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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 accident prevention also contributes to the reduction of accidents.

The first summary of accident reports and safety material received from States was issued in October 1946 (List No. 1, Doc 2177, AIG/56) under the title of "Consolidated List of publications and documents relating to Aircraft Accident Investigation Reports and Procedures, Practices, Research and Development Work in the field of Aircraft Accident Investigation received by the 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 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 commen 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 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 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 reflect the views of the International Civil Aviation Organization.

A change has been made in this issue by the addition of Part II "Aircraft Accident Statistics". The material in this Part has been derived to a large extent from Air Transport Reporting Form G, submitted by States and covers the years 1952, 1953 and 1954. Subsequent issues of this Digest will contain similar material.

Owing to the length of some of the Accident Reports and the introduction of this new statistical material covering three years, the part dealing with Publications and Reports included in past issues of the Digest, has been omitted from this issue.

ACCIDENT CLASSIFICATION TABLE AND SUMMARY OF REPORTED ACCIDENT CAUSES - 1954

This issue of the Digest contains forty-four reports of aircraft accidents occurring in 1954 prepared from reports received from States.

The Digest contains for the second time an accident classification table which is based primarily on the phase of operation and is intended to provide an ample 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 table 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.

This classification of accidents closely follows the suggestions contained in the ICAO Manual of Aircraft Accident Investigation (Doc 6920-AN/855). While the table 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 classification has been based on accident reports which have been founded on a variety of reporting and analyzing techniques. Also the accidents reported in 1954, and included in this classification, 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. Further, no effort has been made in this report 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 the table.

It has been suggested that the table be based on accident cause instead of phase of operation, the trend in causes being of more interest to the reader. It was not possible, however, to include this aspect in this issue but a second table based on causes will be included in our next issue.

Although considerable care has been taken in drawing up the table to ensure that the information contained therein in no way alters the findings of the reports from States, the very brevity of the table might give a wrong impression in some instances. The reader is, therefore, invited always to refer to the report in the Digest.

A survey of the accident reports for 1954 suggests that the following features are worthy of attention:

i) 31% of the accidents reported occurred during the en-route phase (a 12% decrease when compared with the 1953 percentage); of these, 50% were collisions with terrain or water.

ii) 44% of the accidents reported occurred during the approach and landing stages and of these 30% were collision with terrain or water and 25% were due to undershooting the runway. This is a further breakdown than given in Digest No. 5, the reason being given in sub-section (v).

iii) Of the remaining 25% of the accidents reported which occurred during the take-off and climb stages, 60% were during the initial climb phase.

iv) Of all the accidents, 60% were reported to have been probably due to pilot error. This figure indicates a 5% increase over last year's number. However, caution should be exercised in accepting these figures, due to the many variations in the manner of definiting pilot error, without due regard to the reasons set out in those accident summaries relating to pilot error. Examination of these accidents indicates that four were due to failure to carry out normal climb-out procedures and inexperience in emergency procedures, three were caused by inadequate flight planning, two collisions were because of failure to observe the other aircraft and ten were due to approved approach procedures not being carried out together with factors such as fatigue and reduced visibility. The remaining accidents due to pilot error were ascribed to miscellaneous reasons.

v) It should be noted that five accidents occurred during 1954 which have been classified as "undershoots" which might previously have been classed as "collisions with terrain or water". However, because of the fact that several cases have been reported of aircraft primarily undershooting the runway and then secondly colliding with terrain or water it has been decided that these accidents should be placed under the former classification.

vi) No accidents were reported during 1954 as "missed landings".

vii) Fatigue as a contributing factor was mentioned in some of the 1954 reports, notably Reports No. 11, 40 and 41. Due to the increased interest in studies in this subject and the part that fatigue might play in causing aircraft accidents, full details of these investigations are included to show that although fatigue was not the major cause of the accident still it might have had noteworthy effects on the ability of the pilot to judge his distance on approach and react in his usual satisfactory manner. Another point to be noted, in the case of Report No. 11, is the fact that the co-pilot was relatively inexperienced thereby causing unequal distribution of work load.

The on duty and flight time element and its effect on the fatigue question (Reports Nos. 40 and 41)is another point which has been considered in accidents during 1954.

Report 40 shows a period of sixteen hours on duty which is not generally thought of "as a long day for a crew to be on duty provided that adequate rest has been secured prior to the flight". The accident has been attributed to negligence on the part of the pilot.

Report 41 states that the time en route (twenty-two and one half hours) and its extension for another two and one half hours strongly suggests the possibility of fatigue especially during the last approach when the pilot showed poor adherence to the localizer path, slow response to wind shift, descent to a very low altitude, and abrupt control action.

viii) Two reports of helicopter accidents (Nos. 20 and 39) have been included in this issue.

ix) Report No. 2 presents together the investigations of the two B.O.A.C. Comet crashes.

ACCIDENT CLASSIFICATION - 1954

Phase of Operation	No.	Type of Accident	No.	Apparent Cause	No.	Description	No.	ICAO Ref.	* Type of Operation	Page
Take-off Run	2	Ground loop	1	Material failure	2	Loss of power followed by sudden picking up of No. 1 engine, added to inherent tendency of aircraft to veer to the left.	1	AR/309	S	13
		Nose over	1			Burst tire during take-off.	1	AR/341	NS	130
Initial Climb	6	Wheels-up landing	2	Material failure	2	Failure of right elevator trim tab push-pull rod due to reversed installation of right elevator trim tab idler.	1	AR/325	S	86
						Mechanical failure of torquemeter boost pump that automatically feathered left propeller. Incorrect procedure for unfeathering.	1	AR/313	S	46
		Other collisions	1	Pilot error	1	Failure of one engine and delay in feathering due to inexperience in emergency procedures.	1	AR/335	NS	101
		Collision with terrain or water	3	Pilot error	2	Failure to co-relate and interpret instrument indications during flap retraction.	1	AR/351	S	
						Took aircraft into air at speed below minimum control speed after loss of directional control during ground run.	1	AR/374	T	163
				Weather	1	Rapid loss of airspeed due to strong gusts or divergent winds accompanying local rain shower.	1	AR/336	S	118
Climb after Take-off	2	Collision with terrain or water	2	Material failure	1	Excessive climbing angle and stall due to engine failure and icing.	1	AR/370	NS	176
				Pilot error	1	Failure to carry out normal climb-out procedure and turn to left instead of right thus flying into mountains.	1	AR/326	S	143
En route	14	Airframe failure in flight	2	Material failure	2	Structural failure of pressure cabin due to material fatigue.	2	AR/357	S	16
						Inadequate flight preparations leading to ice accretion and loss of control.	1	AR/338	NS	56
		Collision with terrain or water	7	Pilot error	4	Descent below minimum altitude specified.	1	AR/366	S	97
						Pilot continued VFR flight into unfavourable weather.	2	AR/368 AR/396	S S	170 160
				Undetermined	1	Sudden emergency under adverse weather conditions.	1	AR/327	S	99
				Weather	2	Unable to maintain altitude due to heavy rain, divergent winds, and strong downdrafts.	1	AR/331	S	153
						Encountered downdraft at too low an altitude to avoid crashing.	1	AR/356	NS	158
		Stall	1	Pilot error	1	Attempted to maintain altitude by frequent trimming of automatic pilot without further reference to air speed indicator and without increasing power.	1	AR/345	NS	68
		Collision with other aircraft	1	Pilot error	1	Failure to observe other aircraft.	1	AR/359	S	93
		Other collisions	1	Material failure	1	Failure of main rotor blades due to striking cable.	1	AR/342	NS	113
		Emergency condition (immediate forced landing)	2	Pilot error	1	Fuel exhaustion caused by inadequate flight planning.	1	AR/340	S	131
				Material failure	1	Bearing failure of No. 3 engine generator.	1	AR/358	NS	115

ACCIDENT CLASSIFICATION - 1954 (Cont.)

Phase of Operation	No.	Type of Accident	No.	Apparent Cause	No.	Description	No.	ICAO Ref.	Type of Operation*	Page
Landing Procedure	2	Collision with terrain or water	2	Pilot error	2	Improperly executed approach.	2	AR/376 AR/350	S S	180 188
Final Approach	11	Collision with terrain or water	4	Weather	1	Loss of control due to icing conditions and use of deicer boots at low air speeds.	1	AR/337	NS	49
				Pilot error	3	Exhaustion of fuel in starboard main tank to which both engines had been selected.	1	AR/346	S	105
						Fuel exhaustion due to inadequate flight planning.	1	AR/329	NS	205
						Erratic approach resulting in descent to an altitude too low to avoid striking pier. Pilot fatigue was a contributing factor.	1	AR/383	S	197
		Other collisions	1	Pilot error	1	Approved procedures for ILS approach not followed and aircraft struck a tree.	1	AR/312	S	64
		Undershoot	5	Pilot error	5	Misjudged approach due to ground fog patch and unconscious reversion to landing technique for other type of aircraft.	1	AR/371	S	54
						Did not conform to desirable safe flight path.	1	AR/360	S	70
						Because of lack of knowledge of terrain, aircraft struck a mound on approach to runway.	1	AR/310	NS	52
						Misjudged distance due to reduced visibility caused by low cloud.	1	AR/380	S	211
						During single engine approach the aircraft was allowed to stall and struck the ground short of the runway.	1	AR/372	NS	151
		Collision with other aircraft	1	Pilot error and errors of other personnel	1	Traffic control situation created by air traffic controller in tower. Failure of both crews to observe the other aircraft.	1	AR/333	S	121
Landing Run	7	Overshoot	2	Pilot error	2	Too high approach, excessive threshold speed and failure to apply proper stopping-technique.	1	AR/317	S	90
						Failure to execute a missed-approach procedure.	1	AR/373	S	178
		Ground or water loop	2	Material failure	1	Failure of port undercarriage back stay attachment fitting causing collapse of undercarriage and swinging of aircraft off the runway.	1	AR/324	NS	109
				Undetermined	1	-	1	AR/343	S	111
		Collapse or retraction of landing gear	1	Pilot error	1	Accidental retraction of landing gear before the safety system became effective.	1	AR/355	S	156
		Wheels-up landing	1	Pilot error	1	Omission of actuation of undercarriage to the extended position prior to landing.	1	AR/379	S	140
		Heavy landing	1	Weather	1	Intense rain and gusts causing loss of visual reference to the runway and loss of air speed resulting in hard nose-low landing which failed the landing gear.	1	AR/354	S	173
Missed Landing	-	-		-		-				

* S = Scheduled NS = Non-scheduled T = Training

† The report of this accident has been withheld pending a further investigation by the State of Registry and will be included in Digest No. 7.

†† The report relating to Comet G-ALYY indicates the cause as undetermined but probably due to structural failure.

PART I

No. 1

Compagnie Air Liban Languedoc Bloch 161 aircraft swung on take-off at Beyrouth International Airport on 6 January 1954. Directorate of Civil Aviation, Lebanon, Accident Report No. 7

Circumstances

The aircraft using Runway 18 was departing at 0352 on a scheduled flight from Beyrouth to Kweit with 5 crew, 4 passengers and cargo. The aircraft behaved normally on take-off for the first 450 metres until it reached its critical speed (90 mph) when it swerved to the left. The captain took corrective action and the aircraft travelled a further 50 metres parallel to the centre line of the runway and then suddenly swerved to the right. Corrective action to prevent the swing was in vain and the throttles were closed and brakes applied. The aircraft continued to swerve and 70 metres further on, left the runway. The speed at this time was about 50 - 60 mph. After leaving the runway, the aircraft rotated 70° to the left, the left landing gear collapsed and the aircraft burst into flames. The crew and passengers were safely evacuated.

Investigation and Evidence

The investigation considered a number of factors that might have caused the accident, such as unlocked tailwheel, defective rudder trim tabs, defective brakes and failure of the wing flap jacks. These factors were rejected. Evidence showed that when the aircraft reached its critical speed (90 mph) and as it swerved to the left, the flight engineer standing between the pilot's and co-pilot's seats, noticed a reduction in the manifold pressure and engine speed of No. 1 engine. The pressure fell from 48 inches to 42 inches and the engine speed from 2,500 rpm to 2,200 rpm. This sudden reduction caused the flight engineer to look around to check his own station instruments. The readings of both the oil temperature and pressure gauges were normal. Resuming his initial position, he found the manifold pressure and engine speed on No. 1 engine had returned to normal. Meanwhile, the pilot, unaware of the reduction in pressure and engine speed, opened up No. 1 engine and eased back on No. 4 engine at the same time giving right rudder to correct the swing to the left. A sudden picking up of No. 1 engine just as the pilot was counter-acting the left swing, had the effect of sending the aircraft into a swing to the right. In view of the very great inertia of the aircraft and the sharp curve, all the efforts of the pilot to correct this swing proved in vain, and the aircraft ran off the runway.

The cause of failure (and subsequent picking up) of No. 1 engine could not be ascertained due to the damage sustained by the engine. Possibilities could only be considered and these wer

a) air lock in the carburettor or fuel system;

b) water in the carburettor;

c) defective carburettor diaphragm.

A test flight was made on 10 January 1954 on a similar aircraft. The test involved two take-offs, one made at 0753 Z and the second at 0805 Z. The tendency of this aircraft to veer to the left was demonstrated during the take-off run. It was further proved that it is very difficult, if not impossible, to control the turning of the aircraft simply by using brake differential and without the assistance of the outer engines. During the take-off, it was necessary to correc the tendency of the aircraft to veer to the left by applying slight pressure to the right rudder pedal. This was also necessary on landing.

Recommendations

1. The procedure followed on take-off was as follows: The co-pilot handled RT communications and was assigned no particular duties unless specifically directed by the pilot-in-command to perform certain functions.

The flight engineer stood between the pilot's and co-pilot's seats. He assisted the pilot in starting the engines and watching the throttle levers to see that they did not slip back. He locked the tail wheel and checked the flight instruments on the pilot's panel. He also was required to look back to check on the readings of the instruments at the flight engineer's station.

The radio operator also had to remain standing without any specific duties leaving the cockpit clear in order not to hamper the movement of the flight engineer. Thus, during both take-off and landing, the flight engineer and the radio operator are standing and are therefore, almost certain to be seriously injured in the event of a crash or if the aircraft overturned.

It was therefore recommended:

a) that the co-pilot be made responsible for the flight engineer's duties in connecti with starting the engines, locking the tailwheel, reading the instruments on the pilot's panel and throttling down the engines after take-off;

b) the flight engineer should be in his seat with his safety belt fastened. He should be responsible for checking the instruments at his station and be able to raise the landing gear without rising. He should remain seated until the take-off is completed;

c) the radio operator should remain in his seat with his safety belt fastened until the take-off is completed.

2. The two cargo compartments aft of the passenger cabin and forward of the main door should be eliminated. According to the statements of the stewardess and one of the passengers, the cargo in these compartments had broken the webbing holding it in place, and had spilled into and blocked the passageway, compelling those who were in the cabin to climb or jump over the obstruction. This could have caused such confusion that lives might have been lost, particularly if the number of passengers had been greater.

It was necessary, therefore, to re-locate these compartments forward of the cabin, between the main bulkhead behind the cockpit and the covering of the main spar in the cabin. Furthermore, the webbing should be much stronger or should be replaced by chains.

The space reserved for passengers would extend from the mainspar to the rear. The passageway leading to the main door would thus always be kept clear.

3. It should be possible to close off the compartment behind the cockpit by means of webbing or metal chains in order to prevent the contents spilling out and blocking the exit from the cockpit to the cabin, as happened in this accident. If fire breaks out on the right hand side, the crew members can escape by this door only, and it is, therefore, necessary that it be kept clear at all times.

4. The take-off procedure for the Languedoc should mention the particular tendencies of the aircraft, and specify the action to be taken if the aircraft veers to one side.

The take-off of a Languedoc aircraft which veers either to the right or to the left should never be completed if the speed when it begins to veer is less than 100 miles per hour.

The following suggestion is made regarding the procedure to be applied in such cases:

When a Languedoc aircraft veers to the left or right on take-off at a speed of less than 100 mph, the throttles of all four engines should immediately be completely closed. Immediately thereafter the throttle of the outer engine on the side to which the aircraft is

turning should be opened and then closed again. The brakes should be applied as soon as the speed permits. The aircraft should then return to the end of the runway, carry out run-up procedure, test the engines at full power, and then resume take-off if nothing abnormal is noted.

Probable Cause

The accident was due to a loss of power followed by a sudden picking up of No. 1 engine, added to the inherent tendency of the aircraft to veer to the left. The flight engineer noticed this loss of power but did not warn the pilot before checking the instruments at his own station. Having noticed that his instruments read normally, and finding, on turning back to the pilot's panel, that the engine had picked up, he did not consider it necessary to report the loss of power to the pilot-in-command.

The pilot-in-command must have presumed the swerving of the aircraft to be normal and have corrected the motion of the aircraft on that basis. Owing to the complexity of the flight engineer's duties on take-off and to the fact that he had to stand, thus being subject to inertia and centrifugal forces, he was hampered and delayed in his motions.

The aircraft was destroyed as a result of the fact that, in running over sandy ground, its left wheel sank into a soft spot causing the left attachment fitting of the left landing-gear to break. In collapsing, the landing-gear caused No. 1 and No. 2 engines to come into contact with the ground.

The fuel cocks and the cut-off valves were not closed. Fire broke out on the left wing and destroyed the aircraft.

No. 2

B.O.A.C. (British Overseas Airways Corporation) de Havilland 106 Comet Series 1's, G-ALYP and G-ALYY (on Charter to South African Airways). G-ALYP crashed into sea off Elba, Italy, on 10 January 1954 and G-ALYY crashed into the sea off Naples on 8 April 1954. Civil Aircraft Accident Report C.A.P. 127, published by H. M. Stationery Office, London, England.

Circumstances

First Accident

The Comet G-ALYP (Yoke Peter) left Ciampino airport, Rome, at 0931 hours on 10 January 1954 on a flight to London with 29 passengers and 6 crew. After taking off the aircraft was in touch with Ciampino control tower by radio telephone and from time to time reported its position. These reports indicated that the flight was proceeding according to flight plan and the last of them, which was received at 0950 hours, said that the aircraft was over the Orbetello Beacon. The captain of another BOAC aircraft, an Argonaut, gave evidence of communications which passed between him and Yoke Peter. The last such message received by the Argonaut began "George How Jig from George Yoke Peter did you get my" and then broke off. The captain of the Argonaut gave it as his opinion that the message was not merely interrupted by another aircraft but that transmission ceased after the word "my" and he estimated that the message was received by him at approximately 0951 hours.

The evidence of four witnesses from Elba suggested that Yoke Peter must have crashed into the sea at about 1000 hours and it therefore appeared that something happened to the aircraft with catastrophic suddenness which may have accounted for the interruption of the transmission of the last message to the Argonaut. It was also clear from the evidence of the Elba witnesses that part of Yoke Peter fell into the sea in flames.

The chart (Figure 1) contains the estimated flight track of the aircraft and the position in which bodies and wreckage were found. It was estimated that at 0951 hours the aircraft was probably approaching a height of 27 000 feet.

Second Accident

The Comet G-ALYY (Yoke Yoke) left Ciampino Airport, Rome, at 1832 hours on 8 April 1954 on a flight to Cairo with 14 passengers and 7 crew. After taking off, the aircraft gave its position from time to time by radio telephone to Rome Air Control at Ciampino and on the last such occasion at about 1857 hours reported that it was abeam Naples and climbing to 35 000 ft. This position and those given earlier indicate that the flight was proceeding according to flight plan. At 1905 hours Cairo received a signal from the aircraft reporting its departure from Rome and giving its estimated time of arrival at Cairo. Thereafter no message was received from Yoke Yoke and all attempts to make contact failed. A chart (Figure 1) shows the probable flight track of the aircraft. It also indicates the position in which bodies and wreckage were found on the day following the accident. It was evident that something catastrophic happened to the aircraft at about 1910 hours when it must have been at or near the end of its climb to 35 000 ft.

Investigation and Evidence

The report commences by outlining the functions of the Air Registration Board, the Air Safety Board, the Royal Aircraft Establishment and the de Havilland Aircraft Company of the United Kingdom, and continues with a summary of the history of the Comet from its first conception.

At the end of the war de Havillands were faced with the problem of recommencing the manufacture of civil aircraft. During the war they had been building only military aircraft. They decided that it would be inadvisable merely to build another version of the conventional aircraft; with this end in view, they commenced design by the end of September 1946. Some idea, however, of the amount of work involved is indicated by the fact that it was not until 27 July 1949 that the first prototype Comet made its first flight.

Throughout the design de Havillands relied upon well-established methods, essentially the same as those in general use by aircraft designers. But they were going outside the range of previous experience and they decided to make thorough tests of every part of the cabin structure. They had not only to prove to their own satisfaction that their design was basically sound, but also to investigate the effect, on the large variety of materials involved, of the extreme conditions which would be met. They gave special attention to the structural integrity of the pressure cabin.

For the design of the basic structure of the cabin they adopted a multiple of the working pressure difference, P, in excess of current requirements in any country. The British Civil Airworthiness Requirements (BCAR) called for a "proof" pressure of 1/2 P (under which the cabin must show no signs of permanent deformation) together with a "design" pressure of 2 P (at which the material may reach its ultimate strength). These requirements were the same as those of the International Civil Aviation Organization (ICAO) and also those of the United Kingdom for military transport aircraft. De Havillands used a design pressure of 2 1/2 P and tested the cabin to 2 P. Two test sections of the cabin were built.

The Company had two reasons for adopting these substantially higher figures. They believed, and this belief was shared by ARB and other expert opinion, that a cabin which would survive undamaged a test to double its working pressure, 2 P, would not fail in service under the action of fatigue due to the pressurization to working pressure, P, on each flight, and to other fluctuating loads to which it is subjected in operations. Secondly they considered that it would ensure a larger margin of safety against the possible failure of windows, doors and hatches.

So much importance did they attach to this latter consideration that they made many tests of window panes to very high pressure. In addition, they applied pressures of between P and 2 P some 30 times to the test section of the front part of the cabin together with a series of 2 000 pressurizations to rather over P. These tests were not intended as a test of the fatigue-resisting properties of the structure, but rather as providing an assurance that the cabin would be satisfactory as a pressure vessel. They undoubtedly contributed to de Havillands' confidence in the soundness of the cabin.

Simultaneously with the design and testing of the pressure cabin, all other parts of the structure were receiving treatment based on the same outlook - design to at least the current requirements, coupled with exhaustive tests. The wing is of special interest since it is here that the requirements specifically directed to resistance to fatigue first became important. During the period 1949 to 1951 there had been growing among all aircraft designers and users, a realization that the life of the essential structure of an aircraft is not unlimited. In the light of this knowledge, repeated loading tests of the wings of transport aircraft became accepted as necessary. Tests of the Comet's wing were made in close co-operation with RAE.

Until about the middle of 1952 the likelihood that the fatigue resistance properties of a pressure cabin demanded further precaution, either in design or by test, than were provided by the current static strength requirements had not been realized. The matter first came to de Havillands' notice through the problem on Service (RAF) transport aircraft. The Joint Airworthiness Committee (JAC) of the Ministry of Supply, Draft Requirements (Paper 579, Oct. 1952) called for a static test to 2 P, a proof test to 1 1/3 P together with repeated loading tests of 1 1/4 P applied 10 000 times.

At about the same time ARB were reviewing the civil position. In due course, they issued proposals in Paper No. 230 (19 June 1953) which called for the same static test to 2 P and proof

test to 1 1/3 P but raised the number of applications of 1 1/4 P to 15 000. At the same time the paper suggested that certain structural parts, such as riveted joints, door and window frames, etc. might have to be designed to 3 P (on the ultimate strength of the material) in order to meet these requirements. It also stated that the figure of 15 000 was intended to cover the number of applications of P during the life of an aircraft, and the test pressure of 1 1/4 P was intended to cover the phenomenon of "scatter" in the fatigue strength of different cabins built to the same design.

The result of these developments was that in July 1953, de Havillands reconsidered the position of the Comet's cabin. Up to that time no Comet had exceeded 2 500 hours flying - say 800 pressurized flights. In order to discover its probable safe working life, they carried out repeated loading tests of the test section of the fore part of the cabin, applying the working pressure P about 16 000 times. By September, 1953, this specimen had withstood 18 000 applications of P in addition to some 30 earlier applications of pressures between P and 2 P.

These tests were ended by a failure of the skin in fatigue at the corner of a window originating at a small defect in the skin, but the number of pressurizations sustained was so large that, in conjunction with the numerous other tests, it was regarded as establishing the safety of the Comet's cabin with an ample margin.

Meanwhile, on 2 May 1953, Comet G-ALVY had crashed in a tropical storm of exceptional severity near Calcutta. An inquiry was directed by the Central Government of India and the court reported on 26 May 1953 that the accident was caused by structural failure of the airframe during flight through a thundersquall. Fatigue failure of the cabin was not then suspected as a cause, and it was the opinion of the court that the evidence adduced in the course of the present Inquiry afforded no sufficient reason for doubting the conclusion of the Indian Court.

After detailing the circumstances of the accident on 10 January, the action taken by the Ministry of Transport and Civil Aviation and the steps taken for the salvage of the wreckage by the Royal Navy, the Report goes on to deal with the deliberations of the Abell Committee.

The Abell Committee - Immediately on receiving news of the accident to G-ALYP, BOAC decided to suspend their normal Comet passenger services, for the purpose of carrying out a detailed examination of the aircraft of the Comet operational fleet in collaboration with ARB and de Havillands and to this end the Chairman of BOAC called a meeting at London Airport for 11 January 1954, which was attended by representatives of BOAC, the Accidents Branch of the Ministry of Transport and Civil Aviation, de Havillands, the de Havilland Engine Company Limite and ARB. As a result of that meeting a Committee under the chairmanship of the Deputy Operations Director (Engineering) of BOAC and composed of representatives of ARB, BOAC, and de Havillands was appointed to consider what modifications were necessary. According to the evidence, they came to the view that possible main causes of the accident were as follows:

a) Flutter of control surfaces: It was decided to make an inspection of the whole of the control mechanism.

b) Primary structural failure: They considered, in particular, the possible effects of gusts, and surveyed all parts of the structure of which there was any suspicion in the light of previous experience.

c) Flying controls: Many possible sources of malfunctioning both of the hydraulic power units themselves and of these mechanical circuits were examined and special investigations initiated.

d) Fatigue of the Structure: They had in mind more particularly fatigue of the wing. They re-examined also one or two other parts of the structure at which they felt fatigue effects might be appearing.

e) Explosive decompression of the pressure cabin: They had no reason to suspect the primary structure of the cabin itself. Their main concern, however, was the window panels, where they thought it necessary to consider possible defects which might cause weakness not revealed in the tests made during the design at de Havillands.

f) Engine Installation: Their main preoccupation here was with the possibility of fire and investigations were made at a number of points in order to remove every cause of possible fire risk which they could imagine.

As a result of the inspections and tests which followed the meetings of the Committee, a large number of modifications were made both to the power plants and to other parts mentioned above. At the conclusion of their work the Committee still regarded fire as the most likely cause of the accident.

Following the report of the Abell Committee, BOAC, the ARB and the ASB indicated to the Minister of Transport and Civil Aviation that they saw no reason for not resuming Comet services when the modification programme was completed. Acting on this advice, the Minister gave permission for flights to be resumed and the first Comet aircraft to resume passenger service took the air on 23 March 1954.

On 8 April 1954, Comet Aircraft G-ALYY which was on charter to South African Airways crashed near Naples while on a flight from Rome to Cairo. The accident occurred at approximately the same height and after approximately the same lapse of time after departure from Rome as in the case of Yoke Peter. On receiving news of the accident, BOAC decided immediately to suspend all Comet services until more was known and on 12 April 1954, the Parliamentary Secretary to the Minister of Transport and Civil Aviation informed the House of Commons that the Minister, after consulting ARB and ASB and discussing the matter with the Chairman of ARB, had withdrawn the United Kingdom Certificate of Airworthiness from all Comet aircraft.

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The loss of Yoke Peter and Yoke Yoke presented a problem of unprecedented difficulty, the solution of which was clearly of the greatest importance to the future not only of the Comet, but also of Civil Air Transport in the United Kingdom, and indeed, throughout the world. Accordingly, shortly after the Naples accident, the Minister of Supply instructed the Director of RAE to undertake at RAE a complete investigation of the whole problem presented by the accidents and to use all the resources at the disposal of the Establishment.

The RAE Report (which was part of the evidence before the Court) is divided into twelve parts. The first part contains an outline of the investigation and states the opinion RAE formed as to the cause of the accident. Paragraph 4 thereof which states the opinion of RAE is in the following terms:

"We have formed the opinion that the accident at Elba was caused by structural failure of the pressure cabin brought about by fatigue. We reach this opinion for the following reasons:

i) The low fatigue resistance of the cabin has been demonstrated by the test described in Part 3 and the test result is interpretable as meaning that there was, at the age of the Elba aeroplane, a definite risk of fatigue occurring (Part 3).

ii) The cabin was the first part of the aeroplane to fail in the Elba accident (Part 2).

iii) The wreckage indicates that the failure in the cabin was of the same basic type as that produced in the fatigue test (Parts 2 and 3).

iv) This explanation seems to us to be consistent with all the circumstantial evidence.

v) The only other defects found in the aeroplane (listed in Section 3), were not concerned at Elba, as demonstrated by the wreckage.

Owing to the absence of wreckage, we are unable to form a definite opinion on the cause of the accident near Naples, but we draw attention to the fact that the explanation offered above for the accident at Elba appears to be applicable to that at Naples."

It should be added that the medical evidence as to the state of the bodies recovered was consistent with the conclusion thus reached.

The "other defects" mentioned in sub-paragraph (v) quoted above are:

a) Relatively low resistance of the wing to fatigue,

b) Possibility of fuel from the fuel tank venting system entering the trailing edge area of the wing near the jet pipe shrouds.

c) Risk of internal damage during refuelling to the outer wing tanks under conditions which, though abnormal, may sometimes have occurred in practice.

RAE made a complete review of the conclusions which had been reached by the Abell Committee, and particularly of the implications arising from the fact that there had been two accidents in what appeared to be similar conditions, each occurring at about the same time when the aircraft was nearing the top of its climb. They thought it necessary to satisfy themselves about the structural integrity of the aircraft, in particular of the cabin and the tail and to consider in more detail possible sources of explosion and loss of control. They also considered that flight tests would be required in order to investigate the possibility of flutter of control surfaces. It soon became evident that it was probable that more wreckage would be recovered than had at first been expected. The wing centre section was received on 5 April (the engines had been recovered and sent by air to de Havillands on 21 March) and the front part of the cabin arrived on 15 April. But at the time when their attention became directed to fatigue of the pressure cabin they were influenced chiefly by the apparent similarity of the circumstances of the two accidents, and by the fact that the modifications carried out at Elba seemed to rule out many of the other possible causes.

On 18 April, it was decided that a repeated loading test of the whole cabin ought to be made in a water tank. This was regarded as one of a number of lines of inquiry which had to be pursued as it was necessary to study every possible cause in detail.

By a remarkable effort, to which de Havillands and the firms who built the tank contributed to the full, and by the use of all the resources of RAE, repeated loading tests began early in June on aircraft G-ALYU (Yoke Uncle). The object of the tests was to simulate the conditions of a series of pressurized flights. To this end the cabin and wings were repeatedly subjected to a cycle of loading as far as possible equivalent to that to which they would be subjected in the period between take-off and landing. Moreover, the programme of tests included, at intervals of approximately 1, 000 "flights", a proving test in which the pressure was raised to 1 1/3 P (11 lb./sq. in.).

Yoke Uncle had made 1 230 pressurized flights before the test and after the equivalent of a further 1 830 such flights, making a total of 3 060, the cabin structure failed, the starting point of the failure being the corner of one of the cabin windows. Examination of the failure provided evidence of fatigue at the point where the crack would be most likely to start, namely near the edge of the skin at the corner of the window.

The failure of the cabin of Yoke Uncle marked the point at which the character of the investigation changed to one in which the problem of fatigue in the structure of the cabin began to dominate all others, although many possible sources of trouble were continually investigated during the whole of the summer. The inference suggested by the tank test, that the primary failure of Yoke Peter was the bursting of the pressure cabin, was confirmed by a close examination of the wreckage and by the experiments referred to in the Report.

Further experiments in the water tank were made on the cabin of Yoke Uncle, after the first failure had been repaired by de Havillands. It now seemed highly probable that the stress

near the corners of the windows was higher than had been believed by the designers, and the strain gauges were, therefore, fixed to the surface of the skin, at various positions near the corners of the typical windows, including the window corresponding to the one which had failed but on the other side of the cabin.

A discussion of the evidence bearing on the reliability of the estimates of the stress at the edge of the window is given in this report. The highest stress in the skin at the edge near the corner of the window of Yoke Uncle was probably over 40,000 lb./sq. in. when the pressure difference was 8 1/4 lb./sq. in. and that the general level of the stress in the skin in these regions was significantly higher than had been previously believed. In the light of known properties of the aluminium alloy D. T. D. 546 of which the skin was made, the conclusion of RAE of the failure of the cabin skin of Yoke Uncle by fatigue after a small number, namely 3 060 cycles of pressurization, was accepted.

In considering the possible bearing of this result on the accidents at Elba and Naples, it was recognized that there are inevitable differences between individual aircraft structures built to the same drawings. The nature and extent of these depend on a number of factors such as variations in the thickness of metal sheet of nominally the same gauge, and local regions of high stress due to the methods employed in joining the various parts, such as rivets, bolts, etc. If a number of such structures are tested under repeated loading, there will be appreciable differences between the number of cycles of application of given loading before failure occurs. Experience suggests that there will be a variation of at least 9 to 1 in the number of cycles necessary to produce failure when the general level of stress is high, and the number of cycles undergone before failure therefore low. If a large number of specimens could be tested, it would undoubtedly be found that the weak and the strong were relatively few in number, and that the majority would be more or less evenly distributed round a mean value. However, it is impossible from a single test to say where, in the total range to be expected from general experience, a particular specimen lies.

At the time of the Elba accident, Yoke Peter had make 1 290 pressurized flights and at the time of the Naples accident Yoke Yoke had made 900 pressurized flights. The Director of RAE said in evidence that in the light of the experiment on Yoke Uncle, and of the measurements and calculations of stress referred to above, he considered that the cabin of Yoke Peter had reached a point in its life when it could be said to be in danger of failure from fatigue, and that the cabin of Yoke Yoke would also be in danger. Another witness from the RAE said that he did not regard the picture presented by the three failures (on the assumption that these were all due to the same fundamental cause) as surprising, since the three results taken together are consistent with general experience of the strength under repeated loading of a number of nominally identical structures, in which the stress level is high. They lie within a range of just over 3 to 1, whereas experience suggests a total range of at least 9 to 1.

As a result of further salvage RAE received a piece of cabin skin which had been found by an Italian fishing boat. It was identified as coming from the centre of the top of the cabin approximately over the front spar of the wing. It contained the two windows in which lie the aerials, which are part of the ADF (Automatic Direction Finding) equipment. At the same time RAE received a part of the aileron of the port wing and a part of the "boundary layer fence" fitted to the leading edge of the port wing not far from the tip.

The latter parts provided important evidence about the bursting of the cabin. There were marks on them which were identified as made by pieces from the cabin itself. Taken together with the paint mark on the leading edge of the centre section not far from where the outer wing broke off, which was identified as caused by the piece of the cabin wall containing the first window (escape hatch), they established that the cabin burst catastrophically in the neighbourhood of the front spar of the wing when the aircraft was flying normally.

By examination of the piece containing the ADF windows and the adjacent pieces it was established that it was here that the first fracture of the cabin structure of Yoke Peter occurred. In general terms, it took the form of a split along the top centre of the cabin along a line approximately fore and aft passing through corners of the ADF windows. The direction in which the fracture spread was determined by examination of the lines of separation of the material.

In the light of all this evidence, RAE's conclusion that the first fracture of the cabin occurred near the rear ADF window and spread fore and aft from it was accepted.

It was not considered possible to establish with certainty the point at which the disruption of the skin first began, but it was considered that it probably started near the starboard aft corner of the rear ADF window, at a point where examination by experts showed that fatigue had existed, at the edge of the countersunk hole through which a bolt passed.

The only alternative point suggested was the opposite (port forward) corner of the same window. Here the fracture passed through a small crack in the re-inforcing plate, about 0.2 in. long, made accidently during the building of the aircraft. This had been dealt with by de Havillands in accordance with their procedure for dealing with any departure from the strict requirements of their drawings which might appear during the manufacture of their aircraft. All such matters were required to be reported to the Technical Office, and each was dealt with as a special case by a qualified expert. In this case approval was given to the use of the normal process of "locating" small cracks in the skin of the aircraft by drilling small holes at their ends There was no reason to doubt that this would have been a satisfactory method of dealing with the crack in question had it not been for the fact that the stress in this region was relatively high. It was suggested that such a crack might be a possible place of origin of fatigue, but no witness was able to identify any evidence of fatigue at the material point.

It was the opinion that the fundamental cause of the failure of the cabin structure was that there existed around the corners of the windows and other cut-outs, a level of stress higher than is consistent with a long life of the cabin, bearing in mind the unavoidable existence of points, within the areas of generally high stress, at which it will be still further raised by relatively local influences, such as the countersunk hole near the starboard rear corner, and the small crack with its "locating" hole near the port forward corner. It was impossible to say, definitely, on any evidence before the Court, which of these operated first. However, since the existence of fatigue near the bolt hole was established, this was thought to be more probable.

On the other defects discovered by RAE and referred to in the Report, the conclusion reached by RAE was that none of these defects was in any way the cause of the accident.

It was clear that the separation of both port and starboard outer wings from the centre section was not the primary cause of the accident, for there was ample evidence from the distribution of paint marks and scratches on both wings that they were made by parts of the cabin structure, forming a pattern which was consistent only with the whole wing having been intact when they were made. For the same reason, the known point of fatigue weakness in the wing skin near the edge of the wheel-wells is not suspect. Moreover, the fracture of the wings occurred some distance outside this region.

As regards escape of fuel from the fuel tank venting system, examination of the wreckage disclosed that fire did not start until after the disruption of the cabin. It was clear, therefore, that escape of fuel from the tank vents during take-off or climb had nothing to do with the accident.

Turning to refuelling, the danger apprehended could only occur by a concatenation of five events. The risk was, therefore, said to be a remote one and in any event in the present case RAE state that examination of the Elba wreckage made it plain that even if the aircraft had sustained damage of the type indicated in Part 6 of the RAE Report (which deals with this subject), such damage was not the cause of the accident to Yoke Peter. There had, however, been a recorded instance of trouble due to this cause, and it was observed that de Havillands have indicated their intention of devising a method of removing the possibility of damage of this kind.

During the operation of BOAC services, there had been some experience of small damage to the cabin skin, due to the buffeting by the efflux from the jet engines. This damage was partly in front of and partly behind the pressure dome of the cabin. As soon as it was observed, a systematic inspection was made of all Comets, and where any signs of cracking were detected a repair was made according to a scheme specially devised by de Havillands. Internal inspection showed that the buffeting was also causing slight loosening of the joint between the stringers and the skin in this region, and rivets were, therefore, inserted in order to ensure that this would not give rise to danger.

This point of possible weakness was under continuous observation. The steps taken to deal with it may be considered to be satisfactory, particularly since where the repair had been carried out, no further trouble occurred.

It is, however, recognized by de Havillands that a situation in which it is known that such cracks are likely to occur is unsatisfactory, and among the improvements they intend to make on future Comets is one which they believe will reduce the cause of this damage, namely, a slight change in the direction of the jet pipes at their exits, with the object of diverting the jets away from the sides of the cabin.

Repeated Loading Tests in 1953

The Report dealt with the repeated loading tests carried out by de Havillands in 1953. Wher the RAE test revealed the short life of the cabin structure of Yoke Uncle the question arose as to how to reconcile the result of that test with the result of these earlier repeated loading tests. The Director of RAE suggested that the explanation might well be that the 1953 tests were carried out on a nose section which had previously been subjected to static tests up to a differential pressure of 16 1/2 lb./sq. in. and that the effect of such a test might be to prolong the life of the specimen subjected to it. The Chief Structural Engineer of de Havillands stated that he was aware of this possibility but he considered that if there was any increase in life of the nose section attributable to pre-loading the tests so amply covered the life of the aircraft both at the time of the tests and for the immediate future that de Havillands could safely accept the test as satisfactory. It was considered that in the then state of knowledge this conclusion was reasonable.

Investigation of the Engines

The RAE investigation did not deal with the engines. The history of their recovery and investigation is as follows:

The centre section of the wing of Yoke Peter was recovered from the sea on 15 March. It was severely damaged by fire and by impact with the water. It contained the four Ghost engines substantially intact with the exception of the turbine disc of No. 2 engine (port inner) which was missing. The shaft on which it had been mounted had broken near the hub to which it was bolted, and it had escaped through a large gash in the exhaust cone. The disc has not been recovered. The Chief Engineer of the de Havillands Engine Company Limited, said in evidence that there were no signs consistent with seizure of any engine, or of any excessive internal heat, or of any failure having occurred before the break-up of the aircraft. The extensive fire damage was all external to the engines. The four compressor impellers were intact on their shafts.

The turbine discs from Nos. 1, 3 and 4 engines showed no signs of failure. No blades were missing from them. In No. 2 engine, there was no evidence of penetration of the shroud ring surrounding the turbine, either by a blade or by the complete disc. There was no evidence of failure of any blade in any of the engines. Examination of the hubs to which the turbine discs of Nos. 1, 3 and 4 engines were bolted showed that all were on the point of failing. Cracks were found in the same regions as those which had resulted in the fracture of No. 2 engine, which led to the loss of the disc.

The remarkable similarity of the damage to the turbine shafts of all four engines pointed to a common cause external to the engines, and further examination showed that the most probable cause was a sudden and very rapid rotation of the whole wing about a transverse axis, nose downwards, while the engines were still running normally.

In the light of all this evidence and these considerations, it was concluded that there was no failure of any part of any engine which could have been the cause of the failure of Yoke Peter. The fire which damaged the engines externally was in the opinion of the Court subsequent to and not a cause of the disintegration of the aircraft.

Other Evidence

In dealing with the evidence of a witness, who postulated a failure of the Redux bonding under the stress of large and rapid changing of temperature, the Report examined his theories in detail and the Report describes the tests carried out in flight at the RAE on the Comet G-ANAV, the background of Redux testing conducted by de Havillands, and the examinations of the wreckage by the RAE experts. In the light of the evidence, the Report rejected the suggested alternative cause of the failure of the cabin.

The only other witness who did not completely accept the suggestion advanced in the Report was the chief technical officer of the ARB. He did not dispute that the primary cause of the accident was the bursting of the cabin structure, but he expressed himself as not entirely satisfied that fatigue was the cause of that disruption. He appears to have proceeded on the basis that the 9 000 hours (3 000 flights) at which Yoke Uncle burst could be regarded as a fair average life for the fuselage and to have been impressed by the improbability, on this basis, of both Yoke Peter and Yoke Yoke failing from fatigue after only about 3 000 hours (1 000 flights). He was unable, however, to suggest any other cause. He admitted that he could find no evidence either (a) of excessive internal pressure in the cabin or (b) of excessive stresses in the cabin structure due to external action such as gusts or failure of the control system. He agreed that he could not name any alternative cause of the failure which RAE had failed to consider.

Bearing in mind that the chief technical officer of the ARB will be responsible for advising ARB when an application is made for a new Certificate of Airworthiness for Comet aircraft, his caution was understandable, but the Court considered it necessary to express conclusions on the evidence, relying in this connection on an answer given by the chief technical officer of ARB which seemed to represent the proper approach to adopt in the circumstances of the case. The chief technical officer of ARB had said: "I think in concluding on the likelihood of the cause one has to take the thing as a whole; one has to take the tank test evidence and say that that shows that fatigue is possible, although on my argument not necessarily probable, that is the tank test by itself; one then has to look at the other half of the matter, namely, all the other possible causes, and if in the process of eliminating possible causes you become completely confident that you have eliminated every other possible cause, then you are driven to say that the possible fatigue rises to the most probable cause." Applying these observations to what was done in the course of the investigation by RAE and by the de Havilland Engine Company Limited and to the evidence given in the Inquiry before them, the Court unhesitatingly came to the conclusion that RAE were right in their conclusion that the accident at Elba was caused by structural failure of the pressure cabin in the region of the ADF window, brought about by fatigue.

Responsibility

No suggestion was made that any party wilfully disregarded any point which ought to have been considered or wilfully took unnecessary risks. However, in the course of the evidence, questions were put which made it necessary to consider a number of points in the light of the conclusion expressed as to the cause of the accident.

Dealing first with the period prior to the commencement of the scheduled passenger service on 2 May 1952, the calculations made by de Havillands were criticized, and it was suggested that the tests they carried out were inadequate to guard against the risk of fatigue in the cabin structure. In support of this contention, particular reference was made to certain calculations included in paragraph 4 of Part 3 of the RAE Report and to other calculations produced by the Director of the RAE in the course of his evidence. It was, however, observed that the primary object of de Havillands was to lay the foundation for extensive tests which they regarded as the soundest basis for the development of a project rather than to arrive at a precise assessment of the stress distribution at the corners of the cabin windows.

The report indicated that de Havillands could not justly be criticized for this approach to the problem. This was supported by a Memorandum which was prepared by the Assessors (see page 26) and which confirmed the evidence of the witnesses that de Havillands were proceeding in accordance with what was then regarded as good engineering practice. The Court was also satisfied that in the then state of knowledge de Havillands could not be blamed for not making

greater use of strain gauges than they actually did or for believing that the static test that they proposed to apply would, if successful, give the necessary assurance against the risk of fatigue during the working life of the aircraft.

There was one other question bearing on responsibility to which the Report refers. This concerns certain cracks, revealed by the examination of the wreckage, which had occurred in the process of manufacture and had been dealt with by location. The Director of RAE said that such manufacturing cracks might form foci for fatigue and thus shorten the life of the structure. It was suggested in cross-examination that the fatigue which led to the disintegration of Yoke Peter had originated in these cracks, that they ought not to have been dealt with as they were and that accordingly some responsibility ought to attach to de Havillands for allowing the aircraft which contained them to be put into service.

It has been the general experience that certain parts of the structure of aircraft develop cracks as the result of fluctuation of load, vibration or casual damage and that the external skin, whether in the wings, tail or fuselage is particularly vulnerable. Cracks which occur during manufacture do not differ materially in their significance from those which may develop subsequently save, of course, that their presence may indicate an unsatisfactory manufacturing process.

It is the ordinary practice to make careful inspection of the structure, both during manufacture and subsequently, particularly in regions known to be specially susceptible and, if cracks are found, to deal with each case on its merits in the light of a now very wide experience of the problem. Where frequent inspection shows that a particular crack is likely to spread, it is dealt with by a carefully considered repair scheme, either prepared by the designers or by the operators in collaboration with the designers. However, if after such repair the crack continues to spread, it is considered as a matter of major concern, possibly requiring a radical modification to the design to reduce the stress which gave rise to it.

For small cracks in regions not highly stressed the method of location is generally found to prevent further spread, provided that care is taken to ensure the inclusion of the end of the crack in the hole drilled. All witnesses who dealt with this matter in the Inquiry were agreed that location was a reasonable method of dealing with such cracks.

Most aircraft experience cracks due to one or more of the causes mentioned above and it would, indeed, be hardly practicable to insist on a standard of design and construction which would preclude completely the possibility of any crack in the skin.

The methods employed by de Havillands in dealing with manufacturing cracks were in no way different from those used to deal with other deviations from the strict requirements of the drawings to which the aircraft was being built. Defects whether discovered by the workman or the inspector would be dealt with by the procedure known as "Concession", a procedure which varied according to whether the defect was classed as major or minor. Manufacturing cracks were required to be dealt with as major defects with the result that "Concession Notes" containing the proposals for dealing with them would have to go forward to the Chief Inspector and, if approved by him, would have to be submitted to the Design Department for final approval. In the case of Yoke Peter three cracks were discovered in the reinforcing plates of the ADF windows. The action taken, which was approved by the Chief Inspector and the Design Department, was "splits have been located with a 1/16th dia. drill hole." According to the then current engineering practice this action would have been appropriate had the stresses been as low as de Havillands believed them to be, but was, in fact, inappropriate as the region concerned was one in which there were high stresses. However, the Report stressed that de Havillands could not be blamed for their ignorance of the true state of affairs; it follows that no responsibility attaches to them.

The evidence disclosed other cracks in Comet aircraft. Thus, in the wreckage of Yoke Peter there was a crack in the skin at the starboard front corner of the rear ADF window. This had been located at both ends. No Concession Note was available in relation to this crack and it would appear that there had been a defect in the operation of the Concession procedure. Although this crack had spread during the life of the aircraft beyond one of the points at which

it had been located, the actual fracture did not take place there nor was there any sign of fatigue. Other cracks were referred to in Yoke Uncle and Yoke Yoke but in no case was there any evidence that the crack had contributed to the failure of the aircraft.

The Report in concluding this matter of manufacturing cracks of this type noted the statement put in on behalf of de Havillands records that if in future a crack does occur at any time either in manufacturing or subsequently during the life of an aircraft, no repair scheme for such a crack will be sanctioned unless it ensures that, after it has been carried out, the part of the aircraft concerned will be as strong and will have as long a life as it would have had, had there been no crack.

Memorandum by Assessors

"During the design of the Comet, de Havillands did not make use of calculations in an attempt to arrive at a close estimate of the stress distribution near the corners of the cabin windows. We have examined such of their calculations as had a bearing on this question; these led to the stress of 28 000 lb./sq. in. It is clear that this stress refers to an area of the skin in the neighbourhood of the corners and may fairly be said to be an average value over a width of 2 or 3 inches. De Havillands believed that their method was satisfactory for the pupose they had in mind, namely, the design of a test specimen. They did not consider that a closer estimate of the highest value of the stress could be made by any method which they would regard as reliable. They preferred to rely on tests of specimens designed on the basis of their calculations.

Since their estimate of the general level of stress in the region investigated was less than half the ultimate strength of the material (about 65 000 lb./sq. in.) they were confident that they could demonstrate by static test that there would be no failure at twice the working pressure, and that there would be a considerable reserve in hand. Their tests of panels about 3 ft. square, including a window, substantiated this view.

We note, however, that in these tests, the panel was supported on the face of a stiff steel "pressure box", and not in conditions truly representative of those which existed near the window in the pressure cabin itself. It is not possible to say what the effect of this would be. De Havillands were reassured by the results of the tests in which the specimen withstood nearly 20 lb./sq. in. without failure.

De Havillands used the same approach to the design of the whole pressure cabin. The static tests which they made on the two parts of the pressure cabin, respectively 26 and 24 ft. long, gave them confidence in the integrity of the whole cabin. Since they believed, with general support from then current practice and opinion, including that of ARB, that this basis of design and static tests would give ample assurance against risk of failure under repeated applications of the working pressure, and other known causes of fatigue, they felt that the cabin was good for the life of the aircraft (say 10 000 pressurized flights, or 10 years).

Here again, however, we note that the test sections of the cabin differed from the cabin as fitted to the aircraft in several respects. In the first place, each was incomplete, and incapable of sustaining pressure if it had not been fitted with a stiff bulkhead at the open end or ends. It is not possible to say whether the constraint which these bulkheads imposed on the structure would make it stronger or weaker than when it formed part of a complete cabin. However, it must be recognized that the stresses in the structure near the bulkheads would be appreciably affected by the constraint, and the reliability of deductions about the strength of the cabin would thereby be reduced. Secondly, neither section was fitted with the complete number of windows, etc. Moreover, the windows of special interest to this Inquiry, which were in the front test section, were rather near the bulkhead mentioned, so that the stresses in the skin round them might have been appreciably different from those in similar places in the complete cabin.

The increasing attention which de Havillands gave, during the period mid-1952 to the end-1953, to the fatigue life of pressure cabins has been mentioned in paragraphs 21 to 24. In their repeated loading tests the front test section of the cabin survived 16 000 applications of just over the working pressure. They felt confident that the Comet's cabin would have a safe life well beyond their target of 10 years in service.

The repeated loading test on Yoke Uncle at RAE led to an unexpected failure after some 3 000 applications of load. Though this was about three times the life of Yoke Peter at Elba or Yoke Yoke at Naples it was suprisingly short, and led directly to the inference that there were high local stresses. Steps were, therefore, taken at RAE to measure the stress near the corner of the window, using strain gauges placed as near as possible to the edge of the skin where the failure started. These measurements led to an estimated stress of 43 000 lb./sq. in. at the edge at the normal pressure difference of 8 1/4 lb./sq. in.

This estimate of the stress was regarded by de Havillands as unreliable, partly because the process of deriving it from the experimental measurements involved some extrapolation, but also because it would imply that in their own test to twice the working pressure, there was a local stress of double this amount, namely, 86 000 lb./sq. in., which is some 30 per cent above the ultimate strength of the material. This apparent paradox can be explained by recognizing that it neglects to take account of the effect of the ductility of the material in relieving "stress concentrations".

Calculations were made by the Director of RAE to explore the problem in the light of such theoretical solutions as were known of the problem of stress distribution, round a cut-out of the shape of the cabin windows, in a cylindrical shell of metal under pressure. These calculations were not put forward as exact, but, with due allowance for the fact that the window frame, and the cabin stringers and hoop frames, would influence the result, they supported the reasonableness of the estimate made from measurements on Yoke Uncle.

It is our view that the two results taken together point strongly to the conclusion that the stress in the skin at the edge of the window near the corner was far higher than had been suspected by de Havillands, and was probably over 40 000 lb./sq. in. under the normal pressure difference.

In the course of the Inquiry much attention was paid to an estimate, given in Part 3, paragraph 6 of the RAE Report on the tests on Yoke Uncle, of the stress which might be predicted on the basis of their measurements by strain gauges, as probably existing in flight. The figure "70 percent of the ultimate strength" was obtained by adding to the 43 000 lb./sq. in. (mentioned above) due to the working pressure, another 2 700 lb./sq. in. due to other known loads, leading to a total of 45 700 lb./sq. in. This was contrasted with de Havillands' own estimate of 28 000 lb./sq. in. It has already been pointed out that de Havillands' figure related to an average over a considerable distance near the corner of the window, and due only to the working pressure, whereas the estimate made by RAE related to a particular point where the stress would be expected, on general grounds, to reach a maximum. A direct comparison between them is, therefore, misleading. Having regard to the different approach the two figures cannot be said to be inconsistent.

It is natural that de Havillands and RAE should have approached the problem of the "safe life" of the pressure cabin of the Comet from different points of view. De Havillands were the designers and looked at the problem as designers would, having confidence in their methods based on their experience. RAE had had virtually no previous knowledge of the design background of the Comet, since it is a civil aircraft and their connection with it before 8 April 1954, was primarily advisory in character and was wholly concerned with fatigue of the wings. In the early stages of the Inquiry there was, therefore, a sharp disagreement between them on the interpretation of their calculations and tests. These differences of opinion diminished in the course of the Inquiry as greater mutual understanding developed. While there are still minor points on which they do not quite see eye to eye, a situation which is by no means unusual in technical problems of such difficulty, there is now no longer any substantial disagreement between them. Our own interpretation of the situation so far as it can be determined by existing evidence, is set out above, and we believe that it would be accepted by de Havillands and RAE."

The Future

The Report noted that the problem of securing an economically satisfactory safe life of the pressure cabin of an aircraft needed more study, both in design and by experiment, if the lightest possible safe structure is to be achieved. This de Havillands recognized in their policy in regard to the future of the Comet.

In Appendix IV, paragraph 4 (iii), of the Report, reference is made to the problem which arises owing to the variation among the lives, under a given loading cycle, of nominally identical parts, known as "scatter". In the pressure cabins of aircraft there are probably a number of causes of scatter. Tests of a large number of specimens are, however, virtually impracticable, and in order to ensure a safe life well above the minimum that is economically acceptable to an operator, methods must be devised of ensuring that design, combined with a reasonable programme of tests, can guarantee that the pressure cabins of transport aircraft will be entirely safe.

The policy which de Havillands propose to adopt for the Comet is directed to achieving this end, primarily by reducing both the general level of stress and the local excesses, due to all known causes, above the general level of stress. The knowledge which has been acquired as a result of the investigation of the accident to Yoke Peter, and the tests made on Yoke Uncle at RAE strongly suggests that steps should be taken to determine by calculation, by tests of typical parts of the cabin, and by tests on one or more complete cabins, both the distribution of stress throughout the structure in considerable detail, and the influences which determine both the highest static load which it will sustain, and its life to failure under repeated loading. In the present state of knowledge, it is likely that two complete cabins will have to be tested, one under static loads and one under cycles of repeated loads.

From the evidence it was clear that there exist methods of calculating the stress distribution in the structure of a pressure cabin which could with advantage be employed more widely. Moreover, the result of RAE's investigation indicates that in tests of pressure cabins or parts of them the stress distribution should be determined by wide use of strain gauges. This procedure will enable the calculations used in the design to be verified or amended and will lead to a fuller understanding of the problem.

When these measures have been applied and the tests completed, de Havillands will no doubt ask ARB to recommend the grant of a Certificate of Airworthiness to the redesigned Comet aircraft. The Commissioner expressed the hope that this procedure will reassure the public as to the integrity of pressure cabins and will justify the Director of the RAE's confidence that the Comet aircraft will fly again.

The Report then discusses the use made of the facilities available at the RAE and suggests that manufacturers should make full use of the research establishments of the Ministry of Supply. It also recommends certain scientific and technical matters on which further research could usefully be undertaken, such as the influence of ductility of the aluminium alloy forming the cabin skin on the manner which the stress distribution in the skin is related to the difference between internal and external pressure on the cabin. The Report continues:

The remaining question which requires study relates to the system used to operate the aircraft controls. Most of the evidence on this subject was concerned with the alleged excessive "break-out" force and indicated a difference of opinion, among pilots, as to whether the existing system was satisfactory in this respect, though none suggested that the alleged defect had in any way contributed to the accident. A different criticism was made by one of the Assessors to the Indian Court of Inquiry into the accident to G-ALY V and apparently prompted that Court's second recommendation, which was as follows: "That consideration should be given to the desirability of modifying the flying control system of the Comet aircraft in order to give the pilot a positive "feel" of airloads exerted on the control surfaces." The Report contains a recommendation that the characteristics of the control system of the Comet should be reconsidered by de Havillands an by ARB in the light of both the criticisms which have been made.

The Report then deals with the system of delegated responsibility for inspection during manufacture and comes to the conclusion that the present system is essentially satisfactory. In connection with the constitution of the ARB flight testing organization the Report suggests that while there is no criticism of the flight testing carried out by de Havillands and the ARB some consideration should be given to the possibility of using the facilities of the Ministry of Supply Establishments.

Questions and Answers

A list of questions was submitted to the Commissioner by the Attorney-General of which 1 a 3 are quoted below with the Commissioner's answers. The other questions dealt with Certificates of Airworthiness and Maintenance, the competence of the crew, etc.

Question 1. What was the cause of the accident?

Answer The cause of the accident was the structural failure of the pressure cabin brought about by fatigue.

Question 3. Was the accident due to the act or default or negligence of any party or of any person in the employment of that party?

Answer. The accident was not due to the wrongful act or default or to the negligence of any party or of any person in the employment of any party.

Court's Conclusion and Probable Cause

The opinions expressed in the RAE Report were supported by the evidence. Their conclusions were accepted by de Havillands and BOAC. All parties appearing at the Inquiry paid a warm, and well deserved tribute to the RAE Report and to all who had co-operated in the work done at RAE.

The main conclusion of the RAE Report that the cause of the accident to Yoke Peter was the structural failure of the pressure cabin brought about by fatigue was accepted.

The Accident to G-ALYY

After reviewing the available evidence on the accident to G-ALYY the Commissioner stated:

> "RAE's conclusion as regards the cause of the accident to Yoke Yoke is expressed in the following paragraph: 'Owing to the absence of wreckage, we are unable to form a definite opinion on the cause of the accident near Naples, but we draw attention to the fact that the explanation offered for the accident at Elba appears to be applicable to that at Naples.' I agree with this conclusion and have only to add that it is impossible in the case of the Naples accident to be dogmatic that defects of the kind considered in paragraphs 108-114 of my Report on Yoke Peter were not contributory causes to the Naples accident. I am, therefore, glad to note that the programme of future action outlined by the de Havilland Aircraft Company Limited and set forth in Appendix VIII to my Report on Yoke Peter includes measures to deal with those defects."

There was one matter on which criticism was made which is applicable only to Yoke Yoke and that is the decision, after the accident to Yoke Peter, to allow the Comet passenger services to be resumed on 23 March 1954. Paragraphs 52 and 53 of the Report on the accident to Yoke Peter set out the nature of the full investigation carried out by the Committee under the chairmanship of the Deputy Operations Director (Engineering) of BOAC and the modifications made on the recommendation of that Committee.

Before deciding to authorize the resumption of the Comet passenger services, the Minister of Transport and Civil Aviation consulted ARB and ASB. Both of these bodies recommended that consent should be given. When they did so, there had been only one accident to a Comet aircraft for which no explanation had been furnished. According to the evidence it was certainly not the practice either in the United Kingdom or elsewhere to ground all aircraft of a type because of an unexplained accident to one aircraft of that type. The evidence indicated that steps had been taken to deal with what the experts then considered to be all potentially dangerous features. In those circumstances the Report gave the opinion that no blame could be attached to any one for permitting the resumption of the services.

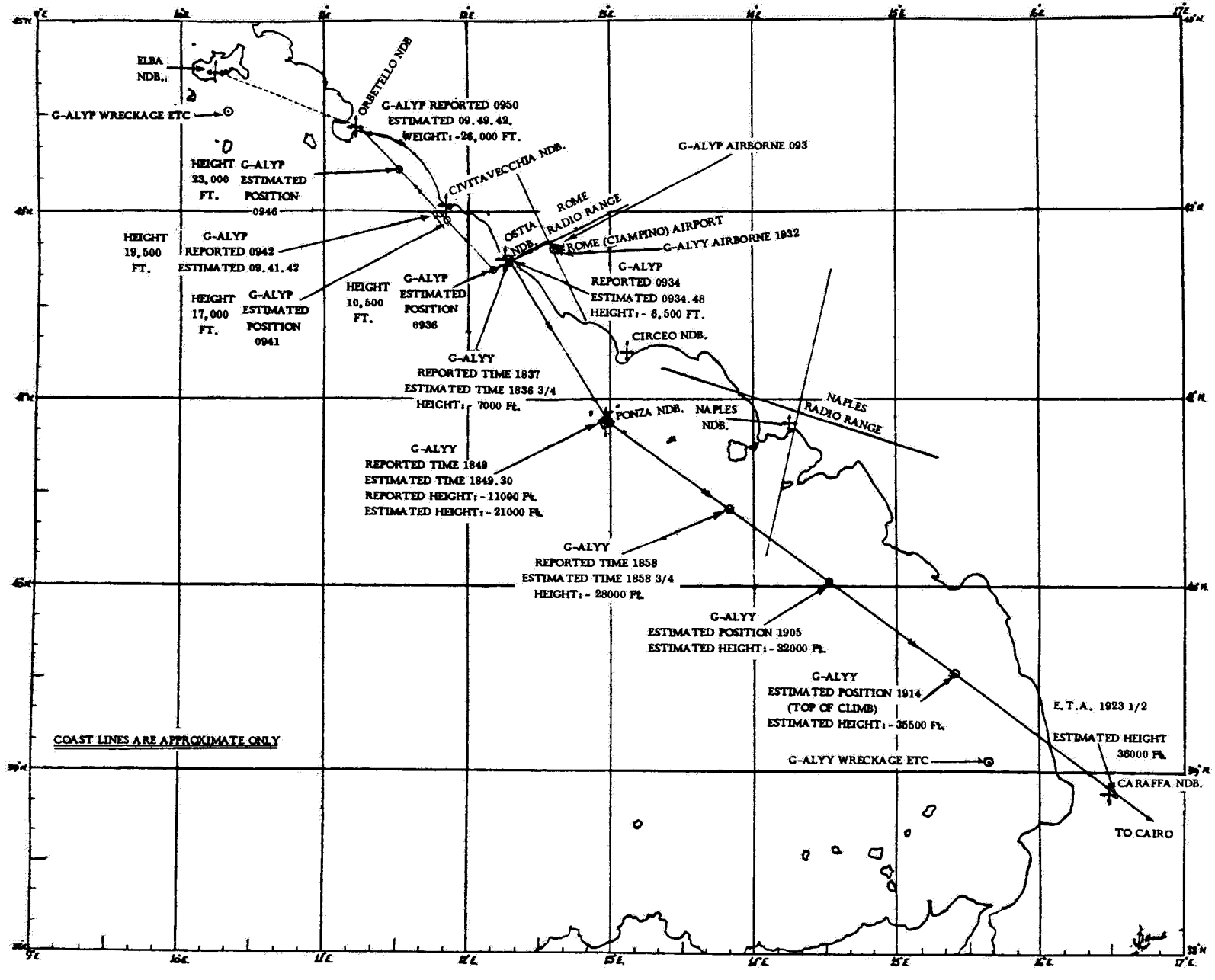


CHART OF AIRCRAFT TRACKS G-ALYP AND G-ALYY FIG. 1

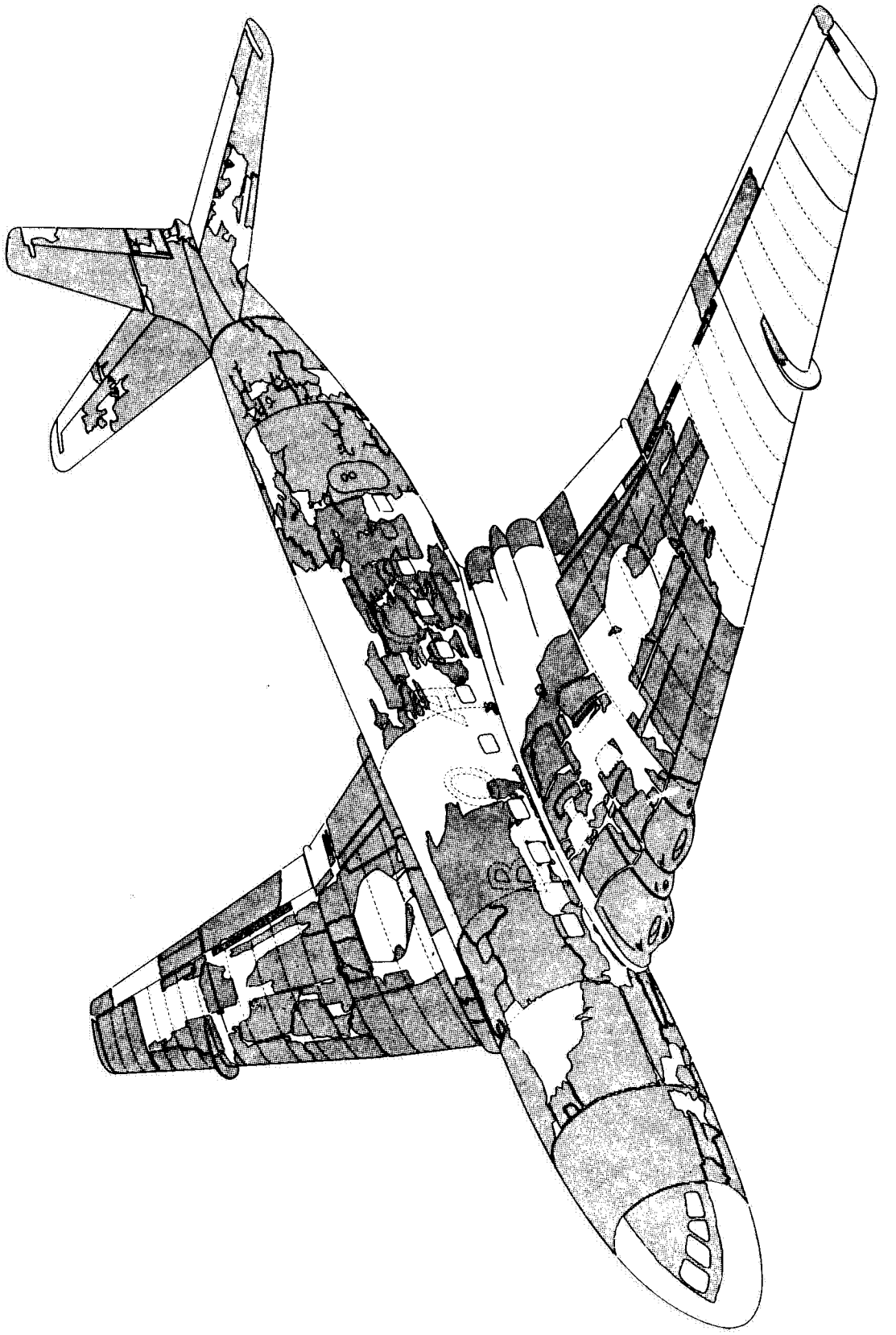


FIG. 2. DIAGRAM SHOWING AMOUNT OF WRECKAGE RECOVERED—G-ALYP.

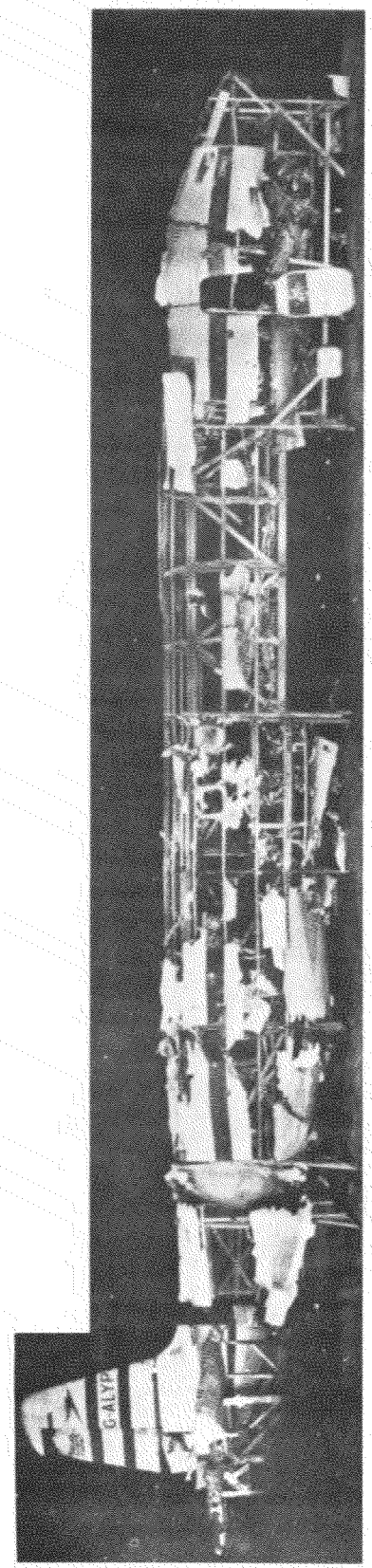
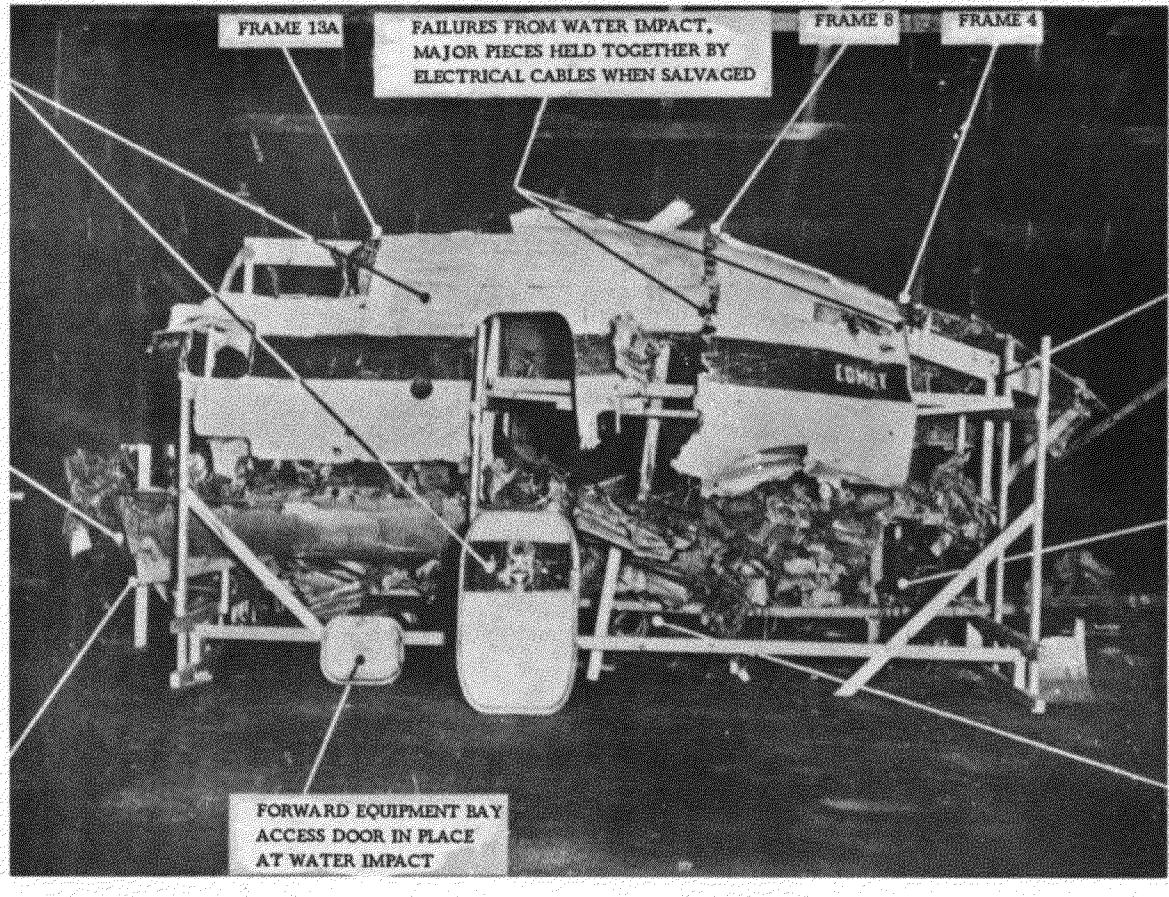


Fig. 3. RECONSTRUCTION OF FUSELAGE AND TAIL UNIT WRECKAGE—G-ALYP.

