control at 1112 hours approximately 35 miles off the Oregon coast under near ideal sea conditions. All 23 occupants were evacuated but four fatalities and one serious injury occurred. The aircraft sank after an estimated 20 minutes, in water about one mile deep.

Investigation and Evidence

Immediately following the loss of No. 3 engine and propeller the captain disconnected the autopilot. Severe buffeting ensued, the nose went down and the aircraft swung to the right sharply. At this point, the emergency "Mayday" signal was broadcast on both VHF and HF. Direct return to Portland was authorized by Seattle Air Route Traffic Control.

Airspeed was about 220 knots and going higher so the captain closed the throttles to keep the airspeed down. He still could not get the nose up and it felt to him as though the elevators were still on automatic pilot. He then tried the elevator trim tab and could not turn it.

After rapid loss of altitude to about 5 000 feet, the captain directed the first officer to assist him with the controls. Their combined efforts finally brought the nose up very rapidly but the aircraft then went into a steep climb. It turned sharply to the right about 180 degrees and, according to the captain, appeared to be on "the verge of a spin." Level attitude was regained by pushing the yoke forward, and by use of the rudder and aileron trim the turn was stopped. At an airspeed of 150 knots, flaps extended 25 degrees, buffeting decreased immediately, however, the aircraft continued to descend rapidly. Attempts to get rated power were futile and at approximately 1106 hours a message was broadcast that ditching was imminent. Contact with the water 6 minutes later was severe, and the impact dislodged life rafts from their storage bins and some seats were torn loose. Evacuation was orderly and the three rafts, although dislodged from their stowage receptacles, were launched without undue delay.

Because the failure originated in the No. 3 engine or propeller, followed very quickly by that power package wrenching free, investigation was aimed at ascertaining the nature of the malfunction and reason for the failure.

Loss of the engine and propeller could have been caused by, (1) failure of the engine mount, (2) sudden stoppage or seizure of the engine, or (3) an unbalanced propeller caused by failure of a blade. Since the engine and propeller could not be recovered there was no opportunity to examine them.

The first possibility - failure of the engine mount - seems unlikely as testimony indicates that when the engine left it took its mount with it leaving nothing forward of the firewall except small parts such as wires and lines.

Regarding the second possibility - that of sudden engine stoppage or seizure - investigation disclosed that there have been no known cases in which an engine has torn free from this model aircraft as a result of sudden stoppage.

The third possibility - an unbalanced propeller - must, therefore, be the cause of the failure. Other blade failures of this propeller-engine combination have produced similar results.

There have been five previous instances of total powerplant separation from like aircraft and one of partial separation. Of these six , two were definitely caused by propeller blade failure, and the remaining four (where engines were not recovered) undoubtedly resulted from the same cause.

During the service life of this propeller, the manufacturer developed modifications and more restrictive inspection and maintenance procedures, all of which were aimed at improving the integrity of the blade. The most recent modification was to nickle-plate the blade surface to minimize service-incurred nicks and gouges. Blades on the PAWA fleet of B-377 aircraft were nickle-plated and maintained in accordance with the manufacturer's latest service instructions.

The investigation of this accident included a study of the results of special inspections that were initiated subsequent to the accident to determine the integrity of service blades. These inspections included X-ray, magnaflux, and detailed visual examinations of blades externally in areas normally not readily accessible, i.e., under rubber fairings. Hitherto this area had not been suspect.

This comprehensive program disclosed nicks and gouges beneath the garter caused during a manufacturing operation following plating. Furthermore, as the program proceeded, a cracked blade, not nickle-plated was found on the aircraft of another carrier. Study of this crack revealed that it resulted from fatigue and that it originated at a corroded area under the rubber fairing.

Until the date of the accident, no cracks had been reported as being found on nickle-plated blades. However, the intensive inspection program revealed three cracked model 2J17 blades that were associated with corrosion and one blade failed from the same cause while undergoing fatigue testing at the factory. The X-ray program revealed one new blade at PAWA cracked beneath the rubber boot. This crack had occurred during blade manufacture but had remained undetected.

Corrosion which is known often to serve as foci for fatigue failure was found on 13.5% of the PAWA-Pacific-Alaska Division blades.

The routine in transit service maintenance on the subject aircraft at Portland consisted of a visual inspection of propellers, landing gear wheels, tires, control surfaces, engine cowling, etc. The inspection was made by two mechanics, who found no imperfections.

The propeller speeds of the aircraft were electrically controllable. Control could be individual or simultaneous. The electrical system employs fuses for the four individual engine circuits and master circuit breakers, both of which are common to all four circuits. One master circuit breaker is in the automatic synchronization circuit and the second one is in the circuit for manually selecting engine r.p.m. In this instance, the tearing away of No. 3 engine obviously created a short in that portion of the system serving No. 3 engine. A subsequent attempt by the flight engineer to increase r.p.m. by use of all switches simultaneously (for rated power) resulted in opening of the master circuit breaker so that the r.p.m. of none of the remaining three engines could be changed. Testimony indicates that the engineer closed the circuit breaker and again attempted unsuccessfully to get simultaneous increase of r.p.m. By this time the aircraft was nearly to the water. The captain stated that the r.p.m. never increased.

The flight engineer attended two classes in 1955 on propeller control circuity. It has been established, however, that the specific contingency that occurred in this accident was never taught in any of these classes, nor had the company issued any specific instructions in regard thereto. Nor could this particular type of situation be approximated precisely in the Dehmel flight engineer simulator course.

The assistant flight engineer, who was occupying the jump seat at the start of the emergency, stood for a while behind the engineer and observed that the aircraft's behaviour was similar to that previously described; i.e. heavy aerodynamic buffeting and difficulty of the captain and copilot in controlling the aircraft. He recalled that the three engines were running smoothly.

At this point the assistant flight engineer suggested to the flight engineer that the pilots would have less difficulty in raising the right wing if he would give them more power from No. 4 engine. The flight engineer replied that he was unable to get any r.p.m. change. The assistant flight engineer then reached over and advanced No. 4 throttle several inches. At this time he observed the altimeter reading to be 600 feet.

The assistant flight engineer then watched the flight engineer actuate the propeller toggle switches, also with no effect, saw him reset the propeller control circuit breakers, and then he went to the passenger cabin for ditching.

The manufacturer of this aircraft had prepared performance curves for three-engine flight of the Boeing 377. These performance curves were based upon actual flight tests and wind tunnel tests of the aircraft to verify flight conditions that existed following the loss of No. 4 engine from a sister ship.* The curves depict the flyability of this model aircraft with No. 3 torn free, as happened in the subject case. They show, assuming landing gear up, flaps extended 25 degrees, an airspeed of 130 knots, which is the airspeed for minimum power requirements, that the aircraft, grossing 131 000 pounds, would have been flyable at take-off power, 2 7000 r.p.m. (131 000 pounds is the computed gross weight after separation of the No. 3 power package.) These deductions by the manufacturer are premised upon there being no structural deformation of the aircraft (as from impact by part or parts at time of failure). If such existed, additional power requirements of unknown degree, would have been imposed.

Testimony also indicates that the subject aircraft would require a weight reduction of 11 000 pounds to reach 120 000 pounds, the weight necessary to sustain level flight in the vicinity of sea level with the power obtainable at 2 040 r.p.m.

The captain testified that prior to extending flaps about one minute before ditching there was not even sufficient time to consider dumping fuel.

The three 20-man life rafts were loaded with 13, 5, and 2 occupants. The nearest raft to any of the three persons who were not rescued was estimated to be 100 feet or more. The heaving lines in all three rafts were 25 feet long.

Two of the life rafts were of one make, the third of another. The first two had less distinct and more limited stenciled instructions for use than had the third. Crew members were acquainted with these instructions but passengers were not and consequently were handicapped in their efforts to assist in rescue efforts.

The first two rafts had small nylon lifelines, extending completely around the outside circumference, to assist in boarding. Passengers stated this cord was not visible after being coated with oil on the water. The third raft had a fabric braided strap which was more readily seen.

These rafts had inflatable center chambers to provide extra buoyance, rigidity, and to prevent occupants from sliding toward the center. The center chambers had to be inflated after launching with a hand pump carried in the raft. Until this was done, occupants slid toward the center because it was depressed and the surface was oil covered. Moreover, the action of occupants slipping toward the center raised the rim which made boarding even more difficult, and prevented those in the raft from helping persons in the water. The equipment bags containing paddles, heaving lines, etc., are outside the raft after inflation, and it is necessary to reach the edge of the raft to recover them.

Both passengers and crew members testified that the evacuation was orderly and conducted in an expeditious manner, with the exception of the difficulty heretofore mentioned.

Pan American had an established Aircraft Emergency Equipment Training Course for crew members. Prior to taking this Emergency Equipment training all flight personnel must have completed a course of aircraft familiarization, including a complete knowledge of the aircraft's doors, emergency exits, etc.

The flight was under surveillance of ground radar. A plot of its observed positions confirms the crew's testimony as to the aircraft's manoeuvres while descending. It shows, specifically, that starting from cruising altitude of 10 000 feet on a southwesterly course, the aircraft made a full 360-degree turn to its right and then turned rather sharply about 180 degrees, also to its right, and was then lost to the radar as it went below 500 feet. (Just prior to ditching.) The direction of ditching was about opposite that of the initial cruising flight; about a full turn and a half to the right was made between the start of the trouble and the ditching; the total elapsed time was recorded as nine minutes.

Analysis

a) Initial failure

The vibration which occurred immediately before No. 3 power package wrenched free followed a familiar pattern of known propeller blade failures. Despite the power package not being recoverable, the Board had no reason to doubt that the trouble was due to blade failure. This belief was based on the known history and subsequent examination of model 2J17 blades.

* See Civil Aeronautics Board Accident Investigation Report, PAWA, between Honolulu and Wake Island, 6 December 1953. (ICAO Circular 39-AN/34-Aircraft Accident Digest No. 5, Report No. 35)

This basic blade is, as demonstrated by its service history, prone to crack at surface irregularities. This fact dictates meticulous inspection during manufacture and while in service.

b) Control difficulty

The Board was unable to determine the reason for the initial control difficulty. It may have been aggravated by an indeterminable irregularity of air flow over the empennage caused by the large, flat plate area of No. 3 firewall. It may also have been due to some deformation of the airframe, particularly of the empennage, caused by some violently slung object or objects from the No. 3 power package. This possibility is strengthened by the difficulty the pilot had in moving the yoke which necessitated his calling on the first officer for assistance. However, no impact at the time of or immediately after the failure was sensed by any occupant.

c) Inability to increase r.p.m. of other three engines

The flight engineer on duty at the time of the accident did not survive. Consequently, the nature of the difficulty that he experienced in attempting to increase engine speeds can only be learned from other testimony. There was no evidence that there was mechanical or electrical impairment of the control system of Nos. 1, 2, and 4 propellers. There had been no trouble of any sort prior to the emergency. In view of the known characteristics of the protective devices in the propeller control circuity, it can be concluded that the inclusion of the No. 3 toggle switch in the simultaneous actuation of the toggle switches was the responsible factor in not getting increased r.p.m.

Effective as of approximately 20 April 1955 the 10 amp. magnetic circuit breakers were replaced by slower acting 5 amp. thermal type circuit breakers in both master circuits and the 5 amp. fuses in the individual circuits were replaced by 2 amp. fuses. This change allows the fuse associated with the malfunctioning circuit to blow and thus leave the remaining circuits unaffected. This modification was detailed in Hamilton Standard Service Bulletin No. 283 entitled, "Synchronizer Toggle Switch Circuit Protection," dated 21 December 1953. Compliance with this bulletin was not mandatory by the CAA although the importance of its text was effectively demonstrated by the circumstances of this accident and it was made mandatory by the CAA on 21 April 1955. It may be pointed out that this modification was also applicable to the carrier's fleet of Douglas DC-6's and had been made on them; it was the company's intent to make similar modifications on its fleet of Boeing 377's as soon as practicable.

d) Nondumping of fuel

Engineering opinion is that the subject aircraft would have been flyable with No. 3 engine gone at 2 040 r.p.m. had its weight been reduced to a gross of 120 000 pounds. This would have required a weight reduction of approximately 11 000 pounds. The maximum rate of fuel flow during dumping at 165 knots indicated is approximately 2 160 pounds per minute. Thus it would have taken slightly more than five minutes to lose 11 000 pounds; from initial difficulty to ditching was approximately nine minutes.

It appears that if fuel dumping could have been started immediately after the failure the aircraft could have been lightened rapidly enough to have been more flyable on the three good engines. However, the captain's time was occupied in attempting to control the aircraft and the problem of the inability to increase r.p.m.

e) Ditching

The aircraft was ditched in daylight under near ideal sea conditions. This was the first ditching of a civil B-377 aircraft, consequently, there was no direct knowledge of its ditching characteristics. The aircraft remained afloat for approximately 20 minutes.

Under these favorable circumstances and with comparatively few passengers (15) it might be anticipated that little difficulty would be experienced in getting everyone aboard life rafts. Such was not the case.

f) Corrective action

The occurrence and investigation of this accident resulted in a number of corrective measures being initiated, among which were:

1) Life rafts were stowed more securely.
2) Additional inspections of the propeller blades were required and the periods between previously required inspections were in some instances shortened.
3) The schedule of installation of propeller blade imbalance detectors which had previously been developed to warn the crew of an impending blade failure was expedited and their use made mandatory by the

CAA as of 30 July 1955.

4) The manufacturer resumed development of a solid aluminum propeller blade for use on B-377 aircraft. The CAB recommended to the CAA that all Hamilton Standard 2J17 hollow steel blades be removed from service on the B-377 aircraft at the earliest possible date consistent with the manufacturer's ability to supply satisfactory blades.

5) The Administrator, by letter dated 28 June 1955, advised operators of the B-377 aircraft as follows:

"As a result of this investigation, and of the investigations conducted following six other accidents or serious incidents, we have concluded that, in the interest of safety, the Hamilton Standard Model 24260 propellers having 2J17 series hollow steel blades presently used on Boeing B-377 aircraft should be removed from service and replaced with propellers having solid metal blades. This shall be done at the earliest possible date consistent with the ability of the propeller manufacturer to supply satisfactory blades."

6) Special inspections as determined to be required were made mandatory by the Administrator, first by telegraphic alerts and subsequently by Airworthiness Directives dated 11 April 1955, 6 June 1955 and 10 October 1955.

Development of solid aluminum alloy blades suitable for use on the Boeing B-377 has been a high priority project with the manufacturer, Hamilton Standard. As of 20 October 1955 four slightly differing experimental propellers have been built. Flight testing is required, and is scheduled for the immediate future, to determine the best of the four.

Probable Cause

The probable cause of this accident was loss of control and inability to maintain altitude following failure of the No. 3 propeller which resulted in wrenching free No. 3 power package.

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ICAO Ref: AR/400

No. 17

Sikorsky S-55 helicopter crashed shortly after taking off from Burgeo, Newfoundland, on 28 March 1955. Canadian Department of Transport Report No. 55-15.

Circumstances

At approximately 1520 NST on 28 March 1955 the Sikorsky S-55 aircraft left Burgeo for St. John's Newfoundland, on a non-scheduled contract flight with one pilot and four passengers on board.

About five minutes after taking off adverse weather conditions were encountered and the pilot decided to return to Burgeo. When within one mile of the north of Burgeo the aircraft was cruising smoothly and normally when a sudden rapid rate of sink developed. The pilot attempted to land the aircraft on the top of a hill but due to the rate of descent the aircraft received substantial damage when it struck the ground in an upright attitude and then toppled over onto its side. Neither the pilot nor passengers were injured.

Investigation and Evidence

There was no evidence of malfunctioning of the engine, airframe or controls. The carburettor heat control was found to be set at about three-quarters of its travel to the full hot position.

The rotor blades did not strike the tail cone immediately following impact indicating that the aircraft landed with the blades at a high coning* angle and that power was still being delivered at the time of impact.

The pilot held a Senior Commercial Pilot Licence which was valid at the time of the accident and had accumulated a total of 6 000 hours of flying experience of which 700 hours had been acquired on helicopters and 150 hours had been obtained on Sikorsky S-55 type of aircraft.

The flow of air at the time of the accident was from the north and it would, therefore, have been flowing from the centre of Newfoundland to the south coast. Under this condition, coastal conditions would be better than those inland. The rugged country in the area of the crash would not only be conducive to very turbulent air and possibly rather sharp downdrafts but also to ragged cloud bases and possibly some moderate snow flurries.

The weather in the afternoon was reported as overcast at 1 500 feet with visibility 6 to 8 miles in haze and occasional light snow. After the take-off, the weather was said to have deteriorated with heavier snow and reduced visibility.

The likelihood of the sudden rapid descent being due to a downdraft is discounted as the aircraft was on the northwest side of the hill and the wind was from the northwest at 15 mph.

The temperature and dewpoint in the area of the accident are not known but Stephenville reported the temperature as 33°F. and the dewpoint at 31°F. and other reporting stations showed a difference of 4° and 5° between the temperature and humidity. Conditions conducive to carburettor icing are, therefore, believed to have been present.

Probable Cause

For reasons that were not conclusively determined, the aircraft developed a rapid rate of descent and struck the ground in an upright attitude during the forced landing that ensued.

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* The average angle between the span axis of a blade or wing of a rotary wing system and a plane perpendicular to the axis of rotation.

No. 18

United Air Lines, Inc., DC-6 aircraft, crashed at MacArthur Field, Islip, N.Y., on 4 April 1955. Civil Aeronautics Board (U.S.A.) Accident Investigation Report No. SA-306, File No. 1-0071, released 4 October 1955.

Circumstances

Under the command of the UAL New York area flight manager the aircraft departed New York International Airport at 1428 hours Eastern Standard Time on a Visual Flight Rules flight plan for an estimated two hour flight in the vicinity of MacArthur Field. Two captains were aboard to receive their periodic instrument proficiency check. On completion of the checks the flight was scheduled to return to La Guardia. The flight reported at 1501 that "they were doing air work around Hempstead" and shortly after 1527 requested approval for an ILS (Instrument Landing System) approach and landing at Islip (MacArthur Field) which were carried out. The controller then cleared the flight to take position on Runway 32 and take-off clearances were transmitted at 1548 and 1550.* Take-off and initial climb appeared normal and the aircraft remained on the runway heading. When about 50 feet high the right wing lowered and the aircraft started turning to the right as the landing gear was retracting. The climbing turn was continued and the degree of bank increased to approximately vertical by the time the heading changed about 90 degrees and the aircraft had attained an estimated altitude of 150 feet. The nose dropped sharply and the aircraft dived into the ground, cartwheeled and came to rest right side up. All three occupants were killed and intense fire consumed a large portion of the wreckage in spite of prompt arrival of fire fighting equipment.

Investigation and Evidence

The MacArthur weather observation at 1532 hours showed scattered clouds at 20 000 feet, broken clouds at 25 000; visibility over 15 miles; temperature 53; dewpoint 30; wind NNW at 20 knots; gusts to 30 knots.

The wreckage was quite localized. The main portion was 173 feet from the east edge of Runway 32 and 321 feet from the north edge of Runway 24, about 1 300 feet from where it became airborne. Forward of the front cabin bulkhead, the fuselage structure was destroyed, but the seat belts held.

Early in the investigation, the general integrity of the fuselage, wing, and control surfaces was the subject of careful examination to determine if any malfunction or failure occurred during take-off. No malfunction or failure was indicated by these examinations. The landing gear was retracted at impact and the flaps were extended 15 to 20 degrees (normal for take-off). The automatic pilot was disengaged. All trim tabs were in place on their hinges and no evidence of failure or malfunctioning was noted. The gust lock was disengaged, and all mixture controls were found in auto rich; these positions were normal for take-off. No evidence of malfunction or failure in any of the flight control systems was found.

No evidence of failure in operation was found in any of the engine wreckage. Examination of the propellers indicated that each engine was developing power at impact, though the degree of power output could not be ascertained.

The propeller governors were positioned for take-off r.p.m. No. 4 propeller was rotating in its normal direction at impact but in reverse pitch. The No. 4 propeller shim plates showed that it was in full reverse pitch, or minus eight degrees. Nos. 1, 2, and 3 propellers were found at 34 degrees positive pitch, normal for take-off. Examination of all four propellers disclosed no evidence of faulty operation.

Examination of all electrical units concerned with control of No. 4 propeller disclosed no evidence of operational malfunction or failure.

* It is the custom of UAL pilots on check flights to make a final check of significant items after taking position, before starting a simulated instrument take-off.

The propellers of the DC-6 aircraft may be used to provide reverse thrust for braking while the aircraft is on the ground. Propeller reversal is initiated by retarding the throttles aft of the forward idle position at which time an electrical control system is activated causing the blades of the propellers to rotate within their hubs to a position wherein reverse thrust is developed. The extent of engine power and reverse thrust developed is in proportion to the extent of rearward throttle movement. The propellers are unreversed and forward thrust is restored by returning the throttles to the forward idle position or beyond.

While the aircraft is airborne a throttle latch mechanism prevents inadvertent throttle movement aft of the forward idle position and thus prevents unwanted reversal. Operation of the throttle latch is controlled by switches, on the landing gear struts, that close when the aircraft's weight is on the landing gear. This action energizes a solenoid which in turn releases the throttle latch. At the same time the reverse warning flag swings up into view on the control pedestal to show that the latch is out of the way. Mechanically linked to the solenoid, this red metal flag may be raised manually by the crew to operate the latch should the solenoid fail to operate.

When the aircraft becomes airborne the strut switches open and the solenoid becomes de-energized. The latch returns to the locked position and the flag swings down out of sight.

Approximately three years ago United Air Lines, concerned over the possibility of an unwanted inflight propeller reversal due to an electrical malfunction, modified the propeller control circuits of its DC-6 fleet. This modification results in the automatic removal of electrical power from the circuits controlling propeller reversal whenever the aircraft is airborne. Electrical power is restored to these circuits when the aircraft is on the ground. Removal and restoration of electrical power is accomplished automatically through the addition of a relay (known as the H-relay) controlled by switches which are in turn actuated by the throttle latch solenoid. The propeller control circuit of the subject aircraft had been so modified.

Investigation disclosed that once a propeller starts into reverse position it need not cycle completely but can be unreversed from any negative blade angle. Should the propeller become reversed due to movement of the throttle rearward past the forward idle position, while the aircraft is on the take-off run and, should the aircraft then become airborne in this configuration, the propeller may be unreversed by (1) feathering or (2) lifting the reverse warning flag and advancing the throttle. Raising the flag serves the same function as the landing gear switch when the aircraft is on the ground; i.e. the reverse control system of the propeller is again energized permitting unreversal to take place. If the flag is not lifted when the throttle is moved forward the blades will remain in reverse pitch and the amount of reverse thrust developed will depend upon the amount of throttle applied.

Within a few days following this accident UAL conducted a series of flight tests to further investigate, among other things, the effects of a reversed outboard propeller upon the handling characteristics of a DC-6 at low airspeeds.

These tests indicated, among other things, that in the take-off configuration with METO power or higher on No. 1, No. 2, and No. 3 engines, the aircraft almost immediately became uncontrollable when full power was applied in reverse on No. 4 engine and the aircraft speed was 100 knots or less. In this test the roll was delayed for a short time by using full opposite aileron. The violent yawing continued, however, with an attendant loss of airspeed, and within a few seconds a violent roll and pitch developed. The resulting aircraft manoeuvre closely approximated the manoeuvre which the aircraft made.

One of the most significant points developed during the tests related to the positioning of the throttle following an unintentional displacement of the throttle into the reverse range. The tests confirmed the fact that if the throttle is moved into the reverse range during a take-off run, moving the throttle back into the forward thrust range after becoming airborne will not bring the propeller out of reverse but will only result in increased thrust power. This follows since, as described earlier, the reversing circuity is de-energized upon becoming airborne, and the propeller remains in the reverse range, in which position it was placed while on the ground. Unreversing can only be accomplished under this condition by depressing the feathering button or by raising the reverse warning flag and advancing the throttle.

In the investigation, computations were made to determine what the V_1 and V_2 speeds would have been for the aircraft at the time of take-off.* This brought out that the V_1 speed was approximately 80 knots and the V_2 speed approximately 92 knots. The take-off distance, as measured, showed that the aircraft became airborne at about V_2. Witnesses stated that the take-off appeared normal in all respects.

UAL's instrument proficiency check procedures were studied by Board investigators, and the sequence in which the check pilot usually introduced the various check items was ascertained from persons familiar with his check technique. It was found that he consistently gave airwork items, a radio range problem, and an ILS approach and initial landing at MacArthur, in that order, and conscientiously followed UAL's thorough check procedures. When he was checking two captains, he would usually give both of them the airwork and range problem before the ILS approach was made. The pilot who made the landing at MacArthur would then be told to make an instrument take-off and advised that he would be given a simulated failure of an outboard engine on take-off. After this was accomplished they would change seats in the air and the other pilot would then be checked on his ILS approach and landing, and on his instrument take-off, with a simulated engine failure.

Company instructions specify that the simulated engine failure will be accomplished by reducing power to zero thrust. This is about 1 200 r.p.m., or 300 r.p.m. more than forward idle. In testimony interpreting flight manual instructions on when the power reduction is to be initiated, UAL's director of flying stated that the power reduction will be made in the vicinity of and following V_2. The manager of flight operations for the New York area, the immediate superior of the check pilot aboard the aircraft, further advised that the throttle reduction is started on the ground and zero thrust position is reached shortly after becoming airborne. Climb should be made at V_2. At least three seconds are to be taken in retarding the throttle steadily and positively; this is to prevent snapping or chopping the throttle back, with attendant difficulty in maintaining control of the aircraft. On a check flight shortly before the accident, a CAA Aviation Safety Agent noted that the check pilot took five or six seconds to retard the throttle to zero thrust in a positive and deliberate manner.

The company also has instructions that the check pilot will consider several factors, such as wind conditions, location of buildings on the airport, and the proximity of congested areas near the airport, in selection of the outboard engine on which he will simulate failure. In this case, No. 4 engine was the proper one for the simulated failure.

The UAL manager of flight operations for the New York area testified that the check pilot would logically have given an instrument take-off and simulated engine failure at this point in the check.

Following acquisition of DC-7 equipment and favorable operating experience with the sequence gate latch (or Martin bar) on those aircraft, UAL decided to equip its DC-6 and DC-6B aircraft with the device. In principle, it consists of a bar placed across the throttles at the idle position. It may be moved out of the way by the pilot when he wishes to pull the throttles back into reverse; when in position, it is impossible to pull the throttles into reverse. Orders were placed for the Martin bar kits several months prior to this accident and the first DC-6 was modified about a week before the accident occurred. UAL expects to have its DC-6 and DC-6B aircraft modified with the Martin bar by February 1956. A UAL engineer testified that although the present propeller control system has functioned quite satisfactorily, the mechanical lock feature of the Martin bar (actuated by the pilot) should make it a more reliable and safer device than the previous installation (as in this aircraft), with its numerous switches, relays, and automatic operation.

Reverse thrust indicator lights were not installed on the aircraft. At the time of the accident a program was in being to install them on UAL DC-6 and DC-6B aircraft. The light comes on as warning to the pilot that a propeller is reversing when the propeller, in the UAL installations, passes the zero degree blade angle.

The flight experiments showed that at take-off configuration and airspeed, the aircraft will become uncontrollable with an outboard propeller in reverse pitch and its engine operating at full power. Control will be lost so quickly that there is little, if anything, that

* V_1 - Critical engine failure speed, with adequate control to permit continuance of take-off.

V_2 - Minimum take-off safety speed, permitting a specified rate of climb.

the pilot can do if it occurs at low altitude. He must recognize what is occurring, analyze it, and take action to unreverse in a very limited amount of time. It is doubtful that unreversing could have been accomplished in this instance before control was lost. Owing to the time element, it is also questionable that propeller reversing warning lights would have been of any aid in this instance.

The tests brought out that if the throttle of the reversed propeller is at either forward or reverse idle, the engine will stall when the aircraft is airborne. There was evidence that the No. 4 engine was running at impact. The tests also showed that in order to approximate a flight path similar to that of the aircraft, full reverse power was required on No. 4 engine (with the propeller in reverse), and the other three engines developing METO power. Further, it would be a natural reaction for the pilot to move the throttle from the reverse range in an effort to unreverse. However, if the reverse warning flag were not lifted, additional reverse power would continue to be delivered. This evidence leads to the conclusion that the throttle was in some position other than idle and an undetermined amount of reverse thrust was being delivered.

The reverse pitch position of the No. 4 propeller could have been the result of (1) failure or malfunction in the propeller control system, or (2) unintentional action by the check pilot in retarding the throttle too far just before becoming airborne.

Examination of all relays, switches and other components of the electrical system of No. 4 propeller failed to disclose any evidence of operational failure or malfunction. It is reasonable to conclude, therefore, that propeller reversal did not occur as a result of electrical system failure or malfunction.

Investigation showed several things which indicate an instrument take-off and simulation of engine failure. In accordance with company requirements, No. 4 was the proper engine to select for the simulated failure; this was the logical point in the check to give these two items; and the short delay at the end of the runway coincided with the practice of making a final check of all items before an instrument take-off. An instrument take-off would normally be followed by a simulated engine failure; had an instrument take-off not been made, there might be some question that a simulated engine failure was given. These things, plus the fact that examination of the propeller control system produced nothing indicating malfunction, make it more probable that the pilot unintentionally brought the throttle too far back rather than a malfunction having occurred.

The Martin bar, or sequence gate latch kits were being delivered to UAL at the time of this accident, and installation was proceeding as fast as deliveries could be made. UAL's decision to install the Martin bar was predicated on its belief that the device was a simpler and more positive means of reducing the possibility of unwanted reversals. Recognizing these desirable features, and on the basis of service experience, the CAA on 29 August 1955, issued Airworthiness Directive 55-18-2 which required that DC-6 and DC-6B aircraft (among others) be equipped with the sequence gate latch, or equivalent, by 1 January 1957.

It should be noted that the circumstances of this accident were entirely peculiar to pilot proficiency testing and would not occur in scheduled operation, for the reason that a throttle would not be retarded in scheduled operation to simulate engine failure. To do so requires considerable rearward movement of the throttle, and normal power reductions fall far short of this amount of retardation.

Probable Cause

The probable cause of this accident was unintentional movement of No. 4 throttle into the reverse range just before breaking ground, with the other three engines operating at high power output, which resulted in the aircraft very quickly becoming uncontrollable once airborne.

Fire Aspects (Excerpts from NFPA Special Aircraft Accident Bulletin, Series 1955: No. 2)

Fire extinguishment progress was painfully slow in this accident because

1) the fuel tanks ruptured at impact;

2) the flame spread was unimpeded and "raked the fuselage" (with magnesium complicating the fire control efforts);

3) fire equipment response was delayed by terrain conditions.

Response to the accident by fire apparatus of the Airport (Sperry Fire Department) was commenced immediately as the control tower gave the alarm promptly. The first units reached the accident site in approximately 1-1/2 minutes; a very severe fire existed at this time. The site was visible by flame and smoke but the land on which the aircraft came to rest was marshy and extremely muddy. Heavy brush covered the field and was ignited in the immediate area. A drainage ditch blocked the closest approach route.

The bogging down of the vehicles on approaching the accident site highlights one of the worst problems in designing adequate "crash" equipment. There is always the desire to hold cost down to a minimum by buying a standard chassis with conventional truck drive, gears and tires. The performance recommendations for these vehicles, however, require that very special attention be given to acceleration, speed, traction and flotation to assure that:

"the vehicle ... is ... suitable for carrying its full load at relatively high rates of speed over all types of roads, trails, open and rolling country under all reasonable conditions of weather and terrain on the movement area of the airport and in the immediate vicinity thereof." NFPA No. 403 Para. 307 (b)

This problem is becoming more and more serious as vehicle weights are increasing and is deserving of increased attention by airport authorities. Ditches which bar approaches to potential accident sites should be bridged or filled in advance of the emergency and trials conducted with vehicles to assure their cross-country ability on airport terrain and on surrounding properties, especially along take-off and approach paths.

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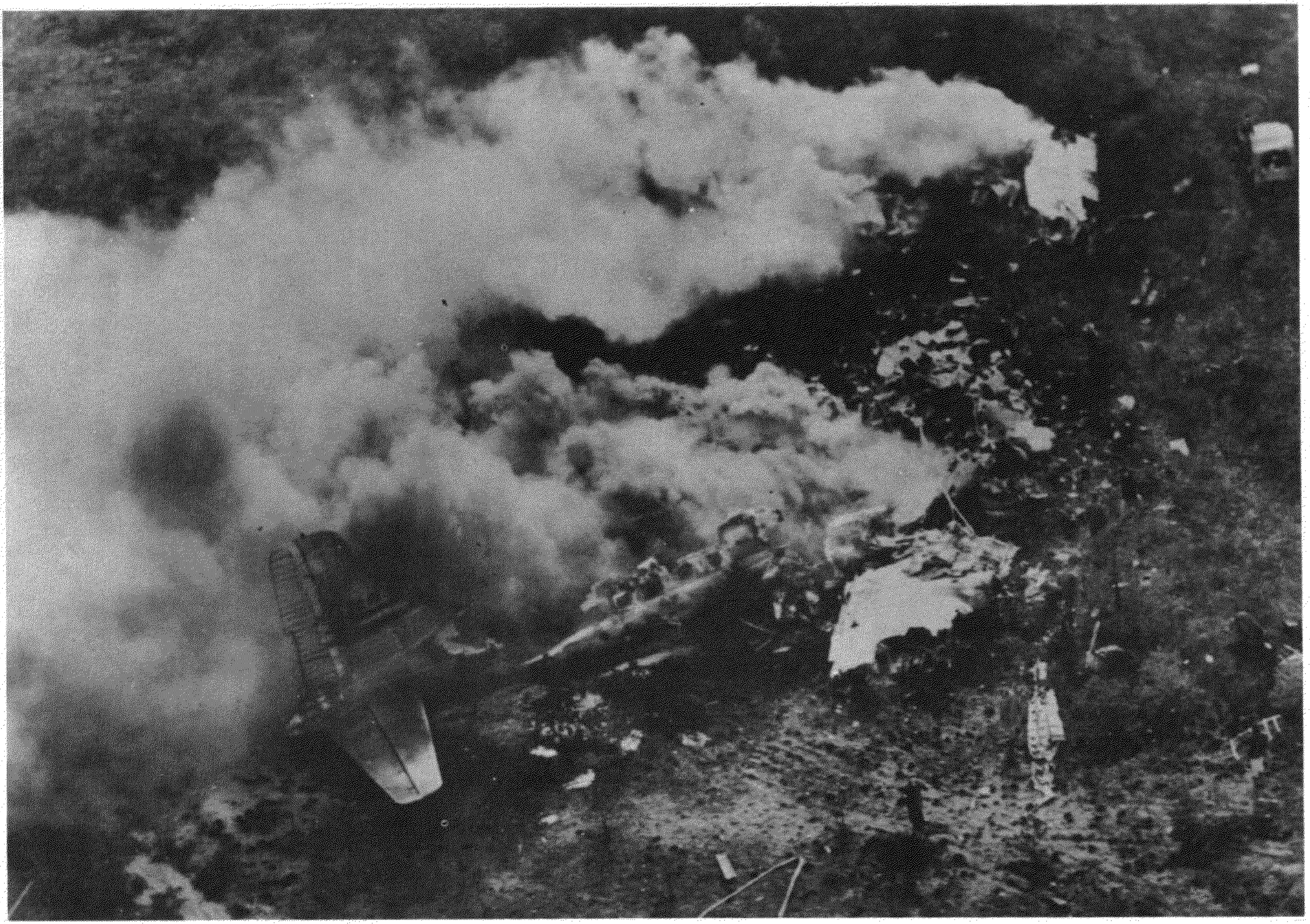

Figure 12 National Fire Protection Association Photo

United Air Lines DC-6 which crashed while on a pilot qualification check flight at MacArthur Field, Islip, New York - 4 April 1955. Intense fire consumed a large portion of the wreckage in spite of prompt arrival of fire fighting equipment.

Figure 13 National Fire Protection Association Photo

United Air Lines DC-6 - Islip, N.Y. - 4 April 1955. The off-runway land on which the aircraft came to rest was marshy and extremely muddy. A drainage ditch blocked the closest approach route.

No. 19

Eagle Aviation Company, Dakota DC-3 aircraft, Lebanon, G-AMYB, groundlooped on landing run at Beirut International Aerodrome, 8 April 1955. Aircraft Accident Report No. 15 released by Air Safety and Accident Inquiry Department Ministry of Public Works, Directorate of Civil Aviation, Lebanon.

Circumstances

The aircraft had been chartered by a tourist agency for a group of Americans wishing to visit the major cities of the Middle East. The flight departed Frankfort on 7 April 1955 at 2230 GMT en route to Beirut with numerous intermediate stops carrying 4 crew and 28 passengers. At 1720 GMT on 8 April the aircraft reported being on final approach over Beirut. On landing at 1724 GMT in a strong crosswind, the aircraft bounced twice, groundlooped and came to rest 920 metres from the runway threshold facing into the wind. While skidding, the main door of the cabin came ajar and the stewardess, not seated with her safety belt fastened, was thrown from the aircraft to a point 12 metres from its tail and seriously injured.

Investigation and Evidence

Meteorological conditions reported by the control tower at the time of the accident were as follows:

surface wind:	direction	270 °
	force	30 knots
pressure:	QNH	1015.0 mb; 29.97 "
	QFE	1011.5 mb; 29.87 "
visibility:	5 miles	

no gusts

The investigators attempted first of all to determine the tracks of the aircraft and the first well-defined point of contact was found opposite marker 34G i.e. 660 metres from the runway threshold, and 14 metres to the left of the runway centre line. For a distance of 120 metres this track remained parallel to the centre line, then, over a distance of 50 metres it bore to the right and at this point the aircraft definitely skidded to the right and stopped 90 metres farther on i.e. 260 metres from the first observed point of contact.

Inspection of the cabin showed a number of cases and cartons of beverages littering the floor of the entire cabin, and a small food locker of the type used on Vikings was found overturned. The arrangements of such cases as were not thrown forward showed that they must all have been behind the last row of seats on the starboard side. The cases were stacked higher than the top of the seat-back. One of the wooden cases and one of the cartons were a few centimetres from the cabin door, level with the handle of the lower lock.

The door locks by means of two independent locks operated by two handles positioned one above the other. The upper handle acts upon an ordinary horizontal latch, the lower one upon a rod locking the door vertically. Because the customs officers closed the door and affixed seals, it was impossible to determine the position of the handles at the time of the accident. However, examination of the locks revealed that the upper inside handle operating the horizontal latch often turned without engaging the lock mechanism, and furthermore that the latch was covered with rust. The corresponding outside handle worked perfectly on every operation. The upholstery of the door exhibited the trace of the impact of a pointed instrument. However, it was impossible to determine either the cause or the date thereof.

The statements of the witnesses brought out the following points:

1) the aircraft had been shaken before touchdown;

2) the landing at Beirut left much to be desired no doubt due to bad weather;

3) the door of the aircraft was open when the stewardess was thrown out and she did not hit the door;

4) the stewardess usually sat down at the time of take-offs and landings, however, on the day of the accident no one remembered seeing her do so;

5) no witness was able to determine the exact point on the runway at which the first contact occurred. One passenger

declared that the right wing was so high that it shut off her view of the ground from her seat;

6) no passenger noticed any increase in the power of the engines which would have been apparent from a louder engine noise;

7) the order to fasten safety belts had been given long before the landing;

8) the captain of another aircraft which had landed a few minutes before the subject aircraft testified that the latter made a low landing on the runway and appeared to be holding a perfectly straight course when the right wing lifted to a considerable angle and he felt that the aircraft might overturn. Then it skidded to the right and stopped.

Several theories follow as to the cause of the accident, however, those concerning the opening of the door cannot be proven particularly in view of the action taken by the customs agents who, by closing the door, made it impossible to determine the position of the handles operating the locking mechanism.

At the time of take-off, the stewardess always checks that the door is safely locked by trying the handles. In so doing she might have opened the top lock, since it was found thus and since the top inside lock operates only one way ... to unlock. The door, therefore, locked only by the vertical rod operated by the lower handle.

When the aircraft went into a sudden skid, one of the cases, in falling, probably hit the lower handle, thus unlocking the door. A 5 centimetre movement of the handle was sufficient to produce this result. The stewardess must at this time have been standing behind the rearmost right-hand seat. The small food locker, in falling, must have hit her and knocked her over. If she was facing the door at the time and holding onto the top bar of the seat with her right hand, her fall would have assumed a spinning motion which would explain why one of the passengers saw her fall backwards. The finding of the stewardess' right shoe in the small food locker appears to fit in with this theory.

The pilot had put the flaps full down for a landing in a 60 ° crosswind with a force of 30 knots. The instructions for a landing under such conditions specify: approach with power, flaps up or at most 1/4 down. The effect of the wind on flaps in the full down position is to force the aircraft to turn into the wind. No action taken by the pilot could have corrected this.

Such a mistake seems illogical when it is noted that the pilot had logged over 5 300 hours as pilot-in-command. However, the crew had been flying for nearly 21 consecutive hours (from 2030 GMT on 7 April 1955 to 1724 GMT on 8 April 1955) without any rest, landing having been made only for technical reasons. A second pilot-in-command had left the flight at Nicosia. The pilot stated that he had had two rest periods of three and a half hours each. This would reduce his actual duty time to 14 hours. However, these periods cannot be considered as rest as the pilot had no opportunity to rest properly. Therefore, there is a possibility of fatigue having influenced his judgment.

Another aggravating circumstance was the presence in the cabin of a food locker and cases, completely unsecured, which in falling also contributed to the accident.

Probable Cause

The pilot made a full flap landing in a strong crosswind causing the aircraft to groundloop, whereupon the main door of the cabin opened and the stewardess was thrown from the aircraft.

Contributing factors were:

1) possibility of fatigue effecting pilot's judgment;

2) presence of unsecured cases in the cabin (loading fault);

3) the state of the horizontal lock (mechanical fault);

4) violation of rules by the stewardess in that she was not seated with safety belt fastened at time of landing.

Suggestions

1) When there is a strong crosswind the fire truck and ambulance should be near the first intersection of the runway in use. In this instance there was a five minute time lapse between the time of the accident and the arrival of the ambulance. This delay was due to the fact that the tower waited for the pilot's request before sending help.

2) Orders should be given to all official agencies at the aerodrome and in the various ministries stipulating that no aircraft involved in an accident should be touched before arrival of the investigators. The aircraft should be placed under guard and no evidence disturbed unless absolutely necessary for the extraction of passengers.

3) A technical memorandum should be circulated reminding all crew members of the absolute necessity of being seated with belts fastened on landing and at take-off.

4) A control followed by checks must be made and measures taken if any case is revealed of non-observance of hours of duty for crew members.

ICAO Ref: AR/364

No. 20

Air India International Corporation, Bombay, Lockheed Constellation 749-A, VT-DEP, "Kashmir Princess", ditched following mid-air explosion in South China Sea, off Great Natuna Islands on 11 April 1955. Report by Ministry of Transport and Communications, Republic of Indonesia, released 25 May 1955.

Circumstances

The aircraft took off from Hong Kong for Djakarta at 0425 hours Greenwich Mean Time carrying 8 crew members and 11 passengers. The flight was uneventful until approximately five hours after take-off when a muffled explosion was heard in the aircraft, then cruising at 18 000 feet over the sea. Smoke started entering the cabin through the cold air ducts almost immediately and a localised fire was detected soon after on the starboard wing behind No. 3 engine nacelle. A rapid descent was commenced for ditching the aircraft and distress signals broadcast. In spite of fire fighting action, during which No. 3 engine was feathered, the fire spread very rapidly and caused hydraulic failure followed by electrical failure. During the final stages of the descent, executed under extremely difficult circumstances, dense smoke entered the cockpit reducing the visibility to almost nil. The aircraft impacted the water with the starboard wing tip, and the nose submerged almost instantaneously. Only three crew members survived the accident. The aircraft was destroyed.

Investigation and Evidence

The aircraft had crashed into the sea 235 miles northwest of Kuching. The wreckage was located by Indonesian fishermen on 12 April 1955 at an average depth of 35 feet of clear water, but it could not be seen from the surface. Salvage operations, which were hampered due to the presence of sharks, commenced on 25 April and lasted for ten days. The wreckage indicated that the aircraft had suffered considerable damage on impact with the sea, in addition to fire damage. Salt water corrosion was most noticeable on magnesium alloy engine parts; other parts were comparatively free.

The aircraft had been inspected by licensed aircraft maintenance engineers at Bombay on 8 April 1955 and had then taken off on the evening of 8 April to operate a scheduled flight to Singapore, returning to Bombay on 10 April after an uneventful flight. On arrival at Bombay, a terminal check was carried out, together with rectification work for the defects reported during the previous flight. The aircraft then taxied out to the runway to operate a scheduled flight to Hong Kong via Calcutta and Bangkok, taking off on the afternoon of 10 April. At Bangkok a fresh crew took over the aircraft. The composition of the crew was then the same as that of the subsequent Hong Kong-Djakarta flight. The aircraft was at Hong Kong for 80 minutes during which the crew received their briefing, a transit check was carried out under the supervision of the aircraft maintenance engineer and the aircraft was loaded and refuelled. At 0425 hours Greenwich Mean Time the aircraft took off from Hong Kong for Djakarta and was routed to overfly the Natuna Islands for navigational check purposes.

After take-off, routine messages were exchanged by the aircraft with ground stations. The explosion occurred at approximately 0923 hours. Once a rapid descent and depressurization were commenced a bank of CO_2 bottles was discharged into the rear baggage compartment in accordance with the fire drill. By this time the navigator had noticed a fire on the starboard wing behind No. 3 engine nacelle which was spreading very rapidly and this was reported to the captain. The generators were switched off as a precaution against electrical fire but again switched on later. At this time the crew prepared for ditching. The fire spread rapidly and was approaching the fuselage. The aircraft maintenance engineer estimated that the wing would not hold on for long as metal was melting. The fire warning in No. 2/3 Zone of No. 3 engine then came on. No. 3 engine which was functioning normally was feathered and the remaining bank of CO_2 bottles was discharged in No. 2/3 zone. The starboard heater fire warning then came on but the extinguishers had been exhausted. A left hand turn was executed in an attempt to ditch near land. The navigator had in the meantime located the position of the aircraft and passed it to the co-pilot, who had to help the captain with the controls as the aircraft was getting uncontrollable due to the starboard wing dropping. At this stage hydraulic failure was reported, and the auxiliary boosters were switched on. Smoke then entered the crew compartment. The aircraft maintenance engineer opened two port emergency exits in the cabin over the wing and one in the crew compartment. At this stage very thick black smoke entered the crew compartment which obscured forward visibility just prior to ditching. The co-pilot opened the sliding window on his side and had to peer at the instrument panel to check the airspeed indicator reading which was 140 knots when he last observed it.

In spite of all efforts to level off the aircraft for ditching, it continued in a shallow right hand turn and hit the water with the starboard wing. Flaps could not be used because of hydraulic failure.

It is clear that the explosion was followed by a combination of circumstances which embraced practically all emergencies that could have faced the crew.- a serious fire that threatened to burn off the wing any minute, hydraulic failure, electrical failure, partial loss of control and dense smoke in the cockpit which restricted the visibility to almost nil during the most critical stages of the descent.

Fortunately the right wing which included the starboard wheel well was recovered. Positive confirmation is available of an explosion having taken place in this area.

In addition to the physical evidence of bulging skin and bent members, there was also deep pitting by shrapnel in the skin surrounding the explosion area, and on the 24 ST struts and steel tubes which were facing the explosion charge. Glancing dents have also been deeply defined in those strut faces which were parallel to the flight of shrapnel. The fuel tank wall was punctured inwards.

Finally parts of a twisted, burnt and corroded clockwork mechanism, which had no relation to any equipment of the aircraft, was found trapped in the very same area where an explosion took place.

The explosion caused by this device resulted in puncturing of the fuel tank, and fire, which developed intensely as it was fed by large quantities of high octane fuel. Heat from this fire travelled forward to No. 3 zone of No. 3 power plant, causing a fire warning from this zone. The discharge of CO_2 in this area caused the warning to go off. This fire also burnt through the rear beam web, which had also opened up due to the explosion. Once the flames had spread to the trailing edge area behind the beam, they started consuming the cabin air ducting, cables and the fuel and hydraulic lines.

This explains the entry of streaks of smoke noticed by the aircraft maintenance engineer soon after the explosion, and the hydraulic failure experienced at a later stage. This hydraulic failure compelled the crew to switch on the auxiliary boosters for the rudder and elevator. The heavy drain of electrical energy required for the operation of the boosters, combined with the fact that the generators had also to be switched off at one stage as a precautionary measure against electrical fire, would undoubtedly exhaust the batteries. It seems most probable, however, that the complete electrical system went 'dead' as a result of the fire, and this explains why the co-pilot was unable to send out the position report during the final stages of the descent.

The crew also stated that just before the aircraft hit the water, dense black smoke filled the entire cabin and cockpit. It is estimated that it took at least 5 to 6 minutes for the aircraft to descend from 18 000 feet. During this period the flames had spread to the right side of the fuselage. The wreckage showed positive evidence of this area having burnt off in the air. The dense smoke which entered the aircraft was undoubtedly caused by the fire having entered the cabin after burning through the side of the fuselage.

The aforementioned facts combined together provide irrefutable evidence of an infernal machine having been placed by some party unknown in the starboard wheel well area, presumably to destroy the aircraft. The task of this person was rendered easier by the fact that access to this area is extremely easy through the openings in the bottom skin of the wheel well, when the aircraft is on the ground.

Probable Cause

The cause of this accident was an explosion of a timed infernal machine placed in the starboard wheel well of the aircraft. This explosion resulted in the puncturing of No. 3 fuel tank and an uncontrollable fire.

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ICAO Ref: AR/397

No. 21

Christian and Missionary Alliance, Short Sealand JZ-PTA, crashed on mountain in highlands of Netherlands New Guinea on 28 April 1955. Report released by Director of Civil Aviation, Netherlands New Guinea.

Circumstances

The amphibian aircraft departed Sentani aerodrome near Hollandia on a VFR flight plan for the Baliem River at 0840 hours (local time) on a transport flight carrying a load of furniture, foodstuffs and aluminum sheets. At 0922 the Biak area control centre and Sentani aeronautical radio station both received a report from the aircraft that it was over the Idenburg River, course 220 degrees, VFR at 9 000 feet in slight rain, operation normal. When the next position report over the Baliem became overdue, the Sentani aeronautical radio station and the Biak area control centre attempted to contact the aircraft, but to no avail. The aircraft was found after one month of extensive searching, crashed on a 10 335 foot high mountain. The sole occupant, the pilot, did not survive the crash.

Investigation and Evidence

Prior to departure a Visual Flight Rules flight plan was filed with Sentani air traffic control station indicating a flight to be flown clear of clouds and with a visibility of at least one mile. There was sufficient fuel on board for four hours. The flying time to the Baliem and from there back to Sentani was estimated to be two hours and thirty five minutes. The gross weight of the aircraft at the time of take-off was within the allowable gross weight of 9 600 lbs. and the load was properly distributed.

After departing Sentani the flight progressed in a routine manner and the following position reports were received at the radio communications stations at Sentani and Biak:

2317 Z 4 000 ft. climbing 8 000, course 225° VFR.

2341 Z 60 miles out, course 225°, 9 000 ft. operation normal, slight rain.

2412 Z over Idenburg River, course 220° VFR, 9 000 ft. operation normal, slight rain.

This was the last radio contact with the flight.

On the morning of 28 April the weather was as follows: - the intertropical front was situated along the north coast of New Guinea. It was rather active and locally even very active. Overcast at 10 000 ft. with rain over the lowlands, mountain tops well in clouds with valleys partly closed with stratus, generally westerly winds of approximately 20 knots. Air reports from scheduled flights into and out of Sentani aerodrome gave poor weather conditions in the Hollandia area.

At take-off time the Sentani weather conditions were: - no wind; visibility 2 km; moderate continuous rain.

past weather - rain, cloud 4/8 stratus 1 200 ft. 8/8 alto stratus 10 000 ft.

At 0915 (local time) an improvement message was issued.
- no wind, visibility 5 km. moderate continuous rain.

past weather - rain, clouds 3/8 stratus 1 800 ft. 8/8 alto stratus 10 000 ft.

At 0930 (local time) the Sentani synoptic report indicated:
- no wind, visibility 3 km. moderate continuous rain.

past weather - rain, 2/8 stratus 1 800 ft. 8/8 alto stratus 10 000 ft.

Since no arrival report from the aircraft was received over the Baliem River an alert was declared by the Biak area control centre at 1045 hours (local time).