THIS PANEL (INCLUDING CREW ENTRY DOOR) RECOVERED SEPARATELY AND SHOWS WATER IMPACT DAMAGE ON OUTER FACE.

FORWARD EQUIPMENT BAY REAR BULKHEAD TORN FROM FRONT FUSELAGE AND REMAINED ATTACHED TO WING.

NOSE DOWN BENDING FAILURE OF PICK UP POINTS ON WING WITH FINALLY SOME BENDING TO STARBOARD.



STARBOARD WINDSCREEN MISSING.

EXTENSIVE CRUSHING OF WHOLE UNDERSIDE OF FRONT FUSELAGE BY WATER.

NOSE WHEEL RETRACTED WHEN SALVAGED.

FIG. 4. FRONT FUSELAGE—VIEW ON STARBOARD SIDE—G-ALYP.

FIG. 5. AERIAL VIEW OF COMET G-ALYU IN TESTING TANK.

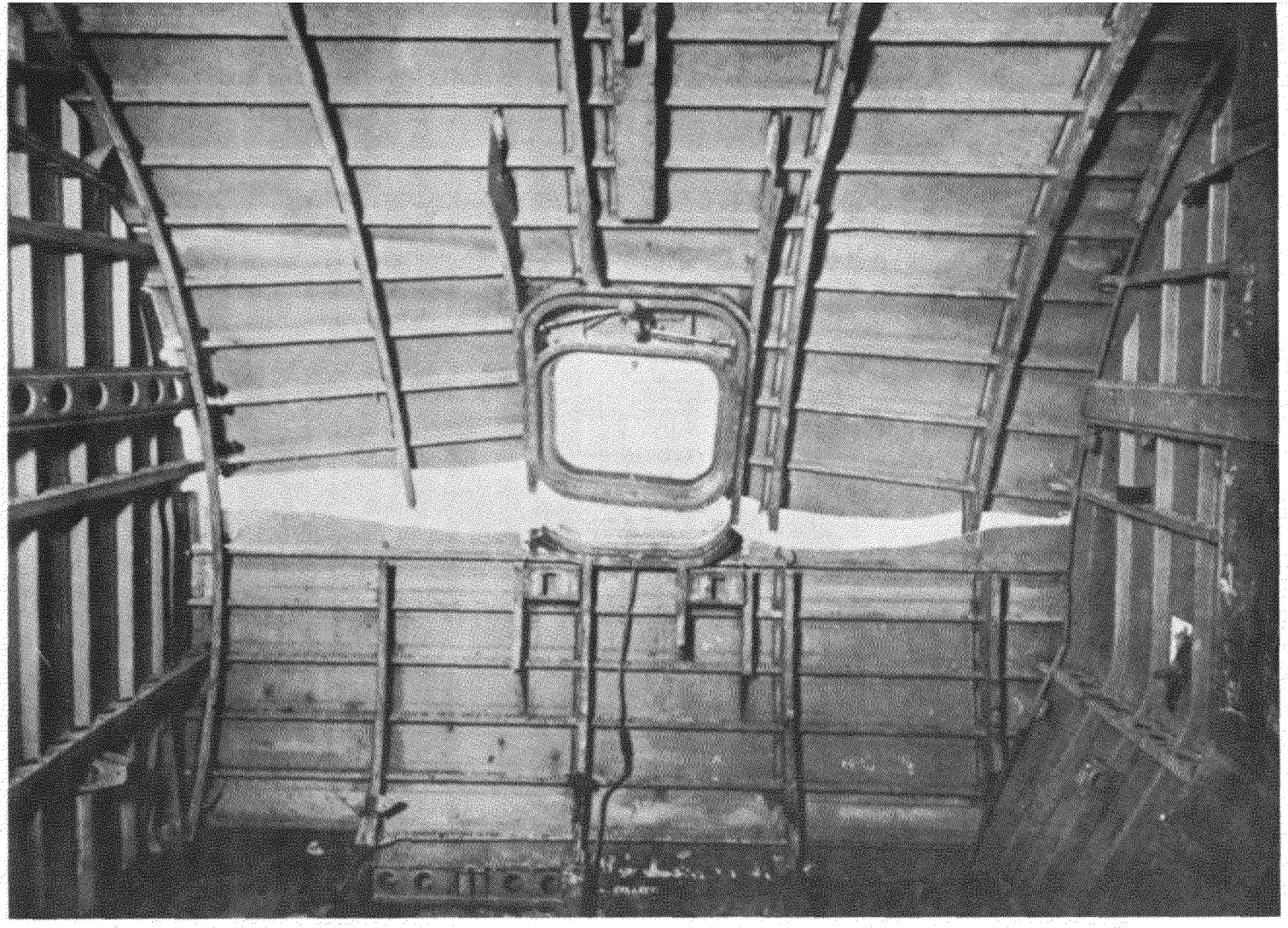


FIG. 6. VIEW FROM INSIDE OF FAILURE AT THE FORWARD ESCAPE HATCH ON THE PORT SIDE—COMET G-ALYU

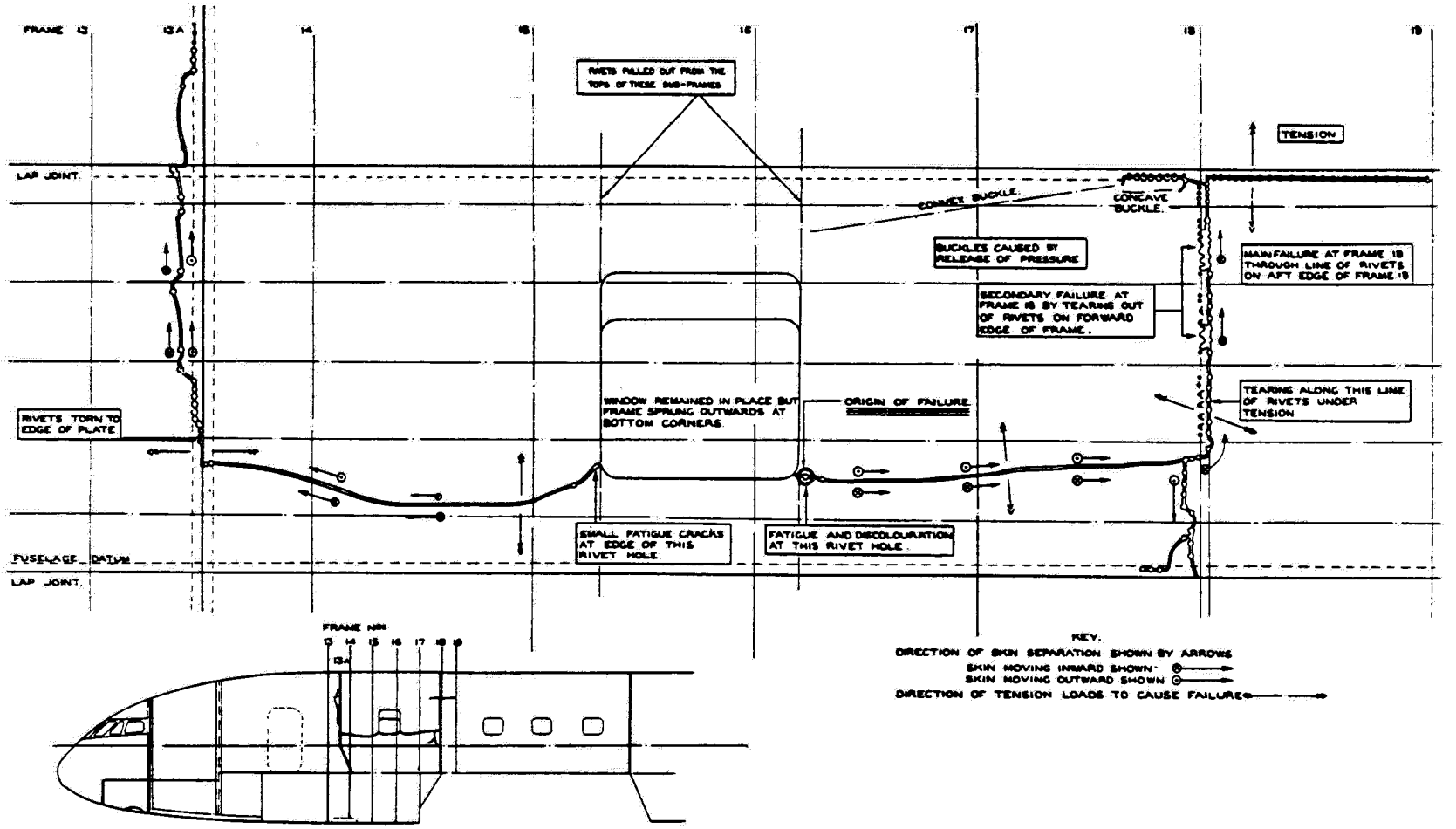
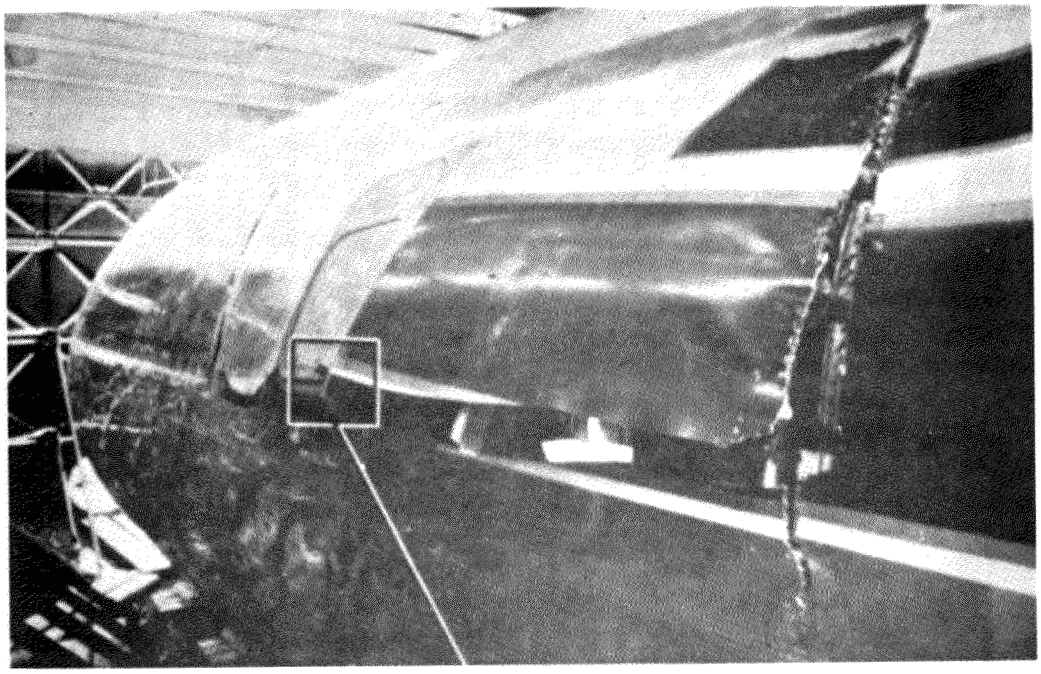
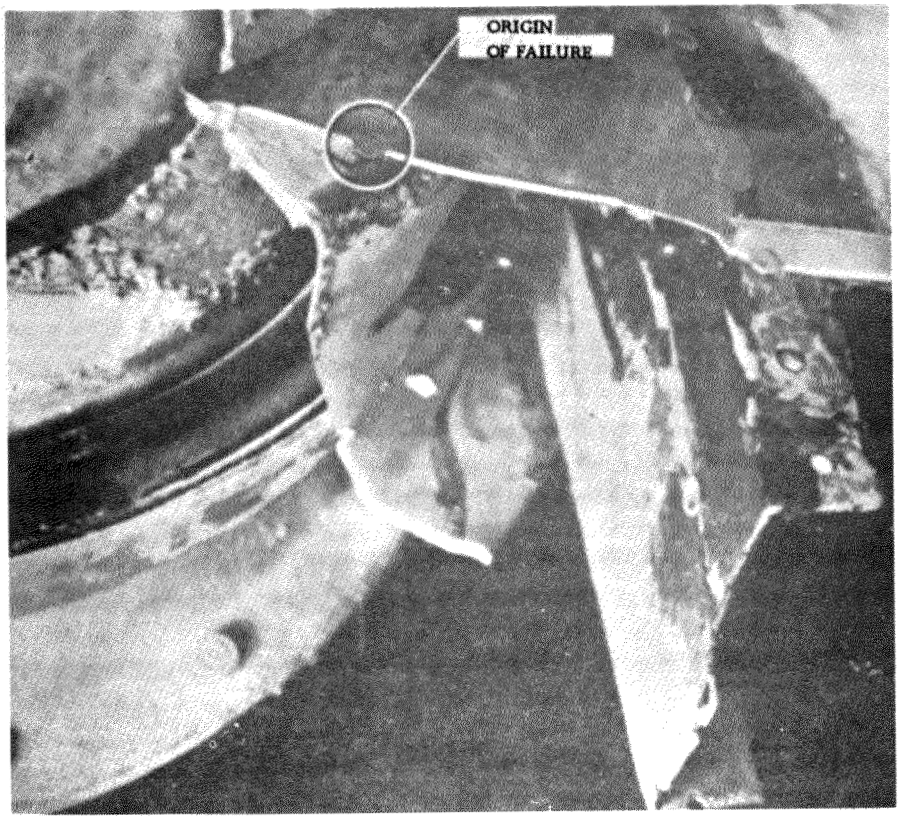


FIG. 7. THE PROGRESS OF THE FAILURE OF THE FORWARD ESCAPE HATCH ON THE PORT SIDE—COMET G-ALYU.



a. GENERAL VIEW LOOKING FORWARD.



b. CLOSE-UP OF SKIN AT BOTTOM REAR CORNER OF ESCAPE HATCH.

FIG. 8. FAILURE OF FRONT FUSELAGE AT 10.4 lb/in² (3057 TOTAL FLIGHTS)—G-ALYU.

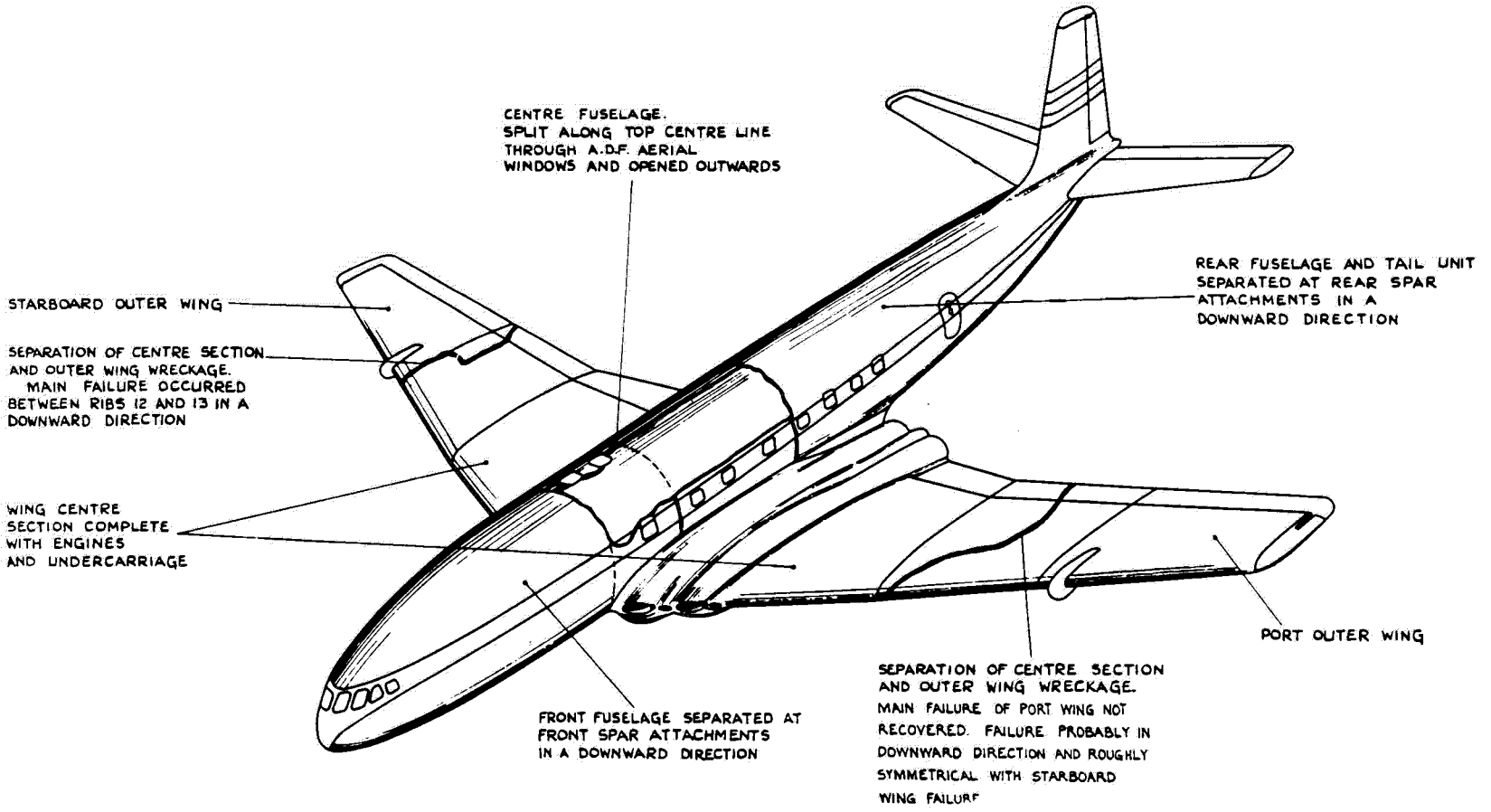


FIG. 9. LOCATION AND DIRECTION OF MAIN FAILURES—G-ALYP.

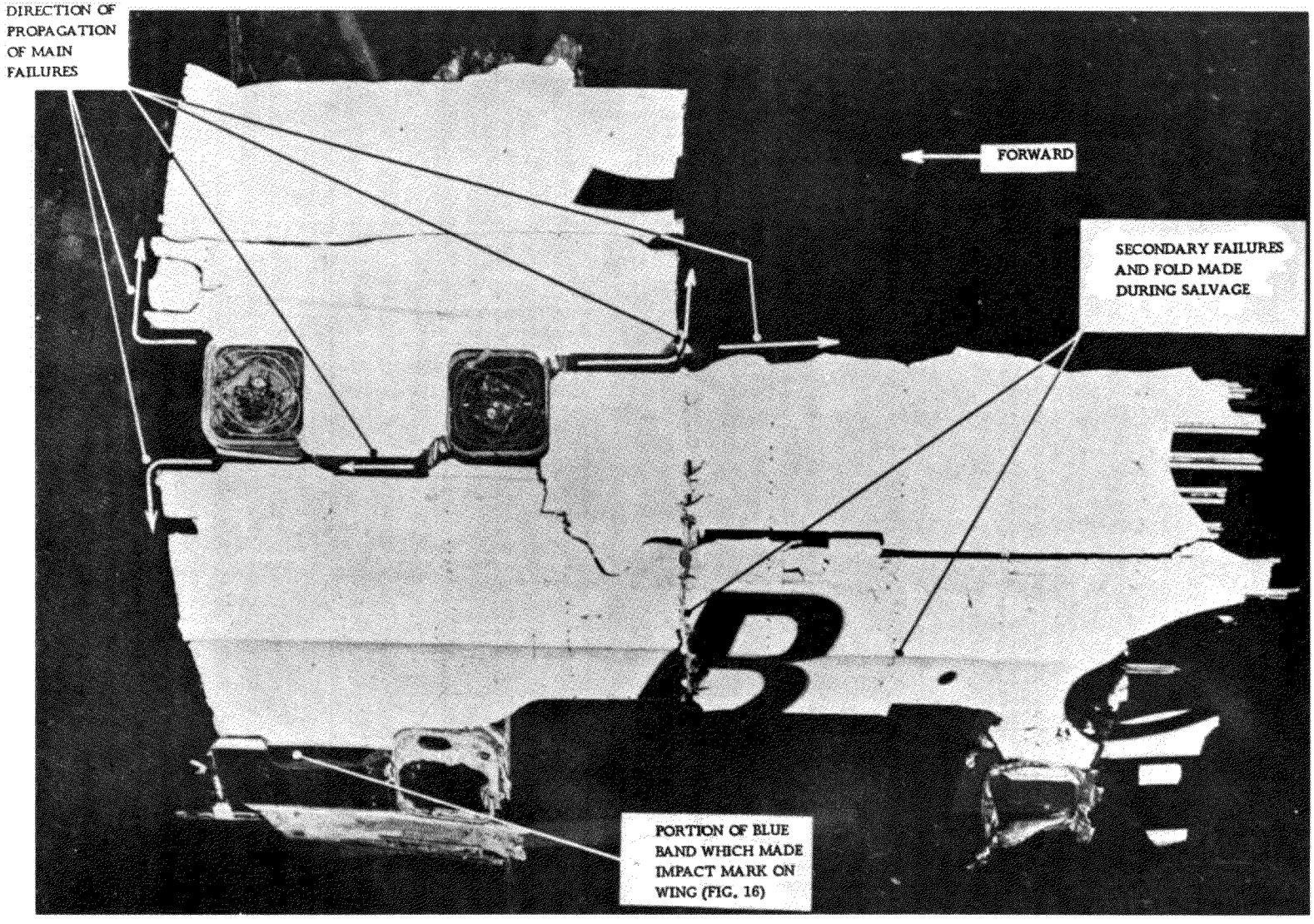
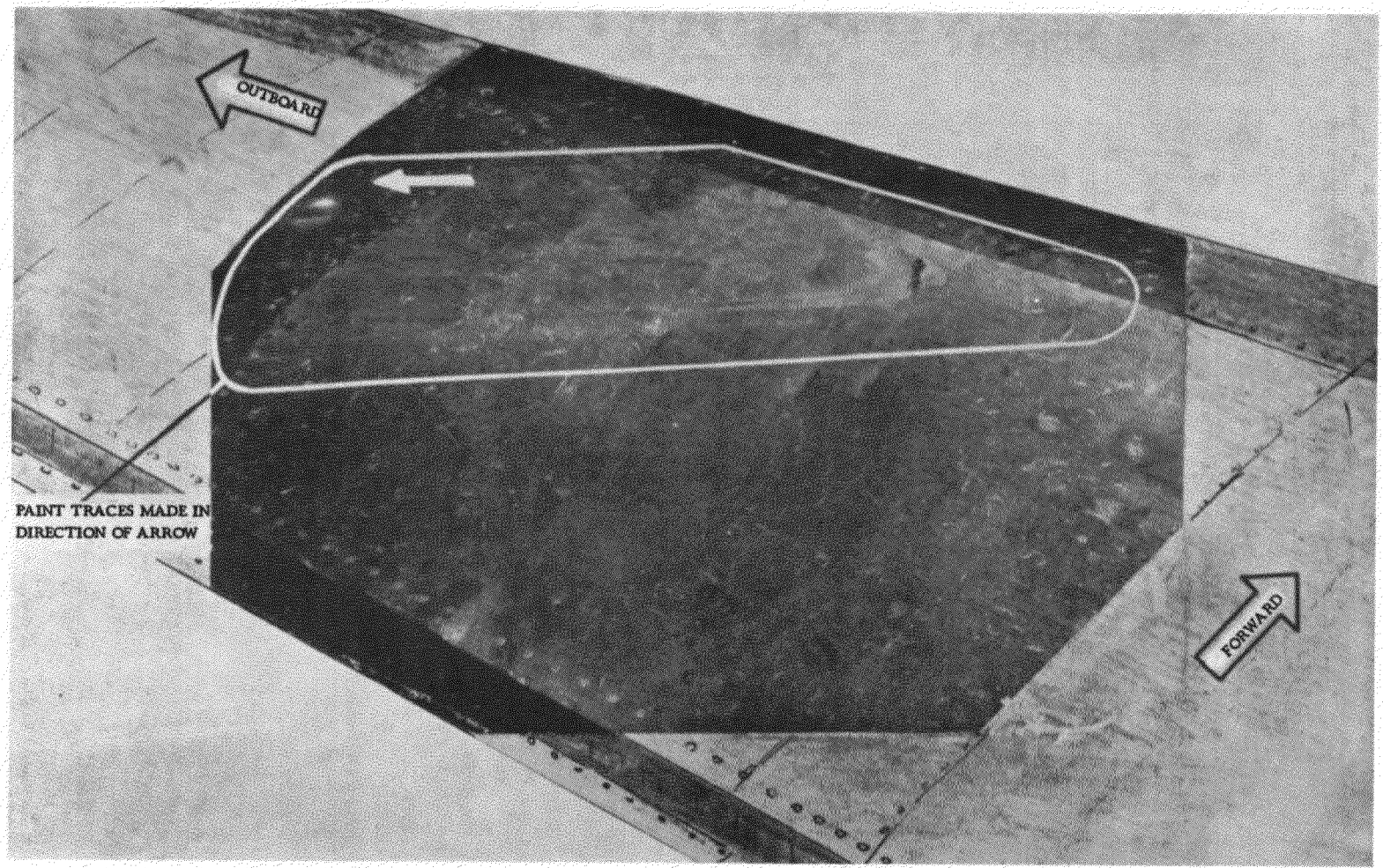


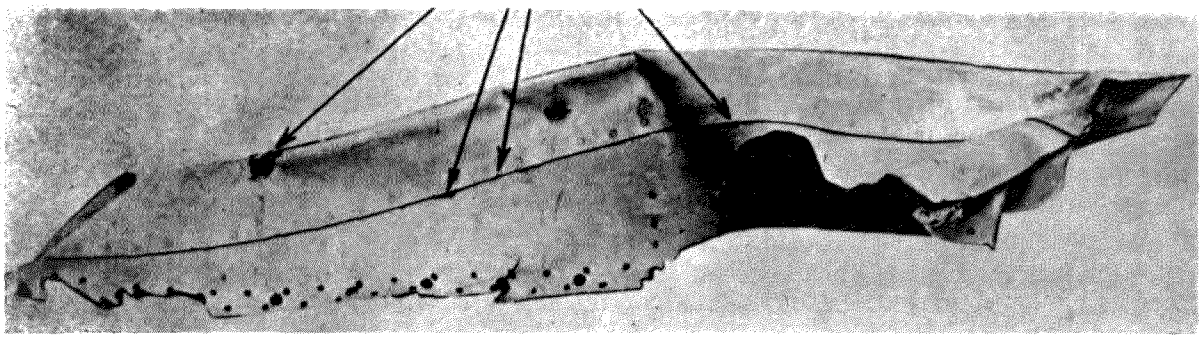
FIG. 10. PHOTOGRAPH OF WRECKAGE AROUND ADF AERIAL WINDOWS—G-ALYP.



(FOR LOCATION ON AILERON SEE FIG. 16.)

FIG. 11. PAINT TRACES OVER PORT AILERON UPPER SURFACE—G-ALYP.

PARTICLES OF FIBREGLASS AND WOOD JAMMED INTO SKIN AND UNDER LAP JOINT PROBABLY FROM FUSELAGE CABIN FLOORING



GENERAL PATTERN OF METALLIC SCORES AND PAINT TRACES OVER INBOARD FACE PROGRESSING FROM WING SKIN TO UPPER EDGE OF FENCE

NO COMPARABLE DAMAGE ON OUTBOARD FACE OF FENCE

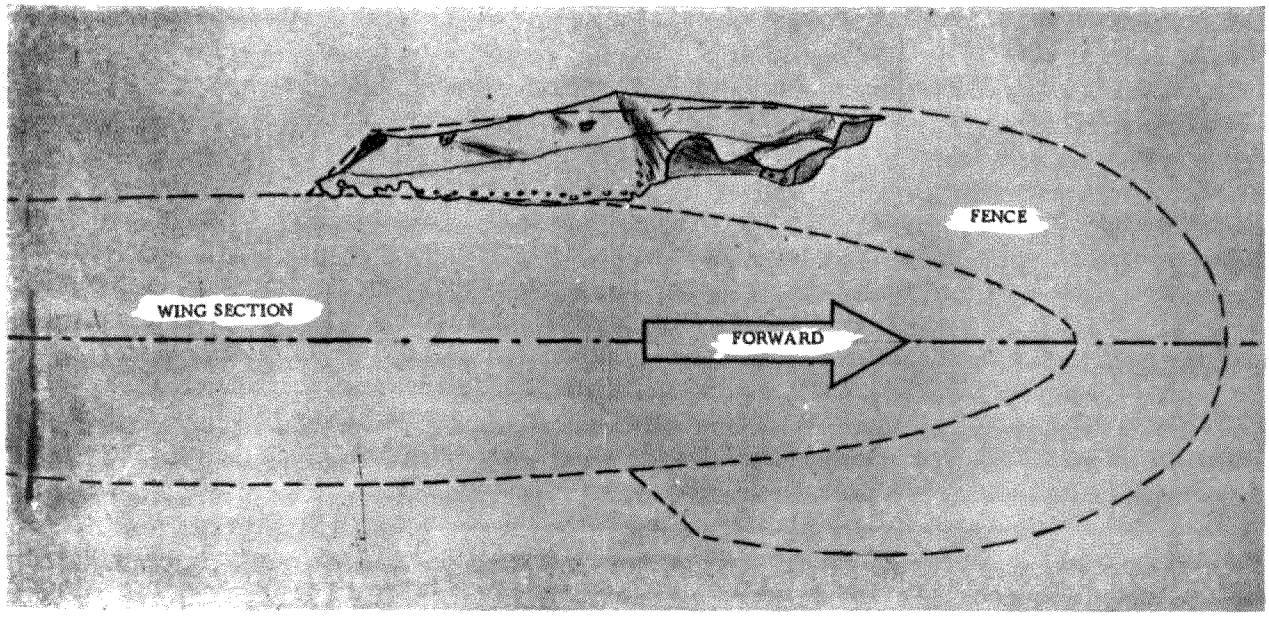
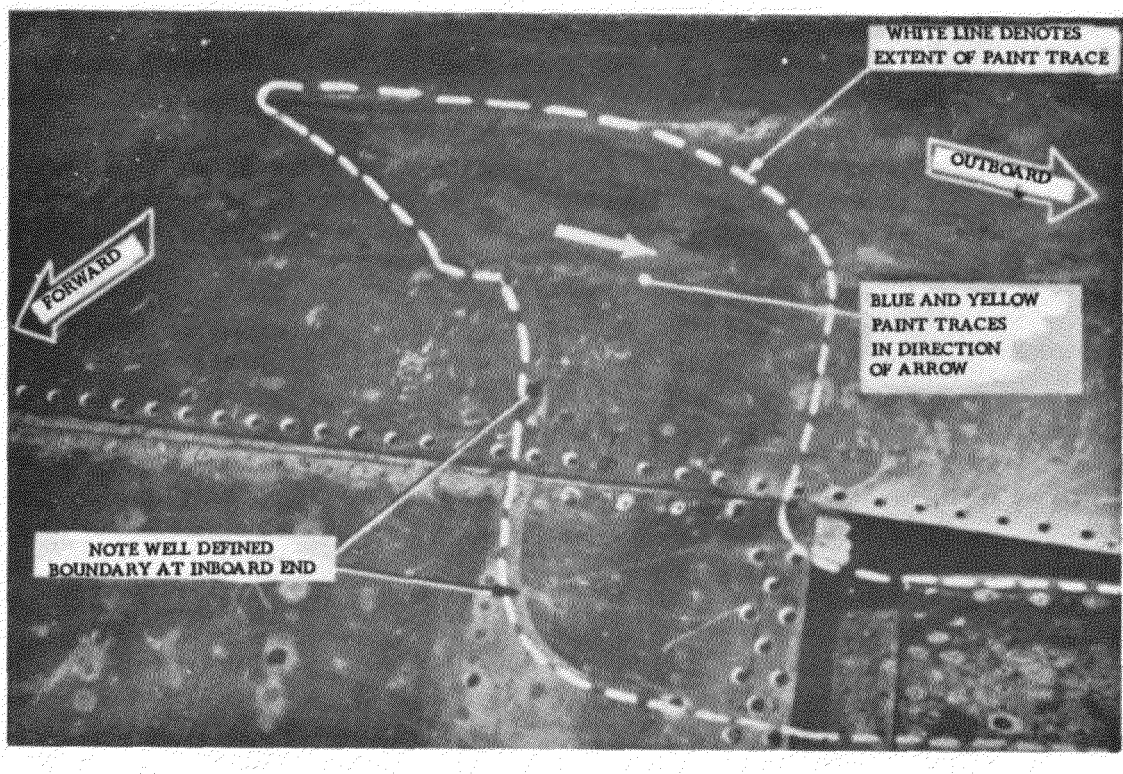
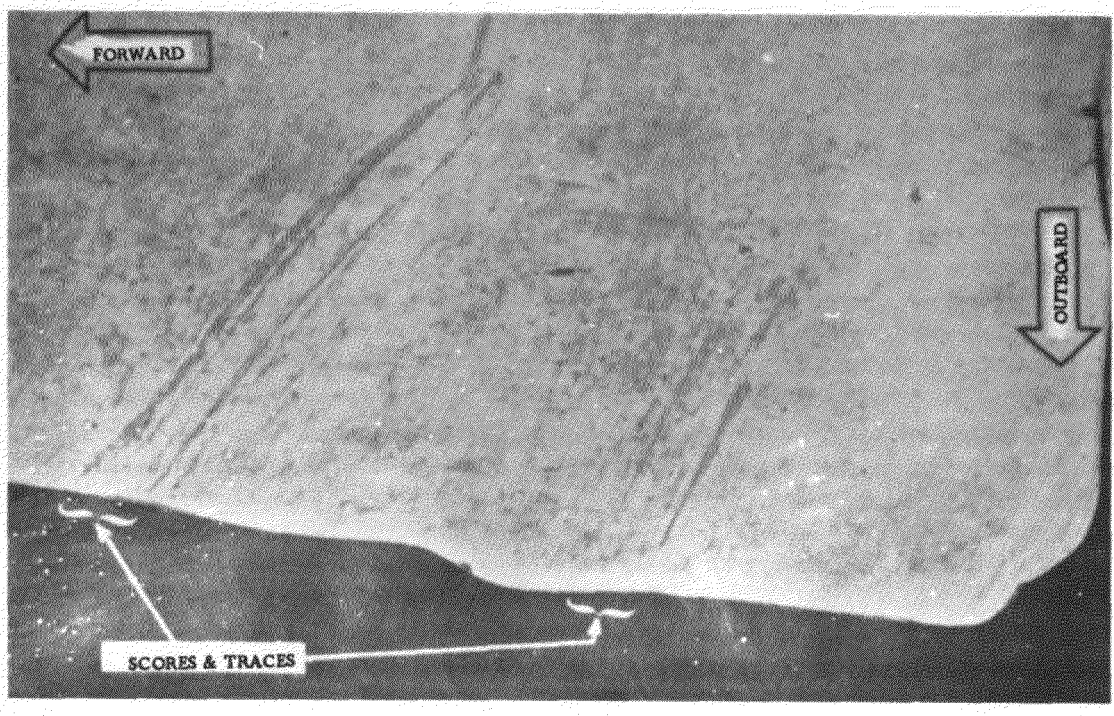


FIG. 12. PORT BOUNDRY LAYER FENCE, IMPACT DAMAGE TO INBOARD FACE—G-ALYP.



PAINT TRACES MADE BY PORTION OF CABIN WALL
(FOR LOCATION SEE FIG. 16).



HEAVY METALLIC SCORING WITH BLUE PAINT TRACES CONTINUOUS OVER FRACTURE EDGE
(FOR LOCATION SEE FIG. 16).

FIG. 13. PAINT TRACES ON PORT WING UPPER SURFACE—G-ALYP.

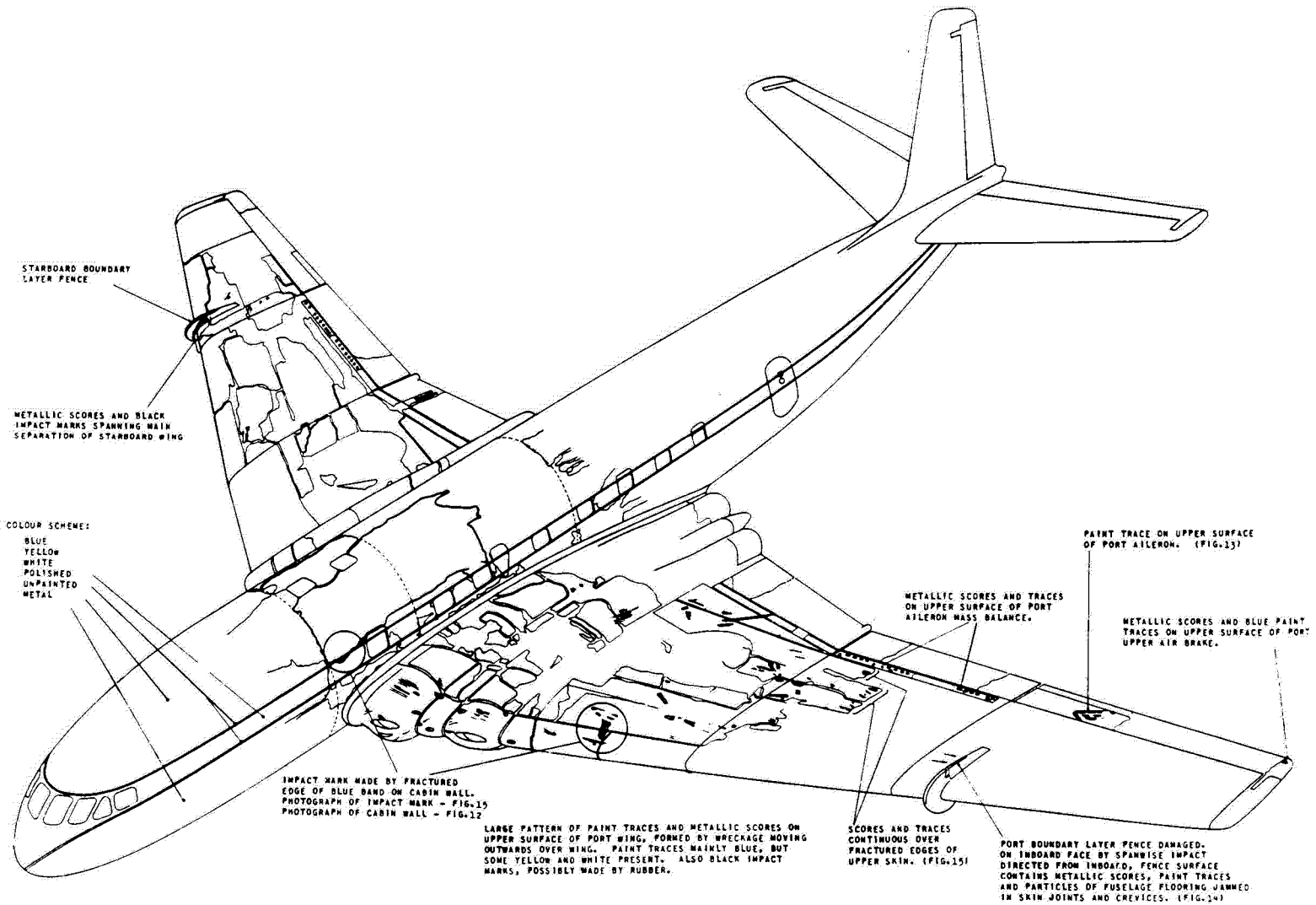
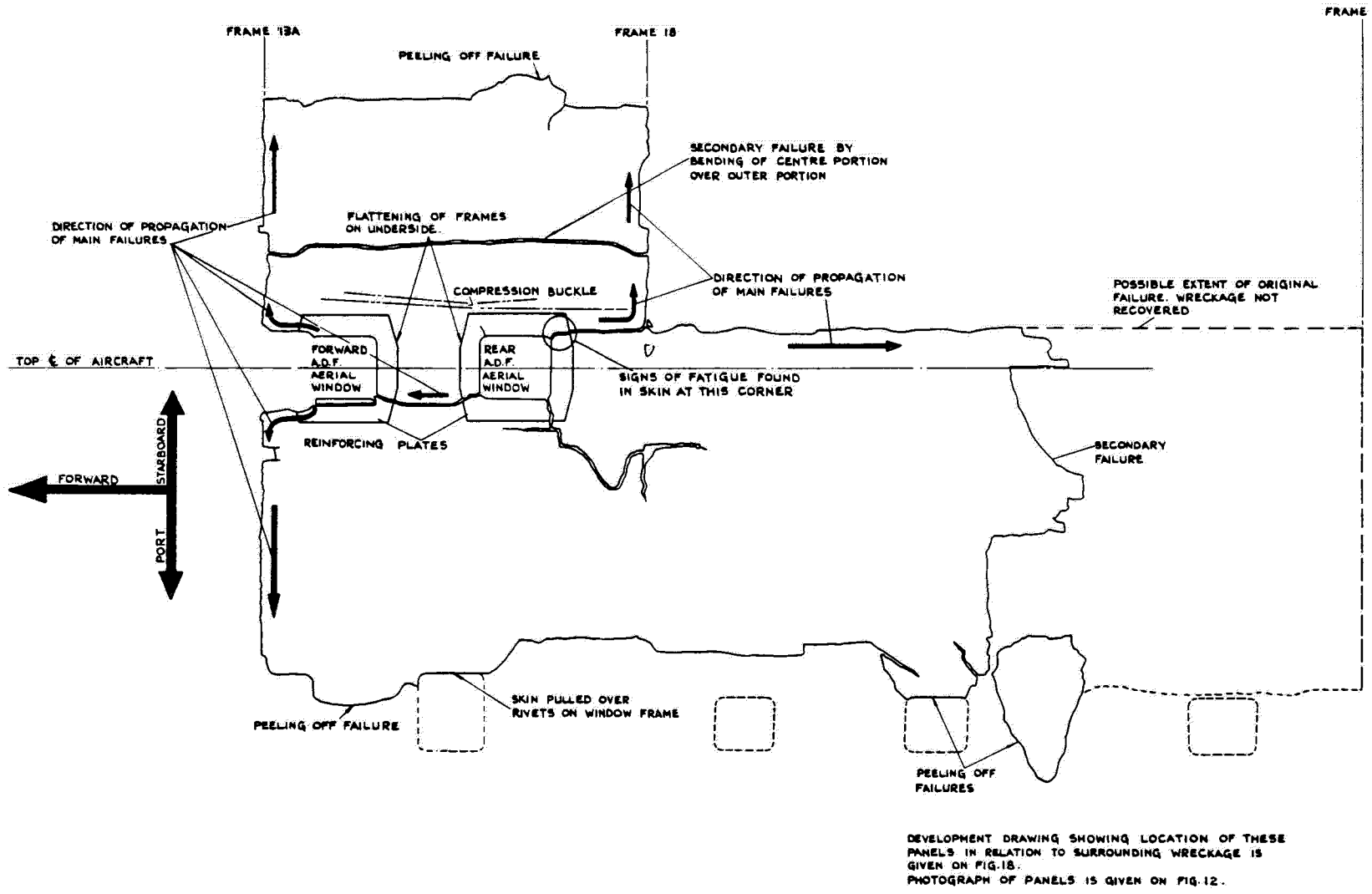
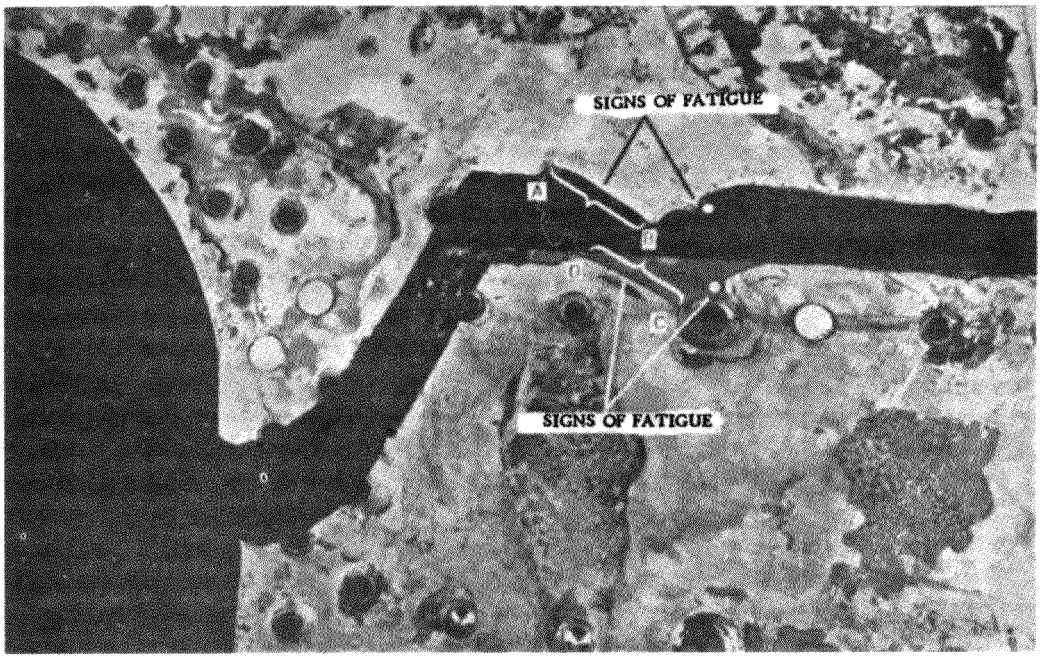


FIG. 14. IMPACT DAMAGE TO UPPER SURFACES OF WINGS—G-ALYP.

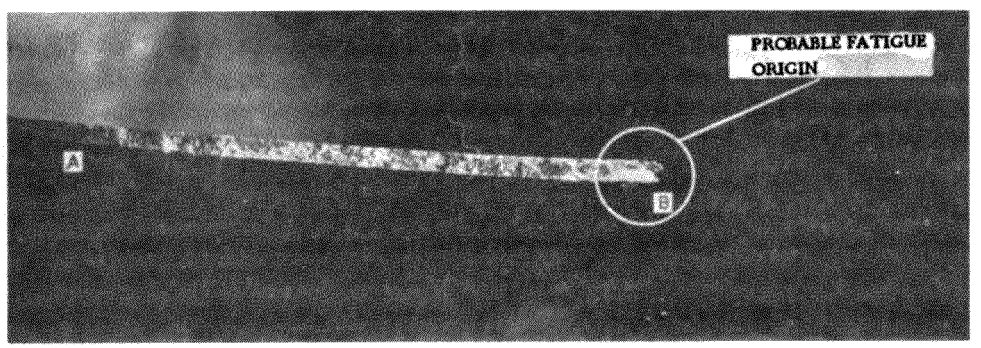


DEVELOPMENT DRAWING SHOWING LOCATION OF THESE PANELS IN RELATION TO SURROUNDING WRECKAGE IS GIVEN ON FIG.18.
PHOTOGRAPH OF PANELS IS GIVEN ON FIG.12.

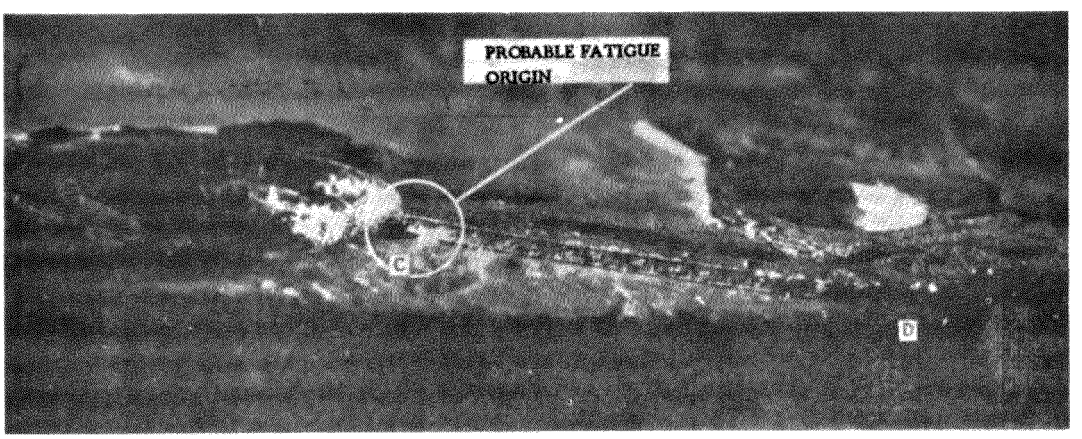
FIG. 15. SALIENT FEATURES OF DISRUPTION OF PRESSURE CABIN—G-ALYP.



(a) PLAN VIEW OF FAILURE IN SKIN.



(b) VIEW OF EDGE A B.



(c) VIEW OF EDGE C D.

FIG. 16. SIGNS OF FATIGUE IN SKIN AT STARBOARD REAR CORNER OF REAR ADF AERIAL WINDOW—G-ALYP.

No. 3

American Airlines Inc., Convair 240, forced landed one mile south of Buffalo Airport, New York, 20 January 1954. C.A.B. Accident Investigation Report No. 1-0010: Released 24 May 1954

Circumstances

The flight originated at Albany, New York, on 24 May 1954 and was scheduled to St. Louis, Missouri, with intermediate stops. The flight arrived at Buffalo Airport at 1618 and took off again with 3 crew and 21 passengers at 1640. During the climb the left propeller feathered itself automatically. Unable to maintain height, the pilot landed the aircraft wheels up in a field. The passengers and crew evacuated the aircraft in an expeditious and orderly manner. The crew and several passengers were injured.

Investigation and Evidence

Normal pre-take-off checks were performed and the take-off roll was started at 1640. The aircraft became airborne after using approximately one-half of the 5,630-foot runway. Immediately after leaving the ground the gear was raised and the first officer saw the left feathering button light come on dimly, which indicated that the left propeller was in the process of being feathered by the auto-feathering system. After definitely determining the light was on and visually checking the left propeller, the auto-feathering system was disarmed and the captain, in an effort to stop the feathering cycle, pulled the feathering button to neutral. This effort was unsuccessful, the left propeller feathered, and the engine stopped. During the climb an air speed of 140 mph was reached and maintained, the right engine remaining at full take-off power. Approximately 250 feet above the ground a shallow left turn was started and the first officer was ordered to restart the left engine, the captain believing the aircraft would climb no farther. In the effort to restart the left engine by unfeathering the left propeller, only 600 rpm could be obtained and the captain felt a buffeting through the control yoke. The aircraft at this time had progressed in the left turn approximately 180 degrees from the take-off direction and the captain, fearing he would be unable to clear obstructions, including high tension lines, decided to make a wheels-up landing. The landing was made in a field approximately one mile south of the airport.

The aircraft came to rest 1,201 feet beyond its initial contact with the ground and on a magnetic heading of 71 degrees. It struck several trees along its path, one of which sheared the left wing outboard of its engine nacelle and another the left horizontal stabilizer and adjoining elevator. A large hole was torn in the left side of the cockpit by the trees. The forces resulted in severe damage to the airframe although no fire occurred. Examination of the damaged components of the airframe revealed no evidence to indicate failure or malfunction prior to the accident.

Investigation directed to the power plants revealed both engines had sustained only minor impact damage. The accessories of the left engine were intact and the various components failed to reveal any pertinent discrepancies prior to a test stand run. During this test the engine was started and given a magneto check at 2,200 rpm and 30 inches of manifold pressure. At that time it was noted the torquemeter boost pump delivered only 65 psi (pounds per square inch), the normal being 250 psi at 1,600 rpm. Increased power failed to give a pressure increase. The front oil pressure and torquemeter boost pump assembly was immediately removed and disassembled. This revealed a sheared torque boost pump drive gear key as well as a failure of the boost pump drive gear. The drive gear failure occurred in the radius of the gear key slot and extended through the nearest gear tooth valley. Microscopic examination revealed evidence of a fatigue-type failure with the progression lines radiating out from a tool mark on the edge of the chamfered area. The gear shaft was heavily worked and metal displaced in the gear key way. The boost pump body section was scored approximately 30 degrees around on the outer edge of the pump pocket. This failed assembly was subsequently replaced and the engine restarted with a resultant satisfactory engine operation with normal pressure and BMEP indications.

Investigation of the auto-feathering system failed to reveal any evidence of malfunction or failure. A functional test of the torque switch and BMEP transmitter on another Convair 240 aircraft revealed normal operation when power was reduced to 78 BMEP; the torque switch closed normally activating the auto-feathering system.* Functional testing of the left propeller feathering switch light circuit revealed intermittent operation causing the light to flicker. Also, the light appeared less brilliant than the right feathering button light. Examination revealed this discrepancy was caused by a loose terminal to the light circuit as well as the light bulb being loose. The reduced brilliancy was caused by a frosted white bulb being installed in the left switch as compared to a clear amber bulb in the right. The investigation further disclosed that a failure of the boost pump drive gear and/or key with the attendant loss of pressure to the torquemeter system will cause auto-feathering of the associated propeller in the same manner as a loss of engine power.

During the investigation and subsequent hearing, the first officer stated that in his attempt to restart the left engine he pulled the feathering button to the unfeather position and held it probably more than two seconds, repeating this action several times. He also stated he was unaware that continued holding of the button would result in the propeller blades rotating back and forth in a six-degree travel (hunting) in the high pitch range. He thought that by holding the button, unfeathering would be expedited. He further stated that the mixture control remained in the off position because the engine rpm never exceeded more than 600 and did not attain the required 1,300 rpm for returning the mixture control to the "auto-rich" position. In regard to unfeathering as required to reach starting rpm the company flight manual stated, "For unfeathering the button must be pulled out and held out as required to accomplish unfeathering," the world "held" being underscored. The emergency procedure instructions appearing elsewhere in the same manual, however, stated to hold the button for two seconds maximum. This ambiguity was corrected immediately subsequent to this accident.

The captain stated that he attempted to stop the auto-feathering and was unsuccessful. He also stated that he pulled the feathering button to neutral and upon releasing it, it "sucked back in" to the feathering position. Based on the functional design of the propeller auto-feathering system and the fact that when functionally tested the system operated normally in all respects, pulling the button to neutral would shut off the feathering pump causing the feathering cycle to stop. The propeller would then windmill, immediately returning to governoring range and starting rpm. The feathering itself was caused by the failure of the torquemeter boost pump drive gear and key and a resulting loss of pressure which activated the auto-feathering system.**

The captain stated that his decision to order restarting of the left engine was based on several factors: weather was further deteriorating in the direction of flight with lowering ceiling and poorer visibility, and turbulence added to the single-engine situation made instrument flight inadvisable. When the left propeller feathered, the captain stated that he believed by feel of the aircraft controls and by the engine sound that the feathering was not the result of power failure but a malfunction of the auto-feathering system. This belief, he said, was predicated on his knowledge of previous instances of such featherings, and his decision was based on his belief that he could not continue flight on one engine under the existing circumstances.

When the first officer attempted to restart the left engine, it is indicated that he held the feathering button to the unfeather position longer than two seconds in each of the attempts and as a result the hunting condition took place. This condition is evidenced by the engine rpm

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* This is normal because the switch is designed to close between 73 and 78 BMEP.

** In order to prevent, so far as possible, recurrence of this failure and to improve the component, American Airlines issued a directive 1 April 1954. The directive requires that Woodruff keys be replaced on all Convair engines which have more than 800 hours of operation. It also requires the torquemeter boost pump component to be replaced with a spline type pump on all engines having under 800 hours since overhaul as they reach 800 hours.

remaining at approximately 600. The engine did not start because the mixture control remained in the "idle cut-off" position; the first officer waiting for the required 1,300 rpm before returning it to "auto-rich". It is very probable that had the correct unfeathering procedure been used at this time the engine was capable of restarting and would have done so. The Board was of the opinion that some responsibility for this incorrect procedure must be placed on training and on the manner of presenting the unfeathering procedure in the pilot's manual. The presentation was subject to misinterpretation as to the time required for holding the unfeathering button out to accomplish unfeathering, and did not explain the resulting "hunting" condition which could develop if it were held too long. Training was deficient as indicated by the first officer's testimony that he did not follow the correct unfeathering procedure. The company recognized the significance of this discrepancy and immediately following the accident amended its publication to clarify and explain the unfeathering procedure.

Probable Cause

The Board determined that the probable cause of this accident was (1) a mechanical failure of the torquemeter boost pump that automatically feathered the left propeller immediately after becoming airborne, and (2) the use of an incorrect procedure for unfeathering which resulted from the ambiguity of the instruction for unfeathering contained in the company's manual.

No. 4

Zantop Flying Service DC-3A aircraft, crashed near Kansas City, Missouri, Municipal Airport on 20 January 1954.
CAB Accident Investigation Report No. 1-0003.
Released 29 June 1954

Circumstances

The flight operated as a cargo flight and, carrying a crew of 3, departed Jackson, Michigan for Atlanta, Georgia, at 0252 CST on 20 January 1954. While on an ADF approach to Fairfax Airport, Kansas City, for a landing on runway 21, the aircraft crashed 400 feet North and 150 feet West of the approach end of runway 17 of the Kansas City, Municipal Airport. All 3 crew members were killed.

Investigation and Evidence

Prior to departing Jackson, the crew went to the CAA Communications Station on the airport and reviewed the weather sequence reports and en route forecast and the captain also telephoned the U.S. Weather Bureau Office at Detroit, Michigan, to obtain more detailed information. Following the review of the weather data, an IFR (Instrument Flight Rules) flight plan to Kansas City, Kansas, was filed which indicated a cruising altitude of 10 000 feet, estimated elapsed time of four hours plus 20 minutes with seven hours of fuel on board and Springfield, Missouri, as the alternate airport. According to company records, the weight of the aircraft at take-off was under the allowable gross weight of 26 900 pounds and the load was distributed so that the centre of gravity of the aircraft was within approved limits.

Routine position reports were made and when over Burlington, Iowa, at 0536, the flight was cleared to the Liberty Non-Directional Beacon, 16 miles northeast of Kansas City, to descend to and maintain 2 500 feet. At 0627, ARTC (Air Route Traffic Control) cleared the flight to the Kansas City, Missouri ILS (Instrument Landing System) outer marker to maintain 2 500 feet and to contact approach control when over Liberty. Twenty-nine minutes later, at 0656, the flight reported being over Liberty and approach control gave it the 0635 Kansas City, Missouri, weather as follows: ceiling measured 600 feet, overcast, visibility 1-1/2 miles, light freezing drizzle, fog, and altimeter setting 29.89. At this time approach control also verified that the aircraft was to land at the Fairfax Airport, Kansas City, Kansas, and immediately gave it the 0655 Fairfax Airport weather report: ceiling measured 600 feet, overcast, visibility 2 miles, light freezing drizzle, light snow, fog and wind northwest 30 mph. This airport is one and one-half miles northwest of the Kansas City Municipal Airport and across the Missouri River. The flight was then cleared to make an ADF approach to Fairfax for a landing on runway 31 and was requested to report leaving the outer marker.

The aircraft reported leaving the outer marker inbound at 0705 and was advised to contact the Fairfax Tower. The flight complied and requested the wind direction and runway in use. The tower replied that the runway was 31, the wind was from the north-northwest 20-30 mph and gusty, and the altimeter setting was 29.88. A few seconds later the tower also advised that the high intensity approach lights at the Kansas City Municipal Airport were on and if too bright would be turned down. The flight's acknowledgment was negative and there was no further radio contact.

At approximately 0755 the wreckage was located by the Kansas City Municipal Airport patrol 400 feet north and 156 feet west of the approach end of runway 17 of that airport.

First contact with the ground was made by the right main landing gear when it struck the top of a mound of dirt which jutted 21 feet from the east bank of the Missouri River. The river at this point is approximately north and south. It was determined by the examination of the wreckage and the ground marks that at the time of impact the aircraft was in a nose-high slightly

left wing low attitude on a heading of approximately 60 degrees. The lower left side of the aircraft's centre section and fuselage struck the river bank next and the aircraft then slid 60 feet farther.

The aircraft was equipped with de-icer boots. When examined an hour after the accident, approximately one-half inch of clear ice was observed on the leading edges of the wings. The crazed patterns of this ice indicated that the de-icer boots had been in operation prior to the accident. Ice, similar in amount to that found on the wings, was also found on the leading edge of the horizontal stabilizer. It was determined that the landing gear was extended at the time of the accident.

Control positions, subject to change by impact in some cases, were as follows: left throttle open, right closed; left mixture - auto-lean, right between auto-lean and idle cutoff; carburetor air, left and right cold; landing gear, neutral; flaps, neutral; wing de-icer boot control on; the ignition, master and pitot heat switches were "on".

Examination of the airframe and control systems revealed no evidence of malfunction or structural failure before impact.

The condition of all propeller blades indicated that the propellers were rotating at impact. The propellers were equipped with de-icing equipment. It was not possible to determine if this system was operating at the time of the accident.

The damaged engines were given a teardown inspection and no evidence was found to indicate any malfunction or structural failure prior to impact.

A large cold air mass was moving southeastward into the Plains States at 0000, 20 January 1954. A wave type low center located in extreme southwest Kansas was moving rapidly northeastward in the transition zone of the cold air mass. At the time the flight departed Jackson, Michigan, the cold front extended southwestward from central Wisconsin through southeastern Iowa, northwest Missouri to approximately Topeka, Emporia and Wichita, Kansas. The cold front passed Kansas City about 0355 and at the time the flight reached Kansas City, the cold front was approaching Columbia, Missouri, 100 miles to the east. Showers and thundershowers were preceding the front. A narrow band of rain showers existed immediately behind the front, changing to freezing drizzle and snow farther back of the front. The temperature gradient to the rear of the front was extremely steep.

The captain, before departure, was advised by FAWS (Flight Advisory Weather Service), Detroit, that conditions upon arrival at Kansas City could not be expected to be better than the area forecast. This forecast indicated icing in below freezing temperatures with the freezing level at 8 000 feet plus an additional freezing layer at the surface with moderate to heavy icing in the low clouds. The flight crossed the cold front near Burlington, Iowa, and as it progressed temperatures below freezing were encountered. Moderate ice and moderate turbulence were experienced for the remainder of the flight after passing Kirksville, Missouri. The weather at Springfield, the alternate, at the time of the approach to Kansas City was: ceiling measured 2 000 feet, broken clouds, visibility 15 miles and wind from the south-southwest 15 miles per hour and was also well above minima throughout the entire flight.

The crew flight kits contained current CAA Flight Information Manuals and this manual describes the ADF approach for Fairfax Airport. The ADF procedure requires the use of the Bluff Fan Marker (3.7 nautical miles inbound - course 184 degrees from the outer marker) and specifies a right turn at the Bluff Marker to 224 degrees. This turn is 0.8 nautical miles from the approach end of Runway 22. Manual minima for the ADF approach to Fairfax are 700 feet and one mile.

Investigation disclosed that all crew members had previously landed at Fairfax Airport, but it could not be ascertained under what weather conditions this experience had been gained. However, the tower controller asked the pilot during his approach whether he was acquainted with the missed approach procedure and he replied that he was.

Two ground witnesses south of Fairfax Airport observed the aircraft flying overhead at an estimated altitude of 100-200 feet above the ground. These witnesses observed the aircraft making a left-hand pattern rolling violently from side to side while descending. They described the motion of the aircraft as wallowing. One witness, an aircraft mechanic, stated the aircraft appeared to be out of control. The other witness, located farther along the pattern, stated he thought the aircraft would crash before getting back to the airport. Both witnesses testified to the freezing drizzle, slippery ground conditions, low ceiling and poor visibility. They lost sight of the aircraft when it disappeared to the east behind ground structures.

Analysis - When the flight was in the vicinity of Liberty, Missouri, it received the latest Kansas City Municipal and Fairfax Airport weather information which indicated that the ceiling of both these airports was 100 feet below the company's prescribed minima with freezing drizzle at the surface. This report was received by the pilot nine minutes prior to the start of the approach at the outer marker. Therefore, it is evident the pilot started the approach with full knowledge that if the approach was continued, he would be descending below his approved minima and into known icing conditions. The weather at the alternate, Springfield, throughout this period was above the minima with respect to both visibility and ceiling. Why the pilot elected to land under these conditions instead of proceeding to his alternate is not known.

It is the responsibility of a pilot to be familiar with the Civil Air Regulations pertaining to instrument approaches*. This is especially true since CAA control tower personnel assume only the responsibility of traffic separation.

The evidence indicated that the pilots were not only familiar with the Kansas City area but also with the procedures involved in making an ADF approach to Fairfax Airport. The initial portion of this approach was apparently normal; however, the aircraft crashed while circling to land on runway 31. During the entire approach the ceiling was reported as being 100 feet below the company's authorized minima.

The banking of the aircraft, observed immediately prior to the crash, could have been due to the approach being made at low air speed with de-icer boots in operation. At low air speeds portions of the wing can stall due to the cycling of the de-icer boots.

Study of all available weather data indicates that icing conditions and turbulence were encountered near Burlington. However, when the descent was made to 2 500 ft. after passing Burlington, above freezing temperatures together with light turbulence were encountered. Between Kirksville and Liberty the flight entered a cold wedge which was behind the cold front. This air was below freezing temperature and throughout the remainder of the flight moderate turbulence and moderate to heavy icing conditions existed. Ice accumulation would require a higher than normal air speed to continue a safe landing approach. In addition, wing de-icer boots due to their pulsation would cause considerable loss of lift if the aircraft were flying at a low air speed. Therefore, it is probable that de-icer boot operation and ice accretion in this case caused loss of control at an altitude too low to effect recovery.

Probable Cause

The Board determined that the probable cause of this accident was the loss of control of the aircraft at an altitude too low to effect recovery. The loss of control resulted from an accumulation of ice and the use of de-icer boots at low air speeds.

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* CAR 42.56 "INSTRUMENT APPROACH. No instrument approach procedure shall be executed or landing made at an airport when the latest United States Weather Bureau report for that airport indicates the ceiling or visibility to be less than that prescribed by the Administrator for landing at such airport....."

ICAO Ref: AR/337

No. 5

Compagnie Autrex, DC-3 aircraft damaged on landing at Beyrouth International Airport on 24 January 1954. Directorate of Civil Aviation, Lebanon, Accident Report No. 8

Circumstances

The aircraft, belonging to the Compagnie Autrex, was on a delivery flight from Paris to Hanoi. It departed from Paris on 22 January 1954 at 0650 Z and arrived at Brindisi the same day at 1305 Z. The following day the aircraft left Brindisi at 0720 Z and landed at Nicosia at 1330. From Nicosia the aircraft intended to fly to Basra, but a failure in the HF radio equipment caused a change in the schedule, and it was decided to fly to Beyrouth where specialists and the spare parts necessary for the repair were available. While landing, the aircraft struck a mound short of the runway damaging the right undercarriage. The aircraft subsequently landed on the runway when the undercarriage collapsed. There were no injuries.

Investigation and Evidence

At 0630 Z the pilot contacted Beyrouth requesting permission to land. After a routine circuit the aircraft reported that it was down wind and received the following information: QNH 29.99, Visibility 4 miles; Surface wind Northwest 10 knots. Temperature 13°; QFE 29.90; Runway 36.

The runway was lighted and the aircraft made a normal approach to land at 0656 Z. The approach was a little short and at 30.30 metres from the entrance to runway 36 the wheel struck a mound rising on an incline to a height of 78 cm above the runway.

The impact caused a blow-out in the right tire and damage to the right landing gear. The airplane bounced after the impact and landed on the runway at some 20 meters from the beginning of the runway. The pilot held the aircraft on the left wheel, but at 600 metres, following loss of speed and of lift, the aircraft settled on the right landing gear which collapsed, causing the tip of the right wing to scrape against the ground. As a result, the aircraft swerved to the right and left the runway at the intersection of runway 36-18 and the first taxiway.

The aircraft broke three markers -- one runway marker and two taxiway markers -- and cut a high tension cable which caught fire.

The first witness to arrive at the scene extinguished the fire. The end of the severed cable was located at 1.50 metres from the tip of the right wing of the aircraft.

In his evidence the captain explained that on final approach he had half flaps, landing gear down and locked and an approach speed of 105 mph, with 2350 rpm, auto-rich with manifold pressure of 16-17 inches. No turbulence was experienced. After the impact the aircraft continued to move in a fairly normal attitude. When the aircraft touched down, the captain noticed that the landing gear would not hold and he then cut all switches without, however, starting the fire extinguishers. After the stop, "fire" was reported which, when checked, proved to be fire in the cable connecting the markers. (Note: The cable carried 5,000 volts).

Marks left on the mound showed that the right wheel touched before the left. The aircraft was, therefore, inclined slightly to the right on landing. The right wheel touched about 1 metre before the left wheel and the furrow made by the right wheel was deeper. However, the mound sloped down on both sides and the impact should not have been strong enough to cause the landing gear to break.

The altimeter reading after the accident showed a setting of 29.97. However, according to information provided by the tower to the pilot before the accident, the QNH was 29.99 and the QFE 29.90.

The load sheet on departure from Nicosia contained several errors, the combined effect of which gave a landing weight at Beyrouth which exceeded that permitted by the Certificate of Airworthiness by 27 kg.

The main cause of the accident was probably an unduly short landing which, in view of the length of the runway and the perfect condition of the aircraft, was unwarranted and must, therefore, be ascribed mainly to error on the part of the pilot, due largely to his lack of familiarity with the terrain. The pilot had never landed at the Beyrouth International Airport. The faulty altimeter setting was possibly an additional reason for the defective approach. Also, restricted visibility prevented the pilot from seeing the mound and taking appropriate action to avoid a crash.

The presence of the mound at 26.60 metres from the runway entrance was a contributing factor. Since this mound was 78 cm high, the variation in level was 3%.

Probable Cause

The accident is attributed to pilot error due to lack of knowledge of the terrain. The existence of the mound was only an aggravating circumstance. The failure of the right landing gear may be explained by the excessive landing weight of the aircraft.

Recommendations

A regular inspection of the runway ground approaches is necessary to reveal natural obstacles caused by the movement of sand as well as all variations in land caused by the wind. A special crew should always be ready to smooth out areas which might be considered as dangerous.

Any unusual condition should be brought to the attention of the airport manager who will act accordingly.

In addition, the manager should be advised of any temporary installation of electric cables which does not meet the required conditions, and measures should be taken so that these installations shall be of the shortest possible duration. The breaking of the electric cable could have caused much more serious results.

ICAO Ref: AR/310

No. 6

Pan American Airways, Douglas DC-6B damaged on landing at Shannon Airport, Ireland, on 15 February 1954. Department of Industry and Commerce (Ireland) Investigating Officer's Summary Report

Circumstances

At 1800 hours on 14 February 1954, the flight with 9 crew and 37 passengers on board departed from Idlewild, New York, on a scheduled flight for Frankfurt, with intermediate stops at Shannon and London. After an uneventful flight the aircraft landed under VFR at Shannon Airport at approximately 0500 hours on 15 February in calm and clear weather.

While making the landing at Shannon Airport the aircraft undershot runway 05 by about 407 feet, and in running over rough grassland before rolling on to the runway excessive undercarriage loads were imparted to the wing structure causing damage. The aircraft came to rest 4,075 feet along runway 05. There was no fire, and no one was reported injured.

Investigation and Evidence

1. The aircraft and crew were properly certified for the flight.

2. The aircraft load and centre of gravity dispositions were within the prescribed limits.

3. There was no evidence to show that the accident was caused by any structural or mechanical failure of the aircraft.

4. The captain and first officer were pilots of considerable experience and had lengthy experience as captains with PAWA.

5. The captain had had lengthy experience as a captain on DC-6B aircraft; but the first officer, who was at the controls during the landing, had had little experience and no experience as captain on that type.

6. After a lengthy period as captain on Boeing 377 aircraft, the first officer had not adjusted himself fully to the different approach characteristics of the DC-6B.

7. The first officer was not suffering unduly from fatigue at the time of the accident.

8. A patch of ground fog was present between the localizer building and the threshold to runway 05.

9. On final approach it is possible that the first officer's view of the threshold lights to runway 05 was obscured by the patch of ground fog.

Probable Cause

The cause of the accident was a misjudged approach on the part of the pilot, who was under the impression that the aircraft was 30 feet to 40 feet above the ground at the point of touch down.

Probable contributory factors were:

a) a ground fog patch between the green threshold lights to runway 05 and the ILS localizer building which possibly resulted in poor depth perception;

b) previous familiarity with, and unconscious reversion to, the technique of landing Boeing 377 aircraft, an aircraft type with appreciably different characteristics and cockpit visibility from that of the DC-6B. This could be a contributory factor, especially when coupled with the fact that this was the pilot's second night landing on the DC-6B type of aeroplane.

ICAO Ref: AR/371

No. 7

Olstead Aircraft, D.H. 89A Rapide aircraft, crashed near Hexham, Northumberland, England, on 19 February 1954. Civil Aviation Accident Investigation Branch, Report No. C-620

Circumstances

The aircraft took off from Newcastle Municipal Airport at 0850 hours on a charter flight to Dublin Airport. About 10 minutes later when flying in cloud the pilot saw that ice was forming on the wing leading edges and found that the aircraft would not climb above 3,200 feet. He decided to return but a minute or so afterwards lost control of the aircraft, which went into a dive. While the pilot was trying to regain control it levelled out but immediately afterwards struck the ground. None of the occupants was seriously injured. Fire broke out on impact and the aircraft was destroyed.

Investigation and Evidence

During the preparations for the flight the Newcastle control officer gave the pilot a copy of the route forecast and showed him the two weather warnings.

1. The forecast given to the pilot for the route Newcastle-Dublin during the period 0815 hours to 1115 hours on the day of the accident was as follows:

"Inference:

A complex depression centred over the British Isles is slow moving.

Winds:

Surface E. 10-15 kts becoming variable 5 kts becoming W.N.W. at 10 kts.

2,000 feet 120° 15-20 kts becoming variable 10 kts becoming 360° at 10-15 kts.

5,000 feet 130° 15-20 kts becoming variable 10-15 kts becoming 340° at 10 kts.

10,000 feet 140° 15-20 kts becoming variable 10-15 kts becoming 320° at 10 kts.