Search and Rescue flights were executed by PBY aircraft of the Royal Netherlands Naval Air Services, a Piper Pacer of the Unevangelized Fields Mission and a de Havilland Beaver of New Guinea Airline "Kroonduif". Extensive searching was done over jungle covered mountainous terrain for more than two weeks in succession. When reports came in that an aircraft had been seen to crash into Sentani Lake adjacent to Sentani aerodrome, an extensive diving operation was carried out, but not the slightest traces of an aircraft could be found.

On 28 May an Australian Avro Anson was chartered in order to carry out a final search flight. This aircraft spotted JZ-PTA at an altitude of approximately 10 000 ft. crashed on a mountain slope. There were no traces of fire, but from pictures taken from the searching aircraft it was learned that the aircraft had completely disintegrated and survival of the crash by the only occupant - the pilot - was highly unlikely.

In view of the inaccessibility of the terrain where the aircraft crashed it was not possible to send out a ground party to the scene of the crash.

Probable Cause

The investigating authority reached the conclusion that the probable cause of the accident was the fact that the pilot was caught in adverse weather conditions during his attempt to reach better visibility conditions by climbing to a higher flight level and during this manoeuvre collided with a mountain.

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ICAO Ref: AR/378

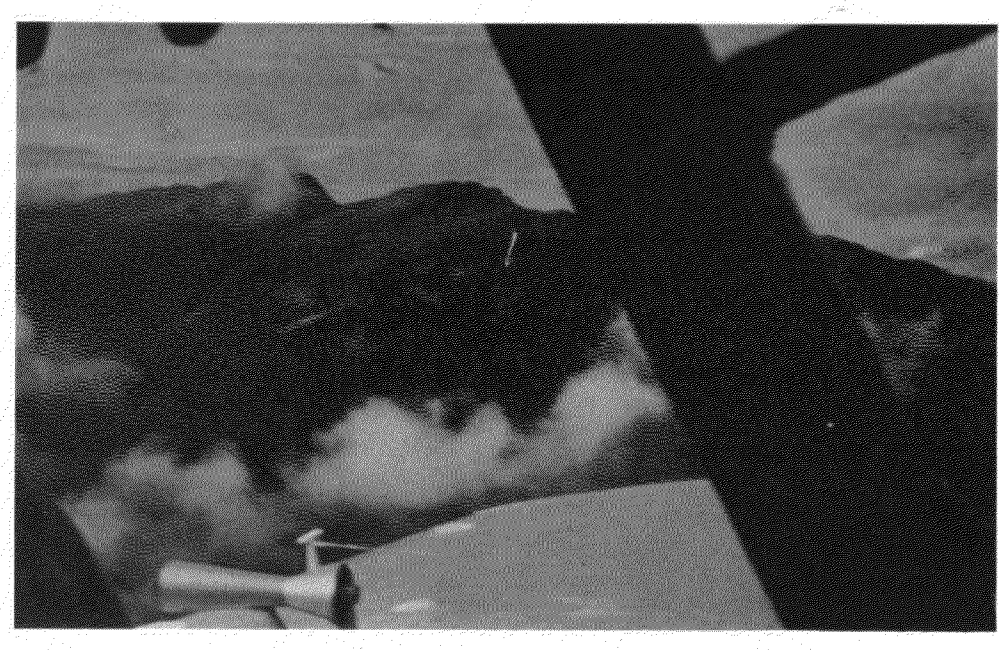

Figure 14
Arrow indicates location of wreckage of Short Sealand, JZ-PTA, which crashed in highlands of Netherlands New Guinea on 28 April 1955.

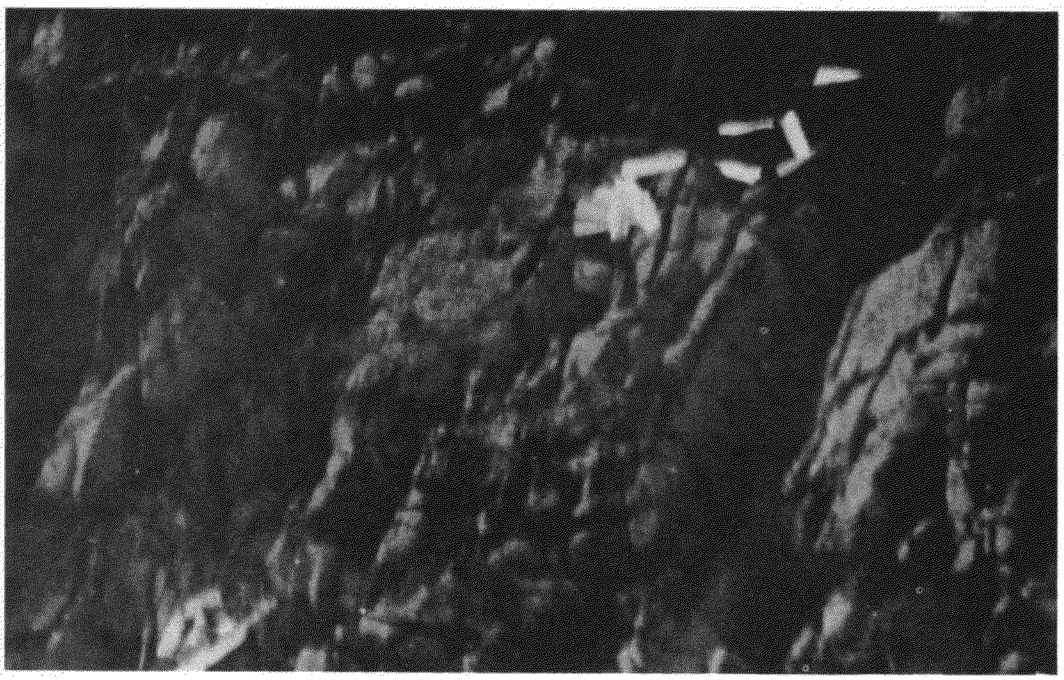

Figure 15
In view of the inaccessibility of the terrain where JZ-PTA crashed it was not possible to send a ground party to the scene of the accident.

No. 22

Trans-Canada Airlines, Inc., Vickers Viscount 724 aircraft, was damaged on landing at Winnipeg, Manitoba, on 16 May 1955. Canadian Department of Transport Report No. 55-21.

Circumstances

The aircraft took off from Winnipeg at 1233 hours Central Standard Time on a local training flight carrying three pilots. The take-off was a normal three engine take-off and after the aircraft was airborne the pilot-in-command pressed the undercarriage selector switch but the undercarriage failed to retract. "Down" and "up" were again selected but without result. The hydraulic selector valve was then inspected visually and found to be in the "down" position indicating that the undercarriage was down. The visual indicators on the wing and the nose wheel indicator indicated that both the undercarriage and nose wheel were down. The undercarriage lights remained green throughout the flight and the horn did not sound. On touching down, the undercarriage retracted and as the aircraft was sinking the horn sounded twice. The aircraft was substantially damaged.

Investigation and Evidence

No evidence was found of malfunctioning of the engines or controls but considerable wear was found on the cam which operated the nose-centreing micro switch. This could cause failure of the micro switch to operate on take-off, but on landing the micro switch would complete the circuit to the actuator when the nose wheel touched the ground thereby positioning the valve in the "up" or "down" position, depending upon the position selected on the undercarriage selector switch. Thus, if the undercarriage selector switch had been selected "up" the undercarriage would retract. Similarly, expert testimony was given to the effect that if the undercarriage selector switch had been selected "down" it would not be possible for the undercarriage to retract unless there had been another failure in the system.

The Trans-Canada Airlines Airplane Operating Manual for Vickers Viscount 724 Aircraft contains the following note:

> "If landing gear fails to retract, rock nose wheel steering to ensure centralising."

This instruction was not carried out.

Probable Cause

The undercarriage selector switch was left in the "up" position due to the failure of the undercarriage to retract after take-off. This resulted in the retraction of the undercarriage on landing.

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ICAO Ref: AR/393

No. 23

Douglas C-47, LV-ACQ, crashed at Río Chico Aerodrome, Santa Cruz Territory, Argentina, on 20 May 1955. Argentine Accident Investigation Report No. 494, released 17 November 1955.

Circumstances

The aircraft, a cargo plane, was attempting a night take-off on the last leg of a circuit begun two days earlier in Ezeiza, with stops at all aerodromes on the Atlantic seaboard. After a run of about 600 metres, it lifted in a gentle curve to the left but hit the ground again off the runway, skidding to the right. The impact broke the left landing gear strut and the aircraft came to rest after travelling a short distance. Fire broke out in the left engine nacelle and could not be put out because of the lack of adequate fire fighting equipment at the aerodrome. No injuries were sustained by the four crew members and one passenger on board at the time of the accident (approximately 0820 hours).

Investigation and Evidence

Weather conditions as shown in the official report were as follows:

> Sky with 6/8 alto-cumulus, pressure at runway level 1 000.8 mbs., visibility 40 kilometres, temperature 3°C, dewpoint 2°C, wind from 70° at 16 knots.

The aircraft was operating with a weight of 10 268 kg, 1 332 kg below the company's maximum authorized take-off weight for this aerodrome. The load was properly distributed according to the specifications of the controller and the dispatcher. The runway in use was Runway 03, which is constructed of compacted earth, with a slightly uneven surface; it had been properly marked with kerosene flares.

The routine pre-take-off engine and equipment checks were made according to company regulations; they indicated normal operation, except for a slight overspeed of the left engine, which had been noted previously. Take-off was then started on clearance from the control tower, which is situated at one of the four aerodromes in the zone, and from which the operation was not visible.

The pilot-in-command, at the controls, began the manoeuvre from the intersection of the two runways, leaving unused about 100 metres of the runway in use; this was quite in order in view of the total length of the runway, the light load of the aircraft and the fact that the unused portion was a recent extension as yet incompletely surfaced. He noticed a tendency of the aircraft to veer to the left soon after accelerating the engines to take-off power, i.e. 48 inches intake pressure. Becoming airborne at too low a speed because of a surface bump, he found that the swing to the left increased to a point at which it could not be arrested with the rudder nor with the trimming tab.

Once airborne, the aircraft left the runway obliquely, inclining slightly to the left. When the pilot attempted to land within the limits of the aerodrome by reducing power in the right engine, the aircraft hit the ground with a violent lateral skid which caused the left strut of the landing gear to break, the left engine was torn from its mount, and fire broke out. The aircraft travelled 96 metres from the first point of impact till it came to rest at an angle of about 120° left of its original heading.

The investigation revealed the following factors:

1) The weather was fine; wind speed and direction estimated by witnesses as north to north-east from 7 to 28 km/h differ from the official report, which gives north-east at 40 km/h. In neither case, however, could the wind have anything to do with the tendency of the aircraft to swing sideways.

2) The safety lock of the main landing gear struts was on and the tail wheel was in longitudinal alignment and locked in normal position.

3) The rudder tab was found in the position in which the pilot stated he had placed it.

4) Both propellers were torn from the engines and were found some distance away.

a) No. 2 propeller broke free, and it is considered, taking into account the twisting of the blades, that it hit the ground, partly breaking the front housing, and was then shaken off by vibration. The blades of this propeller were within the normal pitch positions.

b) The blades of No. 1 propeller were on feathered pitch, only one being twisted backwards, probably from having supported the weight of the aircraft. Two of the blades bore the marks of twisting starting at the propeller hub, probably due to rearward pressure; it was inferred that this occurred when they hit the ground while feathered.

Tests carried out on the governor and on the propeller itself showed no operating defects, except for some looseness of the speed stop lug of the governor, which would have resulted in a speed greater than normal, and this factor, in operation, would have facilitated the correction attempted by the pilot.

5) A number of parts of No. 1 engine were fused together by the fire, so that it was impossible to check its feed, carburation and igniting systems; however, the inspection revealed nothing abnormal in the remaining elements.

6) The electric circuit controlling the feathered pitch of the propellers could not be checked, as it was completely destroyed in the fire.

Analysis focuses attention on the left propeller blades, which were folded back in a manner suggesting that they were feathered when they touched the ground. For undetermined reasons, the propeller appears to have been feathered during the take-off manoeuvre; this would explain the tendency of the aircraft to pull to the left because of asymmetrical traction. In accidentally becoming airborne too soon, it did not have sufficient lift to be controlled, hence the consequences set out above.

Probable Cause

The probable cause of this accident was the fall of the aircraft when the pilot decided to discontinue a take-off which he considered abnormal and which is attributed to the fact that the propeller was probably feathered, for undetermined reasons.

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ICAO Ref: AIG/ACC/REP/GEN/No. 7
(Arg. Bulletin No. 4, p. 46.)

No. 24

Associated Airways Limited, Avro York aircraft, CF-HMY, crashed on take-off from Edmonton Airport, Alberta, Canada on 26 May 1955. Report by Board of Inquiry appointed by Minister of Transport.

Circumstances

The aircraft was taking off at 1427 hours from the north-south runway (33-15) of Edmonton Municipal Airport when it hit an obstacle in line with and off the end of runway 33-15 causing it to crash at the north (15) end of the runway and burst into flames. Both occupants, the pilot and the co-pilot, were killed and the aircraft was completely destroyed.

Investigation and Evidence

The following facts were brought out in the investigation:

1) The aircraft was duly licensed by the Department of Transport as were the pilots.

2) Edmonton airport is 2 185 feet above mean sea level.

3) The runway used is 5 700 feet in length with no approved overrun.

4) The aircraft was loaded to 67 683 lbs. gross, the maximum permitted by the Certificate of Airworthiness being 68 000 lbs.

At the time of take-off the temperature was 69° Fahrenheit, the wind was light and variable, averaging less than 7 m.p.h.

The Performance Schedule for this type of aircraft disclosed that under the prevailing loading and weather conditions, the aircraft, to take-off in safety, would have required a runway 7 100 feet in length. Under the prevailing conditions, the aircraft, operating normally and under full throttle could not, and in fact did not, effect a safe take-off.

A breach of paragraph 813, Air Regulations, occurred in that the captain neglected "the precaution that may be required by the ordinary practice of the air, or by the special circumstances of the case".

The following additional items of negligence were found:

a) the Department of Transport issued a licence to the captain of the aircraft without examination either as to his flying ability or as to his knowledge of the flying characteristics and performance limitations of York aircraft under the conditions which prevail as to weather and airport altitudes in Canada;

b) the Department of Transport did not assure itself before issuing a Certificate of Airworthiness for the York aircraft, that the owners of the aircraft had in their possession the necessary Performance Schedule;

c) the owners of the aircraft did not provide the pilots with the Performance Schedule for the aircraft so that the captain had no accurate means of knowing what load he could safely carry under the prevailing circumstances;

d) the owners of the aircraft had not tested the pilots as to their ability and as to their knowledge of the limitations of the York aircraft.

Probable Cause

The primary cause of the accident was the attempt of the pilot to take-off under the prevailing unfavourable conditions. As a result, the aircraft hit an obstacle in line with and off the end of the runway.

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ICAO Ref: AR/414

No. 25

Northeast Airlines, Inc., Douglas DC-3, overshot the runway on landing at Lebanon, New Hampshire, on 31 May 1955. Civil Aeronautics Board (USA) Accident Investigation Report, File No. 1-0074, released 31 August 1955.

Circumstances

The flight took off from La Guardia Airport, New York, at 1612 Eastern Standard Time on a Visual Flight Rules flight plan en route to Lebanon Airport, New Hampshire. Due to thunderstorms and poor radio reception Keene, New Hampshire, a scheduled stop, was overflown. After finding a 5 000 foot ceiling at Lebanon the flight cancelled its Instrument Flight Rules clearance and proceeded VFR for landing at Lebanon. During the landing run the aircraft rolled off the end of the runway, struck a ditch and came to rest on the underside of its fuselage 57 feet from the end of the runway. There were no injuries among the 12 passengers and 3 crew members.

Investigation and Evidence

The weather report two minutes after the accident (1828 hours) was: sky partially obscured, 800 scattered, estimated ceiling 3 000, overcast; visibility 2, light rainshowers and fog; temperature 59, dewpoint 58; wind calm; altimeter 29.86 - Remarks: scattered clouds variable to broken.

The airspeed crossing the airport boundary was reported as 90 knots and touchdown on the wet runway as 900 feet from the approach end on the main gear with the tail wheel off the runway surface. On a 4 000 foot dry runway this would have been safe, however, landing at this speed on a wet runway is a marginal operation. Keeping the tail up on the DC-3 in order to maintain good directional control and to put more weight on the main gear for better braking is a practice often used in landing. Since the captain stated that the tail wheel was not in contact with the runway until near its end, the speed at touchdown must have been somewhat excessive in order to permit keeping the tail in the air for approximately 3 000 feet. He also stated that he did not attempt to groundloop because of the speed.

Wet runways affect braking action adversely. The captain reported his braking effectiveness as "poor to nil" and when this condition was definitely established there was not sufficient time or distance remaining in which to carry out corrective action.

High speed and resulting momentum in the landing roll would retard dissipation of the wing lift, adversely affecting braking action and increasing the distance required for stopping.

There was no mechanical failure or malfunction in the aircraft or its components, including the braking system, prior to the accident.

Probable Cause

The probable cause of this accident was an approach too high and too fast under the existing calm wind and wet runway condition and the subsequent ineffective braking action.

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ICAO Ref: AR/390

No. 26

Associated Airways Ltd., Lockheed 14-08, CF-TCI aircraft, crashed on test flight at Winterburn, Alberta, 7 June 1955. Report No. 55-28 released by Canadian Department of Transport. Air Services Branch, Civil Aviation Division.

Circumstances

The aircraft took off at approximately 1700 hours Mountain Standard Time on a local test flight carrying a crew of 2 and 4 passengers. The purpose of the flight was to test the single-engine performance of the aircraft when loaded to the maximum permissible weight for take-off and to determine the correct power setting and performance. Just before 1705 hours witnesses stated that they saw the aircraft turn onto its back with a sudden cessation of engine noise and white or grey vapour was seen to come from both engines as it dived in a very steep nose down attitude to the ground. From statements of witnesses it was deduced that it was probable that the aircraft was below 1 000 feet when it turned onto its back. The aircraft exploded on impact and caught fire. All the occupants were killed and the aircraft was destroyed.

Investigation and Evidence

A major inspection (100 hour) had recently been carried out on the aircraft by the Company but had not been certified in the aircraft log books.

It was computed that the aircraft was overloaded by an amount in excess of 917 lbs. This included four cement blocks carried as ballast and weighing 125 lbs. each. Moreover, it appeared that the crew were not properly conversant with loading requirements and centre of gravity limitations.

Although hampered by fire damage, the engines and air-screws were stripped and no evidence of malfunctioning was found.

The ignition switch was found with the master switch in the "off" position. The master switch was of the type that is pulled out for the "off" position.

No evidence was found of an emergency situation having arisen but in view of a previous emergency single-engine flight having been caused by an oil leak, it is possible that such might have reoccurred shortly after take-off.

Weather was not considered to have been a factor in the accident.

Probable Cause

For reasons that were not conclusively determined, the aircraft assumed an unusual position at an altitude above the ground which was insufficient to permit recovery. The aircraft was overloaded by at least 900 lbs. and this would raise the stalling speed and affect the controllability of the aircraft.

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ICAO Ref: AR/407

No. 27

Panair do Brazil, S.A., Lockheed Constellation L-0-49, PP-PDJ, crashed at Tres Bocas, 12.9 km southwest of Asuncion National Airport, Asuncion, Paraguay, on 16 June 1955. Released by the Directorate General of Civil Aviation, Paraguay.

(Additional comments and findings by Brazil, the State of Registry, have been added as footnotes to the following report released by Paraguay, the State of Occurrence.)

Circumstances

The aircraft was on a scheduled flight from London to Buenos Aires with stops at Paris, Lisbon, Dakar, Recife, Rio de Janeiro, São Paulo and Asuncion, carrying 14 passengers and 10 crew.[1] At 0105 hours (local time) the Constellation called the Asuncion control tower who cleared the flight to land on Runway 02 and requested the aircraft to call when on final approach. The last contact with the flight was made at 0115 hours. From that time on a control tower employee reported the aircraft moved towards the south-southwest. He tried to sight it and noted that it headed towards the city, made a turn to the left and appeared to initiate its final straight-in approach. When sufficient time for a landing had elapsed the employee called attention to the lack of communication between the aircraft and the control tower. He continued to look out to the south where the aircraft would have appeared and saw a sudden burst of flame near the Paraguay Aero Club, south of the airport. Five passengers and three crew members survived. The aircraft was completely destroyed by fire which broke out immediately after impact.

Investigation and Evidence

The weather before the time of the accident was as follows:

0010 partly cloudy, visibility 15 kilometres

0020 wind ESE 8 knots, pressure 1[illegible] mbs.

0040 3/8 ST. 170 metres; rain fell for a few minutes just at this time and then ceased completely.

0050 3/8 ST. 170 metres; visibility 15 km; wind ENE 8 - 10 knots, variable.

All information supplied to the aircraft was provided by the Panair do Brazil radio station. It was entirely accurate and in accordance with the records of the equipment at the control tower of Asuncion National Airport.

From an examination of the wreckage and of the path flown by the aircraft, it is presumed that the aircraft was coming down at a landing angle on a track of 30 degrees,[2] crossing the Tres Bocas road at right angles. The place where the crash occurred is at an elevation of 650 feet above sea level. The area is fringed on the southwest with trees 15 metres high and is covered with banana and pineapple plantations.

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1) "The flight plan, for the part São Paulo-Asuncion of the flight, was cleared IFR at 5.400 m, off airways, having as alternatives Galeão (Brazil) and Lima (Perú)."

2) "... with a small rate of descent, practically almost in level flight."

The aircraft, coming down at an angle of approximately 5° hit a 12 metre tree with the tip of its left wing, [1] causing a section of the wing 1.5 metres long to break off, [2] continued on the same path until, 50 metres from the first impact, the propeller of one of the engines cut a branch of a tree 8 metres from the ground and several coconut trees were cut down or overturned. The rudder and the vertical stabilizer were found at a point 200 metres from the point of first impact. A one metre section of the right wing tip was found 20 metres further on and a 1.5 metre section of the tail was found to the right of the aircraft path.

The complete nose landing gear[3] was found 350 metres from the point of first impact. Seventy metres further on, but somewhat to the left, was the cockpit with both panels and the entire left landing gear. Approximately 70% of the right wing and its entire aileron were found at the same level but to the right of the path.

Finally, 500 metres from the point of first impact, the aircraft came into violent contact with a tree at ground level, uprooting it, so that the fuselage fell over in a position facing about 30° to the left of the path of flight. At this point the fuselage and left landing gear caught fire.

No. 1 port engine was found 450 metres from the point of first impact and the No. 2 port engine a little further on. The two starboard engines were found nearby, to the left of the fuselage.

The dual wheel of the right landing gear was found without major damage 150 metres from the point of final impact and at approximately 15° from the path of the aircraft.

The co-pilot at the time of the accident stated that the aircraft was making an instrument approach[4] to Runway 02 having been cleared by the tower. He stated that the final approach was being made at 130 knots and the aircraft had been flying in cloud.[5] The altimeter showed 820 feet the last time he looked at the instrument panel. He thought that they had deviated excessively from the approach path owing to the wind which was probably stronger than estimated. Visibility a few seconds before the accident was zero. The aircraft had been functioning normally up until the accident.

The steward remembered that the flight radio operator commented that he had received a radio report that Asuncion was free of cloud and that when the tower was contacted it reported a 300 metre ceiling.

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1) "At this time the flight level of the plane was 195 metres, i.e. below the minimum prescribed flight level, which is 254 metres for an instrument approach on the 02 runway."

2) "The vestiges on the trees indicated that the plane, shortly after losing the wing tip, inclined suddenly towards the left about 28 degrees, and increased substantially the angle of descent."

3) "... the nose wheel hit the ground and caused the nose section to break apart from the fuselage, disconnecting also the instrument panel, the cockpit floor and the pedestal with the engine controls. A little before the nose wheel, engine No. 2 also hit the ground and was disconnected and impelled forward, ..."

"At this time, or a little before, the plane, while sliding on the ground began to rotate around its vertical axis, counter clockwise, and finally came to rest at an angle of 110 degrees."

4) "When the plane was on its final approach track, the co-pilot raised his arm in order to put the landing lights on. At this moment, he heard the pilot say: "Increase power, we are too low." The co-pilot lowered his hands to increase power, glanced at the altimeter which was indicating '247 metres' and at this instant the plane hit the tree."

5) "The pilot told the co-pilot that he would make an outbound track of 1 minute and a half to compensate for the wind."

Another witness stated that the entire area of the accident was obscured by dense clouds.

Probable Cause[1)]

The accident was due to a piloting error in making the approach circuit on instruments. An error in timing resulted in the final approach being initiated at too great a distance from the airport. Proof of this was provided by the fact that the landing gear was found extended, the flaps down, the mixture control set at "rich", all of which indicated that the aircraft was in the ready to land condition.

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1) "The accident was caused by personnel failure: pilot error. The pilot did not follow the recommended procedure for instrument final approach and he descended below the height prescribed in the final approach chart.

Concurring factors were:

1. Flight fatigue, due to excess flight time. The pilot flew in the preceding months an average of 113 hours.

2. The crew did not follow the normal cockpit procedure. The co-pilot did not set his altimeter to the received altimeter setting.

3. Bad layout of the face of the chronometer of the instrument panel, which did make the readings more difficult."

ICAO Ref: AR/398

No. 28

British Overseas Airways Corporation, De Havilland Dove 104, G-ALTM, crash landed outside the western boundary of London Airport, England, on 22 June 1955. Report dated 9 December 1955 released by Ministry of Transport and Civil Aviation (U.K.)

Circumstances

The aircraft carrying the captain and two photographers was on a filming flight of London Airport. Three runs over the airport had been successfully completed and the aircraft was positioning for a fourth when the pilot noticed a decrease in airspeed. During a check to ascertain the cause a low oil pressure reading was observed and because of this, combined with rough running, the pilot decided to shut down the port engine. A single-engined approach was commenced with the intention of landing on Runway 10 Right. Shortly afterwards the starboard engine ceased to develop power and the aircraft was crash landed in darkness at approximately 2152 hours Greenwich Mean Time. No one was injured and there was no fire.

Investigation and Evidence

The captain of the aircraft had made arrangements to make a series of day and night colour films of the approaches, runways and take-off paths at London Airport. A successful 2 1/2 hour filming flight was completed during the afternoon. Later that day the captain, with two photographers, boarded the aircraft for a filming flight in darkness. The aircraft took off at 2106 hours on Runway 28 Right. Two approaches, low runs and overshoots were completed on Runway 28 Right followed by a low run over Runway 10 Right. During the whole of the flight the aircraft was in radiotelephony contact with London Tower and radar control was used to assist the pilot in making the runs. At 2147 hours when the aircraft was 6 miles south-south-west of London Airport at 1 500 feet it was directed on to a heading of 330°M to bring it on to a right hand base leg for an approach to Runway 10 Right. When established on this heading the pilot noticed that the airspeed had decreased from 128 to 110 knots although the power settings had not been altered. A check proved that this was not caused by increased drag due to drooping undercarriage or flaps. The pilot then checked the engine instruments and he states that he observed a low oil pressure and a high oil temperature on the port engine gauge. The photographer, to whom the pilot pointed out these abnormal readings, states that the gauge to which his attention was drawn was that of the starboard engine. The pilot then passed the following messages to London Tower; they were electrically recorded:-

2149 hrs. "Tare Mike to Tower I'll do this run and then I'll have to land I'm getting failing oil pressure on the starboard engine".

2151 hrs. "Tare Mike I'm feathering".

London Tower informed him that he was three miles out on final approach and clear to land. At 2152 hours the pilot reported "failing power on the other engine" followed by the final message "Crash landing I'm sorry".

Shortly after noticing the low oil pressure reading the pilot states that he carried out the approach check, selected 20° of flap and as rough running was developing he decided to take feathering action. He states that he moved the port pitch control lever back through the feathering gate but he did not press the feathering button. He further states that when the propeller stopped rotating he switched off the port engine ignition switches and the rough running ceased. He increased the power setting for the starboard engine and lowered the undercarriage in preparation for a single-engined landing; a further increase in the starboard engine power setting resulted in a noticeable increase in power output. Shortly afterwards marked vibration developed and the rate of descent increased due to failing power from the starboard engine. The rate of descent was checked as much as a safe airspeed would allow but without engine power it was impossible to reach the runway. After warning his passengers and Control the pilot crash landed the aircraft just short of the first bar of the approach lights.

The Aerodrome Fire Service was warned immediately of the impending crash by Air Traffic Control and the fire and rescue vehicles left their station as the aircraft crash landed. Nevertheless, about 15 minutes elapsed before they arrived at the scene of the accident which was just outside the airport boundary. This was due to a 2 1/2 mile detour over winding class 2 roads in order to cross a river which forms the airport boundary.

Examination of the wreckage showed that both outer wings had been torn off after striking telegraph poles and that the main wreckage, consisting of the fuselage and centreplane, had come to rest 10 yards from the first cross bar of the approach light system. The engines remained in position and did not appear to have suffered much crash damage although all three blades of both propellers were bent, indicating some degree of rotation on impact. The port engine cowlings were clean but the starboard engine cowlings were splashed with engine oil which had also been thrown back over the fuselage and starboard tailplane during flight.

The engine controls in the cockpit were found with the following settings:-

	Port Engine	Starboard Engine
Throttle Lever	Fully closed	Fully open
Pitch Control Lever	"Min. R.P.M."	"Max. R.P.M."

The evidence indicated that both port and starboard engines had been adequately supplied with fuel and oil.

The two engines were removed from the airframe and sent to the manufacturers for detailed examination. The port engine was mounted on a test bed and given a test run for one hour. This test proved to be satisfactory and showed that the engine was in normal working order.

Examination of the starboard engine showed that the crankshaft had fractured at the forward web of No. 3 crankpin and that No. 4 crankpin had cracked. Both the fracture and the crack showed evidence of slow fatigue. In both cases there were fatigue nuclei adjacent to a plugged hole which is considered to have been the primary stress raiser.

Micro examination and hardness tests showed that the material and heat treatment of the crankshaft were satisfactory.

A strip examination of the port propeller by the manufacturers revealed no evidence of a pre-crash failure. As far as could be determined the feathering mechanism was in working order.

It has been established that there was a major mechanical failure of the starboard engine before the crash landing. Despite the pilot's statement to the contrary, there is ample evidence that symptoms of the impending failure were indicated by low oil pressure and high oil temperature on the starboard engine gauge and that the complete failure was brought about by running the failing engine at almost maximum power instead of shutting it down.

The pilot correctly identified the faulty engine in his radiotelephony report but thereafter shut down the sound engine which was capable of giving full power with normal oil pressure and temperature. It is difficult to find an explanation for this mistake, particularly in view of the pilot's experience as an instructor on the type of aircraft. It is noted that the pilot was flying from the left hand seat although he was more accustomed to fly from the right hand seat, that the engine instruments in this aircraft were grouped on the right hand panel away from the engine controls and that a low oil pressure in the starboard engine would be indicated by the left hand pointer of the starboard oil pressure/temperature gauge. It is possible that within this combination of circumstances lay a seed from which confusion grew.

Investigation of the defect in the starboard engine showed that the crankshaft had failed as a result of fatigue cracks. During the course of this investigation another accident occurred to a Dove aircraft in which there had also been a crankshaft failure of a similar nature. Although these two cases are the only ones associated with accidents, an additional eight crankshafts have manifested symptoms of failure during flight. Altogether there have been thirty-two cases of crankshafts developing fatigue cracks since 1950, most of them discovered during inspection at overhaul. Since December 1951 all new crankshafts have been manufactured with strengthened webs. A modification removing the screw threads from the plugged holes was later introduced; this applied to both new and old type crankshafts. There is to date no record of a crack having developed at a plugged hole in a strengthened crankshaft but several have occurred in the modified pre-1951 crankshafts. Since the accident the engine manufacturers have reproduced a characteristic failure by fatigue loading a crankthrow in a special rig. The knowledge gained from this test has suggested new methods for restoring the reduction in fatigue strength caused by the presence of the plugged holes. When the tests are complete further modification action will be considered.

The weather conditions had no bearing on the cause of the accident.

The pilot's licence had expired although his medical assessment was in order. The expired licence did not include an aircraft type rating in Group I.

Probable Cause

The accident was caused by an error on the part of the pilot who shut down the port engine instead of the starboard engine in which trouble was developing. Subsequently, a complete power failure of the starboard engine occurred.

Recommendations

It is recommended that:-

i) The attention of all concerned with the operation of Gipsy Queen 70 engines be drawn to the possibility that a low oil pressure reading may be indicative of a fatigue crack in the crankshaft.

ii) The adequacy of the existing access for Aerodrome Fire Service vehicles to the land sector adjoining the western boundary of London Airport be reviewed.

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ICAO Ref: AR/422

No. 29

Trans World Airlines, Inc., Douglas DC-3 and Baker Flying Service, Cessna 140-A aircraft, collided 2 miles NNW of Fairfax Airport Control Tower, Kansas City, Kansas, Missouri, on 12 July 1955. Civil Aeronautics Board (USA) Accident Investigation Report SA-307, File No. 1-0078 released 11 January 1956

Circumstances

The Trans World Airlines' DC-3 was scheduled for a pilot requalification check flight. The aircraft took off at 1001 hours Central Standard Time from the Kansas City Municipal Airport, [1] Kansas City, and requested clearance to carry out the first portion of the check which was to include two touch-and-go landings at Fairfax Airport. The flight was cleared by Fairfax and at approximately 1011 hours touched down on Runway 35 at Fairfax following which a normal take-off was made. On reaching 1 050 feet power was reduced to 39" of manifold pressure and when at 1 250 feet and at an indicated airspeed of 105 knots, power was further reduced to 32" manifold pressure and propeller settings were changed from 2 450 rpm to 2 050 rpm. A left climbing turn was then begun. At approximately 150 knots, on a heading of 200 degrees and at an altitude of between 1 750 and 1 900 feet, the pilots heard a noise similar to an explosion and felt the aircraft swerve to the left. Immediately the Fairfax tower controller called the flight and advised that he thought it had collided with a Cessna. The DC-3, which had been substantially damaged, landed safely at Fairfax Airport. Neither of the two occupants was injured.

At 0830 hours, the morning of the same day, a Cessna 140-A had departed the Municipal Airport on an instrument training flight. At 0945 this aircraft was cleared by Fairfax tower to make a simulated low frequency range approach and was advised to report upon completion of its procedure turn inbound. It reported as directed, the aircraft passed the range station, executed a missed approach procedure and disappeared from the control tower's view, heading west. At 1002 the Cessna again called the Fairfax tower, gave its position as over the range station, altitude 3 000 feet, and requested clearance to make another simulated low frequency range approach. The aircraft was cleared to Runway 13 and requested to "call procedure turn inbound". This was acknowledged and was the last radio contact with the aircraft. The Cessna did not report inbound. At 1014 the controllers observed the TWA flight north of the tower making a turn to the southwest and saw yellow objects falling below and behind it. As the Cessna was yellow they concluded that it was involved in a collision. The two occupants of the Cessna were fatally injured.

Investigation and Evidence

The Cessna sustained severe damage during the inflight collision and subsequent ground impact. Examination of the entire wreckage accounted for all components of the aircraft and no evidence was found of structural failure or malfunctioning prior to the collision.

The Cessna wreckage was transported to a suitable location where it was laid out for a more detailed examination in an effort to determine the manner in which the two aircraft came together. The most significant of many inflight impact markings was a series of eleven propeller cuts on the left wing, cabin, and right wing. These were essentially parallel and almost evenly spaced. The force of the cuts destroyed the structural integrity of both wings while the aircraft was in flight and in such a manner that the left wing was severed in five pieces and the right wing in two. Examination of the cuts revealed typical skin curlings and feathering associated with high-speed cuts made by the DC-3's left propeller rotating clockwise as it moved over the Cessna from left to right.

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1) The Kansas City Municipal Airport and the Fairfax Airport are about 1-1/2 miles apart and separated by the Missouri River.

It was determined that gouges and scratches on the blades of the Cessna propeller were made when the propeller contacted the leading edge and bottom surface of the DC-3's left wing.

The major damage to the DC-3 was confined to the left propeller, the left oil cooler scoop, and the left wing outboard of the nacelle. The leading edge of this wing was badly damaged and two propeller cuts were found in it. Other portions of the wing bore numerous scuff marks, cuts and scratches. Blue and yellow paint, the color scheme of the Cessna, were observed in many places. Small pieces of the left and right wing panels of the Cessna were hanging from the DC-3 and embedded in tears near its left landing light. The left propeller blades of the DC-3 were gouged along their leading edges and both sides of the blades showed yellow and blue paint. The lower and outboard leading edges of the left oil cooler scoop were crushed rearward and also showed evidence of paint from the Cessna. Examination of the DC-3 and testimony of the crew revealed there was no malfunction or failure of the aircraft or its components prior to the initial impact.

Examination of the Cessna VHF radio transmitter revealed that the shaft of the frequency selector switch was displaced rearward and jammed. It could be rotated a distance of approximately one frequency selection only. The switch was in a position to select 119.1 mc., the frequency normally used in contacting the Fairfax tower. The VHF receiver was badly crushed by impact so that the tuning condenser was deformed and the fixed and movable plates were pressed together. The frequency setting of this radio unit could not be determined.

The low frequency receiver of the Cessna aircraft sustained severe impact damage. The selector switch was set to "range" position and jammed. Examination revealed that the unit was jammed on 355 kc., approximately that of the Kansas City low frequency range (359 kc.).

The Cessna was equipped to transmit on VHF frequencies 118.3 mc., 119.1 mc., 122.1 mc., 122.5 mc., and 121.5 mc. It could receive on these frequencies as well as on common low frequencies. On the day of the accident the crew of the Cessna reported to the Fairfax tower over the low frequency range station and asked permission to make the approach. This was learned by examination of the recordings made of all transmissions on this frequency in the nearby municipal tower.

The Fairfax tower was equipped with numerous transmitting and receiving frequencies. With respect to the request for the simulated instrument approach made by the Cessna crew, however, the tower answered on 119.1 mc., with a portion of the reply being transmitted simultaneously on 278 kc. until that transmitter key was opened, ending the transmission on that frequency. This was done during the transmission just before the portion when the Cessna was requested to report inbound on its procedure turn. Investigation disclosed that the low frequency receiver was tuned to the Kansas City low frequency range at the time of the accident; however, if the Cessna was receiving on 278 kc. only at the time the clearance was issued, its crew would not have heard the instruction to report on the procedure turn inbound. If the VHF receiver was tuned to 119.1, the pilots would have heard the complete clearance.

The crew of the DC-3 took off from Kansas City Municipal Airport at 1001 using tower frequency 118.3 mc. After climbing to about 2 000 feet they changed to the Fairfax tower frequency of 119.1 mc. and requested clearance to enter the Fairfax traffic pattern for Runway 35. The DC-3 crew could not hear communication between the tower and the Cessna on 119.1 mc. because it occurred shortly after 1002 hours while the DC-3 was still tuned to 118.3 mc. The crew of the DC-3 also stated that they did not know that the Cessna was making the approach.

The Kansas City low frequency range station is located .7 statute miles northwest from the approach end of Runway 13. The low frequency range instrument approach procedure used by Baker Flying Service provides that the aircraft pass over the range station at 3 000 feet, then proceed outbound on the northwest range leg (328 degrees) for approximately seven miles. It then requires a procedure turn on the east side of the range leg and return to the low frequency range station on the same leg using approximately a reciprocal course. During this time a descent is made to 1 600 feet.

The approved VFR departure pattern on Runway 35 of the Fairfax Airport for aircraft above 12 500 pounds gross weight prescribes a left turn as soon as practicable after take-off to a magnetic heading of 330 degrees, climbing to at least 2 000 feet before making any other turns or proceeding on course.

During the accident period there were two controllers on duty in the Fairfax tower. Traffic was light and weather conditions were clear with visibility approximately 10 miles. The approach controller stated that when the Cessna requested the second simulated instrument approach he issued the clearance and had prepared a progress strip for the flight. The strip had spaces for the time the flight reported inbound on the procedure turn and the arrival time over the range inbound. The controller noted that transmissions from the Cessna were a little weak. He stated that while issuing the clearance he terminated the transmission on 278 kc. feeling sure that the aircraft was listening on 119.1 mc. frequency. The flight acknowledged the clearance.

The local controller in the meantime was controlling other traffic, including the DC-3. He testified that after the DC-3 became airborne following the touch-and-go landing at Fairfax, he asked the other controller if the Cessna had reported on its procedure turn, noting that the time had not been recorded on the progress strip. Informed that it had not, both controllers, realizing it was an important traffic factor, looked for the Cessna in the area of the range station. Neither saw it but both were able to see the DC-3 in a left climbing turn north of the tower. The local controller then turned to check the separation between the DC-3 and another Cessna making touch-and-go landings. Noting there was good separation he again looked for the Cessna belonging to the Baker Flying Service. He then saw the DC-3 just northwest of the range station and at the same time saw yellow objects falling below and behind it. At no time was advisory information offered either the DC-3 crew or the Cessna crew relative to the presence and activity of the other.

During the public hearing the officials of Baker Flying Service testified that under a contractual agreement with TWA they gave an instrument flight training course to the airline's newly hired first officers in order that these persons could obtain a CAA instrument rating. The program included supervised flight during which the student practised IFR (Instrument Flight Rules) voice procedures, orientation procedures, and the use of instrument facilities, and maintained precise control of the aircraft solely by reference to instruments in the aircraft. The instructor monitored the student's performance, instructed him in the training phases, and acted as the safety pilot for the flight.

The Cessna was used for the instrument flight training. The aircraft, a single-engine high-wing monoplane, was fitted with a cockpit instrument training hood to prevent outside vision by the trainee, thereby requiring him to fly solely by reference to instruments. The hood consisted of a rubberized cloth extending downward from the cabin top and diagonally across in front of the student. The left side window was covered by a louvre type blind. The trainee's vision to the right was also blocked by the diagonal blind and the instructor seated beside him. Construction of the hood permitted the instructor to see outside the aircraft. Although his vision was obstructed to some degree he could maintain a lookout with some movement of his body not normally necessary without the hood. This hood was within the requirements specified.[1] Outside vision is necessary because much of the instrument training is conducted during good weather conditions. A flight under such conditions is considered a VFR (Visual Flight Rules) flight and the responsibility for separation between aircraft rests on the pilots to see and avoid the other. The CAA Flight Information Manual states in part, "When flying in VFR weather conditions (regardless of the type flight plan or air traffic clearance) it is the direct responsibility of the pilot to avoid collision with other aircraft."

Tests were conducted when weather conditions and wind factors were nearly identical to those on the date of the accident. The time of these tests was also comparable to the time of the accident. A DC-3 was flown in conformity to the same configuration used by the DC-3 flight in question, based on the information given by its crew and in conjunction with the observations given by the numerous eyewitnesses. A Cessna was flown in conformity

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1) CAA Manual of Procedure.
"The term proper hood is construed to mean a hood which will completely exclude all outside visual reference to the pilot on instruments yet not unduly restrict vision of the safety pilot, agent, or examiner. Sufficient visibility to permit clearance for turns in either direction, as well as adequate forward visibility is required ...."

to the final approach portion of the standard low frequency radio range approach inbound to the station and at speeds normal for that aircraft. An identical instrument training hood was used on the Cessna. The flights were also timed so that their flight paths intersected at the position in space approximately where the DC-3 and the Cessna collided. The test aircraft used only minimum safe altitude separation to keep that variable to the smallest effect. The purpose of these flight tests was to obtain, as accurately as possible, a reconstruction of the flight paths of the accident aircraft and to learn when, how long, and in what relative positions each aircraft was visible to the crew of the other. Board personnel were present on each aircraft as observers. During the tests other Board personnel watched from the control tower to learn whether or not the aircraft could be seen from there and if so what difficulties were experienced in locating and following them visually.

During the tests the Cessna was first seen from the DC-3 by the pilot seated in the left seat. This occurred when the DC-3 was about 23 seconds from the approximate collision position and while it was making the left climbing turn through about 300 degrees magnetic. There was then approximately one mile separation between the two aircraft. The Cessna remained visible to this pilot through the left front windshield panel for 17 seconds, during which time the Cessna moved from the left center of this windshield toward the bottom edge. It disappeared from view at the bottom of the windshield panel near the center post which divided the entire windshield.

The tests disclosed that the Board observer in the right seat of the DC-3 first observed the Cessna during the same left climbing turn about 16 seconds from the collision position. The Cessna was then estimated to be about 3 500 feet away. The Cessna remained visible to this observer through the right front windshield panel for about 13 seconds, at the end of which time the Cessna was estimated to be about 600 feet from the DC-3. During this time the Cessna moved from the lower left center of the windshield panel diagonally toward its bottom edge, continuing until it disappeared below the edge near the center of the windshield panel.

From the Cessna, with the instrument hood in place, there was no opportunity during the tests for the pilot in the left seat to see the DC-3. From the observer's or instructor's seat the DC-3 could be seen for 29 seconds; however, in order to do so it was necessary for that pilot to lean forward enough to see along the front plane of the hood component installed in front of the trainee-pilot seat. It was testified that observer-pilots always assumed this position. During the time the DC-3 was visible it moved from alongside the compass across the lower center of the windshield parallel to the glare shield toward the left door post, where it disappeared. The CAB observer said that at no time while observing the DC-3 did it appear to be on a collision course with his aircraft.

All the participants said that, throughout the series of six flight tests, the position of the sun did not cause glare. Each stated that knowing in advance the position of the other aircraft was of material assistance in sighting it when they did.

During these tests the time was almost identical when each aircraft was first sighted by the observer in the other. Repeated test flights did not improve the ability of the pilots to locate the other aircraft more quickly. The participants were impressed with the difficulties in seeing each other.

The observer in the tower stated that from that position the DC-3 was clearly visible and could be easily located during the entire series of flight tests. The Cessna beyond three miles was extremely hard to see and follow while it was proceeding either directly toward or away from the range station. When the Cessna was proceeding inbound it first appeared to be so small and far away that it seemed unlikely that both it and the DC-3 would arrive at the collision point at the same time. It was only during the last few seconds prior to arrival over the collision point that the Cessna appeared to be in close proximity to the DC-3.

Nearly all eyewitnesses to the collision agreed that the weather was clear and that visibility was good in all directions. Those best positioned to observe the aircraft stated that the DC-3 appeared to be heading south or south-southwest. Witnesses who saw the Cessna saw it only a few seconds before impact. They said it appeared to be flying southeast just before the accident and also that the collision did not seem imminent until a few seconds before it occurred. Others stated that even then there appeared to be vertical separation between the aircraft. None saw either aircraft take evasive action.

The weather recorded a few minutes after the accident was: clear; visibility 10 miles; wind east-northeast 10 knots.

Considering all the available evidence it is probable that the Cessna pilots heard the tower clear them for a simulated low frequency range approach, including the instruction to report on the procedure turn inbound. It is believed that this was heard on 119.1 mc. because the low frequency receiver was probably then being used for navigational purposes and would not have been available for receiving the tower on 278 kc.

The tower controllers did not receive a report on the procedure turn from the Cessna. This is substantiated by the lack of a recorded tower transmission on 119.1 in response to such a call which would have been recorded in the Fairfax tower. Had the Cessna reported on any other frequency, such as 122.5, this would have been recorded by the Municipal tower. Since there was no recorded response from the tower or recorded transmission from the aircraft, it is believed that the pilot of the Cessna did not report as requested or the transmission, for mechanical reasons, could not be made or did not reach the tower. Although the radio equipment of this aircraft was severely damaged, it is believed that normal operation could have been expected before impact.

Since the Cessna flight had been instructed to report on the procedure turn, it is reasonable for the tower personnel to have expected it to do so, thereby alerting them to its position. Although they did not receive the report, after a reasonable time both controllers attempted to locate the Cessna visually but were unable to do so. Considering the distance, the head-on view presented by the Cessna, and other factors affecting their ability to locate it, the Board is of the opinion that it is not unreasonable for them to have failed to see it. With respect to advisory information, it is believed that the tower personnel did not carry out their full function. Both controllers knew that the Cessna was conducting an instrument approach and that it could be expected by time expiration to be in the latter portion of the procedure and would be an important traffic factor at that time. It is believed that under these conditions the DC-3 crew should have been advised during the touch-and-go landing clearance that the Cessna was making a simulated approach and might be expected as a traffic factor.

In determining whether or not each aircraft could have been seen from the other and the collision thus avoided, several factors must be considered. The first is the angular limits of cockpit vision. This factor is the opportunity to see another object afforded by the cockpit structure only. A second factor is visual range or the distance that an object can be seen. This includes the angular size and shape of the object, its background contrast, the degree of lighting, and apparent motion of the object. A third factor is the time element during which the object is within the angular visual limits of the cockpit and within visual range. Finally, consideration must be given to the numerous physiological factors affecting the human ability to locate and see an object.

The DC-3's climb-out following a touch-and-go landing was not in accordance with the airport's approved traffic pattern, in that a climbing left turn was made instead of climbing on a heading of 330 degrees magnetic until reaching an altitude of 2 000 feet. If the proper pattern had been flown the DC-3 might have passed over the collision area; however, the aircraft's altitude then would have been 2 000 feet. Also, the aircraft would have been in level flight after reaching this altitude and making the left turn, thereby affording both pilots a broader field of vision. The clearance issued by the tower to the DC-3 to make touch-and-go landings does not constitute a waiver to deviate from the approved traffic pattern.

As shown by the flight tests it is clear that both crews of the accident flights were afforded the opportunity to see the other's aircraft and although the time element during which this opportunity existed was not long, it was adequate. It is recognized that the time elements as shown by the test flights were obtained by pilots who were primarily engaged in locating the other aircraft, knew where it should be at all times, its altitudes, and the tract it was going to follow. This knowledge aided the test crews in sighting the other aircraft.

Civil Air Regulations[1] clearly state the responsibility of pilots to observe and avoid other aircraft. Under these regulations it was the responsibility of both crews to see the other's aircraft and for the DC-3 crew to take evasive action as it converged on the Cessna from the left and rear. This responsibility also rested with the Cessna safety pilot as the flight entered the traffic pattern area in close proximity to the DC-3 already operating in the pattern.

With regard to the various factors affecting observance of traffic, it must be recognized that both flight crews were engaged in flight activity which by their nature would require a diversion of attention both within and outside the respective cockpits. The qualification check flight would, by its precise nature, require considerable attention inside the DC-3 cockpit by both the pilot flying the aircraft and the check pilot observing him. In the case of the Cessna only the instructor would be able to see the DC-3. His responsibility was certainly divided between watching for other aircraft and the duties of an instrument flight instructor.

The Board recognizes the aforementioned factors which made it difficult for these pilots to see the other aircraft and acknowledges that to do so required the highest degree of vigilance. However, the Board expects flight crews to exercise the utmost vigilance in order to carry out their responsibility and is of the opinion that if both crews in this instance had maintained a lookout commensurate with their responsibility this accident could have been averted.

As a result of this accident the Board's Bureau of Safety Regulation is studying the Civil Air Regulations to see if any revision or modification is necessary.

Probable Cause

The probable cause of this accident was the failure of the DC-3 crew to observe the Cessna and to comply with the prescribed airport traffic pattern which resulted in their converging and overtaking it. Contributing factors were the failure of the tower controller to advise the DC-3 that the Cessna was making a simulated instrument approach and the failure of the instructor-pilot of the Cessna to report inbound, and to see and avoid the other aircraft.

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1) "60.12 Careless or reckless operation. No person shall operate an aircraft in a careless or reckless manner so as to endanger the life or property of others.

c) Lack of vigilance by the pilot to observe and avoid other air traffic. In this respect, the pilot must clear his position prior to starting any manoeuvre, either on the ground or in flight."

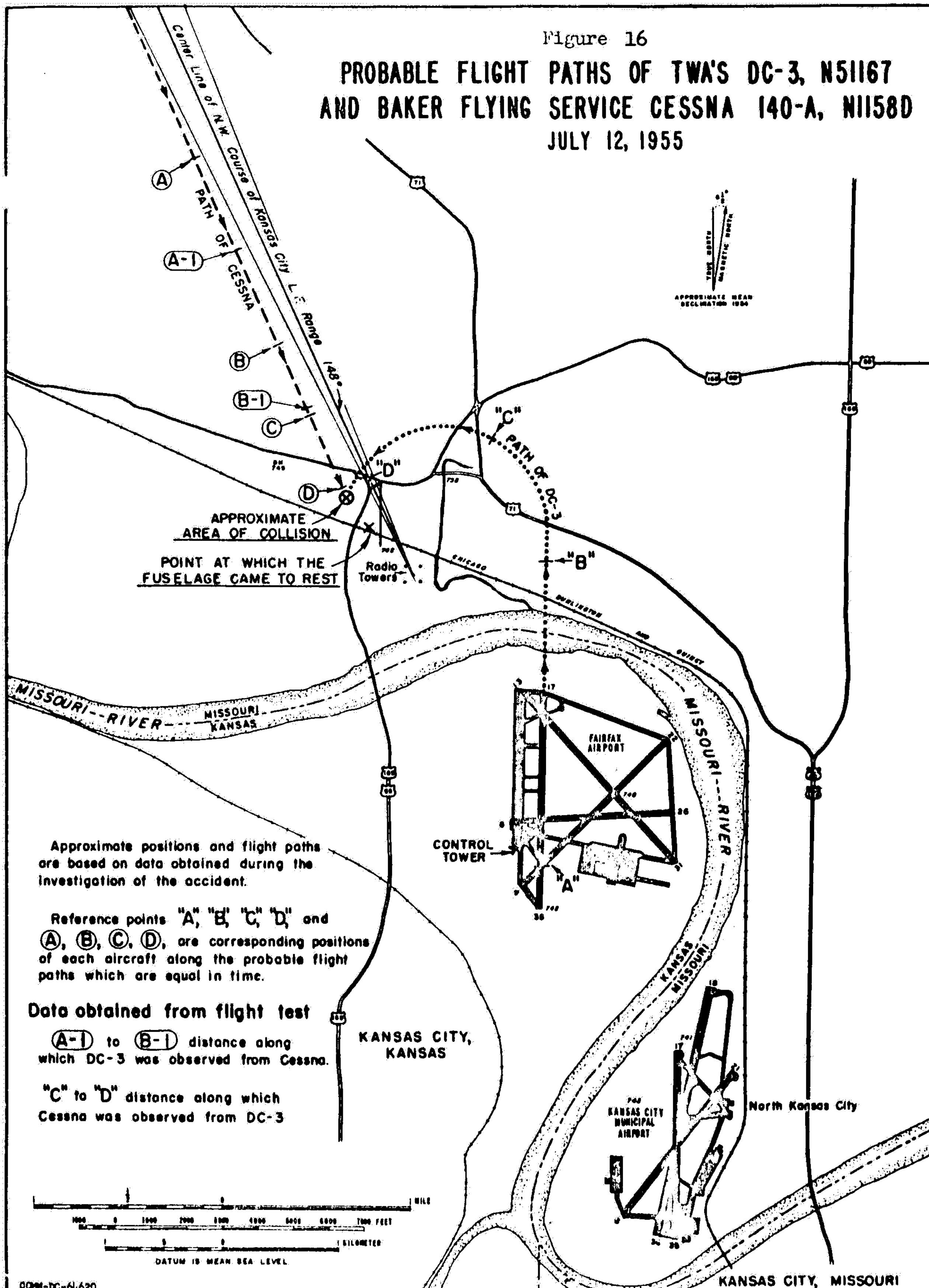
"60.14 d) Overtaking. An aircraft that is being overtaken has the right-of-way, and the overtaking aircraft, whether climbing, descending, or in horizontal flight, shall keep out of the way of the other aircraft by altering its course to the right, and no subsequent change in the relative positions of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

"60.15 Proximity of aircraft. No person shall operate an aircraft in such proximity to other aircraft as to create a collision hazard. No person shall operate an aircraft in formation flight when passengers are carried for hire. No aircraft shall be operated in formation flight except by prearrangement between the pilots in command of such aircraft."

ICAO Ref: AR/410

Figure 16

PROBABLE FLIGHT PATHS OF TWA'S DC-3, N51167 AND BAKER FLYING SERVICE CESSNA 140-A, N1158D JULY 12, 1955



No. 30

Port of New York Authority, Bell Helicopter 47G, crashed during take-off from heliport in New York City, N. Y., on 13 July 1955. Civil Aeronautics Board (U.S.A.) Accident Investigation Report, File No. 2-0019 released 8 November 1955.

Circumstances

The aircraft landed at 1450 hours Eastern Daylight Time at the heliport atop the Authority's building, 111 Eighth Avenue, New York. One passenger then boarded the helicopter to take photographs at Staten Island of projects in connection with the work of the Authority. The pilot plugged into the helicopter an external power line and started the engine. Take-off was to the southwest into a wind of 16 m.p.h. When the helicopter was about 10 feet high, it nosed down and its rotor blades struck the side of the building at the edge of, and immediately beyond, the heliport. It turned over and fell crashing (approximately 1515 hours EDT) in an inverted position against the west wall and at the edge of the heliport. The main wreckage balanced precariously at the edge of the heliport as fuel burned violently. The fire burned through the webbing of both safety belts allowing both occupants to fall a few feet to the tiled roof, both landing on their heads. The aircraft was destroyed by impact and ensuing fire, and both occupants were seriously injured.

Investigation and Evidence

External power supply was used for starting. It is commonly used in helicopter operation as individual flights are often too short to allow recharging of the helicopter's battery.

It was ascertained that the auxiliary battery boost cable, used for starting, had not been disconnected from the helicopter prior to take-off. This cable is 32 feet, 9 inches long and consists of two conductors of No. 6 wire using a standard AN-2552-2A cannon plug. It is rather large in cross sectional area, strong in tension, and durable.

The external power supply receptacle was installed on the helicopter at the Bell factory, with CAA approval. It was located at station minus 12 on the left side (just rear of fire-wall and pilot seat) and faced outward horizontally.

Almost immediately after take-off a right turn was made to the west toward the nearby Hudson River as a safety measure (the helicopter was fitted with pontoons). When the slack in the external power cable was used up, the cannon plug did not pull free because the direction of pull was at a large angle to the axis of the plug. Consequently, the helicopter was abruptly snubbed resulting in the nose dropping and the aircraft crashing. The pilot had sensed this drag only an instant earlier and there was no time to remedy the situation. A witness on the street below saw the helicopter "quiver" before it crashed.

The heliport is 376.50 feet above mean sea level and is privately operated by the Authority for its own use. The landing area is 40 feet by 45 feet and is surrounded by a heavy mesh wiring approximately 5 feet wide and at an upward angle of 15 to 20 degrees. Marking is conspicuous with a yellow center circle 20 feet in diameter with a white border one foot wide and white diagonal lines one foot wide.

Investigation disclosed that from May 1951, until this accident, there had been over 7,500 helicopter take-offs from, and landings on, the subject heliport. All had been uneventful.

Gross weight at take-off was 2 097 pounds as against a maximum allowable of 2 350 pounds. The location of the center of gravity, which is critical and extremely important on helicopters, was within prescribed limits. A breakdown of the gross weight follows:

Empty weight	-	1 524 pounds
Photographer	-	170 "
Aerial camera	-	35 "
Pilot	-	140 "
Gas (34 gallons)	-	210 "
Oil (10 quarts)	-	18 "
		2 097 pounds

Weather at the approximate time of the accident was reported by the U.S. Weather Bureau at New York as follows: Cumulus clouds .4 (approximately 5 000 feet); visibility 9 miles; relative humidity 39 percent; wind south 16 m.p.h. The Port of New York Authority has arbitrarily limited the use of their helicopters at this heliport to winds of less than 30-35 m.p.h., or 25 m.p.h. if gusty.

Maintenance on the helicopter had been thorough and in full compliance with all manufacturer's and CAA directives. Records indicated all periodic inspections had been meticulous. The total operating time was 1 089 hours of which 89 hours had been since the last 100-hour inspection on 14 June 1955. Individual components of the helicopter had been used well within their specific limits. The Port of New York Authority had set high operational standards for their helicopters as well as for the experience levels of pilots and mechanics.

Examination of the wreckage yielded nothing to suggest that there had been any malfunction of any sort and the pilot testified that there had been none.

The Port of New York Authority helicopters do not carry a take-off check list and are not required to. But it is the established custom for the pilot, and his exclusive responsibility, to handle the plugging in of the auxiliary power cable before starting the engine and to disconnect it before taking off. This is so because, as a safety measure, no persons are allowed on the confined area of the heliport while a helicopter is there with rotor turning. In this instance the pilot forgot to disconnect the cable and said so to Board investigators.

Immediately after this accident engineers of the Port of New York Authority devised a quick and automatic release fitting cable plug intended to prevent similar accidents. This new installation was soon applied to the Authority's sister helicopter and at all their landing sites.

On the new installation the receptacle on the helicopter faces vertically down. The plug is inserted vertically upward. A weight of several pounds rests on the surface of the heliport and is attached by a small chain with a few inches of slack to a quick-disconnect arm on the plug. Should the disconnect operation be forgotten and the helicopter rise only these few inches, the weight trips the arm and the plug is forcibly ejected. This type of device is known generically as a mouse trap mechanism.

Probable Cause

The cause of this accident was the pilot's oversight in not disconnecting the starting cable, causing the aircraft to crash.

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ICAO Ref: AR/387

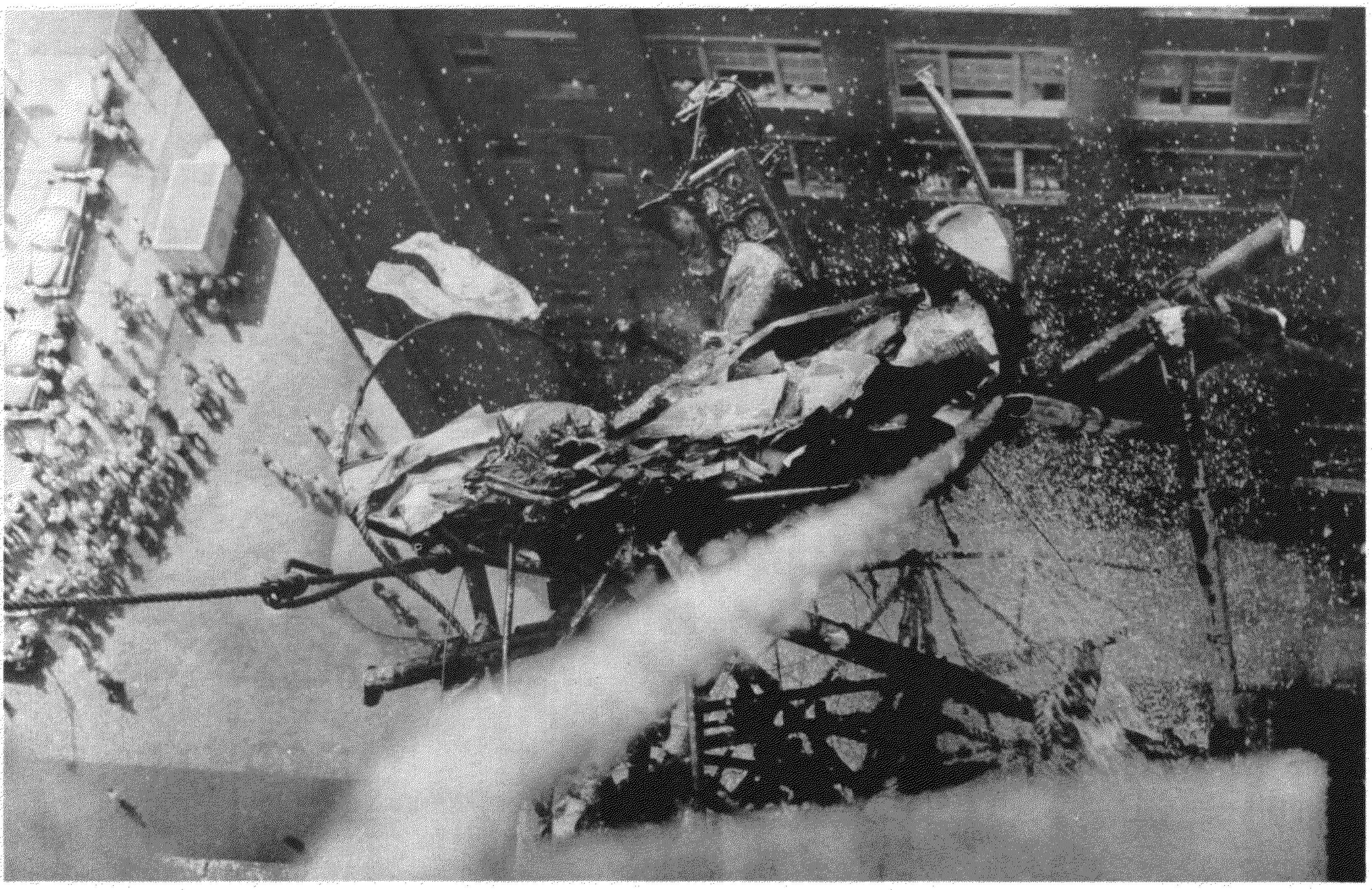

Figure 17 United Press Photo

As the wreckage of a New York Port Authority helicopter hangs precariously on a 15th floor ledge of the Port Authority Building in Manhattan, extinguishing foam is sprayed over it by firemen (not shown). The starting cable was not disconnected on take-off - 13 July 1955.

No. 31

Northwest Airlines Inc., DC-3 aircraft, collided with powerline pole during attempted go-around at Yakima Airport, Washington, on 15 July 1955. Civil Aeronautics Board (U.S.A.) Accident Investigation Report, File No. 1-0077, released 21 November 1955.

Circumstances

The aircraft departed Seattle-Tacoma Airport at 1730 hours Pacific Standard Time en route to Spokane, Washington, with a scheduled stop at Yakima, on an IFR (Instrument Flight Rules) flight plan via Green Airway 10 at 9 000 feet cruising altitude, carrying 12 passengers and a crew of 3. At 1738 the IFR flight plan was cancelled and refiled DVFR (Defence Visual Flight Rules) direct to Yakima. At 1805 the flight was advised by Yakima of storm activity south of the Yakima Airport. As a result the flight changed at 1809 to the Yakima Control Tower frequency and was cleared for an approach to Runway 22. When on base leg the tower advised that the wind was south 10 knots and the flight was then cleared for approach to Runway 16 and altered its flight path accordingly. At 1819, one minute out on final approach, the flight was advised of a 13 knot south wind and cleared to land. The aircraft touched down in the first quarter of the wet runway, rolled 2 000 feet and due to no braking action the captain started a go-around, 3/4 of the way down the runway. From a low altitude it settled to the ground 110 feet beyond the end of the runway, rolled 219 feet and again became airborne. Fifty nine feet beyond this point the right wing struck a powerline pole (15 feet above the ground) and the aircraft continued to fly just above the ground for a half mile over a pasture, came in contact with a 10 foot tree, touched down 55 feet further on and rolled 575 feet to a braked stop. No one was injured but the aircraft was substantially damaged.

Investigation and Evidence

The change from the approach to Runway 22 to Runway 16 was made while the flight was far enough north of the airport to permit proper runway alignment. Witnesses stated that the aircraft's approach appeared to be at a normal altitude but faster than usual. The runway was covered by .08 inches of rain at the time of landing. The captain stated that the touchdown was made at an indicated airspeed of 70 knots approximately 1 000 feet from the approach end of the runway and the brakes were applied repeatedly with no braking effect. He said that there was a "hydroplaning" effect caused by the water on the runway. Hydraulic pressure was normal and brake pedal pressure felt satisfactory. Flaps were retracted immediately after touchdown and during the first portion of the landing roll the tower cleared the aircraft to the ramp. The captain advised the first officer of no braking effect, advanced the throttles to take-off power and started a go-around. The aircraft became airborne at 70 knots indicated air speed and as the aircraft passed the south end of the runway at an altitude of 25 feet and an indicated airspeed of 78 knots the captain ordered "gear up". The first officer did not raise the gear but pulled both throttles back to the closed position. The captain then lowered the nose to hold air speed and re-applied full throttles. He did not land immediately after striking the powerline pole because of numerous cattle in the pasture.

Touchdown on the first quarter of a wet runway with no resulting braking action created a definite possibility of overrun, therefore, the captain's decision to go around appears to be proper. He had made previous go-arounds on Runway 16 during his twelve years of piloting for Northwest Airlines and there is no reason to doubt that this one would not have been successful had it not been for the unexpected power interruption caused by the first officer's action of closing both throttles instead of retracting the landing gear as ordered by the captain. The captain stated that the approach to Runway 16 was over high trees and powerlines and necessitated a slightly higher than normal approach. He further testified that although the 70-knot airspeed was lower than desired for the start of a go-around there was no difficulty, and he expected none, until the throttles were closed at 78 knots airspeed when he ordered "gear up!"

The first officer testified that he was not advised of the go-around and that the order for gear up was the only thing said by the captain after power was applied and the go-around started. In accounting for his action of pulling the throttles back his testimony was: "At the time the command was given I was expecting an order to reduce power and inasmuch as it looked like a crash was inevitable - when the order came, I moved them by spontaneous action." The first officer's left hand was resting on the control pedestal but not touching the throttles as the go-around started. He further stated that he estimated the aircraft's altitude ten feet or more above the ground when near the end of the runway and at that time he was waiting for the captain's order to reduce power and cut switches.

The storm that passed over the Yakima Airport shortly before the flight landed travelled from the southwest to the northeast and was over the field for not more than ten minutes. Maximum gusts of 40 knots were reported during the storm and no windshift noted. The U.S. Weather Bureau at Yakima Airport recorded .08 inch precipitation during the storm.

There was no failure or malfunctioning of the aircraft or its components prior to striking the pole.

Probable Cause

The probable cause of this accident was the copilot's action in closing the throttles* which resulted in its striking a powerline pole.

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* The power interruption caused the aircraft to momentarily settle to the ground.

ICAO Ref: AR/401

No. 32

Braniff Airways, Inc., Convair 340 aircraft, crashed at Midway Airport, Chicago, Illinois, on 17 July 1955. Civil Aeronautics Board (U.S.A.) Accident Investigation Report No. SA-308, File No. 1-0081. Released 15 November 1955.

Circumstances

The flight departed Dallas, Texas on schedule at 0100 hours Central Standard Time en route to Chicago, Illinois, with intermediate stops at Oklahoma City, Oklahoma; Wichita, Kansas; and Kansas City, Missouri, carrying 40 passengers and 3 crew members. Fog was forecast for the Chicago area and the visibility was expected to be restricted to possibly one-half mile, on arrival. The flight segments between Dallas and Wichita were uneventful; however, while starting the No. 1 (left) engine at Wichita prior to departure a small carburetor intake manifold fire occurred. This was immediately extinguished and the flight proceeded to Kansas City where it landed at 0416. At 0435 the aircraft departed Kansas City in accordance with a VFR (Visual Flight Rules) flight plan. It climbed to 15 000 feet mean sea level and at 0519 requested and received an IFR (Instrument Flight Rules) flight plan for the remainder of the trip. At 0547 Air Route Traffic Control cleared the flight as follows: "ATC clears Braniff 560 to the Napierville Omni via Peoria, Victor 116 over Joliet, maintain at least 1 000 on top, tops reported 2 000 mean sea level, contact Chicago Center on 118.9 mc. passing Peoria." Chicago ARTC broadcast a special weather observation at 0556 which was: "Thin obscuration, visibility one-half mile." The flight was asked whether it could land with one-half mile visibility and 1 000 feet obscuration and it replied that it could. The crew reported over Napierville at 0618 and the aircraft was radar vectored by Approach Control to the outer marker for an ILS (Instrument Landing System) approach to Runway 13R for landing. At 0624 the aircraft hit a commercial sign, crashed through the airport boundary fence and stopped inverted on the airport. Two crew members and 20 passengers received fatal injuries, one crew member and 11 passengers sustained serious injuries and the remaining 9 passengers received minor or no injuries. The aircraft was demolished by impact and fire.

Investigation and Evidence

The weather conditions reported at the time of the accident were: Partial obscuration; visibility one-half mile, fog, and smoke: sea level pressure 1014.2; temperature 71; dewpoint 68; wind south 6; altimeter 29.94; remarks, fog .8.

The commercial sign that was struck was located on the northeast corner of the intersection between 55th Street and Central Avenue where they bound the northwest corner of the Chicago Midway Airport. The sign was mounted near the top of a steel post 11 inches in diameter and 18 feet, 2 inches high. The sign was located approximately 82 feet from the nearest airport boundary fence and 1 000 feet from the threshold lights of Runway 13R. Relative to the ILS glide path and localizer course center lines, the top of the sign was about 84 feet below and 122 feet left, respectively. The height of the sign at its location was also approximately 12 feet lower than the allowable height as determined by the obstruction clearance criteria.* The glide path intersects the runway 1 600 feet past the sign. A single row of red high intensity approach lights are installed on the left side of the runway center line and extend 1 300 feet outward into the approach area. These lights slope gradually higher toward the outward end and opposite the sign are nearly its height.

The right wing of the aircraft struck the sign about 18 inches below the top. Impact marks showed that this wing was down about 11 1/2 degrees at this instant and the aircraft was on a magnetic heading of approximately 140 degrees. The impact caused failure of integral wing structure just outside of its engine nacelle and the wing quickly separated upward and rearward into the right horizontal stabilizer. The

* In the establishment of instrument approach procedures as outlined in the ANC (Air Force-Navy-Civil) Manual, criteria have been developed with respect to obstruction clearance between objects on the surface and the flight path of the aircraft. In the case of ILS procedures the minimum clearance in feet is a function of the distance outward from the glide path unit. In order to adhere to the obstruction criteria the effective length of the runway may be reduced.

aircraft then rolled progressively to the right as it crashed through the fence and struck several approach light installations. Nearly inverted, the aircraft slid through raised concrete runway identification markers onto the north-south taxiway where it stopped inverted on a magnetic heading of 290 degrees. Fire broke out during this time and rapidly increased in intensity until it was quickly extinguished by airport firemen who reached the scene less than a minute after the accident.

Impact forces with the sign, ground, light installations, and runway markers were severe. They mutilated the nose section of the aircraft, caused extensive damage to the fuselage, and tore off the empennage. In several areas the top and bottom of the passenger cabin were crushed close together, preventing several passengers from escaping until freed by the efficient efforts of the emergency personnel.

The investigation disclosed that the landing gear was down and the flaps were extended equally about 15 degrees when the accident occurred. Complete and exhaustive examination of the severely damaged aircraft structure failed to disclose evidence of fatigue cracking, structural failure, or control malfunction prior to impact.

The left engine was free of impact or fire damage. Its combustion chambers, oil and fuel screens disclosed no evidence of malfunction or failure. The undamaged condition of the engine permitted it to be functionally tested without significant alteration or repair. The results of the tests indicated normal operation.

The right engine was separated from its nacelle and extensively damaged. Its propeller shaft, nose case, and front accessory case were separated from the engine near the forward support plate. Disassembly of the engine and subsequent examination did not disclose evidence of operating distress, malfunction, or failure before the initial impact. Areas of fire damage were clearly those caused by fire following impact.

The shim plates of the left and right propellers bore impact markings which indicated that both propellers were in positive pitch and positioned about 38 degrees. Measurements of the propeller governor speeder spring racks showed that governors of both propellers were set for about 2 400 engine r.p.m. This evidence indicated that both engines were developing nearly equal power at impact and the amount was normal for the aircraft during the latter portion of the approach.

The radio and ILS receivers were damaged but capable of being tested without significant alteration. Test results showed that this equipment operated within allowable tolerances and indicated normal operation could have been expected before impact. Positive evidence revealed that this equipment was properly tuned to the Chicago ILS facilities. The associated cockpit indicators and flight instruments were so severely damaged that their indications could not be determined.

There were two models of the Bendix omni-mag indicators installed in the aircraft. The model installed on the captain's panel was an MN97-G-1 and incorporated an expanded localizer range feature. The first officer's indicator was an MN97-B and did not have the expanded range. The instruments are designed to indicate to the pilots the position of the aircraft with respect to the ILS glide path and localizer course during an ILS approach. Bench and flight tests were conducted to determine whether or not course deflections were different between the two models. Results showed that during the approach of the flight, as indicated by radar, including its position at initial impact, the indications of both instruments would have been alike and the deflection of the captain's instrument would not be within the area affected by the expanded scale feature.

Pertinent ground radio and navigation facilities were checked immediately following the accident and all were operating normally. During the investigation the possibility of interference affecting the performance of the ILS components was considered. Tests were made attempting to induce malfunctioning of the system by interference but these failed to produce any significant effect on it. Lighting facilities for the approach and landing on 13R were on and set next to the highest intensity, the position most commonly desired during IFR conditions. Commercial lights and street lights below the approach zone had been turned off at daylight and were off at the time of the accident.

Before the approach was started positive radio and radar contact was established and at this time the flight was given the latest weather information and altimeter setting.

The radar advisories and testimony of the radar controller revealed that the flight was initially vectored onto the ILS course and was properly aligned with it before reaching the outer marker (located 5.8 statute miles from touchdown). Advisories began five miles from touchdown and continued periodically until the flight was observed one-half mile out. In each advisory until it was 1 1/2 mile from touchdown the flight was told that its course and glide path were good. The controller said that his last transmission to the flight ended with it correcting right toward on course. He stated, in summary, that the approach was very good and his advisories were not required. He said advisories are mandatory only when the flight exceeds certain defined tolerances relative to the glide path and course line which vary progressively commensurate with the distance from landing. He said the flight was continuously well within these limits throughout the approach and at the time he discontinued the advisories.

The synoptic weather situation which existed during the trip and when the accident occurred consisted of a broad trough of low pressure which extended from Lake Erie through northern Indiana, central Illinois, and Missouri. Bounding the low pressure on the north and south were two high pressure areas. The spread between the temperature and dewpoint was narrow over the Chicago area and the terrain was moist from previous rain. These factors, together with light surface winds, made radiation fog easily predictable for the Chicago area and it was forecast before the flight originated. The fog was especially expected during the early hours of July 17.

An experienced forecaster stated that fog of this type is commonly variable in density over relatively short distances either as a result of its movement or the variable factors producing the fog. He also stated that slow dispersion of industrial smoke around the airport was another factor affecting the density of fog. As a result weather observations were made continuously during the night and early morning hours. These reflected a gradual deterioration of the visibility until at the time of the accident (0624 hours) it was one-half mile in fog and smoke. Thereafter, at 0655, the visibility was reported to be one-fourth mile in fog and smoke. The observations were taken approximately 1 1/4 mile from the accident scene and they did not incorporate the use of electronic "end-of-the-runway" visibility measuring equipment.

Under the reported weather conditions the flight was permitted to land. Company minima for the ILS approach are: ceiling 300 feet, visibility 3/4 mile. Applying the sliding scale * the landing was permissible with one-half mile visibility. Accordingly, the flight was permitted to descend along the ILS glide path to the minimum altitude and if visual contact was established with the runway threshold or approach lights it could continue to descend and land. After visual contact has been established the landing may be made without further adherence to the landing system. If, however, visual contact cannot be made at the minimum altitude the approach must be discontinued in accordance with the missed approach procedure.

During the investigation and public hearing many witnesses who were located in the immediate accident area testified or gave statements concerning their observations. Several heard the aircraft but because of dense fog could not see it until the instant it struck the sign or immediately thereafter. These persons said the approaching sound of the engines seemed normal, but judging by the volume, the aircraft seemed very low. The most qualified said that power was reduced a few seconds before impact. One witness who saw the aircraft hit the sign stated that it appeared fairly level at that instant.

Many witnesses offered important information concerning the fog and its density. Many on the scene at the time of the accident concurred that the fog there was very dense and pointed out that the fog density rapidly increased a few minutes before the accident, then decreased after it. Objects only a few hundred feet from them could not be seen at the time. Motorists stated that west of the accident the fog was quite dense and in several cases they used headlights while driving. Others approaching from the east said that the fog did not hamper their driving but when they reached the immediate area visibility rapidly deteriorated until it became extremely

* Operations Specifications, Part 20, par. 26 (2) (ii)
<u>Straight-in Approaches</u>

For each increase of 100 feet above the minimum ceiling specified, a decrease of 1/4 mile in visibility is authorized, until a visibility of 1/2 mile is reached.

poor. An air carrier flight crew testified that while taxiing on the north taxiway from the terminal to Runway 13R visibility became somewhat poorer but remained at least one-half mile. One crew member noted several drifting fog patches while taxiing.

A flight captain, whose flight was behind the subject flight and next to land, said he did not pass the outer marker inbound but recalled that he was unable to see the airport at any time. He remained above the clouds and estimated their tops to be about 1 700 feet m.s.l. He said that the fog appeared like the top of an overcast, becoming a heavy haze over the airport. While flying in the vicinity of the outer marker he noted a few small breaks with the ground visible through them.

Nearly all surviving passengers agreed that the flight was smooth and involved very little time in the clouds. Approaching Chicago the aircraft descended smoothly until it was above a uniform cloud coverage. It made several turns and then flew relatively straight for several minutes. The aircraft began to descend again and as it entered the clouds several passengers recalled a series of left and right banks. None recalled any appreciable power changes but all agreed that the engine sound was smooth and uninterrupted. Two passengers stated that the descent seemed a little steep and one, a former pilot, said the rate of descent increased sharply a few seconds before the accident.

Although the Board considers construction of the type exemplified by the commercial sign below an approach area undesirable, it believes this accident resulted primarily because of the extremely low altitude of the flight rather than the height and position of the sign.

Analysis of the physical evidence, testimony of witnesses, and the probable flight path indicate the flight was well established on the ILS in the area of the outer marker. Evidence indicates thereafter the rate of descent was well stabilized and the greater portion of the approach appeared to be executed in a nearly perfect manner. Strict adherence to the ILS during this time indicates that the flight was being flown with reference to the ILS glide path and localizer course and that the associated ground and airborne equipment were operating normally.

After passing the one-half mile from touchdown position the aircraft departed from the glide slope and descended rapidly. Considering the various factors involved this descent averaged at least 2 000 feet per minute between the one-half mile position and the sign.

It is believed that as the flight approached the middle marker the pilots probably established visual contact with the outward end of the approach lights and proceeded visually. This is the normal position where visual contact must be established for landing or the approach must be discontinued. As near as can be determined it was approximately in this position where two passengers saw roof tops and one witness on the ground heard a reduction in power. Both observations are indicative that visual reference was being made then.

Without doubt the accident area was engulfed in dense fog which would limit flight visibility to near zero. It is believed that this was confined to a relatively small area and was unknown to the pilots or to ground personnel in a position to alert them.

The importance of more precise and accurate weather reporting for the normal breakout area of an ILS approach has resulted in an endeavor, for several years, to develop instruments to measure the conditions in this area. As a result "end-of-the-runway" electronic equipment is becoming available. The U.S. Weather Bureau has obtained 20 sets of end-of-the-runway instruments consisting of a rotating beam ceilometer for ceiling measurement and a transmissometer for visibility measurement. Installation of these instruments is being accomplished on a priority basis with high volume traffic airports receiving first consideration. As a result a ceilometer has already been installed and is in operation at the Chicago Midway Airport; the transmissometer has also been installed but was not yet in operation as of 31 October 1955. The program for the installation of the balance of these instruments at various airports will continue during this fiscal year, with 45 additional sets programmed for the fiscal year 1957 as received from the manufacturer. The Board wishes to endorse this program and recommends that it progress as expeditiously as possible.

Based upon available evidence the Board does not believe

1) that the pilot continued below the prescribed minimum altitude without having had visual references, or that

2) as he descended visually he saw the heavy fog before entering it.

Although it cannot be positively stated on the available evidence and without the first officer's recollection, it is believed that after visual contact had been made and the aircraft adjusted for landing the flight unexpectedly encountered the area of fog which reduced the flight visibility to zero. During the necessary transition back to flying the aircraft by reference to instruments it is believed that the pilot experienced momentary disorientation during which the aircraft descended more rapidly before corrective action could be taken.

Probable Cause

The probable cause of this accident was momentary disorientation caused by the loss of visual reference during the final visual phase of the approach resulting in an increased rate of descent at an altitude too low to effect recovery.

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Figure 18 Aviation Crash Injury Research Photo

Braniff Airways, Inc., Convair 340 crash at Midway Airport, Chicago - 17 July 1955. View looking back along the approach path; the aircraft initially struck the 18 ft. high electric sign (1), which was approximately 90 ft. from the airport boundary fence. A portion of the line of approach lights (outside of the airport boundary) are shown at (2). The Convair was to the left, and below, the normal approach path - as indicated by the aircraft silhouette (3).

Figure 19 Aviation Crash Injury Research Photo

Braniff Airways, Inc., Convair 340 - Right side of cockpit and forward baggage area. The co-pilot survived. Note intact cockpit door (1).

No. 33

Bristol Aircraft Company, Bristol 171 Mark IV, CF-HVX, accident at Vancouver Airport, British Columbia, Canada, on 19 July 1955. Report released by Canadian Department of Transport, Air Services Branch, Civil Aviation Division

Circumstances

The aircraft was being flown commercially by a pilot employed by Okanagan Helicopters Limited.

At approximately 1420 hours Pacific Standard Time the aircraft, CF-HVX was engaged in ferrying injured personnel from the scene of an accident to a Royal Canadian Air Force aircraft located off the end of Runway 25 at Vancouver Airport, to the Royal Canadian Air Force apron on the same airport.

Of the large number of Royal Canadian Air Force personnel standing along the wall of an office as the aircraft landed, several ran out towards it. The pilot maintained power and some pitch to get the rotor blades coned to prevent the possibility of anyone walking into the rotor blades. The crewman then got out of the aircraft to attempt to keep the crowd back.

In spite of these precautions and shouts of warning from the crew and spectators, one man ran into the tail rotor and was struck on the head sustaining injuries which resulted in his death.

Investigation and Evidence

A temporary Certificate of Airworthiness which was valid at the time of the accident had been issued for the aircraft. The aircraft was correctly loaded; and the last inspection of the engine and aircraft was on 4 July 1955.

The pilot held a valid Senior Commercial Pilot Licence and had approximately 6 100 hours of flying experience of which 2 050 hours were on helicopters.

Of several people who approached the aircraft to assist in the removal of an airman injured in the earlier crash, the one who was struck by the tail rotor seemed to be unaware of its existence, and did not hear or did not heed the shouted warnings of bystanders, or the warning signals of the crewman.

Substantial damage was caused to the tail rotor blades of the helicopter.

Probable Cause

Spectators converged on the aircraft after landing and due to lack of experience of helicopters a Leading Aircraftsman ran into the revolving tail rotor.

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No. 34

Cambrian Airways Limited, Dove DH 104 Series 1B, G-AKSK, crashed at Sloden Enclosure, New Forest, 1 1/2 miles west of Fritham, Hants., on 23 July 1955. Ministry of Transport and Civil Aviation (U.K.) Aviation Accident Report No. C636

Circumstances

Before leaving Cardiff (Rhoose) Airport the pilot filed a Visual Flight Rules flight plan giving an elapsed time of 35 minutes for the flight to Eastleigh Airport, Southampton at a cruising altitude of 5 500 feet and then on to Paris. The aircraft took off at 0825 hours Greenwich Mean Time carrying the pilot and 6 passengers. At approximately 0850 hours he called London, asked for clearance to Southampton Zone and was told to call Southampton Zone. He then acknowledged this request. Shortly after 0850 the engines became unsynchronised and the aircraft vibrated. The port propeller stopped rotating and the aircraft lost height. On reaching 200 feet the port engine was restarted and the aircraft flew very low over a line of high tension cables. It continued to fly at 200 feet at low speed with increased vibration over undulating country and after climbing slightly to clear a ridge it descended into a densely wooded area. When near the tree tops it banked to the left and the port wing tip struck a tree. The aircraft then travelled 400 yards further, struck the tops of several trees and crashed, killing the pilot and seriously injuring 4 passengers.

Investigation and Evidence

Inspection at the scene of the accident showed that the aircraft had crashed into a dense wood after striking the tops of tall oak trees. The port wing tip was the first part to become detached and was found 400 yards from the main wreckage. The cockpit was crushed and the passenger compartment had been ripped open. The starboard engine had been torn out of its mounting and was lying about 15 yards from the fuselage. The port engine remained in its mounting. Both propellers were attached to their respective engines but only the port propeller showed evidence of being under power on impact. There was no evidence of fire. The inertia switch of the fire extinguishing system had operated but the methyl-bromide bottles had not discharged electrically due to disruption of the electrical circuits during the crash.

The engines were salvaged and sent to the manufacturers for detailed examination. After replacing certain components which had been damaged in the crash the port engine was mounted in a test bed and given a thorough testing. Subsequently it was stripped for detailed examination. The results of the test and strip examination showed that the engine was in sound working order.

The starboard engine had sustained considerable impact damage. When dismantled it was found that the crankshaft had broken at No. 3 crankpin. This failure had occurred before the crash as a result of a fatigue crack which had developed at a plugged hole in the rear web of No. 3 crankpin. Heavy scoring on the faces of the crankcase web and cap of No. 1 main bearing showed that Nos. 1 and 2 cylinders continued working after the crankshaft had failed. The crankshaft had run for a total of 1 205 hours since manufacture including 619 hours since the last overhaul when a modification designed to prevent failures of this nature was embodied.

Both propellers were subjected to a strip examination, including the units connected with the system for feathering the starboard propeller, but no evidence of any pre-crash defect was found. The blades of both propellers were in fine pitch.

This is the second accident to a Dove aircraft within one month in which the pilot shut down the port engine instead of the starboard engine which had developed serious mechanical trouble.

In both accidents the pilots were experienced and had completed over 500 hours flying as pilot-in-command in the type. Three factors which might possibly give rise to this kind of mistake were suggested in the report on the first accident (H.M.S.O. ref. C.A.P. 133). Only one of these factors is, however, common to both accidents, namely, the combined oil pressure/temperature gauge. This instrument is duplicated, one for each engine, and normally mounted side by side. Each instrument is marked "OIL" at the top centre and although annotated "LB/□" and "°C" respectively at the bottom the marking of adjacent pressure and temperature scales are not dissimilar. A fall in oil pressure in the starboard engine would be recorded by the left-hand pointer of the starboard gauge. It is possible that a pilot seeing the left-hand pointer of the starboard gauge falling could, in the stress of the moment, associate "left" with "port" and in consequence shut down the sound port engine instead of the failing starboard engine.

In the subject accident the pilot appears to have realised his mistake and restarted the port engine. Unfortunately, by this time the aircraft was down to a very low altitude. Even then, had the starboard engine been shut down and its propeller feathered, the accident might have been avoided. Why this was not done could not be determined.

Probable Cause

The accident was the result of the pilot mistakenly shutting down the port engine instead of the starboard engine in which a serious mechanical fault had developed. This led to a rapid loss of height and although the pilot restarted the port engine the starboard engine was not shut down.

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ICAO Ref: AR/424

No. 35

El Al, Israel Airlines Ltd., Lockheed Constellation 149, 4X-AKC, was shot down near the Bulgarian-Greek border on 27 July 1955. Report of Commission of Inquiry, Ministry of Communications, State of Israel, released 18 August 1955

Circumstances

The aircraft took off at 2015 hours Greenwich Mean Time on 26 July from London for Tel-Aviv with stops at Paris and Vienna. On 27 July it departed (0253 hours) Vienna with an estimated time of arrival over Belgrade of 0436 hours. While in the area of the Yugoslav-Bulgarian border at an altitude of approximately 18 000 feet the aircraft was fired upon by two Bulgarian fighters. Following two more attacks the aircraft broke up in mid-air at an altitude of 2 000 feet and fell to the ground in flames at a point 3-1/2 kilometres southeast of the junction of the Rivers Strumica and Strumon in Bulgarian territory near the Bulgarian-Greek border, killing all 51 passengers and 7 crew members.

Investigation and Evidence

At 0537 on 27 July Athens Air Traffic Control received an SOS from 4X-AKC on a frequency of 3 481 kc/s. This message was relayed immediately to Lod ATC. However, before search and rescue action could be taken Athens ATC was informed that the aircraft had been observed falling in flames near the Bulgarian village of Tserbanova and notified Lod ATC.

The weather conditions over the route have been divided into three sections as follows:

1. Weather on the Amber 10 Airway between Belgrade-Kraljevo-Skoplje and Gevgelia-Salonika.
2. Wind direction and velocity over the above route.
3. Weather over the South Bulgarian territory.

1. Weather on Amber 10 between Belgrade and Kraljevo

Broken clouds (average 3/8), 3/8 of Strato-Cumulus, 3/8 of Cumulus, cloudbase approximately 2 000 feet, cloudtops about 8 000 feet, temperature at 500 mlb. level (18 000 feet) -11°C., visibility 10 km., but hazy due to sunrise hour.

Kraljevo-Skoplje

Increasing cloud amounts (6-8/8). 3-5/8 Cumulus and Strato-Cumulus, base at 4 000 feet, 3/8 of Alto-Cumulus base 9 000 feet, but considerable locally isolated build ups of Cumulus and Cumulonimbus reaching to 20-25 000 feet with thunder, showers, lightning, icing and severe turbulence. Spread of these developed Cu and Cb's on west-easterly belt about 80 MILES WIDE and extending at least 100 MILES either side of Airway Amber 10.

These clouds have been reported as "past weather" (last three hours) and as "last hour" and "present weather" at 0600 hours. The international synoptic actual weather for South Yugoslavia and Northern Greece for the 27th at 0500 hours reads: "Fair to cloudy, local overcast with thundery showers mainly to north."

Skoplje-Salonika

Weather cloudy to fair, rapid improvement of local cloudy conditions. 1/8 Cumulus at 4 500 feet, 2/8 of Alto-Cumulus at 9 000 feet. Visibility 10-25 km. Temperature at 18 000 feet Minus 11°C.

2. Upper Wind Direction and Velocity on Amber 10 Airway between Belgrade and Yugoslav-Greek Border

The direction of the upper wind (18 000 feet) was constant from 260-270° throughout the 300 MILES stretch.

At Belgrade and up to a point about 50 miles south, the velocity was as forecast about 20-25 knots. From then on, the wind increased sharply to a velocity of 70 knots, due to the development of a large "LOW" pressure area in the North and a "HIGH" pressure area in the South at 18 000 feet level, after that decreasing from the Yugoslav-Greek border southwards.

International Synoptic Report for Upper Winds

South Yugoslavia and Northern Greece - the 27th, 0500 hours

at 10 000 feet	270°/35 knots
at 18 000 feet	260°/70 knots

Note:- Another JAT pilot flying the same route at 0900 hours at 12 500 feet reported wind of 270°/78 knots.

3. Weather over South Bulgaria

The weather was fine, traces of medium and high cloud. Visibility good. Wind as in previous paragraph.

Of the weather as discussed above two factors are most relevant to this flight:

Firstly, the presence of Cumulonimbus clouds on the route, and secondly, the sudden unpredicted change of the wind velocity from 20 to 70 knots.

The Commission immediately on appointment applied to the Bulgarian Legation in Tel-Aviv for visas to enter Bulgaria in order to proceed with the investigation on the spot. Furthermore, the Bulgarian Legation was approached by the Israel Foreign Ministry with the request that the Israel Commission of Inquiry act in conjunction with the Investigation Committee appointed by the Bulgarian Government in accordance with international practice. The answer to the application for visas was that the matter had been referred to Sofia with the request that visas be issued by the Bulgarian Legation in Athens in order to save time. No answer was received to the request to participate in a joint investigation.

The Commission, immediately on arrival at Athens, approached the Bulgarian Legation which had not yet received instructions to issue the necessary visas. The approach was made through the Israel Legation in Athens. The Bulgarian Legation agreed to endeavour to arrange for visas to be issued at the frontier. Again in order to save time, the Commission proceeded to a Greek border village named Kula, 14 kilometres from the site of the wreckage, where it remained waiting for permission to cross into Bulgaria. During this time it interviewed and took the testimony of a number of Greek eye-witnesses who were stationed at border posts.

The Commission spent 28 and 29 July on the border awaiting permission to enter and was able to observe portions of the wreckage and the activity on the site. The activity was considerable. Trucks were seen moving around in the area and wreckage was being transported to places out of view.

Permission was eventually granted to enter Bulgaria on 30 July, but the number of persons was limited to three and they were obliged to return before sunset.

The team found that

1. many parts of the aircraft had been removed from the places where they originally fell;
2. a most thorough search had been made of the wreckage. Lining had been ripped off and all closed structures had been opened for examination;
3. there were holes of various calibres too numerous to detail in the short time available;
4. all traces of bodies, luggage and personal belongings had been removed;
5. nearly all cockpit equipment, such as radios, instruments, electrical panels, had been removed and were not available for examination. Only one radio compass indicator and some completely smashed radio sets were found.

Before leaving Bulgaria the team requested permission to interview witnesses who could give further information. They requested particularly to see the pilots of the jet fighters who were obviously the only witnesses to give full and detailed information as to what had happened. They further requested permission to interview the Commanding Officer who had ordered the fighters to take off and, in addition, persons along the flight path. They also asked for the return of aircraft parts that had been removed from the site. The response to this request was that it would be referred to the authorities at Sofia. Unfortunately, no answer had been received to these requests up to the time of writing this report and the Commission was obliged to prepare it without this vital evidence being available from Bulgaria. The only Bulgarian evidence is the official communiqué (quoted at the end of this report) of the findings of the Bulgarian Investigation Committee which established beyond any doubt that the aircraft was attacked and brought down by Bulgarian fighters.

The Commission next sought permission to enter Yugoslavia in order to gather evidence there. Visas were duly granted by the Yugoslav authorities at Salonika and at 1400 hours on 2 August four members of the Commission crossed the Greek-Yugoslav border at Gevgelia. The witnesses interviewed by the Commission were all military personnel who had been stationed at points along the Yugoslav-Bulgarian border. One member of the Commission visited Skoplje and Belgrade aerodromes and gathered information from the Civil Aviation authorities. He also interviewed the Flight Control Officer who had been on duty at the time the aircraft passed over Belgrade and a JAT Airlines Captain who had flown the Airway Amber 10 on the morning of 27 July.

Aids to Navigation

The aircraft reported over Belgrade at 0433 hours. Belgrade has the following navigational aids: Two non-directional beacons with call signs BD and ZN. The aircraft used the BD beacon in its flight plan and when reporting. Both beacons were, at this time and date, serviceable. The BD beacon has an aerial output of 1 500 Watt. In addition to these two beacons, Belgrade has a VOR which was working normally.

The next reporting point Kraljevo has no navigational aid.

The reporting point at Skoplje, where Airway Amber 10 changes its direction from 161° (magnetic) to 142° (magnetic), is equipped with a non-directional beacon with an aerial output of 1 200 Watt. This beacon was working normally at the time of the flight. Between Belgrade and Skoplje, a distance of 177 nautical miles, no other radio aid is available either on the airway or abeam of it.

The reporting point at the Yugoslav-Greek border is the town of Gevgelia. There is no navigational facility whatever at this point.

The next navigational aid is a 350 Watt non-directional beacon at Salonika. There is, therefore, a further distance of 107 nautical miles between Skoplje and Salonika without any intermediate navigational aid. It should be mentioned in addition that according to information received from a Pan American Airways flight using the Salonika beacon at this time, reliable reception was limited to a small area over the beacon.

The Constellation was fitted with two serviceable radio compasses (Bendix), each radio compass being an independent unit from the indicator to the loop and sense aerial. There were also two independent VOR units (Bendix) installed in the aircraft. There were, in addition, 1 magnetic compass and 1 Fluxgate compass. These had been swung and adjusted on 18 May 1955. Both pilot positions were equipped with full instrument panels, including 3 directional gyros. There were also 2 ILS installations with 75 Mc/s Marker receivers. One Radar altimeter and a Loran set were installed at the navigator's position.

It is assumed that when within range of the BD beacon and the VOR at Belgrade, these aids were used. The VOR was, no doubt, helpful in keeping the aircraft in the airway for the first part of its flight from Belgrade towards Skoplje. The range of the VOR should not be considered reliable beyond 70-80 nautical miles. The range of the BD beacon owing to thunderstorms could not have been considered reliable for steady course indication. This applies, and even to a greater extent, to the Skoplje beacon which was surrounded by static. The Salonika beacon due to its low output and the possibility of coastal refraction would not have been reliable. It should be noted that the effectiveness of all three non-directional beacons may have been reduced by sunrise conditions.

The Flight

There is no doubt that, when the aircraft reported over Belgrade, it was, in fact, over the reported position. This was confirmed by the Control Officer at Belgrade who stated that he had heard the aircraft overhead at the time of its report. The radio facilities at Belgrade described earlier and the airborne equipment available would ensure that the aircraft could not be off course at this point.

Belgrade to Point 0510 (Vicinity Skoplje)

From Belgrade the aircraft heading would be along the Airway Amber 10, that is to say on a magnetic course of 161°. The winds forecast for this part of the route and used in the flight plan were 270°/20 knots at an altitude of 18 000 feet. The altitude for which the aircraft was cleared was 17 500 feet. The wind as forecast required a correction of 4° to the right, giving a heading of 165°. This was the heading used in the flight plan. The time for the leg

Belgrade-Skoplje calculated in the flight plan was 44 minutes. The planned arrival over Skoplje was, therefore, 0517. The actual reporting time over Skoplje was given as 0510, that is to say 37 minutes elapsed between the report over Belgrade and the report over Skoplje. The wind for the first half of this leg was, in fact, as forecast.

Plotting the aircraft's position after completion of the first half (70 nautical miles) of the leg on the basis of an indicated airspeed of 200 statute miles per hour at an altitude of 17 500 feet with an outside temperature of -11°C., which gives a true airspeed of 230 knots, we arrive at the point marked 0451 1/2. (See Figure 20).

From this point on the winds actually encountered were 260°/70 knots. The winds forecast were 270°/20 knots. The pilots could not have been aware of the wind increase and would not, therefore, have made any correction to the course. The aircraft must, therefore, have continued on the same bearing as before (165°) until reporting over Skoplje (at 0510). At this time the aircraft would, in fact, have left the airway and arrived at the point 0510. (See Figure 20). The premature report over Skoplje beacon was probably due to an erroneous indication of the radio compass influenced by the thunderstorms which were well developed near the actual flight path. It should also be noted that the easterly trend of the flight path could not have been checked by air to ground observations owing to the fact that the aircraft was passing over clouds.

In the section of this report dealing with the weather it was noted that from Kraljevo to south of Skoplje there were considerable build-ups and isolated cumulonimbus reaching great heights with lightning, icing and severe turbulence. Encountering these conditions, the pilots would, as a matter of ordinary airline practice, make small detours wherever possible, to avoid passenger discomfort. In reconstructing the flight path it has not been possible to reflect slight variations of course due to such detours but these should be borne in mind in evaluating the accuracy of the reconstruction.

Vicinity Skoplje (Point 0510) to Vicinity Yugoslav-Bulgarian Border (Point 0528)

Assuming they were at Skoplje beacon, the pilots at 0510 altered course to the new heading of the airway, namely 142° corrected for the forecast winds to 146°. They steered this course for 18 minutes before reporting over the border at 0528. Plotting the course taken during the 18 minutes with allowance for the actual wind, we arrive at the point 0528. (See Figure 20). We conclude this was the aircraft's actual position when it reported over the Yugoslav-Greek border. It was, in fact, close to the Yugoslav-Bulgarian border at a point approximately 26 nautical miles north of the Greek border. Continuing on this course for a further few minutes, the aircraft would cross into Bulgarian territory.

The place of this crossing corresponds to the position where the Yugoslav eyewitnesses observed the aircraft.

At this stage we feel obliged to refer to the findings of the Bulgarian Investigation Committee (quoted at the end of this report) which were to the effect that the aircraft entered Bulgaria at the town of Trn and after penetrating Bulgarian airspace for 40 kms. turned south and flew over various Bulgarian towns. South of the town of Stanke Dimitrov the plane was intercepted by two Bulgarian fighters which warned it to land. Having regard to the fact that the town of Trn is on a bearing of 135° (magnetic) from Belgrade and at a distance of 147 nautical miles from it, such a course is quite unrelated to the pilots' flight plan or to the direction in which they were making. The winds in this region were as predicted. The pilots were assisted for 70 miles out of Belgrade by reliable track indicating navigational aids (VOR). They were experienced pilots familiar with the route. We are satisfied that they could not have flown for some 41 minutes on an entirely arbitrary course, then turned sharply south on an entirely new course without apparent reason, and thereafter reported without comment over the Greek border.

It is stated in the above findings that the fighters warned the aircraft to land "in conformity with established international regulations. In spite of this it would not obey and continued in its flight towards the south in trying to escape". It is inconceivable that an unarmed civil aircraft with an experienced crew having 51 passengers aboard would not obey orders adequately given by two armed fighters. Further, the subsequent behaviour of the fighters is inconsistent with any previous warning having been given. The fighters attacked the aircraft a second time when it had lost considerable height and was evidently seeking for a place to land. A last attack was carried out at a time when the course of the aircraft was northward heading further into Bulgarian territory; the aircraft had already been hit and was obviously making an approach for a forced landing either in the Strumon valley or on an abandoned airfield further north. Finally, no radio warnings on the frequency fixed by the International Civil Aviation Organization for aircraft communication in this region were intercepted by either Greek or Yugoslav aeronautical stations keeping watch.

The Commission, therefore, after careful consideration cannot accept the findings on this point as set out in the official Bulgarian Communiqué.