Weather: Cloudy-occasional rain or drizzle with snow or sleet on hills.

Visibility: 2-3 miles but 1-2,000 yds in precipitation and in hill fog.*

Cloud: 8/8 Sc. and St. 1,200 feet - 1,800 feet base falling to 8/8 at 500 feet - 800 feet in precipitation covering hills, tops 6-8,000 feet, 8/8 Ac. As. 10,000 feet - 15,000 feet.

Icing Index: Moderate or severe.

Freezing Level: 1,500 feet.

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* The words "and in hill fog" were incorrectly substituted for "much hill fog" in the forecast given to the pilot.

2. The following warnings were shown to the pilot before departure:

a) Issued by Preston MET Station at 1900 hours on 18 February 1954 "Severe icing with moderate or severe turbulence expected in cloud above freezing level* over Northern FIR for next 18 hours."

b) Issued by Watnall MET Station at 0700 hours on 19 February 1954 "Extensive fog and low stratus and icing over Watnall FIR with severe icing above 2,000 feet will persist for a further 24 hours."

After perusal of these documents the pilot filed a flight plan giving inter alia IFR flight at a cruising level of 6,000 feet. He next weighed the passengers and luggage and made out a load sheet.

The pilot then ground tested the engines and after switching on the pitot head heater took off at 0850 hours. Cloud was entered at an altitude of about 500 feet and the pilot set course flying IFR during the climb to his intended cruising altitude of 6,000 feet.

Clearance from Newcastle Control to Preston ATC was then obtained by R/T but contact with Preston could not be made; this the pilot attributed to his low altitude. Approximately 10 minutes after taking off, when an altitude of 3,000 feet had been reached, the pilot saw that the windscreen was becoming opaque and that the airspeed indicator was fluctuating. He immediately opened the side panels to find that thick ice was forming on the wing leading edges and interplane bracing. The aircraft then started to vibrate and would not climb above 3,200 feet. Since control of the aircraft had also become sluggish and the port engine revolution indicator showed a drop of 200 rpm the pilot decided to return to Newcastle and turned on to a reciprocal track. A minute or so later he lost control of the aircraft which went into a dive and lost height rapidly. The pilot tried to regain control by the application of full engine power but as this appeared to have little effect he throttled back. Shortly afterwards the aircraft struck the ground and fire broke out but all the occupants were able to escape without serious injury.

The accident was not seen by any ground witnesses as sleet was falling and visibility was very poor. The occupants did not know their whereabouts so some of them set off in different directions to obtain help. The police were eventually contacted and rescue services were then sent promptly to the scene, the first arriving at 1040 hours.

The aircraft had crashed on soft moorland 750 feet above sea level and was destroyed by fire. Inspection showed that it had struck the ground with little forward speed when in an almost level attitude. On impact the landing wheels had penetrated the ground to a depth of 2-1/2 feet and the undercarriage had collapsed. The aircraft had then bounced forward 20 yds and caught fire. The fire had probably started from petrol spilled from the tanks which were ruptured when the undercarriage collapsed on first impact.

The condition of the propellers indicated that the engines were not under power at the time of striking the ground.

Detailed examination of the burned wreckage did not reveal any pre-crash defect in the aircraft.

The pilot states that he chose a cruising level of 6,000 feet as he thought the freezing level given in the route forecast was 15,000 feet and that the weather given in the warnings would not affect his route. A pilot with a Commercial Pilot's Licence should have sufficient knowledge of meteorology to realize that in mid-February and with a forecast giving snow and sleet on hills a freezing level of 15,000 feet was most improbable. In addition, the warning issued at 0700 hours that morning predicting severe icing above 2,000 feet should have made him suspect there was some mistake.

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* The forecasting station gave the freezing level as 2,500 feet. Owing to an error during telephonic transmission the height i.e. "at 2,500 feet" was omitted in the warning shown to the pilot.

The airframe and propellers were not equipped with the means for the removal of ice or the prevention of its formation. In consequence, the flight was made in contravention of the Air Navigation Order, 1949, and the Air Navigation (General Amendment) Regulations, 1950.

Probable Cause

The accident was the result of loss of control by the pilot due to ice accretion on the aircraft.

The pilot must be held responsible for the accident in that he did not exercise care when studying the weather forecasts and in consequence made a flight that should not have taken place.

ICAO Ref: AR/338

No. 8

Western Air Lines, Inc., Convair 240, crashed near Wright, Wyoming, USA, on 26 February 1954. CAB Accident Investigation Report No. 1-0036, Released 18 August 1954

Circumstances

The aircraft departed Los Angeles, California, on a scheduled flight to Minneapolis with scheduled intermediate stops. After taking off from Salt Lake City at 0850, radio contact was maintained until 1027 after which attempts to contact the aircraft failed. The wreckage of the aircraft was located, from the air, on 28 February 1954 in an isolated ranch area. The crew of 3 and 6 passengers had been killed.

Investigation and Evidence

The time of the accident was established as being approximately 1032. The finding at the scene of one wrist watch, impact-stopped at 1032, plus the testimony of several persons, located from five to ten miles west of the crash, placing at approximately 1030 the time of an aircraft passing low eastbound substantiate this figure. No other timepieces, either aircraft or personal, were found.

Investigators canvassed the sparsely inhabited area approximately ten miles on each side of the airway and thirty miles back on the flight path for possible witnesses. Due to the heavy snow falling at the time of the accident, there were no eyewitnessess. Twelve persons were located who heard an aircraft over-head in the storm the morning of the accident. All of them are in accord that from the sound the aircraft was at a low altitude and much lower than aircraft usually pass over. Six persons, west of the crash point, place the time around 1030 with the aircraft heading east at a low altitude and the engines sounding loud but normal. No variation in heading or altitude was noted by a majority of these witnessess. However, two witnessess stated that the aircraft was heard twice in a short period of time and from different directions, as if it had circled.

The scene of the accident was in Campbell County, 19 miles east-northeast of Wright, Wyoming. This location is two miles north of the centerline of Civil Airway Red-2, 102 miles west-southwest of the Rapid City LF (Low Frequency) range station. The relatively level sagebrush-covered terrain is at an elevation of 4, 700 feet MSL (mean sea leval).

The aircraft first contacted the frozen ground on a heading of 22 degrees magnetic. The angle of impact was nearly flat with the aircraft in a slightly left-wing-low attitude. The impact force was of great magnitude as shown by the completely disintegrated and widespread wreckage which was found in an area 1, 500 feet long and 450 feet wide. Within this area a few small flash ground fires occurred. A search was made for fallen parts back along the flight path with negative results; no components of the aircraft were found away from the impact area.

Due to the severity of weather conditions only a limited examination of the wreckage could be made at the scene; the wreckage parts were identified or numbered and their location plotted on a distribution chart. All wreckage was then transported to Ellsworth Air Force Base, Rapid City, South Dakota. There the aircraft structural parts were laid out in their proper relative positions on a hangar floor and studied. The engines and propellers were disassembled and examined at Denver for evidence of failure or malfunction. Examination of all components of the aircraft indicated that the following conditions existed at ground impact: aircraft structure intact with no determinable evidence of structural failure or control malfunctioning; no evidence of structural failure or malfunction in engines or propellers; both engines in high blower; condition of the propeller blades indicated rotation with blades at angles greater than for normal

cruising range; electric and vacuum turn and bank, horizon and compass gyros rotating; the ADF receivers were found to be set on frequencies used by aircraft in the general area of the flight; landing gear and wing flaps retracted; passenger loading stair retracted; heat source and heat anti-icing valves in the open (heat demand) position; the cabin altitude selector at a setting of 17,000 feet aircraft altitude; no evidence of in-flight fire or fire damage on any component. The broken webbing of the safety belts of the pilot seats indicated that both pilot seats were occupied.

The aircraft was not equipped with an automatic pilot or a flight recorder. A thorough review of its maintenance records disclosed no irregularities that could be considered pertinent in this accident.

Three small pieces of ice, approximately the size and shape of a man's curved little finger, were found lying on the screen of one carburetor at the crash scene. However, there were several thaws and freezes occurring between the day of the crash and the day the wreckage was first examined. These small pieces of ice matched the folds of the rubber adapter boot which was attached above the carburetor screen. The bottom sides of the ice pieces did not bear the imprint of the screen, indicating that the pieces had fallen from the folds of the rubber adapter during movement of the wreckage. The carburetor and adapterboot were detached from the engine by impact and lying on the ground in a position to receive moisture during the snows occurring during and after the accident. Ice of similar texture was found in an overturned lid of a film container that had been part of the aircraft cargo.

According to the loading manifest and testimony there were 900 pounds of cargo loaded on the six front seats of the cabin. This cargo was secured in the seats by the seat belts and then wrapped with blankets and roped around the seat bases. Portions of cargo were found throughout the wreckage area. It could not be determined if the cargo fastenings had loosened allowing the cargo to shift prior to impact.

The crew obtained their briefing in the company dispatch office at Salt Lake City where surface weather reports, surface maps, forecasts and upper air reports were available. The dispatcher on duty assisted the crew in the briefing.

The surface synoptic weather map for 0530, 26 February 1954, showed a cold front extending eastward from southern Oregon into southwestern Idaho, then north of Pocatello into Wyoming north of Rock Springs, Casper and Douglas and south of Chadron and Valentine, Nebraska. The cold front was moving southward and reached Casper, Wyoming, at 0850, several hours earlier than the forecast time of passage. At the time of the accident the cold front had moved into southeastern Wyoming.

The United States Weather Bureau forecasts for the route involved, available to the crew before departure from Salt Lake City, indicated broken clouds with bases 7,000 to 9,000 feet and tops 20,000 to 25,000 feet MSL, rain and snow showers along the frontal zone, moderate to locally heavy icing in shower clouds above 10,000 feet MSL and moderate to heavy turbulence in the frontal zone. In central and eastern Wyoming the forecast indicated mostly overcast with bases 6,000 to 8,000 feet MSL. Showers were expected following passage of the front, changing to snow with ceilings dropping to 400 - 600 feet and visibilities one-half mile in moderate snow. Icing was expected in snow areas and in clouds, with the freezing level at 9,000 feet MSL ahead of the front and dropping to near the surface behind the front. Heavy turbulence was expected as the front passed with locally heavy to severe turbulence and strong downdrafts along the east slope of the mountains south of the front.

Most of the weather connected with the frontal system was occurring behind the front due to the potential instability of the warmer air mass being released as it was lifted by the cold air wedge. The front passed Casper at 0850 with snow beginning soon after the frontal passage. The flight had probably been above a cloud layer as it approached Sinclair at 15,000 feet. It appears that the top of this cloud layer rose behind the front and may account for the flight's request for a 17,000 feet cruising altitude. Analysis indicated that the clouds built up behind the front to several thousand feet above the 17,000-foot level and that the flight was on instruments by the time it was over Casper.

Weather analysis indicated that the flight was also continuously on instruments from Casper to the crash area. At this time cumulus cells were building to high altitudes. These developing cells contained rather large quantities of subcooled water droplets. As the flight intermittently entered these cells conditions for both aircraft and carburetor icing suddenly increased with indications that icing became at least moderate and turbulence became heavy to possibly severe.* A strong air current or jet stream existed at about 25,000 feet and contributed to the severity of the weather encountered by the flight.

Analysis

At the start of the descent of the aircraft from 17,000 feet MSL (approximately 12,000 feet above the ground) it was operating on instruments under probable conditions of moderate to heavy icing and moderate to severe turbulence. The reason for the descent from the assigned altitude, shortly after ending a normal and routine radio contact with the company radio at Casper, is undetermined, but the Board is of the opinion that weather was a major factor in the accident. Whatever emergency occurred resulted in the aircraft's striking the ground within approximately five minutes after a normal radio contact and only 10 miles east of its last radio position, as computed from the Rapid City ETA (estimated time of arrival) ground speed.

Assuming that the aircraft was over Wright intersection, 17,000 feet at 1025 as reported and then over a position computed from the estimated ground speed of 294 mph ten miles east at 1027, there remain only ten miles and two minutes of flight time to the crash at 1032 if an easterly heading was maintained. This leaves an unaccountable three minutes in the air. If the aircraft, for some undetermined reason, went out of control and lost altitude immediately after the end of the radio contact and regained partial control while circling over the area east of Wright, the widely scattered locations of the witnesses who heard the aircraft passing overhead and the three minutes of unaccounted for flight time are explained, as is the apparent circling inferred by two of the witnesses.

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* U.S. Weather Bureau Definitions of Icing

"Light - An accumulation of ice which can be disposed of by operating de-icing equipment, and which presents no serious hazard. Light icing will not cause alterations in speed, altitude, or track.

Moderate - An accumulation of ice in which de-icing procedures provide marginal protection; the ice continues to accumulate, but not at a rate sufficiently serious to affect the safety of the flight unless it continues over an extended period of time.

Heavy - An accumulation of ice which continues to build up despite de-icing procedures. It is sufficiently serious to cause marked alteration in speed, altitude, or track and would seriously affect the safety of the flight."

U.S. Weather Bureau Definitions of Turbulence

"Light - Usually associated with small cumuliform clouds or with low-level flight over rough terrain. Some passenger discomfort.

Moderate - Associated with towering cumulus, average frontal conditions and in the vicinity (but not interior) of isolated thunderstorms. General passenger discomfort.

Heavy - Usually associated with the interior of thunderstorms, either frontal or isolated. Difficult to maintain flying altitude.

Severe - Rarely encountered. Usually impossible to control aircraft. May cause structural damage."

A high speed at impact is shown by the severity of the disintegration of the aircraft and by the widespread wreckage distribution. A flat attitude with a considerable sinking component in the impact velocity is indicated by localization of the most severe structural damage to the bottom surfaces of the aircraft.

During the investigation at the scene and later, the damaged components were carefully examined for indications of failures or malfunctions that could explain the facts mentioned in the previous paragraphs. Many possible causes were considered and checked thoroughly. Any elimination of the possibilities is restricted to an evaluation of the physical evidence available in the wreckage and does not preclude the possibility of the substantiating evidence being destroyed or undeterminable due to the severe damage to all components.

Possibilities

A. Incapacitation of the Crew

This is not considered probable due to the normal tone of voice and absence of any emergency report or any unusual circumstance during the numerous radio contacts with the Casper company radio operator. Air contamination is discounted by reason of the lack of scorching and arcing marks on electrical equipment. The heating and ventilating ducts showed no signs of discoloration from smoke or fire. There was no evidence to indicate use of oxygen masks which were available in the cockpit. Both pilots were in their seats with safety belts fastened at the time of the accident.

B. Fire in Flight

A few small pieces of wreckage were found indicating fire damage but these were definitely from ground flash fires. Mating of these pieces revealed no consistent fire pattern, indicating that the fire damage occurred during the ground fire after the pieces had torn free from adjacent parts.

C. Explosion in Flight

No evidence in wreckage and aircraft was intact at impact.

D. Structural Failure

Although all components of the aircraft were found in the wreckage area the damage to these components was so severe that it was impossible to determine definitely whether a minor structural failure or malfunction of any of the components had occurred. Major aircraft components and systems were reconstructed sufficiently to indicate that the aircraft was intact at ground impact.

E. Control Malfunctioning

Items which would affect the controllability of the aircraft, such as leading edge material, surface hinges, engine cowling, or control system parts, were carefully examined for evidence of failure or malfunctioning, but none was found. The possibility of some object lodging in the control system and then breaking loose during impact exists since it is extremely difficult, if not impossible, to find evidence of such a condition from a study of the wreckage. Consequently, control system malfunctioning remains a possibility.

F. Loss of Control at Altitude Due to Icing

The probable heavy icing conditions existing at 17,000 feet MSL, coupled with the heavy to possibly severe turbulence, could have caused temporary loss of control resulting in loss of altitude. The possibility of carburetor ice causing temporary power interruption also exists, despite the unanimous testimony of pilots that ample carburetor heat is available, upon demand, for extreme weather conditions. Although the captain had experienced power interruption due

to carburetor ice (carburetor heat not on) twice before, it is highly improbable that power loss because of carburetor icing could have continued long enough to cause an altitude loss of 12,000 feet. This conclusion is based upon the efficiency of the carburetor heat system. Undoubtedly the aircraft was also encountering wing icing but the thermal wing de-icing of the Convair, although only certificated for light icing, is efficient and would probably dissipate ice buildup in a short time. This de-icing would have been aided by the descent to the low altitude above the ground where the snow was melting as it reached the surface. Examination of the wreckage disclosed that the heat source and anti-ice heat valves were in the open or heat demand position.

G. Cabin Cargo

The loosening of ropes securing the cabin cargo and the consequent shifting of cargo could have created a hazard. Investigation disclosed that the cargo had been adequately secured and further, that the company had never experienced any previous trouble with similarly secured cabin cargo.

H. Lightning Strike

None of the ground witnesses saw lightning and there was no indication of it in the weather records. No evidence of a lightning strike was found on the wreckage.

I. Sabotage

There was no evidence of sabotage found in the wreckage and a check of the cargo contents revealed nothing suspicious.

J. Power Plants

The extensive impact damage prevented a determination of the amount of power developmen at the time of the crash. However, examination revealed that both propellers were rotating and in positive pitch at impact. This, coupled with witnesses hearing engines operating at low altitude some miles back on the flight path, definitely indicates power development during whatever emergency occurred. The examination revealed the engines to be operating in the high blower position. The fact that engines are normally operated in low blower below 10,000 feet further points out the critical situation confronting the flight crew that interfered with normal aircraft operation.

Probable Cause

The Board, after intensive study of all evidence, determined that the probable cause of this accident was a sudden emergency of undetermined origin under adverse weather conditions resulting in rapid descent and impact with the ground at high speed.

No. 9

Piedmont Airlines, DC-3D aircraft, damaged while landing at Tri-City Airport, Bristol, Tennessee, U.S.A., on 28 February 1954. C.A.B. Accident Investigation Report No. 1-0012. Released 2 June 1954.

Circumstances

The flight was a scheduled operation between Norfolk, Virginia, and Knoxville, Tennessee, with a number of intermediate stops, and carried 3 crew and 6 passengers at the time of the accident. While making an instrument approach to the Tri-City Airport at Bristol, Tennessee, at approximately 2140 EST on 28 February 1954, the aircraft collided with a tree top. Recovery and pull-out were effected and the aircraft proceeded to Winston-Salem, North Carolina, its alternate, where a safe landing was made. The aircraft was substantially damaged but there were no injuries to crew or passengers.

Investigation and Evidence

The flight departed Lynchburg at 1949 on an IFR (Instrument Flight Rules) flight plan for Tri-City Airport to cruise at 8,000 feet via Airways Red 37 and Green 5 with Raleigh-Durham and Winston-Salem, North Carolina, as alternates. The flight made routine position reports en-route and at 2035 received an ARTC (Air Route Traffic Control) clearance as follows: "83 cleared to the Tri-City Range Station climb to and maintain 9,000. Report leaving 8,000. Contact Tri-City Approach Control at 2059 for further clearance." The flight then reported leaving 8,000. Over the Abingdon intersection* at 2059, the flight was cleared to the Tri-City Range to descend to and maintain 7,500 feet. The flight estimated over the range at 2109. At 2110 approach control cleared the flight for an ILS approach, descent from 7,500 feet to 5,500 feet to be made east of the outer marker eastbound. Tri-City weather was given the flight: precipitation ceiling 600 feet, obscuration, visibility 3/4 mile, light snow.

Some time after 2110 the flight reported being unable to receive the compass locator at the outer marker due to precipitation static and requested ARTC clearance to Winston-Salem. This clearance was relayed to the flight. At 2127 the flight reported receiving the compass locator and was then cleared for an ILS approach to Tri-City Airport.

At 2128 the flight reported eastbound over the range, leaving 7,500 feet. At 2134 when over the outer marker inbound at 4,500 feet, the flight advised it would circle and come over the outer marker a second time. At 2137 approach control was advised that the flight was over the outer marker at 3,200 feet, inbound. Three minutes later the flight advised it was pulling up after "hitting the ground" and requested another clearance to Winston-Salem. This clearance was immediately granted and the flight proceeded to that aerodrome.

En route to Winston-Salem, some roughness in the left engine and smoke in the cockpit were encountered. Oil from the left engine dripping on the exhaust manifold caused smoke to enter the cockpit through the heater duct. The heaters were shut off and the smoke dissipated. A normal landing was made at Winston-Salem at 2245.

Weather at the time of the accident at the Tri-City Airport was: precipitation ceiling 600 feet, obscuration, visibility 3/4 mile, light snow, temperature 34, dew point 32, altimeter 29.57, wind west-southwest 5-10 mph.

Investigation disclosed that the aircraft contacted a tree during the approach instead of the ground as reported by the crew. This tree was located on a bearing of 80 degrees, 7,500 feet from the approach end of Runway 27 and 1,300 feet north, to the right, of the extension of the localizer course. The tree is at an elevation of 1,560 feet MSL (mean sea level); the top of the tree is 60 feet above the ground and about 100 feet above the runway level which is 1,523 feet

* This reporting point is on the northeast course of the Tri-City low frequency range, twenty-two miles northeast.

MSL. The top of the tree was 319 feet below the glide path and the upper ten feet of it were severed by the aircraft. Contact with the tree damaged the left engine, the left propeller and the leading edge of the left wing.

Examination of the aircraft, the engines and aircraft ILS instruments revealed no evidence of a structural failure or malfunction having occurred prior to impact.

Monitoring records of navigational and landing facilities indicate normal operation during the time of the flight's approach. A flight check by the CAA the day following the accident found all facilities to be operating within specified limits.

According to a chart in the company's flight manual two ILS approaches at Tri-City are approved: (1) Descent inbound to begin at 5,500 feet MSL from the Emmett MHW marker which is 14.5 miles from Runway 27 after a procedure turn east of the marker and north of the localizer course has been made, (2) Descent inbound to begin at the outer marker (glide path interception altitude minimum of 2,740 feet MSL) after a procedure turn at 3,000 feet MSL outbound and north of the localizer course. Minima for a straight-in approach to Runway 27 are 600 foot ceiling and 3/4 of a mile visibility. In addition to the charts in the company's manual, an excerpt from Chief Pilot Letter No. 19, dated 8 October 1952, gives the following instruction to all company pilots: "Glide Path Check - After the completion of the turn (procedure) the aircraft should be flown to the outer marker at the altitude specified in the ILS procedure chart for glide path interception ...

"In order that this check may be performed it is absolutely necessary that no attempt be made to institute an ILS approach by turning inside the outer marker, since the outer marker site provides the initial localizer and glide path check at an altitude which will insure safety. The flight should continue past the outer marker for a sufficient distance to insure that the inbound track will permit a stabilized course prior to reaching the outer marker site. The above check should be completed prior to inaugurating any ILS approach."

According to crew statements, the aircraft was flown by the captain from the Abingdon intersection descending to 7,500 feet MSL at the Tri-City Range. The crew testified that in the descent to 4,500 feet, a southwest wind of 40 to 50 knots existed which necessitated a 20-degree heading correction on both the east and west legs of the pattern. A procedure turn was made outbound at 4,500 feet MSL and the aircraft came inbound over the outer marker at this altitude, which is in excess of the prescribed height of 2,740 feet MSL and too high for glide path interception. A right 360-degree descending turn was then made and the outer marker was crossed inbound the second time at 3,200 feet MSL. The crew stated that the localizer needle was centered with the glide path needle indicating full "fly-down" deflection at the outer marker. An air speed of 120 mph with a descent of not more than 535 feet per minute was maintained after passing the marker. The Captain stated that he checked his descent on approaching an indicated altitude of 2,200 feet — 700 feet above runway level — and the landing gear was retracted and carburettor heat removed. Then, according to the crew, a severe downdraft with moderate turbulence forced the aircraft from above to below the glide path until the left wing struck the top of a 60-foot tree knocking off the top 10 feet. The aircraft was in an approximately level attitude when the left wing struck. Some yaw was experienced but control of the aircraft was not lost and a climb-out and a missed approach procedure were accomplished and a new clearance to Winston-Salem obtained.

The 1330 synoptic map of 28 February 1954 showed a low pressure trough and a cold front extending south-southwestward from eastern Ohio through eastern Kentucky, extreme southwest Virginia, and between Tri-City and Knoxville, Tennessee. A rapid fall in temperature was occurring behind the cold front from Tennessee northward. The cold front passed Tri-City at about 1725 and was approximately 50 miles east of Tri-City at the time of the accident.

It appears that the entire flight was either in the overcast or between layers and that intermittent moderate to possibly heavy turbulence existed to near the Abingdon intersection, which is about 22 miles northeast of Tri-City. Light to moderate turbulence is indicated thereafter until the flight descended below 5,000 feet after which only intermittent light turbulence is

indicated. Strong southerly winds of 30 to 40 knots existed en-route but the wind velocity decreased in descent and became westerly 10-15 knots below 4,000 feet in the Tri-City area. The inflow of cold air behind the cold front stabilized the air in the lower levels. This condition was confirmed by the testimony of other flight crews in the area near the time of the accident.

In the analysis of the evidence, the report states that it was the captain's intention to descend to 700 feet above the ground, the company's low frequency range minimum altitude, rather than to 600 feet, the ILS minimum altitude. It was evident that the ILS approach was not made in accordance with the company's flight manual and the chief pilot's instructions. Both passages over the outer marker inbound were higher than the glide path interception altitude. The procedure turn outbound was 1,500 feet above the specified minimum altitude and this altitude was maintained inbound to the outer marker. The 360-degree right descending turn to 3,200 feet MSL at the outer marker did not allow sufficient time or distance to establish a stabilized course or air speed for the final approach. The second attempt to intercept the glide path was too high; therefore, the corrective action by the captain should have been to execute a missed approach procedure or, after advising approach control, to proceed outbound again on the localizer course a sufficient distance to make his procedure turn and return inbound descending to the specified altitude.

The Board recognized that downdrafts can be isolated and transitory and the fact that other flights did not encounter any downdrafts in the Tri-City Airport area is not alone sufficient evidence to state that none existed. However, both that evidence and the analyzed structure of the air in the area fail to lend any support to the severe downdraft described by the pilots.

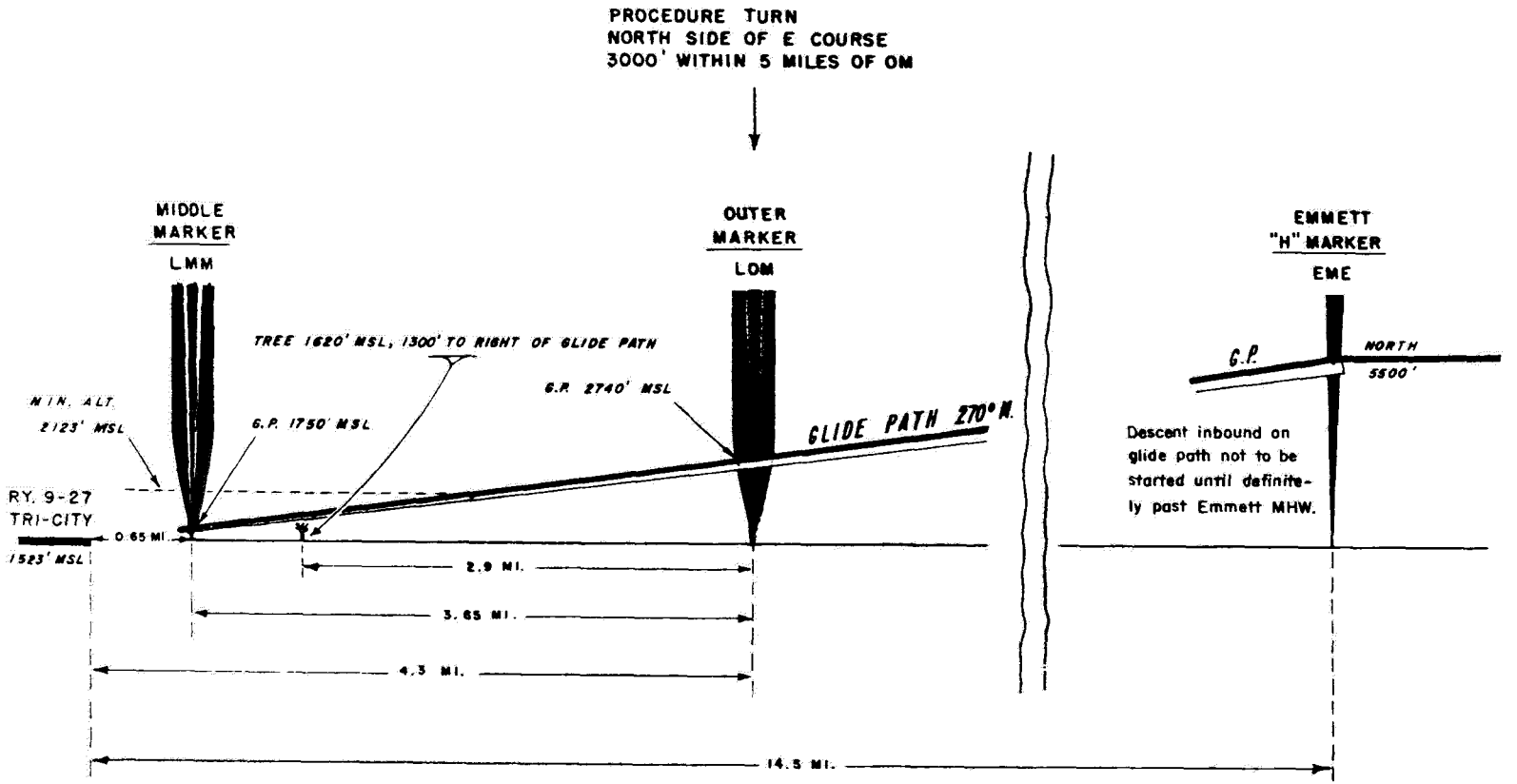
A study of all available weather data indicates smooth air to light turbulence below 5,000 feet MSL. The air was stable in this lower layer and precluded the formation of downdrafts within it and prevented downdrafts that might generate at high levels penetrating this stable air mass. Downslope air flow was likely on the lee (east) side of the hills at low altitude, but due to the configuration of the hills in the approach zone and the light winds at hilltop levels, not only would the downward component have been very small but the duration in such downslopes at 120 mph air speed would have been only a fraction of a minute. Therefore, it seems improbable that the flight encountered the single severe downdraft described by the crew as forcing the aircraft downward several hundred feet to a position well below the glide path. It seems more probable that with the aircraft over the outer marker nearly 500 feet above the glide path the descent was steepened in an attempt to get on the glide path and the aircraft went through and below the glide path before the "pull-up" was made. According to the captain, contact with the top of the tree occurred within 30 seconds after he had started his missed approach. The tree which was struck is 2.9 miles west of the outer marker and 1,300 feet to the right of the localizer course and 319 feet below the glide path. If the captain had maintained a constant air speed of 120 mph and a constant descent of not over 535 feet per minute after passing the outer marker inbound, according to his testimony he would have been several hundred feet above the top of the tree and above the glide path. It is obvious, considering that the point of impact was 1,300 feet to the right of the localizer course, that the aircraft had deviated seriously from the intended course.

Probable Cause

The Board determined that the probable cause of this accident was the action of the pilot in not following the approved procedures for an ILS approach which resulted in the aircraft striking a tree.

PIEDMONT AIRLINES, FEB. 28, 1954
TRI - CITY AIRPORT, BRISTOL, TENN.
ILS GLIDE PATH SHOWING RELATIVE POSITION
AND ALTITUDE OF TREE STRUCK

Figure 17



Not drawn to scale

No. 10

Aviation Traders Ltd. Tudor Mark 1, Freighter aircraft, loss of control in cloud 30 miles southeast of Paris on 2 March 1954. Ministry of Transport and Civil Aviation, London. Accident Report No. CA-164.

Circumstances

The aircraft was on a charter flight carrying freight from the United Kingdom to Bahrein via Malta. At 1245 hours when approaching Paris at 9,500 ft. in VFR conditions with the automatic pilot engaged the aircraft entered the tops of cloud. Slight airframe icing was seen, the de-icing and anti-icing systems were applied, and it was observed that the cruising speed decreased from 155 kts to about 135 kts. The captain maintained altitude by automatic control, but he did not increase engine power nor did he again refer to the airspeed indicator. At about 1255 hrs. while flying in cloud, the captain noticed that the automatic pilot was applying large corrections of aileron control and that the directional gyro indicated a turn to port. He disengaged the automatic pilot and the aircraft made a rapid descent in a spiral manoeuvre. Control was regained when the aircraft broke cloud at about 2,500 ft. and the flight was continued to Malta.

Investigation and Evidence

The captain filed an IFR flight plan to fly on airways at 9,500 ft. with an estimated flight time to Malta of 6 hours 30 minutes and the aircraft was airborne from London Airport at 1132 hrs. On departure the aircraft had 2,090 Imp. gals.of fuel and fuel oil, which gave an endurance of 9 hours 30 minutes. During the pre-flight check both pitot head heaters were switched on and the carburettor air intake filters were put into operation. The latter, contrary to engine operating instructions, were left in this position throughout the flight. Upon reaching cruising altitude in VFR conditions the captain, who was piloting the aircraft, engaged the automatic pilot and power was set to 2,350 rpm. 40" Hg. which gave an indicated airspeed of 155 kts. Neither of the pilots was strapped in. Flight conditions in VFR were maintained until shortly before reporting over Orly radio-range station at 1245 hrs., when cloud increased and the aircraft entered the tops of cumulus type cloud. Light rime ice was observed on the wing leading edges: turbulence was slight. It was then noticed that the outside air temperature had fallen from -3°C. to -10°C. Consequently, as a precautionary measure, the Captain instructed the Flight Engineer to switch the T.K.S. wing and tail anti-icing system to "manual" and to switch on the engine hot air supply. It was then observed that the I.A.S. gradually decreased from 155 kts. to about 135 kts. The captain maintained altitude by frequent trimming of the automatic pilot, but no increase of engine power was made and he did not refer to the air speed indicator. The aircraft reported passing airways fan marker Coca at 1249 hrs. and about six minutes later, while flying in cloud, the captain observed that the automatic pilot was making large corrections of aileron control and the directional gyro indicated that the aircraft was turning to port. The automatic pilot was disengaged, the port wing dropped immediately and the aircraft commenced a spiral manoeuvre to port which the crew consider may have been a spin. Neither the captain nor the first officer observed the I.A.S., but the latter stated that all engine boost and r.p.m. indications appeared normal. Corrective action was applied but without effect, so the throttles were closed and controls centralized. It was noticed that the captain's artificial horizon had toppled and that the altimeters indicated a rapid continuing loss of height. The turn and slip indicator showed that the aircraft was in a rapid turn to port while skidding violently. In an effort to regain control the inboard engines were momentarily opened up, but as this had no effect, the throttles were again closed. The captain stated that when at an estimated altitude of about 4 000 ft. he felt a violent snatch and found that the controls became effective. The rate of rotation then decreased, the airspeed rapidly increased to 280 kts. and considerable "g" was experienced. Almost immediately afterwards the ground became visible as the aircraft (whilst still turning to port) broke cloud at about 2 500 ft.

Cruising conditions were resumed and a check of the aircraft, including the freight, failed to reveal any abnormality except that the captain's artificial horizon was still in the toppled position. The captain did not inform the French control authorities of the incident or of the change of altitude, but continued the flight VFR at 3 000 ft. until reaching the Lyons area, where a VFR climb was made and a clearance given to fly at 11 500 ft. The handling characteristics of the aircraft appeared to be normal and the flight continued to Malta, where a landing was made at 1830 hrs. On arrival the air craft was inspected and it was found that damage had occurred.

An inspection of the aircraft carried out at Malta revealed that tearing of the skin on the underside of both wings, together with considerable wrinkling of the top surface had occurred in a number of places. The port inner flap was buckled and the forward fuselage bulkhead skin was wrinkled and buckled. The tailplane leading edge root fairing had been bent upwards about 3/8 inch, the tailplane top skin on each side showed slight buckling from the leading edge root ends and the fuselage skin in the vicinity was slightly and evenly buckled.

As a result of a statement made by the captain that he had lost control of the aircraft when cruising at an indicated air speed of 135 kts it was decided to check the handling characteristics of the Tudor in this respect. A series of flight tests was carried out in which the Operators, Air Registration Board and the Accidents Branch participated. None of these tests indicated that the behavior of the Tudor was abnormal.

Tests to assess stalling and low speed handling characteristics with ice accretion on the airframe and the effect of ice formation in the engines had to be discontinued owing to the unsuitability of the weather conditions.

The captain has subsequently stated that after observing that the airspeed had fallen to 135 kts. he made no further reference to the airspeed indicator and, on disengaging the automatic pilot, the aircraft was in a stalled condition. He has agreed that had he taken remedial action when the airspeed commenced to decrease the loss of control could have been averted.

Observations

When the captain instructed the Flight Engineer to switch on the hot air supply to the engines the latter operated the hot air supply intermittently at about 30 second intervals. The flight engineer stated that he did this in order to conserve fuel. The captain observed that soon after the hot air was applied the I.A.S. decreased from 155 kts. to about 135 kts. In the prevailing flight conditions with an O.A.T. of -10°C. the use of hot air in this manner, apart from being contrary to normal practice, could raise the temperature in the carburettor air intakes sufficiently to bring it within the icing range. Contrary to engine handling instructions, the flight engineer had left the filters in the operating position and it is, therefore, possible that ice may have formed on the filters resulting in a reduction of power in addition to the normal loss associated with the use of hot air.

The captain failed to appreciate that in maintaining altitude solely by frequent trimming of the automatic pilot he allowed the aircraft to adopt a nose-up altitude which resulted in a considerable drag increase.

The rime ice on the leading edges of the wings, of which the Captain was aware, would disturb the air flow and thereby increase the stalling speed.

Probable Cause

The accident was due to loss of control of the aircraft while flying in cloud and icing conditions. The loss of control was the result of serious errors of flying technique by the captain in that, although aware that there was a reduction of engine power, a substantial loss of air speed and airframe ice accretion, he attempted to maintain altitude by frequent trimming of the automatic pilot without further reference to the air speed indicator and without increasing power. This resulted in an increase of the angle of attack of the aircraft until flying speed was lost.

No. 11

British Overseas Airways, Lockheed Constellation, aircraft crashed on landing at Kallang Airport, Singapore on 13 March 1954. Report of Public Inquiry published for the Colonial Office by H. M. Stationery Office London

Circumstances

At 1132 hours (2132 hours Standard Australian Time) on the evening of 12 March the aircraft (hereinafter referred to as Able Mike) took off from Sydney on a scheduled flight for London. The aircraft landed at both Darwin and Djakarta, which are scheduled stops, taking off from the latter in good weather conditions at 0512 hours on 13 March for Singapore, with a crew of 9 and 31 passengers. At approximately 0734 GMT while carrying out an approach to land on Runway 06 the aircraft struck the ground short of the runway, became airborne and touched down on the runway some 80 yards further up the runway when the starboard undercarriage gear collapsed. Fire broke out and the aircraft was destroyed; 31 passengers and 2 crew lost their lives.

Investigation and Evidence

Apart from certain cloud which was avoided by climbing, Able Mike's flight from Djakarta to Singapore met with no weather conditions presenting any difficulty. The flight was carried out at 10 500 feet - Visual Flight Rules - and at 0707 hours the aircraft called Air Traffic Control, Singapore, on 119.7 megacycles and gave its position as 100 miles out at 0706 hours. It requested and received permission to start a VFR descent - the expected time of arrival being 0735 hours. Radiotelephony procedure seems to have been normal and at 0720 hours the aircraft reported that it was 50 miles out, at 7 500 feet, descending VFR. The altimeter setting was given as 1 009.7 millibars and the aircraft was cleared into the Singapore Control Zone VFR.

When 10-15 miles out Able Mike changed to Tower frequency and passed a Malayan Airways Dakota which was also bound for Kallang. Two messages in the same terms were passed from the Tower to Able Mike - one that the wind velocity was 100 degrees/20 knots, that Runway 06 was to be used, that Able Mike should land ahead of the Dakota and that if it could not stop before the intersection of the North-East taxiway and the runway it should expedite its roll to the end of the runway and wait there in the turning circle or pan. This last instruction was new to the captain who said, indeed, that he had never previously received a similar one. Its purpose, however, was presumably to allow the Dakota to land as soon as possible after Able Mike had turned in the pan, back-tracked to the North-East taxiway and cleared the runway. The captain found nothing abnormal in it - nor, he says, did it affect his decision as to his landing.

A straight-in approach from a right hand base leg was made. The gear was put down across wind and by the time Able Mike was over or abeam the spire of St. Andrew's Cathedral (some 2 670 yards on a bearing of 245° from the centre of the threshold) it was 650 to 700 feet high, in a steady rate of descent with 80 per cent flap, 20" MP., a speed of 120-125 knots, and a rate of descent of approximately 1 000 feet per minute. At this stage, or soon after, it was on the North side (downwind side) of the centre line, tracking directly for the end of Runway 06. This is a method of cross-wind approach, though it is not clear from the evidence that the captain was using it as such. The approach was steady and constant from the Cathedral spire until a point about 900 yards from touch down. At this stage 100 per cent flap was taken, probably to reduce speed. As the schooners' anchorage was passed the nose was eased down to prepare for a short landing. The track probably passed close to the South end of the schooners' anchorage and at approximately 550 yards, 25" MP was called for and the flatter approach was begun. The speed was then reduced nearly to 100 knots, and the captain banked slightly to starboard in order to regain the centre line before the runway threshold. The rate of descent continued at something like 400 feet per minute until about 250 yards out when the aircraft was

probably about 15 feet higher than the sea wall and flaring out. A second later the captain called for "My Throttles" and as he eased the power up to 30" he must have been swinging the nose down the runway with left rudder and keeping the wings level or slightly right wing down. The aircraft continued to sink gently and as the sea wall came up the nose was lifted for a landing just over the threshold marking. Such a landing, however, was not achieved as the aircraft was too low and passed the sea wall at an estimated height of three or four inches, assuming that it was flying level at that time.

Able Mike first touched the ground with the right wheel of the starboard main gear, 3-1/2 inches above the height of the sea wall, about 13 feet from its edge and 10 feet short of the white threshold line. The left wheel of the starboard gear touched 2 feet later, the gear being virtually in line with the runway centre line. The initial scuff marks indicated a light touch-down, but the marks became deeper as the wheels met the resistance of the up-sloping grass until the actual earth was being broken and the tyres were making definite grooves in the grass. Some 5-1/2 feet after the initial brushing of the grass the starboard main gear came into contact with the ridge (described later) between the end of the perforated steel plating and the grass slope. The impact caused the undercarriage to receive a horizontal shock beyond its designed maximum which must have disrupted No. 3 integral fuel tank causing a leakage of fuel which streamed behind the right side of the aircraft like a white vapour. The right wheels rolled over the threshold line. Although the tyres were completely compressed, so that the wheel rims bit into the tarred ridge (leaving their own distinct grooves within the impressions caused by the tyres), they did not burst and were later found inflated and partly scorched. After the first impact the aircraft became airborne, touching again some 80 yards further up the runway when the starboard gear collapsed, moving rearwards, the wing went down and the starboard propellers struck the runway. The aircraft turned to the right and continued roughly in a straight line till the edge of the runway. There the angle of tilt increased as the aircraft turned sharply to starboard rolling at the same time until it came to rest facing the South-West (i.e. the direction from which it had come), on its back and leaning a little on its starboard side, roughly 350 yards from the South-West threshold. As it overturned the starboard wing broke at its root and the tail plane snapped near the rear pressure bulkhead. The starboard propellers had struck the ground while their engines were developing a high degree of power; the port outer propeller struck the ground while its engine was developing some degree of power, and there was no forward motion of the aircraft. As the starboard wing root came into contact with the ground it is probable that fire broke out on the starboard side. The broken-off starboard wing came to rest parallel to the runway on the runway's edge and the fuselage about 15 yards to the south of it.

While the ridge at the sea wall end of Runway 06 was untidy, and perhaps undesirable from the perfectionist view-point, it was considered that it was not the cause of the accident. If the ridge had been "faired off" to a slope running from the end of the runway to the inner edge of the sea wall and stressed to take the initial touch of a heavy aircraft, the accident admittedly might never have happened. Again, if the sea wall and grass slope had been a continuation on a level plane of the runway it is equally possible that the aircraft would either have struck the sea wall, or just made that portion of the runway delimited for landing purposes. But why should either of these steps have been taken? No aircraft could conceivably be expected to land where this aircraft in fact did i.e. off the runway and within a few feet of a clearly marked and most dangerous hazard. The cause of the accident was not the ridge but the fact that the captain touched down at a place where his aircraft had no right to be. The presence of the ridge no doubt contributed to the extent of the accident - but did not cause it. The ridge has now been "faired off" and marked as a hazard, but not strengthened to take a heavy aircraft; this is not considered to be necessary.

Down-draught was discounted as being a serious contributory factor and although the various lines of the runway, the ridge, the sea wall, the markers, the sea itself and the choppy conditions, the grass slope and the paint on the sea wall might all have blended to form a misleading picture of height, the captain must have been aware, by whatever processes a pilot's vision guides his judgment, that he was low, and that his intended point of touch-down was closing with the threshold marker with every second of the "flatter approach".

The captain testified that he was not fatigued, but told a doctor that he was tired, though no more so than usual. Fatigue as a cause of the accident in itself was ruled out, and it was not thought that tiredness led to the initial decision to land short; indeed, the captain was making a pattern of approach that roughly corresponded to his usual approach at Singapore. However, there was little doubt that tiredness played a part in the captain's ability to deal with the last fifteen seconds of the approach which, in view of the difficult position in which he found himself, called for a high degree of judgment.

The cause of the accident, i.e. the touch-down off the runway was attributed to the approach of the aircraft. While certain eye-witnesses describe the approach as normal, it was not normal relative to maintaining a steady glide path and rate of descent. The various rates of descent could be considered to be within normal bounds for a Constellation aircraft, but their general pattern was neither normal nor, having regard to the sea wall hazard, desirable. The extent to which the captain's original decision to land short on such a runway as 06 was an error can only be judged in relation to the wide range of expert pilot opinion as to what is a safe first point of touch-down. The fact that his first point of touch-down came back closer to the threshold markings than he originally intended can probably be attributed to a degree of tiredness of which he may or may not have been aware.

There was one inescapable fact, however, which could not be influenced by any factor that might have contributed to the error of judgment. The captain was low enough long enough and had been sufficiently warned of the wind conditions for him to have realized that his position, aircraft configuration and altitude did not conform to a desirable safe flight path consistent with a civil aircraft landing on Runway 06 at Kallang. The fact that he applied 30" MP unhurriedly so close to the threshold confirms that his last intention was to land on or inside the threshold markings, as was his own evidence when recalled. To attempt virtually to spot land a large civil aircraft in a light to moderate crosswind when off the centre line, so close in to such a runway and so close to a dangerous hazard, was something incompatible with civil aviation safety requirements. The aircraft touched where it did because the captain was unable to deal with the situation he found or put himself into during the last 10-15 seconds of the approach. He should not have been in such a situation. At a time when he wanted all the lift and speed effect his configuration would give him, the yawing of the aircraft and wing down attitude, together with the possible effect of a slight down-draught, were testing the fineness of his judgment. The movement of the sea against him possibly helped to confuse his correlation of distance and ground speed. In any event, when his estimated first point of touch-down moved towards the threshold markings and the hazard of the sea wall he did nothing to arrest that movement until the aircraft was virtually on the marking itself. It was then too late. The error of judgment was a fine one, though by that it does not mean that it was excusable; the error of decision depended upon what could be considered within the margin of a safe height over the sea wall, and by standards as disclosed in evidence, that margin is a wide one. The cause of the accident, thus, in the opinion of the court was an error of the pilot.

Fatigue. Much evidence has been heard on the subject of Fatigue - but the part it plays in aircraft accidents remains as elusive as ever. The Sydney - Singapore sector is the longest of the Corporation's scheduled sectors and allowing a minimum period of 1-1/2 hours for preflight preparations at Sydney, the captain was on duty for slightly over 21-1/2 hours ending with the crash at Kallang. These are undoubtedly long hours and the Assistant Director of Medical Services BOAC stated that it would be very desirable if everything could be planned to a 16 hour duty day. He added further that physiologically it is not a good thing for a crew to leave Sydney at 2130 hours (Australian time) as happened on this flight - i.e. at the end rather than at the beginning of the day. The difficulty which faced the Corporation here, however, was that both Darwin and Djakarta were unsuitable as night-stops and a morning departure from Sydney would result in Singapore being reached very late at night. The doctor gave as his opinion that for this particular crew a 24 hour day would not be unreasonable and several most experienced pilots confirmed this opinion. However, although the court could not deny this it was considered a very long period of duty.

Three considerations were given in the report as material to Fatigue:

a) The provision of a bunk on which officers temporarily off-duty can sleep. On long distance flights BOAC aircraft are not fitted with a bunk but a mattress is provided which some, though by no means all, crew members use for resting. The mattress is placed over the luggage carried in No. 3 Hold and it seems unlikely that it presents a very comfortable resting place. (A recommendation in this regard was given in the report).

b) The question whether there should be two or three pilots on long sectors. Qantas Empire Airways, under an Australian Air Navigation Order, invariably carry three pilots on long-distance aircraft on a flight of more than 12 hours and this permits of 30 hour sectors, though in fact there are none as long as this. If weather or other conditions present any difficulty, it was considered that the captain would wish to be at the controls himself and his co-pilot should readily be able to take over from him at all other times.

c) Whether, if only two pilots are carried, it is necessary that both should be extremely experienced. This was noted in the report as an important matter. The co-pilot was a young man and his total flying experience of 1 000 odd hours, relative to flying heavy four-engined civil transports, was considered as only just sufficient to qualify him for his crew duties, if indeed it did suffice. The minimum flying experience of a first officer in Qantas Empire Airways is some 2 000 - 2 500 hours and as the co-pilot fell very far short indeed of this standard, which is considered to be reasonable, there can be no doubt that his usefulness in giving his captain any appreciable rest during long duty hours was entirely inadequate. (A recommendation in this regard was included in the report).

In the words of the report:

"To sum up the position as regards this accident, the captain just prior to it had been on duty for many hours. The word "fatigue" I do not like, because I do not know its meaning - but undoubtedly the captain was tired when he brought Able Mike in to land and in view of the long hours and the inexperience of his co-pilot this was only to have been expected. Although it is perfectly possible for any man, including one of the experience of the captain, to make a mistake - I do not think that he would have made this error of judgment at the beginning of a day's flying and it is at least possible that he would not have done so even after 16 hours of duty."

Fire aspects of the accident

When the aircraft came to rest, it was completely inverted. Fires were burning in the broken-off starboard wing, the starboard wing root and the tail plane (empennage). Very soon afterwards, fire broke out in the port wing. Survivors reported there was darkness, dirt and noxious fumes in the aircraft within a few seconds. The door used by the crew for access to the cockpit would not open.

The flight engineer in the cockpit remembered that a clear vision panel was just wide enough (14 inches by 10 inches) to permit the passage of a human body and having opened one, he promptly climbed through it and lowered himself to the ground. In the seconds that followed, another flight engineer, the radio officer, the first officer and the captain followed suit. Several had minor injuries.

In the compartment immediately behind the cockpit were the flight stewardess, one of the two flight stewards, and, at his desk, the navigation officer. All three found themselves lying amidst brief cases, bundles and other articles packed in the No. 3 hold. The area was dark and a thick yellow-brown smoke rapidly filled the compartment which had a heavy choking effect. The navigation officer saw fire on his right-hand side and seeing a patch of light from a gash in the fuselage near the port crew rest chair, he eventually managed to struggle through it to freedom. The flight steward, his lungs bursting, found a slit in the fuselage on the starboard side through which he clambered to safety.

Thus, within a very few minutes, all the crew had escaped with the exception of the flight stewardess in the aft crew compartment and the second flight steward who was in the main passenger compartment.

One of the flight engineers ran around the aircraft trying to find a means of exit for the passengers. He tried but found that the main passenger door would not open. He discovered that when the tail plane had broken off, the hatch of the rear pressure bulkhead had become exposed.

This hatch is normally used to permit access for engineers to work on the wiring and control cables inside the empennage. The hatch is situated at the aftermost extremity of the pressurized portion of the fuselage (in this particular aircraft, through the ladies' lounge). The hatch is circular, some 24 inches in diameter, and is normally opened by inserting a key (kept in the cockpit) which operates a four-armed plate on the rear of the hatch. To each of these arms is connected a rod which travels from the arms to the outside edge of the hatch and which, in turn, operates pawls (the actual locking mechanism for holding the hatch in place).

The flight engineer and at least one other crew member tried to move the operating rods from the exposed side by hand but unfortunately failed to do so. The flight engineer then seized an axe and hurried to the forward starboard side of the aircraft to join the other flight engineer who was attempting to make a hole near the place in the crew compartment where they could hear the cries of the flight stewardess. They were aided by two Qantas Empire Airways station personnel and a KLM ground engineer at Kallang, who had rushed to the scene from the Airport Terminal. Taking turns, their axes bit deep into the strutted fuselage and they were just about to extricate the stewardess when the nose of the aircraft under which they were working started to fall on them to the accompaniment of several exploding fuel tanks. With frantic effort and great heroism, the two Qantas Station employees finally succeeded in pulling the stewardess from the wreckage. Tragically, the stewardess subsequently died of injuries received.

Airport Activities

While all this was going on, many other things were happening at the airport.

The tower controller testified in the inquiry that he realized before the aircraft came to rest that a crash was imminent. He stated that he immediately instructed his companion in the tower to telephone the City Fire Brigade and he rang the fire alarm bell to call out the Airport Fire Service. Unfortunately, the inquiry could not verify accurately the time factors. The time of the accident was established at 3.03 p.m. Singapore time. If the call was made immediately it should have been received before the City Fire Brigade log indicated - 3.08 p.m. (All clocks meticulously kept accurate.) It appears that five minutes were "lost" between the time the aircraft first touched down and the call was made to the City. In the opinion of the investigators "this interim was critical" and "if outside assistance had arrived before the fire had reached an advanced stage in the center section of the aircraft, many lives might well have been saved".

The Airport Fire Service had one leading fireman, 6 firemen and 4 drivers on duty. Two vehicles (a foam "tender" and water "tender") were at the fire station and a rescue jeep was about three-fourths of the way down and just off the 6 000 foot runway. These three units constituted the mobile rescue and fire fighting force available at the airport and the foam tender was judged "a somewhat antiquated machine". The personnel to man this equipment were all native Malays, poorly trained and inexperienced.

Airport Fire Fighting Response

The leading fireman had watched the arrival of the aircraft and, gaining the impression an accident was likely, he proceeded to the scene before the aircraft came to rest. He guessed incorrectly that the aircraft would come to rest considerably further down the runway than it did and he committed himself and his vehicle to a route which took longer to travel than might otherwise have been the case. (Had he used the western rather than the eastern taxiway the

route would have been shorter. Crossing the grass area was hazardous as the area was soft in parts and the two-wheel drive tender was not constructed for cross-country service. Test runs later show that the travel time over the route selected was 2 minutes, 3 seconds.) The water tender followed the foam tender and the rescue jeep proceeded straight down the runway to the scene (travel time about 1-1/2 minutes).

The fire suppression efforts by the Airport Fire Service were described unanimously by witnesses having skilled fire protection backgrounds as being inefficient. No leadership was evident, the fire was attacked at the wrong place, the foam was of poor quality and no concerted attempt was made to rescue the trapped passengers. In a sentence, the deputy chief fire officer of the City Fire Brigade said that: "on 13 March the Airport Fire Service was inadequately equipped, organized and trained". The senior staff officer of the Fire Service Branch of the Ministry of Transport and Civil Aviation (London) investigated the facts and reported: "the attack made on this fire during its early stages by the Airport Fire Service was misapplied ... the manner in which the branches were placed and the manner in which foam was applied ... shows a grave lack of training in tactics".

Going through all the details of inefficient attack on the fire does not seem necessary but the following brief description of events is taken from the official report:

> "On arrival at the fire ground, 7 members of the crew were in the process of escaping from the aircraft. The foam tender took up a position about 30 feet on the upwind side of the fuselage and slightly to the rear of the tail plane. The water tender took up station in an adjacent position to transfer water to the foam tender. A considerable fire was burning in the detached starboard wing and the port wing was also alight. There is no precise evidence as to the exact state of this potentially dangerous port wing fire at this stage, but it is probable that at least the inner engine, and probably the outer also, was well alight. Fire was also present in the stub starboard wing and there are indications that it had begun to penetrate into the center section of the fuselage itself at this stage, or very shortly afterwards.
>
> The fire crew got to work at once with two foam jets, directing the first onto the starboard wing and running the other line of hose round a fin, which had broken off from the remainder of the tail unit, and up the upwind side of the fuselage at a point roughly abreast of the starboard wing root. The CO_2 available (total of 75 pounds) was also applied at this place, but due to the shedding of the discharge horn it is probable that the bulk of the very limited amount of gas available was discharged to waste. Subsequently, the foam from the branch on the upwind side was directed initially into the starboard wing root area and finally, at the suggestion of a civilian, over the top of the fuselage to the port wing root area. It was this fire (i.e. in the port wing), slowly gaining in intensity, which ultimately involved the whole fuselage since it was allowed to develop virtually unchecked. The evidence strongly suggests that this fire developed quite slowly for a petrol fire until the time of the collapse of the nose section at or about 3.16 p.m. (Singapore time) but thereafter very rapidly, probably as a result of increased flow of fuel to the fire resulting from the disturbance of the wreckage. This stage was the critical period of the fire which very soon penetrated the passenger cabin thus reducing further the chances of rescue. At or about this time the City Fire Brigade was in action."

Aside from the unsatisfactory efforts of the Airport Fire Crew, civilians in large numbers arrived at the scene. Some helped free the trapped stewardess as previously reported while others made frantic but undirected efforts with axes and other implements to break into the main fuselage. No serious attempt was made to break open with tools the hatch of the rear pressure bulkhead and it was not until sometime between 3.20 and 3.30 p.m. (Singapore time) that an entrance was made through there to the main cabin. Most of the time was spent to no avail in attempting to cut no less than seven holes through the starboard side of the fuselage with standard axes carried as part of the Airport Fire Service equipment. Detailed investigation showed that the axes used were not capable of cutting through the metal skin in what can be accepted as a reasonable time limit; from all the evidence, with two men, it took 8 to 10 minutes The difficulties were firstly in making an incision to favour cutting, and secondly, when the axe

blade had entered the skin, the metal impinged on the blade of the axe preventing easy withdrawal for a fresh strike. In every case, it was found impossible to enter any of the apertures which were made because of the high temperatures inside and the noxious fumes. Two passengers were extricated through them, one, who was still alive (but died later), from a position immediately aft of the starboard wing root and another, a woman, from the wardrobe in the after section in front of the ladies' cloak room. She was dead.

The City Fire Brigade sent two pumpers and an ambulance after receiving the call at 3.08 p.m. Singapore time. One additional pumper was despatched from Geylang. The Geylang pumper arrived first and was positioned at the sea wall at 3.15 and commenced to run a sea water supply relay to the fireground. The two other pumpers started to produce foam about 3.20. They worked efficiently and independently from the Airport crew and managed to effect reasonable control of the fire by 3.30 by the mass application of foam on the advanced fire originating at the port wing. The rate of foam application by the City Brigade was 2 400 gallons of foam per minute.

Exits from the Aircraft

Apart from the rear pressure bulkhead discussed above which was not a normal means of access to the cabin, there were five methods of egress. One was through a door from the crew's compartment. It is safe to assume that this door was unapproachable early in the fire and there would have been no advantage in using it as we know of the predicament of the 3 crew members who were on the opposite side. Also, this door could not be opened from the crew side.

There were three emergency exits in the shape of removable windows, two on the port side and one on the starboard, which normally can be operated from either inside or outside. After the accident, the forward port window exit was found destroyed by fire and the rear port window exit was badly damaged. The starboard exit operated normally when tested after the wreckage had been moved, and it is not clear if it was overlooked by those inside and outside or whether it and the others were inaccessible either from within or outside owing to the inverted position. All three of these exits, furthermore, were situated over or very close to the wings and the commissioner investigating the accident issued the opinion that they were "entirely inadequate" and fell "grossly short of a proper standard of safety". He recommended that this model Constellation be modified to provide "at least two (and preferably four) more emergency exits, one (or two) on each side of the aircraft ... at the after end of the fuselage away from the point where fire is most likely to occur. This work should be put in hand as a matter of great urgency".

The main cabin door was the last of the standard methods of egress and this failed to function when badly needed. As reported above, one of the flight engineers tried to open the main cabin door from the outside within two or three minutes of the crash taking place but was unable to move the door locking handle more than an inch in either direction (the outside handle must be rotated clockwise 90 degrees to unlock). Some time later a further attempt was made to open the door but this time the handle was found to be in the unlocked position. Since the body of a first steward was found in a position consistent with his attempting to open the door it is probable that the handle was in fact unlocked by him. However, it proved to be impossible to open it by hand and nearly an hour after the crash it had to be broken open by forcing it outwards and sideways from the outside with crowbars, bolt cutters, and block and tackle. The commissioner's findings note that the door operating mechanism is complicated and that no matter whether the frame is distorted or not (and it probably was) it would be far easier to deal with the door from the outside if it opened outwards instead of inwards and then had to be slid aft.

Recommendations

(The following general recommendations were included in the report.)

"1. Fatigue

Fatigue and the part it plays in accidents appear to be a most complex matter far outside the scope of this report. Whilst it seems probable that chronic fatigue played no part in this

accident, it is by no means certain how much the captain's tiredness affected his judgment in the last stages of Able Mike's approach to Runway 06.

The learned commissioner in his report following an inquiry into the accident to a York aircraft G-AHFA in the North Atlantic on 2 February 1953, recommended that "the whole subject of crew fatigue should receive study at an impressive level". I would make a similar plea and would suggest that a study group, to include medical members not connected with civil aviation, be set up; that practical experiments be carried out to gather concrete information particularly on insidious fatigue; that such experiments be carried out, amongst others, under conditions prevailing in tropical latitudes, and include the effect of noise, vibration and recirculated air obtaining in some pressurized aircraft. The results of this study group could then be considered by a Commission set up to advise on any legislation which might be deemed necessary.

Until such time as the Commission's conclusions have been reached it is recommended:

i) That only most experienced co-pilots be considered for first officer duty on sectors where the duty hours are more than (say) sixteen. The co-pilot of Able Mike would be excluded under this recommendation as a co-pilot for some time.

ii) That rest facilities on board be discussed between management and representatives of all crew members flying long sectors, and that a bunk be provided for all sectors where the hours of duty exceed sixteen.

iii) That pilots be made aware of the meaning and possible effects of insidious fatigue, and be directed to take it into consideration when planning any operation or flight technique.

2. Training of air crew for "unpremeditated" crashes

This subject, it is appreciated, is not an easy one because the nature of every unpremeditated crash must necessarily be different. In this accident, however, lives were certainly lost because of the delay in opening the hatch of the rear pressure bulkhead. It has been said during this Inquiry that in aircraft crashes it is by no means uncommon for the tail plane to break off and crew members, it is felt, could easily be trained in the operation of the rear pressure bulkhead hatch. Short lectures might be given to them as to their responsibility for the passengers and every crew member should be made to operate emergency exits. One cannot help feeling that some sort of drill should be devised, as accidents do not occur only at airports where passengers can reasonably expect help from persons other than the crew.

3. Emergency exits

The positioning and number of emergency exits on Able Mike were quite inadequate. I have been told that a modern practice in aircraft design is to make an emergency exit of every window in the main cabin and this is obviously ideal. My Assessors advise me, however, that it would be an extremely expensive undertaking to modify Constellation aircraft in this fashion and there would also be practical difficulties. In these circumstances, I would urge that at least two (and preferably four) more emergency exits, one (or two) on each side of the aircraft, are forthwith constructed at the after end of the fuselage away from the point where fire is most likely to occur. This work should be put in hand as a matter of great urgency.

4. The cabin door

The cabin door is of complicated mechanism and is more than likely to jam in the event of an accident. I would recommend that consideration be given to the suggestion that during the final approach of an aircraft this door should be opened or at least unlocked before the first touch-down. There may be practical difficulties in this regard, but if they can be overcome, if only as a temporary measure pending the installation of more emergency exits, something may well be gained.

5. The rear pressure bulkhead

It is recommended that a key to the rear pressure bulkhead be attached to the wall of the ladies' lounge, preferably under a glass cover. I realize that the tail plane of an aircraft does not always break off in the event of an accident, but at times it does; in any event there is little to be gained in keeping the key in the forward part of the aircraft.

6. Break-in points

I recommend that break-in points should be clearly marked on the outside of fuselages to show where the skin is thinnest. When positioning such marks on the outside, consideration should, of course, be given to the configuration of the inside of the aircraft which varies considerably according to the requirements of the different operators. Some simple marking is suggested which would be easily recognizable in the various territories through which long range aircraft operate.

7. Scales of equipment for fire services

It is recommended that through ICAO, airline operators should urgently approach the Governments of all territories through which they operate with a view to introducing a standard scale of fire-fighting equipment. It may well be said that the ICAO suggestions and the Ministry of Transport and Civil Aviation scales are too expensive to be adopted in all such territories. However, it must be remembered that although the airlines wish, no doubt, to operate through those territories, considerable advantages also accrue to the territories themselves as a result of an airline affording them a regular air service, and the fact that landing fees may not compensate such a territory for the cost of maintaining its airport (including the Fire Service) is of little real relevance.

8. Liaison of operators with airport fire services

I suggest, for consideration by airline operators, that their representatives should work closely with the staffs of all airports through which they operate in matters of the fire service and that they should take an active interest in the fire-fighting facilities. I do not believe that any such interest is being shown at the present moment.

It is recommended that the Department of Civil Aviation should readily make available to representatives of airline operators any information they may require regarding the fire service Such representatives should be encouraged to witness fire drills and exercises of all kinds. In addition to this, I suggest that inspections of the various airport fire services along the route flown by the operators should be made by their own fire officers at regular intervals of perhaps six months and in the event of the operators not being satisfied with what they see and hear, they should consider the cessation of operations through the airport concerned.

9. Runway markings

It is recommended that where pre-threshold and approach conditions give rise to any concern, aviation authorities responsible for runways should actively consider the use of two thresholds, one for landing, and one for take-off."