The Yugoslav witnesses made their observations from points along the Yugoslav-Bulgarian border. One of the three witnesses stationed at the point marked "A" on Figure 20 saw a large aircraft flying in a southeasterly direction over Bulgaria and two fighters approaching it from the east. One of the fighters took up a position between the large aircraft and the Yugoslav-Bulgarian border. The other fighter manoeuvred around the large aircraft. All three witnesses at the point "A" heard bursts of machine-gun fire but none of them saw signs of a hit. The two witnesses stationed at the point "B" heard an aircraft to the northeast of their position and heard bursts of machine-gun fire. They then observed the aircraft moving in a southeasterly direction towards the Greek border. After this they heard more machine-gun fire. The aircraft was flying in a southeasterly direction and was about 7 kilometres distant from the observation post when it disappeared from view. A witness stationed at the point "C" also saw the aircraft to the northeast of his position and observed it flying to the southeast and losing height. He heard machine-gun fire but did not observe fighters or smoke from the plane when it disappeared over the mountain marked on Figure 20 with the co-ordinates 41°28'N 23°04'E.

The next witnesses to see the aircraft were the Greek observers along the Greek-Bulgarian border. The first group of observers (3 witnesses) stationed at the point "O" (see Figure 21) saw the aircraft approach over the mountain from the northwest. When it appeared, smoke was coming from its right side. Before the aircraft came into view one witness heard what he took to be heavy gun fire and another what he thought was thunder. The aircraft was seen flying southeast losing height but under control.

South of Petrici the aircraft started to turn towards the northeast, heading for the plain north of hills 224 and 281. A little beyond this to the north there is an abandoned military airfield. All three witnesses at this post state that when the aircraft was over hills 224 and 281, it broke up and fell in pieces. Part of the debris fell on the northwestern slopes of the hills and burned for a short time. The other part fell on the southeastern slopes and continued burning for more than an hour. When the aircraft broke up in mid-air, it was at an altitude of approximately 2 000 feet.

Other witnesses stationed at points "2" and "3" (see Figure 21) further east along the same border heard machine-gun fire before the aircraft appeared and then saw it coming low over the mountain with fire and smoke at the root of the right wing. They generally confirmed the previous witnesses regarding the path the aircraft took. However, they saw, in addition, two jet fighters above the aircraft. One of the jets disappeared immediately after the aircraft turned north but the other accompanied it right up to the time when it broke up. After this it circled and flew to the north. These witnesses heard a loud explosion at the time the aircraft broke up.

Three other witnesses, civilians, made their observations from the vicinity of Promachonos marked 4 on Figure 21. One of them heard shots immediately before the aircraft broke up. The attention of the others was drawn to the aircraft by what they described as "noise". Of this group of witnesses two saw the fighter.

Vicinity Yugoslav-Bulgarian Border (Point 0528) to Break-up

In the light of the evidence of the eyewitnesses, both Yugoslav and Greek, the reconstruction of the flight path may now be continued from the point 0528. As mentioned before, the aircraft may be presumed to have continued to the Yugoslav-Bulgarian border without altering course. The distance from the point 0528 to the mountain over which it first appeared to the Greek eyewitnesses is 17 nautical miles. The mountain is about 6 000 feet high and the aircraft was described as coming low over it. We assume, therefore, an altitude of some 8 000 feet. As the aircraft had reported at 18 000 feet over the point 0528, it must have lost approximately 10 000 feet of altitude over a distance of 17 nautical miles. This means that the aircraft must have reduced speed to the minimum in order to make a rapid descent. It must have averaged about 150 knots over this distance which it would then have covered in 7 minutes, bringing it over the mountain at 0536. Loss of pressurization as a result of damage to the fuselage caused by one of the earlier bursts of fire may account for the very rapid descent. (It will be remembered that the Yugoslav witnesses heard machine-gun fire before the aircraft came into view.) As the Yugoslav witnesses heard fire when the aircraft disappeared from their view and the Greek witnesses heard fire just before the aircraft appeared smoking into their view, it seems that the aircraft was hit for a second time and a fire started as the aircraft came over the mountain. The SOS message was received at 0537 which would be immediately after the fire started.

Why no SOS message was received earlier is a matter for conjecture. The cause of the sudden loss of pressurization may not have been immediately apparent to the captain: His first action would have been to lose height as rapidly as possible. At the same time he would have tried to find out the cause of the loss of pressurization. It may be that it was only at the second attack that he realized that the aircraft was under fire.

The aircraft continued on towards Petrici accompanied by the two fighters. It was losing height steadily. After crossing the Strumica River, it turned left between Petrici and the Greek border. It then headed in a northerly direction towards the Strumon valley until it reached the hills 224 and 281. Right up to this point the aircraft appears to have been under control and the pilot was making for a landing in the Strumon plain and possibly on the abandoned military airfield north of the hills. One of the fighters accompanied the aircraft to the end.

From the report on the wreckage and technical investigation it can be seen that certain damage was inflicted in the air immediately before the break-up. Explosions of large calibre projectiles in the rear part of the fuselage damaging the control mechanism of the elevators and rudders would not have permitted the aircraft to maintain controlled flight. Furthermore, projectiles had penetrated the tanks of the right wing and it was clear from the scatter of the pieces that the wing had exploded in mid-air. The left wing tanks had also been hit by bullets which must have started a fire followed by an explosion. The technical investigation points to the aircraft having exploded and broken up over the hills as a result of a final attack. The eyewitnesses' evidence supports this conclusion. Nearly all of them saw the aircraft break up in mid-air and some saw a fighter accompanying it. The witnesses to the west and south of the hills did not hear either the explosion or gun-fire. Those a little further to the east along the frontier heard the explosion and some of them also heard gun-fire.

The failure of some of the witnesses to hear the sounds of the explosion and gun-fire may be due to the strong westerly wind which was blowing at the time.

From the condition of the wreckage and the eyewitnesses' description of the break-up of the aircraft in mid-air together with the statement of the Bulgarian Government, it may be conclusively presumed that there were no survivors.

<u>Summary</u>

1. The first firing took place in the area of the Yugoslav-Bulgarian border at an altitude of approximately 18 000 feet. The Commission is satisfied that the aircraft did not receive any warning prior to this firing.

2. Several minutes later the second firing took place over Bulgarian territory at an altitude of approximately 8 000 feet. The aircraft was then evidently in process of descent seeking a place to land and was showing signs of fire. Nevertheless it continued in controlled flight. At the time of this attack it had covered some 17 nautical miles within Bulgarian airspace.

3. After approximately five minutes the third attack took place at an altitude of about 2 000 feet. The aircraft was still under control, heading northward deeper into Bulgaria and making for a forced landing. As a result of this last attack, the aircraft broke up in mid-air.

4. The aircraft entered Bulgarian airspace being approximately 35 nautical miles off track on a course which would have brought it to the Bulgarian-Grèek border after traversing approximately 26 nautical miles (6 to 7 minutes flying) of the southwestern corner of Bulgaria. The Bulgarian statement as to the course and track of the aircraft is inconsistent with the facts as proved.

5. In the circumstances of wind and weather on this flight, the crew could not have been aware of the aircraft's drift from track. In any event, the cause of the disaster was not this deviation but the action of the Bulgarian fighters in shooting down the aircraft.

A. Description of the Wreckage

(The total time spent on Bulgarian territory by the three investigators was only slightly more than seven hours of which approximately 3-1/2 hours were spent on travelling and formalities. Thus, they were able to carry out only a limited survey and could not make a complete investigation.)

The location of the wreckage was near the Greek-Bulgarian border on Bulgarian territory about 9 km N.E. of Petrich. The wreckage was found on hill 224/281 on the western bank of the River Strumon. The wreckage was scattered on the S.E. and N.W. descents of the hill over an area of approximately 35 000 sq. metres. The topographic height of the hill is 232 metres.

The South-East Side of the Hill

The major part of the wreckage was on the S.E. descent of the hill. The aircraft debris was found scattered, some parts broken into thousands of fragments. It was impossible to examine all the parts which were lying around. Therefore, only those parts were examined which in the opinion of the committee appeared significant.

The following parts and components found in this area were noted:

1. Four engines. One engine had been disassembled and many parts had been removed including 17 out of the 18 cylinders. A second engine was found in the water near the river bank. A third engine was in the river partly submerged. The fourth engine was on the slope of the hill.

2. Two parts of the centre section of the fuselage were found partly in the water. They were punctured by numerous inward pointing round and jagged holes of various sizes. Interior lining was missing from the cabin walls and was scattered on the ground. The lining showed no signs of fire.

   One part of the fuselage was the section where the wings are attached. There were several holes in the fuselage that had penetrated into the cabin in the vicinity of the right heater compartment. There were several large and small holes in the right heater compartment situated in the right wing root. Part of the heater assembly itself - the Janitor Combustion Heater - made of stainless steel was missing. It had not broken off by impact but had evidently been dismantled.

   In the heater compartment there was a clear indication of a fire in flight with a "blow-torch" effect: aluminium alloy parts had melted away with diminishing effect along a straight path against the direction of flight.

3. The left wing, broken off from the fuselage at the wing attachment fittings, was lying on the ground in one piece. The underside and ribs of the wing had been partly gutted by fire. Nearly all the ribs had sheared off. Part of the wing was less seriously damaged but even here some rivets of the ribs and lower wing skin were sheared off.

   There were a number of jagged and round holes on what remained of the wing skin.

   In the area of the upper surface at No. 2 tank, just behind the rear spar, there were inward pointing holes. In the rear spar web there was a round inward penetration, measuring 14 mm. in diameter.

4. One complete undercarriage, with wheels in retracted position, was found in the river.

   The wheel assembly of the second undercarriage was on the eastern bank of the river.

5. The only radio equipment found were two radio sets badly smashed. There were no radio dials.

6. Of the instruments there was only one radio compass showing a heading of 114° and a needle setting of 88°.

7. Some twisted seat structures were found but these accounted only for a small part of all the seats. The rest were missing. A partly burned safety belt was noted with the lock in closed position.

8. Two propeller hubs were found, on one of which there was an entirely undamaged blade.

9. An electrical high tension line of about 6 000 volts, running on the western bank of the river, was found severed, lying on the debris. Two broken wooden poles were on the site, one of them strongly burned.

10. Of the many panels lining the front and rear cargo compartment in the body of the fuselage, only one was found, a vertical panel. It was pierced by 12-15 round holes up to 15 mm. in diameter.

11. Many smaller pieces lying around, not specified above, were pierced by round and jagged holes.

12. There were indentations on the ground where heavy parts had been imbedded but the parts were found quite a distance away, unrelated in their location to the original imprints in the ground.

The North-West Side of the Hill

On this side the wreckage was more widely scattered than on the southeast side and consisted mainly of major parts.

13. The right wing was broken off at the attachment fittings from the fuselage and broken in three large parts which were lying at a distance of about 80 metres one from another. At the inner part of the inner wing, the skin was separated from the few ribs remaining. The tank area of this part of the wing, between the front and the rear spar, was almost entirely burned out and the metal of sheets and extrusions was melted down. The ground below the wing showed a fire running downhill, obviously fed by the remaining fuel of the wing at the time of impact. In the outer part of the inner wing, in the vicinity of the engine nacelles, there were indications of a less intense fire and there was less destruction than in the inner part. Here it was still possible to find and identify some holes caused by the penetration of projectiles. (Some of these were of large calibre.)

The outer wing carrying the aileron was partly undamaged. Here, too, there was a fire of lesser intensity. The fabric was stripped clean from the aileron which showed no signs of fire.

14. The fuselage between the wing trailing edge and the rear pressure bulkhead was smashed into several pieces, all of them strongly distorted and almost beyond recognition. Here, again, a number of holes of different sizes were noted. All fibre glass and fabric lining of the accessible cabin sections was stripped from the inside of the fuselage. The steward's call button box cover was found unscrewed and open.

15. Three blankets were found near the fuselage, each pressed into a tight plug-like bundle. The smaller end of each bundle was charred.

16. Two complete inner flap sections, lying separately, showed a number of round holes.

17. The rear part of the fuselage was severed from the main body at the rear pressure bulkhead. There was an inward pointing hole on the lower part of the right side aft of the bulkhead. The hole was broad, oval in shape, with a minimum diameter of 85 mm. The direction of penetration was approximately 15° from the rear to the horizontal centre line of the aircraft. No corresponding outlet to this hole could be found.

The rear pressure bulkhead in this part of the fuselage however was pierced by a great number of round and jagged holes most of them pointing outwards. There was also a large opening torn in the pressure bulkhead.

The bottom segment of the second ring from the tail cone attachment point was pierced by two holes from rear to nose measuring 63 mm. and 75 mm. respectively.

The walking beam of the elevator was found detached from its bracket.

The fuselage structure in the area of attachment of the empennage showed a number of holes.

On the bottom of the fuselage underneath the walking beam attachment brackets there was a jagged opening in the skin with a diameter of 170 mm.

There were indications of a not very intense fire around the emergency elevator booster system apparently sustained by the hydraulic fluid of the main hydraulic system and the emergency booster system including the accumulators situated in this area.

18. The empennage of the aircraft was broken into three pieces which were found 150 metres apart.

Most of the stabilizer and the centre fin were lying near the bottom of the hill. A smaller piece of the stabilizer with the left fin and rudder were close to the top of the hill. The right part of the stabilizer, the elevator and the right fin and rudder were near the bottom of the hill, not severely smashed. Pieces of this section, adjoining the fuselage had been cut away with cutting tools and could not be found.

In the structure of the empennage, where it attaches to the fuselage, there were a number of holes.

19. Deicer boots were clearly cut by sharp instruments and some of the sections of regular rectangular shape were missing.

20. The six high pressure oxygen bottles and one walk-around oxygen bottle were found intact.

21. Many major components and sections could not be found. Conspicuously missing was the section of the fuselage from section 290 forward which includes the cockpit.

22. In addition to the holes mentioned in the above description there were many other holes of sizes ranging from 8 to 85 mm.

23. Despite the large number of holes no projectiles or fragments of projectiles were found.

B. Discussion

The item numbers used in this Discussion refer to the numbers in Description A above.

1. Nothing was found in the wreckage available for inspection to indicate that there had been any defects or failures due to malfunctioning.

2. There was considerable evidence that the wreckage had been interfered with before the committee's arrival. It had been noted that many parts had been removed, including nearly all radio equipment and instruments. (Items 5, 6.) These may have provided useful information. In addition, many parts had been dismantled, cut away and/or removed. Among these were engine cylinders (Item 1), interior lining (Items 2, 14), the heater (Item 2), most of the seats (Item 7), portion of the empennage (Item 18), deicer boots (Item 19), and the whole of the cockpit (Item 21).

Furthermore, marks on the ground indicated that heavy parts had been shifted from the positions in which they had fallen. At least part of the interference above could not have been occasioned by rescue operations.

In spite of the extensive interference with the wreckage it could be determined that some of the parts were lying where they had fallen. For example, the three pieces of the right wing were in their original position. This was clear from the fact that the fire that had burned in one of the pieces extended to the adjacent vegetation and melted material from all three pieces was lying on the ground beneath the places from which the metal had melted away.

3. There was a clear indication of a fire having started some time before the final break-up and having continued in flight for several minutes. The evidence for this was the condition of the heater compartment (Item 2). The fire here must have burned some time in flight in order to have melted the aluminium along a straight part running from fore to aft. The melting of the aluminium decreased along the path. This fire was intensified by the slipstream to which this area was exposed by reason of the holes in the compartment. The

size of the projectiles that had entered could not be determined owing to the deformation of the material through heat and impact.

4. The three blankets, bundled into plugs and charred at one end (Item 15) suggest that smoke and fire were entering the cabin and efforts were being made to stop the holes. This supports the view expressed above, that a fire had started some time before the break-up. It further indicates that pressurization must have been lost at this earlier stage.

5. The condition of the left wing (Item 3), indicated an explosion. Ribs and rivets were sheared off in a manner that could not have been caused by fire or impact. The round holes in the skin of the wing and in the area of the upper surface of the tank behind the rear spar and the hole in the rear spar web appear to have been caused by bullets. Bullets hitting in this area would cause a fire followed by an explosion. It is probable therefore that the attack on the aircraft, in the course of which these bullet holes were inflicted, occurred at, or immediately before the final break-up.

6. There was evidence that the right wing had exploded and that the explosion had taken place in mid-air. Rivets holding the ribs to the skin had been sheared off. The three pieces of the wing were lying at a distance of about 80 metres one from the other. As explained before, the pieces were where they had originally fallen and could not have been so widely scattered except by mid-air explosion.

7. The numerous holes in the cargo compartment panel (Item 10) were caused by bullets of different calibres. Only one could be measured with reliability from the photographs. Its diameter was 14 mm. These holes were round and the panel they penetrated had been in a vertical position. They must therefore have been caused by bullets fired from a direction more or less horizontal to the aircraft.

8. The rear part of the fuselage (Item 17) was heavily pierced by holes, including some of large diameter. One of these larger holes was caused by a projectile entering the unpressurized part of the fuselage at an acute angle from the rear. It must have then exploded, cutting the many outward pointing holes in the skin and the forward pointing rents in the rear pressure bulkhead. One of these was a large rent 40 X 90 cm. From the angle of penetration it can be concluded that the projectile was fired from an aircraft. Its size and explosive effect suggest a rocket.

The two hits in the second ring from the tail cone in this area were also caused by large calibre projectiles. They must have been fired from the rear.

The damage they caused could not be clearly determined. They may have brought about the detachment of the walking beam. They may have also caused the fire noted around the emergency booster system.

The explosive effect of these three large projectiles behind the rear pressure bulkhead, where most of the elevator and rudder control mechanism is situated, would prevent the aircraft from being flown under control.

9. The request to the Bulgarian Government to allow a second access to the wreckage of a committee or two, including the armament expert, was not granted. The conclusions arrived at as to the type and size of projectiles which hit the aircraft were reached by the Commission after the armament expert had examined photos and sketches and had received reports on this aspect of the investigation from the three members of the Commission who had had access to the wreckage.

Probable Cause

The aircraft sustained a hit or hits which caused loss of pressurization and a fire in the heater compartment. The aircraft broke up in mid-air due to explosion caused by bullets hitting the right wing and probably the left wing together with a projectile or projectiles of large calibre bursting in the rear end of the fuselage.

Recommendations

Throughout the European and Middle East regions there are a number of airways which are not adequately equipped with radio navigational aids ensuring that pilots are given a reliable tracking when they need it most, that is to say, in bad weather. Non-directional beacons are inadequate aids unless supplemented by other navigational aids such as radar surveillance of the kind provided, for example, in England. With NDB's alone pilots will be unable to avoid deviations from the airways. The International Civil Aviation Organization has recommended a more extensive use of VOR's which not only give an adequate track but are also unaffected by bad weather (static).

The route Belgrade-Salonika (Airway Amber 10) over a distance of 284 nautical miles is equipped with only one VOR (at Belgrade) and 3 NDB's (at Belgrade, Skoplje and Salonika) but has five compulsory reporting points (Belgrade, Kraljevo, Skoplje, Gevgelia and Salonika). In practice, the Airway Amber 10, when flown from Belgrade in bad weather, can be followed with accuracy only for the first 70 miles with the aid of the Belgrade VOR.

It is, therefore, recommended that:

a) Navigational aids which are not affected by static should be introduced along Airway Amber 10 to supplement the present NDB's and should cover the whole Airway.

b) All compulsory reporting points should be equipped with radio navigational aids.

As far as the Commission is aware, no communication watch on ground to air frequencies, used by aircraft on this route, is kept by the Bulgarian communication centres nor are they obliged to keep such a watch.

It is, therefore, recommended that:

a) A continuous watch be maintained on appropriate ground to air frequencies by those governments which have established prohibited areas in proximity of international airways.

b) There is also need for a standard air to air code of visual signals in the absence of radio communications and/or a common language.

Finally, the Commission is of the opinion that there is urgent need for co-ordinated international action to prevent the shooting down of civil aircraft.

The Commission, therefore, recommends to the Government to examine what steps may be taken to this end through the UN, ICAO and otherwise.

"Bulgarian Note of 4 August 1955

Ministry of Foreign Affairs

NOTE VERBALE

The Ministry of Foreign Affairs of the Bulgarian People's Republic presents its compliments to the Legation of Israel in Sofia and, in reply to the latter's note No. V/0485/02, has the honour to communicate the following, on instructions of its Government:

The following facts have been established beyond doubt by the ministerial commission of inquiry:

At 0710 hours (local time) on 27 July 1955, an aeroplane of the Israeli airline "El Al" penetrated Bulgarian airspace without notice in the area of the town of Trn. After penetrating into Bulgarian territory to a depth of 40 kilometres, the aeroplane then flew over the towns of Breznik, Radomir, Stanké-Dimitrov and Blagoevgrad and proceeded towards the South. It flew over Bulgarian territory for a distance of approximately 200 kilometres.

South of the town of Stanké-Dimitrov, the aeroplane was intercepted by two Bulgarian fighters which had received orders to compel it to land at a Bulgarian airport.

The fighters warned the aeroplane to land, in accordance with established international rules. In spite of this, the aeroplane did not comply, but continued to fly southwards, attempting to escape across the Bulgarian-Greek frontier.

In the circumstances, the two fighters of the local Bulgarian air defence forces, surprised at the actions of the aeroplane, opened fire, as a result of which the aeroplane caught fire and crashed a little later in the vicinity of the town of Pétritch.

In adopting the conclusions reached by the special ministerial commission instructed to inquire into this incident, the Bulgarian Government admits that the causes of the unfortunate accident to the "El Al" aeroplane can be summarized as follows:

1. The aeroplane deviated from its route, violated the State frontier of Bulgaria and penetrated deep into the interior of the Bulgarian airspace without warning. Equipped as it was with perfect air navigation devices, the aeroplane cannot have been unaware of the fact that it violated the State frontier of Bulgaria. Even after it had been warned, it failed to comply and continued to fly southwards in the direction of the Bulgarian-Greek frontier.

2. The Bulgarian air defence forces acted with some hastiness and did not take all necessary measures to compel the aircraft to surrender and land.

3. The Bulgarian Government considers it necessary to draw attention also to the fact that, for many years, certain parties, failing to respect the sovereignty of the Bulgarian People's Republic, have systematically been violating the Bulgarian frontiers. In recent years many illegal crossings of the Bulgarian frontiers by aeroplanes "of unknown nationality" have been recorded. During these illegal flights, subverters equipped with arms, radio stations and other supplies were parachuted into Bulgarian territory. The Government of the Bulgarian People's Republic protested several times to the Secretariat of the United Nations Organization. Unfortunately, however, this produced no results. All these factors created a tense atmosphere which made it necessary to take steps to safeguard the security of the State. It was this tense atmosphere that made possible the unfortunate accident to the Israeli aeroplane.

The Bulgarian Government and People express once again their deep regret at this great misfortune which caused the death of entirely innocent persons. The Bulgarian Government fervently hopes that such misfortunes will never recur. It will discover and punish those responsible for the catastrophe in which the Israeli aeroplane was involved and will take all necessary steps to ensure that similar catastrophes do not recur in Bulgarian territory.

The Bulgarian Government extends its deep sympathy to the relatives of the victims and is ready to undertake to pay compensation due to their families, as well as to bear its share of the material damages.

Ministry of Foreign Affairs
of the
Bulgarian People's Republic"

Sofia, 4 August 1955

The Legation of Israel
Sofia.

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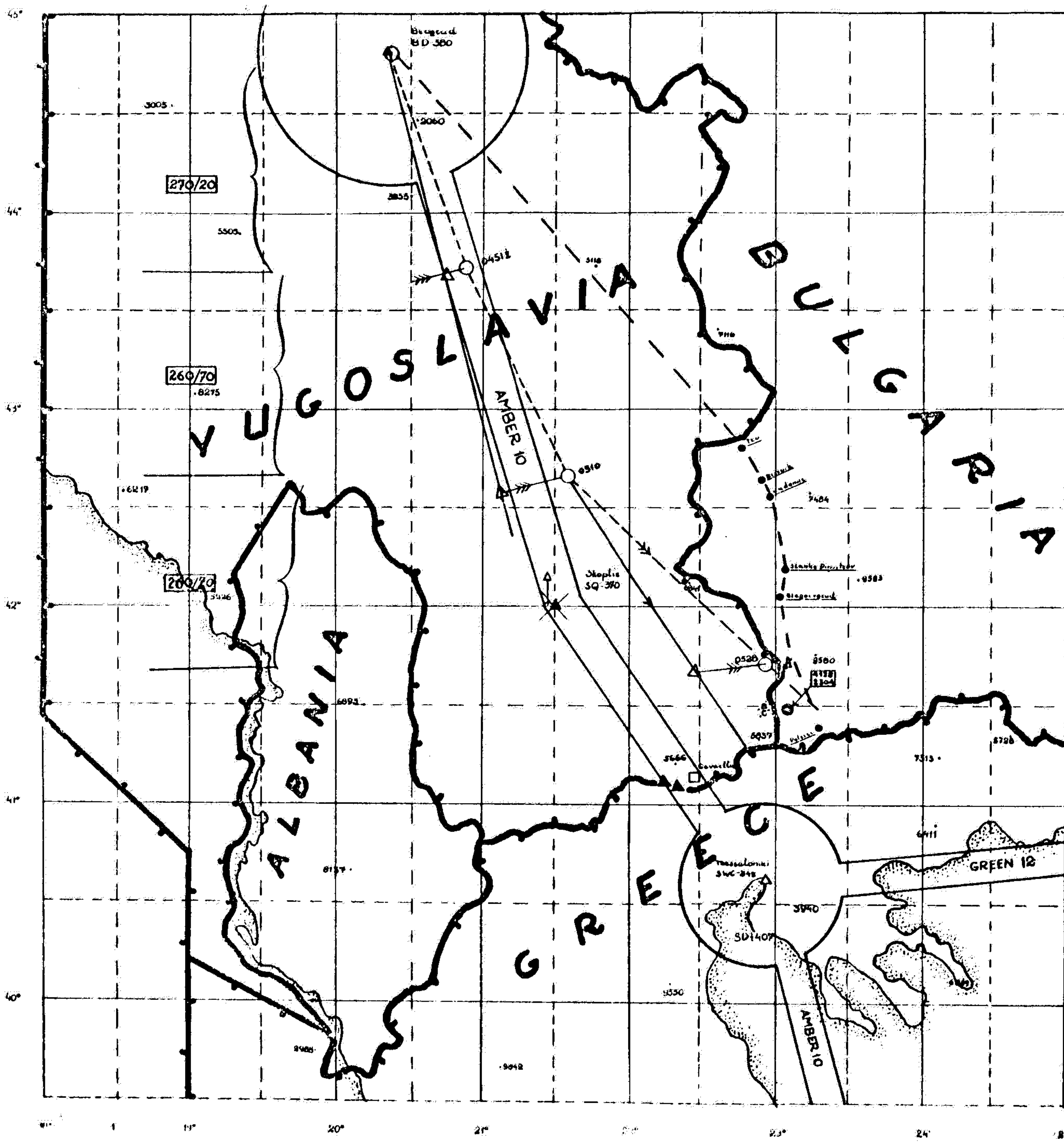
ICAO Ref: AR/389

Figure 20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BULGARIA
ALBANIA
GREECE
AMBER 10
GREEN 12
AMBER 10
270/20
260/70
260/70
Skoplie
SQ-370
Belgrad
BD 380
Thessaloniki
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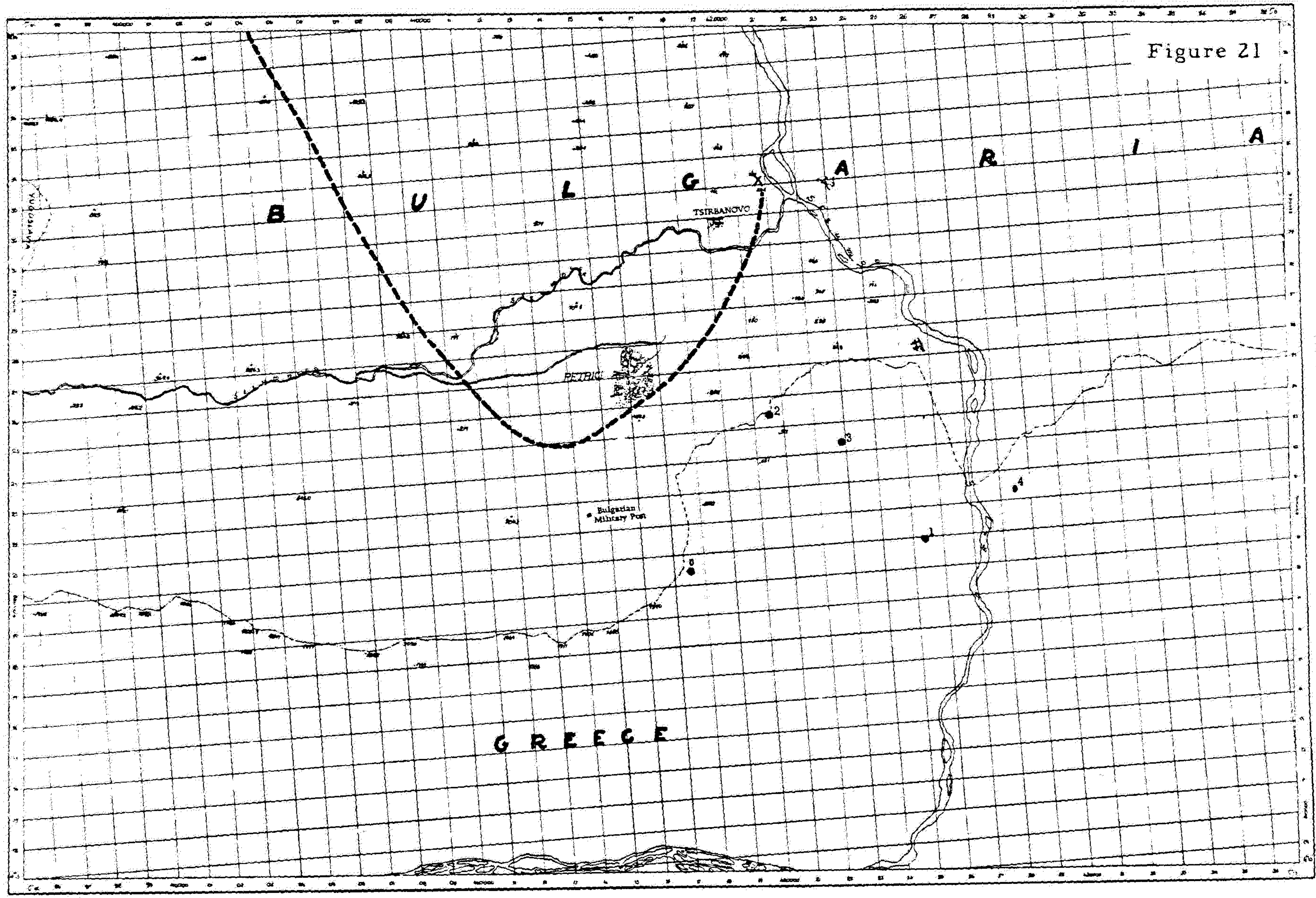
B U L G A R I A
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Figure 21

No. 36

American Airlines, Inc., Convair 240, crashed at Fort Leonard Wood, Missouri, on 4 August 1955. Civil Aeronautics Board (USA) Accident Investigation Report No. SA-309, File No. 1-0110, released 9 December 1955.

"This accident resulted in the largest loss of life of any aircraft fire accident in the U.S. during 1955."

National Fire Protection Association Bulletin No. 142

Circumstances

The flight was a scheduled operation between Tulsa, Oklahoma, and La Guardia Field, New York, with stops at Joplin, Springfield and St. Louis, Missouri. It departed Tulsa at 1006 Central Standard Time carrying a crew of three and eight passengers. Stops were made at Joplin and Springfield and at the latter point two passengers deplaned and twenty one boarded the flight bringing the passenger total to twenty seven. The aircraft departed Springfield VFR for St. Louis at 1153 CST via Victor Airway 14 to cruise at 7 000 feet. At 1217 the crew initiated a general call asking "Does anyone read 476?", which Springfield company radio acknowledged but received no reply. Two other American Airlines flights, one cruising in the vicinity of Springfield, the other 30 miles north-northeast of St. Louis, heard a transmission from the flight that No. 2 engine was on fire. Three minutes later the American Airlines flight in the Springfield area intercepted the following message "Springfield, are you reading 476? We have bad engine fire." This was the last message heard from the aircraft. At approximately 1222 hours the operations officer on duty at Forney Field, Fort Leonard Wood, received a radio message from an Army pilot flying nearby that a two-engine aircraft with a fire in the right engine was on final approach to Runway 14. The tower operator at Forney Field saw the approaching aircraft and gave it clearance to land. Before the operations officer could alert the crash crew the aircraft crashed short of the runway in a densely wooded area about one-half mile northwest of Runway 14, Forney Field, at 1223 hours. There were no survivors.

Investigation and Evidence

Army personnel with portable fire-fighting equipment reached the wreckage on foot. Heavy fire-fighting equipment and ambulances could not reach the scene until the Army engineers had bulldozed a road through the densely wooded area in which the crash occurred.

Investigation revealed that the right wing, right engine, right landing gear, and associated parts had separated from the aircraft in flight, and that bits and pieces, including the right inboard landing gear door, had fallen from the aircraft before the wing came off. The remainder of the aircraft struck the ground approximately 300 feet beyond where the right wing fell. Ground fire and impact damage was extensive and much of the wreckage consisted of burned rubble only. All major components, however, were accounted for at the accident site. Evidence indicated that the landing gear had not been extended, and that the flaps were in the full-up position.

Examination of the right engine showed that the No. 12 cylinder had broken circumferentially just above the hold-down flange. The flange portion remained with the engine; the remainder of the cylinder, with the piston jammed in the open end of the barrel, was found approximately 70 feet distant. The piston pin eye of the No. 12 link rod was broken and the piston pin lay about 30 feet from the engine. Damage to the link rod was relatively minor. Other parts associated with the right engine nacelle were scattered throughout this general area. Two blades of the right propeller, which had been feathered, were broken at impact.

All parts believed to be pertinent to continued investigation of the accident were removed by the Board's investigators to American Airlines' Overhaul and Supply Depot at Tulsa for more detailed examination. At Tulsa the right engine, landing gear, and associated wing structure were assembled in approximately their relative flight positions for the purpose of tracing the fire path. Fire originated in zone 1*

*) Zone 1 - Engine power section; zone 2 - accessory section; zone 3 - aft of the firewall.

between Nos. 11 and 13 cylinders and progressed directly rearward into zone 2 at the diaphragm outer edge seal. The pattern of heaviest fire damage extended directly back from No. 12 cylinder. Fire passed out of zone 2 forward of the firewall at the mating surfaces of the lower and inboard cowls, and of the lower and outboard cowls. It entered zone 3 immediately aft of the firewall on the inboard side of the nacelle. Burned-through fuel, hydraulic, and cabin compressor oil lines in zone 3 released combustibles, and fire of increased intensity progressed rearward along the inboard side of the nacelle to the front spar. The upper and lower rails and web of the front spar were heated to the point where material was weakened and the lower rail failed in tension, resulting in separation of the right wing from the aircraft.

Impact and fire damage was such that the condition of the fire seal between zones 1 and 2 prior to the accident could not be determined. Effective sealing in this area depends on contact between a neoprene asbestos seal attached to the periphery of the diaphragm and the inner surface of the orange peel cowl.

After the accident the carrier ordered an inspection of its Convair fleet to determine if specific undesirable conditions existed with respect to this fire seal, and corrective action was taken in all cases where such conditions were found. Seals are now being renewed every overhaul instead of upon condition or approximately every other overhaul, as was done previously. In addition, a chalk test is being made upon installation to determine more conclusively if there is proper mating between the diaphragm and the orange peel cowl.

In 1952 American Airlines modified the fire detector system in all of its Convair 240's for the purpose of obtaining quicker fire warnings. This modification was worked out with the manufacturer and is essentially the same as the system that is standard on the Convair 340's. A single light in the cockpit shows the crew which powerplant a fire is in but does not indicate the zone. Emergency procedures are to be initiated by the crew as soon as a fire warning is received. These include actuating the extinguishing system, which discharges in zones 2 and 3 only.

During the investigation of this accident it was not possible to make a functional check of the fire detector system for the right engine and nacelle because of extreme fire and impact damage. Also, the fire extinguisher control panel in the cockpit was so damaged that no information pertinent to the accident could be obtained from it. All CO_2 bottles were recovered, however, with their heads, including the thermal discs, intact, and when weighed were found to be empty. The CO_2 retention door in the zone 2 chimney was found closed.

Control linkages to the right side firewall shutoff valves were broken and detached, and the valves showed impact and fire damage. The engine oil, cabin compressor oil, and hydraulic fluid valves were found closed; the fuel shutoff valve was so damaged that its position could not be determined. All of the firewall shutoff valves, however, are mechanically linked to one common control handle.

The electrically operated right main tank fuel shutoff valve, located in zone 3, was recovered in the open position; all wiring had been burned from its electrical connector.

After preliminary examination at Tulsa the No. 12 cylinder, piston, piston pin, and link rod were sent to the National Bureau of Standards for laboratory study. This study revealed that several fatigue cracks, starting at the outside surface of the cylinder wall, had joined to form a single large crack that extended around approximately one-third of the circumference before the cylinder failed completely. It did not reveal any abnormalities in the composition or microstructure of the steel that could have contributed to the cause of failure. Fractures on the link rod and piston appeared to be secondary ones caused by stresses above the yield strength of the material.

A review of the history of the failed cylinder disclosed that it was installed new in the No. 18 location on another engine in October 1954 and had operated there for approximately 1052 hours when eight of its hold-down studs failed, seven of which were adjacent to each other. These failed studs were found during an inspection at Detroit, following which the engine was removed from the aircraft and sent in to American's overhaul base at Tulsa. At the time the cylinder was removed in engine disassembly at the overhaul base a special cylinder stud failure form required by American was made out for the engineering department, and a notation was made on the front sheet of the engine inspection log that eight of the hold-down studs for this cylinder had failed. On another page of this same log the cylinder was marked as "O.K." by inspection. The next record of this cylinder was an inspection card showing an inside and outside inspection with no indication of whether a check had been made for warpage of the flange.

Three days after this cylinder was removed from the engine in which the stud failures had occurred it was put back in service in the No. 12 location on another engine undergoing overhaul at the Tulsa base. When the aircraft involved in this accident arrived at Tulsa for a pattern 1 overhaul (conducted by American every 2 100 hours of operation), this engine was installed as a replacement for the No. 2 engine removed from the aircraft. The aircraft was test flown and released for service on 3 August; the cylinder failed on 4 August after slightly less than six hours of operation.

During the check on the history of this cylinder several discrepancies were noted in the carrier's engine overhaul records. One of these was showing cylinders being removed from the rear row and reinstalled on the front row, which is an impossibility. It was testified that these were clerical errors; that the primary purpose of the records was to maintain historical data on the use of parts and they were not used as a cross check to help insure that unairworthy parts were not returned to service.

American Airlines' procedures provided that any cylinder which had been operated with more than two adjacent hold-down studs broken or the nuts loose should be scrapped or returned to the manufacturer for rebarreling. Such a cylinder was to be tagged in engine disassembly to alert inspection that the cylinder was to have special handling. For this purpose a blank aluminum tag, approximately one-half inch wide and two inches long, was affixed to the cylinder with the same metal safety pin that carried another and larger tag bearing the serial number of the engine from which the cylinder had been removed. Inspection decided whether the cylinder should be scrapped or rebarreled.

American Airlines' overhaul manual specified and the engine manufacturer recommended that the flanges of all cylinders going through overhaul be inspected for flatness by use of a surface plate and feeler gauge. If there was warpage of .005 inch or less, the cylinder was to be lapped; if there was warpage in excess of that amount the cylinder was to be rebarreled. Company personnel testified that this method of inspection had not been followed for some time and that flanges were checked visually instead. They said they considered this visual check sufficient unless an abnormal wear pattern was evident, in which case the procedure called for in the manual was followed. An inspector testified that this particular technique was "handed down" to him by the more experienced inspector who trained him for this operation.

Supervisory and engineering personnel of the company testified that based on experience they considered this visual inspection to be equivalent to the procedure specified in their overhaul manual and recommend by the manufacturer, and that omission of the feeler gauge check by inspection was with the knowledge and concurrence of the engineering department.

There were no written instructions concerning this revised procedure and the Civil Aeronautics Administration had not been informed of it.* CAA maintenance agents assigned to American Airlines' system maintenance at Tulsa testified that the operations there are under constant surveillance and that in addition to daily contacts a general inspection is run every six months, the last one being approximately two months prior to the accident. They all testified, however, that they were not aware of the revised procedure for inspecting cylinder barrel flanges. No one seemed to know exactly when this procedure was put into effect but it was estimated by an American Airlines official to have been the latter part of 1953. Engineering personnel also testified that a cylinder operated with approximately one-half of its studs broken or the hold-down stud nuts loose would show a wear pattern obvious to visual inspection, and that there would be definite warpage of the flange.

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* CAR Part 40.50 - Preparation of manual. The air carrier shall prepare and keep current a manual for the use and guidance of flight and ground operations personnel in the conduct of its operations.

CAR Part 40.52 - Distribution of manual. (a) Copies of the entire manual, or appropriate portions thereof, together with revisions thereto shall be furnished to the following: (1) Appropriate ground operations and maintenance personnel of the air carrier, (2) Flight crew members, (3) Authorized representatives of the Administrator assigned to the air carrier to act as aviation safety agents. (b) All copies of the manual shall be kept up to date.

CAR Part 18.30 - Standard of performance, general. All maintenance, repairs, and alterations shall be accomplished in accordance with methods, techniques, and practices approved by or acceptable to the Administrator.

A Pratt & Whitney representative testified that his company's recommendation concerning inspection of flanges for flatness applied to all cylinders going through overhaul and that a visual check could not be considered equivalent to the precise measurement obtained through use of the surface plate and feeler gauge. He stated further that in most cases warpage and a peculiar wear pattern on the flange would result from operation with loose hold-down nuts or broken studs, the amount being dependent on the length of such operation.

In-service failure of cylinder barrels has been correlated with operation with broken studs and/or loose hold-down nuts. After the accident Pratt & Whitney reproduced the failure on a test stand by simulating, on a new cylinder, failure of the same studs in operation, followed by operation of the cylinder with all studs secure and the hold-down nuts properly torqued. A fatigue crack developed on the outside of the cylinder barrel after three hours of operation at take-off power with the studs secure. A check before the hold-down nuts were tightened showed .0085 inch warpage of the flange.

A check of records after the accident revealed that 23 other cylinders operated with broken studs and/or loose hold-down nuts had been passed by inspection and returned to service without being rebarreled. They were immediately removed from the engines on which they had been installed. One of the 23, which had experienced a four-stud failure, was installed in the No. 16 location of the engine involved in this accident. It was marked "O.K." in the inspection log.

Sixteen of these cylinders, plus two others that were in the overhaul shop but not yet installed on engines, were sent by American Airlines to Pratt & Whitney for examination. Pratt & Whitney's report showed that the flanges of eleven of them were "fretted and galled"; two were "severely fretted"; and one other showed "heavy fretting and galling." This latter cylinder, removed from an engine with no operating time since overhaul, showed crack indications when magnetically inspected. One of the cylinders, on which eight studs had failed, showed flange warpage of .006 inch; flange warpage in the others varied from .0015 inch to .0035 inch.

American Airlines officials testified that despite an intensive effort to determine where a breakdown occurred that permitted such cylinders to be put back in service, they had not been able to pinpoint it closer than one of three locations: (1) engine disassembly, where affixing of the blank metal tag could have been omitted; (2) cleaning, where the alert tag could have been lost from the cylinder (there was testimony that considerable difficulty had been experienced for some time with aluminum tags being mutilated or lost in the cleaning process, and the carrier was experimenting with the use of brass tags in an effort to correct the difficulty); and (3) inspection, where the alert tag could have been overlooked.

Shortly after the accident American Airlines initiated a series of changes in overhaul procedures and in personnel assignments, all pointed toward more stringent supervisory control of work done. The change most directly concerned with this accident involves the handling of cylinders going through overhaul. Cylinders that had been operated with loose hold-down nuts or broken studs now have their barrels mutilated as soon as they are removed from an engine, thus making it impossible for them to be returned to service without first being rebarreled. Such mutilation is witnessed by at least one other person. Further, the check of all cylinder barrel flanges by means of the surface plate and feeler gauge has been resumed, and the warpage tolerance has been reduced from .005 to .003 inch in accordance with a recommendation issued by the manufacturer after the accident.

Failure of the cylinder was accompanied by the release of combustibles consisting of a fuel-air mixture from the disrupted intake pipe and oil from the crankcase section. The most likely source of ignition was the exhaust manifold which is routed rearward of the cylinders.

No. 12 cylinder straddles the mating line of the lower and inboard side orange peel cowls. After the cylinder failed fire passed rearward into zone 2 at the lower left corner of the diaphragm, which is aft of No. 12 cylinder. It is believed that fire progressed into zone 2 quite rapidly. The fire path in that zone is in accord with the zone 2 air flow pattern and the location of original entry of fire into zone 2. More significant is the exit of fire from zone 2, which occurred at the mating line between the lower cowl and both side cowls at and behind the rearmost fasteners. Fire on the inboard side burned the aluminum nacelle skin back of the firewall and between the upper and lower nacelle longerons, permitting fire entry into zone 3.

The crew must have become aware of the engine difficulty and initiated emergency procedures at once. Relatively minor damage to the No. 12 link rod, which was free to flail after the cylinder let go, indicates an almost immediate feathering of the propeller. This would halt the release of combustibles in zone 1 and account for the comparatively light fire damage in that area.

That CO_2 was discharged in flight is evidenced by the fact that all CO_2 bottles were found empty with their heads, including the thermal discs, intact. It is, therefore, reasonable to assume that the fire extinguishing system was actuated at the time called for in the emergency procedure checklist.

The emergency procedure for inflight fire consists of two phases, the second part being a "cleanup" list of items considered less urgent than those directly related to controlling and putting out the fire. One of the items near the end of this list is to close the main fuel tank shutoff valve. Construction of this valve, which was found open, precludes any likelihood of its position being changed because of impact forces. There is no way of determining whether the crew did not reach this item on the checklist or whether by the time they attempted to close the valve its electrical wiring had been so damaged by fire that it was no longer operable. The latter seems the more likely of the two. This valve remaining open unquestionably contributed to the intensity and duration of fire in zone 3 since it permitted gasoline to be released at an appreciable rate. The Board is of the opinion that consideration should be given to making the closing of this valve one of the first of the "cleanup" items called for in emergency procedures to be followed in the event of fire warning.

Radar tracking of the aircraft showed a change of course to the right approximately 17-1/2 nautical miles from Forney Field, which was probably when the decision was made to attempt an emergency landing there. Inasmuch as the zone 3 fire was not visible from the cockpit, the pilots could not have been aware of its extreme severity. Had they been able to recognize the proximity of fire to the wing spar they undoubtedly would have tried to land immediately, regardless of the facilities available.

The Board has given much consideration to the evidence in an effort to determine just how an unairworthy cylinder could have been put back in service at the carrier's overhaul base. If, as testified, a wear pattern caused by operation of cylinders with broken studs or loose hold-down nuts would be evident to visual inspection, there seems no logical reason why this and other cylinders so operated were passed by inspection regardless of whether the alert tag was on the cylinder when it reached the inspection station. In addition, the reported long-existing difficulty with the metal alert tags should have emphasized the importance of rigid inspection to avoid the possibility of passing faulty cylinders. From the fact that cylinders which should have been rejected were returned to service instead, it is obvious that visual inspection alone, dependent on the judgment and evaluation of an individual, is inadequate. After the accident American Airlines was able from its records to locate these cylinders and remove them from service. However, prior to that time no use was made of the records as a crosscheck to prevent the installation of cylinders that should have been rejected by inspection.

Pratt & Whitney's recommendation that the barrel flanges of all cylinders going through overhaul be checked by use of a surface plate and feeler gauge points up the inadequacy of visual inspection. The Board is of the opinion that had the method of inspection specified in the carrier's overhaul manual and recommended by the manufacturer been followed, cylinders with warped barrel flanges could not have been returned to service inadvertently. The Board feels that the carrier should have informed the Civil Aeronautics Administration of the revised procedure for inspecting cylinder barrel flanges in order to determine whether it was acceptable to the Administrator. However, it is difficult to understand why, in their routine inspections, the CAA agents did not become aware that for a period of nearly two years such flanges were not being inspected in accordance with the carrier's overhaul manual.

Following this accident American Airlines took immediate corrective action with respect to its cylinder and fire seal overhaul and inspection procedures. As previously stated in this report, the barrels of cylinders operated with loose hold-down nuts and/or broken studs are now being mutilated upon removal from an engine to preclude the possibility of their being returned to service without rebarreling. New fire seals are being installed at every overhaul and a more positive check is being made to ensure the effectiveness of the seal.

The aircraft manufacturer also initiated a program to improve the nacelle fire protection in all Convair aircraft, and will issue Service Bulletins on these improvements as they are developed.

Probable Cause

The probable cause of this accident was installation of an unairworthy cylinder, the failure of which resulted in an uncontrollable fire and subsequent loss of a wing in flight.

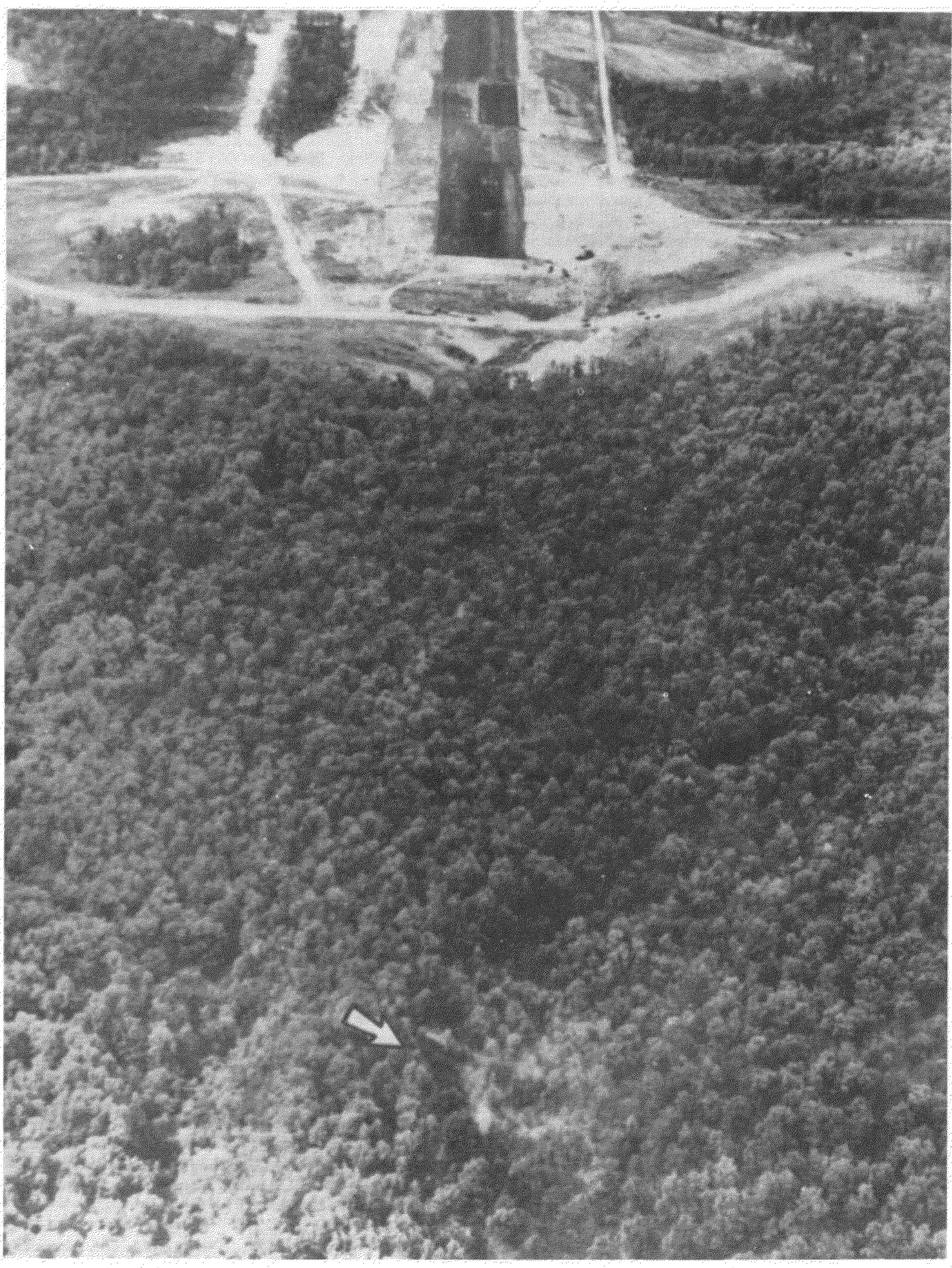

Figure 22 Wide World Photo

The aerial picture above shows runway of the Fort Leonard Wood airport in upper part of picture with arrow pointing to small blackened area of densely wooded section where an American Airlines, Convair 240, crashed on 4 August killing 30 persons.

No. 37

Northwest Airlines, Inc., Boeing 377 aircraft, overshot runway on landing at Chicago Midway Airport, Illinois, on 5 August 1955. Civil Aeronautics Board (USA) Accident Investigation Report File No. 1-0091, released 9 January 1956.

Circumstances

The flight originated at Minneapolis, Minnesota, with its destination Chicago, Illinois. It departed Minneapolis - St. Paul International Airport at 1130 Central Standard Time on an Instrument Flight Rules flight plan carrying 60 passengers and a crew of 8. When the flight reported over Janesville, Wisconsin, an ARTC (Air Route Traffic Center) clearance was received to descend and cross the Wilson Intersection (15 miles NNW of Chicago Midway) at 3 500 feet. The IFR clearance was cancelled by the pilot shortly after passing Wilson Intersection. At 1256 radio frequency was changed to Midway tower and the flight was then advised to report west of the field for a left turn for landing on Runway 31L. Touchdown was about one-quarter down the runway, and the landing roll continued to the end of the runway without appreciable deceleration. At the end of the runway a slight turn to the left was made and the aircraft crossed several hundred feet of grassy area before crashing through the chain link fence bordering the airport. Although the aircraft was substantially damaged, no injuries were received by the passengers or crew.

Investigation and Evidence

The airport weather at the time of the accident was:

> Ceiling 10 000 feet, broken clouds, overcast at 25 000 feet; visibility 10 miles; wind west 8 knots. During the period 1000 to 1300 there had been intermittent light rain showers (.01 inch); however, the runway surface was dry at the time the flight landed.

It was determined that a touchdown had been made in the intersection of Runways 31L and 36R. This location is approximately 1 600 feet beyond the approach end of Runway 31L, which is 6 410 feet long. The first discernible braking marks of the aircraft on the runway were approximately 3 000 feet beyond the point of touchdown. These marks were light in character and extended on the runway for approximately 600 feet. The next 800 feet of marks reflected light to fair braking action, and the final 300 feet of marks at the end of Runway 31L indicated heavy braking action, as did the marks across the 300 feet of grassy area leading to the boundary fence.

According to the testimony of the crew, airspeed at touchdown was approximately 95 knots. Following touchdown brakes were applied lightly. When the throttles were moved into the reverse quadrant, forward thrust was experienced. When this occurred the captain put the throttles into the forward idle position, called for antiskid (a device designed to prevent locking of the wheels) off, and after getting no deceleration from use of the normal brakes used full and continuous application of the emergency system. The captain stated that he turned the aircraft to the left at the end of the runway to avoid striking the large concrete marker just off the end of Runway 31L. All crew members stated there was no indication of propeller reversal at any time during the landing roll. This absence of the noise and deceleration accompanying propeller reversing is substantiated by many passengers and ground witnesses. The captain testified that he felt that there was sufficient runway remaining after the unsuccessful propeller reversal attempt to stop the aircraft with braking. He further stated that he has had incidents at Midway Airport of slippery runways not due to snow, ice, or rain.

The surface of Runway 31L is asphalt with a topping of crushed rock screenings. At the time of the accident the crushed rock covering was more in evidence near the ends than in the middle area of this much-used runway. When temperatures are above 90°F. the asphalt exudes an oily substance that creates a slippery surface. Temperature at the time of the accident was 85°F. and the runway was free of moisture. Although Midway tower had received no pilot reports of poor braking action on the day of the accident, controllers stated there had been instances of pilots reporting poor braking when temperatures were high and the runway was free of moisture.

The flight manual for B-377 aircraft indicates that with a gross load of 110 000 pounds (the approximate landing weight at Chicago of this flight), head wind of 8 knots and temperature of 85 degrees, the aircraft should stop in 3 400 feet when landing over a 50-foot obstacle using normal braking, and without the use of propeller reversing. The minimum runway length under these conditions is 5 700 feet.

A majority of the blades of all four propellers were damaged by contact with the fence. The No. 3 engine mount was damaged to an extent requiring replacement of the powerplant. The four tires of the main gear indicated heavy braking action, as evidenced by large abraded areas extending almost through the casing. The wing flaps and the nose gear received damage from contact with the fence. The left side of the fuselage was sliced open from the top down to the "crease" line by the whirling of the steel fencing which became entangled in the propellers as the aircraft passed through the fence. The right side of the fuselage received lesser damage in the same manner. Contact with a street lighting pole indented the outer leading edge of the left wing.

Cockpit readings taken immediately after the accident revealed, among many other items, the following: Normal brake system pressure 1 500 p.s.i.; emergency brake system pressure 1 500 p.s.i.; antiskid master switch "off"; the reversing control "outboard and inboard" circuit breakers on the overhead panel in the "out" position. All other circuit breakers on this panel were "in".

The deadheading flight engineer, who had no assigned duties on the flight, was in the observer's seat behind the captain at the time of the landing. On his own initiative he pulled and immediately reset the oleo relay circuit breaker after the captain had tried unsuccessfully to obtain propeller reversing. The action of the deadheading flight engineer in pulling out and resetting the oleo relay circuit breaker after the one reversal attempt was an unrequested check on his part to ensure a good contact of this circuit breaker in the event that propeller reversal was again attempted. According to testimony of the crew members, this was the only circuit breaker on the overhead panel moved during the entire flight.

The overhead panel is located in the forward part of the cockpit ceiling between and slightly to the rear of the two pilot seats, and immediately above and ahead of the flight engineer's seat. Dimensions of the panel are approximately 36 inches fore and aft and 18 inches wide. The forward half contains the engine ignition switches, feathering buttons, various engine operation and aircraft lighting switches. The rear half of the panel has five spanwise rows of approximately 25 circuit breakers each. The oleo relay circuit breaker is located in the rear row eighth from the left side and the two reversing control circuit breakers are located in the fourth row, from the rear, at the approximate center of the row. The two antiskid circuit breakers are immediately aft of the propeller reversing control circuit breakers. All circuit breakers can be reached from any of the three crew seats.

Following the accident the aircraft was removed to a hangar on Midway Airport. Structural repairs were made and No. 3 powerplant was replaced before actual testing of the braking and propeller reversing systems. On 19 August functional tests of these units were performed at Midway Airport. A preliminary group runup included the following checks: Magneto, propeller reversing, and manual feathering. No discrepancies were noted and the aircraft was then turned over to the flight test crew. After taxying, in which there were several effective applications of emergency brakes, a thorough engine runup was made, during which a check was made of auto-feathering, manual feathering, and propeller reversing with normal results.

The two reversing control circuit breakers were then pulled and a check was made of engine r.p.m. in the forward idle and reverse idle throttle positions. This test revealed the reverse idle r.p.m. to be from 300 to 500 higher than forward idle r.p.m. on all engines.

The captain and first officer stated that forward thrust was experienced when the throttles were moved past the detent into the reverse quadrant. Forward thrust is obtained when the throttles are moved into the reverse quadrant if the reversing control circuit breakers are "out" at the start of the throttle movement and remain "out" while the throttles are in the reverse range.

Three accelerated stop-runs were made in which the aircraft speed reached was 70-80 knots. During the first run normal brakes were used with the antiskid feature turned off; the second run was with the antiskid on; the third run used propeller reversing only. In all three runs normal braking and deceleration was obtained.

Thorough checks were made on the electrical systems and propeller domes and no malfunctioning was found.

The reversing control circuit breakers' being in the "out" position does not prevent the moving of the throttles back into the reverse quadrant and the increase of engine power in that position, but it does deactivate the propeller control circuits associated with reversing. Thus the propeller blades would remain in forward pitch producing forward thrust. When the oleo relay circuit breaker is "out" a throttle-locking solenoid prevents the throttles from going rearward past the throttle detent.

The Northwest Airlines Supervisor of Flight Engineers testified that this aircraft had been used the day of the accident for a captain's proficiency check and that he acted as flight engineer on that flight. He further testified that during the landing roll of the last flight, one or more of the engines started to die. As a corrective action one, and possibly both, of the propeller reversing control circuit breakers had been pulled and were in this position (off) when he left the aircraft a short time before the crew of the flight in question took over.

It was explained that a number of incidents had been experienced wherein propeller blades moved to the feathered position when coming out of reverse on landing, due to a malfunction in the signal circuit.

Such an increase in blade angle is accompanied by an increase in propeller load that tends to stall the engine. Meanwhile, the auxiliary pump motor temperature increases and the motor will burn out if electrical power is not removed. Pulling out the appropriate circuit breaker results in shutting off the pump which in turn permits the propeller blades to move toward low pitch and the engine to regain normal idle speed.

The flight engineer of the flight testified that he had made a thorough preflight inspection of this aircraft at Minneapolis, including checking the reversing control circuit breakers for "in" position. However, he could not recall whether the check was made by actually touching the breakers or visually. He further testified that he thought it would be possible to overlook a circuit breaker position in a visual check.

The "checklist and procedures" section of Northwest Airlines Manual - Flight Operation - Boeing 377, lists the items to be checked by each crew member during all procedures from "Before start" to "After landing" and "Parking." The manual does not call for a mandatory propeller reversing check for preflight on domestic operations. The flight engineer ground check lists "Overhead circuit breakers - checked".

In the amplified flight engineer's ground check are listed items to be checked on originating aircraft. On page 10 in the "Aft Cockpit Area" paragraph this item (7) appears: "Overhead circuit breakers - CHECKED (a) all circuit breakers IN or ON".

There are no items covering a check of the circuit breakers on the overhead panel of the cockpit area during "Descent procedure," "Approach cockpit check," or "Landing cockpit check."

The manual does not specify how (i.e. visually or by touch) the circuit breakers are to be checked.

As a result of the subject accident Northwest Airlines took action on 6 September 1955, to incorporate in its flight operations manual a check of overhead panel circuit breaker position prior to landing. In addition, instructions were issued to flight instructor and check personnel to place emphasis during periodic training and check flights on the proper checking of circuit breakers.

The severely scuffed condition of the main landing gear tires, observed after the accident, proves that the normal emergency brake systems had effectively stopped wheel rotation and the marks found on the runway indicate that brakes were used during the latter part of the landing roll. The accelerated stop-run tests conducted at Chicago Midway Airport showed that the brake system of the aircraft was in normal operating condition and that by using these brakes alone the aircraft could be stopped in the required distance. It would require approximately 20 seconds to travel the 3 000 feet of runway between the touchdown and the first braking marks if a speed of somewhat less than the touchdown speed of 95 knots was maintained. During this short interval normal brakes were used while preparing to go into reversing, the throttles were moved in and out of the reverse quadrant, and the antiskid device was taken off. The sudden surprise of being confronted with lack of propeller reversing and the ensuing cockpit activities undoubtedly were the factors which determined where the emergency brakes were applied.

The captain testified that he applied emergency brakes when halfway down the runway or approximately 1 600 feet from the point of touchdown. Since no evidence of braking of the aircraft was found in this area it appears that the friction coefficient of the runway surface was considerably less during approximately 1 400 feet of the landing roll than it was where the first braking marks were observed. It was early in the afternoon of a warm day (85°) and the temperature may have induced some slipperiness on the surface of the asphalt runway where the crushed rock screenings were worn away. However, aircraft landing just before and just after the accident did not report such a condition.

Although the crew stated there was no application of power during the entire landing roll, a feeling of acceleration occurred when the throttles were moved into the reverse quadrant. The propellers remained in forward pitch in this instance and engine r.p.m. increases appreciably when throttles are moved to the reverse idle position.

Thorough examination and tests of the propeller and electrical systems showed that these systems were functioning in a normal manner. Air carrier employees on Chicago Midway Airport and tower controllers testified that it is standard practice for operators of Boeing 377 aircraft to use propeller reversing on all landings at Chicago Midway Airport. This is the practice even though the lengths of the NW-SE and NE-SW runways, which are always used for this type aircraft, are in excess of the criteria specified for braked stopping in the flight manual for B-377 aircraft. The captain testified that he fully intended to use reversing on the subject landing.

Since the propeller reversing circuit breakers were found in the "out" position and as this can be the only reason why propeller reversing could not be effected in this instance, it is apparent that they were not thoroughly checked during the preflight check at Minneapolis or the prelanding check at Chicago.

It was concluded that the "out" position of the reversing control circuit breakers was the only reason to account for the captain's inability to obtain reversing when the throttles were moved into the reverse quadrant.

Probable Cause

The probable cause of the accident was the inability of the pilot to stop the aircraft by means of conventional braking and the unavailability of propeller reversing due to the improper position of the reversing circuit breakers.

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ICAO Ref: AR/411

No. 38

Fairways (Jersey) Ltd., Avro 19, G-AHIG, ditched in the Solent River, England, on 6 August 1955. Ministry of Transport and Civil Aviation (UK), Civil Accident Report No. C. 637.

Circumstances

The accident occurred during a passenger carrying flight from Jersey Airport to Blackbushe. The flight was uneventful until the aircraft was approaching the south coast of the Isle of Wight when the starboard engine began to surge and lose power. The pilot decided to divert to Eastleigh but when over the Solent the port engine also lost power, compelling him to ditch the aircraft. Of the 11 occupants on board the aircraft only 2 passengers were injured.

Investigation and Evidence

On the day of the accident the pilot had completed two return flights between Jersey and Blackbushe arriving back in Jersey at 1808 hours Greenwich Mean Time. After an interval of about 33 minutes, during which time he completed arrival and departure formalities, he took off for Blackbushe. Shortly before 1925 hours when at 2 300 feet and about three miles south of St. Catherine's Point, Isle of Wight, the pilot reported to London Air Traffic Control that the starboard engine was running very roughly and, a minute later that the propeller constant-speed unit had failed and the engine was losing power. An attempt was made to clear the surging by operating the starboard throttle and pitch levers through their full range but without effect. The pilot stated that as height was being lost he opened up the port engine to climbing power and then to full power but that descent continued. No feathering action was taken. He had no recollection of checking the fuel pressure warning lights or the contents of the port tanks but said that he checked the contents of the starboard main tank and that the gauge indicated 15 - 20 gallons.

At 1930 hours the pilot reported his position as over the Isle of Wight at 1 000 feet, at 1932 hours as approaching Southampton Water at 800 feet and at 1935 hours as four miles east of Calshot. Almost immediately afterwards the port engine also lost power and a MAYDAY call was transmitted; this was acknowledged by Eastleigh. The aircraft was successfully ditched at 1936 hours. There was no fire.

No warning of the emergency had been given to the passengers but they had themselves concluded that all was not well. One man who did not know how to fasten his safety belt correctly sustained fractured ribs and the passenger in the cockpit received a cut on the face.

When the aircraft came to rest it remained afloat and most of the occupants got out onto the port wing and top of the fuselage where life jackets were put on. One passenger, who had been sitting in the cockpit, did not know where his life jacket was stowed and another passenger had been unable to find his, so the pilot re-entered the aircraft and found life jackets for both of them.

Inspection of the aircraft revealed that it was only slightly damaged during the ditching. There was no evidence of any pre-crash damage or mechanical failure. The fuel tanks were empty except for the starboard inner which contained about five gallons of a mixture of petrol and sea water. The fuel tank cocks were selected "ON" and the crossfeed cock was in the "OFF" position. The fuel filters were clean and free from water; each contained a small quantity of fuel. The fuel system was pressure-tested and no leaks were found. The fuel delivery and vent lines were free and unobstructed. It was not possible to check the fuel pressure warning lights or the fuel tank contents gauge owing to the effects of immersion in the sea.

The carburettors, complete with the boost and mixture control units, were removed and tested at the makers. The tests showed that they were serviceable and that the fuel flows were within the maker's prescribed limits.

Although the pilot stated that before taking off he twice read the fuel contents gauge and was satisfied from the readings that the aircraft had been refuelled, investigation at Jersey Airport revealed that the aircraft had not been refuelled, that the tanks had not been inspected for the amount of fuel they contained and that the aircraft left Jersey with only such petrol as remained in the tanks after the flight from Blackbushe.

Observations

It is considered that the arrangements made by the operator for the refuelling of their aircraft at Jersey were not sufficiently definite and that this led to a breakdown in the procedure.

In addition, the pilot relied on his reading of the fuel contents gauge as a means of satisfying himself that the aircraft had been refuelled and this clearly gave rise to error.

When the starboard engine lost power the pilot did not carry out a thorough cockpit check to establish the cause of the failure and erroneously concluded that because the engine was surging the propeller constant-speed unit was defective. Had he established that the fuel was almost exhausted he might well have been able to land on an aerodrome in the Isle of Wight.

The Company's operations manual makes it clear that in order to maintain height on one engine the propeller of the failed engine must be feathered.

Probable Cause

The accident was due to lack of fuel resulting in loss of power from both engines and a forced alighting in the sea.

ICAO Ref: AR/429

No. 39

DC-3, PP-CBY, crashed at Serra do Caparao, State of Espírito Santo on 26 August 1955. Brazilian Commercial Accident Report No. 3-C-55 published 1 November 1955.

Circumstances

The aircraft took off from Rio for Caravelas with an IFR flight plan specifying flight at 1 500 metres along airway Vd-1, carrying 4 crew members and 9 passengers. After 58 minutes of flight the aircraft reported that it was over Campos at 1 500 metres. There was no further news from the aircraft whose wreckage was later discovered on the summit of Forno Grande in the State of Espírito Santo. There were no survivors and the aircraft was destroyed.

Investigation and Evidence

The weather conditions between Rio and Campos were good. There was an alto-stratus layer at 2 000 metres and 4 to 6/8 of cumulus and strato-cumulus between 400 and 600 metres.

The Forno Grande peak is more than 1 500 metres high but is not marked on current navigation charts which represent the whole of that area as having an elevation lower than 1 200 metres. It is situated a little to the right (10 km) of the direct Rio-Caravelas route and, according to reports obtained locally, was covered by cloud at the approximate time (0800 hours) of the accident.

The appearance of the marks made by the aircraft in crashing shows that it was flying at an altitude of 1 500 metres and heading for Caravelas. It may, therefore, be assumed that the pilot-in-command, instead of following airway Vd-1 along the coast, decided to cut directly across from Rio to Caravelas. He reported flying over Campos when in fact he was only abreast of this location. Finally, pursuing the flight on instruments, he crashed unexpectedly into the uncharted peak.

Probable Cause

The accident was due to the Forno Grande peak not being indicated on current charts, the flight being conducted outside the airway and failure to adhere to the approved flight plan.

Recommendation

It is recommended that the following be shown on navigation charts:

20° 25'S - 41° 06'W, spot elevation above 1 500 m.

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ICAO Ref: AIG/ACC/REP/GEN/No. 8
(No. 3 - C - 55)

No. 40

Continental Air Lines Inc., DC-3, and Hines Flying Service, Piper PA-22, collided on final approach at the Lea County Airport, Hobbs, New Mexico, on 29 August 1955. Civil Aeronautics Board (U.S.A.) Accident Investigation Report SA-310, File No. 1-0111 released on 11 January 1956.

Circumstances

The Continental Air Lines' Flight originated at El Paso, Texas for Houston, Texas and the stops were scheduled at Carlsbad and Hobbs, New Mexico and at Midland-Odessa, San Angelo, and Austin, Texas. The DC-3 left El Paso at 1120 hours Mountain Standard Time and arrived at Carlsbad on schedule at 1215 hours. Departure for Hobbs was at 1217 hours on a VFR flight plan with 11 passengers and a crew of 3 on board. At 1237 the flight asked Lea County Airport if there was any local traffic and was advised that none was visible from the terminal. When approximately 3-1/2 miles from the airport the first officer turned right to a heading of 120 degrees starting a base leg for Runway 3 and maintained an altitude of 4 500 feet m. s. l., about 840 feet above the ground, while on the base leg. A left turn from base to final for Runway 3 was made approximately 2-1/2 miles out and about 800 feet above the ground. At one-half mile out flaps were extended fully at an airspeed of 95 knots. The captain called the airspeed with each 5 knots change and the aircraft crossed the field boundary at 80 knots. At this time the captain saw from the left side window the shadow of an aircraft converging with his flight path over the runway. He skidded the aircraft evasively to the right, used emergency power and called for gear up. He then saw a Piper Tri-Pacer close ahead, above and nearly into his left propeller. Almost instantly the propeller struck the tail surfaces of the Piper. The DC-3 made an emergency pullout, circled the airport and landed on Runway 17 without further incident. None of the 14 occupants were injured.

The Piper PA-22 departed Wichita Falls, Texas, at approximately 0950 hours on a VFR flight for Hobbs, New Mexico, carrying one occupant, the pilot. He proceeded on a southwesterly course at an altitude of 5 000 feet m. s. l. At 1239 the pilot called Hobbs requesting surface wind direction and velocity and altimeter setting. Hobbs replied, adding that the wind favoured Runway 3 and that caution should be exercised because of men and equipment in the field. At this point the aircraft was approximately five miles northeast of the airport and at an altitude of 4 700 feet m. s. l. On nearing the airport the pilot altered his course slightly to the left in order to enter the traffic pattern on a downwind leg for Runway 3. This leg was flown at an altitude of approximately 4 460 feet m. s. l., 800 feet above the ground, about one-half to three-quarters of a mile to the west-northwest of Runway 3. The pilot stated that while flying the downwind leg, he looked for other traffic and saw none. He said he made a left turn, establishing a base leg about 1/4 mile long, and again checked the area for other traffic. None was seen.

The left turn to final was steepened and at an airspeed of approximately 68 knots, full flaps, to the second notch, were applied. As he neared the approach end of Runway 3, he realized that he was too high and started a forward slip to lose altitude and land short on the runway. At this time his airspeed was between 45 and 55 knots. Just after passing the end of the runway, he heard a loud roar and on glancing out of the right window he saw the nose of another aircraft alongside and slightly above him. At this point the two aircraft collided and the Piper crashed to Runway 3 some 560 feet from its approach end. The time of collision was approximately 1245 and the altitude was 30-40 feet.

Investigation and Evidence

The official weather at the airport a few minutes after the accident was reported as: Ceiling estimated 7 000 broken, broken clouds at 25 000; visibility 15 plus; wind east-northeast 5; altimeter 29.95. The sun was plainly visible at a computed elevation above the horizon of 64 degrees; its bearing was slightly west of south. The air was moderately turbulent. The pilots of both aircraft testified that their respective windshields were clean.

Impact was between the left propeller of the DC-3 and the empennage of the Piper. It was possible to reconstruct partially the shattered empennage of the Piper by matching parts and pieces of ripped fabric against a similar aircraft. This study showed that the first propeller blade contact cut off the navigation light on the trailing edge of the rudder. Subsequent propeller cuts sliced through the rudder and elevators, continued forward through the fin and stabilizers, and finally tore apart the aft fuselage almost as far forward as the baggage compartment. The cuts in the rudder and left elevator were quite distinct, nearly parallel, and sufficiently uniform in spacing to allow a computation of the difference in speeds of the two aircraft. The engines of the DC-3 were at a probable speed of about 2 700 r.p.m., and the difference in the horizontal components of the two speeds was approximately 13 knots, the DC-3 travelling faster.

The angles of the propeller cuts relative to the longitudinal axis of the Piper tell the relative attitude of the two aircraft at the time of and for a very brief period immediately following first impact. The longitudinal axis of the Piper diverged about 7 degrees to the left and about 7 degrees downward from the longitudinal axis of the DC-3. The Piper was banked to its left (the DC-3 was level laterally) by an amount not readily determinable from the cuts but the Piper pilot estimates the bank at 30 degrees and the DC-3 captain estimates it at 15 degrees. At the moment of first contact the left propeller hub of the DC-3 was about three feet from the bottom of the rudder and about one-half foot left of the centreline of the Piper.

Damage to the DC-3 was caused by small metallic pieces from the empennage of the Piper being thrown by the left propeller of the DC-3. Some of these pieces penetrated the fuselage and ripped clothing that was hanging just behind the pilots, but control of the aircraft was not affected. The left propeller bore deep marks of impact.

Continental Airlines' Operations Manual prescribes that at all uncontrolled airports approaching flights shall establish a base leg prior to starting final in order to observe other traffic more adequately. The DC-3 pilots testified that they conformed to this requirement as they approached the airport and flew to the left in order to establish a base leg. Their testimony was confirmed by ground witnesses.

The Piper approached the airport from a direction substantially opposite that of Runway 3 and to the northwest of that runway. It was then flown on the downwind leg in a direction approximately opposite Runway 3 to a point about abreast of its approach end. Consequently approximately 180 degrees of left turn was necessary to align with that runway. Testimony of competent ground witnesses indicates that this turn was continuous or nearly so, with the aircraft banked appreciably throughout the turn. It also indicates that the Piper was the higher of the two aircraft as both approached the runway, the DC-3 in straight descending flight and level laterally, the Piper in a rather sharp left turn merging into a left forward slip just before collision. These flight paths were confirmed shortly after the accident by ground observations of simulated approaches of two identical aircraft. (Refer to Figure 23).

At 1237 the DC-3 reported to its own company radio station at the airport. At 1239 the Piper reported to the Hobbs CAA radio. The CAA radioman and the CAL operator, in separated offices in the same building, did not exchange their respective items of traffic information.

Airport authorities had published local traffic rules accompanied by the conventional left-hand traffic diagram several years earlier. These rules and diagram had met with CAA acceptance inasmuch as they had originally been submitted to the CAA and had been posted conspicuously at the airport. The Piper pilot testified that he was familiar with these traffic rules. The DC-3 captain's last route check was on 21 March 1955 and included Lea County Airport. It complied with company approach procedures, which are in accord with local traffic rules.

The Lea County Airport is on flat terrain offering no significant obstruction to vision in any direction. The two aircraft involved were the only two in the air at the time and place of the accident.

Regardless of the numerous devices and measures such as traffic rules and diagrams that have been devised to lessen collision hazard, nothing as yet has replaced fully the cardinal principle of seeing and being seen. This responsibility rests in cockpits. At uncontrolled airports, such as Lea County, the principle of "see and be seen" becomes of paramount importance. Experience has well demonstrated that the approach end of a runway at uncontrolled airports is the focal point of danger. There are two Civil Air Regulations that are pertinent to this collision. *

It is obvious that full utilization of the principle of see and be seen could have prevented this accident. It is also plain that neither pilot did see the other's aircraft until only a very brief time before collision. The DC-3 was flown in such a manner that the Piper should have been within vision from the DC-3 cockpit for a substantial time interval until very shortly before the collision. The Piper was flown in such a manner that the DC-3 should have been visible from its cockpit except for a short period just before the crash (as it made a continuous turn from downwind to final). The Piper is a high-wing aircraft and although the right wing itself would not block vision during a left turn, its fuselage structure could have been interposed in the line of sight toward the DC-3 to the right, and as the Piper was the higher of the two aircraft during the final part of the approaches, this difference in altitude must have become increasingly significant - in reference to taking each aircraft out of the other's normal field of vision - as the paths of the aircraft intersected. Also, under the conditions of being in a forward slip to lose altitude and thus land short, the Piper pilot must certainly have been looking ahead and down from the left side.

The concept of see and be seen requires that under conditions of visibility in which pilots can see other aircraft sufficiently to provide adequate traffic separation, pilots must assume complete responsibility against collision.

It is obvious that had either the pilots of the DC-3 or the pilot of the Piper exercised the continuous vigilance required by VFR flight during landing approach the other aircraft would have been seen in time to avoid collision.

The Board concluded therefore, that neither pilot was sufficiently vigilant and also that the Piper was not flown in full accordance with the airport traffic pattern.

It is probably true that the extremely small amount of air traffic at Hobbs Airport and the fact that neither aircraft was advised of the other's presence may have lessened the pilot's alertness.

As a result of this accident an intercommunication system has been installed between Continental's radio room and the CAA's radio office so that all traffic information can be quickly available to both.

Probable Cause

The probable cause of this accident was lack of sufficient visual alertness on the part of the pilots of both aircraft, and failure of the Piper pilot to comply fully with the local traffic pattern.

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* "60.12 Careless or reckless operation. No person shall operate an aircraft in a careless or reckless manner so as to endanger the life or property of others.

c) Lack of vigilance by the pilot to observe and avoid other air traffic. In this respect, the pilot must clear his position prior to starting any manoeuvre, either on the ground or in flight."

"60.14 Right-of-way.

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

"NOTE: Passing an overtaken aircraft on the right is required because the pilot in side-by-side, dual-control aircraft is seated on the left and has a better view on that side. Further, in narrow traffic lanes, passing on the left of an overtaken aircraft would place the overtaking aircraft in the path of the oncoming traffic.

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

"NOTE: Pilots must recognize that once committed to a landing in certain aircraft the pilot has little chance to avoid other aircraft which may interfere with that landing and, therefore, careful observance of this rule is important to the safety of all concerned."

ICAO Ref: AR/412

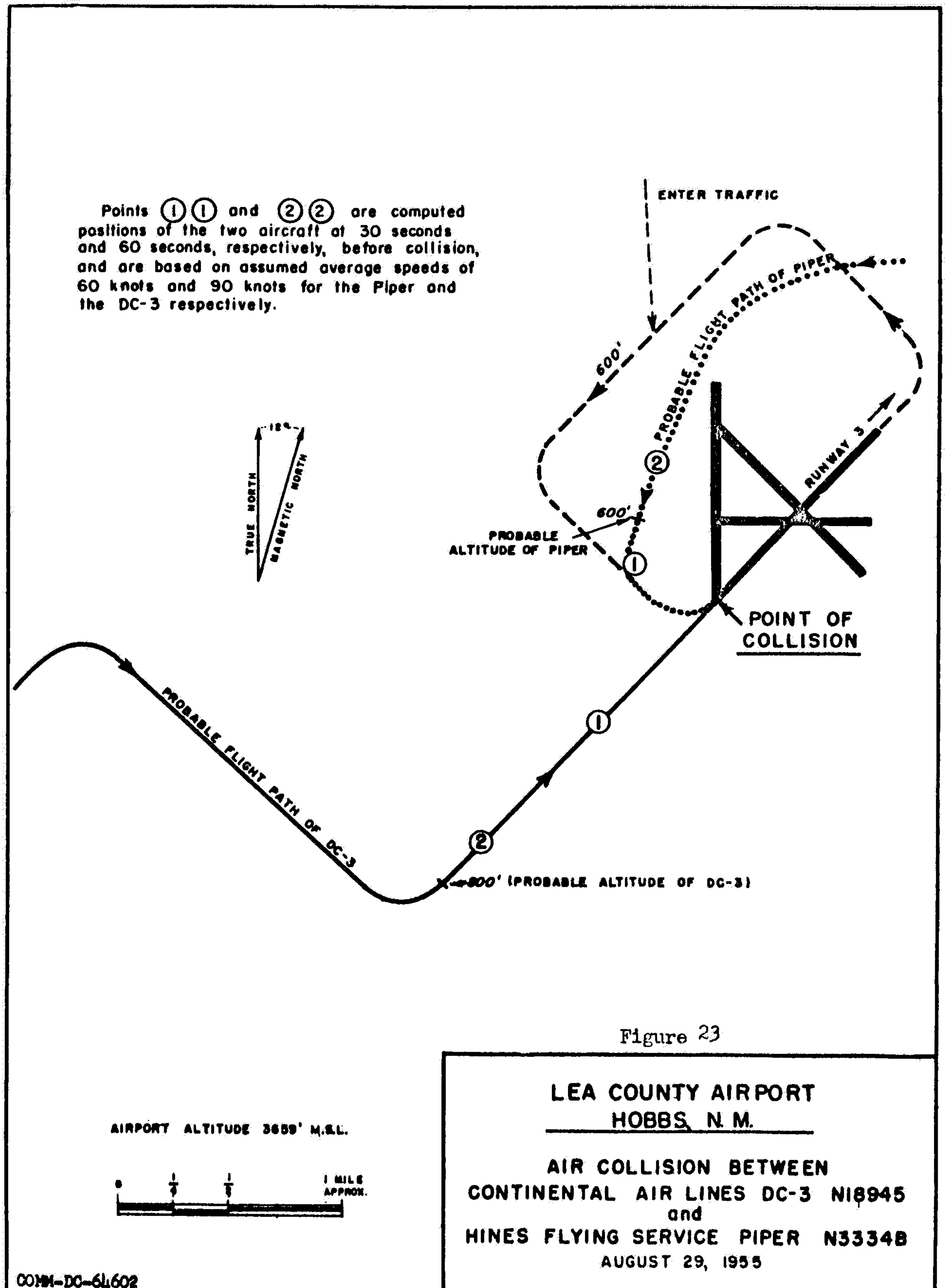
Points ① ① and ② ② are computed positions of the two aircraft at 30 seconds and 60 seconds, respectively, before collision, and are based on assumed average speeds of 60 knots and 90 knots for the Piper and the DC-3 respectively.
ENTER TRAFFIC
PROBABLE FLIGHT PATH OF PIPER
600'
600'
PROBABLE ALTITUDE OF PIPER
RUNWAY 3
POINT OF COLLISION
12°
TRUE NORTH
MAGNETIC NORTH
PROBABLE FLIGHT PATH OF DC-3
800' (PROBABLE ALTITUDE OF DC-3)
AIRPORT ALTITUDE 3659' M.S.L.
0
1/4
1/2
1 MILE APPROX.
COMM-DC-64602
LEA COUNTY AIRPORT
HOBBS, N. M.
AIR COLLISION BETWEEN
CONTINENTAL AIR LINES DC-3 N18945
and
HINES FLYING SERVICE PIPER N3334B
AUGUST 29, 1955

Figure 23

No. 41

Currey Air Transport, Ltd., DC-3C, struck powerlines during attempted emergency landing and crashed at Lockheed Air Terminal, Burbank, California on 8 September 1955. Civil Aeronautics Board (USA) Accident Investigation Report No. SA-312, File No. 1-0109 released 13 February 1956.

Circumstances

The flight (non-scheduled) took off at 0751 hours Pacific Standard Time from Lockheed Air Terminal, Burbank, California for Oakland, California, carrying 30 passengers and a crew of three. A Defence Visual Flight Rules flight plan had been filed. The take-off at 0751 hours from Runway 15 was completed and the aircraft climbed in a normal manner into smoke haze which was more dense towards the south and in which it was lost to observers at the airport. At 0752 the aircraft called the tower requesting an emergency landing clearance which was immediately granted. At approximately 0756 the control tower operator sighted the flight about one mile to the southwest, proceeding in a nose-high attitude toward the airport but not aligned with any runway. Across the approach track being used was a powerline about 500 feet short of the airport boundary. As this line was approached the nose-high attitude increased and immediately after passing this powerline the aircraft executed a slight left turn, banked 10 to 12 degrees. The left wing then struck a service powerline at the airport boundary. The aircraft stalled, its left wing collided with two parked C-54's, it cartwheeled, slid across the apron and struck a Lockheed Service Hangar, coming to rest in the open doorway of that hangar. The fuselage broke open at a point behind the wing and most of the survivors escaped or were rescued through this opening. The captain and co-pilot were killed, the stewardess and one passenger were seriously injured and the remaining 29 passengers received minor injuries. One person on the ground was fatally injured and the aircraft was almost totally destroyed by impact.

Investigation and Evidence

All major assemblies of the airframe were extensively damaged due to impact with the two other aircraft, the ground and the hangar. The landing gear was found down and locked and the flaps were retracted.

All electrically operated powerplant shut-off valves to the two engines were examined carefully. They were positioned as follows: Right powerplant, oil and hydraulic, both fully closed; left powerplant, oil one-half closed, hydraulic two-thirds closed. Fuel crossfeed valves were closed, the right engine fuel valve was in the left main tank position, and the left engine fuel valve was in the right main tank position.

Complete teardown examination of both engines disclosed that: The left engine, except for impact damage, was capable of delivering its power in a normal manner. The right engine had sustained internal damage during operation; a small amount of bearing metal was present in the main oil sump. The front master rod bearing had overheated but there was no appreciable loss of its bearing metal; it had lost about 50 percent of its lead-indium coating but none of its silverplating. The rear master rod had been discolored by heat; the lead-indium coating of its bearing had been worn away and about 40 percent of the silverplating had been worn from the shell of its upper half. The silverplating of the lower half of this bearing was badly scored. The right propeller governor and all the oil passages serving it were free from foreign material and were capable of normal operation.

The blades of the left propeller were at 32 degrees when impact occurred; those of the right propeller were at 18 degrees.

Examination of the feathering circuits of the right propeller disclosed an intermittent open circuit in the wire connecting the feathering button holding coil and the feathering pump relay. The cause of the open circuit was a loose soldered connection on the holding coil terminal. This condition could have been produced by impact forces that severely damaged the overhead panel upon which the feathering switch was mounted.

Examination of the wreckage disclosed no marks of fire that could have occurred prior to impact

Questioning of all witnesses, including available passengers, disclosed that none of them had seen any smoke, sparks, or other indication of real or impending fire during flight.

The right engine had been overhauled on 9 February 1955, 140:54 hours before the accident. At that time both master rods were fitted with bearings reprocessed by the engine manufacturer. Records of this overhaul and of the tests which followed showed that all parts were within manufacturer's limits and that engine performance was normal.

Examination of all maintenance records of the aircraft shows that the last No. 1 check was made three days before the accident when the logged time was 9,849:23 hours, 2:16 hours short of the time when this inspection was due.

Work sheets of the last No. 2 inspection, dated 23 August 1955, and No. 3 inspection, dated 20 July 1955, disclosed that all items written up were repaired, inspected, and signed off.

Review of the flight logs back through 20 August 1955, disclosed no record of any operating difficulty with either powerplant.

Testimony of eyewitnesses made it possible to plot the path of the aircraft back about 3-1/2 miles from the point of impact. Figure 24 shows this portion of the flight path in relation to the runways and to the take-off path. The position of the aircraft at the time the crew became aware of the emergency and immediately thereafter is not definitely known and that portion of the flight path is not shown.

Weather at the time of the incident: 0758. Special observation - Partial obscurement, ten thousand, broken clouds, visibility one and seven eighths miles, haze and smoke, smoke layer ten thousand.

A pilot who had just landed reported that the visibility to the south was worse because of smoke than it was at the airport or to the north. This witness stated that if the flight had as much as 3 500 feet or 4 000 feet forward visibility from the 300-foot level it would be very fortunate.

Several of the ground witnesses described the engine sound and visible rotation of the propellers as normal for the left but slower and irregular for the right. One competent witness stated that the right prop seemed to be "going in and out of feather".

All qualified observers of the emergency approach gave descriptions of the attitude of the aircraft as nose-high and its speed as slow.

The chief pilot of Currey was questioned regarding the training of Currey pilots. With particular regard to the single-engine procedures training of the captain of this flight he testified: "These same procedures were given to the captain in his training program. In fact, I might admit to the record that he had to perform, to the best of my knowledge, three or four of these manoeuvres."

Company training procedure at Lockheed Air Terminal for single-engine return on instruments starts with pilot already under a hood and on instruments. The procedure starts with a climb to 2 000 feet on a course of 255 degrees (parallel to the ILS leg at Lockheed Air Terminal which is 255 degrees outbound). At 2 000 feet and beyond the marker he executes a turn toward the leg and the marker, intercepts the glide path and localizer, and completes his approach. Company method of practising single-engine return after take-off is to use a lightly loaded aircraft; it prescribes throttling the engine to little or no thrust in lieu of feathering. The captain and the co-pilot had both been checked out on this procedure.

The chief pilot also testified that he had used the subject aircraft for a 40-minute pilot qualification flight (of another pilot) ending about 30 minutes prior to the take-off of the flight. This training flight utilized a preflight check which included the functional testing of the feathering of both propellers. (This check is required by the carrier prior to every flight.) No malfunction was noted in engine or propeller performance.

All airborne radio, navigation, and communications equipment was used without malfunction during this flight which included a single-engine instrument approach. During the investigation all airborne radio units were examined and no evidence was found to indicate that it had not been in operating condition prior to impact. Immediately after the accident all ground radio facilities including the ILS for runway 7 were tested; all functioned normally.

Since the crew neither survived nor described the emergency by radio it is possible to reconstruct what transpired on the flight deck only by consideration of the factual material already presented.

Take-off was under visual flight rules and was made toward the south-southeast into haze which restricted horizontal visibility and bordered on conditions requiring instrument flight. There is nothing to indicate that flight by visual references had been discontinued when the emergency was caused by the difficulty with the right engine one to two minutes later.

The malfunction which occurred in the right powerplant would have been evidenced by rising oil temperature, dropping oil pressure, and roughness, all discernible to the pilot. This malfunction did not of itself cause very great loss of power and there is no reason to believe that it included a fire warning. Continued use of power on the right engine for a brief period would have been hazardous but possible. Power reduction at that instant was precautionary.* The propeller of this engine continued to rotate until impact; its pitch was then 18 degrees indicating that little or no power was being developed.

This was the captain's first take-off with this co-pilot. Upon noting the malfunction of his right engine the captain asked the tower for and received emergency clearance to return and use Runway 7. Runway 7 is the ILS runway and its glide path and localizer were available to guide the flight in establishing alignment and completing its landing.

The aircraft was loaded close to but within legal limits and the performance of this model so loaded is known to be such that a safe margin exists which would have permitted it to climb on one engine at take-off power. Under the worst possible combination of propeller and landing gear positions it would have been just able to maintain level flight at METO* power if the airspeed was maintained at V_2 (97 mph) or more. Climb would have been possible if the gear had been retracted, the propeller had been feathered, or any thrust at all had been developed by the malfunctioning engine.

These known performance data indicate that the aircraft was not incapable of making a safe return after use of its right engine had been discontinued.

The observed portion of the flight path, charted in Figure 24 does not include the base leg of the approach.

When the malfunction occurred the captain may have considered his altitude insufficient for safe transition from visual to instrument flight, or for reliance on his co-pilot for much, if any, help on this their first flight together. He may have tried to continue flight by visual reference only, or he may have been guided by the ILS inner marker at the approach end of Runway 7. The flight path after the emergency was announced indicated single-engine operation and since the malfunction did not cut out the engine the captain may have reduced power on that engine as done in Currey's practice of single-engine flight; or he may have tried unsuccessfully to feather the right propeller. The fully closed position of the right engine shutoff valves indicates that feathering was attempted. The shutoff valves of the left engine were in a midposition indicating that the crash may have interrupted their closing.

The captain did not, and possibly could not, climb to 2 000 feet and follow that portion of the company's single-engine training procedure. He did circle to the right for an approach to Runway 7. If he used his radio and the localizer he needed a base leg some distance out to enable him to align the runway by that means. If he depended on visible landmarks he needed a base leg close in to identify known landmarks as aids in accomplishing alignment. It is possible that the base leg he selected was too close in for the one technique and too far out for the other. In any event, alignment was not accomplished.

Although he failed to establish alignment with Runway 7 he did turn to a heading of approximately 76 degrees, parallel to Runway 7, then lowered the gear and descended. Discovering this misalignment he elected to use No. 33 (misnamed No. 31 when informing the tower). He changed heading to approximately 30 degrees, toward the airport. Because of the extended gear, the unfeathered right propeller, and the low airspeed then remaining, he was unable to maintain level flight but continued to the airport area, losing altitude all the way, and failed to clear the last powerline in his path.

Probable Cause

The probable cause of this accident was the captain's irrevocable commitment to a landing without radio or visual confirmation of his runway alignment following engine failure immediately after take-off in near minimum visibility.

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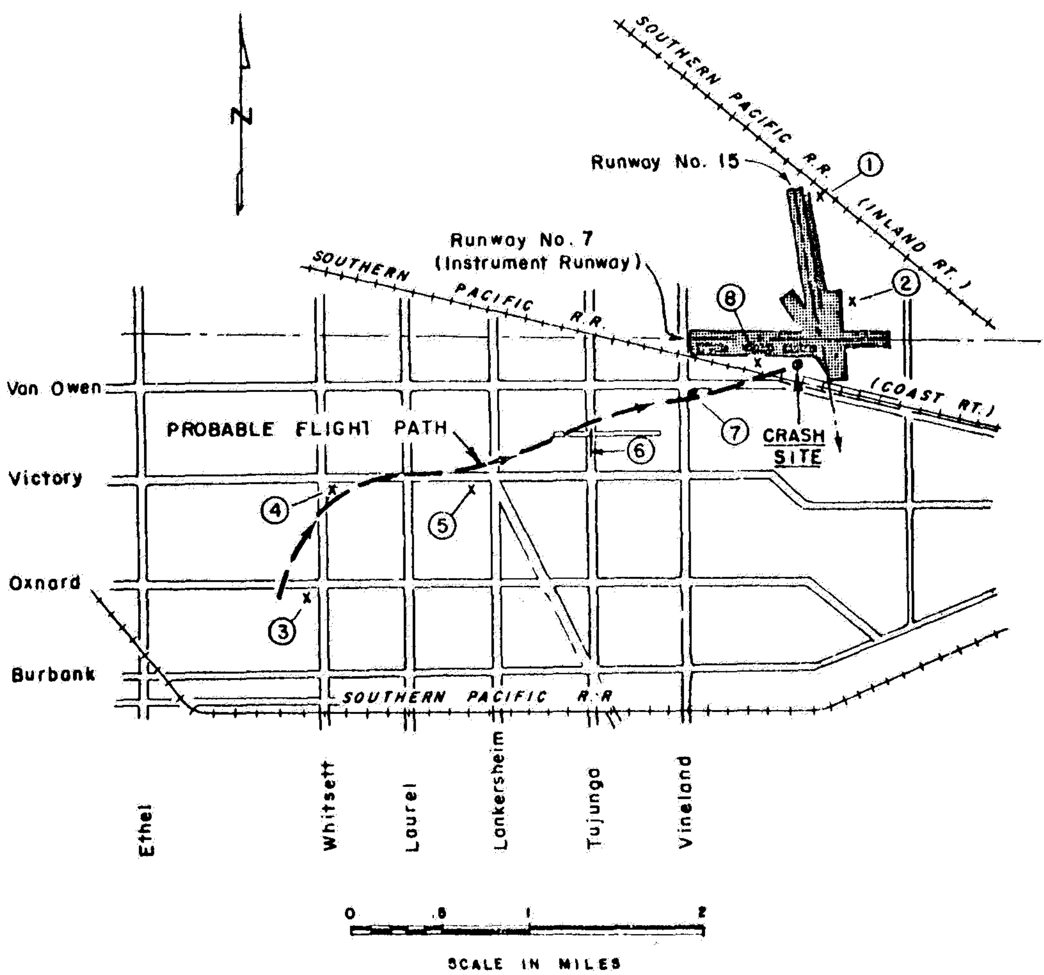
* Cockpit checklist specified "Feather" for single-engine operation; power setting 2 550 rpm and 42 inches; for METO power 2 550 rpm and 41 inches.

PROBABLE FLIGHT PATH

CURREY AIR TRANSPORT, LTD. - N-74663
LOCKHEED AIR TERMINAL
BURBANK, CALIF.
September 8, 1955



Encircled numbers show location of ground witnesses to approach.

Figure 24

COMM-DC-64763

No. 42

Associated Airways Limited, Bristol 170 Mk. 31, CF-GBT crashed near Thorhild, Alberta, on 17 September 1955. Report No. 55-48 released by Canadian Department of Transport, Air Services Branch, Civil Aviation Division

Circumstances

At 0021 hours Mountain Standard Time the aircraft took off from Edmonton for Yellowknife with a crew of 2, 4 passengers and a cargo of freight.

An IFR flight plan had been filed for the flight to be made at 5 000 feet over Blue Air Route No. 84. Clearance out of the Edmonton Control Area was given to the aircraft but VFR was to be maintained while in the area.

About twenty-two minutes after take-off, the tower at Namao heard a distress message from the aircraft indicating that the starboard engine had failed and that the aircraft was returning to Edmonton at 3 000 feet. Two minutes later another distress message was picked up by Namao stating that the aircraft was returning to Edmonton. Two-way communication with the aircraft was not established and although Namao and Edmonton continued to call the aircraft for more than thirty minutes, nothing further was heard from it. Although hampered by darkness and poor weather conditions, an air and ground search was started almost immediately but without success, until shortly after first light when the wreckage was found in a farm field about ten miles north of Thorhild. The pilot-in-command and one passenger had been killed and the co-pilot and three other passengers were seriously injured. The aircraft was destroyed.

There were no witnesses to the accident but evidence from the survivors indicated that the flight had been normal for about the first twenty minutes. At this time the starboard engine began to lose power, miss and backfire and was accompanied by a fluctuation of between 3"-4" of manifold pressure. This condition lasted about three or four minutes. The pilots then feathered the engine and attempted to return to Edmonton. Orders were then given to jettison the cargo and the rear door was opened and groceries, sacks of sugar and flour were thrown out for a period of about ten minutes. It was then about 0055 hours. The crew then stopped jettisoning cargo and waited for the crash which occurred almost immediately.

After the failure of the starboard engine, the aircraft lost nearly 3 000 feet of altitude in about ten minutes and crashed in the open field. The survivors could offer no satisfactory explanation for the accident and, as a result of his injuries, the co-pilot was unable to give complete details of what had occurred, although he did recall that for a time he had taken over control of the aircraft and flown during the emergency.

Investigation and Evidence

A Certificate of Airworthiness, to expire on 22 December 1955, had been issued for the aircraft. Subsequently, however, radio equipment had been changed in the aircraft by the Company and the aircraft had not then been submitted for inspection and re-certification as should have been done. Moreover, the weight used by Company despatchers did not agree with the weight given in the Weight and Balance Report accompanying the Certificate of Airworthiness. In addition, the aircraft had been weighed on 17 August 1955, and the tare weight was found to be 28 578 lbs., which was 1 332 lbs. more than the tare weight which continued to be used by Company despatchers in computing the all-up-weight although the results of the reweighing had been known by Company officials.

As a result the computation of the all-up-weight of the aircraft showed that it was overloaded at the time of the accident by at least 1 400 lbs.

Further, the aircraft was balanced by placing items of equal weight at the same distance on each side of a loading line. Thus the aircraft had not been loaded in conformity with the Certificate of Airworthiness.

A modification to the aircraft's heating system had been made prior to the flight. Shortly before the starboard engine failed, an attempt was made to start the heater without success. Almost immediately thereafter the starboard engine failed. However, no evidence could be found to indicate that operation of the heater system was responsible for the engine failure.

While weather conditions favoured ice formation, it was not possible to determine whether this was a factor. It is improbable that ice formed in the carburetor itself since this was an injector carburetor with an oil heater barrel. It was not possible to determine whether ice formed in the air scoops to the carburetor but this could be considered a possibility in the light of the weather conditions at the time of the accident.

Thorough examination failed to reveal anything that would account for the engine failure. However, further investigation of both of the engines and carburetors is being made by the manufacturer.

A further modification had been made to the vacuum selector control. As a result of this modification only the pilot's or co-pilot's set of gyro-driven instruments would continue to operate in the event of the failure of one engine. The new operation of the selector control had not been clearly marked as should have been done nor had the co-pilot been made aware that certain of his instruments would not be giving accurate indications due to the failure of one engine.

Examination of the wreckage and ground at the scene of the accident indicated that the aircraft was in a slight turn to the right at the moment of impact. This is substantiated by one of the crew members who stated that while jettisoning the cargo the right wing was down.

Information as to the performance figures of this aircraft shows that on single-engine performance, the aircraft should not have lost altitude as rapidly as it did. However these performance figures would not apply to an aircraft that was overloaded and the performance of the aircraft would be further decreased by the rear door being open while cargo was being jettisoned.

The weather forecast for the period 1700 hours on 16 September 1955 to 0500 hours on 17 September, indicated that a depression located east of McMurray was remaining stationary and filling slowly. The circulation was north to north easterly.

Northern half of the Edmonton region.

Clouds and Weather	6 000 feet broken - layers 15 000 feet intermittent light rain with ceilings 2 500 feet and visibility 3-6 miles in drizzle after 1900 hours.
Icing	Light in cloud above freezing level.
Freezing Level	6 500 feet mean sea level.
Turbulence	Light below 8 000 feet.
Wind and Temperature	At 4 000 feet 300° at 35, 6°c 310° at 30, 6c.

Probable Cause

For reasons not as yet determined, the starboard engine failed and as a result of being overloaded, the aircraft did not maintain altitude on one engine and struck the ground with the starboard wing tip.

A further contributory factor was considered to be the failure of the co-pilot's vacuum-driven gyro instruments, without his knowledge.

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ICAO Ref: AR/409

No. 43

British Overseas Airways Corporation, Argonaut aircraft, G-ALHL, crashed on landing at Idris Airport, Tripolitania, United Kingdom of Libya, 21 September 1955. Report released 15 October 1955 by Ministry of Communications, Libya.