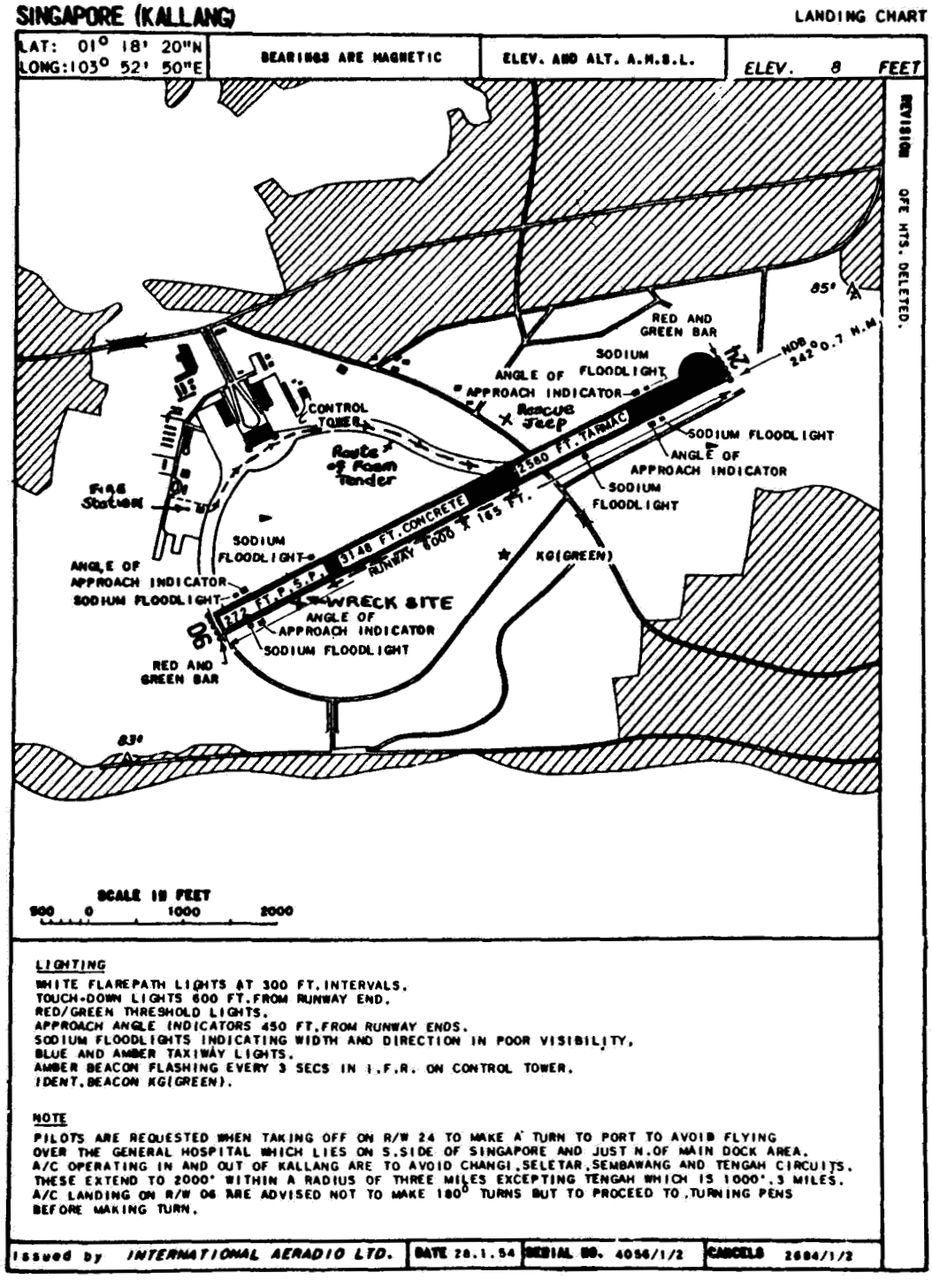

SINGAPORE (KALLANG)
LANDING CHART
LAT: 01° 18' 20"N
LONG: 103° 52' 50"E
BEARINGS ARE MAGNETIC
ELEV. AND ALT. A.M.S.L.
ELEV. 8 FEET
REVISION OFE HTS. DELETED.
RED AND GREEN BAR
SODIUM FLOODLIGHT
ANGLE OF APPROACH INDICATOR
NDB 242° 0.7 N.M.
CONTROL TOWER
Rescue Jeep
Route of Foam Tender
2580 FT. TARMAC
SODIUM FLOODLIGHT
ANGLE OF APPROACH INDICATOR
SODIUM FLOODLIGHT
Fire Station
SODIUM FLOODLIGHT
ANGLE OF APPROACH INDICATOR
SODIUM FLOODLIGHT
5148 FT. CONCRETE RUNWAY 6000 X 165 FT.
KG(GREEN)
272 FT. P.S.P.
WRECK SITE
ANGLE OF APPROACH INDICATOR
SODIUM FLOODLIGHT
RED AND GREEN BAR
85°
83°
SCALE IN FEET
500 0 1000 2000
LIGHTING
WHITE FLAREPATH LIGHTS AT 300 FT. INTERVALS.
TOUCH-DOWN LIGHTS 600 FT. FROM RUNWAY END.
RED/GREEN THRESHOLD LIGHTS.
APPROACH ANGLE INDICATORS 450 FT. FROM RUNWAY ENDS.
SODIUM FLOODLIGHTS INDICATING WIDTH AND DIRECTION IN POOR VISIBILITY.
BLUE AND AMBER TAXIWAY LIGHTS.
AMBER BEACON FLASHING EVERY 3 SECS IN I.F.R. ON CONTROL TOWER.
IDENT. BEACON KG(GREEN).
NOTE
PILOTS ARE REQUESTED WHEN TAKING OFF ON R/W 24 TO MAKE A TURN TO PORT TO AVOID FLYING OVER THE GENERAL HOSPITAL WHICH LIES ON S. SIDE OF SINGAPORE AND JUST N. OF MAIN DOCK AREA.
A/C OPERATING IN AND OUT OF KALLANG ARE TO AVOID CHANGI, SELETAR, SEMBAWANG AND TENGAH CIRCUITS. THESE EXTEND TO 2000' WITHIN A RADIUS OF THREE MILES EXCEPTING TENGAH WHICH IS 1000', 3 MILES.
A/C LANDING ON R/W 06 ARE ADVISED NOT TO MAKE 180° TURNS BUT TO PROCEED TO, TURNING PENS BEFORE MAKING TURN.
Issued by INTERNATIONAL AERADIO LTD.
DATE 28.1.54
SERIAL NO. 4056/1/2
CANCELS 2694/1/2

Figure 18

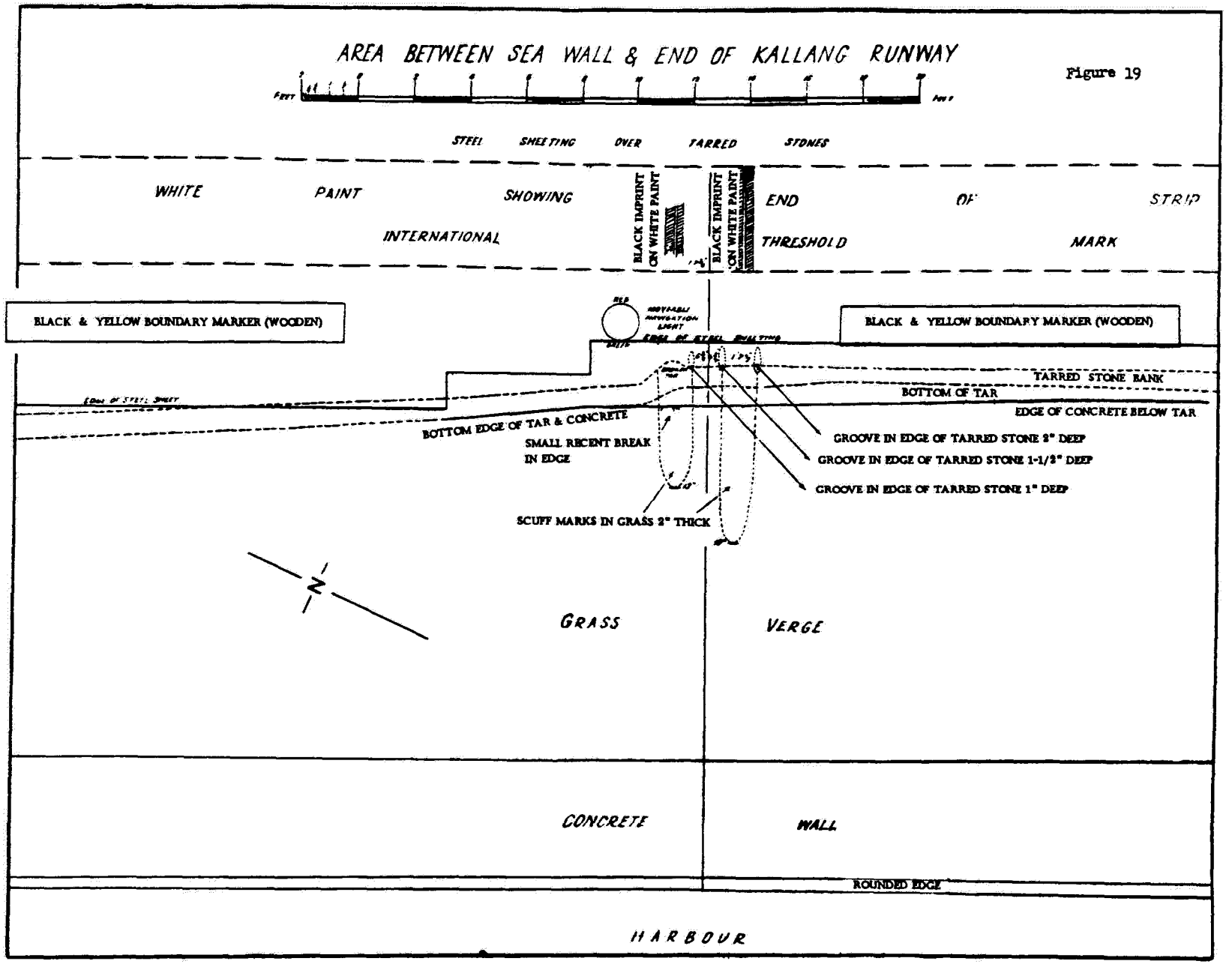
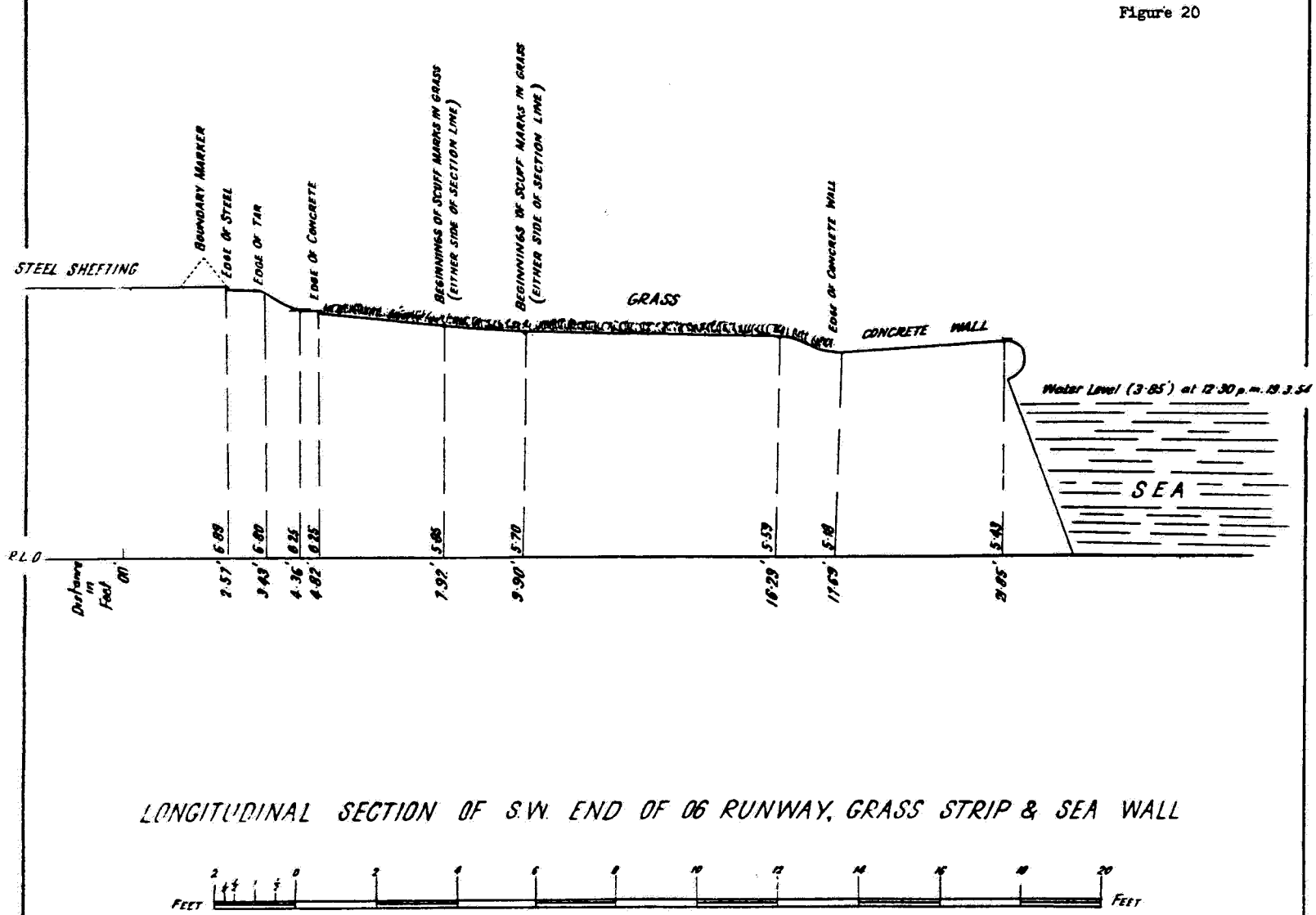

AREA BETWEEN SEA WALL & END OF KALLANG RUNWAY
Figure 19
FEET
STEEL SHEETING OVER TARRED STONES
WHITE PAINT SHOWING INTERNATIONAL
BLACK IMPRINT ON WHITE PAINT
BLACK IMPRINT ON WHITE PAINT
END OF STRIP THRESHOLD MARK
BLACK & YELLOW BOUNDARY MARKER (WOODEN)
BLACK & YELLOW BOUNDARY MARKER (WOODEN)
RED
EDGE OF STEEL SHEETING
TARRED STONE BANK
BOTTOM OF TAR
EDGE OF CONCRETE BELOW TAR
BOTTOM EDGE OF TAR & CONCRETE
SMALL RECENT BREAK IN EDGE
GROOVE IN EDGE OF TARRED STONE 2" DEEP
GROOVE IN EDGE OF TARRED STONE 1-1/2" DEEP
GROOVE IN EDGE OF TARRED STONE 1" DEEP
SCUFF MARKS IN GRASS 2" THICK
N
GRASS
VERGE
CONCRETE
WALL
ROUNDED EDGE
HARBOUR

Figure 20



LONGITUDINAL SECTION OF S.W. END OF 06 RUNWAY, GRASS STRIP & SEA WALL

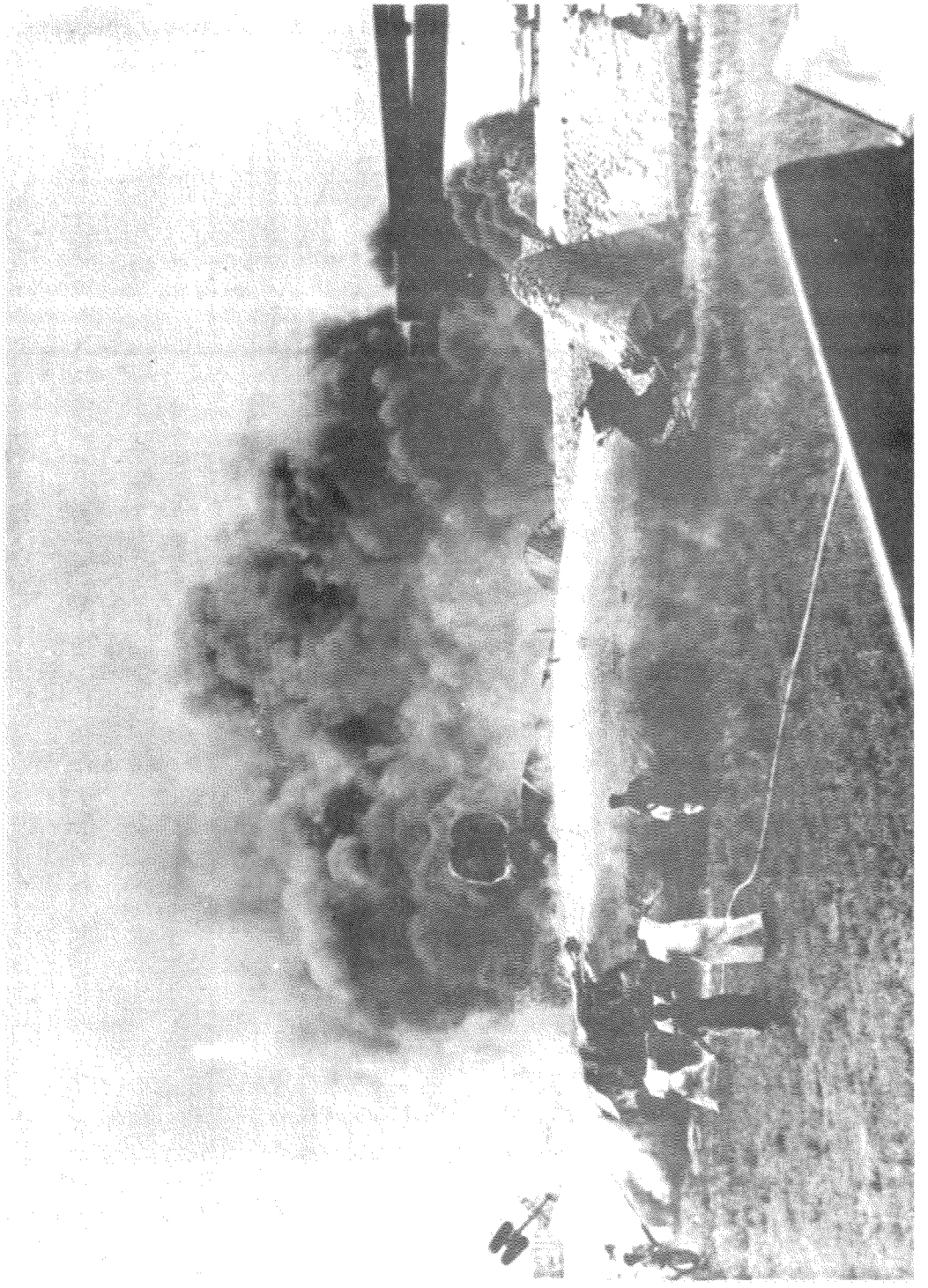


Figure 21

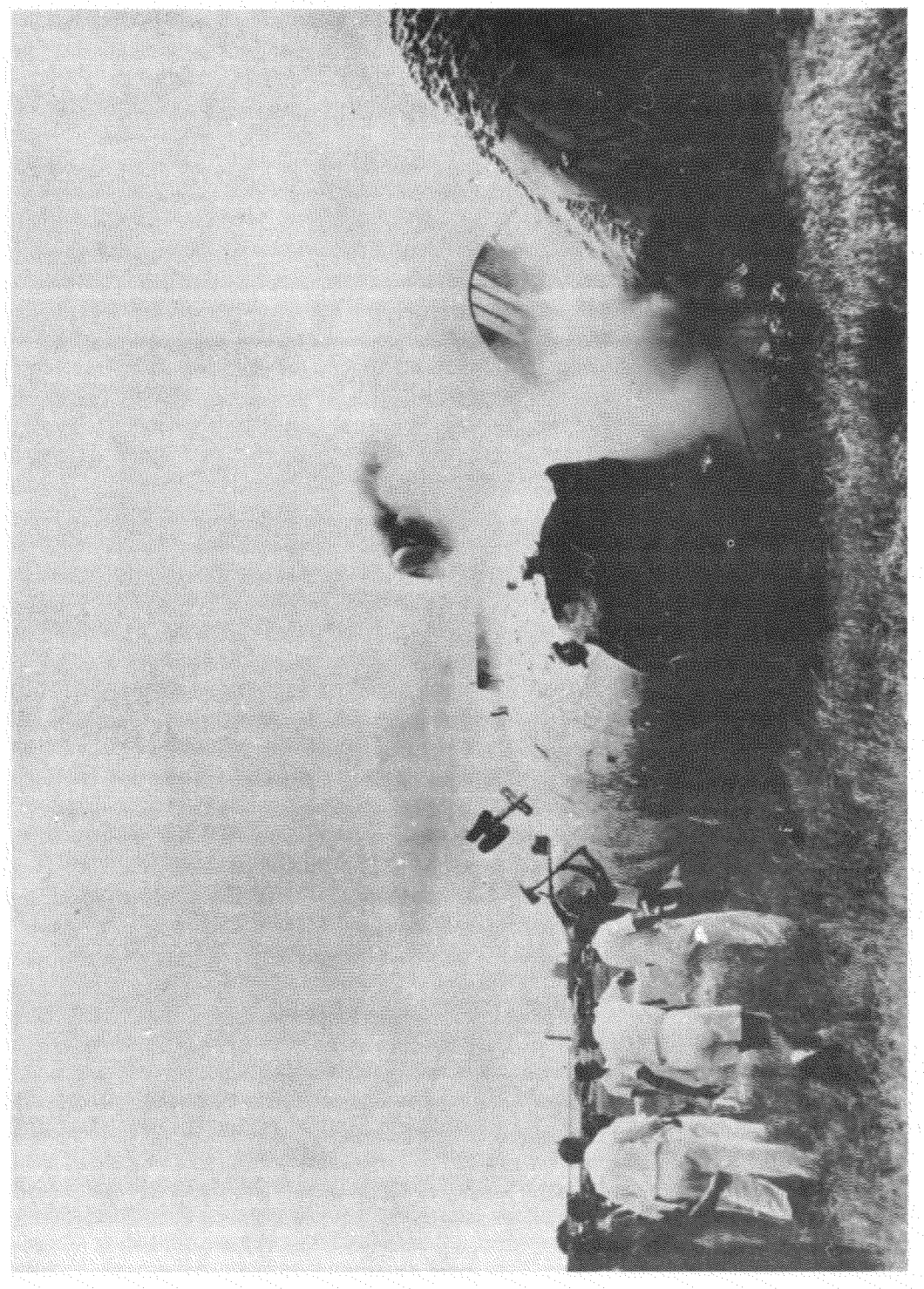


Figure 22

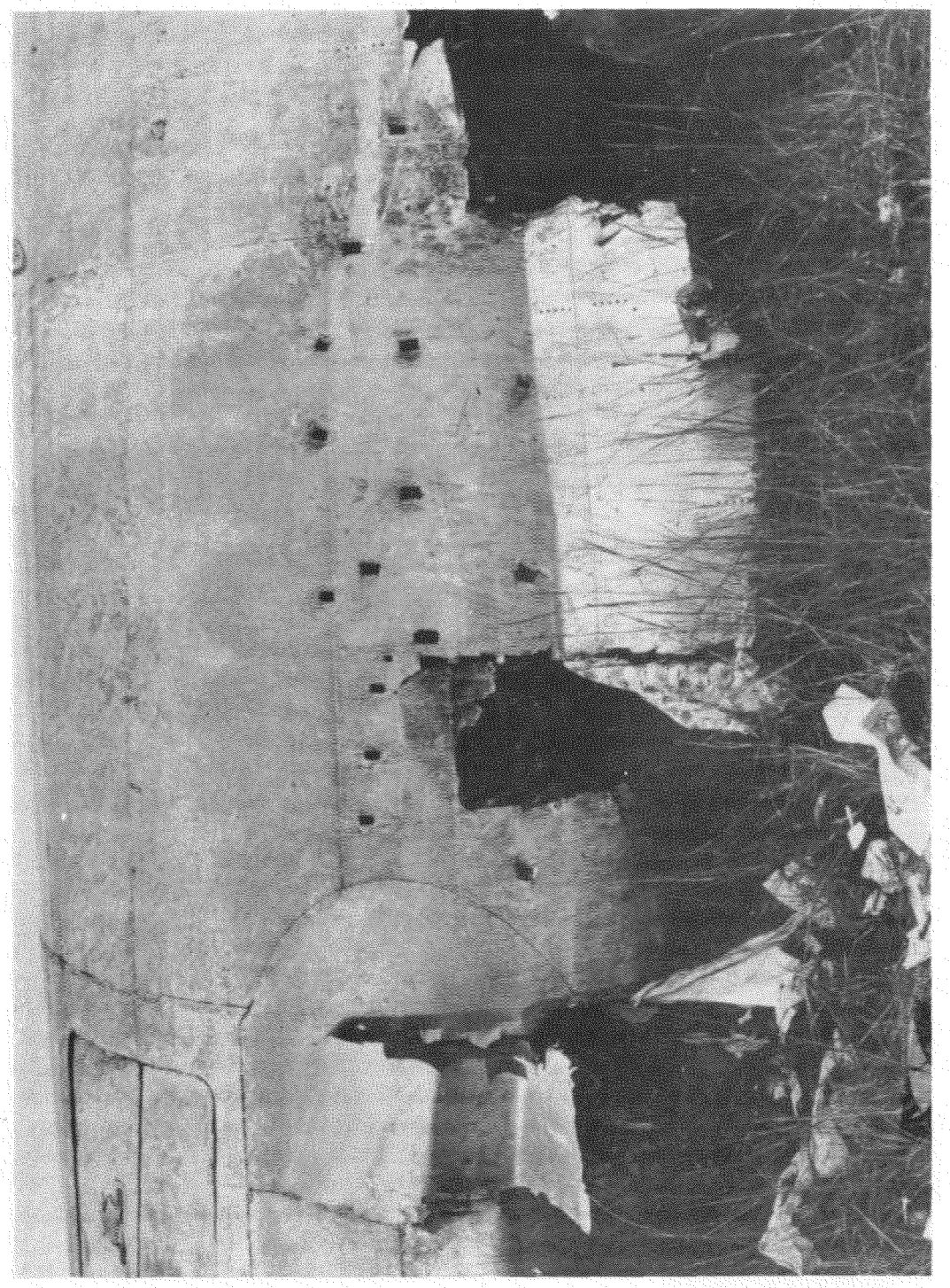


Figure 23

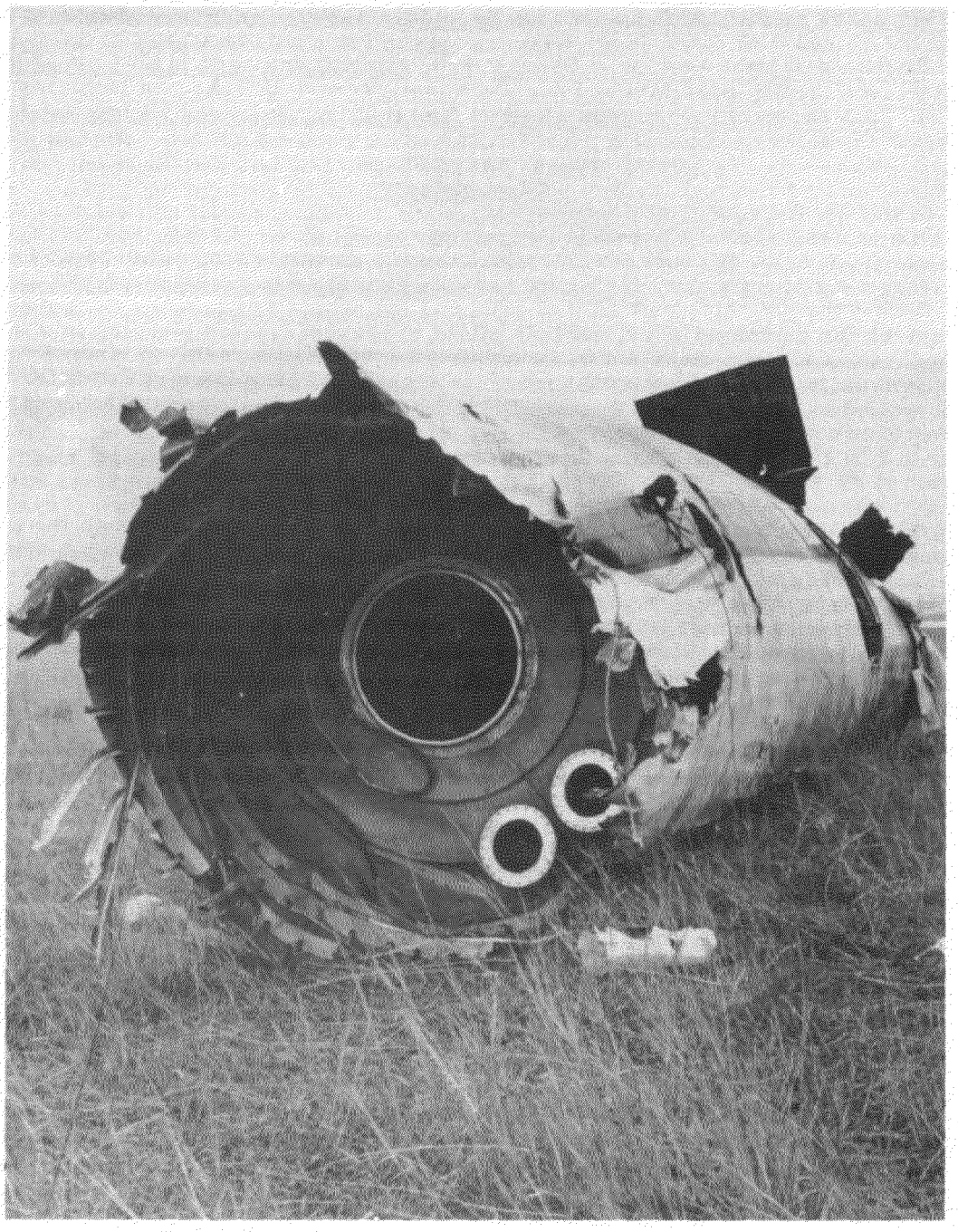


Figure 24

No. 12

Continental Air Lines Inc., Convair 340, aircraft damaged in an emergency wheels-up landing near Midland Air Terminal, Texas, U.S.A., on 16 March 1954, CAB Accident Investigation Report No. 1-0019. Released 19 July 1954

Circumstances

The flight, engaged on a scheduled flight between El Paso, Texas, and Kansas City, Missouri, took off from Midland Air Terminal, an intermediate stop, at 0838 CST with 3 crew and 8 passengers. Shortly after taking off severe vibration was experienced and on reaching a height of 75 feet the vibration suddenly stopped and the aircraft assumed a nose-down attitude which required the combined efforts of both pilots to prevent it from plunging into the ground. As this nose-down attitude could not be completely corrected a wheels-up landing was made in a barren field about 2-1/2 miles northeast of the airport. There were no fatalities but serious injuries resulted to two passengers and minor injuries to several other passengers and 3 crew members. There was no fire.

Investigation and Evidence

A pre-take-off check was conducted adjacent to Runway 10 at which time the propellers, engines and instruments gave normal indications. A part of this check included moving the control column fore and aft and turning the wheel left and right in order to check the control system for freedom of movement and full travel. At 0838 the flight was cleared for take-off which was made using normal take-off power. Immediately after becoming airborne the crew noted a slight vibration which was attributed to an unbalanced condition of the spinning main landing gear wheels. The captain applied brakes during the landing gear retraction to eliminate this vibration; however, it not only continued but rapidly increased in severity. The aircraft reached an altitude of approximately 75 feet, the highest attained, and was near the airport boundary when the vibration stopped with a sudden jolt and the aircraft assumed a nose-down attitude. The first officer, immediately sensing the situation, joined the captain and both exerted their entire strength applying back pressure to their respective control columns to keep the aircraft from plunging into the ground. The captain quickly reduced power; however, the nose-down pressure could not be completely overcome. The first officer used nose-up trim control in an effort to relieve the nose-down pressure; this action had no appreciable effect and during the last attempt the trim tab control wheel appeared to be stuck. The captain established a shallow left turn with the thought of returning to the airport and continued the turn about 45 degrees from the take-off heading. As airspeed decreased power was momentarily increased whereupon it became evident to the crew that using power sufficient to maintain flight resulted in an insurmountable nose-down pressure. The captain, therefore, decided to make a wheels-up landing straight ahead. Close to the ground the first officer closed the throttles and the captain pulled the electrical crash bar. Contact with the ground followed with the aircraft in a near-level attitude and at approximately 100 m.p.h. Although the passengers and crew received injuries of varying degrees, they were able to get out of the aircraft unassisted in an orderly manner. The evacuation was mainly through the rear service door (emergency exit) and was accomplished in about 30 seconds.

Examination of the right horizontal stabilizer and elevator revealed no external damage, however, it was noted that the right elevator trim-servo tab was jammed in a 24-degree up or aircraft nose-down position. There were over-travel marks and notching found on the leading edge skin of the tab at its hinge points. The access door on the lower horizontal stabilizer surface was immediately opened to examine the trim tab actuating mechanism. This examination disclosed that the forward push-pull rod, which normally extends from the jack assembly rearward to the elevator hinge-line idler, had failed. The failure occurred adjacent to the rear rod-end fitting. The free stub end attached to the idler was wedged against the bottom edge of the elevator spar cut-out hole in such a manner as to hold the trim tab rigidly in a full-up position.

The idler showed an interference mark at the base of its fork to which the forward push-pull rod was attached and this mark matched a similar one on the failed push-pull rod. The failure resulted from tension around the sides and bottom of the rod and compression at the top. Matching the fractured ends revealed a set of approximately one-eighth inch due to downward bending before failure. All other components of the assembly were undamaged.

A comparison of the assembly, as installed, with the appropriate Convair drawing disclosed that both the idler and the forward push-pull rod were installed in reverse. Interference between the idler and push-pull rod was caused by the reverse idler.

Company maintenance records showed the right elevator trim tab assembly had been removed, reinstalled and inspected by company maintenance personnel. This work was done during a No. 3 check, 14:40 flight hours prior to the accident, for the purpose of removing excessive play from the assembly. During the reassembly and reinstallation both the Company Convair Maintenance Manual and the Manufacturers Illustrated Parts Catalog were used as references.

Figure 7.4.101 of the Maintenance Manual, entitled "Elevator Tabs Installation", was first referred to during the installation. This figure illustrated the idler as a straight-designed component whereas the actual part is curved, and depicted the forward and rear push-pull rods incorrectly in their inboard and outboard relationship. Instructions 7.4.2 and 7.4.3 of the same publication referred to this figure for removal and installation purposes. From this figure, 7.4.101, correct positioning of the idler could not be determined.

In order to determine which way the curved idler should face in the assembly the maintenance personnel involved used as a reference Figure 2003 of the Manufacturers Illustrated Parts Catalog entitled "Elevator Trim Tab Idler Installation". This figure illustrated an exploded view of the complete left-hand elevator trim tab idler assembly including its left idler. Since the right idler for the right elevator trim tab assembly was of different design than the left, it appeared alone and below the left assembly but on the same plate. It was shown curved, which correctly depicted its actual design. Thus, for a right-hand assembly it was necessary to substitute the right idler in place of the left. It was stated by the company that by conventional interpretation of this illustration the left assembly would be correctly installed in the aircraft and the left idler correctly installed in the assembly, however, upon substituting the right idler as required for the right assembly and following the same conventional interpretation of the figure, the result would be, and was, a reversed idler installation (the convex side forward instead of rearward).

Upon completion of the installation the mechanic told the inspector how he had installed the idler. The inspector referred to Figure 7.4.101 of the Maintenance Manual and Figure 2003 of the Parts Catalog, the same references used by the mechanic, and agreed with the mechanic's interpretation of the reference material. He then inspected the work and thought it was satisfactory. The assembly was functionally tested in accordance with prescribed procedures and the results were normal. Subsequent tests revealed that the normal indications would be obtained with the idler in reverse. Had the check procedure required the trim tab be moved through its travel with the elevator full-up, an interference would have been noted.

Figure 8.2.104 of the Maintenance Manual, commonly called the "rigging page", was not consulted during this installation or inspection. It was stated by company personnel that rigging was not involved and the figure did not include adequate installation and removal instructions. The figure, however, did illustrate correct positioning of the idler.

During the public hearing it was stated by Convair representatives that the Illustrated Parts Catalog should not have been used as a reference during the right elevator trim tab installation. It was stated that this manual was solely published for identification of parts and associated purposes. It was also stated that a question involving installation, as in this case, should have been resolved by consulting the appropriate blueprint.

On the other hand, company witnesses stated that common practice throughout the industry was to use the Manufacturers Illustrated Parts Catalog as a guide during maintenance work and

they expected it to illustrate correctly the relative position of parts in an assembly and in an aircraft. Thus, it was believed the Illustrated Parts Catalog was correctly used as an installation reference but because of the incorrect fore and aft depiction of the right idler it was installed in reverse. They further stated that blueprints were used primarily during modification work, were not available at outlying stations where maintenance was performed, were cumbersome, and it was questionable whether or not an average maintenance employee could read a blueprint effectively. For these reasons company officials believed a blueprint was not satisfactory as a routine maintenance or installation reference.

The Board, subsequent to the hearing, conducted a nation-wide survey of approximately 70 maintenance bases owned and operated by scheduled and irregular carriers. Results indicated that approximately 65 per cent of the operators did not consider the Manufacturers Parts Catalog as a maintenance reference and confined its use to an identification of parts only. The survey also revealed that aircraft manufacturers with one exception do not intend that their Parts Catalogs be used for any other purpose.

Investigation disclosed the blueprint of the assembly, which was available at the time of the subject installation, illustrated the right-hand view but was incorrectly labeled a left-hand view. The blueprint was also designated a plan view; however, to be read as such, it was necessary to hold it overhead or interpret it as if it were in such a position.

Immediately after Board investigators learned the cause of the failure in this accident, an accelerated inspection program was conducted on all Convair 340 aircraft. This was done in the interest of safety to ensure that no others were in operation with the idler reversed. The manufacturer also took immediate measures to apprise all purchasers of these aircraft of the factual situation as well as corrective action if necessary. As a result of the inspection which followed, reports revealed that four Convair 340 aircraft were in service with reversed idlers. Two of them had no maintenance records relative to the assembly and were alleged to have been unaltered factory installations. One other aircraft was found with a forward push-pull rod bent giving evidence of a reversed idler installation some time prior to the inspection. The total flying time on these aircraft varied between 1 600 and 3 000 hours.

Analysis

Immediately after the aircraft became airborne the crew noted a vibration which became more severe as airspeed increased. It is very probable that this vibration was due to tab flutter which occurred after the push-pull rod failed and the air flow over the horizontal tail surfaces increased to the critical flutter speed for the free tab condition. As air speed built up, the oscillations increased in magnitude until the stub end of the failed rod became wedged, holding the trim tab in a full-up or aircraft nose-down position. The trim tab position and resulting nose-down pressure could not be overcome by the crew and necessitated the wheels-up landing which followed. The failure of the push-pull rod was caused by stresses imposed on it as a result of the reversed idler installation.

As shown under Investigation, the Maintenance Manual was first consulted during the right elevator trim tab installation and Figure 7.2.101 of this manual was considered the appropriate reference. Since the figure did not illustrate correct positioning of the idler, nor were instructions clarifying its installation included, this part of the Maintenance Manual was inadequate. Although rigging was not considered to be involved by the mechanic and inspector, it was closely related to this installation. When the idler installation question was referred to the inspector by the mechanic his experience and responsibility should have prompted him to refer to the "rigging page" (Figure 8.2.104 of the Maintenance Manual) in addition to the references previously mentioned. Had he done so the inspector should have realized that the idler was installed contrary to the rigging diagram, alerting him to the inconsistencies of the references.

The carrier is required by Civil Air Regulations to prepare and maintain a Maintenance Manual and it is responsible to determine that this manual is complete, current and adequate. The Illustrated Parts Catalog is not considered a part of, or supplement to, the Maintenance Manual. The Board, therefore, is of the opinion that the carrier did not meet its responsibility

to determine adequacy of its Maintenance Manual and its policy permitting the use of the Parts Catalog as a maintenance guide was incorrect.

The public hearing revealed that other carriers have used the catalog as a maintenance guide. This practice indicates that in most instances the publication has been reliable for this purpose and leads to the conclusion that due to a mistake of the manufacturer in preparing Figure 2003 of the Parts Catalog, the right idler was shown with its convex side forward, or reversed relative to its correct installation. Although representatives of the manufacturer stated this publication was not intended to be used as a maintenance guide, it is evident the carrier was not aware of the publication's limited purpose.

As shown by the Board's safety survey, approximately one-third of the scheduled and irregular carriers have used Parts Catalogs as maintenance references although manufacturers have not prepared them for this purpose. The Board believes that the publication, unless specified by the manufacturer, should not be used for maintenance purposes and, as a result, the Civil Aeronautics Administration has taken measures which will clarify the conflicting opinions relative to the proper use and purpose of the Illustrated Parts Catalog, emphasizing that it is not considered a maintenance guide under Civil Air Regulations. The Board is of the opinion that this action taken by the Civil Aeronautics Administration is appropriate; however, the misuse of the Parts Catalog should have been noted sooner by the CAA through its assigned agents for more timely action.

Probable Cause

The Board determined that the probable cause of this accident was loss of control due to a failure of the right elevator trim tab push-pull rod caused by a reversed installation of the right elevator trim tab idler as a result of the carrier's reliance on the Manufacturers Illustrated Parts Catalog as a maintenance reference.

No. 13

KLM DC-3 aircraft, damaged when landing at "Golden Rock" Airport, Basseterre, St. Kitts, British Leeward Islands on 17 March 1954. Civil Aviation Council, Netherlands Antilles Accident Investigation Report

Circumstances

The flight originated at Curaçao, Netherlands Antilles, at 1325 GMT on 17 March 1954, its destination being St. Kitts, British Leeward Islands. The flight arrived at St. Kitts at 1643 GMT.

During the flight, which was entirely routine, the captain handled the navigation and radio-communication, whereas the co-pilot did the actual flying.

When approximately 1 750 feet past the approach end of the runway a normal landing was made on the main landing-gear wheels. The aircraft then travelled approximately 1 500 feet on its main landing-gear wheels after which the tail settled. The remaining 818 feet of runway were covered on three wheels. The aircraft thereupon overran the eastern threshold of the runway through a ditch of approximately 6 feet deep, overran the tracks of a narrow-gauge railway and came to a full-stop in a sugar-cane field.

Damage to the aircraft was restricted to the right landing-gear, the propellers, the right engine, the right oil-cooler, the bottom of the right engine-nacelle and the undersurface of the nose-section of the fuselage.

There were no serious injuries to passengers and crew.

Investigation and Evidence

The flight was carried out at an altitude of 9 000 feet and was entirely routine until it arrived at a position of approximately 25 miles southwest of St. Kitts. From that position the co-pilot decided to start the descent, his decision however was overruled by the captain. The actual descent started about 5 minutes afterwards, at a rate of 500 feet per minute.

At 1623 landing conditions were given by St. Kitts tower: 5.6/8 Cu/Sc. 1500/2000 vis. unl. wind 230/240 3 to 5, 3003.

When 5 miles out, on the basis of actual wind conditions at "Golden Rock", the co-pilot decided to land in an east-west direction, against a headwind-component of approximately 3 mph. The captain however ordered the co-pilot to land from west to east. He explained his decision by stating that he did not think the wind given by the tower to be representative of the wind over the entire runway. When the "5 miles out" position was reported to St. Kitts tower, the latter gave the following wind conditions to the aircraft: wind 210/240 3 to 5.

Before coming on final approach, the direction in which the aircraft was going to land was reported to the tower; the tower operator thereupon repeated the surface-wind direction and speed.

After turning final the co-pilot called for 20° flapsetting. The captain thereupon ordered the co-pilot to postpone extending flaps until the indicated airspeed had dropped to 120 mph. Later in the final approach the co-pilot called for additional 10° flaps, the captain, however, intervened by saying that it was too early. Full flapsetting was effected at a point approximately 1 500 feet west of the western threshold, the indicated airspeed being approximately 110 mph.

When coming over the threshold the aircraft's altitude was between 40 and 50 feet, the indicated airspeed being approximately 105 mph. The co-pilot then prepared for a three-point

landing. The captain, feeling that the co-pilot was holding up the aeroplane, pushed the wheel forward in order to get the mainwheels on the ground. The aircraft touched down on its main-wheels with a D.I.A.S. of approximately 90 mph.

The co-pilot did not apply brakes immediately due to fear of nosing-over, the captain, however, applied brakes from the right-hand seat. Shortly afterwards the captain ordered the co-pilot to apply brakes gradually, but the latter, still fearing a nose-over, did not follow up.

Thereupon the captain once more ordered the co-pilot to start braking. It appears likely that from that moment on both pilots were braking cautiously, each pilot expecting the other to apply maximum possible brake.

At a distance of 820 feet from the eastern threshold the tail came down, the aircraft still travelling at relatively great speed. Not before the aircraft reached this point was maximum brake-power applied. This, however, did not prevent the aircraft from over-running the eastern threshold with a speed of approximately 30 mph.

An analysis of the tyre marks left by the aircraft brought to light the following:

The spot where the aircraft made its original touch-down could be determined because both main-wheel tyres made unusually heavy marks on the runway.

The runway is 4 050 feet long, therefore the aircraft had 2 302 feet of runway available for stopping.

From the touch-down point the tyre marks were at first fairly weak. They became more pronounced at a point 1 960 feet west of the eastern threshold, indicating that from the touch-down point to this point the aircraft did not have its full weight on the main-wheels, particularly so with regard to the left wheel.

This fact leads to the assumption that the aircraft was at the time travelling at great speed. From the point 1 960 feet west of the eastern threshold the main-wheels remained on the ground from then on. The track left by the tyres was not straight and indicated that the aircraft had swerved over the runway in both directions.

The point where the tail came down could be determined at 3 232 feet from the western threshold. The aircraft had, therefore, covered a distance of 1 484 feet on its main-wheels.

From the tail-down point the tyre marks indicated a pronounced braking action, even skid marks could be observed. There was however no indication that the wheels were blocked at any time. An inspection of the tyres revealed no marks of blocking. The fact that the marks of the tyres were more pronounced than those of other aircraft recently landed confirms the conception that there had been braking action during the entire roll-out. A calculation based on Douglas Report No. SM 3924 (dd. 11.26.42) reveals that under prevailing conditions in regard with wind, temperature, slope of runway, aircraft weight and touch-down speed, the aircraft could have been brought to a full stop after covering a distance of 1 640 feet, provided however that:

a) the braking system was in perfect condition;

b) as regards this particular case, the most effective brake technique was applied, immediately after touch-down;

c) no other special circumstances prevented the aircraft from coming to a full stop within the distance mentioned above.

In order to conduct a practical test on the brakes, parts of the brake system of the aircraft were installed in another KLM DC-3 airplane, extreme care being taken that these parts were

installed in exactly the same condition as when they were taken off the original aircraft. The weight of the test aircraft was equal to that of the original aircraft when landing at "Golden Rock".

During the test the aircraft was twice accelerated to a DIAS of 92 mph whereafter maximum brake was applied. On the first run the temperature of the brakes was normal and the second run was made with hot brakes. On both runs brake action was found very effective.

On the third run the aircraft was accelerated to a DIAS of 60 mph, whereupon once more maximum brake was applied. Brake action was again very effective. Then a test was made with the intention of checking brake performance, when braking was effected from the right-hand seat. During this test the brakes were purposely preheated. This test showed that braking from the right-hand seat was slightly more effective.

Finally it was found that 26 inches of manifold pressure were required to start the aircraft rolling through fully applied brakes, when very hot. After the brakes had been allowed to cool during 30 seconds, 48 inches were required.

Findings

The actual landing weight at "Golden Rock" airport exceeded the official maximum landing weight by 122 kilograms but stayed within the limit of the allowable excess weight. This fact could hardly be a contributing factor to the cause of the accident.

The flight from Curaçao to a point approximately 25 miles from St. Kitts was entirely routine, the co-pilot being in charge of the actual flying, the captain handling the navigation and the radio-communication.

During the remainder of the flight, during which the descent, approach and landing were carried out, decisions of the co-pilot with regard to time of descent, direction of landing, extending of flaps, final approach technique, landing technique and braking had been corrected and/or overruled by the captain.

The aircraft was brought in for landing higher and faster than could be justified under the circumstances. Both threshold and touch-down speeds exceeded the speeds as recommended by the company by approximately 15 mph.

The aircraft landed with a 3 to 5 mph tailwind component and touched down 1 750 feet past the western threshold of the runway.

During the landing roll there was considerable misunderstanding between captain and co-pilot with regard to braking. Although it appears that the captain applied brakes immediately after the touch-down, this action was not sufficiently decisive to effect the required slow-down, probably because of the fact that the aircraft bounced once.

Not before a point was reached 820 feet from the eastern threshold, was maximum brake power applied. At that time the speed of the aircraft was, however, too high to effect a full stop within the runway boundaries.

Investigation and practical testing of the aircraft's brake system did not reveal malfunctioning of the system.

Probable Cause

The probable cause of the accident was the pilot's failure to bring the aircraft to a full stop before the eastern threshold was reached resulting from:

a) too high approach under the prevailing circumstances;

b) excessive threshold speed;

c) failure to apply the proper stopping technique.

It should be emphasized, that the captain's tendency to overcorrection of the co-pilot's actions strongly contributed to the accident.

ICAO Ref: AR/317

No. 14

Trans Canada Airlines, Canadair C4-1 and a RCAF Harvard MK. II, involved in collision over outskirts of Moose Jaw, Saskatchewan, Canada, on 8 April 1954. Report of Board of Inquiry, Ref. AC-5-34, Department of Transport, Canada

Circumstances

Trans Canada Air Lines scheduled west-bound flight to Vancouver, carrying 4 crew and 31 passengers, had been cleared by Air Traffic Control on an IFR flight plan and was flying at 6 000 feet on Green Airway No. 1 between Winnipeg and Calgary, when at 1003 hours MST, a collision occurred with a Harvard which had taken off from RCAF Station, Moose Jaw, on a solo navigation training exercise. At the time of the collision the Harvard aircraft was crossing the airway on a northerly course. The collision was observed by witnesses who shortly afterwards heard an explosion.

Wreckage from both aircraft covered an area of about 1 square mile, and the largest portion fell on a house which was destroyed by the fire that ensued. The only occupant of the house and the occupants of both aircraft were killed.

Investigation and Evidence

The portion of the flight immediately prior to the accident was reconstructed and superimposed on a mosaic photograph. From this it was seen that the TCA aircraft was proceeding in a westerly direction on the right-hand side of the centre line of the airway at a height of 6 000 feet.

At 0957 hours MST a Harvard aircraft took off from Runway 13 at RCAF Station, Moose Jaw, to carry out a navigation cross-country exercise. After take-off a right-hand turn was executed conforming with the right-hand circuit then in effect for RCAF Station, Moose Jaw, and on the assumption that the aircraft carried out the requirements of the navigation exercise, a steady climb on track (031°T) across the airway would have been started. This would have occurred at about 1000 hours MST. At this time (1000 hours MST) both aircraft would have been about 14 miles apart with a relative speed of approach of about 270 mph. The cross-country exercise on which the Harvard was engaged involved an initial climb to 9 000 feet. From approximately 1000 hours MST onward the aircraft were on collision courses, the collision taking place at 6 000 feet at 1003 hours, i.e. three minutes later. Thus the Harvard was airborne only six minutes before the accident. It is accepted that the collision occurred at 6 000 feet as the flight plan was for that height and only thirteen minutes before the TCA aircraft had given his position as by Regina at 6 000 feet.

There were no survivors to the accident in either of the two aircraft from whom evidence regarding the collision could be obtained. However, eye-witnesses agreed that the aircraft were on converging courses on the airway, the Harvard crossing the airway north-bound and the TCA aircraft west-bound and no action to avoid collision was taken.

The Board was aware that the provision of an adequate field of view has long been a difficult problem for designers and considered that there might be a blind spot in either or both aircraft.

A Vector diagram showing the collision tracks of the two aircraft was prepared and this showed that the line of sight prior to the collision from the Harvard to the TCA aircraft was about 50 degrees to the right from dead ahead and similarly the line of sight from the TCA aircraft to the Harvard was about 23 degrees to the left from dead ahead. This suggested that there might be blind spots in either or both aircraft along the line of constant bearing thus preventing either pilot from seeing the other aircraft. As a result, the Board proceeded to Montreal

to examine the field of vision from the Canadair C4-1 type of aircraft from the pilot's seat and obtained a diagram from TCA which was prepared at the request of the Board. This diagram illustrated that from the captain's seat of the TCA aircraft there is an upright member of the structure of the windows (window post) causing a blind spot 6 degrees in width from the pilot's eye and whose centre line is 16 degrees to the left from dead ahead. In other words the line of bearing between the two aircraft comes within only 4° of the blind spot.

Similarly the angle of depression from the pilot's position between the horizontal line of sight and the lower structure of the windows was found to be about 13-14 degrees. The gradient of climb of the Harvard aircraft was computed and found to be of the order of 4-1/2 degrees.

While these figures are based on the pilot holding his head in a fixed position, it was recognized that for reasons of comfort, the pilot will change his position from time to time and thus cause the position of the blind spot to move.

Any variation in the seat position will cause a considerable change in the angle of depression, but it was realized that a pilot will adjust his seat to suit his own personal preference.

If there was an adequate field of view and as no avoiding action was taken, the pilots might well have been preoccupied with other matters related to the operation of their aircraft. In discussing this aspect, the Board considered that a continuous lookout may not always be feasible, or even sufficient, in view of the speeds of modern aircraft. This pointed out the need for altitude separation of aircraft even in VFR weather when crossing airways. Recommendation No. 1 refers.

Consideration was given to increasing the height of the uncontrolled or free airspace below the airway from the present 700 feet to some figure such as 2 000 feet. This idea, however, was rejected due, inter alia, to the serious interference that this would cause flights operating in accordance with Instrument Flight Rules particularly in approaches preparatory to landing.

The air navigation exercise being undertaken by the RCAF pilot required that he should climb to 9 000 feet en route to his first turning point. The track of the aircraft led directly across the airway at an altitude commonly used by scheduled aircraft. The Board was cognizant of the policies leading to the use of airports which were built on airways for the British Commonwealth Air Training Plan and that there is salvage value in the use of these airports, but nevertheless considered that their continued use for training constitutes a hazard to other traffic.

The Board considered that in the interest of maintaining a proper lookout, as required by the Air Regulations, the practice of allowing passengers on the flight deck in scheduled aircraft while en-route should be discouraged, as should the custom of the pilots leaving the cockpit to mingle with the passengers.

In order that concerted action might be taken to prevent such accidents in future, the Board considered that its recommendations should be brought to the attention of both the RCAF and ICAO.

The speed of approach of modern aircraft, especially jet aircraft, is such that the time available to pilots between sighting another aircraft and taking evasive action is so small that the human machine may be unable to maintain safety in flight under some conditions when reliant on human senses alone. Accordingly, the Board considered the possibility of adapting some war-time or post-war proximity warning device for use on aircraft and considered that this field should be explored by the Telecommunications Division of the Department of Transport.

Probable Cause

1. Failure on the part of the pilots of both aircraft to maintain a proper lookout, the onus of responsibility for keeping out of the way being with the Harvard aircraft as it had the other on its own right side.

2. The Harvard aircraft in crossing the airway climbed through altitudes normally used by aircraft flying along the airway.

3. The Board, up to the present, has been unable to determine whether the window post on the left side of the Canadair C4-1 aircraft hid the Harvard aircraft from view, but there are indications that this was possible.

Recommendation

It is recommended that:

1. Series V.A.N.O.2, be cancelled and a new A.N.O. issued as follows: when an aircraft is in level cruising flight at 1 000 feet or more above the surface of the ground or water, it shall be operated in accordance with the following cruising altitudes:

a) For VFR flights. The cruising altitudes specified herein shall be complied with in so far as possible while maintaining the separation from cloud minima specified in Air Navigation Orders, Series V, No. 3.

1) Along designated airways or air routes - at the even or odd thousand foot level appropriate to the direction of flight, as in Table 1 below;

2) Across designated airways or air routes:

i) at an altitude of 500 feet above an even or odd thousand foot level, and

ii) in level flight, and

iii) at an angle of at least 45 degrees to the airway or air route.

3) Elsewhere - at the altitude level appropriate to its direction of flight, as in Table 2 below.

b) For IFR flights

1) Within designated airways and air routes

i) under IFR weather conditions: unless otherwise authorized by air traffic control, at the even or odd thousand foot level appropriate to the direction of flight as in Table 1 below;

ii) under VFR weather conditions: at the even or odd thousand foot level appropriate to the direction of flight as in Table 1 below.

2) Elsewhere - at the altitude level appropriate to its direction of flight as in Table 2 below.

NOTE: All altitudes in the Tables below are ABOVE MEAN SEA LEVEL.

TABLE 1

GREEN or RED Airways or Air Routes

Eastbound - ODD thousand foot levels (3 000, 5 000, etc.)
Westbound - EVEN thousand foot levels (2 000, 4 000, etc.)

AMBER or BLUE Airways or Air Routes

Northbound - ODD thousand foot levels (3 000, 5 000, etc.)
Southbound - EVEN thousand foot levels (2 000, 4 000, etc.)

TABLE 2

Magnetic Track	Cruising Altitude
0°- 89° inclusive	- ODD thousands of feet (3 000, 5 000, etc.)
90°-179° inclusive	- ODD thousands of feet plus 500 feet (1 500, 3 500, etc.)
180°-269° inclusive	- EVEN thousands of feet (2 000, 4 000, etc.)
270°-359° inclusive	- EVEN thousands of feet plus 500 feet (2 500, 4 500, etc.)

2. Elementary Flying Training be conducted clear of airways and that flying training establishments be located at points at some distance from the airways.

3. All airlines be required to amend their Operations Manuals to include clauses to the effect that the pilots are required to remain at the controls and maintain a proper lookout within a radius of 25 nautical miles from an airport, also persons other than the flight crew shall not be permitted on the flight deck within the aforementioned area, except as may be required for the safe or efficient operation of the aircraft.

This recommendation does not reflect any conclusions that either pilot was absent from the flight deck at the time of the accident to the TCA aircraft.

4. The above recommendations be drawn to the attention of the Department of National Defence for their consideration and such action as they may deem necessary.

5. A study be made to determine the field of vision from the pilot's cockpit of all Canadian civil aircraft with a view to establishing the adequacy of such field of vision.

This recommendation was made in view of the doubt that exists regarding the adequacy of such field of vision, together with the increased speed of closing of present day aircraft.

6. Recommendation No. 5 be brought to the attention of ICAO for their consideration.

7. A collision warning device to warn the pilot of the proximity of other aircraft be developed.

Consideration was given to radar devices, but it was thought that such devices would not be economically practicable at this time.

It was considered that under VFR conditions it would be preferable to develop an aid to vision, e.g. flashing light, special paint, rather than a cockpit warning device which may distract the pilot from maintaining a proper lookout.

ICAO Ref: AR/359

No. 15

Aerolíneas Argentinas, Douglas DC-3 aircraft, crashed on 23 April 1954 at Sierras de Vilgo (Province of La Rioja). Argentine Aircraft Accident Investigation Report No. 324, (Boletín Informativo de Accidentes de Aviación No. 3) issued on 30 July 1954

Circumstances

The aircraft, engaged on a scheduled flight between Mendoza and Córdoba, Argentina, on 23 April 1954, took off from Mendoza at 1847 hours local time with a crew of 4 and 21 passengers. At 2026 hours local time the aircraft reported that it was diverting to La Rioja as it was impossible to approach Córdoba owing to considerable turbulence. The flight at 2125 reported descent and an estimated time of arrival at La Rioja at 2140. No further contact with the aircraft was made. The aircraft was located on 26 April, in a locality known as Sierras de Vilgo. It was completely destroyed and there were no survivors.

Investigation and Evidence

The meteorological conditions at the departure aerodrome at the time of take-off were as follows: cloudy with low and medium-height clouds; ceiling: 600/1 000 m; visibility: 20 km; wind: light; atmospheric pressure at 1 000 m: 989.9 mb; QFE: 931.2 mb; temperature: 16°C; relative humidity: 83%.

As additional information the pilot-in-command was informed before take-off of the following conditions by the assistant forecaster at the Mendoza airport and by the airline dispatcher: "A cold front which is located south of San Luis is moving northward at a speed of approximately 40 km.h. This front might make it difficult to land at Rio Quarto because of low clouds, but it will not, however, affect the Córdoba area and a safe alternate would be Mendoza rather than Marcos Juarez or Buenos Aires, because the latter points will be affected by the eastern portion of the front."

The flight plan prepared at Mendoza Airport named "Mendoza and Marcos Juarez" as alternate aerodromes. At 1917 hours local time the aircraft reported its position (QTH) over Lagunas de Guanacache. At 1934 hours local time it reported its passage (QTH) over Pampa de las Salina; at 1950 hours local time the aircraft requested the Córdoba and La Rioja weather reports and at 2002 hours local time it gave its position (QTH) over Villa Dolores. At this point it sent the following radiotelephony message to the control tower at Cordoba; "In 15' QGL (control zone) 3300 if it is possible to pass between two cumulonimbuses where there is some turbulence; otherwise, QRF (I am returning) to Mendoza or Rioja". At 2024 hours local time the following message was sent to the Córdoba control tower: "Two cumulonimbuses right and left with considerable turbulence" and at 2026 hours local time the pilot reported that he was heading for La Rioja because it was impossible to make an approach and that he was climbing to 3 600 m.

At 2048 hours local time he reported his position (QTH) over Tabaquillo and at 2125 hours over Salina La Antigua at an altitude of 3 300 m. He reported that he was coming down and estimated his time of arrival at La Rioja at 2140 hours local time. At 2136 hours local time the control tower at the La Rioja Airport listened on 118.1 Mc/s but transmission was suddenly stopped. Further efforts to establish contact with the aircraft having failed, it was declared to be in distress. The wrecked aircraft was located on the morning of 26 April 1954 in a locality known as Sierras de Vilgo.

The aircraft crashed at 29°55'S, 67°30'W at an elevation of approximately 1 600 m. The only part of the wreckage permitting identification were the assembly with its vertical and horizontal stabilizers in an asymmetrical position at an angle of approximately 40°/140°, a small section of the tail cone and the left wing.

The survey of the scene of the accident made it possible to reconstruct the aircraft's final path which was on a true heading of 20°.

In order to determine the probable course of the aircraft after its position report over Tabaquillo, and considering that that point had been given as an estimate and that the aircraft may have flown a straight course between the scene of the crash and the air lane which joins Villa Dolores and Tabaquillo, an investigation was carried out on the ground to check the aircraft's course by questioning the public and officials along the route which the aircraft was presumed to have followed up to the moment of the accident. Witnesses reported that they had heard the aircraft in the neighbourhood and had even been able to distinguish the position lights.

It was thus established that the aircraft had followed a route to the scene of the accident parallel to that which connects Tabaquillo and La Rioja Airport. Two theories in explanation of this diversion were possible.

The first is the possible confusion of La Rioja radio LV-14 and another radio station operating on the same frequency which may have been picked up on the route. The second is that dead reckoning navigation was being used.

The possibility that the LAR radio beacon which had been used as a radio aid was discarded because it was turned on at 2120 hours local time.

In an attempt to corroborate the first of the theories a test flight between Villa Dolores and La Rioja was made on 22 and 23 June, following the route which the aircraft was presumed to have taken on the day of the accident, through the co-operation of the Air Transport Command of the Argentine Air Force and using an aircraft of the same type. The experiment produced the following result. Up to at least 20 minutes before its arrival atLa Rioja, an aircraft on the Córdoba-La Rioja route can tune in on the 1 330 kc/s frequency and hear CX-40 Radio Fenix from Montevideo, and without checking the call letters or the commercial announcements it is easy to confuse this broadcast with that of the LV-14 La Rioja station.

A common drawback of automatic radio compasses is their 180-degree ambiguity in bearing indication, and if not carefully checked they can cause error. In the present case it may reasonably be assumed that upon tuning to the 1 330 kc/s frequency and obtaining the inverted bearing indication the flight personnel of the aircraft were misled into believing that they were on true course for La Rioja. On the other hand during the test flight it was verified that the bearings taken ahead and to the rear were inaccurate and erratic and that no bearing could be obtained at the scene of the accident. Bearing in mind that on the date of the accident weather conditions made reception difficult it was assumed that any bearings taken by the aircraft might have been very inaccurate.

The second theory mentioned, namely, that the flight was being carried out by dead reckoning, would be supported by the difficulty in securing accurate radio bearings en-route and in such a case the navigation error could be attributed to bad calculation.

An analysis of the flight from the time of the aircraft's departure from Mendoza Airport revealed the following facts: the position reports given by the aircraft up to and including Villa Dolores are in complete accord with the flight plan prepared by the airline dispatcher and approved by the pilot-in-command. The flight plan had in fact estimated the following time for portions of the scheduled journey:

Mendoza - Lagunas de Guanacache	29 min.
Lagunas de Guanacache - Pampa de la Salina	16 min.
Pampa de la Salina - Villa Dolores	28 min.
Villa Dolores - Córdoba	24 min.

The flight followed this schedule:

Mendoza - Lagunas de Guanacache	75 nm 30 min.
Lagunas de Guanacache - Pampa de la Salina	42 nm 17 min.
Pampa de la Salina - Villa Dolores	72 nm 28 min.
Villa Dolores - Córdoba (segment not completed)	

The speeds were 150, 148 and 154 knots respectively.

Up to the Villa Dolores position report there was a difference of 2 minutes between the flight plan and the actual flight.

The communications log-book in the control tower at Córdoba indicated that the aircraft made contact with the tower at 2015 hours local time and reported that it was 15 minutes flying time from the control zone. According to this last report which was tantamount to a correction of its earlier position report over Villa Dolores, the aircraft had just then reached the point, which would mean that its actual air speed up to that time had been 130 knots. The aircraft continued its flight, reporting that it intended to pass through two layers of very active cumulus clouds and if this were impossible, it intended to head for Mendoza or La Rioja.

At 2026 hours local time the aircraft reported that it was heading for La Rioja it being impossible to approach Córdoba; the aircraft next reported its position over Tabaquillo at 2045 hours local time and a speed of 150 knots. The approximate distance from Villa Dolores to the point at which it was assumed the aircraft reached the mountains and thence to Tabaquillo is 120 km, and the approximate straight line distance from a point in space between Villa Dolores and Córdoba, along the probable route of the aircraft between Mendoza and Córdoba, to Tabaquillo is 85 km. The aircraft would cover the distance in 20 minutes in the first case and 18 minutes in the second.

On the theory that the flight was progressing according to the figures given and that in fact the aircraft was flying over Villa Dolores at 2002 hours, the time taken to reach Tabaquillo, that is 45 minutes, exceeded by 18 minutes the flight time required to cover that distance at 150 knots. Bearing in mind the history of the flight and the report made to the control tower at 2015 hours local time, the aircraft was over Villa Dolores, at that time, at about 90° from this point and had travelled 354 km at a speed of 130 knots. Assuming that this was the actual speed of the aircraft, it would have needed 29 minutes to cover the 120 km to Tabaquillo. According to this last calculation the aircraft would have reached Tabaquillo at 2048 hours local time if the flight had continued with no loss of time.

While there is no information on the history of the flight between Villa Dolores and its presumed position at Tabaquillo, it is assumed that the aircraft was not flying on any definite course near the mountains. Since the Tabaquillo position report was given nineteen minutes after the decision to return to La Rioja, it is to be presumed that at 2026 hours local time the aircraft was located on the straight line between Mendoza and Córdoba at approximately 85 km from Tabaquillo, with the estimated speed of 150 knots.

The aircraft's passage was seen and heard between the clouds by people on the ground at points located in a line running parallel to and approximately 70 km to the south of the normal air route from Tabaquillo to La Rioja.

Since it would take 17 minutes to cover 70 km at a speed of 130 knots, it would appear in the light of the above analysis that the aircraft did not reach Tabaquillo but a point located approximately 70 km to the south thereof. From there it altered course to 310° and followed the route leading to the scene of the accident.

Both theories revealed that neither of them should be discarded or accepted finally in the absence of any concrete evidence. On the other hand, the fact that the crew had been in constant radio contact with Córdoba and La Rioja and had not needed or used the route beacons would appear to indicate that they did not consider these radio aids necessary.

Although the flight plan prepared at Mendoza and approved by the pilot-in-command named the departure aerodrome as alternate, the pilot had the final decision for the flight and his selection of La Rioja must be accepted as a consequence of conditions which arose during the flight and of his interpretation of reports received.

Another fact which must be considered is the descent recorded in the aircraft's flight. At 2125 hours local time on giving its position (QTH) over Salina La Antigua at 3 300 m the aircraft also reported descent and estimated its arrival at La Rioja at 2140 hours local time. In the section relating to night flying operations the Airline Operations Manual reads: "The en-route altitudes to be maintained while flying contact or on instruments shall not be less than the minima authorized for instrument flying". Also, No. 175 (1) of the Regulations for Flight and Air Traffic Control (RAF. 7) reads: "In-flight altitudes shall not be less than the following safety minima: 1°) The minimum altitudes established by commercial airlines for their own aircraft".

The airline had established the following minimum altitudes for the La Rioja-Córdoba route: 3 000/9 000 feet or 3 000 feet for day flight and 9 000 feet for night flight. The instructions in the Manual, which require the same minima for night flight as for instrument flight, make it clear that the maximum descent en-route was to an altitude of 9 000 feet. The aircraft should have reached the airport zone at this altitude and if unable to make a visual approach (as was the case on the night of the accident because the ceiling was only 600 m) it should have flown over the radio beacon at 8 000 feet, circled down to 5 000 feet and from this altitude carried out an instrument approach as defined by the airline.

It was concluded from the foregoing that the descent of the aircraft below the minimum altitude prescribed by the airline contributed to the accident, since had the aircraft maintained the prescribed altitude, the bearing which was apparently taken on beacon LAB shortly before the crash and which presumably determined the 20-degree change in course, would have been obtained at sufficient height above the obstacle and made it possible to avoid crashing into it.

It was noted that according to evidence regarding flights prior to the accident, the crew had flown 13:37 hours on 21 April, or 1:13 hours in excess of the 12 hours maximum permissible in 24 consecutive hours as laid down in Department of Civil Aviation Resolution No. 124/52, so that the crew rested for only 16:40 hours and not 27 as required. On 22 April they started work at 1414 hours and finished at 0113 on 23 April, with a total of 8:21 hours flight time. On the same day the crew began work at 1523 hours local time following a rest of 14:10 hours, flying 05:18 hours up to the time of the accident. The crew had flown a total of 27:16 hours on 21, 22 and 23 April.

Probable Cause

For reasons which could not be determined the aircraft deviated from the prescribed route and followed a course which led it to crash in mountainous terrain.

Contributing factors:

The pilot-in-command's decision to descend below the minimum altitude specified for weather conditions requiring an instrument approach, contrary to the provisions of the Airline's Operations Manual.

Probable contributing factor:

Probable fatigue of aircraft crew.

ICAO Ref: AR/366

No. 16

Darbhanga Aviation DC-3 Aircraft, crashed near Calcutta (Dum Dum) Airport on 30 April 1954. Government of India Report of Inquiry

Circumstances

Darbhanga Aviation's Dakota aircraft engaged on a non-scheduled flight carrying freight, eight passengers and a crew of three, commenced its take-off run from runway 19R at Calcutta (Dum Dum) Airport at 0918 hours on 30 April 1954. During take-off, the air traffic control officer on duty noticed heavy smoke emanating from the port engine and informed the aircraft accordingly.

The aircraft failed to gain normal height by the time it reached the end of the runway and struck trees, 3,330 feet from the end of the runway. Fire broke out on impact and the aircraft was destroyed. The captain and a passenger died in the accident and the remaining two members of the crew and seven passengers were removed to hospital at Calcutta where the co-pilot, the radio officer and one passenger died. The remaining passengers sustained major injuries.

Investigation and Evidence

During the night-stop routine-inspection of the aircraft on 28 April 1954, metal particles were detected in the port engine oil filter. It was, therefore, decided to change the port engine.

The port engine was removed and an overhauled engine was installed in its place. The installation work was commenced at 1230 hours on 29 April 1954 and was completed the next morning. The records of the company, who had overhauled the engine, were examined. There is no apparent reason to believe that there was any defect in the overhaul of the engine. The installation was undertaken by an experienced engineer. Taking into account the time taken in installing the engine and the number of mechanics who assisted the engineer in completing the task, the installation was performed with due care and caution.

Because of the change of the engine, it was necessary to carry out a test flight of the aircraft in order to check its performance. During the test flight no entries of observations appear to have been recorded by the crew. The engineering personnel testified that they were verbally informed by the captain that the test flight was satisfactory. The same two pilots were scheduled to fly the aircraft to Balurghat a little later and it is difficult to believe that they would fail to report to the engineering personnel, had they not been satisfied that the aircraft was airworthy.

After completion of the test flight, the oil filter of the port engine was removed, checked and re-fitted. That engine was given a short run-up and after a run-up of both engines, a Certificate of Safety for Flight was issued in respect of the airframe and the engines of the aircraft, in accordance with the prescribed procedure.

The aircraft had a valid Certificate of Airworthiness and the previous history of the airframe, engines and propellers, as available from the respective log books, does not denote anything abnormal.

The aircraft was made ready for the flight in the usual manner, with sufficient fuel and oil on board.

Although the captain was detailed by Darbhanga Aviation to act as the commander of the aircraft, the co-pilot reported and obtained the necessary briefing for the flight. He signed the clearance form in which he was shown as the captain and was seen to occupy the left hand seat in the aircraft, which is invariably occupied by the commander.

Of the two, the captain detailed for the flight was a far more experienced pilot than the co-pilot. The captain had to his credit over 7,000 hours' flying experience.

The co-pilot, on the other hand, had limited experience. His flying experience amounted to less than 2,500 hours. He was not entitled to act as a commander of scheduled services or night services. He was, however, qualified to act as commander of non-scheduled flights operated during the day. But the Chief Flying Instructor of Bengal Flying Club has testified that "his impression was that the co-pilot had a tendency to be nervous during an emergency". This is borne out indirectly by the fact that he was involved in three previous accidents.

On 30 April 1954 the aircraft started taxiing to runway 19R at 0910 hours. The aircraft was at the holding point for at least five minutes, until a Constellation which had already lined up on the runway took off. Although the period for which the aircraft was at the holding point permitted a run-up to be carried out, there is no direct evidence of its having been done. After the Constellation had taken off, the aircraft lined up with the runway and obtained permission for take-off.

The aircraft commenced its take-off run and just before it became airborne some persons on the ground noticed profuse smoke emanating from the port engine and heard sounds of "misfiring" and "bangs". The length of the take-off run, as estimated by competent witnesses, was normal or slightly longer than normal. The smoke emanating from the port engine was noticed by officers of the Air Traffic Control just after the aircraft was airborne. The aircraft was informed "Profuse smoke from port engine, watch out". The message was repeated on request and acknowledged by the aircraft.

No perceptible change in the flight path was noticed immediately after the message had been passed on to the aircraft and it continued to climb very gradually, during which time the undercarriage was retracted. Had the take-off been discontinued on receipt of the message, the aircraft might in all probability have been able to pull up within the boundary of the aerodrome. When the aircraft had reached the end of the runway, it had failed to gain normal height and was noticed to veer to the left. However, it straightened out and began to climb in a nose-high attitude, in an obvious effort to avoid trees. The starboard wing then dropped and hit the trunk of a cocoanut tree. The aircraft finally came to rest in a clump of mango trees further on, and fire broke out immediately.

With the exception of the starboard wing and sections of the empennage which had been torn off by the impact with the cocoanut tree, all other components were in the immediate vicinity of the main wreckage at a distance of about 470 feet to the left of and almost parallel to the central line of the runway 19R/01L. Most of the aircraft was destroyed by fire, but the rear section of the fuselage was free from extensive damage.

The condition of the wreckage was such that it cannot be ascertained if fire-fighting equipment on board the aircraft was used.

As a result of the accident, both the engines were torn off from their mounts. The starboard engine was not damaged by fire to a great extent, but the port engine was extensively burnt.

An examination of the propellers indicated that the starboard propeller was in constant-speed range towards the fine pitch position. The port propeller was, however, found to have been fully feathered.

The damage on the leading edge of the starboard wing indicated that the aircraft was in a nose-down attitude at the time of the initial impact with the cocoanut tree. The position of the landing gear in the nacelle showed that it was in the fully retracted position. This was confirmed by the examination of the actuating and compensating cylinders. The position of the flaps in the wing and their actuating jack indicated that they were in the 'up' position. The crew compartment had suffered extreme damage due to the crash and the resultant fire, and it was not possible to find any reliable indications of the position of engine controls and flight controls, nor was it possible to obtain instrument readings. The tab on the rudder was towards the left and the elevator tabs were almost neutral. The pipelines and the connections to the accessory section in the

starboard engine did not indicate any sign of damage having occured prior to the crash and fire. In the case of the port engine, however, no such data could be gathered as the entire accessory section had melted away. Both the port and the starboard engines were removed from the scene of the accident for a detailed examination. All the external damage suffered by the starboard engine was consistent with the type of damage that would be caused by such a crash. The engine was stripped and there were no indications whatsoever of any mechanical failure. The accessories including the injector, magnetos and plugs were also tested. No defect other than what could be attributed to fire or impact was detected.

The port engine was stripped. The front row of cylinders was found to have been damaged extensively by fire and impact. All the cylinder barrels and heads, however, could be accounted for by material recovered from the wreckage in a semi-molten condition, excepting No. 12 cylinder barrel and head which could not be traced in the wreckage or in the surrounding area.

The rear row of cylinders was removed with some difficulty and it was found that the pistons in this bank were in position, although Nos. 3, 5 and 11 had partly melted, while the others had been affected by heat in varying degrees. The blower and rear sections were burned beyond recognition. The rear master rod and its bearing showed no indication of seizure. Traces of oil were detected on the master rod bolts. The articulating rods of the rear cylinders were free on their knuckle pins. The master rod and the articulating rods of the front cylinders were found broken near the knuckle pin ends. The extreme end of the front counter-weight of the crankshaft was damaged. All the front cylinder skirts were spread out by mechanical hammering and the front face of the centre crank-case was also damaged.

The damage in the front row of cylinders, outlined in the preceding paragraph, was obviously caused by the rotation of the crankshaft after mechanical breakdown had taken place and before the aircraft hit the ground. It is clear, therefore, that during the take-off, a serious mechanical breakdown must have taken place internally causing a progressive loss of power. This mechanical breakdown manifested itself in heavy smoke which was witnessed by several persons including the air traffic control officer. It is unlikely that the mechanical failure was the result of oil starvation, as evidence of lubrication was detected during the strip examination.

Probable Cause

a) Delay in feathering after failure of the port engine (due to inexperience of the pilot in emergency procedures), which resulted in loss of height;

b) the subsequent attempt to establish a climb with a nose-high attitude (to get over the obstructions), below the recommended single-engine rate of climb speed, with both gear and flaps up, and

c) the progressive loss of air speed which finally resulted in a stall on a cocoanut tree.

Although there is no doubt that the profuse smoke emanating from the port engine was due to the failure of the engine, it was not possible to determine the primary cause of that failure, and the relevant parts of the engine have been sent to the Director of Inspection (Metallurgical), Tatanagar, in order to have it ascertained.

Recommendations

Check for proficiency in instrument flying and emergency procedures should be made a mandatory requirement for the renewal of the licences of even those pilots-in-command who are engaged in non-scheduled passenger air transport services.

Observations

Some other points which call for further recommendations 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.

a) It was wrong on the part of the police to have allowed the removal of the bales of cloth from the site of the accident before the arrival of the Inspector of Accidents, especially when a warning against it had been given by the Aerodrome Officer.

b) The police should not have been so careless in the watch as to make a theft of some parts of the aircraft possible.

c) All those rules applicable to the scheduled services which are intended for ensuring the safety of the aircraft should be made applicable also to the non-scheduled services.

d) Cock-pit check-lists and emergency check-lists should be available on board every aircraft engaged in public transport, and their proper use should be ensured.

e) In planning the programme for flights, it should be ensured that flying crew are given adequate rest between flights.

f) The traffic personnel in charge of loading an aircraft should possess the requisite knowledge of correct loading, and

g) It should be considered whether the trees in the direction of the runways of Calcutta (Dum Dum) Airport constitute a potential hazard to aircraft operations.

Search and Rescue Action

The profuse black smoke emanating from the aircraft and the failure of the aircraft to gain normal height by the time it reached the end of the runway led the air traffic control officer on duty to sound the crash siren. In the meantime, the fire foreman had also observed the aircraft flying very low and noticed smoke emanating from the port engine. He jumped into the aerodrome crash-tender and rushed out to assist in case anything happened to the aircraft. By that time the crash siren had been sounded. The aircraft crashed immediately thereafter.

Thus the crash siren was sounded before the crash took place and the crash-tender rushed to the rescue before the crash siren was sounded.

The crash-tender reached the spot immediately and commenced fire-fighting action. The aircraft was burning furiously, but within a short time the fire was brought under control. The fire brigade from the city also arrived there and assisted in extinguishing the fire.

It must be observed that the speed and promptitude with which the officers of the Civil Aviation Department took search and rescue action is commendable.

No. 17

New Zealand National Airways Corporation Douglas DC-3, crashed near Paraparaumu, New Zealand, on 22 May 1954. Report of Court of Inquiry, New Zealand

Circumstances

The aircraft, engaged on a scheduled flight from Harewood to Paraparaumu, left Harewood on 22 May 1954 with two crew and twenty six passengers, (including six children and infants). While approaching Paraparaumu and at approximately 500 feet both engines cut out and the aircraft crashed in Kokutuhutu Road at 09.23 hours. The aircraft caught fire and was destroyed. Three children lost their lives.