Circumstances

The aircraft was operating the Rome-Tripoli sector of a scheduled flight London-Rome-Tripoli-Kano and Lagos. The accident occurred during the fourth attempt to land at night on Runway 11 at Idris Airport in conditions of strong wind and poor visibility. During the last approach the aircraft struck trees and crashed 1 200 yards short of runway 11, at 2223 hours Greenwich Mean Time and fire broke out before it came to rest. Of the 7 crew members and 40 passengers on board 15 were killed instantly and 21 were injured.

Investigation and Evidence

The captain and first officer stated that throughout the flight and at the time of the accident there was no malfunctioning of any part of the aircraft, its controls, instruments, engines or equipment.

The Meteorological Office, Idris Airport, issued the following weather reports to Air Traffic Control during the evening of 21 September.

TIME	WIND SPEED & DIRECTION	CLOUD	WEATHER	QNH	VISIBILITY
2100	110° 17 kts. gusting 25	No low cloud	Rising sand	1014 mbs.	2 n.m. 4500 yards
2205	100° 20 kts. gusting 27	Nil	Rising sand	1012.8 mbs.	0.9 n.m.
2224	120° 20 kts. gusting 28	Nil	Rising sand	1012.7 mbs.	2000 yards.

The 2205 hours report was not transmitted to the aircraft. It was taken to the Air Traffic Control Tower by the Meteorological Observer at 2209 hours at which time the Approach Controller on duty was speaking to the aircraft. The Aerodrome Controller was out by the runway with a Very light pistol ready to assist the aircraft by firing signal cartridges. The Air Traffic Control Clerk was temporarily absent. The Meteorological Observer, therefore, left the report on the Aerodrome Controller's desk and it was not seen until after the accident. The 2224 hours weather report was made at the request of Air Traffic Control immediately after the accident.

Note: The Q.N.H. is, briefly, the setting which if set on the sub-scale of the altimeter ensures that the instrument indicates height above mean sea level. Thus, with this setting, when the aircraft lands the altimeter should indicate the approximate height of the airport above mean sea level.

The Q.F.E. is, briefly, the setting which if set on the sub-scale of the altimeter ensures that the instrument should read approximately zero when the aircraft lands.

Prior to the flight the captain visited the Meteorological Office at Ciampino Airport, Rome and obtained a route and terminal forecast for the flight to Idris Airport. The terminal forecast gave the expected visibility at Idris Airport between 1800 and 2100 hours as 16 km. with the possibility of it decreasing to 6 km. in 'suspended sand'. The wind was given as likely to be 120° at 20 kts. He also visited the Air Traffic Control Office at 1825 hours and filed a flight plan giving an elapsed time for the flight to Idris Airport of 3 hours 4 minutes; his endurance was 6 hours 6 minutes and his declared alternate aerodromes were Malta, Nice and Naples. The aircraft took off at 1855 hours with an estimated time of arrival at Idris Airport of 2159 hours. During the climb, icing conditions were encountered and at one stage power had to be increased to maintain the climb; but after passing through the cloud the ice gradually cleared and the flight proceeded normally to Palermo, whence Malta Flight Information Centre gave it a direct clearance to Idris Airport at 18 000 feet. The weather for the remainder of the flight was 'fine'. During the whole of the flight and during the approaches to Idris Airport ultra-violet and dimmed red lighting were used to illuminate the aircraft instruments.

Approximately 90 miles from Tripoli, at 2137 hours, the aircraft began to communicate direct on VHF/RT with Idris Airport

Approach Control on a frequency of 119.7 m/cs. It was given clearance for an unrestricted descent and flight to the airport, and was requested to report both when it was abeam Wheelus Field and when it had Idris Airport in sight. The aircraft crossed the Libyan coast at an altitude of 7 500 feet and when cleared to descend below 4 500 feet it received from Idris Airport the weather report for 2100 hours. The aircraft was also informed that two runways, 11 and 18, were available. The captain elected to land on runway 11 as he knew that there would be a strong cross-wind on 18. He also considered that his landing weight of approximately 71 000 lbs., together with the strong wind blowing down runway 11 would ensure that the length of that runway (1 600 yards) would be more than sufficient. On a previous occasion in a strong wind he had landed on runway 11 without having to use propeller braking. He was fully aware that there were no lead-in or approach lights to runway 11 which was equipped with an electric flare path with 4 sodium lights at each end. Auxiliary gooseneck lighting had also been laid along it earlier that night.

The aircraft approached Idris Airport at 2 000 feet at approximately 2200 hours. The airport lights could be seen from this height but not the actual runway lights. The aircraft commenced a left-hand circuit and flew to the south of the airfield. A descent was made to 1 200 feet QNH, and the flaps were lowered to 15°. Both the captain and the first officer had the 2100 hours QNH set on their altimeters. The aircraft flew towards the downwind or western end of runway 11; as it came abeam of the runway at 1 200 feet the captain could see the runway lights. He flew downwind for 1 minute but before turning left on to base leg he lost sight of the lights. He turned on to base leg slowly descending in the turn to 650 feet QNH which height he then maintained with power settings of 48 inches of manifold pressure and 2 650 r.p.m. As the aircraft came round on to a heading of 110° he saw the runway lights again but he was then 300 yards to the left of the runway. It was impossible to attempt a landing and the captain decided to overshoot and carry out another circuit (time-2206 hours). During this first circuit considerable turbulence was experienced which made good instrument flying difficult and this was particularly so to the west of the airport.

The captain went through the same circuit procedure again with similar results, except that on this second circuit the aircraft arrived slightly nearer the runway on its final approach. On this second and subsequent circuits the captain was given VHF/DF radio bearings to help him line-up with the runway. The captain has said that after these two unsuccessful approaches he was not at all apprehensive about continuing to attempt to land on runway 11. He felt his only difficulty was in lining up with the runway in the poor visibility. He estimated that at the time of his second overshoot he could spend a further 30 minutes over Idris Airport without encroaching on the fuel reserve necessary to take him to his first alternate aerodrome - Malta. After the second overshoot (time 2210 hours) the approach controller told the captain he would assist him to line-up by sending someone to the threshold of runway 11 with a Very light pistol to fire lights as the aircraft made its final approach.

On the third circuit, the aircraft was better aligned with the runway but by the time the runway lights were sighted it was too high and too close in for the captain to attempt a landing. He therefore took overshoot action again (time-2218 hours) and flew low up the runway to assess for himself the visibility conditions for landing. During the low level run up the runway, the first officer reminded the captain that they were flying with QNH settings on their altimeters (implying that their altimeters did not therefore indicate their height above the runway). The captain replied to the effect that he was aware of this. He decided to carry out a low visibility runway approach procedure and climbed to 1 300 feet. The captain instructed the first officer to keep a close look-out for the runway lights during the procedure turns of the runway approach procedure. The up-wind timed turn was completed at a height of about 1 300 feet QNH, and before the aircraft commenced its downwind run the whole length of the runway lights could be seen. This indicated that the visibility was then at least 1 600 yards which was well above B.O.A.C.'s minimum visibility for landing. (Note: B.O.A.C.'s visibility minimum for landing at Idris Airport at night on all runways is 1 000 yards; the crosswind component must not exceed 26 knots. This minimum and this maximum are contained in the Corporation's Operations Manual). As the aircraft approached the downwind threshold of runway 11 at 1 200 feet the captain turned 45° to the right, turned back 10° - 15° to correct for drift, and then continued on the new heading for 45 seconds before commencing a turn to the left. Again the aircraft encountered the more severe turbulence to the west of the airfield. During this turn the captain reduced power and gradually descended to 650 feet QNH; after its completion, in order to maintain height at 125 - 130 knots, he increased power first to 52 inches manifold pressure and then reduced this to 48 inches. During the procedure turn the first officer had completed the landing check which included lowering the undercarriage.

Shortly after the completion of the turn, the first officer reported 'runway ahead' and the captain looked at his altimeter and saw that it was indicating 610 feet (i.e. about 350 feet above the level of the runway). Having a clear view of the lights he decided to make a visual approach and reduced power to 40 inches using this setting because of strong wind conditions and the necessity of making a flat approach. He considered that he would have to do a slight turn to port to line-up with the runway and he estimated that it was about a mile ahead. Shortly after commencing the visual approach, he was about to call for the first officer to switch on the landing lights when he partially lost sight of the runway lights and saw what he thought to be a cloud of billowing sand. Having lost his visual reference he reverted to instrument flying and perturbed by what he saw reached for the throttles to climb. At that moment the first officer called "Look out. Climb", and simultaneously the aircraft shuddered and a series of impacts followed. The aircraft crashed through lines of trees, hit the ground, and came to rest on fire in an olive grove.

The whole aircraft was ablaze within two minutes. The majority of the passengers who survived escaped through the starboard emergency exits, and the crew escaped through the crew door on the starboard side of the flight deck.

The first vehicles from Idris Airport Fire Service reached the scene of the accident approximately 7 minutes after the crash. They took a route made difficult by soft sand dunes through olive groves directly across country from where they had been stationed in readiness adjacent to runway 11. By the time they arrived much of the structure of the aircraft had been consumed by fire, and all survivors were out of the aircraft. The fire party immediately concentrated on putting out the fire. Shortly afterwards, a large number of Royal Air Force personnel from the R.A.F. Station at Idris Airport arrived and together with the Airport Fire Service personnel rendered all possible assistance to the survivors, some of whom were seriously injured. They also made a linked-arm search in the darkness and flying sand for possible missing survivors.

Inspection at the scene of the accident showed that the aircraft had crashed on a soft, sandy cultivated area to the west of Idris Airport about 1 200 yards short of the threshold and 485 yards to the left of the extended centre line of runway 11. The ground at this point is 12 feet below the level of the threshold of runway 11.

The initial impact was with lines of eucalyptus trees bordering a narrow unmade road running east-west. These trees varied in height between 28 and 42 feet and had been cut off about 20 feet from the ground over a distance of 168 feet. The appearance of the gap so formed in the lines of trees suggested that the aircraft was approximately laterally level at the moment of impact.

Commencing 185 feet beyond the line of trees was a series of three ruts made by the landing gear of the aircraft. These ruts were on a heading of 130° and a line joining them with the point of impact with the trees indicated that the aircraft's angle of descent was about 4°.

About 400 feet beyond the initial impact with the trees, the aircraft crossed a second tree-lined sunken road running north-south. A gap 105 feet wide was torn in this second double line of trees; the trees at the left-hand side of the gap were cut 25 feet from the ground, and the trees at the right-hand side of the gap at 10 feet from the ground.

The right main and nose landing gear were torn out of the aircraft structure on first impact with the ground and this caused the right wing to drop and drag the ground resulting in the breaking away of the two right propellers. The right wing was torn away from the aircraft at about this point and its further disruption was the result of passing through the trees lining the second road. The aircraft which had already commenced to yaw to the right, was slewed round still further as a result of the right wing dragging the ground and breaking away so that it passed sideways through the trees lining the second road with the left wing leading.

The fuselage and left wing finally came to rest about 550 feet beyond the first point of impact with the trees, the fuselage having slewed round 90° to the right.

Both left propellers had broken off at their reduction gear casings and lay between the second road and the main wreckage. The left wing had been torn off at the root, and lay parallel to the fuselage, and close to it. It was inverted and with the wingtip towards the tail. The left main landing gear lay burnt-out in the inner wing, having folded inwards.

Both left engines had broken away from the wing; the outer engine having been driven inwards lay burnt-out in the remains of the wing leading edge. The inner engine had become detached from the wing and had also been driven inwards and lay burnt-out in the remains of the fuselage. When the aircraft was travelling sideways with the left wing leading, the wing broke away at the root and turned over. This led to the detachment of the propellers and the breaking away of the engines in an inward direction. The detached left wing, engines, and fuselage travelled forward together and as they came to rest, the left inner engine was driven up into the fuselage from below floor level. The floor of the forward passenger cabin must have been considerably displaced upwards and this resulted in the death or injury of the majority of the occupants.

Fire broke out before the aircraft had crossed the second road and the first evidence of burning was in the wreckage trail about 220 feet beyond the initial impact with the trees. At the time of the crash the aircraft held about 600 gallons of fuel distributed between the main tanks. On first impact with the trees, the integral tanks in the wings of the aircraft were torn open thus releasing quantities of fuel which became ignited before the aircraft came to rest. The detached left and right wings were severely burnt and the fuselage had been almost completely destroyed. The exceptionally severe fire damage was due to the fact that the fuselage came to rest close alongside and on the downwind side of the left wing which contained about 300 gallons of fuel. The rapid outbreak of fire within the fuselage was due to the fact that the left side of the fuselage had been torn open by the left inner engine thus providing entry to the fire already started at the left wing.

Examination of the wreckage showed that at the time of impact the landing gear was fully extended and the flaps partially extended. Due to impact damage it was not possible to determine the precise flap angle but it has been established that it could not have been less than 10°. The condition of the propellers indicated that the engines were developing power at impact, and examination of their pitch change mechanisms showed that they were all set at the fine pitch end of the normal constant speed range. There was no evidence that any mechanical failure of the engines had occurred prior to impact. No evidence was found which would suggest any malfunctioning of the flying control circuits. The remains of the captain's altimeter were recovered and by comparison with a similar instrument it was established that the millibar scale was set at 1014. The remains of the first officer's altimeter were recovered, but it had been so severely damaged by fire that its setting could not be established. The pitot/static system had been completely burnt out and it was not possible to carry out any check of the system or to establish whether it was selected to normal or alternate source.

A total of 6 emergency exits are provided in an Argonaut, 3 on each side of the fuselage. There are 4 of these exits in the front passenger cabin and 2 in the rear. The mechanism of the centre emergency exit on the left hand side was found in the closed position. The remains of the other emergency exits were not identified.

No useful evidence was obtained from the remains of the passenger seats; they had been so badly burned that only the steel components remained. The floor of the passenger cabins had also been consumed so that it was impossible to assess the behaviour of the seat structures during the crash.

The remains of the crew door were found with its operating mechanism in the open position. The main passenger door had been completely destroyed by fire and the position of its operating mechanism could not therefore be determined.

The aircraft's automatic crash fire extinguishing system had operated but the discharge of extinguishing media had little effect on the outbreak of fire which was remote from the areas covered by the installation.

The captain's decision to use runway 11 was justifiable. A civil DC-6 aircraft landed without difficulty on this runway in similar conditions approximately 1 hour after the accident. Although the cross-wind component on the long runway 18 was less than the Corporation's permissible maximum it was sufficiently strong to warrant the rejection of that runway in favour of the shorter runway 11. However, having failed on three occasions to line-up and land on runway 11, it is considered that the captain should have revised his decision not to use runway 18 which had better approach aids namely, lead-in lights, a locator beacon, and the VHF/DF more favourably positioned.

During the final procedure turn, the captain gradually reduced height from about 1 200 feet to 650 feet QNH. The undercarriage was lowered in the turn. On the completion of the turn the captain increased power to check his descent and maintain height, and almost immediately afterwards the first officer reported 'runway ahead'. The captain noticed at that moment that his altimeter was indicating 610 feet. He immediately reduced power to commence a visual approach and descent. The conditions were turbulent which made accurate flying difficult. Within a short space of time - a few seconds - the captain saw the billowing sand ahead and the aircraft struck the trees before he could climb. The height of the ground where the aircraft struck the trees is 243 feet above mean sea level, which is 12 feet below the level of the threshold of runway 11. This indicates that the aircraft lost approximately 350 feet in a short space of time. It would appear, therefore, that the aircraft's descent was never fully checked after the completion of the procedure turn, and that the rate of descent increased after the captain reduced power to make his visual approach. It is significant that after noting the 610 feet and after commencing his visual approach the captain apparently did not refer again to his altimeter. It is apparent that he did not realize that his approach path had become too steep and the aircraft was becoming dangerously low.

The use of a QNH altimeter setting means that in order to obtain the true height above the aerodrome a pilot must subtract the known altitude of the aerodrome from the altitude indicated by his altimeter. When a QFE setting is used the height above the aerodrome is read directly off the instrument. A pilot must, therefore, be quite clear in his mind whether he has a QNH or QFE setting. The Board has considered the possibility that the captain having a QNH setting on his altimeter treated it on the final approach as a QFE setting; and, indeed, this would appear to be the most logical explanation of the accident. The captain stated that he had on occasions used a QFE setting for landings. However, on the overshoot after the third attempt to land, the first officer reminded the captain that he was flying with a QNH setting on his altimeter and the captain confirmed that he was aware of this. The captain, therefore, appeared to be fully aware of the type of setting he had on his altimeter, and in the absence of further evidence to the contrary the Board must accept that he made his final approach with no confusion in his mind as to the type of altimeter setting he was using.

The Board is aware of the circumstances which led to the non-transmission of the 2205 hours weather report, which included a reduction of 1.2 mbs. in the QNH. Had the captain received the amended QNH and made the adjustment to his altimeter, it is assumed that he would have carried out his instrument procedures approximately 30 feet higher, but it is considered that this adjustment would have had little effect on his visual final approach. Consequently, whilst the omission to transmit this report cannot be condoned, the Board considers that an adjustment of 1 mb. during his attempts to land would not have materially affected the course of events. The aircraft crashed 1 200 yards short of the runway on ground that is 12 feet below the level of the runway threshold whilst it was descending at a relatively steep angle. At this distance from the runway, assuming a 2 1/2° glide path and a touch-down point 100 yards up the runway, the aircraft should have been at least 170 feet above the ground.

The trees struck by the aircraft in no way constituted an obstruction to the runway (as defined in ICAO Annex 14, part 5, Chapter 1, para. 1).

Probable Cause

The accident was the result of an error of judgement on the part of the captain who having made three unsuccessful attempts to line-up and land on runway 11 on his fourth attempt allowed his desire to keep the runway lights in view to affect his judgement, in that during a visual approach to the runway he failed to make adequate reference to his flight instruments. In the restricted visibility the runway lights gave him insufficient guidance as to attitude, height and angle of approach and unknowingly he permitted the aircraft to descend below its correct approach path.

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No. 44

Great Lakes Carbon Corporation, Douglas A-26-C, crashed following structural failure resulting from a mid-air explosion near Union City, Oklahoma, on 3 October 1955. Civil Aeronautics Board (USA) Accident Investigation Report File No. 2-0058 released 29 February 1956.

Circumstances

The aircraft departed Bridgeport, Connecticut, for California at 1245 hours Central Standard Time carrying two crew members. Two stops were then made at White Plains, N. Y. and at La Guardia Field where 2 passengers boarded the aircraft. At 1346 the flight left La Guardia for Tulsa, Oklahoma, under Visual Flight Rules and no flight plan was filed. At Tulsa the aircraft was refuelled with 906 gallons of gasoline which filled to capacity both main tanks, the nose tank and the rear fuselage tank. After the pilots were briefed by the Tulsa U.S. Weather Bureau Office, an Instrument Flight Rules flight plan was filed with the Air Route Traffic Centre. At 2114 Oklahoma City Airway Communications Station received a call from the flight on 126.7 mcs. requesting cancellation of the IFR flight plan and asking for a landing clearance at Oklahoma City. The flight was given the special 2100 weather as 10 000 feet overcast, sky partially obscured, fog, visibility 1-1/2 miles, and was advised to contact RAPCON (Radar Approach Control) on 119.3 mcs. for a clearance to land as IFR conditions prevailed. The crew advised that it desired clearance for Will Rogers Field. This was the last radio contact with the aircraft. It crashed at 2117 hours 2-3/8 miles northwest of Union City, Oklahoma, and 23 miles west of Will Rogers Field, Oklahoma City. Two explosions were heard in the air prior to the crash and portions of the empennage and fuselage were found along the last 3 miles of the flight path. There were no survivors.

Investigation and Evidence

Witnesses several miles north of the crash site, who observed the aircraft several hundred feet above the ground, describe two distinct flashes in its descent to the ground. They also mention a light rain at the time but no lightning.

Examination of the wreckage and ground marks indicated that the aircraft, minus the aft fuselage and tail assembly, had dived to the ground, in an inverted attitude at nose-down angle of approximately 45 degrees on a south-easterly heading.

Disintegration in flight was indicated by numerous segments of the fuselage shell and portions of the horizontal stabilizer skin being found back along the flight path as far as three miles from the main wreckage. The main portion of the empennage was found three-eighths of a mile from the main wreckage. All of the scattered portions of fuselage structure were from the area aft of the cabin rear bulkhead.

Examination of these parts gave evidence of internal explosive forces that had blown the skin outward or off and distorted the structure of all empennage components except the rudder and the elevators. There were no indications of heat damage or fatigue in the aft fuselage wreckage which could have resulted in failure under loads less than design. There was no compression buckling of the skin and stringers, characteristics of failures due to overload. However, there were numerous indications of the aft fuselage shell having disintegrated because of excessive tensile stresses throughout the entire shell acting both longitudinally and peripherally at the same time. The fuselage disintegrated along rivet seams, which are areas of least tensile strength, evidencing a practically uniform internal pressure throughout the aft portion of the fuselage. The aircraft was not equipped for cabin pressurization.

No evidence was disclosed to suggest failure or malfunctioning of the engines or propellers prior to impact.

Examination revealed scorched edges at the torn holes in the rudder fabric. Blistered paint was likewise noted at the trailing edge of the left elevator. The source of this flame damage was not associated with the ground fire.

Destruction of the aircraft forward of the cabin aft bulkhead by ground fire was extensive. Major components, including wings, flaps, ailerons, nose and cockpit areas, controls, instruments, fuel tanks, landing gear, nacelles, etc., were all accounted for in the area adjacent to the point of impact. Examination disclosed that the wing flaps and the landing gear were in the retracted position at the time of impact.

Only the following instrument readings were obtainable: Omni Bearing Selector 232 degrees; Radio Magnetic Indicator - double pointer 240 degrees, single pointer (ADF) 198 degrees; Zero Reader Selector 240 degrees; C2 Gyro Compass 246 degrees.

A 125-gallon fuel tank and radio rack were installed in the aft fuselage without a vapor seal separating the two units. The severe fire damage after ground impact precluded a determination of the condition of the fuel system components prior to the accident. The aft fuselage fuel tank vent line was found with its end fittings failed from excessive tension. The Tulsa fuel attendant stated the tank was not overfilled at the time of servicing.

In the tail section of the fuselage, aft of the rear cabin bulkhead, in addition to the 125-gallon fuel tank, there was installed the following electrical equipment: (2) ARN-7 compass; (2) loop antenna; (1) MN5 3B marker receiver; (1) ARN5A glide path receiver; (1) RTA-1B command unit; (1) A-12 gyrosyn repeater amplifier; (2) Collins 51R, (2) Collins 17L-2VHF transmitter; (2) inverters; (1) isolation amplifier; (1) R-89B glide path and (1) BC733D localizer.

The most recent airframe 100-hour inspection was dated 8 September 1955, and the aircraft had flown 14 hours since that time. This inspection covered the security of the interior equipment, such as tank, radio, all lines, cables, and A-12 servos of the empennage and tail compartment. The last line inspection, at La Guardia on 3 October 1955 revealed no discrepancies.

After the accident a flight check of the ground navigational facilities involved in an approach to Oklahoma City disclosed normal operation of all units.

The aircraft had been modified for passenger carrying and was then certificated by the Civil Aeronautics Administration in the limited category which prohibits the carrying of passengers for hire. The work included the following item: No. 15. Installed Army type 125-gallon fuel tank in aft section of fuselage (original installation).

According to records of the Great Lakes Carbon Corporation Aviation Department, all Air Force Technical Orders for the A-26 had been received and compliance had been accomplished.

Facts determined by investigation disclosed that the tail surfaces and fuselage aft of the bulkhead at the rear end of the cabin separated from the airplane in flight.

The manner in which the skin bulged outward and separated from the horizontal stabilizers and bulged outward on the fin could result only from very high internal pressures. It is apparent that the pressures which caused the disintegration built up suddenly and that they originated in the aft fuselage. Only an explosion within the aft fuselage could cause a sudden pressure increase of this nature.

Explosions from concentrated sources, such as sticks of dynamite or containers of TNT, produce severe shattering and fragmentation close to the source of explosion with decreasing fragmentation as distance from the source increases. This type of explosion also leaves soot-like deposits on the structure shattered. Neither of these characteristics was present in this case. Instead, the fuselage disintegration indicated a practically uniform pressure such as is caused by the ignition of an air-gasoline mixture which is much slower than the detonation of high explosives. In addition, this latter type of explosion does not leave deposits on the structure. The Board, therefore, concludes that fumes caused by leaking fuel were ignited by operation of electrical equipment installed in the aft fuselage.

The scorched fabric and blistered paint on the tail control surfaces appear to have been caused by momentary burning of fuel which spurted out of the aft fuselage tank after the first explosion disrupted the fuel lines. This fuel drenched the tail surfaces while the tail assembly was still attached to the main part of the aircraft by means of control cables. This same fuel was probably ignited by sparks from disrupted wires of the electrical equipment in the aft fuselage which could well account for the second explosion described by ground witnesses.

The nature of the accident and the fact that all communications from the flight were routine and conducted in a normal tone of voice indicate that the pilots were unaware of an immediate emergency. The reason for discontinuing the flight to California and the decision to land at Oklahoma City could not be determined.

As a result of the investigation the Board recommended to the Civil Aeronautics Administration that all owners and operators of A-26-B and A-26-C aircraft be immediately advised of the possible fire and explosion hazards inherent in similar installations and that corrective action be taken immediately. Accordingly, the following notification was forwarded to all Aviation Safety District Offices, and to all owners of this model aircraft: "Investigation recent A-26 accident indicates possible fire and explosion hazard in rear fuselage area. For all A-26-B and A-26-C aircraft having rear fuselage tank installed in same compartment with electrical components liable to sparking the following restriction is mandatory until further notice: Rear fuselage fuel tank shall be drained, purged, and marked to prohibit use. Placard cockpit fuel controls and filler cap for information pilot and servicing personnel." This notice was followed by AD 55-26-1 which specifies modifications for reactivation of the rear fuselage tank.

Probable Cause

The probable cause of this accident was the loss of the aircraft's empennage as a result of an inflight fuel explosion in the aft section of the fuselage.

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ICAO Ref: AR/416

No. 45

Jugoslowenski Aero-Transport, Convair CV-340, YU-ADC, crashed on the northwest slope of the Kahlenberg, 25 km. from Wien-Schwechat Airport, Austria on 10 October 1955. Report released by the Accident Investigation Commission, Civil Aviation Office, Federal Ministry of Transport and Nationalized Industries, Austria, on 14 January 1956

Circumstances

The flight departed Belgrade Airport in clear weather at approximately 1230 hours Greenwich Mean Time en route to Vienna carrying 25 passengers and a crew of 4. At 1425 hours the aircraft was transferred by area control to Vienna approach control. The pilot was advised to use the homer for approach and a QDM of 100° was given at 1429 hours. At 1430 the aircraft reported over radio beacon OEW and was instructed to remain 150 metres (500 feet) above the cloud top. A QDM of 123° was obtained at this time. At 1431 the aircraft was cleared to descend to 1 060 metres (3 500 feet) and instructed to report again at this altitude over beacon OEW. The flight was cleared then for an instrument approach, the pilot was given the QNH setting for his altimeter and instructed to use Runway 12. Bearings were taken and QDM's reported to the pilot, the last being: "1439 hours: QDM 140". As requested, this one was repeated. However, it was not acknowledged by the pilot. Shortly after, the aircraft, while flying in the direction of the airport, with landing gear down and flaps at the approach angle, gave full throttle for a moment, pulled up and crashed at 1440 hours into the northwest slope of the Kahlenberg, facing uphill. Fire broke out following impact and the aircraft was completely destroyed. The pilot and five passengers were killed and one passenger received fatal injuries. The other occupants of the aircraft received injuries of varying degrees and seven passengers required no medical attention whatsoever.

Investigation and Evidence

A mass of warm air moving in from the southeast on the tail of a cold front was causing precipitation throughout the Vienna airport area, with visibility of 1 - 1.5 km and 0.5 - 1 km in the Vienna city area. The average height of the base of the massive cloud bank was 300 metres above sea level, while the upper limit, on the basis of the Vienna radiosonde observation at 1500 hours Greenwich Mean Time, must have been 3 300 metres.

The following weather reports and forecasts for the Vienna airport area were issued by the airport meteorological station and transmitted by radio to the crews of approaching aircraft.

1430 GMT 270/02 Kt, 1.4, mist, 5/8 Fs 120 m, 8/8 St 240 m,

QNH 1024.7, QFE 1003.3

1500 GMT 270/02 Kt, 1.3 km, drizzle, 5/8 Fs 90 m, 8/8 St 150 m,

QNH 1024.7, QFE 1003.3

1300 GMT for 14-2000 GMT var/02 Kt, 1.2 km, rain, 7/8 St. 300 Ft prob. 20 tempo 2 km, mist, 2/8 St 600 Ft. 8/8 St 1000 Ft

1400 GMT for 15-2100 GMT var/02 Kt, 1.2 km, rain, 7/8 St 300 Ft prob. 30 tempo 2 km, mist, 2/8 St 600 Ft 8/8 St 1000 Ft

The following aids were available at Wien-Schwechat aerodrome and functioning normally at the time of the accident: Non-directional beacon (NDB) OEW, 408 kc/s - 1.2 KW; non-directional locator beacon (L) WO, 378 kc/s - 40 W, combined with a 75 Mc/s marker beacon, and a non-directional locator beacon (L) WN, 325.3 kc/s - 40 W. NDB OEW which serves as a homer, is located at the western edge of the airport, while beacons WO and WN are to the west and east of the field on the extended centre line of the runway. A VHF D/F is provided to the south of the east runway. During the approach, both the high intensity approach lights and the high intensity runway lights were turned on to full intensity. The approach light system consisted of 102 lights, each of which provided 20 000 candlepower at full intensity. At the time of the incident, the aircraft was in contact with the control tower and the VHF D/F on 119.7 Mc/s.

It was not possible to ascertain, either from the wreckage or from the testimony of the witnesses, whether the aircraft fire extinguishing system had been operated. It can be assumed that it was not since immediately following the crash the crew were incapable of taking any action to prevent fire and the aircraft began to burn when the explosions occurred.

The aircraft crashed at a point 390 metres above sea level, 200 metres west of the intersection of the Leopoldsberg-Kahlenberg and Leopoldsberg-Klosterneuberg roads. Parts of the landing gear were scattered just before the point of impact, together with the left aileron and parts of the left wing flaps which were torn off by the tops of the trees growing on the steep hillside. The fuselage and the remainder of the wing lay facing uphill at the edge of the roadway, and at right angles thereto. The right leg of the landing gear, which was down, was torn off by contact with the roadway and the curb marking stones and was found lying on the roadway.

The forward section of the fuselage and the cockpit were severely crushed and the passenger cabin section was torn off. All equipment and fittings of the aircraft were displaced by the impact. Furthermore, the fire, which broke out immediately following the impact completely destroyed all the equipment and the main components of the aircraft, with the exception of those which were torn off and lay apart. Consequently, no reliable information which could be of use in the investigation could be obtained from the aircraft equipment or instruments. Immediately following the crash and before the fire had been extinguished, the injured passengers were forcibly extricated from the wreckage. Removal of the victims also required displacement of the wreckage. In addition, the fire fighting operations caused considerable displacement of the wreckage before the arrival of the investigators. It was, therefore, impossible to ascertain with any accuracy the manner in which the crash occurred, from the position in which the investigators found the wreckage.

According to information provided by the airline, their pilots are instructed, in the event of IFR conditions at Schwechat aerodrome, to proceed as follows when instructed by aerodrome control to approach on a 120° heading:

a) Reduce altitude to 3 500 feet by circling between beacons OEW and WN;

b) After descending to 3 500 feet and on receipt of clearance from air traffic control, fly on a 320° heading for two and a half minutes, descending to 2 500 feet;

c) On reaching 2 500 feet on 320° magnetic, execute a procedure turn to the left until on 120° magnetic;

d) When on 120° magnetic, descend gradually to reach an altitude of exactly 1 800 feet over beacon WO;

e) From beacon WO, descend gradually on a 120° heading to 1 000 feet;

f) If visual contact is not made from this altitude, climb in the same direction to 1 600 feet and await further instructions from air traffic control.

From the statements made by the air traffic controller and by the pilot of another JAT aircraft which was flying in the vicinity at the time, it is assumed that the pilot-in-command of YU-ADC was already aware of the unfavourable weather conditions prevailing at Schwechat when he approached the airport.

From the evidence given by the air traffic controller it is assumed that the aircraft reported as instructed over beacon OEW. From the bearings taken at 1429 and 1430 hours, however, it is apparent that the aircraft could not have been exactly over beacon OEW

It was further confirmed by the statements of the other crew members that the pilot-in-command showed that he intended to land by switching on the "No Smoking-Fasten Seat Belts" sign. It is also assumed from the statement made by the air traffic controller that the flight on the outbound track until commencement of the procedure turn lasted seven minutes (from 1431 to 1438 hours as confirmed by the direction-finding log) and therefore exceeded by four and a half minutes the duration prescribed by JAT for the IFR procedure. Nor did the aircraft maintain the altitudes prescribed in the airline's landing procedure for unfavourable weather conditions since it did not hold the 3 500 foot (1 060 metre) altitude prescribed for the outbound track and the procedure turn but descended to 1 280 feet (190 metres - height of the point where the accident occurred) and was therefore considerably below the prescribed altitude of 1 800 feet even before reaching beacon WO.

The statements made by the co-pilot and that made by one of the passengers indicate that the pilot must have assumed, shortly before the crash, that he was on final approach since he had lowered the landing gear and extended the flaps. From the statements of the co-pilot and the testimony of two witnesses it must also be concluded that the engines were throttled down for final approach shortly before the crash.

Probable Cause

The accident was caused by the fact that the aircraft flew for a longer period on the outbound track and descended below the prescribed minimum altitude laid down at the time by the airline for operations into Schwechat aerodrome.

Recommendation

It is recommended that any airline which prescribes particular landing procedures or meteorological minima for operation of its aircraft into a given aerodrome should communicate these procedures and minima to the air traffic control authorities of that aerodrome to permit the latter to supervise approaches made by such aircraft and to enable them to intervene with a warning in case of emergency.

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ICAO Ref: AR/413

No. 46

Beech Bonanza, C-35, crashed into an apartment building in North Hollywood, California, on 17 October 1955. Civil Aeronautics Board (USA) Accident Investigation Report No. SA-313, File No. 2-0050, released 9 March 1956.

Circumstances

The pilot filed a Defence Visual Flight Rules flight plan from the Lockheed Air Terminal, Burbank, California to McCarran Field, Las Vegas, Nevada. He estimated his departure time as 2115 hours Pacific Standard Time and indicated that the aircraft had sufficient fuel for four hours of flight. At 2159 the pilot requested taxi and take-off instructions, was cleared to Runway 15 (150 degrees magnetic), and was given the latest wind and altimeter information. He was asked whether he was IFR (Instrument Flight Rules) or just a climb to on top and replied that he wanted a clearance to climb westbound to on top. At 2208 the flight was cleared as follows: "Bonanza 25C taxi into position and hold. Your climb out after take-off, make right turn, climb on magnetic heading of 260 degrees to on top, report on top." The take-off appeared normal to the tower personnel and it was noted that the navigation and two anticollision lights (Grimes lights) on the aircraft were on throughout this time. The aircraft was last seen from the tower turning right and climbing toward the overcast. There were no other radio contacts with the flight. Shortly thereafter calls were received by the Burbank controllers from residents south and southwest of the airport reporting an aircraft in that area flying very low and appearing to be in trouble or stunting. At 2214 the aircraft crashed into an apartment building 4.3 miles southwest of the airport, fatally injuring the pilot and eight residents of the building. One other resident was seriously injured, the building received major damage and the aircraft was destroyed by impact and the fire which followed.

Investigation and Evidence

The weather at the time of the accident was as follows: ceiling 700 feet overcast; visibility 2 miles, smoke and haze; top of the overcast reported variable 2 500 to 3 000 feet mean sea level or 1 800 to 2 300 above the ground. The pilot had been advised of these conditions.

From the information provided by witnesses the probable flight path of the aircraft was reconstructed and is shown at Figure 25.

Witness No. 1, an aircraft mechanic, saw N 25C immediately after take-off as it turned right to a 260 degree heading and climbed into the overcast. Shortly thereafter he heard the engine sound get louder and in a manner which gave him the impression that the aircraft was turning left and descending rapidly. The Bonanza was then seen to emerge from the overcast at very high speed, diving steeply and turning left. The nose of the aircraft jerked up sharply while the turn continued through north to a west heading, completing one 360 degree turn from the first observed direction. The aircraft again disappeared into the overcast, climbing steeply. This witness stated positively that the anticollision lights were on while he could see the aircraft.

The second witness, a pilot, was located west of the first. He stated that N 25C was observed to pass closely over his position three times while it flew a circular path, approximately one-half mile in diameter. During this time he observed the aircraft climb into and dive out of the overcast several times. He stated these erratic movements seemed to indicate the pilot was having difficulty with lateral and longitudinal control. He thought the engine sound increased and decreased with vertical oscillations of the aircraft. The engine sounded as though it were operating with an appreciably high power setting and with its propeller in fairly low pitch. The engine sound, however, was uninterrupted and did not indicate any malfunction. He observed that the navigation lights were on but said the anticollision lights were off. No witnesses after the first observed the latter lights to be on. When the aircraft passed the witness the third time it assumed a westerly heading and again climbed into the overcast.

Next to see the aircraft were several witnesses located more than one mile southwest of the first two, and slightly less than one mile north-northeast of the accident site. One of these witnesses, with dive bomber experience, said the sound was unmistakably that of an aircraft diving and pulling up. In this area the Bonanza again flew at least one complete 360-degree circular path.

Witnesses in the immediate accident area who saw the crash stated that just prior to the accident the aircraft dived out of the overcast at an estimated 65-75-degree angle on a southeast heading but turning rapidly to its right. It pulled up sharply when it reached a southwest heading at which time several large components separated from the main aircraft structure. Rolling violently to the right the major structure plunged into the apartment roof. An explosion and intense fuel fire followed.

The aircraft structure available for examination was greatly limited. Major portions of the right wing, right flap and aileron together with the empennage were found at varying distances up to several hundred yards northeast of the main wreckage site. This was confirmation that the aircraft had sustained an inflight failure of its basic structure.

The primary failure of the right wing occurred just outboard of the wing-to-centre section attachment in upward or positive bending as a result of loads in excess of the strength of the structure. Chord-wise compression buckles were evident on the upper wing surface outboard of the primary fractures. In addition, numerous diagonal wrinkles were found on both the upper and lower surfaces of this wing. The type and direction indicated they were produced by a high nose-down torsional load on the wing box structure.

The right aileron and a major portion of the right flap separated in flight. Evidence clearly showed they were torn from the wing by forces in excess of their strength. The twin inboard flap hinge ribs had been torn from the flap but remained in place in the wing. These were found jammed in the flap's retracted position. This flap position was further verified by comparing the flap drive screw extension of N 25C with that of another Bonanza with flaps retracted. The right aileron failed and separated in three sections. Evidence showed that before separation the aileron had been positioned well past its normal down travel.

The left and right tail sections showed no evidence of fire or that they had been struck by any other component of the aircraft. The primary inflight failures of both occurred at the spar-to-fuselage attachment. Both failures were similar except the right section failed upward under positive loads while the left failed downward under negative force. These failures indicated violent right rotation of the aircraft along its longitudinal axis following the right wing separation.

Evidence showed that the landing gear was retracted at the time of the accident.

Numerous metal samples from the available structure were examined by metallurgists under laboratory conditions. Results disclosed that the material was within the specification limits and there was no evidence of fatigue failure.

Since an inflight structural failure of the airframe had occurred in this accident a review of the design data was made by Board investigators. This review showed that the structural design met and in many instances exceeded the minimum strength requirements of Part 3 of the Civil Air Regulations. It also showed the adequacy of the design was thoroughly verified by extensive laboratory testing. Because the wing failure of N 25C appeared to have resulted from a rolling pullout type of loading, the Board requested the airframe manufacturer to provide data of the airframe strength for this manoeuvre. The manufacturer's report, submitted as an exhibit at the public hearing, indicates that the wing design incorporated strength for an ultimate load factor of from 5.25 to 5.80 g's, as compared with required minimum strength of 4.4 g's.

There was no evidence found to indicate malfunction or failure of the aircraft structure or controls prior to the load-induced failure.

At the time of the accident the Civil Aeronautics Administration was in the process of filing a violation report against the pilot for flying without an instrument rating under conditions and circumstances requiring one.* The first incident on which the violation was based occurred on 10 October 1955 when the pilot was flying N 25C from Fullerton Airport, Fullerton, California, to the Orange County Airport, California. During the flight he climbed without a clearance through the overcast and upon reaching the Long Beach area, and still flying above the overcast, decided to land at the Long Beach Airport. He was given an instrument procedure clearance to descend, however, then exhibited extreme difficulty in understanding it. The Long Beach controller explained the procedure to him in exacting detail but he still showed extreme difficulty in carrying it out. Because of this, traffic in the area was delayed 45 minutes.

While the 10 October incident was under further investigation a second series of complaints against the pilot was submitted to the CAA. It was learned that on 7 and 8 October he took off from the Fullerton Airport without clearance when the visibility was one mile or less and climbed through an overcast to above the clouds. This information was obtained while Fullerton officials were investigating the source of several extremely low flights (buzzing) over the city by an aircraft without lights. Investigation revealed that these incidents occurred when only this pilot had taken off from the airport. An official of the airport testified that the pilot had previously been reprimanded for unreasonably fast taxiing and as a result of the "buzzing" had been requested to base his aircraft elsewhere. It was while moving his aircraft to Orange County that the 10 October incident took place.

On 11 October the pilot voluntarily came to the CAA offices at Long Beach and readily admitted the incidents. At this time he stated that he held no instrument rating but showed he was familiar with the regulations applicable to the aforementioned flights. He was advised at this time to terminate such instrument flights until he demonstrated capability and was certificated for them.

The pilot had purchased N 25C on 10 June 1955. The aircraft was fully equipped at this time with instrumentation and appliances for instrument flight and night flying. It had been completely inspected at the time of sale and was considered to be in near perfect condition.

When purchasing N 25C the pilot was given a demonstration flight and was advised to take instruction before operating the aircraft. He flew with an instructor for about two hours and during this time insisted that the instruction be confined to take-off and landing practice. After the flight the instructor told the pilot that he was not considered checked out; however, the pilot stated that he could fly the aircraft and took no further instruction. The instructor testified during the public hearing that the pilot's flying was "very rusty" and showed little evidence that he had actually accumulated 3 000 hours or that 800 hours were instrument which he had claimed.

Other witnesses stated that the pilot was familiar with the aircraft instrumentation, knew how to use it and that he seemed careful and conservative while flying. One witness said that she had been with him when he climbed through the overcast on several occasions and he did not use the aircraft's auto-pilot. He was in the habit of climbing and descending while controlling the aircraft manually. She added,

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* "60.12 Careless or reckless operation. No person shall operate an aircraft in a careless or reckless manner so as to endanger the life or property of others."

"60.31 Visibility

b) Flight visibility within control zones. When the flight visibility is less than 3 miles, no person shall operate an aircraft in flight within a control zone, unless an air traffic clearance is obtained from air traffic control;

c) Flight visibility within control areas. When the flight visibility is less than 3 miles, no person shall operate an aircraft within a control area;

NOTE: When the flight visibility is less than 3 miles, operations within control areas are to be conducted in accordance with instrument flight rules. Flight below 700 feet above the surface is not within a control area."

"43.65 Instrument flight limitations. A pilot shall not pilot aircraft under instrument flight rules, unless he holds a valid instrument rating issued by the Administrator."

however, that he did use the auto-pilot during en route flight and was fully acquainted with its use and operation.

During the investigation it was learned that a 52-gallon nonstandard auxiliary fuel tank was installed in the aircraft baggage compartment. The modification work and necessary weight and balance computation were complete and the data was submitted to the CAA for approval. The ACA-337 (Major Repair and Alteration Report) form accompanying this data was dated 6 October 1955. Final approval for this installation had not been given and the aircraft should not have been operated pending such approval. The pilot, however, continued to fly it contrary to Civil Air Regulations governing such alteration.

The day of the accident the pilot departed Lockheed Air Terminal at 0444 hours intending to fly to Las Vegas. At 0452 he returned to the airport, landed, and then called the CAA communicator and canceled his flight plan commenting that he returned because the navigation lights, Grimes lights and radio had failed in flight. He further stated that the Grimes lights had been installed on 15 October and he suspected an electrical problem from the installation which incorporated the lights that failed in a common circuit.

During the day the pilot told Pacific Airmotive Corporation employees that he was dissatisfied with the installation and wanted the Grimes lights repositioned farther forward on his aircraft. He insisted that one be mounted above and just behind the pilot seat on the top of the fuselage. The other was installed on the bottom of the aircraft slightly farther rearward than the top light. With the one on top mounted upward and the other inverted the resultant rotating flashes moved in opposite directions. Both lights were controlled by separate switches and could be turned off or on independently of each other and any other lights on the aircraft. The lights were functionally tested and operated normally. Employees of the repair agency stated that because the aircraft logs were not in the aircraft a new computation of the aircraft centre of gravity was not made nor was a Major Repair and Alteration Report, form 337, completed. Also, no electrical analysis was made following the light installation and no flight test was performed to determine how the lights functioned in flight or if any reflection or glare resulted during their operation. While the relocation work was performed it was determined that the prior failure of the navigation and Grimes lights had occurred because an inadequate circuit breaker was installed during the original installation on that circuit. The radio trouble was repaired by replacing a burned-out tube.

During the accident investigation flight tests were conducted to determine what, if any, effect the Grimes rotating lights had on a pilot while flying in the overcast. These tests were considered especially important because the pilot apparently lost control of his aircraft while flying in the overcast. Using a Beech Bonanza, with nearly identically mounted lights, the tests were flown by a qualified instrument pilot and observed by a Board investigator. The suspicions of the accident investigators were borne out during these tests and it was learned that an immediate and seriously distracting effect was caused by the lights. It was learned that the opposite rotation and brilliance of the forward mounted lights caused the clouds to appear to move in, out, up, and down when the flashes struck the aircraft wings and propeller, reflecting into and around the cockpit. The pilot was immediately confronted with serious vertigo* which required the highest degree of skill and concentration to maintain instrument control of the aircraft while being affected by the distracting conditions. From the tests it was concluded that lights installed and operating in this manner could cause distraction and vertigo of a disastrous effect on pilots with limited experience.**

Many persons said that the pilot appeared tired throughout the day and evening before the flight which resulted in the accident.

Officials from the CAA Office in the region where the accident occurred testified during the public hearing and expressed dissatisfaction with the Civil Air Regulations governing flights within a control zone. They pointed out there was no clear delineation in the rules that distinguished IFR and VFR flight conditions. They stated there is misunderstanding regarding the nature of a traffic clearance wherein some pilots believe that a clearance to "take off from" or "enter" a control zone automatically releases the pilot from adherence to pertinent regulations

* See Flight Safety Foundation Bulletin re Flicker Vertigo in Part III of this Digest.

** As a result of the Board's investigation of this accident the Aircraft Owners and Pilots Association and the Beech Aircraft Corporation issued bulletins to pilots describing the effects of flicker vertigo from using these lights in an overcast. Beech advises "turn off your rotary beacons before entering an overcast."

relating to pilot qualification or certification. Many pilots further believed such clearance on a VFR flight plan also permitted a climb through an overcast or other flight when control of the aircraft was possible only by reference to flight instruments. The witnesses emphasized that among highly qualified aviation personnel the intent of the existing regulations to prohibit such abuse was understandable; however, for enforcement purposes, a responsibility of the CAA, the rules were ambiguous and lacked sufficient specificity to provide that intent with adequate enforceability.*

Following the accident, in the interest of corrective action, greater supervision, and safety, CAA operations personnel of the region require a pilot filing a flight plan to indicate whether or not he holds an instrument rating. This information will be furnished the tower controllers interested in the flight and if conditions of weather are less than 1 000 feet ceiling and/or less than one mile visibility the pilot on a VFR clearance will be advised to postpone the flight or file the flight plan according to instrument rules. Further, aircraft arriving in the control zone under a VFR flight plan in the stated conditions will be reported to enforcement officials for investigation.

As indicated the aircraft was observed to take off in a normal manner and to begin a right climbing turn in apparent conformity to the departure clearance. Thereafter it established the climb out heading and disappeared from view in the overcast. Several qualified witnesses stated that during this time the engine seemed to be operating normally and the aircraft was fully lighted, including the rotating beacons. Shortly thereafter, however, the engine and propeller sound increased in a manner which indicated to the observer that the Bonanza was turning left and descending rapidly. This was confirmed when N 25C suddenly emerged below the overcast in a tight left spiral. This series of events and the manner in which they occurred strongly indicate that the pilot lost control of the aircraft and a characteristic descending spiral resulted. It is also believed that the loss of control probably was induced by vertigo and the pilot followed his sensory indications in controlling the aircraft's attitude rather than indications from the appropriate flight instruments. This opinion is supported by the general problems of instrument flight and by other accidents or near accidents which occurred in the same manner for this reason. It is believed that following the initial spiral the pilot was unable to recover full control of the aircraft and continued to reenter and dive out of the overcast. He was apparently flying alternately under visual conditions, immediately thereafter confronted by instrument conditions, and was never able to regain complete control of the aircraft. During this time he flew several circular patterns, obviously influenced by desperation and panic and possibly attempting to return to the airport or avoid high terrain on all sides except the west. It appears that he then tried to climb through the overcast again but before reaching the clear area above it entered another steep descending spiral. An abrupt turning pull-up from this spiral caused structural failure.

The investigation established that the design limitations of N 25C had been exceeded in the abrupt pull-up following the final dive, and that no mitigating structural design deficiencies were involved in the failures. While the excessive loads were undoubtedly imposed inadvertently or as a final desperate move to arrest the dive, this fact cannot be considered as a reflection on the aircraft design. While such factors as cleanness of design, comparatively light stick forces, turbulent air, etc., undoubtedly do contribute to the ease with which control is lost there is no substitute for proper instrument training and proficiency for a safe and sound operation of aircraft in overcast weather conditions.

The Board is of the opinion that the initial vertigo was the result of several adverse factors personal in nature to the pilot and circumstantial to the situation.

The first of these factors is believed to have been his general disregard and disrespect for safe instrument flying practices and procedures. It appears that the pilot was quite willing to climb through the overcast without clearance, proper certification, or regard for other possible traffic. Although violation charges were filed against him and he was recently reprimanded for

* As a result of the extent of the misunderstanding that seems to exist among pilots and the position the CAA has taken with respect to the enforceability of the regulations, the Board has initiated action looking toward the amendment of Sections 60.30, 60.31, and 43.65.

Such amendments would be designed to state specifically those minimum weather conditions below which VFR flight could not be conducted within a control zone even though a traffic clearance were obtained.

these practices he again without the required certification knowingly attempted to conduct another flight through the overcast. The fact that the pilot did not hold an instrument rating does not necessarily mean that he was incapable of instrument flight; however, the Board feels that it may indicate he was unsure of his ability and proficiency to the extent that he was unwilling to attempt to qualify for the rating.

The second factor is considered circumstantial and is believed to have been partially responsible for the apparent vertigo. This factor was the effect produced by the forward-mounted rotating beacons. During flight tests the opposite rotating flashes and the attendant reflection were capable of inducing serious and immediate vertigo on a qualified instrument pilot. The Board is therefore of the opinion that it probably affected the pilot in a like manner. Considering his fatigued condition it is believed he was even more susceptible to vertigo, and it is believed the fatigue would also delay corrective action during the initial loss of control and thereafter while attempting to regain it.

The Board feels that there was little justification for the repair agency having installed an inadequate circuit breaker in the initial installation or for having undertaken the installation or relocation of the lights without determining that the pilot had the necessary aircraft records for them to complete the work and properly return the aircraft to service. Although maintenance personnel were reluctant to relocate the lights because of the suspected glare and reflection the work was done despite this concern. Lacking the necessary completion of the ACA-337 form the aircraft was being flown with an unapproved installation. Further, because of the added electrical load of the rotating beacons and the existing electrical loads of the aircraft equipment, good practice would have necessitated an electrical analysis. Considering all factors, the pilot was operating the aircraft contrary to Civil Air Regutions pertaining to such installations.

The Board has considered the possible use of the auto-pilot during the departure and the possibility of it failing as a factor in the accident. However, complete destruction of the components necessary to determine this possibility precluded the Board's ability to make such a determination. Considering the testimony as to the habit of the pilot to control his aircraft manually during climb out there is no reason to believe he did not do it this way on the subject flight. Also considering that the attitude and directional gyros were vacuum driven the aircraft could have been manually operated if the auto-pilot was not working provided there was adequate cockpit lighting to see the instruments. The continued operation of the navigation lights throughout the flight indicates that there was available electrical power for cockpit lighting.

Probable Cause

The probable cause of this accident was the pilot's loss of control during which the design strength of the aircraft was exceeded causing structural failure. Vertigo, and the pilot's inability to take corrective action, were contributing factors.