Investigation and Evidence

The aircraft was flown by the co-pilot seated in the left seat who was carrying out command practice and the captain, who was seated in the right seat, was carrying out the co-pilot's duties.

The flight was a normal one until within a few miles of Paraparaumu. Flight had been maintained at 6,000 feet for most of the journey until, in the Cook Strait area, height was decreased to 1,500 feet due to frontal conditions, and from then on proceeded under Visual Flight Rules. On approaching Paraparaumu, and about ten miles away, height was further decreased to 1,000 feet. From this height and while still six to seven miles from the airport, the aircraft turned in towards the beach in line with Runway 03. Pre-landing drill was carried out, the engine power reduced, and the aircraft descended to 500 feet when both engines cut out simultaneously. The captain grasped the controls and throttles and found that the co-pilot had already anticipated him in trying to open up the engines. He stated that he carried out a quick cockpit check to find if anything had been overlooked in the pre-landing drill. Feeling if the fuel selectors were in position was part of this check. During this time the aircraft had come down to a very low altitude and was about to cross the beach. It had dropped to a very low flying speed and was dangerously near a completely stalled condition. At this point the engines opened up to high power, the port engine immediately, the starboard engine within a matter of seconds, and the aircraft from a stalled condition assumed a climbing attitude. It would then be below the level of the small hillocks and the trees on them at the back of the beach. From this climbing attitude the aircraft quickly rolled to its starboard side until the wings assumed a vertical position. At this point and condition the starboard wing contacted the corner of a house which carried away about 12 feet of wing. The aircraft continued on through the narrow opening between the house and the adjoining house on the south side, tearing off the top of a water tank, breaking through the boundary fence between the properties, and then demolishing about 10 feet of trellis fencing before impacting a substantial macrocarpa tree, which was uprooted. Other fairly large trees about 76 feet beyond on a bank below the trellis were broken off, and it is considered that in collision with these trees the port and starboard propellers, together with part of the front fuselage, were torn away. At this stage, it is also considered that the underside of the nose of the aircraft sustained damage, and it is likely that the top of the cockpit above the pilot positions was also broken, thereby facilitating the departure of the captain and the co-pilot along with the left-hand crew seat when they were forcibly ejected from the aircraft. This seat was found 15 feet in front of the port main plane, but the right-hand seat remained with the wrecked aircraft. The aircraft, following the impact with the trees, commenced a rotating movement through about 215° and, travelling a further 47 feet, brought down low tension power supply lines and a small telephone pole. The aircraft dropped to the ground in a port-main-plane-down attitude so that the initial shock was taken by the port main plane and the port tail plane. After hitting the ground the aircraft slid backwards a matter of 10 feet in an attitude where the cockpit was facing in the general direction from which the aircraft had come, the remainder of the starboard plane lay across the deep depression on the northern side of Khoutuhutu Road, and the port plane across the road at about 25°. It is clear the series of obstructions which the aircraft hit before settling on the road were sufficient to slow it down without completely wrecking it. It is considered this minimized appreciably more general physical injuries to passengers.

It was established that both propellers were delivering power when they became detached from their respective engines following impact with the obstacles.

On settling on the road, a serious fire almost immediately broke out in the area of the starboard wing root. It is considered it developed in two stages. Initial damage was caused to the starboard main petrol tank during the final crash. This damage, occurring when engines are still running and hot exhaust flames are still in existence, would eject a relatively small quantity of fuel which together with a considerable quantity of alcohol de-icer fluid and some hydraulic fluid, would originate an intense fire of short duration. The second stage, involving residues from the first stage, consumed passengers' baggage in the forward freight compartment, destroyed the cockpit structure, and ignited the cabin through the right-hand side of the forward bulkhead near the floor level. Leaking petrol coming from a broken fuel line of the port main tank added fuel to this fire, for a time, at over a gallon a minute. Subsequent examination established that neither of the engines nor any area in their immediate vicinity bore any sign of fire. The port main tank and port auxiliary with the starboard auxiliary, each containing quantities of 100 octane petrol, were neither holed nor consumed in the crash, by fire, or explosion.

The angle at which the wreckage was inclined caused the contents of the main port tank to be concentrated at the end nearest the starboard main tank. This would cover the inside of the walls of the tank nearest the fire and would provide to some degree a cooling and absorbing effect in this area. A similar effect would operate with the remaining intact tanks.

The opinion formed by the Court is that the major damage to the starboard tank, excluding the impact damage already referred to, would be mainly caused by the fact that there was no petrol in the tank. There was nothing to insulate the thin sheet metal of the tank's structure, and provided the fire continued for some time, as this did, no particularly high heat was required to melt the aluminum alloy.

A check was made of the fuel remaining in the aircraft after the fire. The fuel was pumped into 44 gallon drums and the estimated quantities were as follows:

75 gallons from the port main tank;

25 gallons from the port auxiliary tank;

35 gallons from the starboard auxiliary tank.

It was not possible to withdraw all fuel from the tanks due to the angle at which the aircraft came to rest, and also due to the baffle system in the tanks. Its angle of rest, however, was accurately determined, and a later check made to find how much fuel was not removable. In the case of the starboard main tank, which is relevant to this crash, there would remain 11 gallons. The aircraft, during the whole of its flight, would have used approximately 120 gallons of fuel. If each engine had drawn its fuel from separate main tanks, which the pilots assert was the case, this would leave approximately 50 gallons in each tank. There was, however, 70 to 75 gallons estimated as taken from the port main tank. The broken fuel pipe from this tank, found leaking after the crash, showed after subsequent tests, a leakage rate of over a gallon a minute, and it is estimated that this leakage accounted for a total of 18 gallons. This, added to 11 gallons not recoverable from the port main tank, makes a total of 29 gallons to be added to the 75 recovered. It would appear, therefore, that while from the pilot's evidence he has selected throughout the flight the starboard and port main tank respectively to each engine, this could not have been the case, due to the amount of fuel obviously remaining in the port main tank. On the other hand, the amount used from the starboard tank, if both engines were connected to this, would have sustained the aircraft approximately to the point where the engines cut out.

It was shown in evidence that the sight and feel of the selector setting is of the greatest importance, and it is a fundamental responsibility of a pilot to check the proper setting. If the click in the fuel cock is properly engaged there can be no cross-feeding. On the other hand, if the selection lever is sighted into position without the accompanying click, cross-feeding might occur. After full consideration of all relevant factors, however, it was decided that no cross-feeding occurred in this aircraft.

The sequence of events from the point where the engines cut out, the levelling of the aircraft as it crossed the beach, and the picking up of the engines immediately after this point was completely consistent with a situation where during flight both engines were operating from a starboard main tank which became deficient in fuel, the pilot changed the port selector valve to the port main tank, and the engines opened up in the fashion described by both pilots and witnesses Due to the angle of approach of the aircraft on its descent from 1,000 feet the smaller amount of petrol left in the starboard tank would run forward due to the angle of the aircraft and uncover the outlet. If, later, when the aircraft levelled out across the beach the port selector was turned to the port tank, the fuel in the port tank would pick up the port motor immediately, and either then or within seconds the remaining fuel in the bottom of the starboard main tank, due to the changed attitude of the aircraft, would again run into the outlet and the starboard engine would again be fed by fuel, causing it to open up also. This sequence of events is considered to be consistent with the sequence of trouble the aircraft experienced.

There are twenty-five cabin seats each equipped with a safety belt, eleven on the starboard side and fourteen on the port side. Three emergency exit windows having a clear area of 23 inches by 20-1/2 inches when opened are provided, one on the port side alongside seat No. 17, and two on the starboard side alongside seats 19 and 22 respectively. Each of these exits is placarded at eye level with the word "EXIT" and an indicating arrow, the placard being in red. These emergency exits are operated by a clearly indicated handle being turned and the window pushed open. The main cabin door is on the port side at the rear end of the cabin and is operated from both inside and outside by a lever-type handle with a press-button insert. Operation is by pressing the button and turning the handle. This can be done with one hand.

Probable Cause

The conclusions reached by the Court were that:

a) Either throughout the flight or a substantial portion of it both engines were drawing fuel from the starboard main tank.

b) The selector valves or valve were moved after the engines cut out, and the valves, when found and checked later, indicated a final setting of each engine to its respective port and starboard main tank.

c) The total fuel usage recorded for sixty hours of service by the engines of this aircraft prior to this flight establish that the fuel was used normally by each engine from each tank and there was no malfunctioning of the selector equipment.

d) The failure of the engines of this aircraft was due to exhaustion of fuel in the starboard main tank, to which both engines had been selected.

e) Having regard to the position and condition of the aircraft at the time of engine failure the subsequent accident to the aircraft was inevitable.

Recommendations

1. Emergency Exits

a) A clearer method of marking exits was desirable, and consideration should be given to a luminous method of marking the emergency exits which might be incorporated in the procedure of pre-take-off and pre-landing check action.

b) The information about emergency exits in the conventional folder available in DC-3 passenger aircraft seemed to have been put to no use. Not one of the passengers used the auxiliary window exits, though one at least confessed to a clear knowledge of them.

Accordingly, the Court recommended that an addition be made to the duties of a co-pilot to require him to call the attention of all passengers to the emergency exits and how to use them. In addition, he should explain the fastening arrangements of the main cabin entrance door, and also how to use it.

2. Cabin Attendant

It is not a requirement for cabin attendants to be carried on internal routes in New Zealand. While the aircraft are of the existing seating capacity and the flights between stops of such short duration it did not appear necessary to make such a provision.

3. Fire Equipment

It seemed highly desirable that the mobile fire equipment should carry an asbestos suit and/or a smoke helmet. It was considered such articles, if available, would have enabled a fireman to proceed safely into the aircraft to make a final check, or in appropriate circumstances perform rescue work on passengers.

4. Control of Small Children (Particularly before Take-off and Landing)

This was considered a difficult matter, but it was agreed that consideration should be given to the devising of a method of improving the custody and security of smaller children where necessary in the air, whether for rough air conditions, pre-landing, or take-off. It was considered that for larger children the existing belt system is both appropriate and effective.

5. Method of Check

It was recommended that the National Airways Corporation introduce an operational procedure that all pre-flight and in-flight checks carried out by the pilots be by specific verbal challenge and reply.

6. Main Cabin Door

It was recommended that some method be used whereby this door may be opened with less force than is required at present. The principle of the present door appeared satisfactory except for the fact that there was a double action required to open the door, the press button was small and stiff to operate, and the handle was also fairly stiff to turn. If the press button was enlarged in size this would make it easier to operate, and if the turning of the handle in its original form cannot be made easier, an extension of two or three inches in its length might be incorporated to give greater leverage.

No. 18

Compagnie Chérifienne du Pont Aérien DC-3 aircraft, damaged on landing at Beyrouth International Airport, 1 June 1954. Directorate of Civil Aviation, Lebanon Accident Investigation Report

Circumstances

The aircraft, engaged on a non-scheduled flight to Indo-China, carrying freight and two "dead head" passengers, was landing at Beyrouth International Airport on 1 June 1954 on Runway 18. After touchdown, the aircraft travelled normally for approximately 300 or 400 metres when it started to turn left. The swing could not be corrected and the aircraft ran off the runway into soft sand. The port undercarriage collapsed.

Investigation and Evidence

After making a good three-point landing on the runway about 150 metres beyond the threshold, the throttles were closed and the aircraft ran perfectly straight for approximately 300 or 400 metres after which the aircraft started to swing to port over a distance of 65 metres. The captain vainly tried by rudder and brake to straighten the aircraft. However, the swing to port increased even after application of full starboard brake and increased port engine power. The aircraft ran a further 180 metres before leaving the runway, travelling a further 80 metres before coming to a stop. The left landing gear was destroyed, all its components being twisted, the back stay attachment to the structure having snapped at the two outside bolts.

A technical laboratory examination of the broken fitting showed that it was already cracked before the accident. The aircraft which had previously sustained a similar accident, had been overhauled in May 1954. It appeared that during this overhaul, the attachment fitting of the back stay had not been changed although a thorough examination of the part would have revealed the fissures.

Probable Cause

Failure of the port undercarriage back stay attachment fitting, causing the undercarriage to collapse and the aircraft to swing off the runway.

Figure 25

Compagnie Chérifienne du Pont Aérien DC-3 aircraft damaged on landing at Beyrouth International Airport on 1 June 1954.

No. 19

Philippine Air Lines Inc., Douglas C-47 aircraft, damaged on landing at Mandurriao Airport on 3 June 1954. Philippine CAA Accident Investigation Report

Circumstances

The aircraft was engaged on a scheduled flight with 3 crew and 24 passengers from Cebu to Manila via Bacolod and Iloilo. The aircraft took off from Cebu at 3:20 p.m., and landed at Bacolod normally and the take-off from Bacolod was normal. While landing at Iloilo, the aircraft swerved to the right and ran off the runway finally finishing in a ditch. Evacuation of the aircraft was orderly and there were no injuries.

Investigation and Evidence

The first officer, who was on the left seat, flew the aircraft from Cebu, with the captain occuping the right seat. About 10 minutes out from Iloilo, the first officer called for the wind direction and velocity. He was informed that the wind at Iloilo was north variable northeast at 4-7 miles per hour.

The first officer motioned to his captain that he was going to land towards the south and was told that it was up to him. He then proceeded to land towards the south down wind. The aircraft touched in the first third of the runway and was rolling straight with application of brakes when the pilot felt a jarring sensation followed by a sudden swerve of the aircraft to the right. The aircraft was rolling less than 30 miles per hour when the swerve to the right started. It was thought that there was a flat tire, but when the captain looked out he saw that the right tire was intact. After passing throught the shoulder of the runway, the first officer unlocked the tail wheel and applied power on the right engine but the airplane did not straighten out and, instead, the added power only gave it momentum that sent the airplane into a ditch at the edge of the field.

The runway of the Mandurriao Airport is sufficiently wide and has a length of 3, 770 feet which can well accommodate the landing of a C-47 aircraft. The runway at the time of landing was dry.

The landing from the north towards the south executed down wind, although considered proper at times, was not in accordance with good practice.

The first officer, who flew and landed the aircraft, has categorically stated that his landing was normal and that he had plenty of room to the other end of the runway to stop his aircraft. He was on the final stage of his landing roll when all of a sudden, his aircraft swerved to the right in a matter of seconds for no apparent cause at all. He stated he does not believe there was anything wrong with his brakes as both of them were operating normally upon application.

Technical investigation revealed that there were small cracks in the brake drums of the aircraft. However, such cracks had not penetrated into the outer shell and it was considered that these small cracks could not have caused any disturbance in the normal application of the brakes. It was established that there was nothing wrong with the braking system of the aircraft at the time of the accident.

Probable Cause

From the evidence received, the Board could not with reasonable certainty determine the cause or causes that produced the accident. However, any one of the following might have been the probable cause:

a) Pilot error;

b) Faulty brakes; and

c) A strong gust of cross-wind forced the plane to swerve to the right.

No. 20

Philippine Air lines Inc., Hiller Helicopter, crashed 6 n. miles southwest of Mankayan, Mt. Province, Philippines, on 4 June 1954. CAA Accident Investigation Report, Philippines

Circumstances

The aircraft operated as a non-scheduled flight with two crew, originated at Manila at 6:50 a.m., on 4 June 1954 for Mankayan, Mt. Province. After a refueling stop at Rosales, Pangasinan, the aircraft left for Mankayan at 9:15 a.m. There was no further news of the aircraft until the wreckage was reported six nautical miles southwest of Mankayan at 11:15 that evening. Both pilots were killed.

Investigation and Evidence

There were no eye-witnesses to the accident. However, there were five persons who claimed to be near the vicinity at the time of the accident and who claimed to have seen the aircraft flying normally and approaching from a southwest direction before they heard a loud "plack' which most probably could have been the sound produced by the impact of the main rotor blades with the aerial cables strung between two mountains with a length of 3,000 yards. Immediately after hearing this unusual sound, these individuals rushed to the scene of the accident.

At the vicinity of the crash, three aerial cables were found strung between two mountains estimated to be 5,000 to 7,000 feet high. The distance of the cable from station to station was approximately 3,000 yards. Terrain below the cables was from 3,000 to 5,000 feet high. Two cables, each 3 inches in diameter, were strung parallel, 20 feet apart along the same height, while the third cable, 3/4 of an inch in diameter, was strung another 20 feet below the parallel cables. The cables run in a general direction of north to south and were installed on 20 May 1954, that is, two weeks prior to the accident.

The weather at the time of the accident showed that the visibility and ceiling were unlimited for helicopter operations. The wind was almost calm.

Based on cable markings found on the remains of the main rotors and the main rotor fork, it was established that the main rotor blades of the aircraft collided with the aerial cables. On contact with the cables, the aircraft lost its main source of lift, plummeting directly to the ground below the cables in a direct vertical path for a distance of approximately 600 feet. The first point of impact was the trunk of a pine tree, after which the aircraft continued descending to the ground and thence continued rolling downhill coming to rest 200 feet below at the bottom of the ravine.

Probable Cause

The probable cause of the accident was the hitting by the main rotor blades of one of the three cables strung between two mountains causing the aircraft to lose its source of lift, thereby plummeting directly to the ground in an uncontrolled vertical flight path.

Recommendations

To prevent a repetition of a similar accident, it is recommended that a directive be issued to all mining and lumber companies and other companies installing aerial tramway cables to notify and give to the CAA the following data;

1) Location
2) Elevation
3) Height of the cables
4) Indication of the location on the maps.

Furthermore the directive should call their attention to Commonwealth Act No. 448, the pertinent provisions of which provide as follows:

"Section 2 Any radio towers, tents, poles or any tall structures constructed outside the limits of a city or town proper which project to a height of thirty metres or more above the ground shall have obstacle lights in accordance with the rules and regulations to be prepared by the Civil Aeronautics Administration (Bureau of Aeronautics)."

"Section 4 Any person or persons who violate any provisions of this Act shall be punished by a fine of not more than five hundred pesos or imprisonment of not more than six months, or both, in the discretion of the Court."

Their attention should also be called to the rules and regulations on markings issued by the CAA, which are contained in Aero-Bulletin No. 8.

No. 21

Great Lakes Airlines, Inc., Douglas C54-G, emergency landing at Gage, Oklahoma, U.S.A., 15 June 1954. CAB Accident Investigation Report, File No. 0135. Released 3 February 1955

Circumstances

A Douglas C54-G, operated by Great Lakes Airlines, Inc., made an emergency landing off the runway at the Gage Oklahoma Airport, at 0320 on 15 June 1954, because of an uncontrollable fire in the number 3 engine nacelle. There were no injuries to the 82 passengers and crew. The aircraft was destroyed by fire.

Investigation and Evidence

The flight originated at New York, N. Y., with its destination Burbank, California, and with intermediate planned stops at Chicago, Illinois, and Kansas City, Missouri. The segments of the flight to Kansas City were made without incident and the aircraft landed there at 0005, 15 June 1954.

At Kansas City a routine crew change was effected and the aircraft was refuelled. No service was performed on the aircraft at Kansas City other than refuelling. According to company records the take-off weight of the aircraft was 71 143 pounds, which was within the allowable limits and the load was properly distributed with respect to the centre of gravity of the aircraft. Prior to the take-off the captain made a pre-flight inspection and no discrepancies were noted. The flight, normally dispatched, departed Kansas City at 0107 and was cleared IFR (Instrument Flight Rules) to Burbank, California, via Green 4 and Amber 1, to cruise and maintain 4 000 feet. The estimated en-route time was 7 hours and 40 minutes and there was sufficient fuel for a flight of 11 hours and 30 minutes. There were 75 adult passengers, 4 infants and 3 crew on board.

At 0213, when the flight was over Wichita, Kansas, a routine position report was made in which it was estimated that the flight would be over Gage, Oklahoma, at 0307. The crew testified that when the aircraft was in the vicinity of Gage, radio reception was poor due to static caused by local thunderstorms in that area. At approximately 0305, Gage INSAC, (Interstate Airways Communications) advised the flight that Albuquerque ARTC (Air Route Traffic Control) cleared it to climb and maintain 6 000 feet. Accordingly, the flight began to climb. Shortly thereafter the stewardess entered the cockpit and told the pilots that she had seen sparks trailing from No. 3 engine. The captain immediately requested the first officer to look out of his window and see if he could see anything wrong. This was done but nothing unusual was seen. At the same time the captain checked the instruments and found their indications to be normal. The stewardess was then told to return to the cabin and to again advise the captain if and when she observed anything out of the ordinary.

At approximately 0308, when the aircraft was at an altitude of 5 500 feet and in the vicinity of Gage, the zone 2 fire warning light of the No. 3 engine came on. As soon as this was observed the first officer went to the cabin to make a visual check. He returned a few seconds later and reported there was a fire in the No. 3 engine. The captain immediately returned the aircraft to level flight and feathered the No. 3 propeller. The firewall shut-off valve was then pulled, the CO_2 selector set for the No. 3 engine and the first bank of CO_2 bottles was discharged. As this application of carbon dioxide did not appear to put the fire out, the engine's cowl flaps were closed and the second bank of CO_2 bottles was discharged. Following this action the fire was seen to momentarily die down but almost immediately to flare up again.

The first officer called Gage INSAC at approximately 0312 while the captain was performing these duties and advised that the No. 3 engine was on fire and that its propeller had been feathered. The Gage INSAC communicator immediately turned on the airport runway lights for the north-south runway. There were no other radio contacts with the flight.

The captain, unable to extinguish the fire, began a left descending turn toward the airport. During this turn the No. 3 engine fell from the aircraft at which time a complete failure of the electrical system was experienced. The captain testified that throughout the approach he was unable to see the runway lights on the airport and, not being able to use the aircraft's landing lights, he headed in the general direction of the airport beacon. Throughout the latter stages of descent the first officer used a flash light so that he could observe and call out altimeter and airspeed readings. As the aircraft neared the ground the fire illuminated the surface permitting the captain to see the ground and land the aircraft safely. After rolling a considerable distance the right main landing gear collapsed. When the aircraft came to a stop all passengers were quickly evacuated. Fire eventually destroyed the aircraft.

The Gage weather at the time of the accident was: ceiling estimated 12 000 feet, overcast, visibility 15 miles, thunderstorms, wind south-southeast 10 miles per hour. Weather was not a factor in this accident.

The investigation conducted at the scene of the accident disclosed that the aircraft first contacted the ground on a heading of 110° about 900 feet to the left of Runway 4 (040°) and 1 000 feet inside the airport boundary. After rolling approximately 1 100 feet the right main landing gear collapsed because of fire damage and the aircraft then skidded sideways to the right stopping 1 800 feet from the first ground contact point. The captain ordered an immediate evacuation of the aircraft, which was done quickly and in an orderly manner through the main cabin and pilot doors. Evacuation was accomplished in an estimated 1-1/2 minutes without serious injuries to any of the passengers or crew. The intense fire in the No. 3 nacelle area continued to burn, spreading progressively throughout the entire aircraft with the exception of the left wing and empennage.

The INSAC communicator at Gage stated that at the time the aircraft reported to him he did not receive the information that the aircraft's engine was afire but only that a propeller had been feathered. Another flight operating in the range of Gage, however, heard the flight report the engine was also on fire. When the operator learned that fire was existent the flight had already made its emergency landing. The communicator, alone on duty, was unable to leave his position to go outside because of his attention to radio operation. He was also unable to see the airport landing area from his position, therefore, he did not see the aircraft coming toward the airport or see it land. He did not know that the aircraft had landed until the crew entered his office and advised that it was on the field and burning; also that the Gage Fire Department had been notified by the captain. The fire truck arrived approximately 30 minutes later. The equipment consisted of 2 CO_2 bottles and a water tank, operated by volunteer firemen, and was not designed to combat an aircraft fire but for the use of the small community of Gage, Oklahoma.

The No. 3 engine, which fell from the aircraft, was found 11 miles northwest of the airport. It, being the area of the origin of the fire, was given exhaustive examination. The nose case of the engine was demolished by impact and cylinders 8, 9, 10, 11 and 12 were severely damaged by impact and fire. The diffuser section and accessory case were destroyed. Only portions of the accessories normally installed on the rear case were recovered; all had sustained fire damage. Disassembly of the engine indicated that there was no failure or malfunction prior to impact.

The generator for this engine, a Jack and Heintz Model JH 11300, type R-2, serial No. 772, was recovered. It was badly damaged by the intense fire and impact. Disassembly revealed that the inner and outer races of the front bearing were badly galled and distorted. Three accessory case generator mountain studs were recovered. Two were 6-1/2 inches long and were bent about five degrees at the point where they passed through the generator mounting flange. The third stud had failed in tension and bending at approximately the same place where the others bent. Only the inner race of the rear generator bearing was found. It was still attached to the drive shaft and armature support tube. Approximately 1/4 of the circumference of the forward and rear edges of the bearing groove was cut, distorted, and rolled. The generator drive shaft was broken just aft of the clutch assembly. The shear section of the shaft, designed to fail under excessive loads, was intact although bent one degree. The armature and commutator components of the generator were severely scored, distorted, and burned. The score marks on the armature matched similar ones on the coils and interpoles and were rotational in direction

which indicated they were made while the armature was still turning. According to company records, the generator had accumulated 550 flight hours since overhaul. The overhaul included replacement of the front bearing.

Investigation further disclosed that the Douglas C54-G electrical system originally consisted of four 100 ampere generators, one installed on each engine. This system was subsequently modified on the subject aircraft by the carrier in favour of a two 300 ampere generator system, a generator mounted on No. 2 and No. 3 engines. The modification was made in accord ance with a CAA approved Delta-C and S Airline Engineering Order Number 336, dated 29 July 1946. The modification was made to provide a more efficient generator system for the aircraft. In the specific instance of the aircraft in question, the modification was completed and approved 15 November 1953.

Investigation and examination of the wreckage definitely indicated that the failure of a generator bearing was the initial malfunction. This failure resulted in the generation of extreme frictional heat capable of weakening and burning through adjacent fluid lines causing the release of inflammable fluids which were ignited. The fire progressed so rapidly and became so intense that available CO_2 was insufficient to extinguish it.

The loss of all electrical power at the time the engine separated from the aircraft was most probably caused by a ground fault on the power cables during the physical break up of the nacelle installation. Further radio contact with the Gage INSAC and the use of the aircraft's landing lights were prevented by the electrical power loss. The landing was made on the airport off the runways due to the surface type runway lights being obscured by a growth of tall grass. This tall grass was normally mowed 5 feet on either side of the runways and unless an aircraft, on approach, was lined up with a runway the lights would not be visible from a low approach as in this incident. The Gage INSAC communicator testified that he did not hear any mention of fire when the flight contacted him. It is probable that static and interference from other radio receivers prevented him from hearing the complete message. Before further transmission from the aircraft could be made all electrical power was lost, consequently, the Gage Fire Department was not at the airport when the aircraft landed. It is doubtful that the available fire equipment would have been able to extinguish the fire had it been alerted and present at the time of the landing.

The Board commended both the captain and first officer who, under the emergency conditions present, effected a safe landing at night, without aircraft lights and only the airport beacon as guidance. The stewardess is also to be complimented for the prompt and efficient manner in which she supervised the evacuation of all passengers from the burning aircraft without injury to any of them.

Probable Cause

The Board determined that the probable cause of this accident was a bearing failure of the No. 3 engine generator causing extreme frictional heat and the release of inflammable fluid which ignited in flight.

ICAO Ref: AR/358

No. 22

Delta C and S Airlines, DC-3 aircraft, crashed near Atlanta Airport, Georgia, USA, on 15 June 1954. CAB Accident Investigation Report No. 1-0133. Released 4 November 1954

Circumstances

The flight, engaged on a scheduled cargo flight from Atlanta, Georgia, to Chicago, Illinois, with intermediate stops, took off at approximately 1745 with a two-man crew aboard. As the aircraft became airborne, light rain was encountered. When the aircraft had climbed to 200 to 250 feet, power was reduced to 35 inches of manifold pressure. However, the aircraft began to settle and the airspeed was observed to decrease rapidly. Full power was applied and the nose lowered. The airspeed dropped to 60 knots and the aircraft rapidly settled and struck the ground resulting in substantial damage to the aircraft and minor injuries to the crew.

Investigation and Evidence

Before take-off was started the first officer applied brakes and advanced the throttles to 40 inches of manifold pressure. The brakes were then released and a normal take-off was accomplished with power application continued to 45 inches of manifold pressure and 2 500 rpm. As the aircraft became airborne the landing gear was retracted. Light rain was encountered at this time. When the aircraft had climbed to 200 to 250 feet, power was reduced to 35 inches of manifold pressure and a shallow right turn was begun. Before a reduction in rpm was made the aircraft began to settle and the airspeed was observed to decrease rapidly from above 105 to 80 knots. The nose was immediately lowered to level flight, the turn stopped, and full power applied. When this was done, the airspeed returned to about 100 knots and the settling appeared to lessen considerably. The increased airspeed with the attendant better flying characteristics was momentary, however, as the airspeed abruptly dropped to 60 knots and the airplane again began to settle. As the aircraft continued to settle and it became obvious that it was going to strike the ground, the first officer attempted to raise the nose. Upon feeling the aircraft strike the ground, both throttles were closed. The aircraft then skidded to a stop in a wooded area approximately 600 feet northwest of the far end of Runway 21.

Examination of the damaged airframe and control systems did not disclose any evidence of malfunctioning or failure prior to the accident.

The powerplants were examined at the scene and later in the Delta-C and S shops. A portion of the investigation consisted of a review of the maintenance and overhaul records of the powerplants. No irregularities of a nature that would have any bearing on the accident were found. Both engines were completely disassembled and given a detailed inspection and the propellers were inspected; there was no evidence of structural failure or malfunctioning prior to impact.

An elongated high pressure ridge extended from New England southwestward along the Atlantic Coast on the day of the accident. To the west of this ridge including the Atlanta-Chattanooga area there was a southerly flow of warm, moist and unstable air. No fronts or squall lines were in that area but local showers and thunderstorms developed due to the moist, unstable air and daytime heating. These storms became numerous in the afternoon with some in the vicinity of the Atlanta Airport when the subject aircraft took off.

The forecast for the area, which included the route and times involved, indicated that there would be thunderstorms, with ceilings lowering briefly in the storms to 1 000 feet, visibility 2 miles, and the tops of clouds 25 000 to 30 000 feet. The 1722 terminal forecast for Atlanta, which was available to the crew before departure, indicated scattered to broken clouds

at 5 000 feet, ceilings possibly lowering to 800 feet, visibility 10 miles or better and lowering to 1 mile in moderate thunder showers. Investigation revealed that the thunderstorms and showers were localized and would not preclude a flight made in accordance with visual flight rules.

At the time of take-off the surface wind was from the northwest 7 to 10 miles per hour. The wind, officially reported at 1748 only a minute or so after the accident, was from the southwest at 30 miles per hour with gusts up to 64 miles per hour. The control tower where the wind is recorded is located on the north side of the airport. The unexpected nature of the rain shower is evident by the experience of a light plane operator whose place of business is at the northeast corner of the airport. He thought the shower of no consequence and as a result one of his airplanes, not tied down, was turned on its back by the strong wind and another was moved a considerable distance away. Other witnesses testified that when the subject rain shower was approaching the airport, it did not appear to be violent in nature and that it looked to them to be like many other inconsequential summer rain showers. Witnesses near the scene of the accident at the time it occurred testified that it was raining and that the surface wind was strong and gusty from an east or southeasterly direction.

The captain and first officer were both well qualified pilots and each had several thousand hours in DC-3 aircraft. They stated that they had flown in and out of Atlanta for a considerable period of time and that during the summer months rain showers and thunderstorms were common in that area. They also said that on this occasion, when they were preparing for take-off, there was a large thunderstorm some 8 to 10 miles south of the airport and what appeared to be an isolated rain shower near the southeast end of Runway 33. The rain shower seemed like many such showers they had seen before which had little or no turbulence or wind. Their main concern was to avoid the larger storm farther away.

Both crew members said that during the pre-take-off checks all components functioned normally. After take-off there was practically no turbulence. They were unable to explain the loss of airspeed or the settling of the aircraft. In trying to explain the settling they said that it was as if the engines were not producing sufficient power to sustain flight and yet they sounded normal and the instruments indicated a normal power output. They also said that the aircraft nose was never lowered below level position, in an effort to regain airspeed, because of insufficient altitude.

Analysis

It appears from the testimony of the crew and the examination of the aircraft and engines that this was a weather accident. What seemed to the crew and others to be a light rain shower actually contained a downdraft resulting in a localized area of strong, divergent, gusty winds at and near the surface. The aircraft's contact with this wind pattern resulted in its settling to the ground.

A study of all available weather information, although not conclusive, indicates that the large thunderstorm to the south was being maintained by the continual development of new cells. One such cell, some distance ahead of the parent storm, was the subject rain shower. Being a single cell, detached from the main precipitation area, a local heavy rain shower was produced. Within it a downdraft developed which fanned outward in all directions producing strong winds a short distance from the core. This shower was moving from the southeast toward the northwest diagonally across the runway. To further describe this condition the rain shower should be considered as being somewhat circular in shape with winds radiating from its perimeter.

A theory which could explain the action of the aircraft, as described by the pilots, was that on approaching the rain shower the aircraft encountered a strong southwesterly (head) wind. As the aircraft progressed into the core of the storm the headwind abruptly ceased and changed to a tail wind as the aircraft emerged from the opposite side. This sequence of events, occurring in a sufficiently brief period of time, could explain the abrupt speed changes reported by the pilots and the subsequent settling to the ground. The final speed of 60 knots reported by the pilots was 5 knots below the stalling speed of the aircraft considering its load.

Probable Cause

The Board determined that the probable cause of this accident was a rapid loss of airspeed immediately following take-off caused by unexpected, strong gusts or divergent winds accompanying a local rain shower.

ICAO Ref: AR/336

No. 23

American Airlines, Inc., Convair 240 aircraft and a United States Navy Beechcraft SNB aircraft collided near Port Columbus Airport, Ohio, USA, 27 June 1954. CAB Accident Investigation Report No. 1-0144. Released 8 December 1954

Circumstances

The American Airlines flight was a scheduled operation between Memphis, Tennessee and Cleveland, Ohio with Columbus as one of the intermediate stops. The aircraft departed from Dayton, Ohio at 1952 with 3 crew and 32 passengers. While on final approach to Runway 27 at Port Columbus Airport a collision occurred between the American Airlines aircraft and a United States Navy aircraft also on final approach. The US Navy aircraft crashed and burned and the two occupants were killed. The American Airlines aircraft continued to a landing but during the landing roll the damaged nose gear collapsed and the aircraft slid 4 200 feet along the runway on its nose section. None of the passengers or crew were seriously injured. Two small fires which broke out were quickly extinguished.

Investigation and Evidence

At approximately 2007 the American Airlines flight contacted the Columbus tower advising it was about 6 miles west of the Hilliard fan marker (located 12 miles west of the airport). The tower gave landing information and approved a requested right traffic pattern to Runway 27. The flight, at reduced power, began a shallow descent from its cruising altitude of 3 000 feet MSL. Its flight path was slightly north of the fan marker and slightly north of the business district of Columbus at an indicated airspeed of 185 knots. The first officer, who was flying the aircraft from his right seat position, established a downwind leg 1 200 feet above the ground and approximately 2-1/2 miles northwest of the airport. During the downwind leg the aircraft was slowed to approximately 160 knots with 16 degrees of flaps extended. The tower gave the flight a landing sequence of number 2 following a TWA Martin, which was then making a straight-in approach to Runway 27.

In order to establish a normal interval behind the Martin the first officer extended the downwind leg until approximately opposite the Martin. He then began a right descending turn for the approach to the runway. The turn was completed about 850 feet above the ground and about 3-1/2 miles east of the runway threshold. The approach was made in a normal descent and with a continuous reduction of airspeed. The average airspeed for the approach was about 135 knots. When approximately 0.6 miles from the runway and about 300 feet above the ground the crew felt a violent jar and simultaneous yaw of the aircraft to the left. The captain took control, noticing the left engine was stopped. Together with the first officer he realigned the aircraft with the runway and landed.

During the landing roll the Convair nose gear, damaged at impact, collapsed and the aircraft continued approximately 4 200 feet on its nose and main gear before stopping on the runway on a heading of 280 degrees.

The stewardess opened emergency exits of seats 5, 9 and 17, located on the right side of the cabin, and opened the rear service door. The captain released the forward passenger door but because the nose section of the aircraft was resting on the runway the exit could not be used until the first officer evacuated through the right cockpit window and pulled the exit stairway ramp outward from the aircraft, thus permitting this exit to be used for passenger evacuation. The stewardess pulled the emergency rope from its location above the rear service door and dropped it through the opening. Evacuation was then carried out with 16 passengers using the emergency rope, 2 the seat exits and 13 the forward passenger door. The infant was dropped through the rear service door into the arms of a passenger on the ground. The evacuation was

accomplished in an expeditious and orderly fashion with only minor injuries resulting to 10 passengers and the stewardess who received rope burns on their hands while sliding down the emergency rope. The emergency evacuation chute, located on the side of the rear service door, was not utilized.

Two small friction fires, one located in the nose wheel well and one in the forward baggage compartment, were quickly extinguished by ground emergency crews alerted by tower personnel before the aircraft had touched the runway and on the scene immediately.

The afternoon of the same day a Navy SNB, a twin Beech, was dispatched from the Port Columbus Naval Air Station in accordance with Naval training procedures to be flown to Vandalia, Ohio, West Lafayette, Indiana, and return. The flight departed at 1701 under VFR (visual flight rules) flight plan and on return at approximately 2009, when over downtown Columbus, it called the tower for landing information. The tower advised the flight to use Runway 27. Shortly thereafter the SNB requested and was granted permission to use Runway 30 subject to traffic. It was observed by the tower controller to enter the downwind leg of the left traffic pattern for Runway 30 and was later sighted on base leg for that runway about 2 miles southeast of the tower. The SNB was then advised by the tower controller to follow TWA Flight on Runway 27 or make one circle of the field. The SNB turned right, reported it was on downwind for Runway 27. It later reported on base leg for that runway and was then advised to continue its approach. The SNB and Convair were soon thereafter seen about 2 miles east of the airport on final approach to Runway 27, at which time they appeared to the controller to be close to each other but with the SNB apparently to the right, to the rear and below the Convair. The SNB was instructed to make a three sixty or circle the airport. The landing gear of the SNB was seen to retract and it appeared to make a shallow left turn just before the collision.

The investigation and subsequent hearing revealed that at the time of the accident there were three controllers on duty in the tower. The regular controllers reported at 1600 for a normal 8-hour shift. Local control, flight data, and ground control were manned as primary positions and under routine procedure they were rotated about every two hours. The local controller had assumed that position approximately 45 minutes before the accident.

Under procedures for the control of air traffic the local controller was responsible, among other things, for the issuance of clearances and information to pilots of aircraft for the purpose of preventing collision between aircraft in the traffic pattern.

The Port Columbus Airport served the flying operations of the Naval Air Station located on the field, commercial operations, and North American Aviation production test flights, as well as transient and private flying. The tower personnel were therefore required to control many types of aircraft and regularly approved several types of traffic patterns such as overhead, left, right, and straight-in as permitted by Civil Air Regulations. The personnel on duty were well qualified and thoroughly experienced in this situation. During the critical accident period the tower local controller was busy with ground and air traffic; during the period he made 28 transmissions and received about 43 replies from aircraft, all within 8 minutes before the collision.

The tower was located in the southeast corner of the airport and the runways were as shown in fig. 26. Several qualified witnesses stated that the tower was considered marginally adequate. They stated it was originally constructed as a weather observation tower and was not as high as desirable. The windows consisted of approximately 140 small panes of glass with divisions between each. There were eight one-foot wide concrete support columns equally spaced around the octagon-shaped structure and one large solid entrance door in the south wall. A radar installation covered with a canvas tent had been added to the tower several months before the accident. These conditions required the local controller, whose position faced north, to stand and move continuously while observing airport traffic. At the time of the accident a new tower was being constructed.

Investigation revealed that transmissions to the American flight were conducted on 121.1 Mc and to the Navy flight on 142.74 Mc, both VHF (Very High Frequency). Jet traffic taxiing used 257.8 Mc, UHF (Ultra High Frequency). The local controller transmitted simultaneously on these frequencies thereby enabling the subject crews to hear all transmissions from the tower. The American and SNB crews, however, transmitted on different frequencies to the tower and were thus unable to hear one another. This communications arrangement required the local controller to advise taxiing aircraft using UHF because the ground controller, usually performing this duty, did not have the necessary UHF transmitter available at his position. A recording device was incorporated at the local control position so that all transmissions made were recorded. The recording was one way, from tower to aircraft.

During the public hearing the tower local controller stated that after having approved the Navy request to use Runway 30 for landing, subject to traffic, he first sighted that aircraft when it reported entering downwind leg for Runway 30. The controller observed the aircraft flying southeast about 1 500 feet above the ground approximately 2 miles south of the tower, a normal downwind position. The controller answered the report as follows: "Seven seven three, continue approach for runway three zero. Traffic is on final approach and also on right-hand downwind for runway two seven. I'll get you in on three zero as soon as practical." This transmission was then acknowledged. At this time the controller stated that the American Convair was northwest of the airport entering right-hand downwind for Runway 27 and that the TWA Flight was about 5 miles due east making a straight-in approach for Runway 27 for which it had been previously cleared. This flight followed a DC-3, then well ahead on final approach for the same runway.

The American Convair crew testified that they were entering downwind or had turned onto downwind when TWA reported over the outer marker (6.2 miles east of the threshold of Runway 27). The American crew sighted TWA immediately thereafter just inside the outer marker.

The next pertinent transmission from the tower was to American when the flight was on its downwind leg for its right-hand approach pattern. The tower instructed the flight as follows: "Five seventy-two will be number two to land on Runway 27, traffic is a TWA Martin about three out ... "

The Navy flight then reported that it was on base leg for Runway 30 and the controller testified that this call, to his best recollection, included a report that the aircraft landing gear was down. He stated that at this time he saw the aircraft flying northeast about 2 miles southeast of the tower, a normal base run for Runway 30. This Navy report was answered by the controller as follows: "Navy seven seven three, I have you in sight. I suggest that you follow the TWA Martin or make one circle of the field. I have traffic taxiing on Runway 30 and two on downwind for that runway." The controller testified that he meant on downwind for Runway 27. The Navy flight acknowledged his transmission advising it was on downwind for Runway 27. The controller continued, "Continue your approach for Runway 27, seven seven three." In explanation of these instructions the controller said it was no longer feasible to continue the SNB to Runway 30 because that runway and Runway 27 intersect and spacing of these aircraft was insufficient to enable either to clear the intersection before the other landed as required by controlling procedures. He also said there seemed to be adequate spacing for the Navy flight to land after the TWA aircraft before the American Convair because it was still eastbound north of the tower on its right pattern downwind leg. The controller stated he expected and planned for the SNB to follow TWA from its observed position rather than turn right and establish a downwind leg for Runway 27. He observed the SNB, about 800 feet above the ground, turn right about 30 degrees for the downwind leg. The controller did not advise the American flight of his instructions given the SNB to follow TWA because he stated it was then necessary to turn, view the TWA flight about 1-1/2 miles east of the threshold, and clear it to land.

The SNB flight then reported that it was on base leg for Runway 27. The controller was unable to locate it visually although other tower personnel helped at his request. He advised the aircraft to continue its approach. The controller stated that at this time he was unable to revise the existing sequence because the SNB was not in sight. Shortly after the SNB's base leg report the Convair was observed to make a right turn to the south for its base leg. At this time

the controller stated he did not offer advisory information or instructions to either aircraft although he knew, by radio report, the SNB was on base leg and the Convair, by visual observation, was on base leg. He stated that he did not revise the existing sequence at this time, again because the Navy aircraft was not in sight and he felt that by altering either aircraft's position with instructions might create a hazard. At this time the controller did not ask the SNB for its position or ask the Convair if it had the SNB in sight but instead issued taxi instructions to aircraft on the airport.

The controller next observed the SNB on a final approach about 250 feet above the ground, and approximately 2 miles east of Runway 27. At the same time it appeared to him to be below, to the right, and behind the Convair. He made the following transmission, "Navy seven seven three, I have two aircraft on the final approach, one is American Convair high and you appear to be slightly behind and to the right, is that correct?" The witness stated the Navy crew transmitted, "Roger (or affirmative) I have him in sight, shall I go around?" The controller stated the SNB appeared to be sufficiently behind the Convair that collision did not seem imminent. He then cleared the American flight to land and saw the SNB's landing gear retract. The witness believed 20 to 25 seconds passed between the circling instruction and the collision which followed.

The investigation included an exhaustive search for eyewitnesses to the accident. Many saw both aircraft during final approach and saw them collide The witnesses observed the accident from four locations. Two boys, composing the first group, were located about 2 miles east of the runway threshold. They saw both aircraft during the last portion of their turns onto the final approach. They stated the Navy plane was ahead of and lower than the airliner. Those of the second group were at positions varying between 3/4 and 1-3/4 miles directly east of the runway threshold. Several of this group saw the aircraft pass nearly overhead on the final approach and at that time stated the SNB was below the Convair and slightly to its right. These witnesses were in conflict as to which aircraft was ahead; however, the majority stated the SNB was ahead. The third group was located near the east end of Runway 27. This group was mainly composed of air crews who were in aircraft waiting to taxi or take off and who saw the aircraft which collided coming nearly directly toward them. When these two aircraft were first seen these observers stated that the Convair was 200 to 300 feet above the SNB and that the SNB appeared to be to the right and behind. Several of these witnesses saw the landing gear of both aircraft extended. They then saw the SNB gear retract, the aircraft climb slightly and begin a left turn with the collision following immediately thereafter. The last group of witnesses was located in or near the tower. They were in accord that when first sighted the Navy aircraft was lower than normal for its position approximately 2 miles east of the runway on approach, and was 300 to 400 feet below the Convair. The SNB flew nearly straight and level while the Convair descended normally. These persons stated that the SNB appeared well behind and slightly to the right of the American flight. Several witnesses from all positions observed that the Convair's position and anti-collision (a red flashing light located on top of the vertical stabilizer) lights were on; however, none noticed whether or not the SNB's position lights were on.

In the course of investigation three incandescent position lamps were recovered from the SNB, one from the fuselage position and two from the tail light unit. These lamps were sent to the National Bureau of Standards to determine if the lights were on or off at the time of the collision All filaments were broken when examined. The fuselage lamp, a 2-filament type, indicated that at least one of the filaments failed with voltage applied to it, however, it could not be determined whether failure occurred during the accident or at some other time prior to the accident. The other filament and the filaments from the tail lamps presented no conclusive evidence regarding whether or not these lights were on or off at the time of failure. As a result it could not be determined from the laboratory examination whether or not the SNB lights were on or off at the time of the in-flight collision.

The TWA crew stated that at the time the SNB was instructed to make a three sixty or go around they had just landed and saw the collision immediately after clearing the runway.

The American crew stated that while in the Port Columbus traffic pattern they were aware that an SNB was being controlled as airport traffic. They believed it was going to land on Runway 30 and did not know it had been changed to Runway 27. The crew testified that they were fully cognizant of their visual responsibilities under VFR conditions. Although they stated that they maintained a careful lookout, the SNB was never seen.

The official weather report at the time of the accident was: scattered clouds at 20 000 feet, visibility 15 miles, wind north at 6 mph. Official sunset was 2005, 10 minutes before the accident.

The accident occurred during twilight when the sun was below the horizon and a rapid transition was taking place between daylight and darkness. Witnesses varied in their estimates of the existing visibility from 3 to 15 miles All pilots who were flying at this time agreed that vertical visibility was decreasing with approaching darkness and that it was becoming increasingly difficult to see objects from above. The existing light above the horizon permitted aircraft flying above it to be easily seen in all directions but somewhat easier in the western quadrant.

The most significant of the many in-flight impact markings was a series of six propeller cuts in the left wing of the SNB. The structural integrity of the wing was so affected by the cuts to cause the left wing outer panel to separate in flight. This portion of the wing was found east of the main wreckage area. The cuts progressed forward from the left wing trailing edge across the left engine nacelle centerline. Study of the individual cuts disclosed that in each case the cut was made inboard to outboard with downward directional indications at the start of the cuts and upward directional indications at the outboard end. Further study revealed the cuts were made by the left Convair propeller while it was passing forward over the wing. The pattern of the propeller damage indicated that the aircraft closed both laterally and vertically; both closures were at small acute angles.

The Convair nose gear drag link was fractured by forces mainly in a rearward direction. Although not conclusive, evidence indicated the nose gear tire struck the SNB in the area of the right wing center section and right nacelle. Gash marks and impressions on the sidewall and rim of the left Convair nose wheel appeared to have been inflicted by a glancing blow of the SNB right propeller, a tip of which was found east of the wreckage area.

Although the SNB reported no difficulty careful examination was made to ascertain if any structural or mechanical failure occurred prior to the collision. From the damaged components there was no evidence found to indicate that structural or mechanical failure occurred prior to impact. The American crew substantiated that the Convair was operating normally prior to impact.

The investigation included a careful study of the flight paths and position reports of the four principal aircraft which were flying in the Port Columbus traffic pattern during the accident period. These factors together with witness testimony were incorporated into an engineering study, fig. 26 and indicate the probable flight paths of the aircraft which collided as well as the TWA Martin and the Douglas DC-3 which preceded them. Considering all available data and the probable flight paths a study was made to determine so far as possible the visual limits of each crew member afforded by the cockpit structure of the Convair and SNB. The limits were applied to each crew member throughout the last two minutes of the flight path in consideration of the aircraft attitudes. It was learned that the SNB first entered the cockpit angular limits of vision for the Convair captain when the Convair was on the base leg. At this time the SNB was approximately 40 degrees to the right of the Convair's longitudinal axis and was about 3 miles away. The SNB remained within the visual limits of the captain's position until both aircraft were on the final approach and the Convair was approximately 1/2 mile behind the Navy aircraft. The total time that the SNB was in the visual limits of the captain's position was approximately 1-1/4 minutes. At the start of this period the SNB blended into the horizon and then continued below it for the remaining time.

The SNB first entered the visual limits afforded from the seat of the Convair first officer shortly after he had begun the turn from the downwind leg onto the base leg. When the turn was begun the SNB was approximately 90 degrees to the right of the Convair's longitudinal axis and was about 3-3/4 miles away. The SNB remained within visual limits of the first officer's position except when momentarily obstructed by two vertical windshield formers until the Convair was approximately 1/2 mile behind the SNB on the final approach. The total time during which the SNB was within the visual limits was about 1-1/2 minutes. At the beginning of this period the SNB blended with the horizon and then continued below it for the remaining time.

The Convair first entered the visual limits afforded by the SNB's cockpit structure from the pilot's position immediately after the SNB started to turn from the downwind leg onto the base leg for Runway 27. At this time the Convair was approximately 3 miles away at an angle of approximately 20 degrees to the left of the SNB's longitudinal axis. The Convair remained within the pilot's visual limits above the horizon approximately 15 seconds except when momentarily obstructed by a windshield former. At the end of this time the Convair was about 30 degrees to the right and was approximately 2 miles away and the SNB had progressed to and was on the base leg.

The Convair first entered the visual limits afforded from the observer's seat immediately prior to the start of the turn onto the base leg. At this time the Convair was approximately 70 degrees to the left and was about 3-3/4 miles away. The Convair remained above the horizon from this position and was within the visual limits of the observer approximately 1/2 minute except when obstructed by two windshield formers and upper cockpit structure for about 15 seconds. At the end of this time the Convair was approximately 30 degrees to the right and was about 2 miles away. The SNB was then on the base leg at which time the opportunity to see the Convair terminated as the Convair was obscured by the SNB cockpit structure and was behind the crew's visual limits. The 15 second period during which the Convair was within the cockpit visual limits occurred nearly simultaneously for both crew members.

Three days after the accident, at approximately the same time of day as the accident, several pre-planned flight tests were conducted. These tests were made using DC-4 and an SNB flying in general proximity, with the SNB varying its position, according to prearrangement, relative to the DC-4. The DC-4 is somewhat larger than the Convair 240. Qualified ground observers positioned in the tower and on the airport watched, noting their impressions of the aircraft positions relative to one another while they were on the final approach. Although the SNB changed its position, including being ahead of the DC-4, the observers concurred that the difference in sizes of the aircraft gave the illusion that the smaller was always behind. As the aircraft flew closer toward the runway the smaller aircraft appeared to also overtake the larger.

Analysis

It was recognized that the engineering study of all the available evidence, "The Probable Flight Paths," contains certain variables These variables which include altitudes, distances and airspeeds were carefully considered and the flight paths as shown are the most accurate commensurate with the physical evidence and testimony.

In determining whether or not the crews of the two aircraft should have observed the other, several other factors had to be considered. The first was the angular limits of cockpit vision. This factor is the opportunity to see an object afforded by the physical cockpit structure only. A second factor was visual range. This is the maximum distance at which an object can be seen. This distance is influenced by variable factors including contrast of the object and background, its angular size and shape, the degree of lighting and atmospheric visibility. Finally, the physiological factors affecting the ability of a human being to see an object had to be considered. It can be expected a person may best see an object when it is within the angular limits of his sensitive or focal field of vision, 1 to 2 degrees wide.

An object will also be seen through the peripheral portion of the eye if there is sufficient movement or contrast, otherwise it is necessary to search for the object.

As shown by investigation the SNB crew's opportunity to observe the Convair existed while the SNB was turning from the downwind leg onto the base leg and for a portion of the base leg. This opportunity existed nearly simultaneously for the crew members and lasted approximately 15 seconds during which the Convair was high on the windshield for both the pilot and the observer. During this time, however, had the SNB crew looked in the direction of the Convair, then on the base leg, they should have seen both the Convair's anti-collision light and the aircraft itself which were clearly visible above the horizon under the existing light conditions. During the last part of base leg the opportunity to see the Convair terminated and it was not possible again to see it.

From only the standpoint of cockpit angular limits of vision the Convair crew was first in position to see the Navy aircraft when the Convair was turning onto the base leg. In respect to the captain the SNB remained within visual limits from this time until the Convair was on final approach and was approximately 1/2 mile behind the SNB. The Navy aircraft remained within the visual limits of the first officer's position throughout this period and until the Convair was approximately 1/2 mile behind the SNB on the final approach. While the SNB turned onto the base leg and then onto the final approach it descended until it was approximately 250 feet above the ground and when first seen by witnesses, on final approach, it was estimated to be as low as 200 feet. While the American flight was on its base leg, considering the factors affecting visual range (threshold visibility factor, the dark terrestrial background, the fading light condition, the size and the view presented by the SNB) it is considered improbable that the SNB, which was below the horizon could have been seen from above by the Convair crew. When on the final approach had the Convair crew scanned ahead within the cockpit visual limits, the target presented by the SNB was within their focal field of vision. Although during the first part of the Convair final approach the SNB was low, against a poor background, and with little relative motion or contrast to attract the attention of the Convair crew, it was also within visual range and could have been seen by the Convair crew under the existing conditions.

During the period when the flights which collided were being flown in the Port Columbus traffic pattern all transmissions made from the tower to them were "simulcast" (transmitted simultaneously on all frequencies then in use), This arrangement enabled the crews of both aircraft to hear all transmissions from the tower. Although many extraneous transmissions were made and only the transmissions from the tower could be heard, it is difficult to understand why the conflicting approach sequence, both to approach behind TWA Flight 377, was not heard by either crew. The conflicting approach clearances were pertinent to each flight and directly affected their traffic sequences. Had both crews maintained radio vigilance the conflicting instructions could have been detected and an immediate clarification requested. It is also difficult to understand why the American crew did not request from the tower the position of the SNB when they were searching for that aircraft and were unable to locate it.

It will be recalled that when the SNB reported on the base leg for Runway 30, the tower controller observed the flight approximately 2 miles southeast of the tower. The controller, realizing that he could no longer continue the Navy approach to Runway 30, advised it to follow the TWA flight on Runway 27 or circle the field. This traffic control clearance was given without advising American of it or altering its sequence which was also number 2 to land after the TWA flight. The controller knew that the SNB was going to continue to Runway 27 and not circle. This situation continued to exist unaltered until both aircraft were seen on final approach. Both aircraft were advised to take the same sequence from opposite sides of the traffic pattern onto a common approach path to the same runway.

The controller stated that the SNB did not follow his instructions as he had planned. Instead of following TWA from its observed position it turned right, establishing a downwind leg for Runway 27. In planning its spacing behind TWA it is believed the SNB crew necessarily took the action it did to establish a correct interval.

The spacing which existed behind TWA on final approach was normal. If the SNB's action were not in accord with the controller's planning there was sufficient opportunity to issue other instructions to the SNB and to clarify the sequence between it and the American aircraft. A non-conflicting sequence should either have been given initially or the conflicting sequence revised immediately after the controller turned, viewed the TWA flight and cleared it to land.

The SNB then reported that it was on base leg for Runway 27 but the tower personnel were unable to see it. At this time the controller advised it to continue its approach without asking its position or advising it that it was not in sight. No advisory information was given when the Convair was seen shortly thereafter to turn onto its base leg although the controller knew the Convair was being flown into an area where another aircraft was known, by radio report, to be operating. The controller stated he could not give instructions because the SNB was not in sight and any instructions might result in conflict between the two aircraft. The Board believes that advisory information should have been given alerting the crews to the situation. The Board also believes that when simultaneous left and right traffic patterns are being used the controller should assume greater responsibility for effecting traffic separation.

When both aircraft were sighted on the final approach the controller thought that the SNB was behind, to the right, and below the Convair. Considering reasonable speeds for the two aircraft, the physical evidence presented by the Convair propeller cuts in the SNB wing and testimony of some eyewitnesses positioned nearly below the aircraft, the Convair was then above and behind the SNB. The controller's error in judgment of relative distance was a normal reaction shared by the other tower controllers, pilots who were awaiting take-off or taxi clearances, and confirmed by the experimental flight tests made after the accident under similar conditions. The error was caused by the difference in size of the aircraft when viewed at a considerable distance from nearly head-on angles under the fading daylight conditions. It is reasonable to assume that had the controller known the true position of the aircraft he would have given other instructions which might have prevented the collision.

When the controller advised the SNB of its apparent position relative to the American flight the Navy flight reported that it had "him" in sight. Although the controller's information was clear, under the circumstances, it is believed the SNB crew misinterpreted it and responded with reference to the TWA Martin which, according to its crew, was just landing or on its landing roll when the information was given. In all probability the SNB crew mistakenly identified the Martin as the Convair; both are twin-engined aircraft and look very much alike.

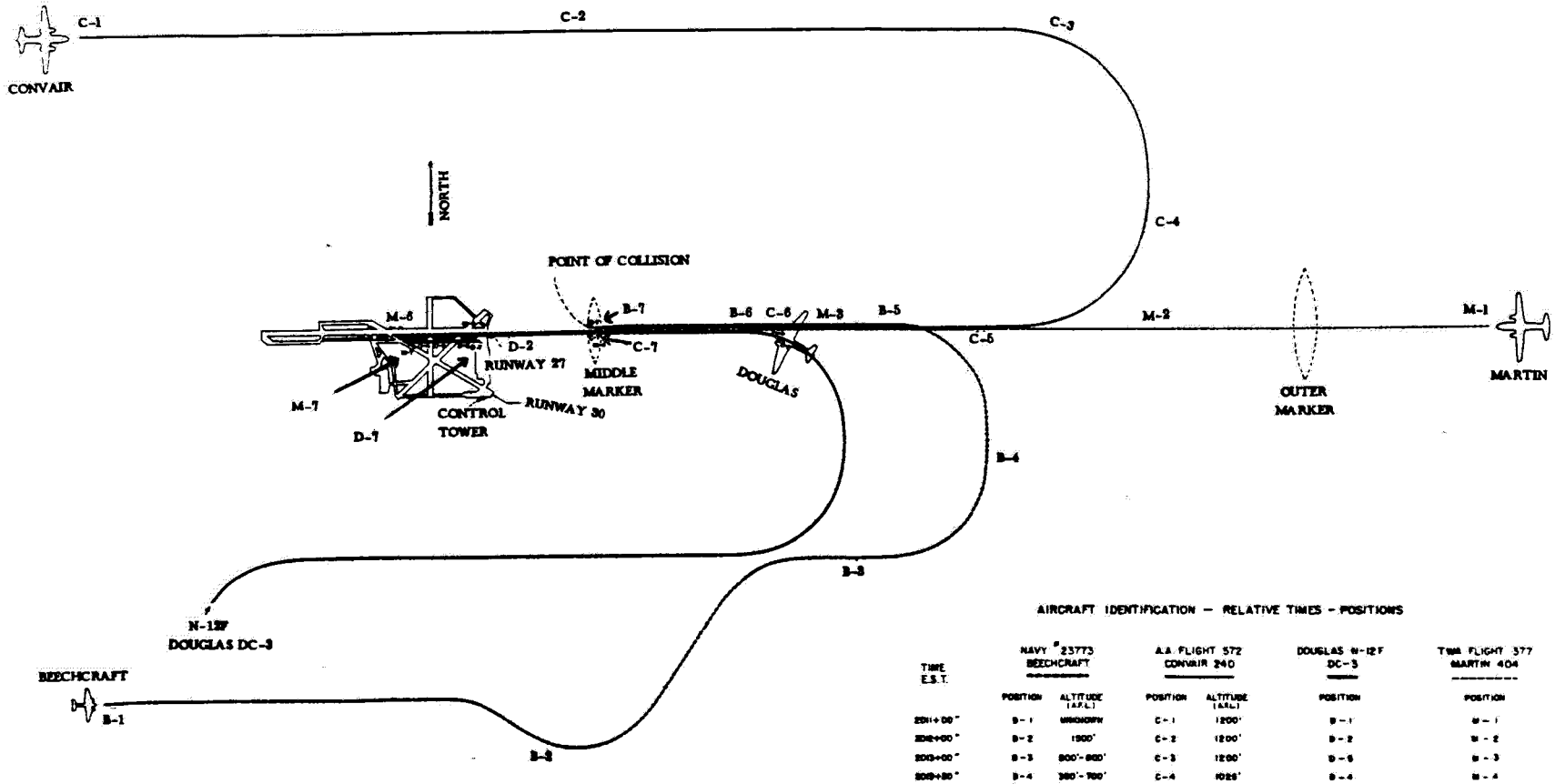
Probable Cause

The Board determined that the probable cause of this accident was a traffic control situation created by the tower local controller which he allowed to continue without taking the necessary corrective action.

A contributing factor was the failure of both crews to detect this situation by visual and/or aural vigilance.

PROBABLE FLIGHT PATHS OF AIRCRAFT IN RELATION TO PORT COLUMBUS AIRPORT

JUNE 27, 1954



AIRCRAFT IDENTIFICATION — RELATIVE TIMES - POSITIONS

TIME E.S.T.	NAVY #23773 BEECHCRAFT		A.A. FLIGHT 572 CONVAIR 240		DOUGLAS N-12F DC-3	TWA FLIGHT 377 MARTIN 404
	POSITION	ALTITUDE (A.S.L.)	POSITION	ALTITUDE (A.S.L.)	POSITION	POSITION
2011:00"	B-1	UNKNOWN	C-1	1200'	D-1	M-1
2012:00"	B-2	1900'	C-2	1200'	D-2	M-2
2013:00"	B-3	800'-900'	C-3	1200'	D-3	M-3
2013:30"	B-4	300'-700'	C-4	1025'	D-4	M-4
2014:00"	B-5	250'-300'	C-5	880'	D-5	M-5
2014:30"	B-6	250'-300'	C-6	570'	D-6	M-6
2015:00"	B-7	250'-300'	C-7	250'-300'	D-7	M-7

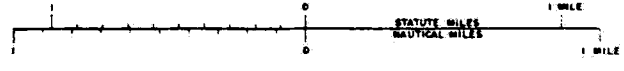


Figure 26

No 24

Philippine Air Lines Douglas C-47 aircraft, damaged during take-off at Lahug Airport, Cebu City, Philippines, on 30 June 1954. CAA Accident Investigation Report, Philippines

Circumstances

The aircraft, engaged on a cargo run with two crew, captain, and first officer, took off at Lahug Airport at 10.42 p.m. on 30 June 1954. During the take-off run the left tire burst and the aircraft swerved off the runway coming to rest on its nose. There were no injuries.

Investigation and Evidence

The first officer was in the left seat flying the aircraft, while the captain was in the right seat. After going through the pre-take-off check, the first officer applied full power to 48" Hg manifold for take-off. During the roll, at approximately 50-60 miles per hour, and after the aircraft had travelled for about 450 feet, the crew heard a loud explosion underneath the left side of the aircraft which started swerving to the left. The captain immediately took the controls and the first officer cut the power. The airplane continued to swerve to the left, so the captain stepped on the right brakes at the same time applying power on the left engine. As the swerving continued despite the efforts of the captain to counteract it, he cut the power from the left engine. The left wheel dug into a soft spot on the left side of the runway, causing the aircraft to come to a sudden stop on its nose.

Investigation revealed that the tire which burst had been recapped once.

There was no defect of the runway except that on the left shoulder of the strip there was a soft spot.

Probable Cause

It was established that the accident was caused by a burst tire during the take-off run.

Recommendations

The Board made the following recommendations:

1. A study and analysis be made with PAL of the serviceability period of recapped tires.

2. PAL be directed to effectuate a periodic and systematic inspection procedure on their C-47 tires.

ICAO Ref: AR/341

No 25

Compagnie Nationale Air France, Lockheed Constellation aircraft, crashed in a field at Preston City, Connecticut, USA, on 3 August 1954. CAB Accident Investigation Report No. F101-54. Released 18 April 1955

Circumstances

The flight which originated at Orly Field, Paris, on 2 August 1954, with 8 crew and 29 passengers, arrived over Scotland Intersection (15 statute miles southwest of New York International Airport) at 1230, 3 August 1954, and received clearance for an ILS approach. The approach was discontinued due to unexpected heavy turbulence, heavy rain and low ceiling. The flight asked for, and was given, a clearance to Boston but thirty three minutes after being cleared to Boston the aircraft declared an emergency and landed with the gear retracted in a field at Preston City, Connecticut. The passengers and crew evacuated the aircraft before fire consumed the cockpit and cabin. The pilot, flight engineer and one passenger were seriously injured.

Investigation and Evidence

The flight departed Paris at 2024 on 2 August 1954 and arrived Shannon at 2247. Fuel tanks were filled and the pilots were briefed on weather for the non-stop flight to New York. The flight departed Shannon at 0003 the next morning (3 August), estimating 11 hours 49 minutes en route, with fuel for nearly 14 hours. The grossweight at take-off, 126 100 pounds, was less than the maximum allowable 133 000, and the load was correctly distributed relative to the centre of gravity of the aircraft.

The Atlantic crossing was uneventful. Routine position reports were made en route and the flight periodically received weather reports for points along the route and at the destination. Stronger headwinds than had been anticipated were encountered near the North American continent, resulting in lower ground speed and somewhat higher fuel consumption per mile. The flight had approximately 600 gallons of fuel left at 1230 when it reported over Scotland Intersection (15 statute miles southwest of New York International Airport) and received clearance for an ILS approach. It was then 38 minutes behind its original flight plan estimate made at Shannon and had approximately 100 gallons less fuel than anticipated.

During the approach, which was being monitored by New York International Airport radar, the flight encountered unexpected heavy turbulence, heavy rain, and a low ceiling, and the captain discontinued the approach at 1237 (0737 EST) when near his minimum prescribed altitude of 200 feet. The heavy turbulence made control of the aircraft difficult and when the missed approach was made, the captain found himself left of the localizer and below the glide path. The tower, which was immediately advised of the missed approach, told the flight to turn right to 130 degrees (the missed approach course), proceed to Scotland Intersection, and climb to 2 500 feet.

Investigation concerning details of the radio contacts with the flight after it arrived in the New York area revealed that while on the missed approach the co-pilot (who was handling all radio contacts for the captain) requested Philadelphia weather and was told a moment later by the captain to obtain clearance to Boston. The captain later testified that his decision not to make a second approach to New York International Airport was predicated on his impression that the weather they encountered on the first approach was general over the New York area.

Before Philadelphia weather could be given the flight, the co-pilot requested Boston weather and shortly thereafter clearance to Boston. The flight was then directed to maintain 2 500 feet to the Idlewild range station and stand by for further clearance, whereupon the co-pilot advised that they were "very short of gas", and repeated his request for clearance

to Boston. Boston weather was then given; the flight acknowledged this and again requested clearance. Approach Control advised that they could not issue the entire clearance at that time because of other traffic and again told the flight to proceed to Idlewild range.

About one minute from the range station, the flight again requested Boston clearance. Shortly thereafter Approach Control cleared them to proceed to Mitchel range station, cross Idlewild range station at 2 500 feet, and climb to 3 500 feet. The flight then requested an airport nearer than Boston and asked if anything on Long Island was available. Approach Control asked if they were in difficulty or declaring an emergency and the co-pilot replied "Negative, negative. Not yet". Approach control then advised that they were obtaining the weather at MacArthur Airport, Long Island.

At this time, owing principally to congestion on approach control frequency, the flight was requested to change to emergency frequency - 121.5 mc. - and contact New York International Airport radar. The co-pilot complied and repeated to New York International Airport radar his request for clearance to Boston. The radar operator told him they had a clearance to Boston but understood the flight had previously requested something closer and asked if they wished to go to Boston or to an airport on Long Island. The co-pilot replied "OK, that is what we wish. We'd like to go to Boston, and if an airport with a runway is open, we'll land there."

Control of the flight was passed to New York Air Route Traffic Control at 1246, with a switch to ARTC frequency - 120.7 mc. About one minute before Mitchel, the flight advised ARTC, "We divert to Boston, we are requesting a clearance." ARTC then cleared the flight to Boston 3 000 feet, via Mitchel, airways Green 5 and Green 2, and gave them MacArthur Weather. The flight reported over Mitchel range station at 1250; while over that point the flight engineer advised the captain that there was sufficient fuel for one more hour of flight. The flight was cleared off ARTC frequency at 1253.

The co-pilot stated that immediately upon being cleared from ARTC frequency he switched to ARINC (Aeronautical Radio, Inc.) frequency but was asked to stand by as the station was temporarily busy with other traffic. After standing by about five minutes he switched back to ARTC but was unable to establish communications. He then again attempted to contact ARINC but was unable to do so. About 1301 ARINC forwarded a message from ARTC to the flight to contact ARTC immediately. The co-pilot acknowledged; however, his subsequent attempts to contact either ARTC or ARINC were unsuccessful.

No other stations were contacted for the next 20 minutes. At 1322 the flight contacted Providence Tower/INSAC, declared an emergency, and requested Providence Airport weather conditions. Providence weather, which was marginal, was furnished and the flight was cleared for an approach. However, at 1329 the flight advised that they were not landing at Providence. The pilots later stated that they did not have a Providence approach plate. Several of the VHF contacts with Providence were handled through relay by a United Air Lines flight which was at a higher altitude than the flight. After discontinuing contact with Providence, the flight returned to and descended through a break in the overcast near Preston City, Connecticut.

When the captain decided to make an emergency landing, he gave instructions to carry out prescribed company emergency procedures. On the flight deck the flight engineer cut off ventilation, turned off the generators, feathered the propellers on final approach on command of the captain, and closed the mixture controls and fire-wall cut-off valves.

Cabin attendants, advised that an emergency landing would be made, told the passengers and checked to ensure that all had their safety belts fastened. One of the stewards removed the covers from emergency exits, told passengers how to pull the release and tore the window curtains off so they could not interfere with release of the exit or evacuation. The co-pilot, navigator, and second flight engineer went to the cabin shortly before landing and assumed their emergency stations. When the aircraft stopped, several emergency exits and the main cabin door were immediately opened.

The aircraft initially brushed through the tops of some trees and contacted the ground 1 159 feet beyond them. The landing gear was kept up and flaps had been extended to the "approach" position. The aircraft bounced twice as it skidded across the wet, grassy field, and a small ravine. It stopped when it struck two trees and a wooden garage, demolishing the garage and an automobile. The nose section struck one tree, and the fuselage broke on a diagonal line just to the rear of the navigator's station. The aircraft came to rest 1 153 feet from first contact with the ground. The outer section of the right wing broke off when it struck the other tree. No. 3 nacelle tore away as did both engines on the left side. Fire after impact consumed a major portion of the aircraft. The prompt arrival of local Civil Defense personnel, volunteer fire departments, and ambulances (in several cases almost at the time of landing) expedited rescue activities.

Investigation revealed that the dispatching, planning, and conduct of the flight to New York, including keeping of the records, met Air France standards, practices, and procedures. Fuel records and their application to progress of the flight were complete and accurate. The back of each passenger seat contained a pamphlet on emergency instructions printed in both French and English. The pamphlet contained illustrations showing precautions to take in case of emergency landing and instructions for evacuation of the aircraft.

The French Government is a member of and one of the signatories to agreements developed by the International Civil Aviation Organization regarding suggested standards for air carrier operations. Air France abides by ICAO standards agreed to by the French Government. In addition to abiding by these standards, Air France operates in accordance with regulations and standards established by the French Government. It is these latter rules that regulate the company's overall operations. French regulations state that aircraft of French registry operating in a foreign state must comply with the regulations of that state except on those instances where the French regulations are more stringent. Part 44 of the U.S. Civil Air Regulations governs foreign scheduled air carriers operating in the United States or its territories.

Based on records kept by the flight engineers, a recapitulation of the actual fuel consumption was made. This study showed that the 600 gallons of fuel over Scotland Intersection was sufficient for the aircraft to have reached Boston with 100 gallons of usable fuel remaining on arrival, or enough for approximately 17 minutes of flight. Bridgeport, Hartford, and several New York metropolitan airports would have fallen within a reasonable radius of action for the flight to have reached any of these points with a comfortable fuel reserve. Boston would have been beyond safe range for consideration as an alternate as a minimum of 720 gallons over New York would have been necessary to leave a comfortable fuel reserve upon arriving at Boston. However, the pilots testified that they did not plan to return to Boston, but planned to land at some available airport en route.

The New York dispatch office of Air France had been advised that the flight would have 700 gallons upon arrival and was not later told by the flight that a lesser amount was anticipated. The dispatcher, who was on duty until 1200, testified that as the flight came from Boston, he had chosen La Guardia as the alternate to which it could be diverted if a landing at New York International Airport could not be made. The relief dispatcher, on duty when the missed approach was made, knew of the La Guardia choice and when it became evident that the flight intended to divert toward Boston, attempted to get a message through suggesting that the flight go to Bridgeport or Hartford.

The first attempt to convey this to the flight was at approximately 1242, five minutes after the missed approach, when the dispatcher called New York International Airport Tower and requested that the pilot be advised Hartford was available. This message was immediately relayed to the New York International Airport radar, but they had discontinued contact with the flight and passed control on to ARTC. The dispatcher then called ARTC at 1255, since he thought the flight was still on ARTC frequency, asking that the flight be contacted and told that if they could not reach Boston to land at either Bridgeport or Hartford; however, the flight had been cleared off ARTC frequency only two minutes earlier. The ARTC controller who spoke to the dispatcher was not the one handling the flight and so did not know that the flight was no longer

on ARTC frequency. He did pass the message on to the appropriate controller and ARTC immediately contacted ARINC and La Guardia INSAC asking that the flight immediately contact ARTC. Neither station was able to contact the flight although all available frequencies were tried. At about 1301, ARINC established VHF communication with the flight and requested them to contact New York ARTC; the co-pilot acknowledged and advised that he was changing frequency. This contact was terminated at 1302.

ARTC controllers testified that they heard no further communications from the flight after it was cleared off ARTC frequency at 1253, nor did their records reflect any further contacts. Similarly, ARINC radio operators stated that they had no contacts with the flight after 1302.

After making the missed approach, the flight was routed as expeditiously as possible back to Scotland Intersection, Idlewild range station, and Mitchel range station by Approach Control. The missed approach was made at 1237, the initial request for clearance to Boston was directed to Approach Control at about 1240, and the clearance was issued by ARTC at 1249, about one minute before the flight reported over Mitchel range station. The approach controller testified that since no emergency was declared (although the flight was asked if it wished to declare one) there was no cause to believe that an emergency existed and the flight was handled like any other missing an approach and requesting diversion to another airport. He also stated that considering other traffic at the time and that the request for diversion was a routine one, such routine was necessary in light of this other traffic. Investigation on the time element and the routing disclosed that the aircraft was not held at any point after the missed approach and the clearance to Boston was issued expeditiously.

The flight reported over Mitchel range station at 1250, was over St. James about 1257 and over Salem Intersection about 1318. St. James is 43 miles from Scotland Intersection, Salem 99 miles. At 1302, the flight was approximately 56 miles from Scotland Intersection. Assuming no intervening physical obstructions, VHF reception at 3 000 feet altitude would normally be effective for 80 statute miles, since such transmissions are line-of-sight. All stations which had contact with or attempted to contact the flight are in the immediate New York area. Near Providence the flight had difficulty maintaining contact with the tower, although well within VHF reception distance. These contacts were aided through relay by a United Air Lines' flight which was holding at the Providence outer marker at a higher altitude. United's reception was, therefore, not affected by any of the obstructions that apparently interfered with communications between the flight and the Providence Tower.

The Air France dispatch office in New York monitors communications with flights through receivers in the office but must rely on relays by ARINC or CAA communications facilities to transmit messages. The Communications Act of 1934, as amended, Section 303L, authorizes the Federal Communications Commission to issue licenses for radio stations only to U.S. citizens; thus, Air France, as a foreign carrier, cannot operate a radio station and communicate directly with its flights within the United States.

It was ascertained that all CAA radio facilities in the New York-Boston area functioned normally during the pertinent period.

Air France assigns two pilots to trans-Atlantic flights, and bunks are provided so that they may rest during the flight. During the 14 hours and 42 minutes in flight between Orly Field and the time of the emergency landing, the captain and co-pilot relieved one another for bunk rests of approximately five hours each and the first flight engineer took a rest period of three hours and 50 minutes. These rest periods were taken while crossing the Atlantic. The captain and co-pilot both had a rest period in excess of 48 hours before going on duty in Paris.

Both pilots had been given English language schooling under a company training program. In addition to furnishing formal language training, Air France has a policy that pilots must demonstrate proficiency in English before assignment to trans-Atlantic flights. This is accomplished through assignment over certain European routes, for a minimum period of three months, during which time radio communications are all in English. Check pilots assure that pilots

understand and speak English sufficiently well to obviate possible language difficulties. Pilots must further demonstrate that they are conversant with U.S. control procedures, phraseology, and regulations. Both the pilots of the flight and the controllers with whom they talked stated that no language difficulties were encountered. This was also reflected in the two-way recording of contacts with the flight in the New York area.

Investigation showed that the pilots, before departure from Paris and Shannon, were properly briefed on en-route weather conditions. Weather over the route was substantially as forecast. The larger headwind component experienced was within the accuracy of forecast winds over the trans-Atlantic route.

During the early morning of 3 August a front extended east-northeast from Tennessee into the Atlantic at about Cape May, New Jersey, with an occluded wave in Virginia and a small low centre in West Virginia at the extremity of the occlusion. This system was moving eastward and during the forenoon a new low centre formed at the apex of the wave, then located in Delaware. The warm frontal surface to the northeast of the wave which overlay New York and New England was being overrun by a flow of warm, moist, unstable air from the southwest. This resulted in a high overcast in New York State and southern New England which lowered as the occluded low moved eastward, followed by rain and occasional moderate to heavy showers. The southwesterly winds aloft strengthened in New York State and the New England area as the wave moved eastward.

The flight began receiving weather information from Canadian stations, as well as TAFOTS (Terminal Airway Forecasts), when in the vicinity of Goose Bay. This information was first obtained from Gander radio and later through the regular half-hourly weather broadcasts of Station WSY in New York.

Terminal forecasts for La Guardia and New York International Airport, issued at 0400 for the period 1100-1400 were: ceiling 2,000, broken clouds, visibility 5 miles, variable to 3 miles, fog, occasional light rain showers. The terminal forecasts for these two airports for the period 1000-1600 (issued at 1000) were: scattered clouds at 800 feet, ceiling 1 200 feet, overcast, visibility 3 miles, light rain, fog, wind east-northeast 12; ceiling occasionally becoming 700 feet, overcast, visibility 1 mile, moderate rain and fog.

The reported weather from New York International Airport showed deterioration of ceiling from 3 000 feet at 0823 to 900 feet at 1222, and visibility dropped from 5 miles to 2 miles with light to moderate rain and fog. Weather at La Guardia was similar, except for occasional heavy rain being reported. Up to 1200, ceiling at Boston remained 7 000 feet or better, with light rain showers.

In the vicinity of Boston when en route to New York, the flight entered the overcast during descent from 18 000 feet, and intermittent instrument conditions prevailed to New York. By that time general light rain was occurring in southern New Jersey, eastward through southern New York and into Connecticut. Moderate to heavy local showers also developed within the general rain area in the New York area and these were moving from southwest to northeast. During the ILS approach to New York International Airport, the flight encountered one of these local storms. The flight, therefore, had considerably different weather during the ILS approach - ceiling about 200 feet, heavy turbulence, heavy rain, and visibility about one-half mile.

The flight encountered considerably worse conditions than the Weather Bureau was reporting, and worse than terminal forecasts indicated. Tower personnel watching the PAR (Precision Approach Radar) scope noted that the flight entered an area of heavy precipitation, and, therefore, was lost on the scope for a short time. The crew of the flight did not see the ground during the approach until near their 200-foot minimum altitude.

When the missed approach was made at New York conditions were deteriorating between 1228 and 1328 as follows: Bridgeport 1 000 feet and 2 miles to 600 feet and 2 miles; Hartford, 1 300 feet and 2 miles to 1 200 feet and 1-1/2 miles; Providence 6 000 feet and 5 miles to 700 feet and 1 mile. Boston was also deteriorating but did not go below 7 000 feet and 6 miles up to 1500. Between New York International Airport and the point of emergency landing at Preston City, overcast existed with variable ceilings; this ranged from very near the surface to about 1 000 feet, accompanied by moderate turbulence and light to possibly heavy rain showers.

During interviews with the captain and co-pilot, investigators inquired of them whether they considered landing at MacArthur after receiving the weather information for that airport. They replied, in effect, that the MacArthur weather was useful as an indication of weather at one of the Long Island airports but that they did not give active consideration to landing there.

The forecasts given to the pilots in briefing at Paris and Shannon were reasonably accurate, taking into account the elapsed time for the flight and the fact that it is normal that revisions to weather data become necessary upon reaching the North American continent.

Development of the second low centre on the apex of the wave east of the original centre resulted in a more rapid northward movement of the warm front toward New York and the New England Coast. Consequent lowering of the frontal surface over the New York area caused the cool air to become shallow in that area. Coincident with this development of the new low centre, southwesterly winds aloft increased in velocity and heavy convective showers developed in the upper unstable airmass sooner than anticipated by the forecasters.

The forecast for lowering ceilings, to as low as 700 feet in the New York area, is known to have been optimistic; however, reporting stations with measuring equipment were not reporting ceilings much lower than 700 feet. Consequently, the forecaster had no reason to believe that the forecasts for ceilings were inaccurate. Light to moderate rain was forecast, with thunderstorm activity starting after 1600, and moderate to heavy turbulence forecast in connection with the thunderstorm activity. No pilot reports of turbulence were received by the forecasters in time for a revised forecast to be issued.

On the other hand, heavy rain showers were being reported in the New York area as early as 1024. While not accompanied by thunder, they did indicate vigorous instability aloft in which turbulence and/or thunderstorms were likely. It would appear that this should have alerted the forecasters to the need of amending their forecast to indicate the earlier beginning of heavy turbulence.

It was one of these local convective buildups embedded in the general overcast that caused heavy local storms such as the one encountered during the flight's ILS approach to New York International Airport. Due to the fact that the cool air became shallow at the surface, the heavy turbulence produced in the storm penetrated to the surface. As these storms were local and moving from the southwest at about 35 miles per hour, they quickly passed a given point.

Flights which landed before and after the Air France aircraft were able to complete their approaches and land, although they did encounter heavier rain and turbulence than expected. The flight encountered a vigorous local storm at the most critical time (in the ILS approach), while these other flights apparently did not. Under these conditions, the decision to make a missed approach was evidence of sound judgment.

Weather information possessed by the pilots before the ILS approach gave them no cause to believe that it would be other than a routine approach. However, the unexpected storm with its low ceiling, heavy turbulence, and heavy rain undoubtedly caused the pilot to believe that another approach at New York International Airport or another airport in the vicinity would not be feasible and he made his decision to obtain clearance to Boston with the intention of landing at one of the airports en route. However, it would appear that the captain should have sought information from New York International Airport Tower as to the feasibility of making a second approach; i.e., attempting to learn if the storm he encountered was an isolated one or whether

it was representative of weather conditions over the area. Had he done so, he would in all probability have learned from New York International Airport radar that the storm was a local condition and a second approach could be made within a few minutes.

On the way down, from Boston to New York, there were numerous breaks in the overcast, and the pilots testified that they had expected to find the same condition going back toward Boston. Movement of the warm front by the time the flight diverted toward Boston resulted in an almost solid overcast below flight level which precluded the crew's sighting any available airports.

The Air France dispatch office at New York International Airport had current information on airports to which the flight might have been diverted and could have been of assistance while the flight was in the New York area. However, the flight did not request such assistance, and the several requests for clearance to Boston gave both ARTC and Air France dispatch the impression that the captain had selected Boston as his alternate. (It was later ascertained through the pilots' testimony that their intention was to land at any suitable intermediate airport.) The Air France dispatcher had analyzed the information available in his office and had selected Bridgeport or Hartford as alternates within range of the remaining fuel supply. He recognized that the range was too great for diversion all the way to Boston and later attempted to get a message through suggesting the two closer airports. Had ARTC given ARINC the dispatcher's message verbatim, the flight would have known of his suggestion. Of course, it would not have been mandatory that the captain follow the suggestion had he known of it since final decision on any action rested with him. Shortly after the 1301 contact with ARINC the flight had progressed so far from New York that it was evidently out of range for VHF communications with New York stations.

After the flight left the New York area it could have but did not contact CAA communications stations other than Providence for information on weather at airports between New York and Boston. While these stations could have given the flight current weather reports only for the various stations, such reports might have been helpful to the captain.

Although the Board recognized that deteriorating weather at both the destination and along the route back toward Boston created an unexpected situation with which the captain had to cope, it would seem that the exercise of a higher order of judgment would have resulted in a landing on one of the airports within range of his fuel supply. Had he been checking fuel consumption more closely he should have realized shortly after the missed approach that the amount of fuel remaining made it desirable to select an alternate rather close to New York or consider a second approach to New York International Airport. It will be recalled that the flight engineer advised the captain over Mitchel range station that there was only one hour of usable fuel remaining. In view of this information, all thought of continuing toward Boston for any considerable distance should have been dismissed since it should then have been apparent to the captain that his effective radius of action was less than he had anticipated. Subtracting a suitable reserve from the one hour of usable fuel indicates that an airport close to Mitchel should have been selected with the least possible delay.

The marginal weather at Providence, plus the fact that they did not have an approach plate and were also having difficulty in communicating with Providence Tower, decided the captain against trying to land there. When he made his decision to attempt an emergency landing he thought they had only 15 minutes of fuel, therefore not enough to reach Boston. The break in the overcast permitted descent and a contact approach while there was still fuel enough to manoeuvre and select an area in which to land. As the captain stated later, this was more desirable than continuing with the possibility of having to land at a place not of his own choosing. He showed considerable skill in landing in such a small area and good judgment in taking actions to reduce the possibility of fire.

Air France had on file with the CAA International Region several airports which could be selected for landing in the event a flight chose not to land at New York International Airport. Although some of these airports were beyond reasonable range in this instance, considering

the amount of fuel available, the flight could have proceeded to one of three or four airports in the approved group had the captain inquired about them, selected one, and requested clearance. It appears that the captain had not selected a possible alternate before making the missed approach, nor did he later make such selection or call upon his dispatch organization for assistance. Furthermore, had he declared an emergency shortly after the missed approach, instead of waiting until he was in the Providence area, assistance would have been rendered which would have aided the flight in diverting to a suitable airport with satisfactory weather conditions, well within its fuel range.

Probable Cause

The Board determined that the probable cause of this accident was inadequate inflight planning, in that the captain did not make a firm selection of a suitable airport within range of the fuel remaining at the time of the missed approach, necessitating an off-airport landing.

ICAO Ref: AR/340

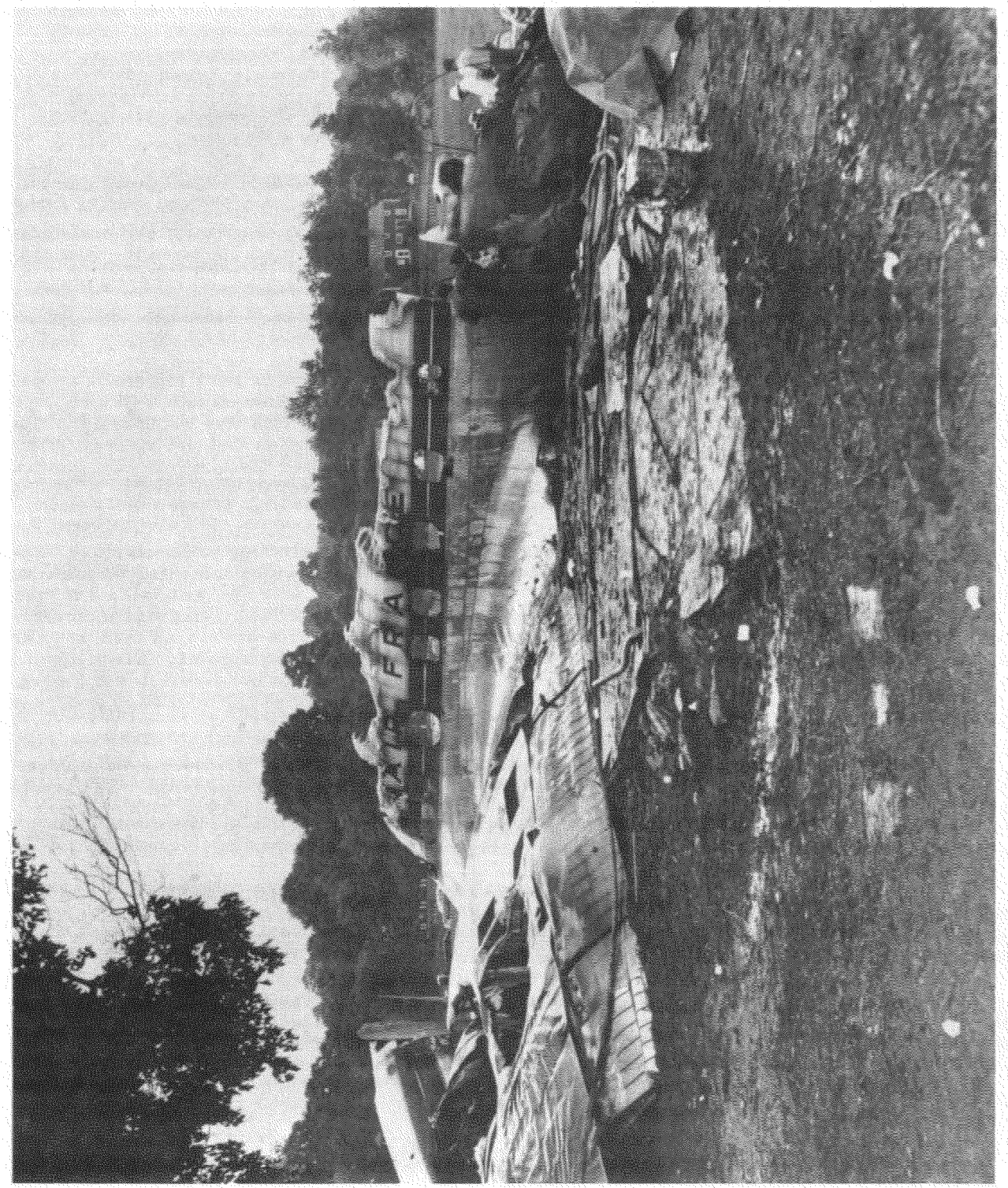


Figure 27

No 26

De Havilland DH-104 Dove, damaged on landing at Kupang Airport, Indonesia, on 3 August 1954. Republic of Indonesia Ministry of Transport and Communications Accident Investigation Report 111/54.

Circumstances

The aircraft was on a scheduled international flight from Dili Portuguese Timor, to Kupang, Indonesia with 2 crew. There were no passengers. The flight was uneventful and proceeded normally up to a landing at Kupang Airport. This landing was carried out when the undercarriage of the aircraft was not in the lowered position. The aircraft suffered substantial damage but there were no injuries.

Investigation and Evidence

When the aircraft was first seen by the tower operator it was on base leg and it appeared that the landing gear was not down. Because there was no radio communication (the radio equipment was, and had been for a year, unserviceable) the tower operator was using a signal lamp and signal pistol. When the aircraft was on long final and it was seen that the aircraft's landing gear was still in the retracted position the tower operator signalled the aircraft with the red signal lamp and fired a red pyrotechnic signal. However, the aircraft continued to a landing on the runway with its undercarriage retracted.

The captain reported that after starting the approach and selecting undercarriage "down" the indicator lights in the cockpit and the visual indicators on the wings indicated that the undercarriage remained in the retracted position. The undercarriage selector was tried a number of times and the emergency bottle was used with no result. As the fuel indicators indicated only 7 gallons of fuel in each wing tank the captain decided to make a wheels-up landing on the runway. The captain reported that he did not see any ground warning signals. After leaving the aircraft the crew shortly afterwards returned to the aircraft. When the aircraft was raised for removal from the runway the undercarriage lowered under its own weight as lifting proceeded and locked down.

A thorough examination revealed no damage, signs of jamming, or defects whatsoever on the undercarriage units and their respective retraction and locking mechanisms. The landing gear was properly locked in the extended position, and the main landing gear locking lever rollers were in the proper position, i.e. pressed against the inboard ends of the lower link radius rod slots.

The undercarriage fairings and doors were completely free from scratches or any other damage, except for the nose gear rearmost door. This door was distorted and bent, and the skin wrinkled; no dents or scratches could be detected, however. Subsequently, it was learned that this door was damaged during jacking up of the aircraft after the landing.

Tests, selected from checks prescribed in the Engineers Manual of the Manufacturers of the aircraft, were conducted after the aircraft had been put onto jacks and after the pneumatic system storage bottles and the undercarriage emergency air bottle had been pressurized to the required amount through the respective ground charging connections.

The tests and checks, carried out, consisted of:

- checks for leakage and on pressure drop in the normal and emergency pneumatic systems under several conditions;
- functioning tests of the pneumatic system pressure regulating units;
- checks on adjustment of undercarriage position indication switches;

- checks on clearance of the landing gear units in the retracted position;
- checks on adjustment and functioning of the landing gear locking mechanism for both retracted and extended position;
- check on functioning of the undercarriage mechanical position indicators;
- check of the undercarriage retraction and extension times;
- functioning tests of the undercarriage safety lock and throttle warning light;
- functioning tests of the undercarriage emergency lowering system.

During these tests the undercarriage was retracted and extended by means of the normal pneumatic system seven times, and four times extended by means of the undercarriage emergency lowering system; no malfunctioning whatsoever could be detected.

It also appeared that all system pressure drops, clearances, times and adjustments were well within the limits prescribed by the manufacturer of the aircraft, and that the functioning of separate undercarriage actuating -, locking -, and position indicating units were entirely satisfactory. No leakage was detected.

The only defect was the unserviceability of the RH main gear position indicating lights.

Photographs taken about 20 minutes after the landing, confirm that, as stated by witnesses, the undercarriage then was in a partly lowered position, however, no marks were detected on the runway which could have been caused by the undercarriage being in a lowered position. Also, nó dents and scratches could be detected on the main landing gear units and on the undercarriage doors and fairings, which indicated that the undercarriage could only have assumed the partly lowered position after the aircraft came to a stop.

Conclusions

The inquiry in considering that

- the aircraft executed a normal circuit, without making special manoeuvres, giving distress signals or attracting attention by other means;
- the fuel quantity left, even when assumed to be as low as reported, positively allowed for efforts to be continued to lower the undercarriage;
- if a wheels-up landing had to be executed, more suitable terrain could have been selected, e.g., runway shoulders instead of the hardened runway surface;
- the statements differ as to what happened immediately after the landing. It was agreed, however, that both crew members had re-entered the cockpit then, and that some time after landing the undercarriage was in a partly lowered position;
- the undercarriage assumed the partly lowered position only after the aircraft came to a stop;
- when the aircraft was jacked up, the undercarriage came down gradually as lifting proceeded and after that locked automatically in the extended position;
- no defect whatsoever could be detected, which could possibly have presented the undercarriage from being lowered, concluded that actuation of the undercarriage to the extended position prior to this landing was omitted, and that after the landing related evidence was destroyed.

Operational disposition of aircraft and crew:

Normally the aircraft was not airworthy, as no Certificate of Airworthiness had been issued for it by the State of Registry. There was no flight manual carried on board of the aircraft.

The aircraft was not suitably equipped for this flight, as its radio equipment was known to be unserviceable.

Although no Certificate of Safety or similar document had been issued for this flight, and no definite data could be obtained as to the maintenance carried out on the aircraft after the last periodic check on 27 July 1954, there were no other indications that the aircraft was not serviceable.

No definite indication could be obtained whether, when the aircraft took off for this flight, the undercarriage emergency lowering air-bottle was pressurized to the required amount.

The aircraft weight and loading, although not recorded in any flight document, were within the prescribed limits.

The crew members held valid licences.

No clear picture could be obtained as to knowledge, skill, and experience of the crew members; their experience with this particular aircraft type seemed to be limited.

Recommendations

With reference to the circumstance that the radio equipment of the aircraft was defective and was known to be unserviceable for considerable preceding periods, it is recommended that the internationally accepted regulations with respect to required aeroplane radio equipment be strictly enforced.

ICAO Ref: AR/379

No 27

Aerovías Nacionales de Colombia (Avianca), Constellation aircraft crashed 9 kilometres west of Lajes Airport, Azores, 9 August 1954. DGCA Portugal Accident Report

Circumstances

The aircraft, engaged on a scheduled trans-Atlantic service, had landed at Lajes Airport, Azores, at 0008 hours on 9 August 1954, having been diverted from Santa Maria where the weather conditions were below minimum. Three minutes after taking off from runway 34 at Lajes Airport at approximately 0240 hours, the aircraft collided with the ground west of the airport at an elevation of approximately 620 metres, immediately after the pilot had informed the control tower he was northeast of the airport. All 9 crew and 21 passengers perished.

Investigation and Evidence

The wreckage was found near the Monte do Boi, in the vicinity of Caldeira de Agualva, 9 000 metres west-south-west of Lajes Airport at an elevation of 620 metres at the crest of a slope of approximately 20%.

The chart at fig. 29 shows the scene of the crash and a horizontal projection of the track assumed to have been flown by the aircraft. The photograph at fig. 28 shows the scene of the accident, part of the wreckage being just distinguishable and the remainder scattered beyond the crest of the mountain. Not only did the marks on the ground indicate a violent impact, but all the evidence led to the belief that the pilot did not see the obstacle in his path.

In view of the nature of the terrain, it was difficult to believe that the aircraft could have come down at this point without first hitting some other high ground. It was, therefore, possible to plot its presumed track, prior to the crash, by drawing a line over the only possible point lower than the crash scene. It was thus determined that the aircraft flew on a heading of approximately 205° (magnetic) at an altitude lower than the elevation of the point where it eventually crashed.

On the basis of the position and condition of the wreckage, the following conclusions were reached:

1 - that the aircraft was descending on a heading of approximately 205° (magnetic);
2 - that the landing gear and flaps were retracted at the time of the crash;
3 - that the accident could not be attributed to any mechanical defect.

The regular aerodrome for commercial flights to the Azores is Santa Maria. The aircraft did not use this airport, however, as the weather conditions there were below the minima laid down by the airline for landings of its Constellation aircraft. These minima were:

Landing: Ceiling 500 feet, visibility 1-1/2 miles.

The aircraft landed normally at Lajes Airport at 0008 hours on 9 August 1954, after making a GCA approach.

According to the statement made by the briefing officer on duty at Lajes, the pilot-in-command and the navigator called at the Navigation Briefing Office at 0115 hours GMT on 9 August 1954. They requested information for preparation of a flight plan for Bermuda. The necessary explanations were provided and, when the flight plan was completed, the navigator asked what was the procedure to follow to reach the point known as "Ponto Sul". It was pointed out to him that if he flew directly to Bermuda without passing by "Ponto Sul", he would have

to fly over the mountains, the highest point of which is the Monte do Pico, rising approximately 7 615 feet above sea level. The normal procedure to be followed to reach "Ponto Sul" was explained to him and shown on his charts: When taking off from runway 34, turn right out of the traffic zone; when taking off from runway 16, climb directly towards "Ponto Sul" after passing over Praia de Vitoria. After receiving this information, the crew members called at the Meteorological Office.

The normal procedure referred to, for take-offs from runway 34, is as follows: "Following take-off, turn right, climb till 2 500 feet on heading 160° and proceed to "Ponto Sul"." This procedure was included in the first stage of the flight plan.

Communications with the tower were not recorded as the Lajes recording equipment normally works on a frequency of 126.18 Mc/s, the frequency normally used by military aircraft, whereas civil aircraft contact the tower on 118.1 Mc/s and approach control on 119.1 Mc/s. The two control officers on duty in the tower reported the communications between the tower and the aircraft to have been as follows:

> The aircraft called the tower on 118.1 and requested instructions for take-off and the following instructions were given "Runway in use 34; wind 330° magnetic, 20 Kt, altimeter 30.24 (observed at 01.56 Z); cleared to south taxiway for engine run up".
>
> This clearance was acknowledged and repeated. The aircraft then took position for take-off and reported ready for take-off.

The tower then gave the following instructions: "After take-off turn right and climb till 2 500 feet on heading 160°, then proceed to "Ponto Sul".

The aircraft took off in a normal manner towards the Northeast. The tower reported time off as 02.37 Z and instructed the aircraft to "turn right".

Shortly afterwards, the aircraft not having turned to the right, the controller asked the pilot to report his position. The pilot replied that he was northeast of the aerodrome.

After looking in this direction and still not seeing the aircraft, the controller asked the pilot whether he was flying on an approach heading or was still outbound. He received no answer.

The crew of a PAA flight which landed at Lajes at 0311 hours on the day of the accident, reported, that on approaching GP range at 9 000 feet, they heard Lajes Tower clearing the Avianca aircraft to take-off and climb to 1 600 feet. They also stated that they were about to break in on the communication as they considered the assigned altitude to be very low, but did not do so as their attention was diverted by communication difficulties.

If, in fact, this crew heard the tower instructing the aircraft to climb to 1 600 feet, without mentioning a right turn it is unfortunate that their attention should have been diverted by anything whatsoever and that they were thus unable to warn the Avianca aircraft of the imminent danger.

From inquiries made in order to clarify this point, it was learned that the controllers at Lajes Tower, in giving instructions, express altitudes simply by reading out the number, whereas for headings they pronounce each digit of the number separately. It is possible that the PAA pilot misheard 160° for 1 600' owing to the communication difficulties referred to.

In fact, according to the record of departures on the day of the accident, all of which were controlled by the same controllers, five other aircraft took off before the Avianca aircraft and all followed the normal take-off procedure. It is, therefore, considered unlikely that the sixth aircraft should have been given completely different instructions.

Probable Cause

The probable initial cause of the accident was the failure of the pilot to carry out the normal climb-out procedure following take-off from runway 34 on a flight to Bermuda and his having made a turn to the left instead of to the right, thus flying into the mountains instead of turning out to sea.

The possibility of the aircraft having been forced to make a left turn may be disregarded since, from examination of the wreckage, it appears that no mechanical failure occurred.

The procedure to be followed had been duly explained to the crew both at the briefing and in the instructions which were certainly given by the tower. It is pointed out, moreover, that the chart of Lajes in the route manual supplied to the crew clearly shows that all turns must be made towards the Northeast.

The question of a right turn following take-off appears to have been deemed a secondary matter by the crew members who called at the briefing office. They simply established that they had to proceed directly to Ponto Sul in order to avoid a collision with the mountains, the highest point of which reached 7 615 feet.

From the heading presumed to have been flown by the aircraft before it crashed, it is quite apparent that the pilot did, in fact, intend to proceed to Ponto Sul. He appears not to have realized, however, that to do so he had to turn eastward towards the sea and not to the west over the land.

It is necessary to mention that, according to his company, this was the first time that the captain had landed at Lajes and that at Santa Maria, where he had already landed several times, the take-off procedure for flights towards the Northwest in the direction of Bermuda also involves a turn towards the sea. The turn at Santa Maria is made to the left, however, as the airport is located on the extreme west of the island.

The point known as "Ponto Sul" is shown on the reproduced 1:1 000 000 chart at Fig. 30. Examination of this chart will immediately explain the reason for the adoption in the Azores control area of the standard procedure whereby aircraft are required to fly over this point before proceeding towards Bermuda, in order to avoid the high ground on Terceira, S. Jorge, Pico and Faial Islands.

Since Lajes Airport is located in the extreme Northeast of the Ihla Terceira, the requirement, for reasons of safety, to turn to the east and out to sea in order to avoid the mountains on the island needs no special comment, being obvious in view of the nature of the terrain.

Recommendations

1. The arrival and departure procedures in force must be strictly applied. These procedures and the charts illustrating them must be carefully studied whenever it is planned to use this aerodrome.

This is of particular importance whenever this aerodrome is being used for the first time.

2. A check must be carried out, in which the flight crew repeat the procedure they are about to follow or the clearance received, before they actually carry it out.

3. The pilot-in-command must always personally contact the briefing office and other information services of the aerodrome, in order to prepare his flight plan.

4. Whenever possible, and insofar as the visibility permits, the tower must follow visually any aircraft completing a take-off, in order that it may inform the pilot if the normal procedure or the instructions issued have not been followed.

Figure 28

INSTITUTO GEOGRÁFICO E CADASTRAL

CARTA COROGRÁFICA
DA
ILHA TERCEIRA
Levantada em 1899

FIG.- 29

CONVENÇÕES

Estrada distrital
" municipal
Caminho visinal
" para carros
" " pedes
Ponte de pedra
Ribeiras e ravinas
Mina
Forte
Area
Moita ou arvoredo
Pinhal
Casas
Igreja
" dentro da povoação
Ermida
Signaes geodesicos
Pharol
Moinho de vento
Cemiterio
Atalaia

Equidistancia 25 Metros

Angra do Heroismo (Monumento)
Latitude 38°39'12",75 ± 0",29

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CARTA AERONAUTICA DO MUNDO
ICAO 1:1000000

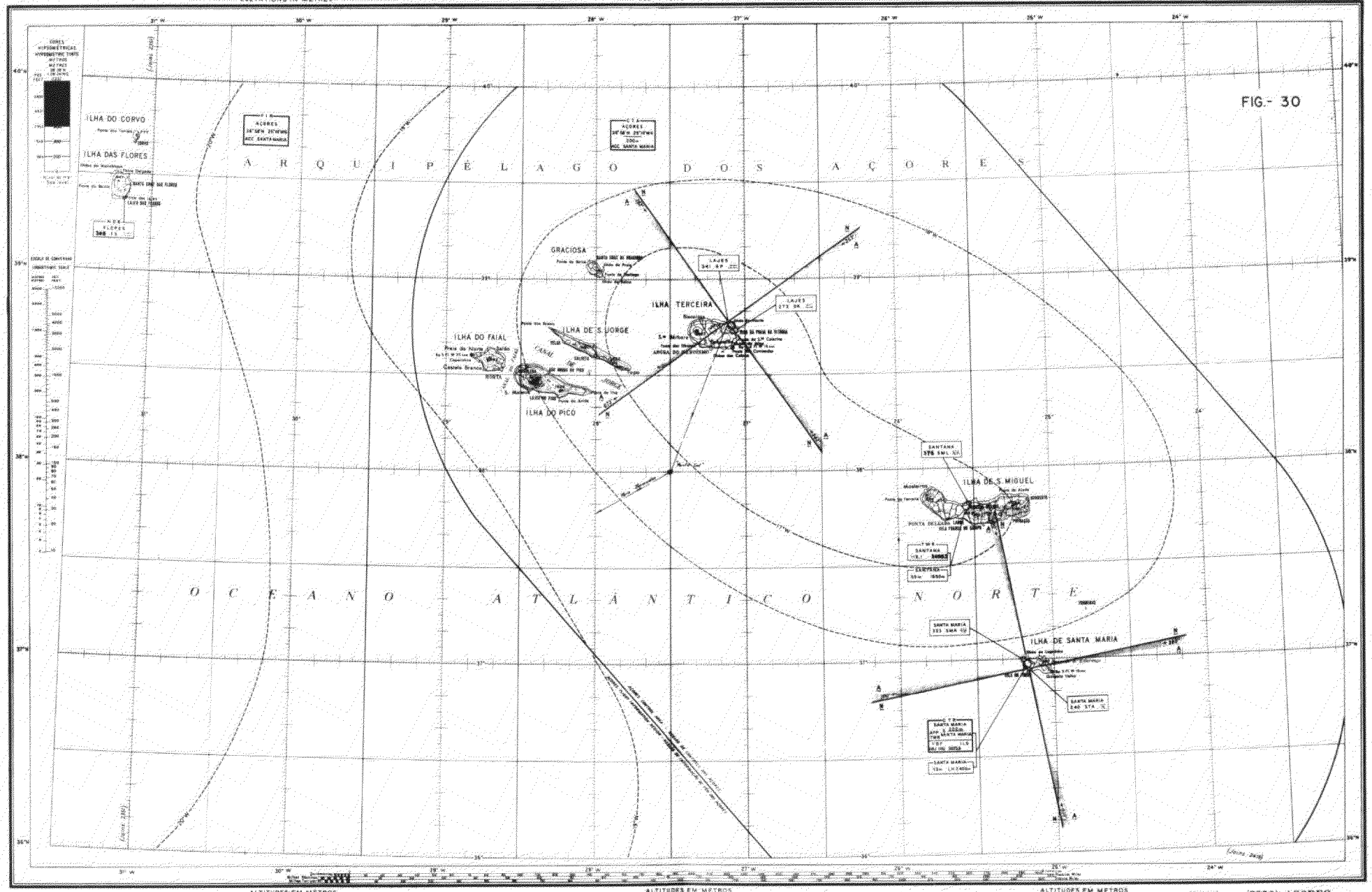
(2351) and (2350) AÇORES

Fig.30

ALTITUDES EM METROS
ELEVATIONS IN METRES

Projecção cónica conforme de Lambert
Paralelos normais 37° e 45° Escala 1:1000000
Lambert conformal conic projection
Standard parallels 37° and 45° Scale 1:1000000

FIG.- 30



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INSTITUTO GEOGRÁFICO E CADASTRAL

(2351) and (2350) AÇORES

AERÓDROMOS - AERODROMES

INSTALAÇÕES DE RÁDIO - RADIO FACILITIES

FARÓIS DE NAVEGAÇÃO AÉREA - AIR NAVIGATION LIGHTS

DIVERSOS - MISCELLANEOUS

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No 28

Airwork Limited, Vickers Viking 1.B aircraft, crashed at Blackbushe Airport, Surrey, England, on 15 August 1954. Ministry of Transport and Civil Aviation, United Kingdom, Report C.A.P. 128.

Circumstances

The aircraft took off from Blackbushe Airport at 0942 hours on 15 August 1954 on a charter flight to Nice, France, with 32 passengers and 5 crew. About ten minutes later, seeing oil streaming from the starboard engine the captain feathered the propeller and returned to Blackbushe. During a single-engine approach to land the aircraft struck the ground 135 yards short of the runway. The aircraft was extensively damaged and fire broke out. Two crew and two passengers were injured, two seriously.

Investigation and Evidence

The aircraft took off from Blackbushe Airport at 0942 hours and about 10 minutes later had reached an altitude of approximately 6 000 feet when oil was seen streaming from the inboard breather of the starboard engine. The captain feathered the propeller and decided to return to Blackbushe.

Blackbushe Approach Control was told of the circumstances and in reply informed the aircraft that runway 26 was in use and the QFE was 999 mbs. Assisted by the Blackbushe Homer, the aircraft returned direct to the vicinity of the airport and on arrival was advised by Approach Control that the surface wind was 300° at 8 knots, and that the captain could use runway 32 if he desired. The captain elected to land on runway 26. At 1002-1/2 hours the aircraft reported to Control that it was on base leg. Control immediately cleared the aircraft to finals. At this time the aircraft was approximately 2-1/4 miles east of the airport at an altitude of about 1 300 feet in visual conditions. During the turn to line-up with the runway the undercarriage was selected down and the engine rpm increased to 2 300 with about 33" boost. The aircraft was lined up at about 1-1/2 miles from the runway at an altitude of about 800 feet and 60% of flap was selected. The captain stated that the engine power was then adjusted to maintain an I.A.S. of 115 knots. A short time afterwards the undercarriage red indicator lights flickered a few times although the green ones remained on. The captain contemplated making an overshoot and checked the indicated altitude which was approximately 400 feet but while he was doing this the red indicator lights went out. The captain then made a visual check of the port wheel and concluding that the undercarriage was down, decided to continue the approach. He states that he then noted the I.A.S. was 100 knots. A few moments later, however, the aircraft sank suddenly and the I.A.S. fell rapidly. Full power was immediately applied to the port engine but the aircraft yawed to the right and sank into a valley which was below the level of the aerodrome. The captain pulled up the nose but was unable to prevent the aircraft from striking the ground. It struck rising ground and bounced and skidded onto the aerodrome during which time the undercarriage collapsed and the outer portion of the starboard wing and starboard engine were torn off. Fire broke out during the disintegration. The occupants quickly left the burning fuselage by the main door and two forward port window emergency exits which had been pulled out by the crew.

Before all the occupants were out of the fuselage the airport fire service arrived on the scene and went into action. About 14 minutes later several ambulances of the Hants and Surrey County Ambulance Services arrived and took the injured to hospital.

Inspection at the scene of the accident showed that the aircraft had first struck the ground with its tailwheel at a point about 20 feet below the level of the runway and 135 yards from it. This impact mark was in line with the right-hand edge of the runway. Other ground marks

showed that the aircraft, in a nose-up and right wing low attitude, had skidded and bounced up an abrupt slope onto the aerodrome. The fuselage with the port wing attached had come to rest 160 yards from the point of first impact and 16 yards to the right of the runway. Fire had almost completely destroyed the fuselage and the inner portion of both wings.

Examination showed that the undercarriage down lock plungers were fully engaged at the time of ground impact and that the extension of the flap jacks was consistent with a flap setting of 60%.

The fire extinguisher system of the aircraft had operated automatically. The circumstances indicated that the fire was probably started by the ignition of spilled petrol either by contact with the engines or by electrical or frictional sparks generated during the break-up of the aircraft. No evidence was found to indicate any pre-crash defect in the airframe.

The port engine had been extensively damaged by fire. The condition of its propeller indicated that the engine was under considerable power at the time of ground impact. Examination did not reveal any pre-crash defect.

The starboard engine was also damaged by fire and was removed for detailed examination by the Engine Division of the Bristol Aeroplane Company Ltd.

Their report stated that the rear of the crankcase had been almost consumed by fire and that a number of cylinder barrels were severely burned. A detailed strip examination did not disclose any mechanical defect and no reason for the failure was established.

The discharge of oil from the engine breather, which took place in this case, is commonly known as "gulping" and is due to the breakdown of the oil scavenge system. Apart from mechanical failure, ineffective scavenging may result from a number of causes such as blockage of the scavenge pump filter by carbon or other foreign matter. Water in the oil can also produce a similar result by creating a steam-lock at the inlet side of the pump. "Gulping" has taken place on numerous occasions over the past 2-1/2 years and the Bristol Aeroplane Company Ltd. have recently introduced several modifications which they hope will alleviate and might eliminate it. None of these modifications was embodied in this engine as it was installed before they were introduced. The Air Registration Board have not considered any modification to be essential because of the indeterminate cause of the trouble.

Probable Cause

The accident was the result of the captain allowing the aircraft to stall when making a single engine approach to land. A contributory factor was distraction of the captain's attention by the flickering of the undercarriage red indicator lights during a critical stage of the approach.

ICAO Ref: AR/372

No. 29

Braniff Airways, Inc., DC-3 aircraft, crashed near Mason City, Iowa, on 22 August 1954. CAB Accident Investigation Report No. 1-0155 Released 27 December 1954

Circumstances

The aircraft, engaged on a daily scheduled flight between Memphis, Tennessee, and Minneapolis, Minnesota, with a number of intermediate stops, departed Memphis at approximately 0835 CST and the flight was routine to Waterloo, Iowa. The aircraft departed Waterloo at 1641 with 3 crew and 16 passengers. Shortly before 1700 the aircraft was observed on its usual northwest course but at a low altitude about 17 miles south-southeast of the Mason City Airport. It was then seen to make a left turn and proceed almost directly west toward a light spot in a thunderstorm. As the flight headed west at an altitude estimated by several witnesses as 400 to 500 feet above the ground, it was observed to enter and disappear in the thunderstorm approximately 1 mile east of where the wreckage was later found. The crash occurred approximately 8 miles west of where the left turn was made. Ten passengers and 2 crew were killed and 6 passengers and 1 crew member received serious injuries. Fire did not occur after impact.

Investigation and Evidence

The location of the crash was 16 miles south of the Mason City, Iowa Airport, the destination of the flight. The heading of the aircraft at the time of impact was 290° True. The time of the crash was established at 1703 by an impact-stopped aircraft clock on the instrument panel. Ground marks at the initial impact point indicated a level lateral and longitudinal attitude, gear and flaps retracted, with considerable downward or sink velocity. A low forward speed was indicated by the short distance (448 feet) that the aircraft skipped forward after the initial impact.

The extremely disintegrated condition of the bottom of the cabin and center section substantiated the level aircraft attitude and high sinking velocity. Both wings, outboard of the attach angle, were relatively undamaged. The de-icer boots on the leading edge of both wings were undamaged and both navigation lights at the wing tips were intact and in place. The left wing tip was distorted downward at an angle of approximately 10° and there were compression wrinkles on the underside of both wing tips adjacent to the tip-to-wing panel attachment. The support legs of the cabin seats incurred compression bends, further substantiating the high sinking velocity at initial impact. No evidence was found to indicate power or structural failure, or malfunctioning of any aircraft control or component prior to impact. Settings and condition of the propeller blades indicated approximate cruise power at impact. All aircraft radio equipment was bench tested and found to function normally. The channel setting of the VOR receiver was 114.9 megacycles, which is the Mason City VOR frequency. Examination determined the course selector of the VOR to be 355°, which is the VOR approach heading for Mason City Airport.

Investigation disclosed that the flight crew was thoroughly familiar with the route. The captain had flown for Braniff, and a predecessor company, regularly over the pertinent route for more than 10 years in the same type of aircraft involved in this accident. The first officer, previous to his employment by Braniff, had flown commercially in the Mason City area.

Investigation disclosed that company dispatching procedures were complied with and the operation of the flight from a dispatching standpoint was entirely normal.

The course from Waterloo, Iowa, to Mason City, Iowa, is on a northwest heading and the air distance is 63 miles. Ground witnesses testified to visual flight rule weather conditions to, and several miles west of, where the flight altered course and proceeded westward towards a lighter spot in the thunderstorm.

Seven minutes after the flight departed Waterloo, Iowa, at 1641, a heavy thunderstorm was over the Mason City Airport and extending southwest. The Mason City Braniff radio operator at this time was unable to contact the flight and requested the Braniff Flight (southbound from Minneapolis) and the Waterloo company radio to relay Mason City weather to the flight. This was complied with and an acknowledgment was received of the message. At 1658 direct radio contact between Mason City company radio and the flight was established and at that time the flight advised it would hold southeast of Mason City due to thunderstorms to the west and northwest.

Approximately 20 persons along the east-west line between the left turn and crash point (8 miles) were questioned as to their observation of the aircraft and weather conditions. The consensus of these witnesses was that a vigorous storm was in the area as the aircraft, at an estimated altitude above the ground of 400 to 800 feet, flew westward over them and disappeared into the lighter spot in the center of the storm. The nearest witness, 1 mile east of the crash, was in heavy rain immediately after the aircraft passed overhead.

Damage from the storm in the vicinity of the crash varied considerably. There were trees 12 inches in diameter broken off 18 feet above the ground a mile east of the crash and evidence of strong winds from all directions. A mile west of the crash a wooden silo was blown down toward the west and chicken coops twisted on their foundations. A mile west-northwest and a half mile east of the crash, corn stalks had been forced to the ground in 100-foot swirling counterclockwise circles. East of this point corn was blown down generally toward the east but with an occasional northeast or southeast direction. A mile and a half east of the crash, five 60 foot high H-shaped power line supports were blown down toward the east. The power company owning this line stated the poles were constructed to withstand a steady wind of 85 to 90 mph.

The synoptic weather maps for the morning of 22 August 1954 showed a low pressure centre in Canada, a pressure trough southward through the Dakotas, Nebraska, and New Mexico. There was an occluded front in this trough from Canada southward to Nebraska with a cold front across northwestern Kansas and southeastern Colorado. A stationary front extended southeastward into Missouri and Kentucky with the west portion becoming a warm front with northward movement. At the time of the accident the trough line and cold front were more than 200 miles west of Mason City. The stationary front had been moving northward as a warm front and by 1700 was in the immediate vicinity of Mason City, Iowa. A heavy thunderstorm area built up southwest of Mason City that passed the Mason City Airport about 1648 with heavy rains and gusty winds up to 48 mph. A southern extension of this line of thunderstorm development existed south of Mason City. It was this storm area that the flight entered.

The Weather Bureau forecast for en-route weather issued at Kansas City for the period of 1300 of 22 August to 0100 of 23 August indicated conditions between Kansas City and Mason City as follows: South portion - scattered clouds at 6 000 feet, high broken clouds becoming occasionally broken at 4 000 feet, visibility 5 miles with light thundershowers. North portion - broken clouds 3 000 to 4 000 feet, and broken clouds at 10 000 feet, occasional light rainshowers and widely scattered afternoon and evening thundershowers in the warm sector. Local turbulence was forecast in the vicinity of thunderstorms. The terminal forecast applying to Mason City for the period 1450 to 1830 was scattered clouds at 600 feet, ceiling 4 000 overcast, winds south-southeast 12, occasional light rain showers or thundershowers, visibility briefly 1 mile. The company forecast for Iowa covering the period 1200 to 2000 was for broken to overcast 1 000 to 1 500 feet, broken to overcast 6 000, occasional moderate rainshowers, visibility 1 mile plus light to moderate turbulence. No amendments were issued to either the Weather Bureau's or the company's Iowa forecast.

The Air Force issued severe weather advisories from Tinker AFB, Oklahoma. These advisories are transmitted on an Air Force teletype circuit and the Weather Bureau forecast centres at Fort Worth, Chicago, and Kansas City have a drop on the circuit. On 22 August 1954 the Air Force issued two severe weather advisories, pertinent to the South Dakota, Nebraska, Minnesota, and Iowa area, one at 0930 and one at 1614, forecasting heavy thunderstorms, gusts to 50 knots, isolated hail at various altitudes and severe turbulence in thunderstorms. This last advisory forecasted a line of thunderstorms that would have been 60 miles west of Mason City by 1700.

Radar storm detection information is normally available from the Weather Bureau at Des Moines but the equipment was inoperative for 24 hours before the accident. Consequently, advisories from that source were not available for use by the flight.

The flight's estimated time en route Waterloo-Mason City was 23 minutes for the 63 mile flight, a ground speed of 164 mph. At the point where the left turn to the west was made, 46 miles, or 17 minutes, of the segment had been flown and the approximate time of the turn would be 1658. This is the time that the flight advised that it would hold southeast of Mason City. It is 8 miles, or 3 minutes, from where the turn was made to the crash point, making an arrival time of 1701 at the crash point. The small time discrepancy between 1701 and 1703 can be explained by the probable reduced airspeed, due to the known turbulence experienced by the flight in the last 5 minutes of flight. From the above it is evident that the flight did not hold southeast of Mason City any appreciable time. Although the aircraft's exact altitude at the time could not be accurately determined, several witnesses estimated its height as 400 to 800 feet above the ground. The reason why the flight proceeded into the thunderstorm area at this low altitude rather than hold clear of the storm can only be conjectured. Undoubtedly the captain had encountered many similar appearing storms during his years of operation over the route and it is quite possible that he entered the lighter area between the darker clouds on either side in order to get on the back side of the storm and subsequently land at Mason City.

At about the time the flight left Waterloo the previously reported towering cumulus had developed into thunderstorms scattered over the State but not forming into a true squall line. One of these thunderstorm areas formed to the southwest of Mason City and moved northeast to the Mason City Airport at 1648. Further thunderstorm building progressed rapidly at the south west end of this development with one or more thunderstorm cells reaching the mature heavy rain stage at about the time the flight arrived in the area of the accident. The light area that ground eyewitnesses stated the flight flew into can be accounted for by the lighter color of the rain curtain in contrast to the darker clouds above and on either side. By the time the flight went into the light spot the rain was very heavy and a downdraft established. It is evident that a very strong downdraft developed in this rain area. Substantiation for the strong, gusty winds is shown by the damage done by these winds in the area of the accident and some of the gusts may have exceeded 80 mph. In the initial stage of a downdraft of this nature the strong downward component continues to the surface and it appears probable that the flight penetrated the storm in the initial stage of this downdraft. Further contributing to the loss of altitude is the possibility of a sudden airspeed loss as the aircraft proceeded into the divergent winds from the storm centre.

Extensive investigation was conducted with regard to possible tornadoes but it can be definitely stated that a fully developed tornado reaching to the ground did not occur. There is insufficient evidence to state whether a vortex aloft occurred. With regard to this storm, had the radar set at Des Moines been in operation it would not have been capable of determining the intensity of the storm due to the distance being beyond its effective range. Radar storm detection information could have been provided by the Air Force station at Waverly (approximately 40 miles from the scene of the accident) had the pilot of the flight requested such service.

The Weather Bureau's forecast for Mason City, Iowa, did not contain information that would properly warn the pilot of conditions that would be encountered, and this is also true of the company forecast. If the storm that developed near Mason City had been anticipated by the forecaster, a severe weather forecast would have been required.

Probable Cause

The Board determined that the probable cause of this accident was that the flight while endeavouring to traverse a thunderstorm area encountered very heavy rain, divergent winds, and strong downdrafts that forced the aircraft to the ground.

ICAO Ref: AR/331

No. 30

Trans-World Airlines, Inc. Martin 404 aircraft damaged while landing at Fort Wayne, Indiana, U.S.A. on 13 September 1954. CAB Accident Investigation Report No. 1-0157. Released 14 February 1955

Circumstances

The flight was engaged on a scheduled service between Baltimore, Maryland, and Kansas City, Missouri, with intermediate stops and carrying 30 passengers and 3 crew. The flight at 0918 was cleared to land at Fort Wayne and it made a smooth touchdown on Runway 22 following which the main landing gear partially retracted allowing the propeller tips to strike the runway. The aircraft skidded down the runway coming to rest 3,325 feet from the approach end. The passengers were evacuated through emergency exits on both sides of the fuselage over the wings. A few of the passengers received bruises in leaving the aircraft. There was no fire.

Investigation and Evidence

When the landing was made the captain was occupying the left pilot's seat and the first officer the right. The latter made the approach and landing while the captain performed the duties of first officer. The captain stated that when the aircraft was firmly on the runway the first officer called for flaps up, cowl flaps open and props full increase rpm. The captain started the flaps up and, according to his testimony, while his right arm was brought back from the flap control (which is on the right side of the pedestal and has a spherical knob) his right hand struck the landing gear lever. He at once noted that the landing gear control was above its neutral position. He quickly actuated the control back to the down position but the propeller tips began striking the runway almost immediately.

Both pilots stated they were certain there had been three green lights during the approach and that the red light was not on, signifying all three wheels were locked in down position. They further stated the landing was without skip or bounce after initial contact of the wheels with the runway. According to the crew there was no intention of using propeller reversal on this landing, as the runway was long, the touchdown was in average location, and there was a checking wind of 13 mph from south-southwest. Both crew members stated they did not recall hearing the warning horn at any time during the landing.

The aircraft was raised with air bags and jacks. During this process, the wheels of the main gear remained on the ground and the gear down locks readily engaged. The aircraft was then towed to a hangar and placed on jacks to permit full landing gear retraction and extension tests. Several cycles of the landing gear were made using auxiliary hydraulic pressure and no irregularity could be found in either the functioning of the landing gear or its warning system. Except for the damaged right gear doors, which were removed, these tests were conducted without any alteration, replacement, or repair. The landing gear cycled normally except that its movement was slower due to the lower hydraulic pressure capacity of the auxiliary power unit. The safety switch on the nose gear torque link was manually operated. The landing gear lever locking solenoid in the cockpit control pedestal actuated properly and the T handle on top of the pedestal moved to the normal "up" position.

The gear actuating control handle is located on the left side of the pedestal and has a cube-shaped knob at the end of the handle. The neutral position of this control is in the centre of a vertically placed quadrant. The release of control is accomplished by lifting slightly and pulling the handle out of its detent against the pressure of a light spring. If the weight of the aircraft is compressing the gear's shock struts enough to actuate any one of the safety switches, the control handle cannot be moved to the "up" position on the quadrant. This safety factor, which is designed to minimize inadvertent retraction of the gear while on the

ground, functioned normally. A movement of the gear's control handle to the "up" position is possible even though the aircraft does not skip or bounce during a landing, if none of the shock struts are compressed by the weight of the aircraft to the point where a safety switch is actuated. It is necessary that the struts compress approximately two inches before they actuate the switches. Any one, or any combination of these struts, if compressed to this point, will prevent inadvertent retraction.

As indicated, the first officer, who was occupying the right seat, made the landing. The captain, on the left, actuated the landing gear and flap controls. He lowered the landing gear during the approach and noted that all three lights, indicating full down and locked condition, were on. After a smooth touchdown and with the wheels lightly on the runway the first officer ordered flaps up. The captain complied. As the flap lever is at the right of the pedestal, it was necessary for the captain to reach beyond the landing gear lever which is at the left of the pedestal He states that as he brought his hand back apparently the heel of the hand struck the landing gear lever upwardly and the landing gear started up. This upward motion of his hand is understandable as his next action would be to reach immediately, as a continuation of his hand motion, for the cowl flap switches located on the over-head panel. The captain instantly saw the landing gear lever above its neutral position (toward "up") and quickly pulled it down past neutral to the "down" position. However, the wheels had, even in that short period of time, started to retract and the weight of the aircraft then took command of the situation, forcing the main wheels upward until the aft portion of the fuselage was scraping the runway. This is believed to be the most logical explanation of the landing gear retraction and one that seems to be entirely plausible.

As stated, the nose gear was found down and locked. It may well have become unlocked at the same time as the main gear. However, the fast and slightly nose high landing probably allowed time for it to return to the full down and locked position when the captain actuated the control handle to the down position.

Following this accident all company pilots were advised of the circumstances and in addition the carrier initiated a comprehensive programme designed to preclude further occurrences of this type. A guard has been installed over the landing gear control handle and deliberate action on the part of the pilot is now required before the handle can be actuated. TWA is also in the process of installing on all of its Martin M-404 aircraft deceleration switches which will lock the gear in "safety" immediately upon touchdown. Further, in the belief that weak spring tension could possibly have contributed to the ease with which the gear handle was displaced from its normal position, TWA conducted a fleet campaign immediately following the accident to ensure that the tension of the handle detent springs on all of the M-404's was within the prescribed tolerance.

The Board concurs with this action by the carrier and has recommended to the Administrator that consideration be given to incorporating these additional safety features on all other aircraft of this type.

Probable Cause

The Board determines that the probable cause of the accident was the accidental retraction of the landing gear during the early stages of the landing before the safety system became effective.

No. 31

Whitehorse Flying Services, Ltd., Canada, De Havilland DHC-2 aircraft crashed near Fox Mountain, Yukon Territory, on 2 October 1954. Summary Accident Report Serial 54-27 Department of Transport, Canada

Circumstances

At about 1320 YST on 2 October 1954, De Havilland DHC-2 aircraft, owned by Whitehorse Flying Services Limited, took off on a non-scheduled charter flight from Whitehorse to Rose River and Vangorda Creek with three passengers on board.

A flight plan for the flight was filed in which it was estimated that the aircraft would arrive back at Whitehorse by about 1730 YST.

On the following day, 3 October, as the aircraft had not returned, a search with company aircraft was made without success and as a result, an extensive search was started by the Royal Canadian Air Force Search and Rescue Organization. On 13 October, at about 1400 hours, the wreckage of the aircraft was sighted. The scene of the accident was visited by a helicopter the following day. All the occupants were dead and the aircraft had been destroyed.

Investigation and Evidence

A Certificate of Airworthiness which was valid at the time of the accident had been issued for the aircraft. The pilot held a valid Senior Commercial Pilot Licence and Class II Instructor's Rating, and had accumulated a total of about 6 000 hours of flying experience of which about 242 hours had been acquired in the last 90 days.

At 0930 YST on 2 October 1954, an Arctic high pressure area was centred over the Northern Alaskan coast with a ridge south-eastward through the Yukon to western Alberta. A moderate northerly flow of moist unstable air existed over the Yukon and the wind at 10,000 feet was 340/25 kts. Along the eastern edge of the ridge a trough in a WSW-ENE line was moving southward at 30-35 knots and weakening. The trough was 100 miles north of Norman Wells at 0330 YST and at 0930 YST had reached a line from 100 miles north of Smith River to just north of Fort Simpson. At 1530 YST the trough would have extended from south of Watson Lake to Fort Nelson and ENE. Snow showers were reported at various localities near the trough line.

The topographical features in the vicinity of the accident include blind valleys, terminating in a steep wall just short of the ridge on which the aircraft crashed. A northerly wind would have an increasingly confined path up the valley then suddenly sweep up over the ridge and down into the valley on the south side of the ridge causing heavy updrafts on the windward slope and heavy downdrafts on the leeward slope. Thus this ridge would be subject to extremely turbulent conditions.

The time of the accident has been estimated as 1700 YST. Another pilot who was flying about 8 - 10 miles north of the scene of the accident at about 1705 YST reported no shower activity in the area to the south but that the weather in that area was, "very good - clear but turbulent".

While the pilot was not briefed by the forecaster, he was present at a briefing given to other pilots for a flight to Calgary and may have heard the discussion and obtained a fairly good idea of the weather situation.

The aircraft crashed while on a southerly course. An analysis of the wreckage indicated that the aircraft struck the ground at a high downward velocity while in a longitudinally level or slightly nose-high attitude.

The evidence thus indicates that the aircraft had turned back prior to the accident. This could have been due to the turbulence existing in the area.

Probable Cause

The aircraft crashed on the lee side of a mountain ridge for reasons that were not determined conclusively, although it is probable that a downdraft was encountered at too low an altitude to avoid crashing into the ridge.

ICAO Ref: AR/356

No. 32

Convair 240-6 aircraft crashed 9 km. south - southwest of Capilla del Señor (Buenos Aires) on 16 October 1954 - Argentine Aircraft Accident Investigation Report No. 467. Released 6 September 1955.

Circumstances

The aircraft, engaged on a scheduled flight non-stop from Ezeiza to Cordoba, took off from Ezeiza Airport at 1500 hours local time with 27 passengers and 5 crew. The approved flight plan provided for a VFR flight at a cruising level of 1200 meters. At 1510 hours the aircraft asked Buenos Aires ATC for clearance to change its altitude to 600 metres due to a marked frontal belt having been encountered. Shortly after this, the aircraft entered a storm area with rain, hail and strong electrical discharges of increasing intensity which caused uncontrolled loss of altitude. It continued descending until it struck the ground at approximately 1520 hours, injuring the pilot, two crew and four passengers.

Investigation and Evidence

According to the testimony of the pilot-in-command and co-pilot, after a few minutes of flight it was noted that ahead and to the left of their course there was a cloudy area clearing to the right; the course was altered 20 degrees accordingly. Shortly thereafter, the aircraft encountered rain, hail and mild turbulence and requested Buenos Aires ATC for clearance to change its altitude to 600 metres. During the descent the rain and hail increased alarmingly causing uncontrolled loss of altitude. An attempt was made to counteract the descent by an increase in the engine rate which was raised to 2400 rpm while the supercharging was brought to some 45 inches. At the same time, course was altered toward the right to try and avoid the storm. Turbulence was not heavy, however, the up and downdraughts were. The aircraft gained and lost altitude repeatedly at indicated speeds of 1,200 and 1,500 feet per minute, until during the final loss of altitude, the descent could not be arrested in spite of the application of maximum power on both engines, and the aircraft crashed into the ground.

Both pilots were of the opinion that the crash was due to the damage which the hail and rain had caused to the leading edges of the blades of both propellers and the effect of the downdraughts.

Prior to the accident the following readings on the instrument panel were made:

Artificial horizon	rising
Speed	150 mph
Indicated altitude	700 feet
Variometer	descending
Gyroscope	20 degrees

The power plants were operating normally.

The Board of Inquiry concluded that after the pilot-in-command had decided to fly at 600 metres, the aircraft encountered a highly active local front. In attempting to leave the storm area the pilot had to alter his course several times, and tried in vain to reach the area to the right which he had noted, before entering the storm area, as being clearer and offering better visibility.

Witnesses at or near the scene of the accident agreed that the aircraft had been seen in horizontal flight at an altitude of not more than 20 metres headed in the direction of the point at which impact occurred shortly afterwards. They also stated that the weather had been poor from mid-day on, the rain and hail causing property damage in the area.

The pilot-in-command testified that the dependent MET Office at Mendoza had forecast the weather conditions encountered and at his request this office was asked to prepare a report for the Ezeiza-Cordoba route on the basis of the relevant facts available at the date and time of the accident. The difference between this report (Mendoza) and the one handed to the pilot at Ezeiza prior to the flight was that the former report indicated the presence of 3 to 5/8 cumulo-nimbus, with cloudbursts and storms that would reduce visibility and lower the ceiling.

In view of this, the National Meteorological Service was asked for a report on the analysis of the weather for the hours 1200 to 1500 on 16 October, which is quoted hereunder:

> "Variable cloudiness with pronounced instability. Isolated cloudbursts and storms with gusts up to the end of the period covered by this report. These weather conditions resulted from a well-defined area of instability, moving from the southwest to the northeast, which developed rapidly and later passed through the area (after 1530 hours)."

It was concluded that the pilot-in-command committed an inexplicable error of judgment, since a turn to the right would have taken him out of the storm without hazard. The Airline Operations Manual stipulates:

> " Safety is the basic concern in the conduct of a flight. This factor will always be given prime consideration in any decisions taken on the ground or in flight."

Further on, the Manual states:

> "When weather conditions such as fronts, icing, turbulence are encountered, whether they are forecast or not, which may place the aircraft in danger, the pilot-in-command is authorized to return to his point of departure or to deviate from his route by as much as 50 nautical miles, making the appropriate report to the relevant ATC office."

A special committee of technical personnel was appointed to study the probable deformations of the airframe and the aerodynamic effects thereof as a result of the exposure of the aircraft to the very violent atmospheric conditions existing at the scene of the accident.

Conclusions

Study and investigation led to rejection of the assumption that the joint action of intense precipitation of rain and hail may have modified to a dangerous degree the aerofoil section and wing load of the aircraft, to the point of modifying its aerodynamic properties.

No structural, operational or maintenance defects were found which might have reduced the normal operating capacity of the aircraft.

The technical conclusions are also supported by the unquestionable statements of witnesses on the basis of which it was possible to establish that over at least 7 or 8 km before the impact point the aircraft was flying at extremely low levels and in very bad visibility.

The possibility of an error in altimeter setting was considered but could not be sustained as shown by inspection of the instruments and by statements of the pilot-in-command and the co-pilot.

The prime reason for the accident must be sought in the pilot-in-command's decision to enter the storm without prior exhaustive analysis of prevailing weather conditions.

The fact that the phenomenon encountered was not included in the forecast was not considered to be extenuating, since the above mentioned Airline Operations Manual refers to "storms, whether they are forecast or not", leaving to the pilot-in-command the option of circumnavigating the area or returning to his point of departure; these are the criteria which would have been applicable in the emergency under consideration.

It should, moreover, be noted that the pilot-in-command stated that he had observed a clear area to the right of his route, through which he could have attempted to go around the storm, as he did after encountering difficulties.

Probable Cause

Through causes which could not be fully ascertained and in circumstances arising while the aircraft, in attempting to leave the area of a violent storm, was flying at a low altitude, the aircraft was carried into the ground.

Contributory Causes

1) The persistence of the pilot-in-command in attempting to climb, without making use, at the appropriate time, of the full power available to arrest the descent caused, according to his own statement, by meteorological conditions.

2) The decision by the pilot-in-command to enter a local storm the violence of which he did not foresee and which he could have circumnavigated as prescribed by the operational standards of the company.

3) The fact that the pilot-in-command had no meteorological information relating to the weather conditions he encountered.

ICAO Ref: AR/396

No. 33

Trans-Australia Airlines, Viscount 720 aircraft, crashed after take-off at Mangalore Aerodrome, Victoria, Australia, on 31 October 1954. Accident Investigation Summary. Aviation Safety Digest No. 4, April 1955 (Commonwealth of Australia, Department of Civil Aviation)

Circumstances

The aircraft crashed after take-off just outside the boundary of Mangalore Aerodrome, Victoria, at 1507 hours on 31 October 1954. At the time of the accident the aircraft, engaged on routine conversion training, was making a three-engine take-off. The two pilots and one other supernumerary pilot were killed, three other occupants received serious injuries, and the remaining two occupants escaped without injury. The aircraft broke up on impact and was destroyed by fire.

Investigation and Evidence

The aircraft employed at the time on pilot conversion training was operating at Mangalore Aerodrome, alternate to Melbourne Airport. Just prior to the take-off in which the accident occurred the aircraft had landed into the northeast on three engines after having completed a circuit during which No. 4 engine was deliberately stopped in the take-off just after V_1 speed, to simulate engine failure. On completion of the landing run the aircraft was lined up for take-off in the reverse direction with No. 4 engine stopped and the propeller feathered. The pilot-in-command, was occupying the right-hand seat and the pilot under training was occupying the left-hand seat. Two supernumerary pilots and an engineer were standing as observers at the rear of the cockpit, and the remainder of the occupants were seated in the cabin.

After a pre-take-off cockpit check had been carried out Nos. 2 and 3 engines were opened up to take-off power, the brakes released, and, as the aircraft moved forward, the pilot under training gradually advanced No. 1 throttle. When the aircraft had travelled some distance a swing to starboard developed but this was corrected by the use of nosewheel steering. However, this was followed almost immediately by another more severe swing to starboard in which the aircraft left the runway and became airborne at a speed below the minimum control speed.

As the aircraft left the ground it continued turning and whilst climbing slightly the starboard wing went down. This turn steadily steepened and the aircraft, which had not climbed above 100 feet, steadily lost height until the starboard wing tip struck the ground. As the aircraft was about to crash one of the supernumerary pilots moved back into the cabin.

Mangalore Aerodrome, is 450 feet above mean sea level. Runway 22 is a sealed gravel pavement 150 feet wide and 5 880 feet long.

The weather on the afternoon of 31 October was fine, warm and cloudless, with unlimited visibility. The wind was light and variable.

Tyre marks left on the runway during the take-off reveal that a swing to starboard occurred approximately 1 100 feet from the start of the take-off run and, as indicated by the marks on the runway, nosewheel steering was used to correct it. Marks of a second swing were in evidence 1 800 feet along the runway and it was during this swing that the aircraft left the runway at a point some 2 000 feet from the commencement of the take-off, and became airborne, 240 feet further on. There were no nosewheel steering marks during this swing. The path of the aircraft is shown in the attached plans. (Figures 31 and 32).

Evidence could not be found of the aircraft having struck the ground, or any tree or object, between the runway and the wreckage site. The aircraft was demolished on impact, the wreckage being spread along a distance of 450 feet. Both wings were torn off, the fuselage was broken in half and the four engines were separated from the main wreckage. The front portion of the fuselage came to rest on its port side with the rear portion, inverted and facing in the opposite direction, lying alongside it. A fire which occurred on impact spread throughout the wreckage but, although the area ultimately affected was extensive, it did not spread rapidly and large portions of the fuselage were not affected by the fire until at least ten minutes after impact.

All the occupants of the cabin survived and reported only moderate deceleration on impact. One of the two supernumerary occupants of the flight deck at impact was killed, and the other escaped through a hole in the fuselage, after receiving serious injuries. Both pilots, who were wearing lap strap type safety belts, but not the shoulder harnesses available to them, received fatal head injuries from contact with cockpit fittings. One pilot had no injuries below his head and the other, apart from head injuries, had a broken thigh. After an examination of all the circumstances it is concluded that had the pilots been wearing the shoulder harnesses available to them they may have survived the accident.

An examination of the engines and propellers established that Nos. 1 and 2 engines were at full power on impact and No. 3 engine was under substantial power, probably full power. No. 4 propeller was fully feathered and there was no indication that any attempt had been made to unfeather it. All the evidence, including calculations of the aircraft's performance in such a take-off, indicates that the three engines were delivering full take-off power.

No evidence was found to suggest that the flying controls were other than serviceable and the trim positions were consistent with a three-engine take-off configuration. From the flap selector lever position and the condition of the flaps it is concluded that flaps were extended 20°. Examination of the pilot system components revealed no defects or evidence of malfunctioning. On impact the undercarriage was down and locked but it had been selected "up" approximately 2 seconds prior to impact, which time is insufficient for the selector valve to expose the undercarriage retract mechanism to system pressure. The port wheels, tyres and brakes were found to be in good condition but no assessment could be made of the starboard wheel assembly because of the extensive fire damage it sustained. The nature of the tyre marks on the runway indicates that there was no malfunctioning of these assemblies, including the brakes, and that the brakes were not misapplied.

The nosewheel assembly sustained relatively little external damage except for fractures of the lower lugs on the ram-foot to which the lower steering link is attached, but the centering helix inside this strut was found broken into a number of fragments. After extensive examination and analysis of this damage it was concluded that it had all occurred on impact.

The nosewheel steering hydraulic circuit was found to be intact and serviceable. The main hydraulic system sustained extensive damage and it was not possible to determine conclusively that this system was operative at the time of impact.

The pilot-in-command held a first class airline transport pilot licence and his total flying experience amounted to over 11 000 hours, of which 3 158 were in-command of DC-4 type, 1 846 CV. 240 type, and some 3 000 hours DC-3 type. He was regarded as a highly competent check and training captain. His experience on Viscount type totalled 21 hours 30 minutes at the time of the accident. After a conversion course, which included ground training in engineering, and flight training lasting 5 hours 30 minutes, his licence was endorsed for the type, on the certification of competence by the Chief Check and Training Captain of Trans-Australia Airlines. During his conversion he carried out several three-engine take-offs. He was rostered for duty as a training captain on Viscount aircraft, covering all aspects of this company's Viscount training syllabus, after a total experience of 10 hours 40 minutes on this type.

The pilot under training held a first class airline transport pilot licence and his experience amounted to just over 12 000 hours, of which 6 715 hours had been as captain on DC-4

type. Prior to this flight he had completed 4 hours conversion training on Viscount aircraft in which he had twice taken-off on three-engines.

Analysis

The take-off from which the accident resulted was being attempted in the most critical three-engine configuration, i.e. with No. 4 engine (starboard outer) inoperative. In this configuration, with flaps extended 20° and the three engines on full power, a minimum speed of 96 knots is necessary in order to ensure that, using both rudder and aileron, a constant heading can be maintained. When flying under these conditions at speeds below 96 knots it is not possible to keep the aircraft from turning.

The take-off safety speed for the conditions existing at the time of this accident is given in the flight manual for Viscount VH-TVA as 106 knots and it has been the practice of Trans-Australia Airlines to teach its pilots not to lift the aircraft off the ground at speeds below 110 knots in a three-engine take-off.