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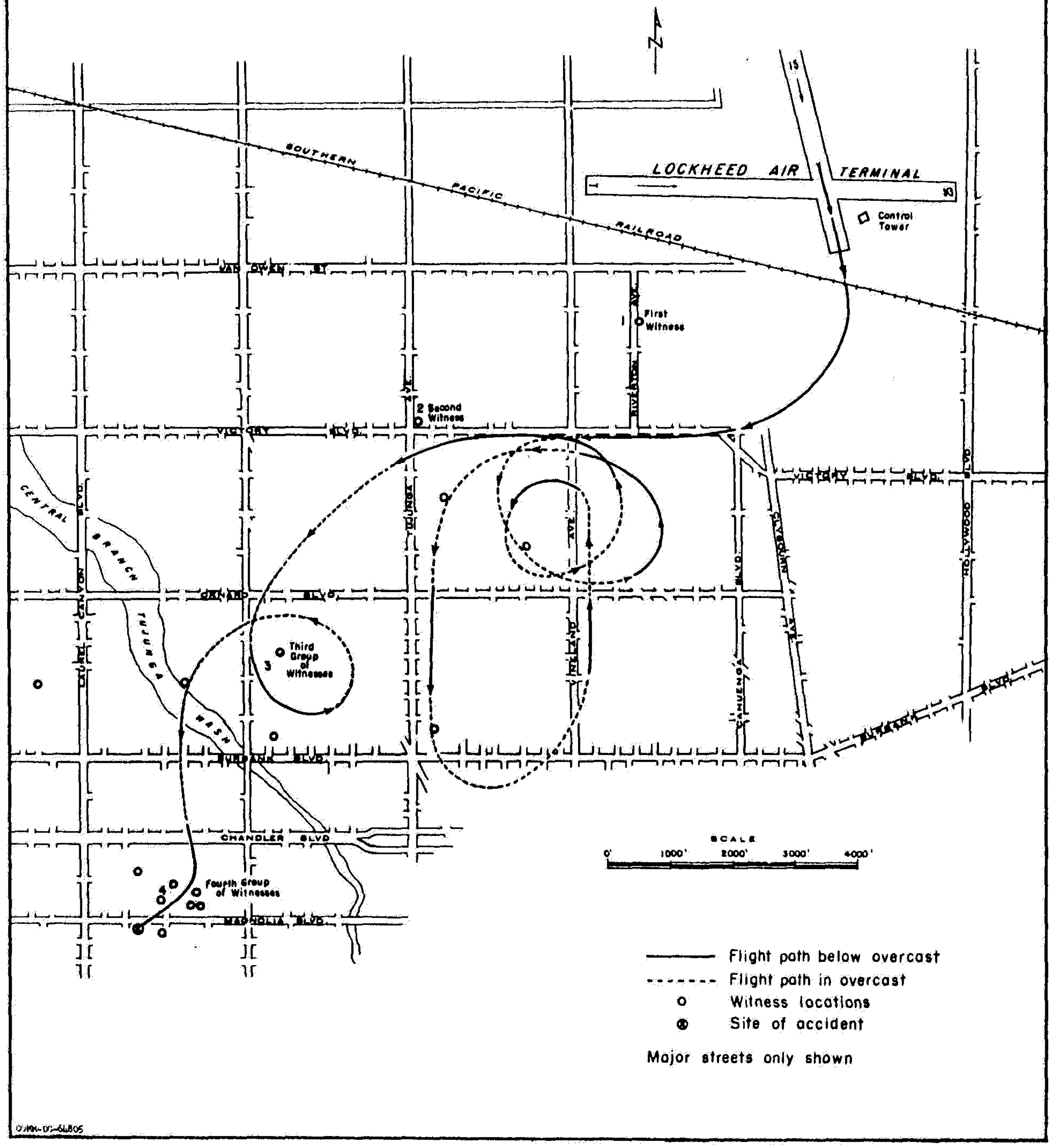
ICAO Ref: AR/419

Figure 25

PROBABLE FLIGHT PATH OF BEECH BONANZA N-5825C NORTH HOLLYWOOD, CALIFORNIA

OCTOBER 17, 1955



No. 47

United Air Lines, Inc., Douglas DC-6B, exploded in mid-air near Longmont, Colorado, on 1 November 1955. Civil Aeronautics Board (USA) Accident Investigation Report, File No. 1-0143 released 14 May 1956.

Circumstances

The flight departed La Guardia Field, New York, for Seattle, Washington, with scheduled stops at Chicago, Illinois; Denver, Colorado; and Portland, Oregon. On board were 39 passengers and a crew of 5. At Denver the rear cargo pit (No. 4) was emptied and reloaded with mail, freight and passenger luggage originating at Denver. The aircraft then received a routine ramp check, taxied to Runway 8R and was cleared for the flight to Portland. The clearance, in part, included compulsory radio reports from the flight upon passing the Denver Omni and when climbing through 18 000 feet to its assigned altitude, 21 000 feet. Following take-off the flight reported its "off time" to the company as 1852 hours Mountain Standard Time and reported passing the Denver Omni at 1856. This was the last communication from the flight. At approximately 1903 hours a mid-air explosion of disintegrating force occurred aboard the aircraft and it crashed killing all 44 occupants.

Investigation and Evidence

The weather conditions for Denver were as follows:-

> Ceiling measured 9 500 feet, overcast; visibility 10 miles; temperature 36; dewpoint 30; wind southwest 5 knots; altimeter 29.84.

They indicated the flight, as planned, would be in accordance with instrument flight rules (IFR).

The wreckage of the aircraft was spread along a north-northwest heading and covered an area of approximately six square miles. Within this area all the major components of the aircraft were found. The tail group was located about 4 600 feet south-southeast of two deep craters which contained large portions of both wings, the four powerplants, and main landing gear. The forward fuselage was roughly 600 feet north of the craters and the left outer wing panel was found approximately 600 feet south of the craters. This scatter of the heaviest and largest pieces of wreckage showed that the aircraft disintegration began in flight at an appreciable altitude and that the separation of the tail assembly occurred before separations of the wings and forward fuselage.

The aft fuselage was found to have been torn into a multitude of bits and pieces. Portions of the structure were strewn over the ground in a wide path extending south-southeast approximately four miles from the main wing wreckage, the less dense fragments being at the farther distances. Pieces of very low density material, such as paper and cabin insulation, were found as far as nine miles south-southeast. Many pieces of the aft fuselage comparable in density to the tail group were found in the area adjacent thereto. This dispersal indicates that the aft fuselage was shattered simultaneously with the separation of the tail assembly and that winds aloft carried the less dense pieces considerable distance during their fall to the ground. The severity of fragmentation indicates extremely violent shattering of this section of the aircraft.

The forward fuselage from the nose rearward to a position approximately in line with the wing spar came to rest where it struck the ground. Although severely flattened by impact, the various pieces remained in their normal horizontal relationship to one another. The complete lower part of this structure was in position at the bottom of the wreckage. The fuselage nose cap bore no signs of impact; however, a small box of electric motor equipment carried as cargo and weighing 164 pounds, was imbedded in the ground directly below a hole it made upon impact through the forward cargo compartment floor. The importance of these observations was that they showed the forward fuselage assembly struck the ground with great force in an upright attitude while descending almost vertically.

As previously stated major portions of the wings and centre section were located in two craters, one of which was about 150 feet north of the other. In the south pit, which was about 20 feet wide, 25 feet long, and 6 feet deep, were located the Nos. 1 and 2 powerplants as well as a portion of the left wing. The north crater, somewhat longer and deeper than the other, contained the Nos. 3 and 4 engines and portions of the right wing. The depth of the craters again indicated the nearly vertical descent of the components that made them. The distance between craters showed that both wings separated from the fuselage prior to impact.

In addition to severe breakup of the structure, extensive fire damage occurred. This was due to ignition of the fuel and oil which saturated the ground in and around the craters. Despite efforts to extinguish the fires, burning continued for three days. The fire pattern in all cases clearly established that the fires occurred following impact.

At an early phase of the investigation the investigators became aware that an explosion had occurred aboard this flight while at an altitude of several thousand feet above the ground. It was also clear that the explosion was of such great intensity that it would be unusual for it to have been caused by any system or component of the aircraft. This awareness was strengthened by smudge marks and odor characteristic of an explosive that persisted on pieces of the fragmentized wreckage known to have been part of the fuselage structure in the area of the No. 4 baggage compartment.

Because of the possibility of adverse weather conditions and in order to reconstruct the fuselage, the hundreds of pieces of wreckage were transported to a warehouse where CAB investigators worked to rebuild the aft fuselage structure in a mockup fashion by refitting each fragment into its original position of construction. The mockup showed that the pieces were progressively smaller from all directions toward a point in the No. 4 baggage compartment. Many pieces were mere fragments or were entirely missing in that area. This reconstruction and examination showed very conclusively that the aft fuselage disintegrated from extremely violent forces which originated in a very concentrated area within the baggage compartment below the aft buffet and just slightly left of the centreline of the aircraft. The forces were shown to have acted in all directions from this point. These blew the cabin floor upward, the fuselage bottom shell outward, the aft bulkhead of the baggage compartment rearward, and its forward bulkhead forward. There is nothing in the structure of this part of the aircraft that could be the source of such an explosion.

No evidence was found of fatigue cracking, structural failure, or malfunctioning controls prior to the explosion.

The four engines and propeller hubs were found buried 6 to 10 feet in the two previously mentioned craters. All propeller blades were also recovered from these pits or from the immediate areas. The locations of these parts indicate that they remained attached to the two main pieces of the wing until ground impact. Examination of these badly damaged components disclosed no evidence which would indicate that any mechanical or operational difficulty was experienced with them prior to the start of disintegration of the aircraft.

Numerous pieces of the aircraft and its contents, bearing the sootlike smudges, were subsequently examined in the FBI laboratory to determine, if possible, what type of explosive material caused the destruction of the aircraft. The chemical analysis revealed that the residues were those to be expected from the explosion of dynamite which contained sodium nitrate. The analysis further disclosed that the residues on many of the parts contained manganese dioxide, a major component of the mixture contained in dry cell batteries. Eleven pieces of material which could have originated from an Eveready "Hot Shot" battery were found. These items are two of the basic components of one type of a bomb.

Descriptions of the explosion given by witnesses fully agreed with the physical evidence. Several, who saw the aircraft before the explosion, stated it appeared to be climbing at an estimated altitude of 5 000 feet and the engines sounded normal. This, they added, was suddenly interrupted by a brilliant flash and followed by a deafening explosion. The aircraft, in many parts, plunged to the ground where another explosion occurred. Flight tests showed that the altitude, course, and position of the flight when the explosion took place were normal for a routine operation.

The evidence, and the analysis of the evidence in this case, pointed to the possibility of an explosion. In the first hours following the accident Board investigators had uncovered definite clues indicating that an explosive force, probably from within the aircraft but alien to it, had torn the aircraft apart in flight. Subsequently, by meticulously piecing together hundreds of pieces of the torn and shattered fuselage on a chicken wire covered wooden frame mockup of the original DC-6B fuselage, Board investigators specifically determined that a dynamite-type explosion had occurred within the No. 4 baggage compartment of the airplane. Consequently, on 7 November, six days after the accident, the Board notified the Denver office of the Federal Bureau of Investigation of its findings so that the apparent criminal aspects involved could be pursued immediately, a police function that is outside the Board's jurisdiction. Therefore, on the following day, 8 November, the FBI notified the Board's investigators that it would proceed with responsibility for the criminal portion of the investigation.

As evidenced by the scatter of the aircraft wreckage and the practically vertical descent of the individual pieces, it is obvious that the aircraft disintegrated at an appreciable altitude. The relative locations of the pieces proved that the first occurrence in the sequence of disintegration was an extremely violent shattering of the aft fuselage with separation of the tail group. Without the tail the remaining aircraft structure probably pitched nose down and fell with uncontrolled gyrations during which the wing and forward fuselage separations occurred.

The reconstruction and examination of the aft fuselage proved that the forces which caused the initial disintegration radiated from a point within the number 4 cargo pit. The very pronounced intensification in severity of fragmentation from all directions toward this point proved that the disintegration of the aft fuselage was caused by an extremely violent explosion emanating from a very localized origin. The violence was clearly shown by fragments which had been projected through the cargo compartment walls and ceiling as well as by tearing, denting, and curling of adjacent structure. This evidence is in sharp contrast to the damage of an explosion resulting from the ignition of any combustibles carried on and used during aircraft operation. Laboratory analysis confirmed this and determined the explosive material was dynamite.

On 14 November 1955 agents of the Federal Bureau of Investigation took into custody the son of one of the passengers. Thereafter, he was indicted for acts leading to the destruction of the aircraft by means of a bomb explosion.

Probable Cause

The probable cause of this accident was the disintegrating force of a dynamite bomb explosion which occurred in the number 4 baggage compartment.

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ICAO Ref: AR/425

No. 48

Peninsular Air Transport, Douglas C-54-DC crashed at Seattle, Washington, following take-off, 17 November 1955. Civil Aeronautics Board (USA) Accident Investigation Report SA-314, File No. 1-0145 released 3 May 1956.

Circumstances

The flight took off at 2358 hours Pacific Standard Time from Boeing Field, Seattle, for Newark, New Jersey, carrying 78 persons, including a crew of three and a third pilot, deadheading to Miami, Florida. The crew had received an Instrument Flight Rules clearance which instructed them, in part, to turn right after take-off and climb on the northwest course of the Seattle Range to 5 000 feet mean sea level. The take-off appeared normal as the landing gear retracted and a right turn was begun. When 300 - 400 feet above the ground the first reduction of power was made and 5 of the 15 degrees of flaps extended were retracted. At this time the No. 4 propeller surged and engine r.p.m. increased to about 2 800. Unable to reduce the r.p.m. of No. 4 by reducing its power an attempt was made to feather the propeller; this also was unsuccessful. The aircraft then began to descend and take-off power was reapplied to Nos. 1, 2 and 3 engines and the power from No. 4 was further reduced. This action did not reduce the r.p.m. of No. 4 which surged again and increased to more than 3 000. The aircraft veered to the right and continued to descend. The captain realizing that a crash-landing was imminent reduced the airspeed until the aircraft was nearly stalled and applied full power to all four engines. The aircraft continued to settle, struck a telephone pole, and several trees before crash-landing in a nose-high attitude. Twenty eight persons were fatally injured, the major portion of the aircraft was destroyed by impact and fire, and the accident caused substantial property damage.

Investigation and Evidence

The aircraft crashed 2 1/2 miles from and 300 feet higher than the take-off position of the flight. Examination of remaining portions of the wings, fuselage and tail disclosed no evidence of structural failure or malfunction prior to impact. No difficulty had been experienced except for that associated with the No. 4 engine and propeller.

Teardown inspections of Nos. 1, 2, and 3 engines and propellers disclosed no evidence to indicate they were factors in the accident.

The No. 4 propeller, attached to the engine nose section, was located about 25 feet from the main wreckage. There was oil covering its barrel, the face side of all propeller blades, and the engine nose section. Examination disclosed that the propeller dome retaining nut protruded approximately one-eighth of an inch above the barrel dome bore and the safety cap screw was pressed against the corner of its safetying recess. The lock screw was safetied. The screw was removed and its examination showed no evidence of bending or mutilation. After the nut and barrel were marked to show their original positions a check was made for tightness. The result showed the nut could be moved with comparative ease with a small drift and hammer for at least 4 1/2 inches in the tightening direction. The nut was then unscrewed and the dome removed to check the propeller blade pitch settings as indicated by the cam gear position. This revealed the cam gear lug was against the low pitch stop, or the normal low pitch blade angle setting. The blade segment gears were marked to show their positions in relationship to each other and to the cam gear. The propeller assembly was then further disassembled and examined after which it was removed from the accident scene for continued examination and testing.

Examination was directed to ascertain the individual blade angle settings. This disclosed that all of the eight spring packs which retain the segment gears, with their respective blades, were mutilated and displaced such that this retention was destroyed. Each of the segment gears was fractured at one of the spring pack recesses. This permitted free rotation of the blades about their longitudinal axis; however, the cam gear prevented any movement of the segment gears, enabling the investigators to determine the individual blade position at impact. Examination showed that the fifth valley from the low pitch end of the segment gears was lined up with the center etched line on the barrel bore for the Nos. 1 and 2 blades. The No. 3 blade segment gear, however, had the sixth valley lined up with the etched mark. This showed that the Nos. 1 and 2 blades were positioned one segment gear toothless, or eight degrees less, than the No. 3 blade. Compared to the low pitch stop the No. 3 blade was positioned at 24 degrees, the normal position, while Nos. 1 and 2 blades were at 16 degrees, eight degrees less than the normal position.

To determine the possibility of oil leakage and, if existent, the amount of leakage from the loose dome assembly, the propeller was reassembled using replacement parts only where necessary; the dome and barrel assembly from the original propeller were used. The exact dome looseness was duplicated on a propeller test stand and oil was pumped into the propeller assembly at various pressures. The tests revealed that there was oil leakage at all pressures and that the maximum oil pressure obtainable was 200 p.s.i. (pounds per square inch), because of an 18-quarts per minute oil leakage past the loose dome. At this time the pump was operating under test conditions which would normally produce about 600 p.s.i. The test further showed the oil supply of the engine would rapidly be exhausted. (Oil capacity per engine is 20 gallons.)

The No. 4 engine was examined in detail. This revealed that the rear master rod bearing was in the process of failure. It also showed the front master rod bearing was beginning to fail. Examination of the bearing failures showed they were characteristic of those associated with oil starvation. Neither, however, had progressed to the extent that it would be expected to appreciably affect the operation of the engine or its power capability. The engine examination disclosed no other evidence of malfunction or failure.

According to company witnesses and records, the No. 4 propeller had been overhauled on 7 September 1955 and thereafter installed on another company DC-4. On 11 November 1955 it was removed as a result of a pilot roughness complaint applying to it or the No. 4 engine. The propeller was examined, repaired, and tested, after which it was installed by Peninsular maintenance personnel on the subject aircraft in the No. 4 position. Maintenance personnel stated a new propeller dome seal was used during this installation. At the time of the accident the propeller had accumulated 475 hours since the major overhaul and 20 hours since this last installation.

During a portion of the 20 hours the aircraft was flown to Kansas City and to McChord Air Force Base, Tacoma. This flight was uneventful except for a failure of the No. 4 starter solenoid at Billings, Montana. There were no adequate repair facilities at Billings so the aircraft (after an airstart on No. 4 engine) was flown to McChord Air Force Base on 13 November and ferried to Boeing Field where the captain contacted Seattle Aircraft Repair Inc., and requested them to replace the No. 4 starter solenoid and to correct other discrepancies noted and/or written up during the previous flight.

The captain instructed the repair agency to examine the No. 4 engine to be sure it was not damaged in any way by the airstart. The crew noted an accumulation of oil on the right wing in the area of the engines and brought it to the attention of maintenance personnel for corrective action. Without cleaning the oil from the aircraft and running the engines to determine the source of leaking oil, the employees concluded from visual inspection that the leak came from the Nos. 3 and 4 propeller dome seals.

During the public hearing the mechanics and helpers who worked on the aircraft, and particularly on the No. 4 propeller, were called to testify. In connection with the personnel working on the No. 4 propeller, the helper had recently been employed and the CAA certificated mechanic in charge had not replaced dome seals for three years. Neither employee was familiar with the experience and capability of the other or the prescribed procedure to be followed in correctly replacing the dome seals. These witnesses, through their testimony, showed there was no clear line of responsibility within the company nor were there reference manuals to define their specific work procedures.

Witnesses testified that the work on the No. 4 propeller was done under adverse weather conditions. It was accomplished outside in very cold weather and with considerable snow falling. The two employees who worked on the No. 4 propeller, said that an accumulation of oil was evident under the right wing and around the propeller dome. The Nos. 3 and 4 domes were removed and, according to testimony, the No. 4 seal was found gouged. New seals were then obtained from the company supply, warmed, and installed in the domes. The mechanic helper said he assisted in placing the No. 4 dome in position, turned the dome retaining nut on a few threads, and left the job to go home. The employee in charge of this work said that with the assistance of his helper he tightened the dome retaining nut with a dome wrench. He further stated that he was satisfied it was tight and that he had replaced and safetied the lock screw. Testimony of the witnesses clearly showed that during the work the propeller was not feathered, as required by good practice, and the positions of the blades were not checked either before the seal was installed or after the work was completed. An inspection of this work was made by an authorized employee but consisted only of a check to see if the lock screw was safetied. It was also learned that neither this engine nor any of the others was run up at any time to determine the adequacy of the maintenance.

While the maintenance work described was in process, a No. 1 inspection was ordered by Peninsular Air Transport officials from Miami. This was completed, according to numerous witnesses; however, the records were apparently destroyed, being aboard the aircraft when it crashed. Company instructions required that one copy of the inspection be mailed to the home office; however, the captain did not do this but instead put all the records in the flight log.

Testimony of the flight crew indicated that they arrived at the Boeing Airport about 1900 on 17 November. They stated that they went to the Seattle Aircraft Repair office and were unable to contact anyone who could inform them concerning the work performed on the aircraft, or the readiness of it for flight. They returned to the terminal thereafter and began preparation for the flight, contacting the weather office and completing other necessary details. Another trip to the repair agency office was made with the same results as the first, after which they again returned to the terminal and found the Vice-President of Seattle Aircraft Repair. According to the captain and the first officer he informed them that the aircraft was ready for flight and that all the maintenance work had been completed. The captain further stated he received the No. 1 inspection form, the daily flight check form, and the repair forms on the work he had ordered. Although not sure who had told him, the captain said he was told that the engines had been run up. He further stated that the forms given him indicated the engines had been run up and that the aircraft was signed off as airworthy. The crew testified that following this they went to Seattle Aircraft Repair to get their aircraft. They performed a walk-around inspection, noting that the evidence of oil had been cleaned from the No. 4 engine. They started all engines, running them at low r.p.m. for approximately 10-20 minutes until they were warm. The aircraft was then taxied to the terminal for loading.

The Vice-President of Seattle Aircraft Repair testified that the crew did not contact him until after the aircraft had been brought to the terminal. He stated the crew brought the aircraft there without knowledge of whether it was ready and without having the various work forms. The witness indicated that the engines were not run up during the nonroutine maintenance work on the propellers. He added that following the type work accomplished on the No. 4 propeller a runup would normally be required. Following the other work, the daily inspection and No. 1, the runup was not done because of the extremely heavy workload upon his organization. He added that the forms given the crew did not indicate the engines had been run and the subject was not mentioned during any conversation with the Peninsular crew. He said he signed the forms given the crew, indicating the aircraft was airworthy.

Weather conditions were substantially as reported by the Weather Bureau - ceiling 1 600 feet broken, 2 300 overcast, visibility 7 miles. The crew said that after the aircraft was cleaned of snow there was no precipitation and thus no chance of ice forming on the aircraft. The weather observer stated that in his observations during the period between 2300-2400 he carefully watched for signs of freezing rain but there were none. The captain said that visibility was good, that weather conditions did not affect the course of his action, and that at no time was the aircraft high enough to encounter the clouds.

The crew stated the pretake-off checks were comprehensive and were completed while waiting their turn to take-off and just after taking position on the runway. During the checks the engines were run up to approximately barometric pressure (30 inches of manifold pressure). Nos. 2 and 3 engines were run up together and then Nos. 1 and 4 together. The crew said no roughness was observed or felt. The co-pilot stated he used the ice light to observe Nos. 3 and 4; however, the captain did not recall it being used. The propellers were exercised at least four times before the response was normal for Nos. 3 and 4 propellers. The customary feathering checks were made.

The captain testified that he made the take-off from the left seat. As was his habit under the existing conditions, control of the aircraft was accomplished principally by reference to instruments. Both pilots agreed the take-off and climb were normal until the first power reduction, 300-400 feet above the ground, at an airspeed of approximately 120 knots, and with a rate of climb of between 500 and 1 000 feet per minute. The captain felt the aircraft yaw to the right when the No. 4 r.p.m. surged at the first reduction of power and again when the power on No. 4 was reduced. The rate of climb immediately decreased and as the engine and propeller began to overspeed an unsuccessful attempt to feather was made. Both pilots noted a reaction from the propeller and momentarily it appeared that the propeller was feathering. The co-pilot said he noted a reduction in r.p.m. to about 1 500-1 800 which the captain said he felt when the yaw was momentarily relieved. Take-off power was added to all but No. 4 engine. Immediately thereafter the r.p.m. of No. 4 increased to more than 3 000 which, after consideration, the co-pilot felt was nearer 3 500. This was accompanied by a loud propeller whine, heard by the crew and numerous persons on the ground. The co-pilot said he felt the feathering button which was still in, the position to actuate feathering. He pulled the button out, pushed it back in, in a second attempt to feather; there was no response. The captain stated that the aircraft was descending during this time, and he raised the nose of the aircraft in an attempt to hold altitude at a slower airspeed. He related that he did not use trim to alleviate the heavy yaw, stating he could hold directional control without trim and he was better able to feel his aircraft without it. He also stated that the No. 4 propeller drag felt insurmountable and it was impossible to gain or even hold altitude. The captain then concentrated on crashlanding the aircraft with as slow an airspeed as possible and in the least populated area. He therefore allowed the aircraft to turn away from a hill toward a flatter area. Both crew members said full power was applied to all engines and the aircraft hit tail first in a full power stall.

During the public hearing a qualified representative of the propeller manufacturer testified concerning the drag which would be expected from the improperly indexed propeller blades of the aircraft. The witness stated that according to engineering data under the following conditions, blades properly indexed at 24 degrees, sea level condition, airspeed 115-150 m.p.h., engine r.p.m. 1 586, propeller drag was 570 pounds. Under the same conditions except with the propeller blades indexed as found on the accident aircraft, two at 16 degrees and one at 24 degrees, the propeller drag was 1 360 pounds, or about 2.3 times greater.

Tests were made to determine what, if any, roughness existed as a result of the improperly indexed propeller blades of the No. 4 propeller. The blade configuration of the accident aircraft was intentionally duplicated on an outboard propeller of another DC-4. Running that engine only, it was noted that vibration could be felt in the cockpit with noticeable swaying of the magnetic compass unit mounted by shock cords. The vibration was apparent around 1 000- 1 200 r.p.m. and was visually noticeable by watching the engine shake on its mount. The vibration was evaluated as severe at the aforementioned r.p.m., becoming less apparent with increased r.p.m. In the experience of the testing group several instances of blade misindexing were known, nearly all of which were discovered during ground runup of the engines. At least one similar condition on a like aircraft went unnoticed during flight operation.

The Peninsular crew stated that after reaching the airport on 17 November and talking with the Vice-President of Seattle Aircraft Repair, Inc., they were assured the aircraft was ready for flight. They stated that the maintenance forms given them were reviewed and showed the work ordered had been done. Because of conflicting recollections it is not known when this occurred, before or after the aircraft was taxied to the terminal.

Testimony of the maintenance personnel showed clearly that at no time after the aircraft was received for maintenance on 14 November were the engines run up. The Board is of the firm opinion that such a runup was essential to a vital part of the work performed on the Nos. 3 and 4 propellers and a responsibility of the maintenance agency. This was important in order to determine if the dome seals had been properly installed and if there were any leaks. It was even more necessary because the maintenance personnel had concluded that the original leaking oil came from the propeller dome seals, without first cleaning the engines and thereafter running them to be sure. Had the engines been run up following the work and the propellers exercised, the loose dome condition of No. 4 would have been immediately evident by leaking oil around it.

As shown by numerous expert witnesses, including a representative of the propeller manufacturer, it was published procedure to change the dome seals with the propeller blades feathered. This was not done and such omission is not considered to be acceptable maintenance.

It is evident that had the correct procedures been followed during the dome seal change, improper positioning of the blades would not have occurred. It is further believed that a thorough engine runup would have revealed this error.

The Board therefore is of the opinion that good maintenance practices and procedures dictated an engine runup. It was the responsibility of Seattle Aircraft Repair, and only poor supervision, an over-extended workload, and poor maintenance procedures were responsible for the omission.

As the result of tests the Board is also of the opinion that considerable roughness would be caused by the improperly indexed No. 4 propeller blades, especially when the aircraft engines were warmed up before the aircraft was taxied to the terminal and while it was holding before take-off. Considering that all four engines were used during taxi and two engines were run up together prior to take-off, it is possible that the roughness would not be noticeable unless the crew carefully looked at the No. 4 engine with their Aldis lamp and/or ice light. Had this been carefully done it is believed the roughness could have been detected.

As indicated, when the crew made the first power reduction the No. 4 propeller did not respond. This was undoubtedly the result of insufficient oil supply to the propeller governor to actuate the propeller mechanism toward a higher blade angle. It is believed that sufficient feathering oil existed to start the process, but soon after the blades started to move the supply was exhausted. Exhaustion of feathering oil resulted in the blades returning to the low pitch setting with an attendant engine overspeeding. This sequence of events is substantiated by the observations of the flight crew when they noted a momentary reduction of r.p.m. and a decrease in rudder pressure during the feathering attempt and by the engine and propeller sound described by ground witnesses. Considering the drag as shown by the engineering data, and that described by the captain, continued flight under these conditions was extremely difficult, if not impossible.

During the sequence of events the oil supply of the No. 4 engine became exhausted during the attempted feathering operation following take-off. As shown by the oil leakage tests, the total supply (20 gallons) was not entirely exhausted during flight but several gallons must have been lost before take-off. It is very probable that this occurred during the power check, the feathering check of the No. 4 propeller, and when that propeller was exercised. It is not known whether the leak could have been seen from the cockpit under the existing conditions and circumstances.

Probable Cause

The probable cause of this accident was the excessively high drag resulting from the improperly indexed propeller blades and inability to feather. These conditions were the result of a series of maintenance errors and omissions.

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ICAO Ref: AR/426

Figure 26 Wide World Photo

Only the tail section remains intact, left, following crash of a four-engined chartered plane on 17 November near Seattle, Washington, following take-off. Twenty-seven persons were killed and forty-seven were hurt, many seriously.

No. 49

Syrian Airways, DC-3, YK-ADD, burned in hangar following explosion at Damascus Airport, Syria, on 22 November 1955. Report released by Department of Civil Aviation, Ministry of Public Works and Communications, Republic of Syria.

(This report is included for information only and is not listed on the classification table.)

Circumstances

At approximately 1607 hours local time the aircraft was in the hangar undergoing a 250 hours check when following an explosion a fire occurred in the baggage and radio section of the fuselage. The radio equipment was destroyed and a large hole burned through the right side fuselage skin. All instruments in the cockpit area were damaged and badly burned. The fire extended into the main cabin and damaged the seats and lining to some extent, also the fuselage top skin was subjected to heat deterioration. No fire damage was sustained by the wings, tail group, undercarriage, engines or propellers.

Investigation and Evidence

The seat of the fire was in the region of the radio equipment and the explosion of petrol fumes took place beneath the floor level, the major effect occurring in the confined area between the tanks in the control cable channel.

The side walls or bulkheads of this channel were forced outwards, shearing the retaining rivets and the force was enough to damage the main fuel tanks, the ends of which now conform to the shape of the damaged bulkheads. The explosion also ripped open the inspection doors along the bottom of the centre section forcing the hinges out of position. It is significant that while the foregoing damage was quite severe, no fire or smoke damage was apparent.

In considering the evidence given by witnesses, the factors which might have been contributing causes of the fire are as follows:

a) cleaning inside the aircraft with petrol;

b) the failure of the hydraulic accumulator;

c) the use of an extension lamp with an inadequate guard.

The possibility of the failure of the hydraulic accumulator being the cause of the fire was effectively disposed of by one witness, who was standing at the forward cabin door after the fire had been partially extinguished and covered with hot hydraulic oil by a sudden gush, evidently the moment of failure of the accumulator.

The same witness disposed of the possibility of the extension lamp causing the fire by stating that he removed the lamp from the aircraft in good condition.

The use of petrol in an open container for cleaning purposes was thoroughly discussed, and it is felt that the accumulation of petrol fumes in the confined area at the front of the fuselage would create a condition of concentrated fumes conducive to an explosion and subsequent fire.

In this connection the committee established that an open pail two thirds full of petrol was being used for cleaning the control cables at the front section of the fuselage, that the pail was located between or near the pilots' seats, that it was there for about twenty minutes, and that the cables were being cleaned by dipping a rag into the petrol and rubbing the cables.

It is considered that the foregoing circumstances were ideal for causing a fire and the ignition of the petrol fumes was carefully considered under the following subjects:

A. Radio: One witness stated that he saw a blue flash coming out of the radio equipment. This is discounted by the radio specialist as being hardly possible particularly since all the switches were in the 'off' position, and by the radio engineer, who stated that the wiring and connections of this installation were in good condition and were grounded.

B. Electrical Wiring: Since much of the wiring was burned it was difficult to locate an indication of failure, but again the switches being 'off' the possibility is remote.

C. Very Pistol: The accidental discharge of the Very signalling pistol was considered, but the pistol was found intact in its holster, and the cartridges showed no signs of discharge.

D. Extension Lamp: The breaking of the bulb, and consequent spark was considered at some length, but since the lamp was removed after the fire this possibility is ruled out. However, it was demonstrated that the guard on the lamp is inadequate, and that the bulb can quite easily be broken.

E. Static Discharge: The possibility of an electrical discharge caused either by atmospheric conditions or by the dropping of a tool or merely by rubbing the steel cables with a damp rag is considered quite logical.

The Chief Inspector stated that the use of petrol for cleaning purposes is normal practice in Syrian Airways and the Chief Engineer agrees that this is a dangerous practice, although he disclaims any knowledge of the use of open containers inside the aircraft.

The atmospheric conditions on the day of the fire were conducive to electrical discharges, but the possibility is considered remote since the aircraft was off the ground and on jacks.

The dropping of a tool onto a metal member can definitely produce a spark which will ignite petrol fumes and the work being done at the time of the fire leaves this a definite possibility.

It is quite possible to create surface electricity by rubbing metal with a rag, and if the rag is moist with petrol the risk of fire is very high.

It is significant that one workman who sustained a badly burned hand states that the burn was caused when he unthinkingly stretched out his hand in an effort to help the boy who was working with him. There was a distance of about 1 1/2 metres between them, and it is felt that if he stretched out his arm through or into the fire he would have sustained a more extensive burn. It is more likely that his hand was at the actual point of ignition and that the initial flash burned the back of his hand, and his evidence is discounted as an effort to protect himself from possible criticism.

It is a well established fact that petrol fumes can be ignited by the small spark produced by two metallic surfaces being struck together and it must be noted that one worker, who was working in the nose section of the aircraft, distinctly heard sounds of hammering coming from the cockpit area. It is, therefore, reasonable to conclude that the explosive fumes which accumulated over a period of twenty minutes were set off by a static spark which was created by one of the workmen inside the aircraft in the course of doing his normal work.

Probable Cause

The explosion and the fire were caused by the ignition of highly inflammable fumes in the forward part of the aircraft and the ignition was caused by some action of the workmen who were working there at the time.

Observations

The use of petrol in open containers in confined areas is considered a highly dangerous practice and contrary to accepted good maintenance methods. It is comparatively safe to use in the open, but the natural fumes which arise in an enclosed section create a definite fire hazard.

While not within the specific scope of the committee, it is felt that some observations on the fire prevention facilities available are in order. First, it is apparent that no fire drill is given to the employees since no attempt was made to extinguish the fire. Secondly, one witness had difficulty in releasing the CO_2 hose from the airport fire truck, having to use considerable force to get it from under another hose. Thirdly, it has been stated that when the hose was finally released and operating it was played on the nose of the aircraft and not at the seat of the fire.

Recommendations

To prevent a similar occurrence in the future it is recommended: -

1. that Syrian Airways cease using petrol for cleaning purposes inside aircraft;
2. that adequate fire extinguishing equipment be placed in the hangar;
3. that adequate fire drill be given to hangar employees;
4. that a properly licensed engineer be in charge and be actually present to supervise all major checks;
5. that extension lamps be provided with guards which will prevent accidental breaking of the bulb;
6. that the batteries be removed from the aircraft at all major inspections.

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ICAO Ref: AR/417

No. 50

C-47, PP-CCC, crashed near Belém Airport, Belém, Pará on 1 December 1955. Brazilian Commercial Accident Report No. 13-C-55, released 15 March 1956.

Circumstances

The aircraft took off at 0957 hours Greenwich Mean Time from Belém Airport, carrying 4 crew and 2 passengers, and had climbed to approximately 100 to 250 metres when the pilot noted signs of malfunctioning in the left engine. A violent stall and loss of power in this engine followed although the propeller continued to revolve. No emergency message was sent and the pilot did not press the feathering control. However, the rest of the emergency procedure appears to have been carried out or to have been in progress at the time of the crash. The hydraulic pump was off and this had the effect of stopping the retraction of the undercarriage half-way. The aerodynamic resistance of the semi-retracted undercarriage prevented the aircraft from maintaining altitude, carrying it down to 20 or 30 metres above the tree tops, possibly without this being noticed. There is reason to believe that the pilot was in the act of switching the fuel selector from one tank to the other when the left wing tip hit a tree breaking off 2.5 metres of the wing and half the aileron. The aircraft swerved 20 degrees to the left and nosed-up violently. The right engine at this time was on full power. The aircraft stalled and hit the ground 200 metres farther on. Explosion of the fuel tanks and fire followed. All occupants were killed.

Investigation and Evidence

At the time of the crash the flap control lever was in the retracted position (routine), the trimming tabs were on the proper setting, the propeller pitch control appears to have been set almost to the "minimum" position (as it was found) and the fuel selector was being switched from the main to the auxiliary tank or vice versa.

It appears that at that time while still flying some 30 to 40 metres above the trees and having close-by, on his left, the clear area of the teletype station and other areas with low shrubs extending to the river's edge, the pilot still considered himself in comparative safety. It is, therefore, believed that the emergency operations claimed his attention within the cockpit, partly distracting it from outside obstacles. This would also account for the right engine not being at full power.

It was proved during the inquiry that although the left propeller was revolving, it was doing so freely i.e., disconnected from the engine, which had stopped some time before. It is assumed that, believing the undercarriage to be fully retracted and seeing the left propeller still revolving, it did not occur to the pilot to switch the hydraulic system selector to the right engine.

It is assumed that the failure of the left engine probably occurred as follows: -

1 - Breakage at one point of the rear bearing spacer of the propeller shaft, allowing one or more rollers to operate outside the raceway and cause distortion of the whole.

2 - Material disintegrated from the above bearing, being ground between the reduction gear and the power section of the engine, caused intermittent longitudinal compression stresses on the above-mentioned bearing and on the front bearing of the power section. These stresses led to fatigue fracture of the rim of the inner raceway of the former bearing and of the outer raceway and casing flange of the latter one.

3 - The above process, which must have gone on for some time, finally led to fracture of the casing flange of the second bearing, which then came out of alignment and slipped backwards, thus disconnecting the power section and ultimately the propeller.

4 - In moving backwards, this bearing came into contact with the middle gear controlling the valve plate, disengaging it from the gear which operates it (crankshaft coupling gear). When this occurred, the valve plate was thrown off phasing, so that explosions occurred out of timing throughout the forward bank of cylinders, causing a back-stroke on the crankshaft, tending to stall it.

5 - At the same time, there occurred a breakage of the end of the axle of the middle valve plate gear, which operates the propeller governor. The oil supply pipe for the propeller pitch control may also have been broken. Consequently, the pitch control was inoperative.

Probable Cause

Failure of the front bearing of the propeller shaft originated a process which led to disconnection of the reduction gear and left propeller and causing sudden stoppage of the left engine.

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No. 51

Eastern Air Lines, Inc., Lockheed Constellation, L-749-A crashed on final approach at Imeson Airport, Jacksonville, Florida, on 21 December 1955. Civil Aeronautics Board (USA) Accident Investigation Report SA-315, File No. 1-0169. Released 5 September 1956.

Circumstances

The flight originated at Miami, Florida, its destination Boston, Massachusetts with an intermediate stop at Jacksonville, Florida. It departed Miami International Airport at 0212 hours Eastern Standard Time on an Instrument Flight Rules flight plan with 12 passengers and 5 crew members. At 0331 the flight reported over Sunbeam Intersection (16 miles SSE of Imeson Airport), was cleared for an ILS approach to Runway 5 and received the Jacksonville weather report - "Partial obscurement, visibility one-half mile; altimeter 30.18." This was followed immediately by another message - "Coming out with indefinite 300 obscurement now one-half with fog".* After acknowledging this information the flight reported leaving Sunbeam at 2 500 feet. Following a later query from the flight, approach control advised that there was no other known traffic in the area. Flight 642 reported over the outer marker inbound as requested and was cleared to land. Shortly thereafter the tower controller observed a large flash in the vicinity of the ILS middle marker. Further calls to the flight were not acknowledged and it was subsequently learned that the aircraft had crashed at 0343 hours approximately six-tenths of a mile southwest of the threshold of Runway 5. All 17 occupants were killed.

Investigation and Evidence

Investigation disclosed the main portion of the wreckage to be 212 feet northwest of the ILS middle marker and 3 486 feet southwest of the threshold of Runway 5.

First impact of the aircraft was with the top of a small pine tree approximately 200 feet below the ILS glide path, 260 feet to the left of the extended centerline of the runway, 4 000 feet from the threshold of Runway 5, and 420 feet southwest of the middle marker. This was followed by striking a 50-foot oak tree, the upper 20 feet of which were sheared off. The aircraft settled toward the ground, striking other large trees which disintegrated both wings and a portion of the empennage. Ground contact was on a heading of approximately 55 degrees magnetic. The distance from the first tree struck to the farthest piece of wreckage was 801 feet. Explosion and fire occurred immediately upon impact.

The cabin and cockpit areas were completely consumed in the ground fire with the exception of the lower fuselage skin and portions of the cabin flooring. The fuselage aft of the rear pressure bulkhead and the center rudder fin and portions of the stabilizer were intact, but with surface scorching indications. The tail cone was found in a relatively undamaged condition with the control booster mechanisms in proper position.

Outer portions of the left and right wings had been separated from the main structure during the passage through the trees and along the ground. The "speedpack" (a large detachable cargo compartment positioned on the underside of the fuselage) was torn from the bottom of the fuselage at ground impact. Wing flaps were determined to have been in the 60 percent extension position, and their positions were symmetrical at the time of impact.

Separation of the right main gear and part of the nose gear had occurred at ground contact. The left main gear was intact and in the extended and locked position; the cockpit landing gear lever was found in the "down" position. Measurement of the right main gear actuating cylinder piston rod revealed the same 15 inches as found on the down and locked left main gear actuating cylinder piston rod.

All boost control assemblies were found in the "boost on" position. A bench check revealed that all boost actuating cylinders had normal travel in both directions and showed no signs of abnormal internal leakage. Relief valves

* Eastern Air Lines' Constellation minima for ILS approaches at Jacksonville, day or night, are ceiling 200 feet, visibility one-half mile.

and bypass controls operated normally. The filters showed a normal differential pressure between inlet and outlet. The elevator boost was installed in a similar aircraft, was flight tested and found to function in a normal manner.

On impact the four powerplants separated at their attach points and came to rest a few feet ahead of the main wreckage. Number 4 engine suffered extensive damage in the ground fire. Examination of the interiors of all four crankcases gave no indication of rotational or reciprocating interferences or operating irregularity of any kind. All oil pumps were free of metal particles and revealed no scoring. There was no evidence to indicate that the engines were not capable of developing power prior to impact.

All propeller blades were broken or bent, with bending generally rearward, and five of them were broken at the butt ends. The dome position and blade angles were found to be in settings that indicated normal operation of all engines.

The tearing free of all powerplants resulted in the pulling and breaking of control cables under tension. Several of the cable-controlled fuel shutoff valves were found in the closed position; the electrically controlled firewall fuel shutoff valves were all open.

From markings presented by ground object contacts of the airframe and propellers it was determined that just prior to impact the aircraft was in a slight turn to the right and banked approximately 11-1/2 degrees. The longitudinal attitude of the aircraft was approximately 4-3/4 degrees nose-up and the angle of descent during the last 200 feet of the flight path was about 2-1/2 degrees, with the rate of descent being 10 feet per second.

Several flight checks of ground navigational facilities soon after the accident showed operation of the systems to be normal. Simulated ILS approaches were made, with a Board investigator as observer, to determine the effect on cockpit instruments caused by vehicles parked on the highway below the glide path. The highway is about 100 feet east of the middle marker. On one approach, with a crane-equipped truck parked beneath the glide path, a flydown indication was noted prior to reaching the middle marker. It was necessary to descend 60 feet in order to center the needle. However, the glide path indication was found to be normal at the middle marker, where the accident occurred.

Several persons saw or heard the aircraft, with normal engine sound. A power surge was heard just before impact. One witness, who was near the middle marker, said he first saw the landing lights, lighted and pointing straight down, and that they partially extended before he lost sight of the aircraft. Other witnesses near the accident scene did not see the landing lights on. Subsequent investigation disclosed that the right landing light had been destroyed but the left light was found in the retracted position. There was no fire observed by any witness prior to impact. One witness saw the aircraft, at a very low altitude, make a slight turn to the right just before it contacted the trees and ground.

A witness who was driving a trailer-truck south along the highway adjacent to the airport said he saw what he believed to be two jet-propelled aircraft pass from right to left in front of him, flying at an altitude of 150-250 feet. He stated that at the same time he observed these aircraft he saw a bright flash, whereupon he immediately stopped his truck and walked down the highway. To his right he saw scattered parts of an aircraft burning. He also said that before reaching the airport he had passed through patches of ground fog, that at the airport there was an overcast condition, and that he again passed through patches of ground fog as he continued south.

The two airport tower controllers in radio contact with the flight stated they heard it pass over the south edge of the field, proceeding outbound. At this time the runway lights were on at their highest intensity. One of the two controllers on duty stated that he went downstairs to the radar room and, on the Airport Surveillance Radar scope, observed the flight just before it reached the outer marker outbound. He also said he saw the start and completion of a procedure turn and observed the aircraft start inbound, after which he gave the flight its three-, two-, and one-mile range positions. The tower recording of outgoing messages does not include the three-mile position message. The ASR equipment at Jacksonville does not show altitude above the ground. The controller stated that forward movement ceased soon after the image of the aircraft on the scope passed the one-mile position from the end of the runway. This radar observation coincides with the geographical position of the crash. During the entire time the controller was watching the scope, set to 10-mile range, he saw no other aircraft. Comprehensive investigation revealed no other traffic, either civil or military, in the area during the approach of the subject aircraft.

The night of December 20-21 weather stations from Miami to Savannah, Georgia, were reporting a small spread between temperature and dewpoint. The company terminal forecast for Jacksonville was ceiling and visibility unlimited; this was not amended until 0345 when it was changed to ceiling 300 feet, broken clouds; visibility three-fourths of a mile; fog. During the briefing the company forecaster advised the crew that patchy ground fog could be expected in the Jacksonville area.

It is evident that all components of the ILS system were operating normally at the time of the accident. This was also indicated by another flight which made an ILS approach and landing approximately 15 minutes before the accident. At that time the system was normal, as it was on two approaches made several hours after the accident. Monitoring records of the system gave no indication of any deviation from normal operation during the early morning of 21 December. All contacts with the flight by Jacksonville approach control were routine and the crew did not report any operating difficulties.

The testimony of witnesses who observed the landing lights of the aircraft come on during the approach and other witnesses who saw no landing lights, is not completely incompatible. Since the lights were found in the retracted position it is indicated that once lowered they might have been retracted to eliminate reflection as the aircraft decended into the layer of fog. Also, some witnesses heard a surge of power just before impact with the trees, which indicates that the pilot was attempting a pullout.

Every possible effort was made to account for jet-propelled aircraft being in the area when the accident occurred. All military services said they had no jet aircraft flying in that area at the time of the accident. Neither the tower personnel, witnesses on the airport, nor witnesses other than the truck driver near the accident scene saw any jet aircraft and such aircraft were not observed on the radar scope. In view of the truck driver's testimony, the Florida Air National Guard, under the direction of a CAB investigator, made several flights (using a jet aircraft) in an effort to simulate the conditions described by the truck driver. Each of these flights was plainly visible on the radar scope. It, therefore, is concluded that no such aircraft were in the vicinity.

From the testimony of other pilots flying in the vicinity a short time prior to the accident, there was a layer of cloud, which included smoke and fog, capping the airport with a general foggy condition existing a few miles to the southwest. All other areas appeared to be clear. It therefore appears likely that the flight was clear of clouds from the Sunbeam intersection to the middle marker and outbound to the outer marker and that it probably did not encounter obscurement until in the vicinity of the middle marker inbound. Although this weather condition has been described as partial obscurement with horizontal visibility of one-half mile, it is apparent from the testimony of pilots that vertical visibility throughout the area was generally good. Some of the witnesses said the ground visibility at and near the accident was poor. There is no way of determining ceiling height or visibility distance at the accident site. However, the weather information reported to the crew was obtained at the control tower. The tower is located approximately one mile north-northeast of the accident scene. At the time of the accident a wind of six knots was blowing from the north-northwest, and it is believed that between the time of the last reporting and the accident the weather conditions at the observation point could have moved to the general area of the accident and therefore should have been essentially the same as that reported to the crew, "indefinite 300, sky obscured, visibility 1/2 mile and fog".

Assuming that weather conditions were similar at the crash point and the observation point, consideration should be given to the decrease of horizontal visibility with elevation. Horizontal visibility must have been near zero at 300 feet above the ground. Normally, slant visibility down the glide path should have gradually increased as the aircraft descended.

The radar scope at Jacksonville does not reflect altitude. However, since the radar operator testified that the aircraft was observed to fly beyond the outer marker, make a procedure turn, and return inbound, it is believed that this was accomplished at the normal altitude of 1 200 feet. The propeller slash marks at the scene indicated the speed of the aircraft at impact to be 140 knots. The company's instructions for this type aircraft show a recommended approach speed of 115 knots from the outer marker to the minimum authorized altitude.

Evidence indicates that the aircraft was flying in a normal manner just prior to impact and there is no known evidence to indicate any malfunctioning of the aircraft or any of its components. The flaps were extended to a position used for manoeuvring and this amount of flap extension is usually used in this type of approach until reaching the middle marker. Although the aircraft was 200 feet to the left of course this is a small deviation at that point in the approach and only a slight correction would have been required to again align with the runway. The fact that the aircraft was in a slight right turn and almost level horizontally at impact would suggest that the pilot was turning toward the localizer course, further indicating the aircraft was under control.

It is not unusual, with weather conditions such as existed this day, for pilots during an approach to an airport to find ceilings and visibilities that vary from those reported. If, on the morning of the accident, the captain found the visibility to be lower than one-half mile, it would then have been his responsibility to execute a missed-approach procedure.

Probable Cause

The probable cause of this accident was that the flight encountered local fog and restricted visibility during the final portion of an ILS approach, and a missed approach procedure came too late to prevent the aircraft from descending into ground obstructions.

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ICAO Ref: AR/438

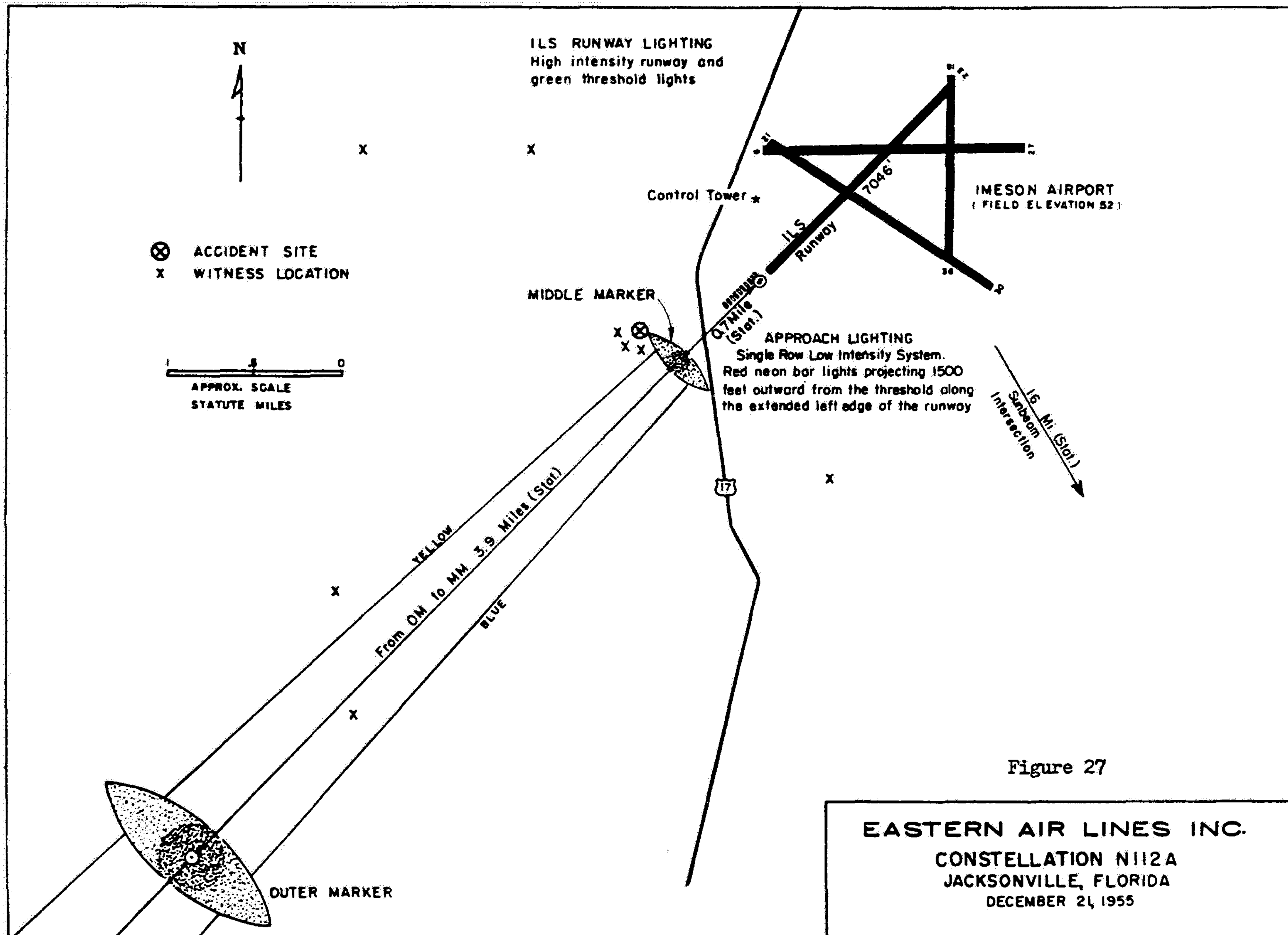
N
ILS RUNWAY LIGHTING
High intensity runway and
green threshold lights
Control Tower
IMESON AIRPORT
(FIELD ELEVATION 52)
7046'
ILS
Runway
ACCIDENT SITE
WITNESS LOCATION
MIDDLE MARKER
0.7 Mile
(Stat.)
APPROACH LIGHTING
Single Row Low Intensity System.
Red neon bar lights projecting 1500
feet outward from the threshold along
the extended left edge of the runway
1 .5 0
APPROX. SCALE
STATUTE MILES
16 Mi. (Stat.)
Sunbeam
Intersection
17
YELLOW
From OM to MM 3.9 Miles (Stat.)
BLUE
OUTER MARKER
EASTERN AIR LINES INC.
CONSTELLATION N112A
JACKSONVILLE, FLORIDA
DECEMBER 21, 1955

Figure 27

Figure 28 Wide World Photo

General view of the Eastern Air Lines Lockheed Constellation that crashed on final approach at Imeson Airport, Jacksonville, Florida, on 21 December 1955.

No. 52

Pan American World Airways, Inc., Douglas DC-7B, lost powerplant due to fire in flight near Venice, Italy on 28 December 1955. Civil Aeronautics Board (USA) Accident Investigation Report, File No. 1-0178, released 31 May 1956.

Circumstances

The flight originated at Teheran, Iran, for New York, N.Y., with scheduled stops at Rome, Italy, and Brussels, Belgium. On board were a crew of 6 and 42 passengers. The aircraft departed Rome at 1818 Greenwich Mean Time on an Instrument Flight Rules flight plan to Brussels which specified a cruising altitude of 19 000 feet. At 1912, No. 3 engine and propeller overspeeded and the tachometer needle swung rapidly past the highest calibration, 3 200 r.p.m. to full deflection where it remained. Power was reduced on all engines, the auto-pilot was disengaged and an attempt was made to feather No. 3 propeller, without success. At this time the co-pilot noticed a flicker of the fire warning light for the power section of No. 3 engine. Airspeed was reduced from 200 to 140 knots and descent was started. The first officer then reported a fire in No. 3 engine. As No. 3 propeller was windmilling at a high speed, an attempt was made to "freeze" the engine by shutting off its oil supply. Accordingly, the firewall shutoff valves were closed. One bank of CO_2 was discharged which reduced the intensity of the fire but did not extinguish it. Meanwhile the flight engineer was intermittently depressing the feathering button. The discharge indication on the ammeter showed the feathering motor to be operating but the propeller did not feather and continued to windmill. Fire warnings were still lacking in the cockpit with the exception of the momentary flicker immediately following the overspeeding. Zone 2 and zone 3 fire warnings from No. 3 engine then appeared, followed by increased fire at the No. 3 engine area whereupon the second bank of CO_2 was discharged. The red warning lights and aural alarm still operated after this second use of CO_2. At this time an intense white fire was noticed through a rupture in the cowling near the air scoop of No. 3 nacelle. The aircraft then advised Rome radio that it was going to make an emergency landing on or near the beach of the Adriatic Sea near Venice. A descent was made to 500 feet where after a series of bright flashes and severe vibration the burning No. 3 engine fell free of the aircraft. Severe buffeting followed, the airspeed dropped to approximately 90 knots, power was applied to the remaining three engines and an airspeed of 140 knots and a climb of 150 feet per minute were soon established. A check indicated that the aircraft was capable of continuing flight and the crew advised Rome that they intended to return. The landing was made at 2040 hours and there were no injuries to passengers or crew.

Investigation and Evidence

The still burning engine was found near Venice and following the taking of photographs it was taken to Rome for examination and subsequent shipment to Pan American's maintenance base at New York.

The propeller governor was undamaged by fire and after an initial examination was flown to the Hamilton Standard factory in the United States where it was disassembled under the supervision of Board investigators. Disassembly revealed a fatigue type failure of the governor drive shaft (Part No. 67035U). Initial failure extended through the web between two of the high pitch oil ports with resulting failure occurring to the drive shaft through the remaining webs. The fracture line passed through one or more quench cracks at the port webs. Total time on the shaft was 407 hours when the failure occurred. Examination of the remainder of the governor revealed that broken parts of the shaft had blocked oil ports which effectively prevented feathering of the propeller.

A review of past governor drive shaft failures of this type revealed four others that occurred during October and December 1955. All of these were in the same type engines and DC-7B's. Further, all were similar in that a fatigue failure occurred at the corners of the rectangular high pitch ports in the shaft. Total times on all of the failed shafts were between 375 and 592 hours.

As a result of these failures Hamilton Standard had revised its heat-treating procedures to reduce quench cracking. All governor drive shafts in service were returned for replacement with those having the improved heat-treatment. The letter "U" after the part number (67035) on the drive shaft involved in this accident indicates that this replacement had been accomplished.

In November 1955 all DC-7B operators were advised by the propeller manufacturer that as a result of the failures a program was being initiated to replace all governor drive shafts bearing the part number 67035 with a new shaft, part number 321822. This new drive shaft incorporates elliptical high and low pitch ports in place of the rectangular ports, thereby eliminating stress concentrations in the corners. All PAWA DC-7B's are currently being equipped with the 321822 drive shaft and an r.p.m. sensitive hydraulic pitch lock* in the dome assembly. This replacement program was established by the manufacturer with priority given to governors having less than 1 000 hours. Those with over 1 000 hours of use were considered to be airworthy.

On 16 January 1956 the Civil Aeronautics Administration issued Airworthiness Directive 56-2-2 making mandatory the replacement of propeller governor drive shaft 67035 with governor drive shaft 321822 on all DC-7 aircraft.

The manufacturer is producing a newly designed drive shaft which increases the web strength between the ports by 50 percent. The new shaft, (Part Number 321841) has four oval ports at the high and low pitch positions, thereby increasing the web size between the ports.

An examination of No. 3 engine at New York indicated that its operation, prior to the shaft failure, had no bearing upon the difficulties encountered by this flight. The examination also indicated that as a result of overspeeding the engine impeller assembly failed and damaged the rear engine case to an extent that the fuel injection lines in the case were broken. This undoubtedly allowed fuel to escape, resulting in severe fire. There was no apparent maloperation of No. 3 engine prior to the drive shaft failure.

The engine impeller assembly must have disintegrated centrifugally, throwing metal particles outwardly through the cowling through which was seen the intense white fire; this failure also accounted for the severed fuel lines that provided a source of fuel for the fire.

The reason for the failure of the fire warning system to function properly could not be determined because of damage to the system during the fire and the tearing away of the engine and propeller. However, in this case there was no delay in applying emergency measures because of alertness of the crew member in the cabin at the time of the overspeeding.

Probable Cause

The probable cause of this accident was failure of No. 3 propeller governor drive shaft which resulted in overspeeding, inability to feather the propeller, an engine failure, fire, and inflight loss of the No. 3 powerplant.

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* A device to prevent blade movement toward low pitch if the r.p.m. reaches a preset value.

PART II

AIRCRAFT ACCIDENT STATISTICS 1955

INTRODUCTION

GENERAL COMMENTS

1. This section of the Aircraft Accident Digest No. 7 contains a detailed analysis of the statistics for the year 1955, as well as an historical record of selected data for the years 1925 to 1956 inclusive. Although figures for the years subsequent to 1951 were obtained largely from the ICAO Air Transport Reporting Forms G (Aircraft Accidents) filed by contracting States, other sources had to be used for those countries which have not yet filed the required reporting Form in order to arrive at as complete a picture as possible of accidents in which public aircraft were involved.

2. The statistics shown are the best available to date but are subject to adjustment when more accurate data is forwarded to this Organization on the Forms G (facsimile copy given on pages 229 and 230).

DESCRIPTION OF TABLES

3. Accident data has been recorded under the country in which the airline which suffered an accident is established and not in the country where the accident took place. Contracting States which were members of ICAO by December 1956, numbering 70, have been included in all tables for the year 1955 and the preliminary data for 1956.

4. The three tables compiled for the year 1955 give the following information:

TABLE A Fatality rate by contracting States whose airlines had an accident causing a passenger to be killed on a scheduled flight.

TABLE B Aircraft accident summary by country (70 contracting States of ICAO) of all operators engaged in public air transport.

TABLE C Aircraft accident summary by type of operation and by country.

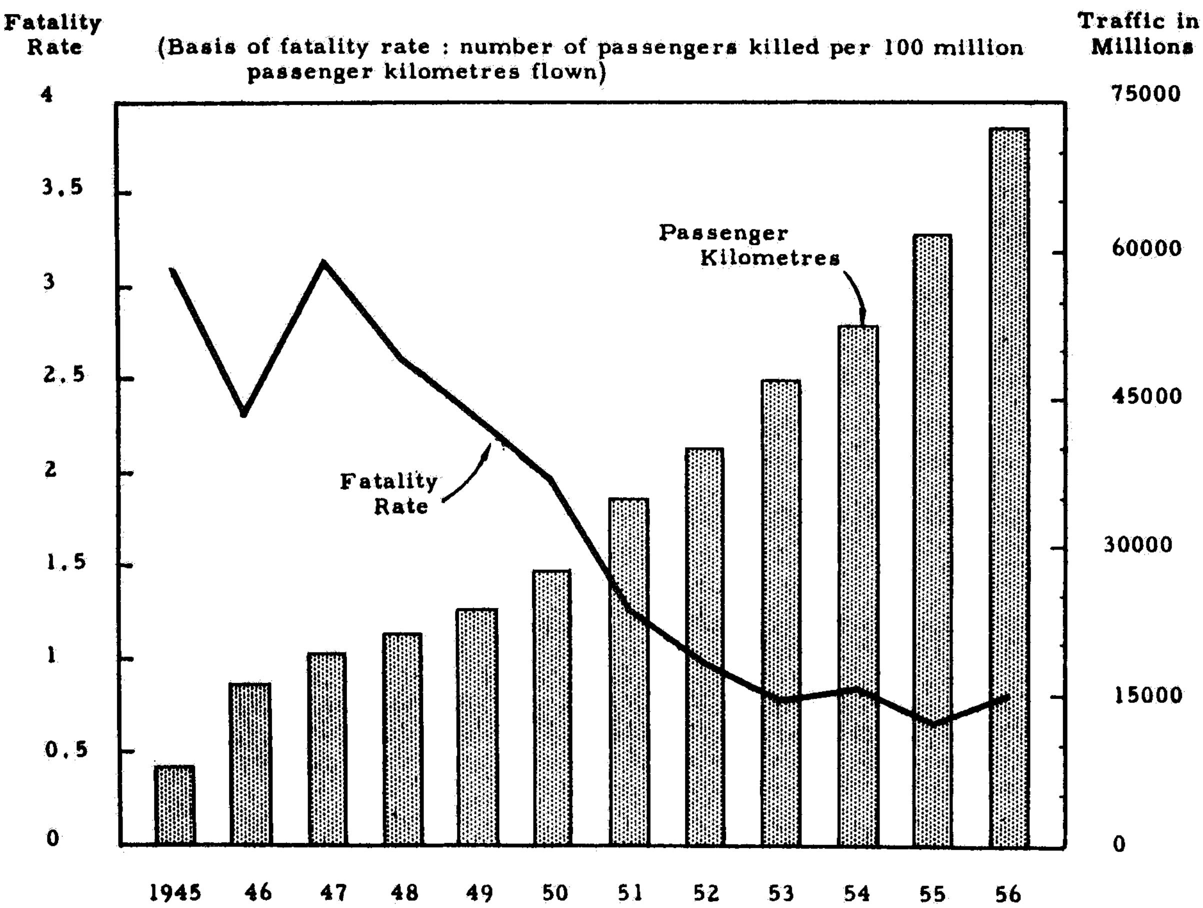
SAFETY RECORD

5. There has been a remarkable downward trend in passenger fatality rates since 1945, indicating a steady improvement in safety in commercial flying over the past twelve years. Despite the increased speeds, weights and range of the aircraft flown today as compared with over a decade ago, the risk of accident occurrence has lessened over the period largely through technical changes and greater experience. However, human errors are still a major cause of aircraft crashes and crashes brought about by deliberate human intent cannot readily be controlled.

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 - 1956), 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 0.84 for the next six years.

7. From a perusal of the chart and table shown on the following pages, it will be observed that the fatality rate per passenger-kilometre of 0.78 for 1956 is 25% of the 3.09 for 1945, although slightly higher than the rate of 0.66 in 1955. For the fifth consecutive year, the 1956 rate has remained at less than one fatality per 100 million passenger-kilometres flown. Although the number of passengers killed on scheduled flights over the period 1952 to 1956 ranged from a low of 356 persons in 1953 to a high of 565 persons in 1956, 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 TREND
COMPARED WITH GROWTH IN TRAFFIC
SCHEDULED AIR SERVICES 1945 - 1956



PASSENGER FATALITIES 1925 - 1956

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	47 000	0.76	132
1954	447	53 000	0.84	119
1955	407	62 000	0.66	152
1956	565	72 000	0.78	127

Exclusions: The People's Republic of China, USSR and other countries not contracting States of ICAO in 1956.

1955

TABLE A

CONTRACTING STATES OF ICAO

PASSENGER FATALITIES OCCURRING ON

SCHEDULED INTERNATIONAL AND DOMESTIC OPERATIONS

YEAR 1955

Description	Country Total of Hours Flown	Number of Fatal Accidents a/	Number of Passengers Killed a/	Country Total of Passenger Kilometres	Fatality Rate per 100 Million Pass.-Kms.	Millions of Passenger-Kilometres per Fatality
	(thousands)			(millions)		
Total Scheduled Operations						
Belgium	86	1	21	579		
Brazil	428	4	26	1 684		
Burma	16	1	6	61		
Colombia	150 *	1	5	484		
France	300	1	10	3 138		
India	126	1	6	515		
Israel b/	13	1	51	141		
Mexico	254 *	1	23	1 517		
Peru	23 *	1	15	93		
United Kingdom	483	3	38	3 283		
United States c/	3 673	9	197	39 186		
Venezuela	98	1	9	325		
All other States	1 696	-	-	10 994		
Total	7 346	25	407	62 000	0.66	152
International Scheduled Operations						
Belgium	43	1	21	261		
Brazil	31	1	11	272		
Israel b/	12	1	51	138		
United Kingdom	339	2	29	2 765		
United States	577	1	2	7 238		
All other States	953	-	-	8 826		
Total	1 955	6	114	19 500	0.58	171
Domestic Scheduled Operations						
Brazil	397	3	15	1 412		
Burma	11	1	6	40		
Colombia	138 *	1	5	338		
France	168	1	10	1 503		
India	86	1	6	221		
Mexico	202	1	23	1 062		
Peru	23	1	15	91		
United Kingdom	144	1	9	519		
United States c/	3 095	8	195	31 948		
Venezuela	81	1	9	199		
All other States	1 046	-	-	5 167		
Total	5 391	19	293	42 500	0.69	145

NOTES:

Accident data have been recorded under the country in which the airline is registered and not in 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.

* Estimated data.

a/ Data excludes one accident for Yugoslavia (a non-member State) in which 6 passengers were killed.
b/ Data includes one accident with 51 fatalities in the forced landing of an Israeli aircraft brought down by anti-aircraft fire in Bulgaria.
c/ Data includes one accident with 39 fatalities in the crash of a United States aircraft caused by a bomb concealed on board.

CONTRACTING STATES OF ICAO

AIRCRAFT ACCIDENT SUMMARY FOR 1955

OF ALL OPERATORS ENGAGED IN PUBLIC AIR TRANSPORT

1955

TABLE B

Contracting States of ICAO	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	noa	noa	noa	noa	noa	noa	noa	noa	noa	noa			
Argentina	1	1	-	-	-	1	-	-	-	-			
Australia	14	1	-	-	37	1	-	5	-	-			
Austria	noa	noa	noa	noa	noa	noa	noa	noa	noa	noa			
ø Belgium	1	1	21	-	-	8	-	-	-	-		103 360	
Bolivia	1	1	-	-	-	2	-	-	-	-			
Brazil	6	5	26	3	14	20	2	4	-	-			
Burma	2	1	6	-	-	3	-	-	-	-			
Cambodia a/	noa	noa	noa	noa	noa	noa	noa	noa	noa	noa			
ø Canada b/	1	-	-	-	-	-	-	-	-	-	169 045g/*	230 849g/	230 849
Ceylon	-	-	-	-	-	-	-	-	-	-			
Chile	-	-	-	-	-	-	-	-	-	-			
China (Taiwan)	-	-	-	-	-	-	-	-	-	-			
Colombia	4	3	9	-	-	6	1	-	-	-			
Cuba	-	-	-	-	-	-	-	-	-	-			
Czechoslovakia	-	-	-	-	-	-	-	-	-	-			
Denmark	-	-	-	-	-	-	-	-	-	-			
Dominican Republic	-	-	-	-	-	-	-	-	-	-			
Ecuador	-	-	-	-	-	-	-	-	-	-			
Egypt	-	-	-	-	-	-	-	-	-	-			
El Salvador	noa	noa	noa	noa	noa	noa	noa	noa	noa	noa			
ø Ethiopia	-	-	-	-	-	-	-	-	-	-			
Finland	-	-	-	-	-	-	-	-	-	-			
ø France d/	34	3	18	-	-	13	-	6	-	2		325 032	325 032
ø Germany a/	2e/	2	6	-	-	1	-	-	-	-	1 500	1 819	
ø Greece	-	-	-	-	-	-	-	-	-	-			
Guatemala	-	-	-	-	-	-	-	-	-	-			
Haiti	-	-	-	-	-	-	-	-	-	-			
Honduras	-	-	-	-	-	-	-	-	-	-			
Iceland	-	-	-	-	-	-	-	-	-	-			
India	10	3	6	-	29	8	-	37	-	-			
Indonesia	-	-	-	-	-	-	-	-	-	-			
Iran	1	-	-	-	9	-	-	4	-	-			
Iraq	2	-	-	-	-	-	-	-	-	-			
ø Ireland	-	-	-	-	-	-	-	-	-	-			
ø Israel	2	1	51	-	-	7	-	1	-	-	3 133	12 848	12 848
Italy	1	-	-	-	-	-	-	-	-	-			
Japan	1	1	1	-	-	-	1	-	-	-			
Jordan	-	-	-	-	-	-	-	-	-	-			
Korea	-	-	-	-	-	-	-	-	-	-			
Laos	-	-	-	-	-	-	-	-	-	-			
Lebanon	-	-	-	-	-	-	-	-	-	-			
Liberia	-	-	-	-	-	-	-	-	-	-			
Libya	noa	noa	noa	noa	noa	noa	noa	noa	noa	noa			
Luxembourg	noa	noa	noa	noa	noa	noa	noa	noa	noa	noa			
Mexico	3	2	42*	-	4	6*	-	3	-	-			
Morocco a/	-	-	-	-	-	-	-	-	-	-			
ø Netherlands	-	-	-	-	-	-	-	-	-	-			
ø New Zealand	9	-	-	-	-	-	-	-	-	-	110 674	55 292	
Nicaragua	2	1	-	-	-	1	-	-	-	-			
ø Norway	3	1	-	-	-	1	-	-	-	-	9 461	8 192	53 705
Pakistan	2	-	-	-	23	-	-	5	-	-			
Paraguay	noa	noa	noa	noa	noa	noa	noa	noa	noa	noa			
Peru	1	1	15	14	-	4	2	-	-	-			
ø Philippines	2	1	-	1	-	1	-	-	-	-	4 475f/	38 524g/	38 524g/
Poland	-	-	-	-	-	-	-	-	-	-			
Portugal	-	-	-	-	-	-	-	-	-	-			
ø Spain	-	-	-	-	-	-	-	-	-	-			
Sudan a/	-	-	-	-	-	-	-	-	-	-			
ø Sweden	17	-	-	-	-	-	1	-	-	-	19 282h/	20 440	68 182
Switzerland	-	-	-	-	-	-	-	-	-	-			
Syria	-	-	-	-	-	-	-	-	-	-			
ø Thailand	2	-	-	-	4	-	-	2	-	-	8 434	13 170	13 170
Turkey	-	-	-	-	-	-	-	-	-	-			
Un. of S. Africa	8	-	-	-	-	-	1	4	-	-			
ø United Kingdom i/	33	8	38	9	314	16	8	67	1	-	274 009	500 818	441 929
j/	(23)	(4)	(13)	(9)	(314)	(6)	(6)	(66)	(1)	(-)	(167 800)	(352 682)	(372 970)
ø United States k/	95	19	224	41	1 339	40	7	257	7	1	2 636 077	4 498 643	4 099 605
Uruguay	1	-	-	-	-	-	-	-	-	-			
ø Venezuela	5	4	15	-	-	7	-	2	1	-	78 550l/	58 336l/	118 476
Viet Nam	-	-	-	-	-	-	-	-	-	-			
Total for 70 States	266	60	478	68	1 773	146	23	397	9	3			
TYPE OF OPERATION													
Scheduled International	24	8	114	12	389	33	7	80	-	-			
Scheduled Domestic	113	24	293	53	1 110	63	7	203	6	3			
Non-Scheduled International	9	2	-	-	33	3	1	16	-	-			
Non-Scheduled Domestic	89	20	67	3	237	39	6	63	1	-			
Non-Revenue	31	6	4	-	4	8	2	35	2	-			
Total Operations	266	60	478	68	1 773	146	23	397	9	3			

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
n.c.a. - No Civil Aviation.
a/ Country became a Contracting State in 1956.
b/ Data for scheduled operations only.
c/ Data for total operations of all scheduled operators.
d/ Excludes all domestic flights in Indo-China.
e/ Chartered aircraft.
f/ Landings at Manila International Airport only.
g/ Hours flown by private operators not available.
h/ Includes some helicopter landings.
i/ Data refer to airlines registered in the United Kingdom and its dependencies. Data somewhat incomplete for number of landings and hours flown.
j/ United Kingdom only. Data incomplete for number of landings and hours flown except in last column.
k/ Data refer to all public air transport i.e. scheduled U.S. and Alaska airlines as well as irregular air carriers.
Data incomplete for number of landings and hours flown.
l/ Data for LAV and RANSA only.

1955

TABLE C

CONTRACTING STATES OF ICAO

AIRCRAFT ACCIDENT SUMMARY FOR 1955

OF ALL OPERATORS ENGAGED IN PUBLIC AIR TRANSPORT

BY TYPE OF OPERATION

Type of Operation Contracting States of ICAO	Number of Accidents		Passenger Injury			Crew Injury			Others Injured		By Operators With an Accident	
	Total	Fatal	Fatal	Serious	Minor or None	Fatal	Serious	Minor or None	Fatal	Serious	Number of Landings	Hours Flown
SCHEDULED INTERNATIONAL OPERATIONS												
ø Belgium	1	1	21	-	-	8	-	-	-	-		43 404
Brazil	1	1	11	3	-	8	2	-	-	-		15 091
ø Israel	1	1	51	-	-	7	-	-	-	-	2 777	12 374
Pakistan	1	-	-	-	23	-	-	5	-	-		6 491
ø United Kingdom a/	15	4	29	8	214	8	5	42	-	-	96 624	304 671
b/	(12)	(2)	(13)	(8)	(214)	(3)	(5)	(42)	(-)	(-)	(86 112)	(263 681)
ø United States c/	5	1	2	1	152	2	-	33	-	-	145 789	521 682
Total for 6 States	24	8	114	12	389	33	7	80	-	-		
SCHEDULED DOMESTIC OPERATIONS												
Australia	5	-	-	-	36	-	-	1	-	-		
Brazil	3	3	15	-	14	9	-	2	-	-		
Burma	2	1	6	-	-	3	-	-	-	-		11 087
ø Canada	1	-	-	-	-	-	-	-	-	-	143 329*	178 006
Colombia	1	1	5	-	-	3	-	-	-	-		56 792
ø France d/	19	1	10	-	-	2	-	4	-	2		299 611e/
India	5	2	6	-	21	7	-	27	-	-		
Iraq	1	-	-	-	-	-	-	-	-	-		
Italy	1	-	-	-	-	-	-	-	-	-		16 069
Mexico	1	1	23	-	-	3	-	-	-	-		
ø New Zealand	1	-	-	-	-	-	-	-	-	-	40 111	45 996
Nicaragua	1	-	-	-	-	-	-	-	-	-		
ø Norway	2	-	-	-	-	-	-	-	-	-	1 085	837
Pakistan	1	-	-	-	-	-	-	-	-	-		5 587
Peru	1	1	15	14	-	4	2	-	-	-		
ø Thailand	1	-	-	-	3	-	-	1	-	-	5 402	5 321
ø United Kingdom a/	6	2	9	-	56	4	1	11	1	-	135 723	146 632
b/	(3)	(1)	(-)	(-)	(56)	(-)	(-)	(11)	(1)	(-)	(64 054)	(68 419)
ø United States c/	60	11	195	39	980	26	4	155	4	1	2 469 041 f/	2 765 426 f/
ø Venezuela	1	1	9	-	-	2	-	2	1	-	35 554	28 672
Total for 19 States	113	24	293	53	1 110	63	7	203	6	3		
NON-SCHEDULED INTERNATIONAL OPERATIONS												
India	1	-	-	-	1	-	-	1	-	-		
ø Thailand	1	-	-	-	1	-	-	1	-	-	128	347
ø United Kingdom a/	2	-	-	-	31	-	1	6	-	-	3 884	10 707
b/	(2)	(-)	(-)	(-)	(31)	(-)	(1)	(6)	(-)	(-)	(1 074)	(4 355)
ø United States g/	3	1	-	-	-	-	-	8	-	-	3 062 f/	40 894 f/
ø Venezuela	2	1	-	-	-	3	-	-	-	-	1 260	5 060
Total for 5 States	9	2	-	-	33	3	1	16	-	-		
NON-SCHEDULED DOMESTIC OPERATIONS												
Argentina	1	1	-	-	-	1	-	-	-	-		
Australia	9	1	-	-	1	1	-	4	-	-		
Bolivia	1	1	-	-	-	2	-	-	-	-		
Brazil	1	1	-	-	-	3	-	-	-	-		
Colombia	2	1	4	-	-	1	1	-	-	-		
ø France g/	6	2	8	-	-	11	-	-	-	-		
ø Germany h/	1	1	3	-	-	1	-	-	-	-	810	735*
India	3	1	-	-	7	1	-	9	-	-		
Iran	1	-	-	-	9	-	-	4	-	-		
Iraq	1	-	-	-	-	-	-	-	-	-		
Mexico	2	1	19*	-	4	3	-	3	-	-		
ø New Zealand	8	-	-	-	-	-	-	-	-	-	70 563	9 256
Nicaragua	1	1	-	-	-	1	-	-	-	-		
ø Norway	1	1	-	-	-	1	-	-	-	-	949	628
ø Philippines	2	1	-	1	-	1	-	-	-	-		1 589 i/
ø Sweden	16	-	-	-	-	-	1	-	-	-	15 395	18 171
Union of South Africa	8	-	-	-	-	-	1	4	-	-		
ø United Kingdom a/	6	1	-	1	11	1	1	3	-	-	18 703	18 271
b/	(2)	(-)	(-)	(1)	(11)	(-)	(-)	(2)	(-)	(-)	(1 138)	(1 177)
ø United States g/ j/	16	4	27	1	205	9	2	36	1	-	18 185 f/	48 063 f/
Uruguay	1	-	-	-	-	-	-	-	-	-		
ø Venezuela	2	2	6	-	-	2	-	-	-	-		
Total for 21 States	89	20	67	3	237	39	6	63	1	-		
NON-REVENUE OPERATIONS												
Brazil	1	-	-	-	-	-	-	2	-	-		
Colombia	1	1	-	-	-	2	-	-	-	-		
ø France	9	-	-	-	-	-	-	2	-	-		15 038 k/
ø Germany h/	1	1	3	-	-	-	-	-	-	-	28	
India	1	-	-	-	-	-	-	-	-	-		8
ø Israel	1	-	-	-	-	-	-	1	-	-	356	474
Japan	1	1	1	-	-	-	1	-	-	-		
ø Sweden	1	-	-	-	-	-	-	-	-	-	145	103
ø United Kingdom a/	4	1	-	-	2	3	-	5	-	-	19 075	20 537
b/	(4)	(1)	(-)	(-)	(2)	(3)	(-)	(5)	(-)	(-)	(15 422)	(15 050)
ø United States g/ j/	11	2	-	-	2	3	1	25	2	-		91 770 f/
Total for 10 States	31	6	4	-	4	8	2	35	2	-		

NOTES: Source of Data: Air Transport Reporting Form 0 filed by countries indicated with a ø. All other country data collected from outside sources.

* Estimated.

a/ Data refer to airlines registered in the United Kingdom and its dependencies. Data incomplete for number of landings and hours flown.
b/ United Kingdom data only. Data incomplete for number of landings and hours flown.
c/ Data for all scheduled U.S. and Alaska airlines.
d/ International scheduled operations are combined with domestic scheduled operations.
e/ Includes some non-scheduled and non-revenue data for airlines other than Air France.
f/ Data incomplete for number of landings and hours flown.
g/ Non-scheduled international operations are combined with non-scheduled domestic operations.
h/ Chartered aircraft.
i/ Hours flown by private operators not available.
j/ Data for all scheduled U.S. and Alaska airlines as well as irregular air carriers.
k/ Air France only.

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

PILOTS SAFETY EXCHANGE BULLETINS

Wind Shear — A Two-Edged Sword

"It's a rare day when there isn't a little wind shear kicking around. If you have the wind blowing one speed and direction here and another speed or direction a short distance away, that's wind shear. A cold or warm front is a good example, with the warm air moving in one direction and the cold air below going in another.

"The strong wind that suddenly springs up just before an afternoon thunderstorm is another example. At one instant it is calm; the next it is blowing and raining. The dividing line between the calm air and the wind is the wind shear line.

"A wind shear between ground and traffic pattern altitude of 15 to 20 knots is common, and a shear of 30 to 40 knots is not uncommon in some parts.

"Suppose you were coming down on final at 15 knots above stalling speed and you passed through a wind shear line where the headwind decreased by 15 knots? The result would be a stall, and the only way to prevent it would be to either sacrifice altitude for airspeed or increase airspeed by adding power. If you have enough altitude, you can drop the nose and hit the throttle, and then drag it on into the field and make a landing. But if your altitude should run out before the added power takes hold, you land short. The opposite could happen, too. You could pick up a 15-knot headwind ... and fly way, way down the field before the plane would give up and finally touch down.

"Wind shear also can be a problem on take-off. Even with maximum take-off power, a heavily loaded transport takes several seconds to build up airspeed to, say, 25 knots above stalling. If you were to run through a wind shear line that decreased your airspeed by 20 knots just as your wheels started up, you'd probably settle back down on the runway with a thud.

Where to Find Wind Shear

"Wherever there is a temperature inversion you nearly always will have some wind shear. Since inversions form almost every clear night, late night and early morning hours are a good time to be extra wary. Night-time inversion caused by the Great Plains high is sometimes low enough to cause traffic pattern wind shear anywhere from the Appalachians to the Rockies, from Alaska to Texas. The effect is more pronounced when there is a cold high pressure cell spread out over the plains and pushing up against the Rockies. In that area you might find a westerly wind of as much as 40 knots, while at the surface the wind would be nearly calm.

Induces Undershoot

"Another wind shear situation exists where there is a strong surface wind blowing. Moving rapidly over trees, etc., the wind closest to the ground is slowed down so that from 25 to 50 feet above the surface and on up the wind is blowing faster than it is at the surface. This friction-induced wind shear always tends to make you land short.

"It is important to be able to recognize a wind shear situation when you see it.

How to Spot Wind Shear

"1. Look for an inversion below traffic pattern altitude. Smoke rising in one direction for a few hundred feet, then suddenly turning and taking off in another direction above that, is a sure sign. Smoke from high stacks going in a different direction than that from short ones. A flat-topped haze or smoke layer also indicates an inversion. This is usually the best way to spot one of the night-time wind shear inversions.

"2. When the wind at pattern altitude is obviously stronger than that reported by the tower, you have shear. Be on your guard.

"3. When the tower reports strong surface winds, say, over 30 knots, you are apt to have a significant amount of friction-induced shear in the lower 25 to 50 feet. Be prepared.

"4. When you see a thunderstorm approaching the field, watch out for wind shear. It's certain to be there.

How to Counteract Wind Shear

"Landing:

"1. Make your final approach longer and flatter. (Be reasonable, of course, don't drag it in for miles.) This enables you to carry more rpm, making full thrust available to you more quickly, should you need it. Also, with the lower rate of descent, you pass through the shear line slower. You then have more time to adjust your speed to compensate for the changed windspeed in the lower air mass, whether it is causing an over- or an undershoot.

"2. When the tower reports strong surface winds, in addition to your longer and flatter approach, plan to land a little long. With the strong wind, you will be able to stop in plenty of time even if you touch down a few hundred feet from the approach end.

"3. When the surface wind is strong and gusty, allow yourself a little extra margin of airspeed on the final.

"Take-off:

"1. Get plenty of airspeed before you pull up the gear. Accelerate to climb speed as rapidly as possible.

"By following these simple rules, you will practically eliminate the chances of your landing too short or too long, or goofing a take-off because of wind shear." - (Adapted from "Change Without Notice!" USAF "Flying Safety," April, 1956.

Pilots Safety Exchange Bulletin 56-106
dated 10 July 1956

Air Transport Division,
Flight Safety Foundation, Inc.

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FLICKER VERTIGO

Recently the Flight Safety Foundation received a letter concerning an experience involving flicker vertigo. The contents of the letter and some additional information on the subject follow:

"Approaching for a landing at a small midwest field, flying a Culver Cadet directly into a setting western sun, during the latter part of the approach I very nearly passed out and felt a general wave of nausea. I was able to land the aircraft, but taxying further on down the runway I still felt this impending sickness which ceased when I finally turned away from my westerly heading.

"It has been only recently that I read a book called THE LIVING BRAIN, by W. Grey Walter, in which reference is made to the fact that a reaction similar to epileptic seizure can be induced in a perfectly normal subject by means of imposing a flickering light on the subject. When the frequency is critical, subjects can react in various ways, from feeling nausea, to passing out, to actually having the beginnings of an epileptic fit.

"The bright, short flashes at frequencies of 10 to 20 per second seemed to be the critical range for most subjects.

"In a single-engine aircraft, approaching a setting sun, a condition such as this can be reached when the throttle is retarded and the engine operating from 300 to 600 rpm. I believe now that this was the condition that existed at the time of my landing, and that the clinical tests conducted by Dr. Walter indicate the remedy for such a situation would be to increase the engine rpm."

Another Experience From a Pilot Engineer

"During a recent flight in the B-26, a condition was encountered in which vertigo could be induced at will. Vertigo is not really rare, but written reports on it seem to be sufficiently uncommon that I thought the following first-hand account might be of interest:

"Webster defines vertigo as 'dizziness or swimming of the head'. In aeronautical circles the word usually means a loss of the sense of the true vertical, as well as a turning sensation. Furthermore, vertigo doesn't mean merely that one does not know which way is up; one feels strongly that some wrong direction is the proper one. The feeling isn't vague. It is almost overpowering. Vertigo is apparently affected by vision as well as the other cues to balance.

"A hood and instruments were installed in the B-26 to allow the co-pilot to fly on instruments. The hood was made of thin Masonite and consisted of several pieces arranged as a baffle, so the pilot (safety pilot) viewed them edgewise and could therefore see out, while the co-pilot viewed them broadside and could not see out. The piece nearest the co-pilot was about a foot in front of his eyes, and ended on the right side at the structure separating the back of the windshield from the front of the canopy. This piece was not fastened down tightly. It could and did vibrate with a high frequency (probably engine frequency) and very small amplitude. Furthermore, it did not fit tightly against the structure, and light could come in between the structure and the hood piece and shine on the hood.

Reflection produces Flicker

"When the airplane was headed in a certain direction relative to the sun, sunlight did come past the windshield structure and shone on the hood. If the rays of sunlight were nearly parallel to the plane of the hood piece, the vibration of the hood piece made a flickering pattern of light across the brown unpainted Masonite. As soon as the flickering appeared it caused an immediate attack of vertigo. There was no appreciable build-up time required, as is necessary for air sickness for example. The vertigo could be turned on and off at will by holding the hood piece tight against the windshield structure, which both stopped the vibration and shut off the light. The independent effects of light and vibration were not investigated. I believe, but do not guarantee this recollection, that the vertigo persisted about one second after the flickering light was shut off, and that the sense of equilibrium remained upset until it came back and settled down, almost with a click, at the end of the second.

"I thought at first that the hood had slipped and was allowing me to see out and see a hillside rushing by. The vibration and the light on the brown Masonite looked like a hillside covered with trees which had not yet gotten any leaves. This impression was all the stronger because it was known to be a possible one, since the airplane was known to be flying low in hilly country.

Effects

"As soon as the vertigo started I felt very strongly that we were in a steep diving turn to the right. After a short period (perhaps 1/2 to 1 second) of astonishment at such a sudden change in the attitude of an airplane which had been giving me no trouble, I recognized the effect as vertigo and concentrated on the instruments. The instruments did not look real, and appeared to be floating in space, but they could be read all right. However, a lot of will power was required to believe them, and a lot of mental effort was required to force myself to mechanically scan and interpret the instruments by direct intellectual effort instead of by habit. The artificial horizon I was using had about a 7° bank angle error, and I couldn't remember which direction the error was in. I therefore looked across to the pilot's horizon instead of the small electric instrument. The vertigo stopped but it was found by trial that it stopped because turning my head sufficiently to see the other instruments brought it well off to one side. A little investigation showed that it was not possible to see the ground through the crack between the hood and the windshield structure. The impression of ground rushing by remained strong, however.

Corrective Measures

"When the source of the trouble was found, I spent a little time turning the vertigo on and off to study the effect. If we wanted to fly on the heading which put the sun in the proper position to make the light shine nearly parallel to the hood, I had to hold the hood tight against the windshield structure. We solved the problem in practice by flying in some other direction. A 15° change in heading would suffice. It was not just a question of sunlight on the hood. That occurred anytime the sun was beside or behind the airplane. The sun had to shine through the crack nearly parallel to the hood to allow the vibration of the hood to modulate the light. I considered the possibility that the light was shining through the propeller disk and was being modulated by the propeller blades, but the angle was wrong, making this impossible.

Powerful impression

"The most remarkable thing about this experience was the strength of the erroneous impression as to the airplane's attitude. It took real will power to toss out that impression and concentrate on the instruments. I have about 320 hours of instrument time and have given considerable instrument instruction, and I am familiar with the more common forms of loss of equilibrium. For example, there is the slight loss of orientation during recovery from a steep turn on instruments, when one thinks the airplane is turning the other way and the nose is going down. There are also the 'leans', when the pilot gradually begins to think a wing is down. He continues to fly by instruments, but gradually leans his body to one side, and may actually reach quite ludicrous angles if the cockpit is big enough. He suddenly realizes he is leaning and 'recovers' with a start, feeling rather foolish. A third example, which occurs rather often, is one in which the pilot has a rather vague feeling that the airplane is doing something foolish, but the feeling is not strong enough to interfere seriously with his flying. The feeling may persist for a long time, such as an hour.

"There was no possibility of shaking the head or blinking the eyes to break up the false impression in the incident I have been describing, because the source of stimulus was still there and started the vertigo going again immediately.

"As pointed out in the beginning, vertigo is not rare, but this was far the strongest case I have experienced, or even heard of. Furthermore, the ability to turn the vertigo on and off as easily as with a switch was interesting."

SCIENTIFIC COMMENT

"Many thanks for your letter about the effects of flicker in ground lighting systems. I am interested to hear that the disagreeable effects of flicker have been noted and guarded against in these systems, but I think those concerned should be warned that a frequency of 5 to 8 flashes per second in what they call the 'flicker' range can also produce unpleasant effects in certain susceptible individuals, particularly during states of mind such as fatigue and frustration. I would recommend very strongly therefore that rather extensive tests should be made of a large population of young people during the appropriate psychological conditions of annoyance and weariness before this frequency is standardized for conditions in which pilots will be predisposed. The subject has been very extensively investigated in our laboratory and elsewhere and results are in fact used for diagnostic purposes in the clinic.

"You may be interested to know that during the war, the German searchlight system was arranged to flicker for various reasons and although the precise purpose of this was never discovered by our agents, it was found that the main effect was to irritate the pilots. There is a detailed report on this subject by our National Physical Laboratory from as far back as 1940. They found that the worst frequency for searchlight flicker was between 4 and 12 c/s. This is described as having an 'almost sickening effect and the observer has to exercise a certain effort of will to continue looking."

"This subject has come up for discussion many times in aviation medicine and, of course, it is not too much of a problem in commercial aviation with most of the aircraft so arranged that the pilot is sitting in front of his propellers. However, I think it is interesting that in single engine aircraft where the pilot is looking through the propeller the possibility does exist of some stroboscopic effect.

"I learned of this phenomenon several years ago when I attended some lectures in brain wave technique at Harvard University. We have had in this airline some inquiries of the effect on passenger personnel when sitting in the cabin and the propellers are cutting sunlight to give a flashing effect on passengers seated at window seats."

(Pilot Safety Exchange Bulletin 55-110 dated 30 November 1955)

Air Transport Division
Flight Safety Foundation, Inc.

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PART IV

List of Laws and Regulations of the Contracting States containing provisions relating to "Aircraft Accident Investigation"

(Replacing lists in Digests Nos. 5 and 6)

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).

AUSTRALIA

1947	Aug.	6	The Air Navigation Regulations, S.R. No. 112/1947, as amended up to 1 March, 1956: Part XVI.- Accident Inquiry (Reg. 270-297).

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, 1937, as amended up to 13 March, 1956: Part X.- Investigation of Accidents.
1949	August		Notice to Airmen No. 5/1949 - Aircraft Accident and Incident Investigations.

CANADA

1954	Nov.	23	The Air Regulations, Order in Council P.C. 1954-1821, as amended up to 2 February 1956: 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 (Reg. 260-271).

CHINA (TAIWAN)

1953	Oct.	31	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.

CUBA

1954	dic.	22	Ley-Decreto Núm. 1863 por la cual se crea la Comisión de Aeronáutica Civil, Organización y Facultades: Art. 11, 17) Investigación de Accidentes.

CZECHOSLOVAKIA

1947			Decree of Ministry of Interior on accident investigation, No. 1600/47.

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. - Investigación y encuesta de accidentes de aviación.

EGYPT

1941	May	5	Decree: Air Navigation Regulations - Article 10.

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 ministérielle 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.
	déc.	11	Instruction du Secrétariat d'Etat aux Travaux Publics et à l'Aviation Civile n° 200 IGAC/SA, concernant les dispositions à prendre en cas d'irrégularité d'incident ou d'accident d'aviation.

GUATEMALA

1948	oct.	28	Decreto Núm. 563 - Ley de Aviación Civil: Capítulo X. - De los siniestros aeronáuticos (Art. 116-121).

HONDURAS

1950	marzo	14	Decreto Núm. 121 - Ley de Aeronáutica: Cap. IV - Sec. Cuarta - Accidentes y Emergencias (Art. 70-88).

INDIA

1934	Aug.	19	The Indian Aircraft Act, 1934, (corrected up to 1 November 1950): Section 7. - Powers of Central Government to make rules for Investigation of Accidents.
1937	March	23	The Indian Aircraft Rules, 1937, as corrected up to 10 July, 1956: Part X. - Investigation of Accidents (Art. 68-77A).

IRAQ

1939	Aug.	6	Air Navigation Law No. 41: Article 5 (h).

IRELAND

1928			The Air Navigation (Investigation of Accidents) Regulations, S.R. and O No. 21, as amended by Air Navigation (Amendment) Regulations, S.R. and O. No. 288, 3 August 1943.
1936			The Air Navigation and Transport Act, No. 40: Part VII - Section 60 - Investigation of Accidents. This Act has been amended by Amendment Acts No. 10, 1942; No. 23, 1946 and No. 4, 1950.

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).

MEXICO

1949	dic.	27	Ley de Aviación (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	Sept.	10	Law - Investigation of Accidents to civil aircraft, amended by Law of 31 December, 1937, (concerns inter alia the greater part of the provisions of Annex 13).
1936	Sept.	22	Royal Decree: Application of paras. 8 and 9 of Article 1 and of para. 5 of Article 32 of the Law dated 10 September, 1936.
	Sept.	22	Royal Decree: Application of para. 2 of Article 6 of the Law of 10 September, 1936.

NEW ZEALAND

1948	Aug.	26	The Civil Aviation Act, 1948: Art. 8. - Power to provide for investigation of accidents.
1953	Nov.	11	The Air Navigation Regulations, Serial No. 152/53, (made in accordance with ICAO Annex 13).

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 up to 1950: VIII. - Aircraft Accidents.

PAKISTAN

1934	Aug.	19	The Aircraft Act, No. XXII of 1934 (corrected up to 26 October 1950): Para. 7. - Power of Central Government to make rules for investigation of accidents.

PAKISTAN (Cont'd)

1937	March 23	The Aircraft Rules, (corrected up to 14 April 1953): Part X. - Investigation of accidents.

PHILIPPINES

1946	May 9	Civil Aviation Regulations: Chap. XVI. - Aircraft Accident Regulations.
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.

SPAIN

1948	marzo 12	Decreto del Ministerio del Aire sobre investigación de accidentes y auxilio de aeronaves.

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. 21	Loi fédérale sur la navigation aérienne (entrée en vigueur le 15 juin 1950): Articles 22-26.
1950	juin 5	Règlement d'exécution de la loi sur la navigation aérienne: XIV. - Accidents d'aéronefs (Articles 129-137).

UNION OF SOUTH AFRICA

1923	May 21	Aviation Act No. 16: Article 10. - Investigation of Accidents.
1949	Dec. 30	The Air Navigation Regulations, No. 2762, 1950, as amended up to 17 September, 1954: Chapter 29. - Investigation of Accidents (Regulations 29.1 - 29.7).

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.

UNITED KINGDOM (Cont'd)

1954 June 24 The Air Navigation Order, S.I. No. 829, as amended up to 3 August 1956: Part VI. - Article 70 - Application of accident regulations to aircraft belonging to or employed in the service of Her Majesty.

UNITED KINGDOM COLONIES

1949 Oct. 28 Article 69 of the Colonial Air Navigation Orders, 1949 to 1954, 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
Cyprus
Falkland Islands and Dependencies
Fiji
Gambia (Colony and Protectorate)
Gibraltar
Gilbert and Ellice Islands Colony
Gold Coast - (a) Colony
(b) Ashanti
(c) Northern Territories
(d) Togoland under United Kingdom trusteeship
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
Nigeria - (a) Colony
(b) Protectorate
(c) Cameroons under United Kingdom trusteeship
North Borneo
St. Helena and Ascension
Sarawak
Seychelles
Sierra Leone (Colony and Protectorate)
Singapore
Somaliland Protectorate
Swaziland
Tanganyika
Trinidad and Tobago
Uganda Protectorate
Windward Islands - Dominica
Grenada
St. Lucia
St. Vincent
Zanzibar Protectorate.

UNITED KINGDOM COLONIES (Cont'd)

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, 1953 (S.I. 1/54).

CYPRUS

1952 Nov. 17 Civil Aviation (Investigation of Accidents) Regulations (G.N. 517/1952).

FIJI

1952 May 1 Civil Aviation (Investigation of Accidents) Regulations (L.N. 90/52).

GAMBIA

1937 May 1, Nov. 25 Air Navigation (Investigation of Accidents) Regulations, No. 8 and No. 17 of 1937.

GIBRALTAR

1952 Jan. 3 Air Navigation (Investigation of Accidents) Regulations, 1952.

GOLD COAST

1937 Feb. 17 Aircraft (Accident) Regulations, No. 5/1937.

HONG KONG

1951 Air Navigation (Investigation of Accidents) Regulations (G.N. 228/51).

JAMAICA

1953 March 24 Air Navigation (Investigation of Accidents) Regulations (G.N. 37/53).

LEEWARD ISLANDS

1952 July 31 Civil Aviation (Investigation of Accidents) Regulations (S.R.O. 18/52).

UNITED KINGDOM COLONIES (Cont'd)

MALAYA (FEDERATION OF)

1953 Nov. 1 Air Navigation (Investigation of Accidents) Regulations (L.N. 584/53).

MALTA

1952 Sept. 2 Civil Aviation (Investigation of Accidents) Regulations.

MAURITIUS

1952 Sept. 4 Civil Aviation (Investigation of Accidents) Regulations (G.N. 200/52).

NIGERIA

1953 April 28 Civil Aviation (Investigation of Accidents) Regulations (No. 15/1953).

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. S 6/54).

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).

ZANZIBAR

1937 Sept. 4 Air Navigation (Investigation of Accidents) Regulations (G.N. 41/1937).

FEDERATION OF RHODESIA AND NYASALAND

SOUTHERN RHODESIA

1952 Jan. 25 Air Navigation Regulations, as amended up to 4 December, 1953:
Part 18. - Investigation of Accidents.

UNITED STATES OF AMERICA

1938			Civil Aeronautics Act - Title VII (Air Safety).
1949	May	1	Civil Air Regulations - Part 62 - Notification and reporting of aircraft accidents and overdue aircraft, (as issued effective May 1, 1949, 14 F.R. 1516; revised effective February 11, 1954, 19 F.R. 891).
1950	Sept.	15	Economic Regulations - Part 303 - Rules of practice in aircraft accident investigation information.
	Sept.	15	Economic Regulations - Part 311 - Disclosure of aircraft accident investigation information.
1951	May	14	Civil Aeronautics Board - Organizational Regulations - Description of Functions: Course and method by which functions are channeled - Scope and contents of documents - Hearings concerning accidents involving aircraft.
1952			Title 22 - Foreign Relations - Part 134 - Civil Aviation; Aircraft Accidents (issued in Department Regulations 108.164, effective October 1, 1952, 17 F.R. 8207).
1954			Public Notice PN 7 - Administrator of Civil Aeronautics: Delegation of certain accident investigation functions, (as issued, effective January 1, 1954, 18 F.R. 7499; reissued as Public Notice PN 7 and amended, April 13, 1954, 19 F.R. 2133).
1954			Public Notice PN 8 - Delegations of final authority related to substantive program matters (as issued, effective October 27, 1954, 19 F.R. 7418): Section 7. Director, Bureau of Safety Investigation.
1955			Economic Regulations - Part 399 - Statements of General Policy, as issued, effective May 25, 1955: Section 399.26 - Investigation of Accidents involving foreign aircraft.
1956			Public Notice PN 10 - Statement of Organization (as issued, effective January 1, 1956, 21 F.R. 3481): 1.3 Functions.

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.

- END -

ICAO TECHNICAL PUBLICATIONS

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

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

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

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

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

ICAO FIELD MANUALS have no status in themselves but 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 PLAN documents 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.

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Annex 13 — Aircraft accident inquiry.
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MANUAL

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(Doc 6920-AN/855). 2nd edition, October 1951. . . . . **$0.75**

ICAO CIRCULARS

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