It follows that in a three-engine take-off whilst the aircraft is still on the ground and at speeds below 96 knots directional control depends on the use of some nosewheel steering to supplement any rudder that may be applied. In order to ensure full effect from steering, the nosewheels must be held firmly on the ground by keeping the control wheel fully forward.

It is appropriate to mention here that an important characteristic of turbo-propeller aircraft, by comparison with piston-engine aircraft, is the marked difference in response to throttles. The proportionate increase in power obtained in the final stage of throttle opening is much greater with the turbo-engine than with the piston-engine. Also, the response to throttle opening in the turbo-engine is slower than in the piston-engine.

The tyre marks show that the aircraft was running 15 feet to the right of the runway centre line, when the first swing to starboard commenced at a point some 1 100 feet from the start of the take-off. It is estimated that the speed of the aircraft at this point would be of the order of 65 knots. Marks on the runway indicate that this swing was corrected by nosewheel steering and as the swing was controlled these marks became lighter until they disappeared when the aircraft was running straight again. Although running straight, it was still heading slightly to the right away from the runway centre line. After approximately 200 feet in this condition, which would have taken about 1-1/2 seconds, the aircraft again swung to starboard, left the runway and a short distance later became airborne. This swing was severe.

The surviving supernumerary pilot, who at this time was standing between the pilots, states that as the aircraft left the runway, the pilot-in-command pushed the throttles fully open and pulled the aircraft into the air at an airspeed between 85 and 90 knots - definitely not higher than 90 knots. It has been calculated that with normal acceleration in a three-engine take-off the speed of the aircraft where it left the runway would have been 85 to 90 knots. From what is known of the characteristics of the aircraft near the minimum control speed, it is clear that it could not be controlled directionally after it left the ground, and its fate was inevitable so long as full power was drawn at speeds below 96 knots. In deciding to lift VH-TVA into the air at this time, rather than abandon the take-off, an error of judgment was committed by the captain and the accident resulted.

The captain may have been influenced in this decision by his considerable experience on other aircraft recently flown by him, the minimum control speeds of which are lower than that of the Viscount. It is felt that in an emergency such as faced the captain he would be inclined to react automatically under the influence of his predominant experience in the DC-4, overlooking the particular characteristics of the Viscount of which he was comparatively inexperienced. It is also possible that he may have been led into error by a natural urge to make the utmost endeavour to avoid damage to this aircraft, which was destined to play an important part in his company's operations. It would have been obvious to him once the aircraft had left the runway, that to abandon the take-off would almost certainly have resulted

in some damage to the aircraft by collision with flight strip boundary markers or other features of the aerodrome outside the prepared flight strip.

It is considered that in these circumstances a training captain fully familiar with the characteristics of the Viscount type would not have taken the aircraft into the air. The fact that the captain attempted to do so at a speed below the minimum control speed, indicates that he was not sufficiently familiar with this type of aircraft for the duties on which he was engaged. It is concluded, therefore, that his limited experience materially affected his judgment at this time.

Whilst the accident is considered to have been caused by the decision to take the aircraft into the air, this decision was precipitated by loss of directional control during the final stages of the ground run. There are a number of circumstances which could have caused the final swing. Some possibilities, such as power plant failure and propeller malfunctioning, have been discarded after investigation, but it has not been possible to eliminate or confirm others.

A puzzling feature of the last swing is the absence of any nosewheel steering marks, which would be expected particularly as marks of this sort indicate that nosewheel steering had been used a few seconds earlier to correct the previous swing. Having regard to the surviving supernumerary pilot's evidence that he was not aware of any difficulty being experienced in the cockpit it is apparent that either the nosewheel steering mechanism failed, unbeknown to the pilots, or that the pilots failed or were unable to use it effectively, at a stage in the take-off when its use was essential for directional control. Although the nosewheel and associated steering mechanism are considered to have been in a serviceable condition at the time of the accident, owing to the destruction of some of the hydraulic system plumbing, it was not possible to determine this conclusively. Complete loss of hydraulic pressure through such a cause as a broken hydraulic line could have deprived the pilots of nosewheel steering. In assessing the likelihood of such an occurrence, the successful use of steering immediately prior to this last swing cannot be overlooked.

On the other hand, if the steering mechanism was serviceable it is obvious from the absence of runway marks that the pilots either failed or were unable to use it. Both were experienced pilots of DC-4 and/or CV.240 aircraft and accustomed to the use of nosewheel steering. It is considered that if either of the two pilots had been in complete and continuous control each would have applied steering instinctively to correct such a swing.

The supernumerary pilot has said that the pilot under training corrected the first swing with steering and the absence of steering marks on the runway in the last swing suggests that he was no longer flying the aircraft, or was flying it in such a manner as to be deprived of effective steering. At first it was thought that this latter possibility might apply if the pilot under training, who with his left hand on the tiller and his right on the control wheel, had released the control wheel in order to operate the throttles, thereby reducing the load on the nosewheels and rendering the steering ineffective.

In tests with another Viscount to explore this possibility, it was found that when the control wheel was released at 75 knots, during a normal four-engine take-off under the same loading conditions as prevailed in the aircraft, the nosewheel did not leave the ground despite a slight up movement of the nose after which the aircraft still responded to nosewheel steering. This suggests that if steering had been applied by the pilot under training, after releasing the control wheel, some steering marks would have been made on the runway in the final swing. In any case, the pilot-in-command might be expected to push the control wheel forward again, thereby restoring full steering effectiveness, if he saw the pilot under training release it. It is thought, therefore, that the likelihood of the pilot under training being deprived of effective steering is extremely remote.

The possibility of the pilot-in-command taking control of the aircraft, during or immediately prior to the last swing, remains. In considering this the absence of any nosewheel tracks in the gravel at the edge of the runway is significant as it indicates that the

nosewheels were off the ground before they crossed the edge of the runway. For this to have happened it is apparent that the control wheel was previously pulled back and, as the supernumerary pilot has said that the pilot-in-command did, in fact, pull it back on taking over control, this points to the pilot-in-command having assumed control before the aircraft left the runway. This deduction conflicts with the supernumerary pilot's evidence, but allowance must be made for the possibility of the sequence of events as recalled by him not being exactly correct in every detail, particularly when the rapidity with which this sequence occurred is appreciated.

If the pilot-in-command assumed control after the first swing had been substantially corrected, and he could easily have felt this to be necessary because the aircraft was still heading so as to run off the runway just before it would have become airborne, the pilot under training would probably take both hands off the controls. The supernumerary pilot says that when the pilot-in-command took over he held the control column with his right hand while he "slapped" the throttles forward with his left. It would not have been possible for him to use the tiller at the same time and this, together with the application of full asymmetric power, could have resulted in the aircraft turning so quickly towards nearby obstructions, such as elevated runway lights and flight strip boundary markers that, influenced by his predominant experience of the handling of aircraft other than the Viscount, he instinctively pulled the control wheel back, in an endeavour to fly the aircraft out of this trouble. It has been suggested that with a comparable configuration a DC-4 could have been taken into the air at 85 knots without loss of control. It seems probable, then, that the pilot-in-command took over after the first swing and in his doing so nosewheel steering was released at a stage in the take-off when its use was essential.

Therefore, whilst failure of nosewheel steering through loss of hydraulic pressure cannot be positively eliminated, its likelihood is considered remote, and it is thought that the development unchecked of the last swing arose through nosewheel steering being released when the captain took over control from the pilot under instruction; this constitutes a probable contributory cause of the ultimate accident.

Probable Cause

The cause of the accident was an error of judgment on the part of the pilot-in-command in that he took the aircraft into the air at a speed below the minimum control speed, following loss of directional control during the ground run.

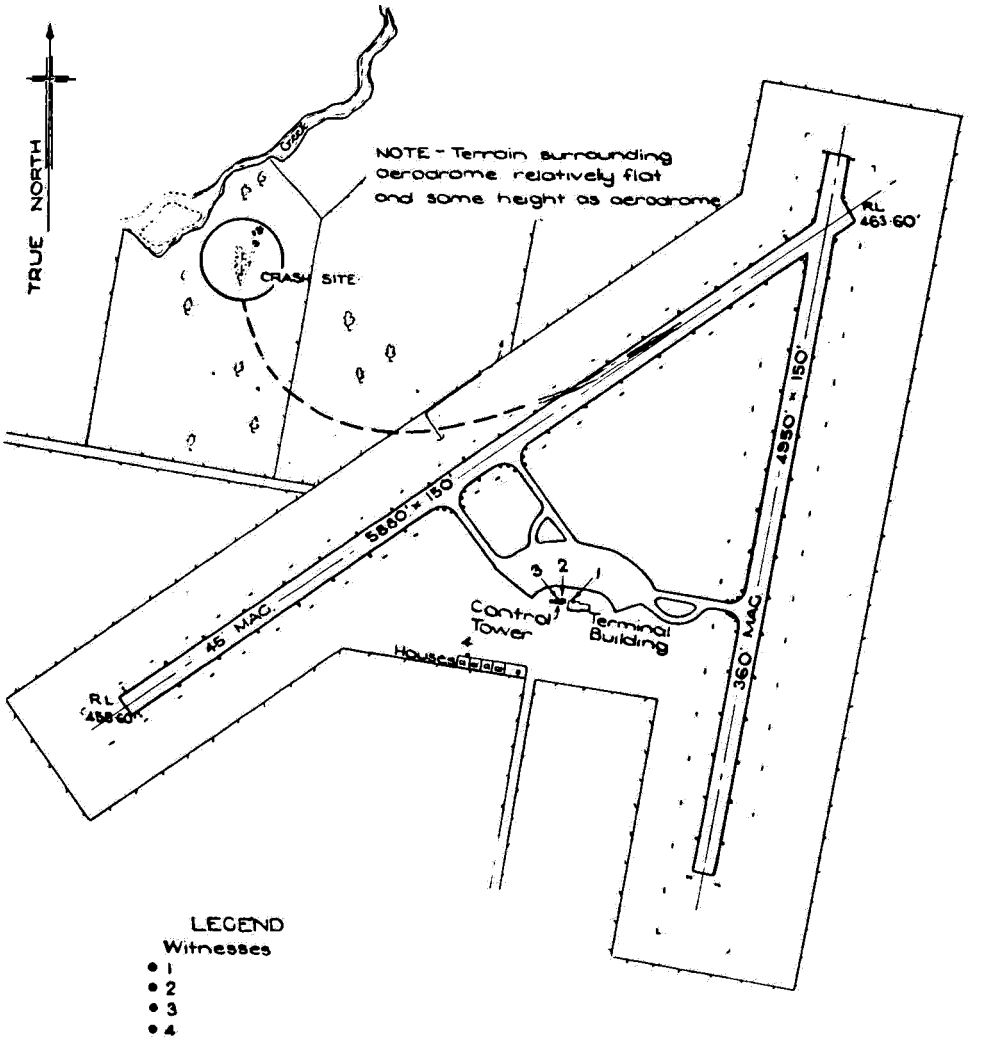
Some difficulty in maintaining directional control had been experienced during the take-off run but the final loss probably occurred through nosewheel steering being relinquished as the pilot-in-command took over the controls.

A factor probably contributing to this accident was the limited experience of the pilot-in-command on this type of aircraft.

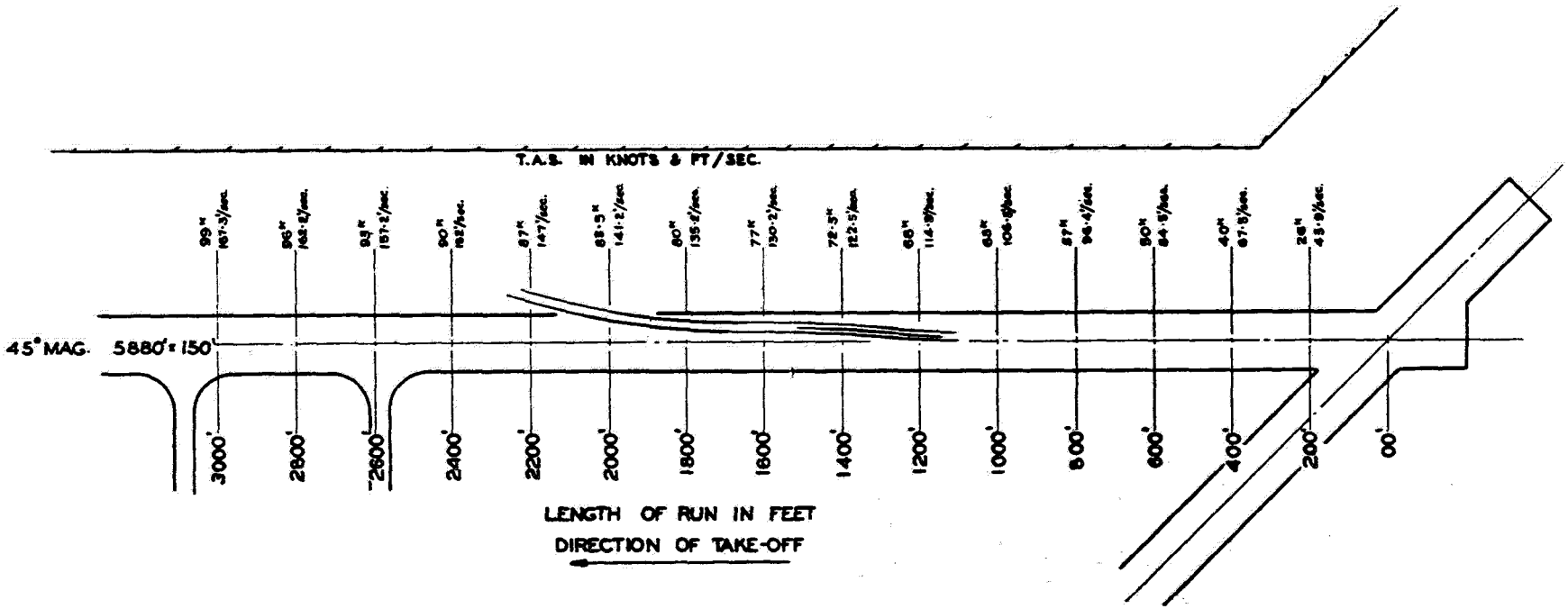
Note: The report included the conclusion that the injuries sustained by the operating crew indicate that they may have survived this accident if they had been wearing the full safety harness provided for their use in the aircraft.

ICAO Ref: AR/374

FIGURE 31



ACCIDENT TO VISCOUNT AIRCRAFT VH-TVA.
AT MANGALORE VICTORIA ON 31 OCT. 1954.
LOCALITY PLAN OF CRASH SITE SHOWING ESTIMATED FLIGHT PATH
Scale - 1" = 1000'



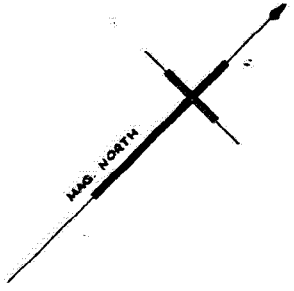


FIGURE 32

ACCIDENT TO VISCOUNT AIRCRAFT VH-TVA.
AT MANGALORE, VICTORIA ON 31 OCT. 1954.

RELATION OF TRUE AIR SPEED TO TAKE-OFF RUN.

Scale: 1" = 300'

CALCULATIONS BASED ON FOLLOWING ASSUMPTIONS.

1. THREE ENGINED TAKE-OFF WITH TWO ENGINES TO TAKE-OFF POWER ON BRAKES AND THIRD TO TAKE-OFF POWER WITHIN SIX SECONDS.
2. NO WIND. STANDARD I.C.A.N. SEA LEVEL CONDITIONS.

No. 34

Alaska Coastal Airlines, Gruman G-44 amphibian, crashed near Pelican City, Alaska, on 4 November 1954. CAB U.S.A. Accident Investigation Report No. 1-0212. Released 17 June 1955.

Circumstances

The aircraft was operating a scheduled service from Sitka, Alaska, to Juneau, with scheduled stops at Pelican City and Hoonah, Alaska. The flight, cleared to proceed on DVFR (Defence Visual Flight Rules), departed Pelican City at 1305 en route to Hoonah, with one crew and two passengers. The only radio contact was the departure message and when the flight became overdue at Hoonah search operations were instituted. The wreckage of the aircraft was found the following morning in a mountain pass several miles southeast of Pelican City; the pilot was fatally injured, the two passengers were seriously injured.

Investigation and Evidence

The survivors stated that after take-off at Pelican City, the flight proceeded southeast up Lisianski Inlet about 11 miles and turned left up a mountain pass near Soloma Point. The sides of the mountains were visible, but clouds covered the tops and extended about halfway down the slopes. The flight encountered rain, fog, and turbulence as it proceeded up the pass.

The pass runs approximately northeast between Lisianski Inlet and Tenakee Inlet, winding between two mountain ridges. There are several sharp bends in its 10-mile length. The floor of the pass rises rapidly for approximately the first three miles from the Lisianski Inlet, or west, side. The highest point is at approximately the 1 500-foot level, whereupon the pass slopes down and widens for the next seven miles to Tenakee Inlet. Ridges and peaks of the mountains on each side rise to approximately 3 000 feet.

Near the summit of the pass, the pilot successfully negotiated a bend, turning right approximately 90 degrees. Almost immediately after negotiating the first bend, it was necessary to turn left for a second sharp bend. The pass at this point is about one-half mile wide. The survivors said that during the moderate to steeply banked left turn, the aircraft encountered a downdraft, dropped, and struck the ground on the left wing tip, and cartwheeled in final impact.

Examination at the scene revealed that the accident occurred at the 1 500-foot level in an open area of soft, moss-covered earth with numerous outcroppings of large rocks. The scene of the accident was about three miles from Lisianski Inlet and approximately one-fourth mile due south of the summit. Two prominent gouges indicated that the left wing float and wing tip struck while the aircraft was in a moderate to steeply banked left turn and on a west heading. The left wing float was destroyed and the wing panel sheared from the center section. Fuel spilled into the wreckage when fuel lines broke and fuel tanks ruptured. Fire broke out and burned unabated until all fuel was consumed.

The landing gear and flaps were retracted at the time of the accident. The pointer of the airspeed indicator was jammed at 160 mph. Both propellers were found in maximum low pitch and evidence indicated that considerable power was being developed. No evidence was found to indicate malfunction or failure of airframe, engine, or propeller components prior to impact.

Weather conditions at the scene of the accident were not observed by any witness on the ground. Weather conditions on the eastern mountain slopes near Tenakee Inlet, observed by an employee of Alaska Coastal Airlines who was hunting in the area, were sky overcast with light rain throughout the day and dense fog filling the pass at about the 1 500-foot level.

The U.S. Weather Bureau advised that the most probable weather conditions prevailing in the accident area were: "Scattered to occasionally broken clouds near 500 feet with an overcast between 2 000 and 4 000 feet with good visibility along the west side of Chichagof Island, but with sharply reduced ceilings and visibility along the higher ridges in rain and fog. Conditions along the eastern and southern slopes were probably worse than along the western side, with the lower deck of clouds broken to overcast and with much lower visibility. The winds prevailing at the scene of the accident are highly problematical since conditions in this area were extremely variable due to the rough terrain. Turbulence was undoubtedly present along and in the lee of mountain ridges and through the passes, with strong gusty easterly winds through the passes." The freezing level over Chichagof Island at the time of the accident was estimated to have been between 4 000 and 5 000 feet.

The Alaska Coastal Airlines station manager at Sitka stated that prior to departure of the flight at 1153 he and the captain studied the 0730 - 1030 weather sequences. Weather from the Chichagof Island area, received at 1020, and the Pelican City weather, received at 1043, were made available to the pilot. This weather information was essentially the same as that reported above.

The routes over which Alaska Coastal Airlines operates serve various coastal and island points in southeastern Alaska. The coastlines are characterized by high mountains, numerous bays and fjords, and islands with high mountains. Since most of these operations are over water, amphibian aircraft are used by the company to a great extent. Several overland routes are frequently utilized, many of which involve flight through mountain passes. The pass in which this accident occurred is the regular route between Pelican City and Hoonah, via Port Frederick Sound, particularly when weather conditions on the overwater route around the north end of Chichagof Island, which is the alternate route to Hoonah, preclude VFR operation. Weather conditions along this alternate route, while poor, appeared to have been satisfactory for VFR flight. All aircraft operated by the company which are 12, 500 pounds or less gross weight are restricted to DVFR flight. That part of the company operations manual pertaining to the overland route between Pelican City and Hoonah, via this particular pass, reads: "This route provides a ten-mile crossing of land between Tenakee Inlet and Lisianski Inlet. This crossing will be made at 3 000 feet."

When the flight departed Pelican City, the pilot apparently did not have sufficient information on weather conditions within the pass and on its Tenakee Inlet side. He should, however, have known of the generally poor conditions in the pass and beyond it through weather briefing before departure from Sitka. The pass is relatively narrow, and once entered, a turn to reverse course is difficult. There is no question but that he flew lower than the altitude prescribed by the company operations manual (3 000 feet) for this crossing. The base of the clouds was lower than this prescribed altitude, thus forming a tunnel through which he attempted to fly. Weather conditions near the summit of the pass, where the accident occurred, were only slightly above zero ceiling and visibility. The tunnel at this point was, therefore, almost blocked for contact flight. The location of the wreckage near the second bend and the heading of the aircraft at impact indicate that the pilot started to negotiate the second sharp bend in the pass when weather conditions made it necessary to turn back.

Study of the short gouges in the earth at the point of initial impact, the nature of the left wing panel damage, and the limited area of wreckage distribution demonstrated that the wing tip struck the ground while the aircraft was in a steep left bank and in a high rate of sink, thus indicating a left slip before impact. This was probably due to encountering severe turbulence while in the steep left turn and resulted in an abrupt and uncontrolled loss of altitude combined with an uncontrolled continuation of the left turn. This assumption is strengthened by testimony of the passengers in their descriptions of what occurred just prior to impact.

It is not known why the pilot elected to take the regular route through the pass, as opposed to choosing the alternate route over the water around the north end of Chichagof Island. The regular route through the pass saves about ten minutes' flying time, which might have been a consideration. As the aircraft climbed after take-off from Pelican City, it must have been apparent to the pilot that the pass could not be negotiated VFR at the prescribed 3 000-foot altitude, since the base of the clouds was lower than this altitude.

Although the captain had a wealth of experience in flying the rugged terrain of this area, this accident is indicative of questionable judgment and failure to abide by company procedures promulgated for safety reasons. The Board therefore concluded that he pressed into prohibitive weather conditions.

Probable Cause

The Board determined that the probable cause of this accident was loss of control of the aircraft during a steep turn in severe turbulence while the pilot was attempting to conduct visual flight at less than the required altitude and weather minima.

ICAO Ref: AR/368

No. 35

National Airlines, Inc., Lockheed Lodestar aircraft, crashed while landing at the Miami International Airport, Florida, U.S.A., on 12 November 1954
CAB Accident Investigation Report No. 1-0203

Circumstances

The aircraft, engaged on a scheduled non-stop flight from Key West to Miami, Florida, and on the return segment which concluded the airline's daily operation of three round trips between these cities, took off from Key West at 1802 EST with 3 crew and 11 passengers. The aircraft made a heavy landing due to the diffusion of the runway lights while landing in heavy rain. The undercarriage collapsed and the aircraft slid to a stop on its fuselage. Passenger evacuation was made through the cabin and was completed in less than one minute. There were no injuries or fire.

Investigation and Evidence

The flight was conducted in accordance with an IFR clearance which specified a flight altitude of 4 000 feet. Flight time to Miami was estimated to require 45 minutes via the Homestead, Florida, radio range (a holding point located 22 miles south-southeast of Miami). The alternate airport was designated as West Palm Beach, located 61 miles north of Miami.

The flight was made through intermittent rain and clouds which required about one-half of the trip to be flown under actual instrument conditions. Some turbulence was encountered which was of sufficient magnitude to require a reduction of airspeed for passenger comfort. At 1812, by en-route report, the flight estimated that it would reach Homestead at 1845.

At 1822, 1829 and 1833 respectively, Miami special weather observations were given the flight by the company dispatchers over company radio. These all indicated short periods of heavy rain, visibility under one mile and precipitation ceiling between 600 and 1 100 feet at Miami. The reports were acknowledged by the flight.

At 1850, the flight reported over the Homestead range station and was cleared by the Miami Approach Control to hold south of this position. At 1855, it was further cleared to the Miami range station, located 5.7 miles west of the instrument runway, 9R. The flight was cleared to descend to 3 500 feet and thereafter to 2 500 feet while approaching the radio range from Homestead. At 1903, the flight reported over the Miami range and was cleared to descend to 1 500 feet west of the range station and to proceed inbound from the range at 1906 for an instrument approach.

Between 1904 and 1906 approach control cleared the flight to land, requested that it report passing the range station inbound, and gave it the latest weather information; wind east-northeast 15 to 20 miles per hour, visibility one-half mile. The flight, at 1908, reported inbound and the approach controller again cleared it to land repeating the same wind and visibility information.

The local approach controller, positioned in the tower, which was 1-1/6 miles northeast of the approach end of runway 9R, was unable to see the approach and called the flight to ascertain its position. Receiving no reply to several calls and seeing what appeared to be stationary lights on the runway he dispatched the emergency equipment as a precautionary measure. Shortly thereafter the captain called the tower over the aircraft radio and stated, "I wiped the gear on landing".

During the investigation the captain of the flight stated that he had been briefed by the company dispatcher and U.S. Weather Bureau personnel on the anticipated weather conditions. While at the flight terminals, additional current weather information was furnished and while en-route special Miami observations were given them over the company radio facilities. The crew stated that they, having flown over the route four times that day, knew the weather was generally poor in variable conditions but except for brief periods they were well above the company night landing minima, ceiling 200 feet, visibility one-half mile.

When approaching the Miami Range Station from the Homestead range both crew members and several passengers interviewed stated that they were able to see the airport lights, the full length of runway lights, and the city lights of Coral Gables and Miami. The captain stated that at this time, under the existing conditions, he believed he could have properly cancelled his IFR clearance and proceeded visually for the approach and landing. Weather information for the airport given other flights by the tower personnel at approximately this time included an overcast ceiling at 2 200 feet, scattered clouds at 700 feet, and 3 miles visibility in rain.

Just before reaching the Miami range, after descending to 1 500 feet west of the range, the co-pilot and captain recalled that a weather report was given the flight by approach control, but they did not recall the details. This report, according to the transcription, was the first one given the flight which indicated visibility at the tower was then one-half mile in rain. This report was given before the flight reported inbound for the approach from the range station. Tower witnesses stated this information was prompted by heavy rain noted in all quadrants, the intensity of which had increased very rapidly. The tower gave the visibility report immediately upon the existence of this condition and pursuant to the tower's responsibility when visibility is observed to be below three miles.

The captain, who was making the approach from his left seat position, stated that during the approach he maintained visual reference and conformed to the ILS (Instrument Landing System) glide path by cross checking the ILS instruments. At the outer marker (located 4.4 miles from the runway) the captain stated he then could see the full length of runway lights. The approach was made at approximately 105 miles per hour, landing lights on, 60 degrees of flaps extended and the landing gear down and checked, a normal configuration for this type of aircraft. Some intermittent rain and turbulence were encountered. During the flare-out for a wheel-type landing, at about 85 or 90 miles per hour, the flight suddenly encountered intense rain which the crew said reduced visibility to near zero. At this point the captain said he heard the tower report one-half mile visibility. Simultaneously, the captain stated he felt the aircraft lifted by a strong gust or updraft and he then lowered the nose of the aircraft in a positive manner in order to stay as close to the runway as possible. At this time the closest runway lights were diffused in the water being pushed ahead of the windshield wipers and it was impossible for him to tell how high the aircraft was above the runway. The captain said that because of the slow airspeed, normal to the flare-out, and with wheels and flaps extended he considered it unsafe to attempt a go-around. He then felt the effect of the gust or updraft decelerate and the aircraft begin to descend, at which time he added substantial power and pulled back on the control yoke to arrest the descent. The aircraft did not respond to this control movement before it contacted the runway in a nose-low attitude. Both crew members stated there was no resultant bounce and the impact did not seem unreasonably hard. Almost immediately the right side of the aircraft went down followed by the left. The propellers began striking the runway and the aircraft slid to a stop on its fuselage.

Examination of the failed undercarriage components revealed that the failures resulted from impact forces in an upward and rearward direction with the aircraft in a nose-low attitude at impact. No evidence was found of fatigue failure.

The synoptic weather situation which existed during the evening of 12 November consisted of an extensive high pressure area centered in the Great Lakes extending southeast to northern Florida. An east-west pressure trough lay across the Caribbean to a low centre located in the western portion of the Gulf of Mexico. The wind, from the surface to 12 000 feet, was from the northeast with a southwesterly wind flow above and overrunning it extending to a high

altitude. The freezing level was at 11 000 feet. Potential instability of these air masses existed from the surface and, as a result of the convergence of the wind fields, shower activity ranging from light to heavy existed over the entire subject area. During the period between 1820 and 1920 several heavy showers occurred within the area of the airport. One airline captain who landed at 1905 stated that he encountered a heavy shower after landing which restricted his visibility to the extent his taxi operation was difficult. It cannot be determined from either the weather data or the shower reports whether there were several showers occurring simultaneously, or whether reports from different areas were the result of shower movement. Most witnesses, however, believed that the showers were moving from the northeast.

The meteorological conditions which existed at the time of the accident were conducive to instability showers varying in intensity. Under the existing conditions it was impossible to anticipate their exact time and place of occurrence. The vertical air mass structure was such that once a buildup of cumulus started, it would continue upward to between 20 000 and 30 000 feet.

It will be recalled the captain stated that when the flight encountered the heavy rain during the flare-out it also encountered a strong gust or updraft which caused the aircraft to lift. To arrest the ascent the captain lowered the nose of the aircraft in a positive manner and immediately thereafter encountered a loss of altitude which resulted in a hard nose-low landing. In order to produce updrafts or downdrafts of sufficient magnitude to affect the aircraft, considerable vertical velocity is required which must be attained by vertical movement of the air mass. It is, therefore, improbable that an updraft occurred so near the surface. There were definite indications, however, that the flight encountered strong, gusty surface winds from the northeast as it reached the edge of the shower. These gusts could have been produced by the horizontal outflow from the rain area. The effect of these conditions on the aircraft could be explained by the following theory. As the flight reached the edge of the heavy rain shower strong northeast gusts (headwinds) were encountered and as the flight progressed into the rain area the strong gusts abruptly ceased. This sequence of events would have resulted in a sudden increase in airspeed followed by an equally rapid loss of airspeed. The loss of airspeed would have resulted in a loss of lift and with the aircraft in a nose-low attitude account for its descent to the ground. Considering the low airspeed and altitude of the aircraft it is believed that there was insufficient time available for effective corrective action.

Probable Cause

The Board determines that the probable cause of this accident was a rain shower of unexpected intensity and attendant gusts which caused the loss of visual reference to the runway and the aircraft to lose airspeed resulting in a hard nose-low landing which failed the landing gear.

ICAO Ref: AR/354

No. 36

Aero/Nord Sweden AB, Airspeed A.S. 65 Consul SE-BTU crashed shortly after take-off from Sundsvall-Härnösands Aerodrome on 24 November 1954. Swedish Accident Investigation Report released 20 December 1954.

Circumstances

The aircraft had completed the outward journey on a newspaper delivery flight from Stockholm-Bromma to Sundsvall-Härnösands on 24 November 1954. At 14.47 hours local time a few minutes after take-off from the latter airport for the return trip, it crashed in woods east of the Indalsälvens river, 1750 metres from the Sundsvall-Härnösands control tower. The pilot was killed and the other crew member suffered serious injuries.

Investigation and Evidence

The aircraft had filed a flight plan with Bromma ATC for a VFR flight from Bromma to Sundsvall and return, with an ETD of 10.15 (GMT). The actual time of departure from Bromma was 10.41 (GMT). While no significant comments concerning the condition of the aircraft on the day of the accident were found in the relevant records of Bromma airport, investigation revealed that the engines had not been operating properly during the month of November and that the ground mechanic responsible for inspection of the plane as well as the crew mechanics who inspected it on the night before the flight did not possess the required certificates. The flight from Bromma to Sundsvall seems to have been quite normal. En-route newspapers were dropped on Mohed airfield since conditions there made it impossible to land. Current weather conditions in the area were generally poor with light snowfall. The 14.55 (local time) weather report for Sundsvall gave ground wind 70°, 6 knots, visibility 7 km, ceiling 450-480 m, 8/8 stratocumulus. The aircraft landed normally at Sundsvall at 14.24 local time, although it appeared to some witnesses that contact was made rather far down the runway. The aircraft unloaded and refuelled rapidly for immediate take-off. During refuelling, the driver of the fuel tanker noticed ice on the leading edge of the wing, which did not appear to be removed. Immediately after refuelling the crew boarded the aircraft, started the engines and taxied out for take-off from runway 34. It does not appear that the engines were tested prior to take-off. Radio liaison with ATC personnel was made at 14.40. Following instructions and latest weather information, take-off clearance was given at 14.42. The ground run appeared unusually long, and the aircraft did not become airborne until it reached the end of the runway. After leaving the ground, it began a gradual climb, the landing gear was retracted and the aircraft turned left continuing to climb. Shortly thereafter the landing gear and wing flaps were lowered as the aircraft turned back towards the airport. Losing altitude, it flew in an easterly direction over the boundary of the airport at a height of 20-30 m and continued at approximately the same altitude over the intersection of runway 16-34 and 08-26.

It was noticed both earlier and when the aircraft came over the aerodrome that its port engine had an unusual note and was coughing. Continuing to fly at this low altitude but in a somewhat more nose-up attitude than is normal, the aircraft crossed the eastern branch of the Indalsälvens. At this point the nose of the aircraft appeared to rise even further as the aircraft commenced a right turn. As this happened the aircraft went into a stall on the left wing, turned on its back, lost altitude and collided with trees in the woods beside the riverbank.

The aircraft was completely destroyed on impact but did not catch fire. Examination of the wreckage indicated that the right engine was operating at full power at the time of the crash, while the left engine may have stopped just before the stall. The landing gear was found extended and locked and the wing flaps were down. A tear-down inspection of the left engine revealed a broken intake valve.

Probable Cause

The accident was caused by an excessive climbing angle and stall with accompanying loss of altitude. The excessive climbing angle and the stall were caused partly by the fact that flight could not be maintained owing to the engine failure and partly by the fact that the aircraft's flying qualities had deteriorated as a result of snow and ice on the aircraft.

ICAO Ref: AR/370

No. 37

Garuda Indonesian Airways N. V., Douglas DC-3C aircraft, damaged on landing at Djambi Airport, Paalmerah, Indonesia, on 25 November 1954. Republic of Indonesia Ministry of Transport and Communications, Aircraft Accident Report VI/54

Circumstances

The aircraft was on a scheduled domestic flight Djakarta-Djambi, with a stop at Palembang, carrying 19 passengers and three crew (pilot, engineer and radio operator). The flight proceeded normally up to the landing at Djambi Airport Paalmerah, during which the aircraft ran off the end of the runway and, after passing the over-run, came to a stop in muddy terrain beyond the aerodrome area.

The aircraft sustained substantial damage; one passenger received an injury of minor nature.

Investigation and Evidence

The aircraft when approaching Djambi airfield received a weather report at 0751 GMT as follows: Wind N/E 6; visibility 25 miles, overcast; cloud base 4/8-1 500 feet, QNH 29.74; rain in sight W and N/E. At 0757 another weather report was received by the aircraft; wind WSW 10-15, visibility West 500 yds, to E 3 miles, overcast with rain, clouds 6/8-300 feet; QNH 29.70; runway slippery. At 0805 GMT the aircraft passed 600 feet overhead of the runway which was seen from the cockpit and the landing procedure was started on Runway 13. When the final approach was started the altitude was about 400 feet; visibility 1-1/2 - 2 miles. The throttles were closed at about 300 feet and full flaps applied. The approach path of the aircraft was too high and as full flap extension was only given when closing the throttles shortly before or just over the runway threshold, the aircraft touched well down the runway. There was the possibility that there existed a tailwind component which promoted delay of touch-down.

Although the actual touch-down point could not be established, study of marks on the ground and evidence in statements indicate that the touch-down might have occurred between 600 and 700 metres beyond the runway threshold. The aircraft attitude was tail-up during a major part of the landing run, the backwheel coming into contact with the ground only after 1080 metres beyond the runway threshold.

The captain stated that slight braking was applied initially but that on the last hardened part of the runway, where a new gravel surface was being made, braking was strong. The aircraft finally ran off the overrun into lower situated soft terrain and the undercarriage collapsed.

It was established that the captain was not familiar with the serviceability of the runway in use. On the date of the accident, notification with respect to the runway length and usability was as follows:

First 656 feet not usable for landing	(NOTAM 726)
End of R/W under water during heavy rains	(" 1036)
First 328 feet closed	(" 1383)
First 656 feet L.H. shoulder closed	(" 1412)
Work in progress on L.H. shoulder	(" 1478)

Accordingly the effective runway length under normal conditions available for landing was:

on Runway 31: 900 m - 2953 feet,
" " 13: 1 000 m - 3 281 feet - during heavy rains these values would be reduced, the last part of runway 31 being under water.

Note: On the first 328 feet of runway 31, closed due to work in progress, reconstruction works had, at the moment of the accident, proceeded so far that new gravel surface had been almost completed, final stage of rolling-in being in progress. So actual runway length available for landing on runway 13 was: 1 100 m - 3 609 feet. Notification with respect to runway surface condition generally recommended extreme caution in all aircraft movements on this aerodrome, and stressed slippery condition during and after rain, and in the Operator's Operations Manual mention is made of soft patches after heavy rains.

The runway length required for landing appropriate to the aircraft's weight at landing (26,604 lbs.) was estimated to be 965 metres - 3 170 feet (Zero wind; full flaps, hard level runway surface; approach speed at 50 feet height 1.2 V_{SO} i.e. 83 mph, normal braking after wheels touch the ground - landing length equals 70% of total runway required).

It was estimated that runway length for landing with a 6 knots tailwind component would amount to 1 060 metres - 3 470 feet.

Probable Cause

The probable cause of this accident was poor technique on the part of the captain, in landing the aircraft too far down the slippery runway at an excessive speed.

Contributory cause of this accident was error of judgment on the part of the captain, in that he failed to execute a missed-approach procedure.

It was recommended that data concerning the serviceability of runways at any time be covered in one NOTAM only. In such a NOTAM should always be included the actual serviceable runway length for landing and/or take-off, with indication of applicable runway direction.

It was recommended that standard practices in relation to weather broadcasts be strictly followed.

It was recommended that ground radio stations keep records of all correspondence.

ICAO Ref: AR/373

No 38

Northeast Airlines, Inc., Douglas DC-3 aircraft, crashed near Berlin, New Hampshire, U.S.A. on 30 November 1954. Civil Aeronautics Board, U.S.A., Accident Investigation Report, No. 1-0226, released 3 August 1955

Circumstances

The flight originated at Boston, Massachusetts, for Berlin, New Hampshire, with intermediate stops and was routine until the approach to Berlin. While on an instrument approach to the Berlin airport the aircraft crashed into the southern slope of Mt. Success, 13 miles southeast of the airport at about 1115 EST. The first officer and a company flight superintendent were killed and the captain was seriously injured. The stewardess and two of the three passengers were uninjured whereas the other passenger was injured.

Investigation and Evidence

A minute or so after take-off from Laconia for Berlin the flight requested an IFR clearance for the 73-mile flight which was at once approved by the company dispatcher at Boston, and issued by the CAA's Air Route Traffic Control Centre - "Boston ATC clears Northeast Flight 792 for an approach to the Berlin Airport via Blue 63 to cruise 8 000 feet."

At 1103 the flight called the company station at the Berlin Airport and asked for local weather. The station agent immediately gave the 1045 observation: Estimated 3 000 feet overcast; visibility 2-1/2 miles, light snow showers. The flight acknowledged but did not give its altitude and position. The agent then made a special weather observation at 1110 and transmitted the following information to the flight: 2 300 scattered, 3 000 overcast; visibility 2-1/2 miles; light snow showers, wind northwest 10; snow showers to the north. (This was close to the Berlin minima of 2 300-foot ceiling and 2 miles visibility.) The flight's acknowledgement of this transmission was logged at 1114; however, the actual time may have been as much as two minutes earlier as the agent was alone and busy. There was no further contact. No position report was received for North Conway, a company-required reporting point about midway between Laconia and Berlin.

At 1125 the company's Boston station asked by teletype for information regarding the flight. Accordingly, the Berlin operator called the flight at 1128 but received no reply. At 1130 he sent a special weather report and suggested that the flight return to Laconia. Again there was no reply. (The accident had already occurred.) This special weather was: Ceiling estimated 1 500 feet broken, 3 000 feet overcast; visibility 2 miles, light snow; wind northwest 10 (below Berlin minima).

Search activities were started when it was evident that the aircraft was down. Continuing low ceiling and snow squalls hampered search. On 2 December, a Northeast Airlines DC-3 sighted and identified the wreckage on the southern slope of Mt. Success, 13 miles southeast of the Berlin airport.

Survivors testified that the seat belt sign came on several minutes before impact and all occupants, including the crew, had their belts fastened. No significant injuries were sustained by the stewardess and the three passengers in the cabin. However, all three flight crew members were thrown forward, and two received fatal injuries. The captain, despite severe injury, supervised survival activities. A fire started under the left engine mount as the aircraft came to rest, but was quickly put out with snow and a cabin fire extinguisher.

Survival was the chief concern. Outside temperature was far below freezing and cabin temperature was dropping fast. Occupants huddled closely to conserve body heat, wrapping themselves with blankets, cabin insulation, upholstery, curtains, seat cushions, soundproofing material, and clothing from baggage.

The following morning the captain managed to send a series of radio messages after experimenting with different frequencies and improvised circuits. Only one message was heard. He also marked his assumed position, some five miles northeast of the airport, on an aeronautical chart. It was decided not to try walking out because of the lack of proper footgear and clothing, and also because the captain, the only one with any knowledge of the local geography, was fast losing vitality.

Late that day the weather improved. The captain could see the countryside and realized that his original position estimate was in error and that the crash site was southeast of the airport in the vicinity of Mt. Success. However, the batteries were then depleted and the radio could not be used. Falling temperature made survival even more critical that evening and night. Early the second morning, the Northeast Airlines' search aircraft spotted the wreckage.

The aircraft had struck the wooded and deeply snow-covered southern slope of the mountain, approximately 100 feet below the crest, at an elevation of 3 440 feet. Snow was falling at the time. Impact occurred while the aircraft was on a heading of approximately 350 degrees and nearly level both laterally and longitudinally. Airspeed was about 140 knots into a wind that was probably of 40-50 knots making the groundspeed 100 knots or less at impact. Ahead, the ground sloped up at an angle of some 10 degrees. The aircraft crashed directly ahead through timber for only about 100 feet. No timepieces were impact stopped nor was the precise time of the crash noted.

Trees tore away the left wing tip, the left engine, and a large part of the right wing. The fuselage was bent to the right at the wing by some 12 degrees so that the forward portion was at a direction of 2 degrees, with the rear part at 350 degrees. The cockpit was generally smashed and telescoped backward and upward but there was relatively little damage to the cabin proper allowing survival of all cabin occupants. The landing gear had been extended and locked before impact. Propeller pitch settings were: left blades 18 degrees, right blades 25 degrees.

Pertinent control and instrument readings were checked. Both altimeters were set to 29.66 inches, the latest altimeter setting given the flight. The directional gyro read 356 degrees. The No. 1 range receiver was tuned to 383 kc. and its volume was set at approximately 5%. The Omni (VOR) receiver was set at 117.5 mc, and its volume was 95%. The No. 2 range receiver ADF unit was tuned to 280 kc. and its volume was set at approximately 5%. The needle of the ADF indicator had broken so that it could swing freely. This No. 2 receiver (the one being used for ADF) was recovered from the aircraft and very thoroughly tested. No irregularity was found in the unit or any of its components. The 280 kc. setting was practically on the frequency of the Berlin beacon (281 kc.). This small difference would have little or no effect. However, the loop and the loop housing, mounted on the underside of the fuselage, were knocked off and the loop was not recovered until 13 May. A detailed study of damage to its main drive gear indicated that the most probable loop direction at the time of impact was 344 degrees. This would correspond, because of quadrantal compensation, to a cockpit indication of 335 degrees.

The H facility (a non-directional continuous low power radio beacon) on the Berlin Airport was ground checked on the day of the accident, both before (routine) and after the crash, and found to be operating normally. It was flight checked three days later when weather allowed, and also found to be operating normally. This beacon is the only radio navigational facility at the Berlin Airport.

The captain stated, in substance, that he climbed to 8 000 feet altitude, as called for in his clearance, while en route to Berlin. At this altitude he was above broken clouds until he was approximately 18 miles south of the airport. Beyond that point he was above a solid overcast. He had been using his ADF in obtaining a tail bearing on the Conway beacon and when about halfway to the city of Berlin, tuned it to the frequency (281) of the Berlin Airport beacon. The needle swung ahead and he followed it. He testified that he did not stay at 8 000 feet (his assigned cruising altitude and also the minimum en-route altitude for that segment of the flight) until he overheaded the Berlin beacon as required in the company's operations manual and as shown on his Jeppeson Berlin Plate. Instead, he started descent before reaching it.

The captain further testified, also in substance, that he entered the overcast at an altitude of about 6 000 feet, and thought that he passed over the beacon, as shown by the reversal of his ADF needle, at approximately 5 500 feet while in clouds; also, that he immediately started the prescribed let-down procedure, taking up a heading of 351 degrees and then turning to 25 degrees, rather than 36 degrees as specified, to allow for a northwest wind. While reversing his course in the procedure turn he struck the ground without seeing it. He experienced sharp turbulence and one or more severe downdrafts while in the overcast, one just before impact. Passengers corroborated the rough air.

Two men flying a privately owned Piper Apache saw the Northeast Flight shortly before it crashed. They were en route from Plymouth, New Hampshire, to Greenville, Maine. This course is about 50 degrees and passes about 11 miles to the southeast of Berlin, New Hampshire. Both men were pilots and one was primarily concerned with navigation which he was studying. Their radio compass was tuned to the commercial broadcast station at Berlin. Their cruising altitude was 7 000 feet where they were in clear weather with a quite solid overcast about 1 000 feet below them.

In the distance, to their right, they saw another aeroplane and as they came approximately abeam of the city of Berlin, 11 miles to their left, the other aeroplane was close enough to be identified (by its blue and white tail marking) as a Northeast DC-3. They watched it start down from their own altitude of about 7 000 feet and descend, with wheels down, into the overcast at 6 000 feet headed in a northwesterly direction. As it did so the Apache pilot retuned his radio compass to the beacon at the Berlin Airport. The needle swung nearly abeam to the left pointing at the Berlin Airport and also at the DC-3, just then entering the overcast about two miles from the Apache.

The Apache pilots landed at their destination and learned that the Northeast flight was missing. Believing it was the DC-3 they had seen, they immediately computed their position and the approximate time when they saw it enter the overcast. The position was 18 statute miles southeast of the Berlin Airport and the time was 1105.

The captain attributed the accident to a premature reversal of the ADF needle. But, as already stated, a detailed study of the ADF receiver disclosed no malfunctioning or irregularity in any of its components that could cause a premature reversal. It is only fair to state, however, that there have been a few extremely rare cases of unexplained premature ADF reversals.

The captain testified that he interpreted his clearance "... to cruise 8 000 feet", as meaning that he could descend from 8 000 feet before overheading the Berlin beacon and even go as low as 5 000 feet before starting his 171-degree approach track toward the airport. However, the operations specifications approved by the Administrator for the Berlin, New Hampshire, airport and the company's manual for guidance of pilots, called for maintaining 8 000 feet until overheading the Berlin beacon. It is difficult to understand why the captain, in view of his long experience including 15 scheduled landings at Berlin, interpreted his clearance to give him authority to descend, when he did, contrary to company requirements.

According to the Flight Information Manual, the term "cruise" rather than "maintain" is used in air traffic clearances to signify that descent may be commenced at the pilot's discretion. Its use is normally confined to relatively short flights under circumstances permitting the issuance of a clearance authorizing an aircraft to proceed to and land at the destination without further clearance. However, the Flight Information Manual also points out that "aircraft operated in accordance with IFR must be flown at not less than the minimum altitude established by the Administrator ... for that portion of the route over which the operation was conducted".

The requirements contained in this type of clearance are outlined in Civil Air Regulations 40.409*.

The type of clearance issued to this flight was an IFR clearance to cruise at 8 000 feet. An IFR clearance which does not specify "over-the-top" requires that an aeroplane shall not descend below the pertinent minimum altitudes for the initial approach until arrival over the facility has been definitely established. In other words, CAR Part 40.409 applied to the subject clearance.

In this case the minimum en-route altitude and the initial approach altitude were the same, 8 000 feet. Therefore the flight had no authority to descend below 8 000 feet prior to arrival over the H facility.

Had the flight been cleared to cruise at a higher altitude, say 10 000 feet, it would have been permissible to let down from 10 000 feet to overhead the station at 8 000 feet on the initial approach. A clearance to maintain 10 000 feet would require that the flight overhead the station at 10 000 feet.

The captain's premature let-down from his 8 000-foot cruising altitude was the dominant factor leading to the accident. The report emphasized that the crash site was nearly in line with the runway of intended landing, that the direction of impact was extremely close to the direction of the airport, that the point of impact was only some 100 feet below the top of a hill which was the highest land between aircraft and airport, only 13 miles ahead, and that the last Berlin weather given the flight was close to Berlin minima and becoming worse. The most probable position of the ADF indicator, 335 degrees, as mentioned previously was 25 degrees to the left of the aircraft's actual heading at time of impact. Because of many intangibles and unknowns entering into a determination of the probable direction, it was believed that the indicator may well have read zero (directly ahead) or close to it at time of initial impact, thus lending credence to the probability of a straight-in ADF approach.

In reconstructing this short flight from Laconia (only 73 statute miles) it is evident that the captain started his descent too early and was attempting a straight-in approach to the runway, in order to get beneath the overcast while short of the airport and ahead of the weather. His position, about nine miles to the right of course when starting down through the overcast, is

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* "40.409 Altitude maintenance on initial approach. (a) When making an initial approach to a radio navigational facility under IFR (excluding over-the-top conducted in accordance with the provisions of 40.408 (c), an aeroplane shall not descend below the pertinent minimum altitude for initial approach specified by the Administrator for such facility until arrival over the radio facility has been definitely established; (b) When making an initial approach on a flight being conducted in accordance with the provisions of 40.408 (c), a pilot shall not commence an instrument approach until arrival over the radio facility has definitely been established. In executing an instrument approach procedure under such circumstances, the aeroplane shall not be flown at an altitude lower than 1 000 feet above the top of the lower cloud or the minimum altitude specified by the Administrator for that portion of the instrument approach procedure being flown, whichever is the lower."

believed not to be accidental due to wind drift, but planned to facilitate a straight-in approach. Since the captain testified that he had visual reference to known objects on the ground up until a very few minutes before entering the overcast, it can only be concluded that he knew his ground position when starting his let-down. Moreover, testimony of the Apache pilots gives a clear time-position picture of the start of this let-down.

Probable Cause

The Board determined that the probable cause of this accident was a premature and unauthorized instrument descent to an altitude that did not permit terrain clearance.

ICAO Ref: AR/376

No. 39

Petroleum Helicopters, Inc., Sikorsky S-55 Helicopter, crashed in Gulf of Mexico near Grand Isle, Louisiana, 2 December 1954. CAB Accident Investigation Report No. 2-0051

(Note: This report has been included for its technical interest in the operation of helicopters. It is not included in the summary.)

Circumstances

A helicopter employed for the purpose of transporting oil drilling employees to Grand Isle from an oil drilling rig located approximately six miles offshore crashed into the sea approximately 200 yards offshore in the Gulf of Mexico during an attempt to land in heavy fog. Four of the five passengers perished as a result of injuries or drowning. One passenger and the crew of two received minor injuries. The aircraft was demolished by impact and fire that followed.

Investigation and Evidence

The helicopter departed Grand Isle heliport at 0115 and returned from the oil drilling rig with two pilots and five passengers at 0218, a flight normally requiring 10 minutes. At departure, lights located on the shore, varying between 6 and 10 miles away, were clearly visible but with a slight halo attributed to haze.

As the flight proceeded toward the shore vertical visibility steadily and rapidly decreased. After reaching the landing area only the hangar lights and an oil residue flare located near the heliport were visible as a glow through the fog from an altitude of 500 to 600 feet. A let-down was started but had to be abandoned through decreased visibility. At 0232 after a second attempt to land, the fuel warning light came on indicating 30 minutes remaining fuel. The pilot then decided to land on a clearing near the flare. An approach was made with approximately 40 knots forward speed. The approach seemed normal until the pilot realized he was overshooting the flare. At this time considerable glare was reflected in the cockpit. The pilot asked the co-pilot to take over the controls, who then applied full power, noting an exaggerated nose-down but laterally level attitude on the pilot's gyro horizon instrument and that the altimeter was then indicating 250 feet. Only a few seconds thereafter the aircraft struck the water.

Most of the wreckage of the helicopter was recovered from the Gulf. Examination revealed that at the time of impact the aircraft was nearly level both fore-and-aft and laterally, and was descending toward the water at an angle of approximately 35 degrees. Impact forces were severe in an upward and rearward direction. The fuselage was moderately telescoped and was broken off at station 206 located at the rear of the passenger cabin. The tail boom, together with the tail rotor and its shaft, remained generally intact. The entire wreckage revealed evidence of impact and fire damage; however, there was no evidence found of structural failure or fire damage prior to impact. Although the weight and balance manifests aboard the aircraft were lost, load computation and the seating arrangement indicated that the aircraft was loaded to a gross weight well under the maximum allowable of 7 200 pounds and that the load was properly distributed in relation to the centre of gravity of the aircraft.

Examination of the power plant and statements of the crew disclosed that no malfunction nor loss of power was experienced before impact and that all controls and instruments were functioning in a normal manner. The engine, a Pratt and Whitney R-1340, had been properly maintained.

At the time of the accident the flying operation of Petroleum Helicopters was varied and extensive in the United States, Panama, and South America. In the Grand Isle area it was a transportation service for oil and oil well drilling companies. The operation was confined to

transporting personnel very short distances between Grand Isle and several off-shore oil drilling locations. The service, a comparatively new method of transportation in the oil industry, was conducted to provide a fast and comfortable means of transportation on a regular and emergency basis, involving approximately 45 flights during a 24-hour period.

Investigation disclosed that the company employment standards for helicopter pilots were high and that training and supervision were continually conducted by the chief or assistant chief pilots to ensure a safe operation. Company policy gave the pilot authority to discontinue or cancel a flight if conditions, in his opinion, made the flight inadvisable. The minimum weather conditions for VFR flights were established at: ceiling 300 feet and visibility 1/2 mile. Other operating procedures and requirements provided that the acting co-pilot ensure that passengers were equipped with and wore life jackets and that the passengers took seats commensurate with the best loading pattern. The co-pilot also prepared the required manifests and ascertained that seat belts were fastened before the flight. According to testimony, these requirements had been met before the subject flight.

Several witnesses substantiated the crew's statements that prior to the time of take-off they could see shore lights and other offshore drilling rig lights which varied between 6 and 10 miles away. Stars were clearly visible. Witnesses offshore and at the heliport stated that at both locations fog formed very quickly soon after the flight departed.

Both crew members were well qualified and had received regular checks on company operating and emergency procedures for helicopters. Both also were first pilots and during daylight hours flew alone. At night, however, as a safety measure two pilots were required to operate the S-55 and the pilots acted as flight commanders on alternate flights. Communications equipment installed in the aircraft, at the Grand Isle heliport, and at each offshore terminal provided continuous contact between the aircraft and any terminal on one fixed radio frequency. Operating procedures gave aircraft transmissions priority over any other messages.

At the present time helicopter flight characteristics have made instrument flight difficult under certain conditions, especially during the approach and landing configurations where low speeds are necessary. Although great progress has been made, the S-55 helicopter and others have not yet been certificated for commercial instrument operations. Therefore, Petroleum Helicopters did not intend that flights be made unless continuous visual ground reference could be maintained.

The weather conditions which existed at the time of the accident consisted of a cold front which extended east and west through northern Louisiana and which was moving slowly south until at 0030 on 2 December it was about 50 or 60 miles north of Grand Isle. The front separated a relatively dry polar marine air mass to the north and a moist tropical stable air mass to the south. Characteristic of the season, the inland water was colder than the Gulf water and night radiation cooled the land surfaces rapidly. As a result, the air near the surface was cooled to the dewpoint, whereas less cooling occurred in the Gulf water. These factors, coupled with the stable air mass and light surface wind, produced fog along the land and the inland and coastal waters in the Grand Isle area ahead of the front.

The crew of the aircraft stated that on the day of the accident they read the weather bulletins which indicated the possibility of patchy inland fog during the evening hours of 1 December and early morning hours of 2 December. They also stated that because of the forecast they were especially observant of the haze condition prior to take-off.

Analysis

The fog which the flight encountered was undoubtedly variable in intensity and thickness and was drifted by the light northwest wind flow. It appears that the fog at Grand Isle formed to a light degree before the flight left and that denser fog formed and moved in very rapidly during the flight. This situation and the accident that resulted showed the need for more frequent, more adequate, and detailed weather forecasts and advisories in Petroleum Helicopters' operation. The rapid formation of fog also vividly pointed out the need for some observation equipment

to be located at Grand Isle so that conditions there can be constantly observed and indicated changes immediately recognized.*

Upon reaching the Grand Isle landing area the crew found it covered by ground fog. (Flight characteristics and instrumentation thus far developed have not been adequate for helicopter instrument approaches and landings.) The situation therefore was an emergency one. Additionally, remaining fuel, although adequate for the company's normal operation, was insufficient for an extensive continuation of the flight. It is believed that in the emergency the crew should have called the oil drilling rig by radio to make a positive determination as to whether or not the fog was existent there also. However, evidence indicates that shortly after departure fog did reach that position and within the time required to make the return flight it would have been fog bound.

During the pilot's attempt to make a visual landing near the oil flare it is believed that he began to lose visual reference with respect to the attitude and position of the aircraft during the descent into the fog. As the aircraft passed over and beyond the flare the condition was aggravated by reflected glare and immediate darkness which followed. At this moment, without visual reference, the pilot lost control of the aircraft.

Probable Cause

The Board determined that the probable cause of this accident was the loss of visual reference caused by fog and glare, which resulted in a loss of control by the pilot during an attempt to land.

* During the public hearing it was learned that Petroleum Helicopters, Inc., has ordered meteorological equipment for measuring wind direction and velocity, temperature, dewpoint, and barometric pressure. This equipment will provide some on-the-spot weather information in the Grand Isle area and especially aid in determination of conditions under which fog may result. The company will also obtain radio equipment so that it may receive CAA aviation weather broadcasts from New Orleans, which will be utilized in their offshore operations. They will install a TWX circuit from Lafayette for receiving forecasts and other information from CAA schedule "A" circuit.

ICAO Ref: AR/339

No. 40

Trans-Canada Air Lines Lockheed Super-Constellation aircraft, crashed near Brampton, Ontario, Canada, on 17 December 1954

Circumstances

On the night of 17 December 1954, at 2132 EST the Trans-Canada Air Lines Flight from Tampa, Florida, with a crew of 7 and 16 passengers, landed in farm country some eleven miles west of Toronto (Malton) airport during an instrument approach to Runway 10 and was progressively demolished through impact with trees during a run of some two thousand feet. There were no fatalities but the crew and passengers suffered injuries which varied from minor to serious. Fuel spilled from the aircraft and caught fire and some of the wreckage also caught fire. When the fuselage came to rest there was a flash fire within the cabin which caused burn injuries to some of the passengers and one stewardess, but it was some time before this main portion of the wreckage began to burn.

Investigation and Evidence

Earlier in the day the same crew had flown the same aircraft on a scheduled operation from Montreal, P.Q., to Tampa, Florida, with an intermediate stop at Toronto, Ontario. This flight had departed from Montreal at 0902 EST and arrived at Toronto after 1 hour and 33 minutes of flying time. There was a stop at Toronto which lasted for approximately 1 hour. The aircraft departed for Tampa at 1157 EST and arrived at 1643 EST. This section of the flight was very slow because the winds aloft were very much greater than had been forecast.

During the entire duration of flight from Montreal to Tampa the aircraft and all the equipment therein, including the engines, functioned normally and satisfactorily to the best of the crew's knowledge.

There was a stop of 1 hour 20 minutes at Tampa. During this time the captain visited the meteorological office and filed his flight plan for the return trip from Tampa to Toronto. The headwinds which he encountered on the flight down were still blowing and he estimated a return flight time of only 3 hours 15 minutes.

The flight departed from Tampa and was airborne at 1810 EST (6.10 p.m.). The flight plan called for a cruising altitude of 21 000 feet which would keep the aircraft well above all local United States air traffic and would, in fact, keep it mostly above the weather. One hour and forty minutes prior to take-off the weather map indicated a southerly flow at the surface from Tampa to Buffalo. Between Buffalo and Toronto there was a weak warm front lying across the route of the flight. This weak front was moving northward and weakening to such an extent that six hours later it could not be identified. By that time, however, a new warm front had developed across the route roughly midway between Tampa and Toronto. A cold front running roughly north and south along the 85° meridian lay to the west of the route of the flight, one hour and forty minutes prior to the take-off.. This cold front moved steadily eastward and six hours later (2230 EST) rain was falling across the whole of southwestern Ontario, and southward across the Great Lakes and down into New York, Ohio and Pennsylvania. These were the conditions approximately one hour after the flight had crashed.

The weather conditions as briefly described were not expected to lead to any unusual or abnormal atmospheric conditions at the height (21 000 feet) of the flight. It was anticipated that the flight would be mostly on top of the weather, especially for the northern portion of the route where the cloud top was expected to be around 13 000 feet. In descending, it was to be expected that the aircraft would run through layers of cloud, the first at 13 000 feet, down to a few hundred feet above the ground where the ceiling was expected to be about 600 feet, variable between 400 feet and 800 feet. On the whole, the weather conditions were acceptable for this type of aircraft and the navigational facilities available. The low ceiling at Toronto (Malton) indicated that an ILS approach would be necessary on Runway 10.

After reaching Erie at 2103 EST, the flight was cleared to descend and it left 19 000 feet at 2104 EST, and began a continuous descent during which time it picked up extra speed.

The Toronto Area Traffic Control Centre assumed control of the flight from the Cleveland Centre, after the aircraft had passed Long Point. At 2112 EST the Trans-Canada Air Lines radio operator, who had been communicating with the flight advised the ATC Centre that the aircraft had reported reaching 13 000 feet and was requesting further clearance.

At 2114 EST the Toronto ATC Centre issued its first clearance to the flight - "ATC clears Flight 661 to the ILS outer marker, Runway 10, cross Ash descending the outer marker at four thousand, no delay expected".

TCA radio recorded that at 2119 EST the flight reported approaching the Ash and descending and was changing to the tower frequency. From this time on all communications with the aircraft were handled by the control tower.

According to the tower incident log, the flight called the tower at approximately 2123 EST to report that it was by the Ash intersection. At this time the tower acknowledged and informed the flight that the Runway was 10, the surface wind 15 mph at 110° and the altimeter setting was 29.65 inches. This was acknowledged and the captain and the first officer set their altimeters accordingly.

Just prior to arriving at the Ash the two range receivers were tuned in. The captain's, the red receiver, was tuned to the Toronto range so that in the event of a missed approach he could use the range to reorientate himself. The first officer's receiver, the green one, had been tuned to the outer marker of Runway 10 so that the aircraft could home onto the marker.

The aircraft crossed the Ash intersection at 9 000 feet or slightly lower, at an indicated airspeed of close to 250 knots. The true airspeed at this height would be about 284 knots which, with the tail wind then blowing, gave a speed over the ground of the order of 332 knots (382 mph). The indicated airspeed for cruising during the earlier stages of the flight was in the neighbourhood of 190 knots or slightly higher. This figure gives some idea of the extra speed picked up during the descent prior to the Ash.

In view of the height and slight additional speed, the captain called to the flight engineer that he had the power and from then on the captain adjusted the power himself in order to control more closely his speed and rate of descent. The aircraft was at this time travelling on a magnetic course of 039° flying along the southwest leg of the Toronto radio range station. Approximately three and a quarter minutes after crossing the Ash the aircraft was over the range station at about 6 000 feet and the captain had decreased the indicated airspeed to about 210 knots. The captain immediately put the aircraft into a 20° banked turn to the left towards the outer marker, continuing at the same time to lose altitude and to decelerate the aircraft to 190 knots so that the flaps could be lowered to the take-off position (190 knots being the maximum speed at which this can be done). At the same time the captain called for the "in range" checks to be done and the "fasten seat belts"and "no smoking" sign was switched on as part of these checks.

At the conclusion of the turn from the range station, the captain established the aircraft on a course of 320° and shortly thereafter the flight passed through the localizer east of the outer marker. The captain did not make a correction to the course and continued for some time to fly on 320° until at length the first officer gave a hand signal to indicate a further turn to the left. Simultaneously with this signal the captain commenced another 20° banked turn to the left. Just about this time, or slightly earlier, the speed was down to 195 knots and the captain lowered the flaps to the take-off position. The aircraft was then at about 5 500 feet.

Half way through the turn the aircraft passed by the outer marker. The captain and the first officer were aware that they were some distance north of the marker, because the ADF (aircraft direction finding) needle of the green range receiver was swinging slowly around pointing to the bearing of the marker from the aircraft. At the same time the captain could hear the bleeping of the Campbell Cross marker in the background. When the aircraft was heading 280° the ADF needle indicated that the outer marker was exactly on their beam. The aircraft must

have been too far from the outer marker to receive a marker signal, which they would have done if they had passed close to it. The captain does not remember getting a marker signal and the first officer implied that there was no marker signal. The altitude of the aircraft was by this time down to between 4 000 and 5 000 feet and the speed was about 190 knots. Through the tower the aircraft reported to Toronto Area Traffic Control that the flight was by the outer marker, outbound at 4 000 feet. The time was 2123 EST. The control tower operators were under the impression that the flight had reported by the Ash at 3 000 feet and were consequently surprised to hear the flight say it was not at the outer marker at 4 000 feet. Accordingly, the tower acknowledged the message and asked the flight to confirm that it was at 4 000 feet. The flight replied immediately "affirmative at four". On one or two occasions subsequent to passing the range station the captain had checked the wing leading edges for ice deposits by turning on the sealed beam lights used for illuminating the leading edges. No icing conditions were encountered during this approach pattern.

The captain brought the aircraft out of its turn, onto the bisector heading, a course of 235°, and continued towards the localizer with speed and altitude progressively decreasing. The flight passed through the localizer at about 165 knots indicated airspeed and at an altitude of 4 000 feet. It was about this time that the captain lowered the undercarriage which helped also to reduce the airspeed. The tower then called the flight to report that another TCA aircraft had just landed (at 2125 EST) and had encountered a cloud ceiling of 300 feet ragged. At 2126 EST the Toronto Area Traffic Control Centre issued its second and final clearance to the flight, which was transmitted by the tower and acknowledged by the aircraft at 2127 EST about one minute after it had passed through the localizer. This clearance indicated that the flight was number one on the approach and was cleared to the Toronto Airport for an ILS approach on Runway 10 and was to report on leaving 3 000 feet.

After crossing the localizer and noting a full scale deflection of the localizer needle, the captain continued on course (235°) for some fifty seconds before he began his procedure turn, a 20° banked turn to the right which would eventually take him back to intersect the localizer once more. The indicated airspeed was now down to 135 knots and half way through the procedure turn the first officer, who was doing all the radio transmissions from the aircraft, called the tower that they were through 3 000 feet. The time was 2129 EST. The landing lights had been lowered at an indicated airspeed of about 150 knots just about the time that the flight was acknowledging its clearance to the airport. They were not switched on, however, and the pratice would be to do so when the aircraft broke through the overcast and became "contact". Some time during the procedure approach pattern, the captain had taken a precipitation check by switching on the white nose lights to determine whether it was raining or snowing. The aircraft continued to descend at about 600 feet per minute.

The flight returned to the localizer and the captain began a 45° turn to the right to align the aircraft with the localizer inbound on a course of 100°. The captain overshot the localizer slightly, not enough to give a full-scale deflection of the localizer needle, and he made immediate course corrections to 120° and then 110° to bring the aircraft back on the correct course in the middle of the localizer beam. The aircraft was at 2 500 feet when it first cut the localizer and this occurred shortly before 2130 EST.

The flight continued to fly along the localizer beam towards the outer marker still descending, and as the 2 000 feet altimeter reading was being neared, the first officer picked up the microphone and called the tower to say that they were at 2 000 feet inbound. The time was 2131 EST. There is some question as to whether this report was initiated by the first officer or by the tower.

As soon as the first officer put down his microphone, he glanced up and noticed that the altimeter read 1 800 feet. As they had not yet intersected the glide path and were still beyond the outer marker, TCA regulations require a minimum altitude of 2 000 feet to be maintained. The first officer appreciated the situation and drew the captain's attention to it by pointing to the "2" on the altimeter. The captain acknowledged by nodding his head and raising his right thumb. He immediately instructed his first officer to carry out the "before-landing" check.

Just prior to this the captain believes the control tower called him and made some reference to the high-intensity approach lights which were full up and would be turned down when the flight so requested. The controller in the tower denies that any such message was sent.

The pre-landing check occupies the first officer for about 45 to 50 seconds, during which time he calls for certain checks from the flight engineer and makes a number of checks himself. The flight engineer is only occupied for about five to ten seconds, and about fifteen seconds after he had completed his portion of the checks he noticed that his altimeter read 1 500 feet.

The first officer, on completing his pre-landing check, put down his check list and returned his attention to the flight instruments. He noted first that the glide path needle was in the full up position, indicating that they were well below the glide path, second, that the airspeed was at 130 knots and finally that the altimeter read 800 feet. He immediately had a feeling of panic and looked at the ADF needle, noting that they had not yet gone by the outer marker. The first officer put out his hand and pointed to the ADF needle and yelled to the captain that they had not gone by the outer marker. As he lowered his hand the aircraft struck the ground and almost simultaneously the first trees. The height of the terrain at this point is 800 feet. The time was about twelve seconds after 2132 EST. At this time the control tower called the flight to give information on the runway conditions but received no reply. Being unaware of the extent of the damage to the aircraft, the captain decided against trying to climb away and called to the first officer to cut the switches. The first officer noted that they were headed for a large tree and he threw up his arm. They hit the tree as the captain finished speaking and the first officer remembered nothing more. He was unable to comply with the order to cut the switches.

The complete flight from Montreal to Tampa and return, via Toronto, involves approximately 12 hours' flying. With stops on the ground included, this entails a total time of about 15 hours. This should be increased by another hour, bringing the total to 16 hours, because the crew must report at Dorval one hour before flight time in order to check the weather and file a flight plan. It was considered that this is a long day for a crew to be on duty, but pilots do not consider it to be particularly arduous provided that adequate rest has been secured prior to the flight.

Approximately one week prior to the flight in question the captain returned from leave. During the ensuing week he made one round trip to Bermuda and two round trips to Tampa, involving a total flying time for the three trips of 43 hours. He was off duty for two days, on Tuesday and on Thursday, the day prior to the flight in question. The captain spent Thursday evening quietly. He remained at home, going to bed at about 10 p.m. and reading until 11 p.m. The first officer's evidence revealed that the captain was reading his Flight Manuals. The first officer had been visiting friends in Dorval and had dropped in on the captain before going to bed himself.

The captain was feeling quite fit when he reported at Dorval on the morning of 17 December. During the previous week he had suffered no illness or indisposition and was not tired or unwell in any way prior to the flight of the 17th. He held an A-1 medical category which was confirmed at his last medical inspection on 10 December, one week prior to this flight.

There is evidence in the captain's testimony that at or about the Ash intersection he prepared for the task ahead of him which would demand all his skill and attention. He took over the power, was flying the aircraft himself and gave instructions for the in-range and before-landing checks to be carried out. He himself checked for ice on the leading edges once or twice and checked the precipitation. He was not feeling tired or unwell or under any stress.

Despite the tower operator's belief that the flight had reported by the Ash at 3 000 feet, the testimony of the crew and the Board's own studies lead them to the conclusion that the aircraft must have crossed the Ash at between 8 000 and 9 000 feet.

In establishing the times and events that happened subsequent to the Ash, the Board was somewhat hampered initially by the absence of clear unequivocal records from the control tower. The tower was equipped with a recorder to provide a permanent record of all messages transmitted from the tower. This equipment is inspected once a week to confirm its serviceability.

One of its major reasons for being there is for just such an accident as that under investigation by the Board. Unknown to the tower controllers, the recorder had been inoperative for some three days due to a broken wire. A controller could quite readily ascertain at any time if the equipment was working by playing back a small portion of the record. This was not done during the three days prior to the crash and no records were therefore available of the tower controller's message to the flight, other than those written by hand by the controllers immediately after the crash and based on their memory of the events that took place. These were not completely satisfactory. Fortunately, the Area Traffic Control Centre could supply accurate times and details of the clearances sent to the aircraft, but there remained some conflicting evidence regarding some of the messages exchanged between the tower and the flight.

From the probable flight path calculated by the Board it was evident that the captain made little, if any, allowance for the wind after turning from the range station towards the outer marker. The course of 320° which he flew caused the wind to drift him steadily to the right. It was appreciated that the tower gave him a surface wind of only 15 mph blowing from 110° but the captain knew he had had strong (90 knot) winds from the south to south-west and he should have made some allowance for these, since he was still between 5 000 and 6 000 feet high. It is difficult to understand why the captain held a steady heading at this point and why he did not use the green ADF needle to home on the outer marker, since it was tuned to it. This is the course which he should have followed in accordance with good airmanship. This would have brought him directly over the outer marker and outbound along the localizer.

The first officer appreciated all this and at length indicated to his captain that a left turn should be initiated. By the time they passed by the outer marker they were about four miles north of it. The captain then turned to a course of 235° intending to cut across the localizer, which bears 280°, at a 45° angle. But here again the strong winds from 220° continued to drift the aircraft to the right and with more effect now because the aircraft was travelling more slowly than it had been earlier. The net result of this was that the aircraft was carried much further west than the captain had imagined. He was aware that the time from the outer marker to the localizer was rather long.

The captain continued across the localizer and out, for what he testified was fifty seconds, before commencing his procedure turn. Actually, from the Board's studies it was evident that he flew out for more nearly two minutes and fifty seconds. He completed his procedure turn and was successful in aligning the aircraft on the localizer inbound after a small initial swing across it. The aircraft was then about nine and one-half miles out beyond the outer marker. Good airmanship would have placed it only three or four miles out from the marker, or maybe five under adverse conditions. The captain himself places five miles as an acceptable limit for this distance but was of the opinion that he was six miles out when he finished his procedure turn on the night of 17 December.

Despite the appreciable distance that the aircraft was beyond the outer marker, a safe successful landing could still have been effected if the TCA and the Department of Transport flight regulations had been adhered to. The ADF needle was still pointing ahead, indicating that they had yet to pass through the outer marker. The glide path needle was fully up, indicating that they were still below the glide path. The regulations prescribe that the aircraft must not be taken below 2 000 feet until the aircraft has flown in sufficiently to intercept the glide path, after which it can follow the glide path down to the runway. In any case, the outer marker of Runway 10 is not to be crossed at less than 1 600 feet altitude. There is a final TCA regulation which concerns the ceiling at Malton. The minimum altitude to which an approaching aircraft shall descend without becoming contact is 300 feet. The elevation of Malton is 565 feet. Accordingly, if an aircraft on the approach reaches 865 feet without breaking out below the overcast, power is to be increased and the aircraft climbed away.

The aircraft was just below 2 500 feet when established on the localizer inbound. If the captain had been using his ILS instrument properly he would, if he flew level, shortly see the glide path needle descend from its full up position. If he continued in level flight the needle would descend below the horizontal, indicating that he had flown through the glide path and was now above it.

The captain continued his descent to 2 000 feet and on down to 1 800 feet. He acknowledged the warning message from his first officer, who pointed to the altimeter and who, in his testimony, also says that he drew the captain's attention to the ADF needle still pointing ahead to the outer marker. The captain appears to have ignored the importance of the message, which may have been acknowledged more as a reflex action than as an indication of understanding. In any case, he took no action. He stated that there was no question that he misread the altimeter as 2 800 feet instead of 1 800 feet. The captain ordered the before-landing check to be carried out and during this time, unfortunately, the check list held by the first officer obscured the flight instruments from him for about one minute.

The flight engineer's altimeter is always set at 29.92 inches, the standard sea level pressure. Under the atmospheric conditions at Malton, at the time of the crash, sea level pressure was 29.65 inches and the flight engineer's altimeter would, accordingly, read too high and an indication of 1 500 feet thereon would correspond actually to a true height above sea level of only 1 245 feet (445 feet above the terrain at the scene of the crash). At the known rate of descent of the aircraft 1 245 feet would be reached at about 45 seconds after 2131 EST or approximately ten to twenty seconds after the engineer completed his portion of the pre-landing check. This corresponds reasonably closely with his testimony (15 seconds) regarding the time at which he noted 1 500 feet. Further, at the rate of descent then occurring the aircraft would descend through the 445 feet, which it was above the terrain, in 27 seconds. In the flight engineer's testimony he stated that the crash occurred about 30 seconds after he noted 1 500 feet on his altimeter. From this evidence the Board concludes that the first officer's altimeter and the flight engineer's altimeter were in reasonable accord and were functioning correctly and that the first officer's altimeter was correctly registering the height above sea level during the descent to the ground.

Instead of climbing back to 2 000 feet, as he should have done, or holding at 1 800 feet or even 1 600 feet, the minimum altitude for going through the outer marker, the captain continued to descend and even when he reached 865 feet, the Company's "minimum" for Malton, he still continued to descend and flew on down into the ground. He appears to have ignored the readings of the ADF needle, the glide path needle and the altimeter. The captain stated that to his knowledge he did not fall asleep at the controls, nor did he daydream or become inattentive. He admitted the possibility of a fixation on one or more instruments to the exclusion of others. The captain heard the first officer shout the warning that they were not by the outer marker yet, but it seemed to have no implication of imminent danger to him.

The Board believed that the captain was not using his ILS glide path needle as an aid to the approach and, under the impression that he was much closer to the airport than he really was, was descending at a steady rate along the localizer expecting at any minute to see the approach lights.

FINDINGS

On the basis of all available evidence, the Board finds that:

1. The Trans-Canada Air Lines, Super-Constellation aircraft and all the members of its flight crew were properly certificated and the flight was properly dispatched.

2. The aircraft had been properly maintained, and there was no evidence of fire, structural or mechanical failure or malfunctioning of any component prior to the crash.

3. The Control Tower and the Area Traffic Control Centre at Malton were properly manned with certificated Controllers.

4. The outgoing message recording equipment in the Control Tower had been inoperative for the last three days prior to the accident due to unserviceability, unknown to the Tower Controllers.

5. The accident occurred in poor weather when the ceiling had fallen to about 300 feet ragged at Malton, but was still within the approved limits.

6. Another TCA aircraft landed at 2125 EST, approximately seven minutes prior to the crash. The pilot of this aircraft also carried out an ILS landing on runway 10 and reported no difficulty and stated that the ILS equipment was functioning properly.

7. Approximately 30 minutes after the crash, air traffic movement was resumed at Malton and a number of aircraft landed successfully, using the ILS equipment on runway 10. The first pilot to land touched down approximately 50 minutes subsequent to the crash. He reported no difficulty in his approach and stated that the ILS equipment was functioning properly.

8. The ILS equipment at Malton Airport is continuously monitored by radio technicians on duty at the airport. Their evidence indicates that the equipment was functioning normally and was in almost continuous use during the evening of 17 December.

9. The crew of the aircraft understood what the weather conditions were to be during the flight and at Malton.

10. The captain had a medical category denoting physical fitness for the renewal of an Airline Transport Pilot Licence which was confirmed at his most recent medical examination on 10 December, one week prior to the flight in question. This medical examination was conducted by an Approved Department of Transport Medical Examiner at Montreal. Subsequent to the crash, examination of the captain by a Medical Board has revealed that: "It is the considered opinion of the Medical Board that the captain was not suffering from a mental or physical condition that would interfere with the safe performance of his duties."

11. The first officer, despite his duties which involved "In-Range" and "Pre-Landing" checks during the approach pattern, displayed an alertness concerning the procedures carried out by the captain, and on three separate occasions indicated to the captain conditions which required correction.

12. The captain of the aircraft showed poor airmanship in the execution of his approach pattern, in that he made inadequate allowance for the strong prevailing wind and failed to utilize the ADF receiver to home on the outer marker.

13. The captain failed to carry out an approved ILS let-down and, in so far as the position and the altitude of the aircraft were concerned, he ignored the indications of the ADF needle tuned to the marker, the ILS glide path needle and the altimeter.

14. The captain ignored the warning from his first officer that he had descended below the regulation height.

15. The captain was under the impression that he was very much closer to the airport than he actually was.

16. The captain broke the regulations regarding the minimum altitude at which the glide path is to be intersected, the minimum altitude at which the outer marker is to be crossed, and the minimum altitude to which the aircraft may descend on the approach at Malton without becoming contact, and continued his descent until he flew into the ground.

Probable Cause

The Board of Inquiry found that the accident was caused by negligence on the part of the captain.

RECOMMENDATIONS

The Board of Inquiry has already referred to the fact that messages transmitted from the Control Tower were not recorded because of equipment unserviceability. In view of the importance of the records provided by this equipment in cases of emergency, the Board is of the opinion that more frequent checks of the equipment should be carried out than once a week to ensure its serviceability at all times.

At the present time, existing equipment is designed to provide a record of outgoing messages only. The Board believes that this is inadequate and there should be available a record of all two-way communications carried out between aircraft and the Control Tower. The Board recommends that consideration be given to the installation of such equipment.

The Board has been impressed by the importance of the time element in its investigation of this accident. The Board observed that all Traffic Control personnel are time conscious in that messages received and transmitted are given a referenced time. At the same time, the Board recognizes that this timing is provided by jump-clocks, which can be in error by as much as plus or minus 30 seconds. It is further evident that the various control agencies involved in the passage of an aircraft in flight may not have their time references synchronized. This also applies to the aircraft's own time clock.

The growing speed of air transportation and the gradual introduction of turbine engined aircraft would indicate a need to improve the accuracy of the methods of recording the time and to adopt a uniform time reference. The Board's inquiry indicated that in many cases, the time recorded by hand applied not to the position of the aircraft, but to the time at which the Controller wrote the message down. An attempt should be made to ascribe to the position report from the aircraft the precise time at which it reported.

The weather reported for the flight from Tampa to Malton was an accurate forecast of the weather encountered both during the flight and at its terminal point. The weather conditions at Malton were steadily deteriorating and it is to be noted that the flight arrived at Toronto when the weather conditions were at their worst. However, these conditions at Malton Airport were still within the approved limits for ILS approach. The conditions persisted for several hours subsequent to the crash although it is believed that the ceiling lifted to between 500 and 600 feet during this time. Aircraft continued to make ILS approaches on Runway 10 throughout the night.

The Board had the impression, when the captain was giving testimony, that he was vague in describing the technique which he employed to carry out an ILS landing. In examining the evidence provided by the captain regarding his behaviour during the approach to Malton Airport, there are a number of actions which he took which indicated that he was fully alert to the task which engaged him. At the same time, there are a number of things he failed to do, which indicated at least a lack of alertness.

In the fact of a possible lack of alertness, the Board had to consider whether or not the basic techniques and procedures which the captain was employing during his approach were of an approved nature. The Board had the impression that the captain may have been using a method of approach which ignored the Glide Path needle and would not be approved by the Company or the Department of Transport. If the aircraft had not been so much further from the outer marker than the captain believed, it is quite conceivable that some other method of approach, which ignored the glide path needle and which he may have been using, might have led to a successful landing.

The Board recommended that Trans-Canada Air Lines and other operators should check more closely the procedures adopted by their pilots in the conduct of ILS approaches, what techniques they use and what instruments they observe. The Board is aware that it could be argued that had GCA equipment been installed and in use at Malton on the night of 17 December, this accident might have been avoided. On the other hand, a recent accident at Idlewild Airport in the United States occurred under a GCA approach due, it is believed, to a failure of the pilot to obey the instructions of the GCA Controller. The Board did not wish to enter into the discussion of GCA versus ILS, but pointed out that the success of either system still depends on rigid adherence on the part of the pilots to the approved procedures.

The Board gave careful consideration to the total flying time and time on the ground involved in the round trip from Montreal to Tampa and return. It was admitted that it is a

long working day, but it is less arduous than a typical Transatlantic flight. The Board found itself in agreement with the Company in concluding that if the crew have had adequate rest on the day preceding, the flight is not a particularly arduous assignment with modern flight equipment.

The Board gave most careful consideration to the question of inter-communication between the captain and the first officer during periods of flying which demand more than normal concentration, such as an instrument approach. The first officer was aware of the breaking of a Company regulation at a time when the condition had not yet become critical. He adopted the existing standard procedure to draw the attention of his captain to this condition. He received an acknowledgment from the captain and was therefore entitled to assume that the captain had received and understood his message. It is obvious from the sequence of events that the captain paid little attention to what his first officer was trying to indicate to him, and despite his acknowledgment, he made no deduction regarding the message from his first officer and certainly took no corrective action. Later, when the condition had become critical, the first officer still adopted standard procedure, pointing to the necessary instrument to bring to the attention of the captain, who was doing the flying, the imminent danger that threatened them. If, instead, the first officer had quickly assumed control of the aircraft, it is quite possible that disaster could have been averted.

The Board considered quite strongly that the present standard procedure is unacceptable when an emergency exists, and recommends to Trans-Canada Air Lines and all other operators that consideration be given to a method of inter-communication between the crew which shall be more positive and less subject to inattention or misunderstanding at such a time.

The whole problem raises the question of the relationship between the captain and the first officer. The Board is aware that the captain of the aircraft is usually a man with extensive flying experience, who is fully cognizant of the superiority of this experience over that of his first officer. The tradition has been established that the first officer is very much the junior in the cockpit; and to some extent, this is as it should be. However, this had led to a condition where the first officer has some hesitation in interrupting the captain to say or do anything which might be taken as a criticism of the performance of his captain. Particularly is this the case when the captain is involved in concentrated flying as during an ILS approach, and it is believed that many first officers have been reprimanded for interrupting the captain at such times. Under the circumstances, therefore, for a first officer to take over the controls from the captain to avert disaster would be considered a drastic step. Despite this situation, the only reason for carrying two pilots in the cockpit is in order that the load and responsibility can be shared and the safety of the flight increased.

The Board recommends that Trans-Canada Air Lines and all other operators re-examine this problem to see if there is not a better method of defining the responsibility of the first officer to his captain when the safety of the flight is in question and corrective actions are to be taken.

ICAO Ref: AR/350

No. 41

Italian Airlines (Linee Aeree Italiane), DC-6B aircraft, crashed at New York International Airport, Jamaica, New York, on 18 December, 1954. Civil Aeronautics Board Accident Investigation Report File No. F.105-54. Released 19 September 1955.

Circumstances

At approximately 1400, on 18 December 1954, an Italian Airlines DC-6B Italian registry I-LINE, on a scheduled flight from Rome, Italy, to New York, U.S.A. crashed into the pier which supported the left row of slope line approach lights to runway 4 at the New York International Airport (Idlewild). The accident occurred during the flight's fourth instrument approach to the airport. The entire crew of 10 and 16 of the 22 passengers were killed; 4 of the 6 survivors received serious injuries. The aircraft was demolished by impact and sank in Jamaica Bay. An intense fuel fire followed the impact and spread over the water surface and pier.

Investigation and Evidence

The aircraft departed Rome at 1810 G.C.T. (Greenwich civil time) on 17 December, 1 hour and 10 minutes behind schedule because of a late connecting flight. The multiple flight crew of 10 consisted of the captain, first officer, two second pilots, first and second flight engineers, radio operator, two stewards and a hostess. The stops at Milan and Paris were cancelled because of local ground fog and the flight reached Shannon at 2320 G.C.T. There the aircraft was refuelled and checked.

Flight over the North Atlantic was uneventful. Routine position reports were made and the flight periodically received and logged en route and destination weather reports. This and the previous segments were described as very smooth, little or no actual instrument flight, and no apparent mechanical difficulties. Arrival and departure times at Gander were 0945 and 1038 G.C.T.

As the flight neared Boston instrument conditions were encountered but were of little consequence and I-LINE landed at 0928. Nine passengers deplaned and the aircraft was serviced with 804 gallons of fuel, making the total fuel on board approximately 2 415 gallons, sufficient for about 7 hours of flight. The crew filed an IFR (Instrument Flight Rules) flight plan with the Boston ARTC (Air Route Traffic Control) Centre through TWA (Trans World Airlines) which performed under contract station operations functions, exclusive of dispatch or control, for the Italian Airlines. No alternate airport was specified in the information furnished TWA. The aircraft was loaded to a gross weight of approximately 90 000 pounds, well under the maximum allowable of 107 000, and the load was properly distributed in relation to the centre of gravity of the aircraft. The flight departed Boston at 1013.

After an uneventful instrument flight involving normal Air Route Traffic Control routing and control, the flight reported at 1122 to the Idlewild Approach Control as being over the Mitchell Radio Range Station at 7 000 feet. The flight was then cleared to enter the Scotland holding pattern (located approximately 13 nautical miles southwest of the airport) and was subsequently "laddered down" to the number one position to approach.

Between 1147 and 1159 weather conditions deteriorated below the ceiling minimum of 400 feet for landing on runway 22, the runway then in use. The flight continued to hold.

At 1159 reported weather conditions improved and the aircraft was cleared for an approach to runway 22 using the back course of the ILS (Instrument Landing System). At 1218 the flight reported it had discontinued this approach. It was then issued missed-approach instructions and returned to the Scotland holding pattern. Shortly thereafter weather conditions

were again reported below minimums for runway 22. They were then reported as: Ceiling 300 feet, broken, 2 500 feet, overcast; visibility 2-1/2 miles, light rain and fog; wind south-southeast 20 knots.

While holding, the flight was asked by Approach Control if it would be able to make an approach to runway 4, the ILS runway, considering the tailwind component. The flight accepted runway 4 and was cleared at 1307 for an ILS approach. At 1313 the tower was advised by the flight that the approach had been missed.

The flight was next offered, and it accepted, a GCA (Ground Controlled Approach). This approach was abandoned at 1324, a missed-approach procedure was followed, and the flight returned to the Scotland holding position.

At 1327 the Italian Airlines Station Manager, in a message relayed by the tower, asked the flight its remaining fuel, and received the reply that there was three hours of holding fuel. The Station Manager then suggested that the flight hold for 1-1/2 hours and if unable to land to proceed to Washington, D.C. At 1329 the flight acknowledged this message.

At 1349 the flight was again cleared for an ILS approach, the third approach to runway 4 and its fourth to the airport. At approximately 1400 the aircraft struck the left pier. The impact was accompanied by a violent explosion and followed by an intense fire. Tower personnel immediately sounded the crash alarm and initiated emergency procedures.

At the time of the accident weather conditions were reported as: Ceiling 200 overcast; visibility 2-1/2 miles, light rain and fog; wind south-southeast 16 knots. Italian Airlines' minima for ILS approaches to runway 4 are ceiling 200 feet and visibility 1/2 mile.

Investigation at the accident scene disclosed the aircraft struck the left inbound pier. The pier, primarily constructed of heavy wooden piles, extended approximately 2 000 feet into Jamaica Bay with its offshore end 2 530 feet from the approach end of runway 4. The floor of the pier was approximately 14 feet above the water level in the Bay at low tide. At the offshore end a vehicular turnaround was constructed of numerous piles forming each of its four corners, the tops of which were about six feet above the pier floor.

First contact was with the pier only a few feet above the water. At impact the aircraft was moving nearly parallel with the pier toward runway 4. The impact shattered the east half of the end of the pier, breaking and splintering the tops of most of the 11 piles composing the southeast corner. The bulk of the aircraft wreckage then sank in approximately 30 feet of water, mainly along the right side of the pier, over a distance of approximately 1 550 feet toward shore. The nature of damage to the pier, its closeness to the water, and the fact that little wreckage came to rest near the point of impact indicated the aircraft struck without an appreciable rate of descent.

A propeller slash mark made by a blade of the number one propeller was found in the centre pile at the offshore end of the pier. This cut disclosed that the number one engine nacelle was nearly centered with that position and the aircraft was slightly nose-up at impact. This propeller axis having been established made it apparent that the number two engine crashed into the south-east corner of the pier. Comparison of the heights of damage marks across the end of the pier revealed that the aircraft was nearly level laterally at the instant of impact.

The six surviving passengers were seated at various positions in the main passenger cabin. Two were able to extricate themselves from the wreckage and climb onto the burning pier, but ahead of the fire, enabling them to proceed immediately to safety. The others were forced into the Bay and were rescued by a private boat operator or helicopters dispatched by the New York Port Authority, the New York Police Department, and the Coast Guard. Smoke, fire, and the location of the accident presented great difficulty in rescue activities; however, they were accomplished as quickly and efficiently as possible under these circumstances.

Recovery operations, undertaken in extremely difficult conditions, produced about 80 percent of the aircraft. The wreckage was laid out for detailed examination, the result of which disclosed no evidence of fatigue cracking, structural failure, or malfunctioning controls prior to impact.

Examination of the components of the landing gear and flaps indicated that at impact the landing gear was fully retracted and the flaps were extended approximately 18 degrees.

Only the number three and four propellers were recovered. Most indicative of the power settings at impact were propeller cuts found in the pier made by the number one and number two propellers and the r.p.m. setting of the governor of the number four propeller. This evidence indicated appreciable, probably take-off, power at impact.

Supporting the evidence of the structures, powerplant, and propeller examinations were the statements of surviving passengers, one a pilot, which indicated they did not hear or see anything unusual relative to the performance of the aircraft. The crew at no time in the many radio communications made with various facilities en route and at the airport mentioned any difficulty.

During the accident period a normal crew was on duty in the Idlewild tower located about one mile north-northwest of the approach end of runway 4. A two-way recording unit made a permanent record of the transmissions between flights and the various control tower positions. A feature of the recorder enabled determination of the elapsed time during and between transmissions.

The radar controller, located in the IFR room several floors below the tower cab, gave radar advisories to all flights making ILS approaches. The purpose of the advisories was to inform the flights of their positions as observed on radar relative to the glide slope, the localizer path, and distance to touchdown. The advisories were given as a responsibility of the controller at various intervals during the progress of the approach. A study of the recorded advisories was made as a phase of the investigation. Its purpose was an effort to reconstruct as accurately as possible the probable flight path of the aircraft during the last approach. (See Fig. 33). Considered in conjunction with this study were the explanatory testimony of the radar controller, observations of two eyewitnesses, and testimony of surviving passengers.

It was learned that before the instrument approach was started positive radio contact had been established and the flight had been given the latest weather and altimeter information.

During the initial portion of the ILS approach radar contact was established and as the aircraft approached the four-miles-from-touchdown point it was observed to be somewhat to the right of the localizer path drifting left. Before reaching this position the flight was slightly left of course and lower than normal. During this time it was advised to maintain altitude; the flight continued to descend.

At approximately the three-mile point the radar controller advised the flight that it appeared to be at 500 feet altitude and still descending. He then emphatically advised the pilot to level off.

While the aircraft approached the two-mile point the controller advised the flight as follows, "Item Nan Easy level off, your altitude shows as 200 feet. About to intercept the glide path, 150 feet below glide path." In explanation of this advisory the controller stated that the flight descended to 200 feet, or lower, then it arrested the descent and began to climb.

Investigation disclosed that one of the eyewitnesses apparently observed this portion of the approach. His ground position was about 2-3/4 miles from the touchdown point and nearly aligned with the localizer course. He testified that he saw the flight descend below the overcast to a low altitude, then sharply pull up and climb steeply back into the overcast. The witness did not recall the position of the landing gear.

The controller stated that as he observed the aircraft climbing he gave course information, "Two miles from touchdown, 400 feet left of course, 300 feet left of course." While he was offering this information the aircraft entered another descent to a very low altitude. He advised, "Your altitude is very, very low, pull up. Item Nan Easy pull up unless you have the runway in sight." At this time the controller stated the aircraft began a sharp ascent turning right. The angle of ascent was decreased momentarily, then resumed. The climb continued until the aircraft was at or above the glide path altitude. At this time the controller believed the flight had begun a missed-approach procedure and he continued, "Item Nan Easy I see you're pulling up, 500 feet left of course, a right turn heading 130 . . .

Upon reaching the peak of the climb the controller then observed the aircraft begin a sharp descent. He then advised, "If you have the runway in sight you're cleared to land." Observing the descent continue he added, "Item Nan Easy check the approach lights. Item Nan Easy you're very low on glide path." The controller saw the aircraft merge with the pier and heard a muffled explosion.

A second eyewitness, positioned approximately 1-1/4 miles north of the approach end of the runway 4, stated that he saw the aircraft descend below the overcast in what appeared to be a slightly steeper than normal nose-down attitude. He then saw the nose rise quickly to a nearly level position. He said the aircraft at this moment appeared to be slow and seemed to wobble. The aircraft continued to descend throughout his observations until he could no longer see it behind slightly higher terrain. Seconds later he heard a roar of the engines and almost simultaneously saw fire and smoke spout vertically upward. He then heard another roar of the engines.

The surviving passengers varied in their observations. All were in accord that the last approach seemed lower than the others and at one point there was a sensation of an extremely sharp pull-up, followed by a sensation of a pitch down during which power was applied and galley equipment spilled down the cabin aisle. Three passengers, in positions enabling them to observe the main landing gear, stated that during the early portion of the last approach they were sure it was down. Weather conditions were poor, only fleeting glimpses of the water and swamp area could be seen. One passenger seated on the right saw the right line of approach lights at an angle approximating 30 degrees and he guessed about 40 seconds transpired between this observation and the impact which followed.

The approach lighting at the airport at the time of the accident was the slope line approach lighting system. It was installed and commissioned for use in 1949. This system provides two converging rows of bar lights, one row on each side of the centreline leading to the runway. The system is designed using the lights to inform the pilot of his position. The angle at which the lights are viewed informs him whether his position is left, right, or on the centreline to the runway and also whether his position is on, above, or below the glide path. From any of these positions the lights are also designed to indicate the correction, if necessary.

Officials of the Italian Airline testified that prior to the 1950 inaugural flight over the subject route many months were devoted to preparation for the forthcoming operation. Studies were made of the operating procedures and policies used by other airlines in their North Atlantic operations, from which many features were adopted for the Italian flights. Visits were made for the purposes of examining the airports and facilities involved in the route and the most experienced flight personnel were selected for the operation. Prior to the first flight several non-passenger trips were made under supervision of experienced North Atlantic flight crews to another airline. The operation into the United States was made in accordance with ICAO recommended standards incorporated in the Italian regulations.

Company officials testified that on a normal North Atlantic flight the captain and one of the other pilots would fly the aircraft to Shannon and then would rest during the Atlantic crossing while the other pilots flew the aircraft. After reaching the more congested areas of the United States the captain again would take the controls until the flight terminated. This procedure afforded each pilot nearly equal rest periods. The bunks on board the aircraft

provided them the best rest possible considering it would be under flight conditions and with continuing respective responsibilities for the flight.

Crew training was in most respects patterned after United States carrier programs. Investigation revealed the Italian program included ILS, instrument, and GCA training. In many respects various training phases were given more time than the accepted standards. Company policy required that at least one member of the flight crew speak English fluently. The captain of this flight was able to speak and understand English. A review of the recordings and transcriptions indicated that communications with the aircraft were conducted in a normal manner and no language difficulties were indicated. Transmission of messages and responses from the flight were prompt and in accordance with standard practices

The synoptic weather situation when the flight left Gander consisted of a low pressure system centered over the Great Lakes with an occluded front extending to a secondary low over southern Virginia. This secondary center formed the junction of a warm front which extended east-northeast into the Atlantic ocean and a cold front that extended southward. This system was moving northeast and the position of the warm front was about 225 miles south of New York when the crew was briefed at Gander. This briefing indicated deterioration of the ceiling and visibility in the areas ahead of the front as it moved northward.

Additional factors were a high pressure ridge off the east coast and a steepening pressure gradient between this ridge and the trough to the west. These factors indicated a rapid advection of air from the warmer ocean water northward over the coastal area. A cold low pressure trough aloft somewhat west of the surface trough resulted in a steep pressure gradient eastward into New England. This indicated a strong southwesterly flow to about 20 000 feet and an extensive lifting of warm air over the colder surface air north of the warm front.

At 0945, after the flight departed Boston, a special weather report for Idlewild was transmitted by Station WSY. The reported conditions were: Scattered clouds 1 500 feet, ceiling 7 000 feet, overcast; visibility 1 mile, moderate rain and fog; wind south-southwest 23, gusts to 31. This report was received by the flight and copied in the flight radio log. At this time the warm front had progressed northward to approximately 100 miles south to New York City.

Investigation revealed that the crew did not receive a formal weather briefing at Boston as was customary for Italian Airlines crews; however, at 1015 the latest weather report for Idlewild was received from WSY and again copied by the flight. The reported conditions were: Ceiling measured 800 feet, broken clouds, 6 000 feet overcast; visibility 2 miles, light rain and fog; wind south-southeast 21 with gusts to 30. At this time the following terminal forecast was also broadcast: Ceiling 600 feet, overcast; visibility 2 miles, light rain and fog; wind south-southeast 25 with gusts to 45; occasionally becoming ceiling 200 feet, overcast; visibility 1 mile, heavy rain and fog.

At approximately 1300 the warm front passed Idlewild with warm moist air flowing over a relatively cold land and water surface. The strong surface winds produced turbulent mixing and as a result rather definite ceilings of a few hundred feet with fairly good visibility were maintained. After 1300 the surface wind velocity diminished somewhat. This resulted in less turbulent mixing in the lower layers and was reflected in a lowering of the reported ceiling to 200 feet overcast with 2-1/2 miles visibility at the time of the accident.

Ceiling and visibility observations used in the reports for the Idlewild Airport incorporate the use of electronic equipment. Ceiling reports were based on ceilometer readings obtained from a rotating beam ceilometer located on the left inbound pier, at the accident site. Visibility observations were made from the Weather Bureau located approximately two miles from the accident scene. A transmissometer, an electronic means of measuring visibility, was located along runway 4 near the approach end; however, this instrument, owing to its design, does not measure accurately when visibility is above 1-1/2 miles. For this reason the instrument was not used in observations during the accident period although it was operating. Investigation disclosed that during this time the transmissometer record continued to indicate more than 1-1/2 miles visibility.

Several airline captains who made ILS approaches and landings between the first and last approaches of the Italian flight stated that in the normal breakout area they found weather conditions equal to or better than reported. There was little turbulence and the bottom of the overcast was fairly well defined. One captain stated, however, that conditions left of the localizer course seemed somewhat worse than reported. Another captain, the last to approach before the accident, stated that when he was above and between the approach lights on the glide path he was unable to see them. These witnesses also stated that while descending along the approach path there was a decided wind shift from left to right. This condition required commensurate drift corrections as the wind shift level was traversed. This factor, according to these witnesses, together with the eight-knot downwind component, was an important factor to contend with in a successful approach and landing. Statements of these pilots confirmed the investigation which found the approach radio facilities operating normally.

Analysis

Weather conditions during the accident period were greatly influenced by the velocity of the surface wind. The resultant turbulent mixing probably kept the ceiling and visibility from deteriorating to near zero. After 1300 the wind velocity decreased somewhat and the effect was reflected in the subsequent reports. Since electronic equipment for measuring the conditions was located at and near the accident site, the reports were especially applicable to this area, the normal breakout area during an ILS approach to runway 4. The general weather movement was from the offshore area over the measuring equipment. The reported conditions therefore should also have been quite representative of those immediately beyond the piers. Still farther out along the approach path evidence indicates poorer conditions. Less turbulent mixing over the smoother water surface in this area lends credence to this possibility.

During the first three approaches the crew adhered to the established minimum altitude and apparently maintained some margin above it. The decision to discontinue these approaches was an exercise of the captain's judgment when he was not entirely satisfied to continue. It is believed that the tailwind component and wind shift encountered during the approaches to runway 4 were important factors which influenced these decisions. The tailwind component caused other airline flight crews some difficulty and one expressed it as, "It made me feel I had done a day's work." Although landings were being made downwind this was necessary because no other runway was equipped with ILS and weather conditions prevented the use of runway 22. This factor also probably caused the pilot to use a slower indicated airspeed during the last approach.

Evidence indicates that on the last approach the pilot began a descent before intersecting the glide path and continued to descend, although repeatedly advised by the radar controller to level off. Altitudes throughout the approach indicate the ILS glide path indicator would have shown a full scale fly-up indication. This evidence strongly suggests that the pilot was not attempting to follow the glide path but decided to descend until visual reference was established. The pilot apparently descended below the overcast in the area between the outer and middle markers, probably in an attempt to proceed visually below the overcast to the runway. While attempting to do so, however, he may have encountered a drifting fog which was not recorded. Such procedure is not in accord with good operating practice and the reasons for it in this instance have not been definitely ascertained.

When the aircraft broke out below the overcast in the vicinity of the outer marker, the pilot possibly saw the surface of the water and swamp without seeing the approach lights and reacted quickly, pulling up into the overcast. In order to arrest the ascent, or again descend to establish visual contact, it is believed the pilot lowered the nose of the aircraft and in so doing got very low. As a result he apparently again pulled up sharply, the aircraft drifting slightly left. The ascent seemingly continued, during which the aircraft lost airspeed and began turning right. The nose of the aircraft was then lowered and power was applied.

The landing gear was probably retracted at some time during this series of events. These movements of the aircraft are strongly supported by the testimony of the surviving passengers, the second eyewitness, and the path of the aircraft as observed by the radar controller.

The final descent obviously continued until the aircraft was a short distance from the pier but too close to avoid it.

During the Board's investigation and analysis of this accident careful consideration was given the possible misinterpretation of the approach lights or an illusion associated with them. Evidence regarding misinterpretation or illusion would be primarily the testimony of the crew. This was not available for consideration, the entire crew being fatally injured. The Board recognizes these as possible factors; however, from all the available evidence the Board was unable to determine whether or not the lights were a factor.

Although the entire crew was lost and actual rest periods are unknown there is no reason to believe that normal rest procedures were not followed. It is nevertheless believed fatigue was a factor in this accident. It was not only present as a result of the time en route, approximately 22-1/2 hours, but mostly a result of the additional extended 2-1/2-hour period devoted to the four approaches and the high mental and physical demands made upon the pilots. The element of fatigue is strongly suggested especially during the last approach. Fatigue is evidenced by the pilot's poor adherence to the localizer path, the last descent to a very low altitude before the sharp pull-up, and the evidence of abrupt control action. It may also be noted in some degree in the pilot's slow response to the wind shift and the probable loss of airspeed which caused the sinking descent before the aircraft struck the pier. These factors lend credence to the belief that the pilot's efficiency and normal ability were seriously impaired by fatigue.

Probable Cause

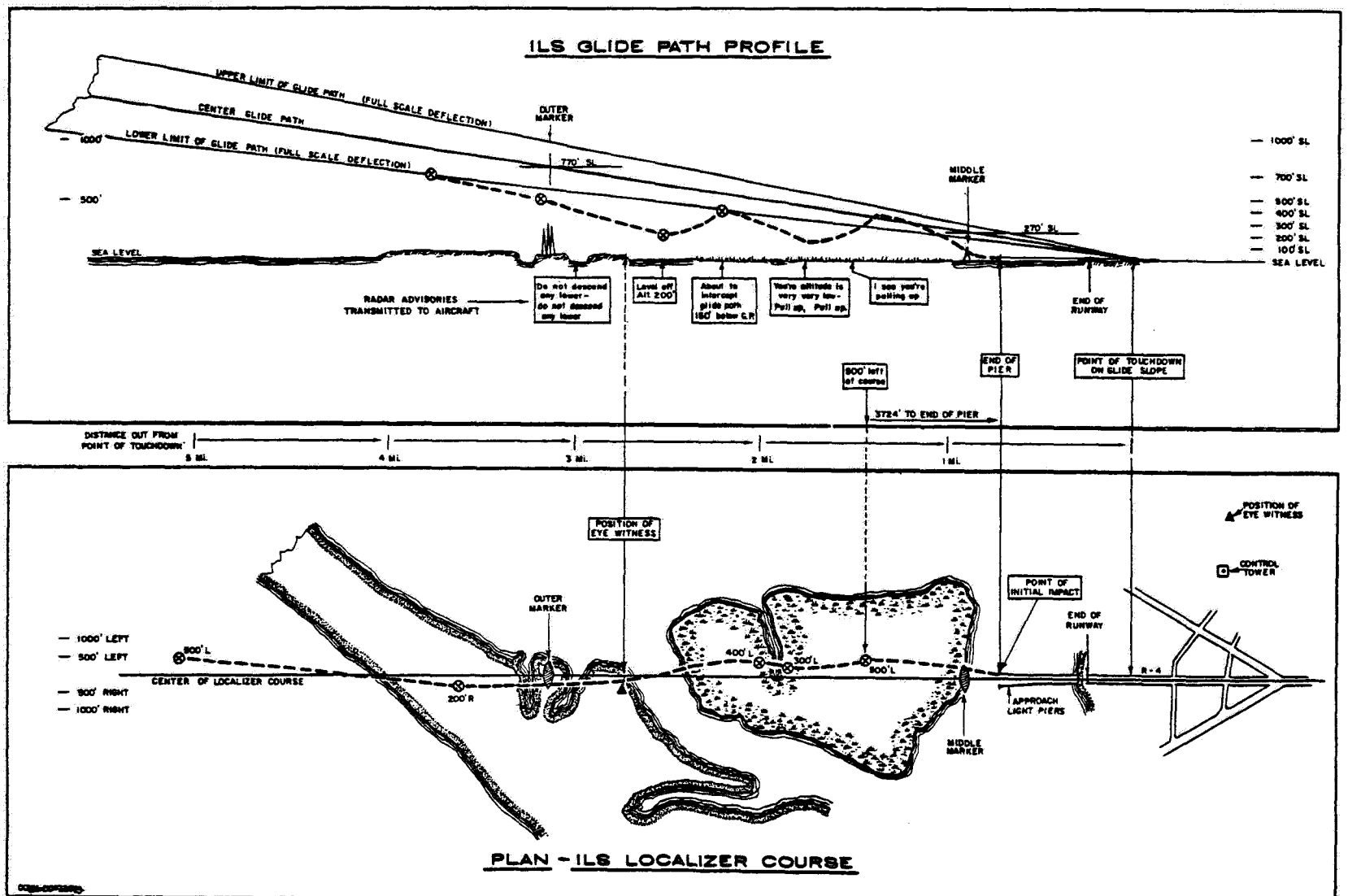
The Board determined that the probable cause of this accident was an erratic approach which resulted in a descent to an altitude too low to avoid striking the pier.

A contributing factor to this accident was pilot fatigue due to the particular and difficult circumstances.

FIGURE 33

PROBABLE FLIGHT PATH AND POSITIONS OF AIRCRAFT (LAI FLIGHT 451)
DURING LAST APPROACH TO R-4 NEW YORK INTERNATIONAL AIRPORT
DECEMBER 18, 1954

Approximate Positions and Flight Path are Based on Data Obtained from Transcription of Radar Advisories



No. 42

Johnson Flying Service, Inc., DC-3C aircraft ditched in the Monongahela River, Pittsburgh, Pennsylvania, U.S.A. on 22 December 1954. C.A.B. Accident Investigation Report No. 1-0241

Circumstances

The aircraft was engaged on a civil air movement of military personnel (CAM) from Newark, New Jersey, to Tacoma, Washington with planned intermediate stops. The aircraft carried five crew and twenty-three passengers. While approaching to land at Allegheny County Airport, Pittsburgh, Pennsylvania the fuel was exhausted and the aircraft was forced to ditch in the Monongahela River. Ten of the twenty-eight persons on board including the captain were drowned.

Investigation and Evidence

Prior to departing Newark the aircraft was serviced with 170 gallons of 100 octane fuel which was placed in the two main tanks in equal amounts, making a total of 225 gallons according to the weight and balance manifest. According to the company's Weight and Balance Manifest the aircraft at the time of departure weighed 25, 317 pounds, which was within the allowable gross weight of 25, 346 pounds; the load was distributed within the prescribed limits with respect to the centre of gravity of the aircraft. The captain filed with the CAA by telephone a flight plan indicating a flight to be made in accordance with visual flight rules (VFR) to the Allegheny County Airport, Pittsburgh, Pennsylvania. The route to be followed was via Amber 7, Green 3, and Red 21 Airways. The flying time to Pittsburgh was estimated to be one hour and forty minutes, at a true airspeed of 155 knots with two hours and forty minutes of available fuel.

The flight departed Newark at 2038 and routine en-route position reports were made and at 2206 the flight reported over Philipsburg, Pennsylvania, VFR estimating Westover, Pennsylvania, at 2219.

At 2225 the flight reported to Brookville, Pennsylvania, radio that it was over Westover at 2220, VFR, estimating Pittsburgh at 2252.

Pittsburgh radio received a call from the flight at 2238 asking if fuel was available at "Johnson Marker." Pittsburgh interpreted this to mean Johnstown, Pennsylvania, and replied "Reference fuel at Johnstown, they do have 91/96 octane and lower and we're attempting to contact Allegheny Airlines at Johnstown now to see if they would be open at this time of night. The Air Guide doesn't list any hours that they are open. You'll have enough fuel to land at Allegheny County, original destination, won't you, over ?" The pilot advised he was not sure, and then requested that the runway lights at the Johnstown Airport be turned on. Pittsburgh radio attempted to contact the Johnstown Airport by telephone and interphone without success and advised the flight that they were unable to contact them at this time but would continue trying. At 2244 the flight called Pittsburgh radio and advised that it was over the Johnstown Airport. The pilot was asked to stand by and as soon as it was determined that Johnstown could not be contacted, Pittsburgh radio so advised. The flight, at 2247, told Pittsburgh radio that it had passed Johnstown and was continuing to the Allegheny County Airport. Two minutes later Pittsburgh again asked the flight if it wished them to continue attempting to contact the Johnstown Airport. The pilot then said he would continue to Pittsburgh and asked for information on other fields where he might land. This was answered, "Douglas 4320 Pittsburgh radio. Nothing for a DC-3 Douglas 4320, it's either Greater Pittsburgh or Allegheny County, over." At 2251, Pittsburgh gave the flight

the current Allegheny County weather as: Clear, temperature 20, dew point 10, wind south-southwest 9. When asked his altitude the pilot answered 3 200 feet. He was then given the winds aloft at 3 000 feet as being 260 degrees, 10 knots. A minute later the flight advised that it was 7 miles east of the Allegheny County Airport and could see it; that it was crossing the river and could see the field lights. Pittsburgh radio then called the Allegheny County tower and advised that the DC-3 was approximately 10 miles east, low on fuel, and was landing at that airport. The tower requested that the aircraft change to tower frequency. Pittsburgh radio called the flight at 2254, and asked it to contact the tower on 121.3 Mc. In reply the pilot said that he did not have 121.3 Mc. but would contact the tower on 126.18 Mc. He was advised that frequency was satisfactory.

The flight immediately called the tower and requested landing information. It was then cleared for a straight-in approach to Runway 27 and asked to report when 3 miles out. The weather was given as: Wind southwest variable south, calm to 10, altimeter 29.84. At 2256, the flight reported it was 3 miles east on final approach; it was then cleared to land. At 2257, the flight reported that it was out of gas. At this time the tower observed the aircraft to be approximately 2 miles from the airport on final approach. The tower immediately asked if the pilot believed he could make the field. The pilot replied, "I doubt it very much. We have both engines feathered, we are coming down over the red lights. I don't know if we'll make it or not. We are 2 000 feet." At 2258 the pilot advised, "We are going to set it down." The tower observed the aircraft make a left turn and head toward the south. It then disappeared from the controller's view below the hills southeast of the airport. Necessary calls pertaining to the emergency were immediately effected. The aircraft, heading in a southerly direction, was ditched wheels-up in the Monongahela River at approximately 2300.

Ditching was one and one-half miles south of the McKeesport, Pennsylvania, bridge and approximately two miles southeast of the Allegheny County Airport. The aircraft came to rest about 35 feet from the west bank of the river at a point which is 600 feet below the elevation of the airport. According to witnesses it floated for a short time and was completely submerged in approximately 15 minutes. Prior to sinking, the current of the river turned the aircraft to the left and slowly moved it approximately 450 feet downstream to a position about 75 feet from the west shore.

Following ditching all passengers were evacuated through two emergency exits, one over each wing. None of the passengers or crew received injuries during the ditching. The last person to leave the cabin was the captain, who estimated that it took approximately seven minutes to get everyone out of the cabin and onto the wings or fuselage. Some of the passengers could not swim and the icy waters made it difficult for even good swimmers to reach the shore.

After recovery from the river the aircraft and engines were examined and found to be capable of normal operation at the time of the accident. Each of the four fuel tanks contained approximately a gallon of fuel. Water in varying amounts found in these tanks was unquestionably the result of the aircraft's submersion in the river.

At Newark the fuel gauges registered a total of 85-90 gallons. This was divided as follows: left main 35 to 40 gallons, right main 50 gallons, and left and right auxiliary tanks empty. However a co-pilot stated that he thought there were 65 gallons on board prior to refuelling. This was based on his observation of the fuel gauges on arrival at La Guardia; also, on what he observed from the aisleway during the flight to Newark, and, by again reading the gauges on departure from the ramp at Newark. He did not discuss the amount of fuel on board with the captain or the other crew members. Upon arriving at the ramp the captain ordered 125 gallons of 91 octane fuel to be distributed equally between the two main tanks, but inasmuch as 91 octane was not available, 100 octane fuel was accepted. Subsequently, when it was found that passenger and baggage weight was less than originally estimated, the captain changed this order to 170 gallons of fuel instead of the 125 gallons previously ordered. The refuelling crew then metered 85 gallons into each of the two main tanks, but did not stick the tanks to determine the total amount in each since the crew did not request that this be done.

The captain prepared and signed the weight and balance form for the flight, and the second captain initialed it as loader. This form indicated that 844 pounds of baggage were in the front

baggage compartment. This latter compartment, which has a maximum allowable capacity of 350 pounds, was loaded in accordance with the captain's instructions. The crew stated that the total baggage weight of 1 252 pounds did not include crew baggage weights or that of their flight kit. The weight of each passenger was computed at 165 pounds and each crew member at 170 pounds. The weight of the crew's baggage was included with their weight. Following the accident, all baggage was recovered. This consisted of 23 duffel bags, 16 gym bags, and 5 crew bags.

All military baggage was completely dried and weighed by the military authorities and its total weight was found to be 1 512 pounds, 260 pounds more than that shown on the weight and balance form. In addition, the weight and balance listed 225 gallons of fuel at a total of 1 350 pounds; 36 gallons of oil at a total of 270 pounds; aircraft empty weight 17 800 pounds, useful load 7 517 pounds; gross load 25 317 pounds; and the maximum allowable gross as 25 346 pounds. This form indicated that the rear compartment was overloaded by 58 pounds but that the entire load was distributed within the prescribed centre of gravity limits of the aircraft.

The captain filed a flight plan with the CAA prior to departure. However he did not discuss this with the co-pilot or prepare the required company Flight Plan and Log. It could not be determined where or how he computed the flight time of 1 hour and 40 minutes from Newark to Pittsburgh, or why he selected Red 21 airway for a part of the route to be flown when the airway had been discontinued since 8 December 1953. The other crew members disclaimed any knowledge of the contents of this flight plan. The Company Operations Manual states that it is the pilot's responsibility to use current airways charts for flight planning and navigation and such charts were in the flight kit on board the aircraft.

On the trip from Seattle to New York the flying of the aircraft was divided between two crews, with the first captain and co-pilot flying three segments and the second captain and co-pilot flying two segments. Just prior to departure from Newark the first co-pilot was told by his captain that they would fly the aircraft to Pittsburgh. The co-pilot testified that because he did not know until then that he was to fly this portion of the flight, he had not prepared in advance the required portions of the company's Flight Plan and Log. He made out this form in flight after departing Newark with some of the data supplied him by the fifth member of the crew, a pilot, who was sitting in the jump seat. The route indicated on this form was determined without consulting the first captain to find out which route he intended to fly. As a result the flight plan and log was made out using a current RF 8 chart, to show a route via Amber 7, Green 3, Red 13, Red 8, and Red 13 airways to McKeesport, Pennsylvania. (However, the flight plan filed by the captain specified a route over Amber 7, Green 3, and Red 21 airways to the Allegheny County Airport at Pittsburgh.) Examination of these flight plans revealed many errors, including distances, headings, radio frequencies, and airways.

The company's operations manual required as a minimum for VFR flight sufficient fuel to fly from take-off to the airport of intended landing, plus 45 minutes of reserve fuel (60 gallons) and an additional 25 gallons to allow for variations in performance, etc. This manual also provided that an additional 11 gallons be included for use in taxiing, engine run-up, and take-off, which was not to be shown on the flight plan, clearance, or weight and balance forms. Based on 225 gallons shown on the weight and balance manifest the fuel consumption on the subject flight averaged 96.5 gallons per hour. The co-pilot stated that approximately 700 hp was used for cruising. According to the company's operations manual, this is about 100 hp more than specified. Between Newark and Philipsburg the co-pilot advised the captain of ground speed made good at each check point. He also said that when in the vicinity of Philipsburg, he advised the captain that their fuel was getting low and that to continue would mean using the reserve supply, which was contrary to company instructions.

Both co-pilots stated that an ADF (Automatic Direction Finder) approach, using the radio beacon, was made to the Johnstown Airport. Also that when this approach was made neither the airport's lights nor the lights of the city of Johnstown were seen. Investigation disclosed that it was the custom at this airport for lights to be turned on daily at sunset. It was established that on the night of 22 December 1954, the lights of one runway, the rotating beacon, and a ceiling light were turned on at sunset and remained on all night. No witness was found who observed an aircraft in the vicinity of the radio beacon or airport at the time the flight reported being there.

Weather along the route between Newark and Pittsburgh was good, permitting the aircraft at 4 000 feet to remain well below all clouds, with good visibility along the entire route. The forecast en-route winds aloft for the 4 000-foot level, available to the crew prior to departure, were as follows: Newark to Harrisburg, 310 degrees at 20 knots; Harrisburg-Altoona, 300 degrees at 20 knots; Altoona-Pittsburgh, 270 degrees at 15 knots. According to the U.S. Weather Bureau the flight encountered winds as forecast, except that the Altoona-Pittsburgh winds were 25 knots. The captain advised the co-pilot before departure that the expected winds would be from the west-northwest at 10 to 15.

Analysis.

The chief pilot and operations manager of the company had many duties. Since he was frequently away from base, flying another company aircraft, he delegated some of his duties to two of the company's pilots. These men were both made check pilots and one was allowed to employ other pilots. No training program as such, other than ground school, was organized. Flight training was normally en-route training and was given by one of the check pilots or another captain. The overall program did not ensure that all pilots were proficient according to the standards set forth in the operations manual.

It was apparent that this accident was operational in nature. Many things must be considered in properly planning and completing a flight. The general conduct of this flight clearly indicated poor judgment, carelessness, and lack of supervision and training. The fact that a Flight Plan and Log was not prepared prior to departing Newark and that the co-pilot did not know the route to be flown was the result of poor crew co-ordination and flight planning.

While it is not known exactly how much fuel was on board when the aircraft departed Newark, it is apparent that there was not a sufficient amount of fuel to fly to Pittsburgh by either of the planned routes and arrive there with any margin of safety. The elapsed time of the flight from take-off to ditching was two hours and twenty-two minutes. Considering the altitude and distance flown, and the various power setting which the co-pilot testified were used, together with other known factors, it is calculated that approximately 260 gallons of fuel were consumed. This would have made the aircraft overloaded at the time of take-off.

The passengers' baggage when recovered weighed more than that shown on the manifest. In addition, the operations manual required that the baggage of all crew members and the flight kit be weighed and this amount shown on the manifest. While it is not possible to determine with precise accuracy the total weight of all the above-mentioned items, it is obvious that the aircraft was overloaded at the time of departure. The inclusion of any additional weight to the figures shown on the weight and balance manifest would have reduced the allowable fuel load below the minimum of 200 gallons required for take-off.

The captain estimated the flying time to Pittsburgh to be one hour and forty minutes. The distance, along the route shown in the CAA flight plan, is approximately 271 miles. To accomplish this in the estimated time would require an average ground speed of 163 knots. With the wind along the route forecast to be from the northwest and west averaging over 17 knots at the planned cruising altitude of 4 000 feet, this ground speed is unrealistic. Under these conditions a reasonable ground speed would be approximately 126-130 knots and would require an average elapsed time of two hours and seven minutes.

The Flight Plan and Log which the co-pilot prepared after departure included many mistakes, among which were: Wind directions and velocities different from those that were forecast; a higher true airspeed than is reasonable to expect for a DC-3 unless flying at higher altitudes; airways which differed from the route filed by the captain; some stations, courses, and radio frequencies that did not agree with either the filed CAA flight plan or the airways shown on the Flight Plan and Log; some errors in ground speed of 13 knots or more; and an estimated total time which exceeded the one hour and forty minutes estimated by the captain. The estimated ground speed used was 148 knots, whereas the actual ground speed made good averaged only 126 knots.

The company operations manual states, "The average hourly fuel consumption for a DC-3 to be used in flight planning is as follows: 80 gallons." Based on this figure the 225 gallons on board, as shown on the weight and balance manifest, should have allowed the aircraft to remain airborne for two hours and forty-eight minutes. Instead, the fuel was exhausted in two hours and twenty minutes of flight. There are many variables such as power settings used, altitude flown, and load, to mention but a few, which must be considered in order to accomplish any flight at a specified average fuel consumption.

It could not be positively determined just where the aircraft was when it reported being over Johnstown at 2244: however, if it had been over Johnstown at this time, the average ground speed from Johnstown to the point of ditching would have been about 178 knots. This ground speed is unreasonable, considering the headwinds encountered in that portion of the flight and the fact that power was reduced to conserve fuel. The co-pilots testified they believed they were over the Johnstown radio beacon and later over the airport area. However, when there they did not see the airport rotating beacon, runway lights, or the lights of the city. These lights were on at the time and should have been seen if the aircraft was in that vicinity. It appears, therefore, that a navigational error must have been made and that the aircraft was actually some place else. As an example, it may have been over the New Alexandria radio beacon, which is approximately 27 miles west-northwest of the Johnstown Airport and nearly on course between Westover and Pittsburgh.

One of the cardinal rules of safety which is set forth in the operations manual is, "Pilots are not to pass up a refuelling facility unless they have sufficient fuel and oil to reach the point cleared within reserve limits established." On the subject flight the captain was advised when the aircraft was near Philipsburg, an available refuelling point, that to continue the flight would necessitate the use of reserve fuel. Again the crew demonstrated a decided disregard for the principles of safety by passing an acceptable DC-3 refuelling airport.

The captain's judgment may have been influenced by his desire to accept the entire assigned payload in an effort to save money for his company. This limited the amount of fuel which could be carried and made necessary frequent and costly en-route refuelling stops. Because of this he may have elected to use a part of his reserve fuel to extend each leg of the flight. It is incredible that an air carrier aircraft flown by accredited personnel could be forced down for lack of fuel on a short night flight in good weather when the great progress aviation has made to date is considered, particularly with respect to pilot training, aircraft instrumentation, navigational aids, and airport lighting.

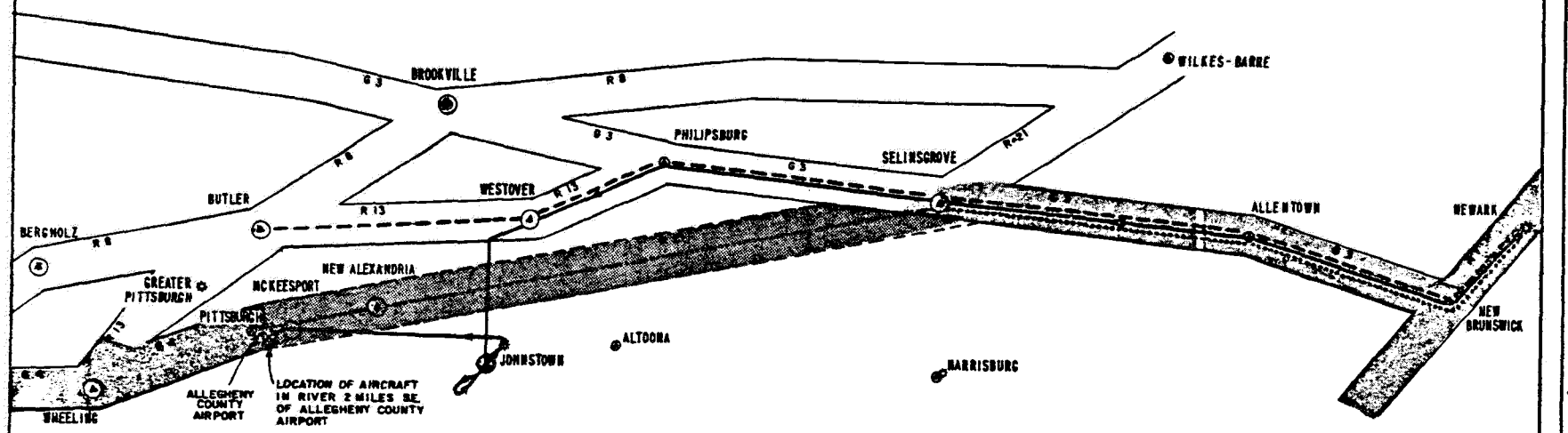
Probable Cause

The Board determined that the probable cause of this accident was fuel exhaustion brought about by inadequate flight planning. Contributing factors were inadequate crew supervision and training.

ICAO Ref: AR/329

FIGURE 34

AIRCRAFT ACCIDENT - PITTSBURGH, PENNSYLVANIA
JOHNSON FLYING SERVICE, INC. - DC-3C N-24320
DECEMBER 22, 1954



FLIGHT ROUTE ACCORDING TO CREW AND POSITION REPORTS TO CAA.
FLIGHT ROUTE AS SHOWN ON FLIGHT PLAN AND LOG: A 7, G 3, R 13, R 8, R 13.
FLIGHT ROUTE FILED BY CAPTAIN POE ALONG: A 7, G 3, R 21.

NOTE:
AIRWAYS SHOWN ARE THOSE LISTED ON FLIGHT PLAN AND LOG, AND AIRWAYS SPECIFIED IN FLIGHT PLAN FILED WITH CAA.
RED 21 AIRWAY WAS DISCONTINUED IN DECEMBER, 1953 FROM PITTSBURGH TO SELINSGROVE AREA.
RED 21 AIRWAY STILL EXISTS N.E. OF SELINSGROVE TO WILKES-BARRE.

No. 43

British Overseas Airways Corporation, Boeing Stratocruiser Aircraft, crashed at Prestwick Airport, Scotland, on 25 December 1954. Aircraft Accident Report No. C.A.P. 129 Ministry of Transport and Civil Aviation, United Kingdom

Circumstances

At about 2158 hours on 24 December 1954, a Boeing Stratocruiser aircraft, took off from London Airport on a flight to Prestwick. It was manned by a crew of eleven, and carried 25 passengers and a quantity of cargo. The flight had been scheduled to leave London at 1745 hours, but a delay was occasioned through a passenger being flown from Manchester to London to join the aircraft there. Owing to the failure of the port wheel to retract on take-off it became necessary for the aircraft to return to London and in order to make a safe landing some petrol had to be jettisoned. Ultimately a landing was made at London Airport about 2245 hours.

Arrangements were made to transfer crew, passengers and cargo en bloc to another Boeing Stratocruiser. The crew comprised a captain, first officer, navigating officer, radio officer, 3 engineer officers, 3 stewards and 1 stewardess. One of the engineer officers was supernumerary. The ultimate destination of the aircraft was New York, but the crew were only to travel as far as Prestwick where a fresh crew were to take the aircraft over the Atlantic. The aircraft took off from London Airport at 0120 hours on 25 December for Prestwick.

The flight from London to Prestwick was uneventful. Throughout the flight the captain kept in touch with the weather conditions and Prestwick Approach Control received the aircraft about 0248 hours. Preceding the aircraft by approximately four minutes in arrival at Prestwick was a Constellation, and these two aircraft were fed into the stack at Prestwick; the Constellation at 4 000 feet and the Stratocruiser at 5 000 feet. The runway to be used was Runway 31 which required the approach to be made from the southeast. The Instrument Landing System (hereinafter called "I.L.S.") without the Glide Path and the Ground Control Approach system (hereinafter called "G.C.A.") were available on Runway 31. G.C.A. took over the Stratocruiser about 0314 hours and at 0323 hours the talk-down controller took over the aircraft. Meantime Meteorological Reports had been passing from ground to air. The talk-down was completed at 0325 hours when the aircraft was 400 yards from the threshold of Runway 31. The approach up to this point had been high but uneventful. A few seconds later the aircraft struck the ground 127 feet short of the threshold of Runway 31, sustaining some damage. It then ran on to the runway and proceeded for some 90 feet where it was again airborne for another 400 feet. It then contacted the runway and sustained considerable damage, and came to rest with the passenger compartment in an inverted position on the south side of the runway about 550 yards from the threshold. Except for the front portion of the fuselage which lay on its port side, severe damage resulted from fire which broke out and spread rapidly, due probably to the partial detachment of the port wing and rupture of the fuel tanks.

From the accident there survived seven of the crew and one passenger.

Investigation and Evidence

Runway 31 is 6,997 feet long which is amply sufficient for a Stratocruiser to land in safety. The runway lights consist of two rows of white lights spaced at 200 feet apart and of variable intensity; each row of white lights is inset 75 feet from the edge of the runway and laterally there is a distance of 150 feet between the rows. At 120 feet from the east end of the runway there are green threshold lights inset 75 feet from each edge of the runway.

The approach lights consist of a single line of sodium and red low intensity lights spaced back from the threshold at regular intervals of 300 feet for a distance of 3 000 feet. There was no Crossbar System of lighting installed.

There was a G.C.A. system in operation the purpose of which is to give the pilot guidance in Azimuth and along the glide path. The glide path is 3-1/2° to the horizontal. The G.C.A. touchdown point is 1 235 feet from the end of the runway. The runway falls 16 feet in the 1 235 feet between the threshold and the G.C.A. touchdown point, and thereafter a further 15 feet.

Before the captain left London he received a Flight Forecast for the route from London to Gander via Prestwick and a weather briefing at about 0005 hours on 25 December from the senior forecaster on duty. The Prestwick weather conditions were forecast as follows:- The surface wind direction, 230 degrees true, speed 12 knots; the surface visibility, 3 miles, occasionally 1 700 yards; the weather, occasional drizzle; the cloud structure, 4/8th stratus, cloud base 800 feet, with 8/8th stratocumulus, cloud base at 1 200 feet with occasionally 5/8th stratus, cloud base 400 feet and 8/8th stratus 800 feet. In view of the weather actually encountered at Prestwick the above forecast proved remarkably accurate reflecting the greatest credit on the system and those engaged in the preparation of the forecasts.

Icing conditions were experienced by the aircraft at 8 500 feet, but the anti-icing and de-icing systems of the aircraft were operating and no difficulty was encountered due to icing conditions. As has already been stated, preceding the Stratocruiser was the Constellation aircraft, also owned by B.O.A.C. She was received into the stack at Prestwick at 4 000 feet and the Stratocruiser 5 000 feet. At 0248 hours the Constellation received a weather report from Prestwick Approach that the surface wind was 270, six knots, surface visibility was 2-1/2 miles with slight continuous rain, cloud 8/8th at 1 200 feet, 5/8th at 500 feet and 1/8th at 300 feet; the runway in use was Runway 31. This message was also received by the Stratocruiser which was at that time on the same frequency and at 0249 hours it received the same weather report direct from Prestwick Approach and was given Q.N.H. as 1012 millibars. At 0250 hours both aircraft received an amended report on the cloud, 8/8th at 1 200 feet, 6/8th at 700 feet and 3/8th at 400 feet and that "there appears to be cloud on the approach Runway 31". The Constellation was then informed of a delay due to a technical fault in G.C.A. which kept the aircraft in the stack for some seven minutes while the fault was rectified. At 0301 both aircraft received a further weather report which indicated surface wind 270, seven knots, visibility 2-1/2 miles, with continuous slight rain, cloud 8/8th at 1 200, 6/8th at 700, 4/8th at 400, 1/8th at 100 feet and again referred to patches of cloud on surface on approach to Runway 31. At 0312 hours the Constellation received another weather report and landed at 0318. At 0318 the Stratocruiser asked G.C.A. to give a report from the Constellation on the cloud state which he had experienced during landing. In answer to this request the Stratocruiser was informed at 0320 by G.C.A. that the Constellation reckoned he broke cloud at 700 feet and that the visibility was 2-1/2 miles. A further amended report was passed by G.C.A. to the Stratocruiser at 0322 hours to the effect that the Constellation had reported that although he broke cloud at 700 feet there was a layer of cloud below that again. This report was later confirmed by the captain of the Constellation who said in evidence that he became visual at 700 feet, when he was about two miles from touchdown and that he remained visual for the rest of his approach until his touchdown. The captain of the Stratocruiser on his final approach broke cloud at 700 feet when he could see the extreme end of the runway lights and he remained visual until the last few seconds before the aircraft hit the ground. During these last few seconds the visibility had become somewhat reduced due to the presence of low scud clouds on the approach to Runway 31.

The weather minima laid down for pilots of B.O.A.C. are contained in the Operations Manual for Boeing 377. The critical height for Runway 31 at Prestwick during this approach was 600 feet and the visibility 1 mile. It is provided by Paragraph 4.3(i)(a) of the Manual;- "When using a recognized runway approach system a captain must not descend except in emergency below his critical height unless he is completely satisfied that he can thereafter continue his approach and landings by continuous visual reference to the ground or to the visual aids provided. This clearly indicates that no cloud is acceptable upon the approach

path below the critical heights". While the meaning of the first sentence of this paragraph is clear, the interpretation to be placed on the second sentence is not so clear. On one reading of this latter sentence it would prevent a pilot landing if there was cloud between him and the ground on his approach path notwithstanding that the intended glide path was clear. But this was not the interpretation placed on this sentence either by B.O.A.C. or by any of the pilots who gave evidence. It is in practice interpreted in the sense that a pilot may land although there is cloud below his critical height on the approach path, provided the glide path is clear. On this interpretation, if the captain's evidence that he became visual at 700 feet, when he could see the end of the runway, is true, his decision to land at this stage was a correct one. In any event weather conditions played no part in this accident until the talk-down had been completed.

The wording of Paragraph 4.3(i)(a) of the BOAC Boeing Operations Manual leaves a great deal to be desired for clarity and if the interpretation placed on the second sentence is to be the meaning of the clause, this should be made clear by an amendment.

As has already been stated, the flight was uneventful until the aircraft arrived in the stack over Prestwick about 0257 hours. While the aircraft was in the stack, the landing lights were extended and checked and left in the extended position. When the captain received the weather report above referred to at 0301 hours, he in common with the captain of the Constellation decided that there was nothing to prevent his landing. There was a 700 feet ceiling, being the lowest altitude at which more than 4/8th of the sky is covered with cloud. The captain however, in view of the other weather reports given to him was not unprepared to find patches of cloud beneath him on the final approach. He decided to proceed to his critical height. At 0319 the aircraft was given Q.N.H. 1012 millibars which was duly acknowledged. At 0321 the aircraft was just coming up on the final approach, and given a heading of 305 degrees and told to descend to 2 000 feet. Thereafter the aircraft was given headings from time to time by G.C.A. which were in turn acknowledged. At 0323 the final talk-down commenced and finished at 0325+44 seconds. The recorded talk-down is as follows with the calculated times:-

Time	
0323	Ah, that is correct three one five, do not acknowledge further instructions, check your minima, turn left left five degrees heading three one zero, I say again heading three one zero,
0323+14	five and a half miles from touchdown, check wheels down and locked, you are right of the centre line slowly closing on heading three one zero,
0323+22	five miles from touchdown, shortly approaching the glide path, heading three one zero,
0323+30	begin your descent now at six hundred feet per minute,
0323+34	four and a half miles from touchdown, turn left left five degrees heading three zero five, I say again heading three zero five, and you are
0323+43	settled on the glide path now, on the glide path, three zero five is your heading,
0323+49	four miles from touchdown, heading three zero five, and you are just
0323+55	fifty feet above the glide path now, heading three zero five, turn right three degrees heading three zero eight, I say again heading three zero eight,
0324+4	eighty feet above the glide path now, eighty feet too high,
0324+9	three and a half miles from touchdown turn right a further three degrees heading three one one, I say again heading three one one and you are still
0324+17	eighty feet above the glide path, three one one is your heading,

Time	
0324+22	three miles from touchdown, fifty feet high now, forty, thirty,
0324+27	twenty, on the glide path now, heading three one one,
0324+32	on the glide path now, your heading is three one one,
0324+35	two and a half miles from touchdown, turn left left three degrees heading three zero eight, I say again heading three zero eight, and you are
0324+41	going above the glide path now,
0324+44	one hundred feet too high, one hundred and thirty feet above the glide path now,
0324+48	one hundred and forty, heading three zero eight,
0324+51	two miles from touchdown, obstacle clearance limit is two six three feet, turn left left three degrees heading three zero five,
0324+58	eighty feet above the glide path now, fifty feet high, coming back to the glide path, and
0325+4	on the glide path now, heading is three zero five,
0325+7	one and a half miles from touchdown,
0325+8	on the glide path, heading three zero five is good, and you are just
0325+13	twenty feet high now, turn right three degrees heading three zero eight,
0325+18	one and a quarter miles from touchdown,
0325+19	sixty feet high now, turn right a further three degrees heading three one one,
0325+25	one mile from touchdown, you are one
0325+26	hundred and fifty feet above the glide path, two hundred feet above the glide path now, if you are overshooting, climb to one five zero zero feet on heading three one one,
0325+36	three quarters of a mile from touchdown, I will continue with talk-down,
0325+40	one hundred feet high now, and
0325+42	four hundred yards from the runway, talk-down completed,
0325+44	out.

Unfortunately the evidence of the captain and the first officer as to what happened during the final talk-down does not agree. The captain's account in evidence was that he became visual when he was approximately a quarter of a mile short of the most easterly approach lights, which would place the aircraft approximately three quarters of a mile from the threshold or half a mile from the point where the talk-down was completed. The captain stated that he could then see all the approach lights and all the runway lights. He was able to estimate his height from the ground visually and by reference to his altimeter which he reckoned to be 700 feet. During the final stage of the approach he was flying port wing low to counteract the cross wind. All the appropriate checks were carried out including the extension of the flaps to 25 and then 30 degrees. The landing lights were checked during the approach prior to the outer marker beacon. There was a slight drizzle which caused him to put on the wind-shield

wipers. Just as the aircraft was coming over the most easterly approach light, the captain gave an order to the first officer- "Landing Flaps, Full Flap; Landing Lights On". He says that from the feel of the aircraft in his hands he is certain that the flaps had been extended to the 45 degrees position, but that no acknowledgment of this order was given by the first officer. The landing lights were not illuminated and he again asked the first officer for the landing lights to be put on. According to the captain the first officer replied "They are on". The captain says he was misled into thinking that the landing lights were in fact on by the glare of the approach lights. All the eye-witnesses, except one who was undoubtedly mistaken, agree that the landing lights were never illuminated during the final approach. According to the captain the final manifold power setting was 20 inches or 25 inches. Up to the time of the completion of the talk-down he experienced nothing unusual. The aircraft had behaved normally and he made no complaint of the talk-down. He then describes what happened next in these graphic words- "I was slightly high on the glide path, I steepened my approach and when I reached the altitude that I wanted to soften my rate of descent I eased the control column back. The aircraft responded inasmuch as it changed attitude. Then it seemed to fall out of my hands. Visibility deteriorated to the extent that the lights were then visual as if seen through haze. We came out of that condition and hit the ground, I think port wheel first and it probably took much less time to happen than it has taken me to tell you". His steep descent was necessitated because he was high relative to his aiming point which was 200 to 300 yards up the runway. His speed was 130-135 knots until full flap was selected, then a decrease from 130 knots to cross over the threshold at 115 knots. His stated intention was to cross the threshold at a height of about 3 to 5 feet from the ground.

The first officer's evidence tallies with the captain's evidence up to the beginning of the final approach. Thereafter it differs to some extent. He agrees that they became visual at about 700 feet and that the captain ordered full flap before the approach lights. This order he acknowledged. The first officer executed this order by operating the flap selector switch until the instrument on the panel showed 45 degrees. When the indicator had gone to 45 degrees he said to the captain "You have Full Flap". He stated that he received no order from the captain for landing lights on during the final approach and accordingly did not apply the landing light switches and the landing lights were never illuminated. He had the impression that the aircraft was high for an approach and that the descent was fairly steep. His recollection is that the aircraft was in cloud for a few seconds. He obtained no impression of the aircraft sinking except in the last split second before the aircraft hit the ground.

The remainder of the crew gave no assistance on the conflict between the captain and the first officer. No one overheard the orders given by the captain on the final approach. The flight engineer, who was at the panel as engineer for the approach and landing, says that the power settings ordered were 37-1/2 inches, 28 inches and 25 inches all at an engine speed of 2120 rpm. These were, according to the witness, perfectly normal settings for an approach to Prestwick.

A number of eye-witnesses on the ground gave evidence as to the behaviour of the aircraft before and at the time of the crash. The most valuable evidence came from the Approach Controller who witnessed the approach of the aircraft and the accident through binoculars from the control tower. He observed the navigation lights when the aircraft passed the range of one mile from touchdown. The landing lights were never on. According to him, the aircraft appeared rather high and when it was about three quarters of a mile from touchdown it descended more rapidly than is normal. During the approach of the aircraft he was able to see all the runway lights, the threshold lights and all the approach lights except one, which was obscured by the configuration of the ground.

The aircraft struck the ground nose wheel first. Almost immediately thereafter the port landing wheels contacted the ground at a distance of 127 feet from the threshold; the starboard wheels first contacted the ground 70 feet from the threshold. The marks indicated that the aircraft had made a fairly straight approach to the runway being only 12 feet to the right of the centre line. The port main landing wheels continued their marks for a distance along the runway when the aircraft again became airborne for a distance of 373 feet. The second impact probably caused the collapse of the main landing gear and thereafter the aircraft

skidded along the runway for about 1 200 feet to its final position. Following the collapse of the port undercarriage the port wing folded back and trailed beside the fuselage. Various portions of the aircraft were shed during its course along the runway and No. 4 engine was completely detached during the final break-up on the south side of the runway. A severe structural failure occurred in the area of the wing root and the aircraft lay with the crew compartment on its port side and the main fuselage in an inverted position and resting on its tail fin. The port wing was partially covered by the fuselage.

A careful and minute examination was made of all parts of the aircraft after the accident. The position of the flap mechanism indicated that the flaps at the final point of rest were at the 35 degrees setting. The left elevator compensator trim tab was at a setting which would be commensurate with the flap setting at 35 degrees. The torque bar which operates the flaps was fractured: the wing flap indicator was found, but it was so badly damaged that no setting could be determined. The wing flap and landing lamp control panel was also recovered, but this had been so destroyed by fire that it was impossible to make any safe deduction as to the position of the switches at impact or final rest. The left landing light was in the fully extended position. The rear spar of the port wing was fractured, but it was impossible to say whether this occurred at first or second impact. When the rear spar fractured it is possible that the torque tube which operates the flap mechanism became out of alignment and this, if it occurred, would have prevented the flaps from operating further in either direction.

Various possibilities were canvassed as to the likelihood of the flap mechanism operating after the first impact. There is a remote possibility that the flap mechanism operated after the first impact either by the relay making a connection or the switch being moved in the course of the crash, but the Court considered that the strong probability is that the flaps were in the 35 degrees setting at the moment of first impact and never moved from that position after.

The marks on the ground and the damage to the aircraft indicate that at the time of hitting the ground the port wing was low to the extent of about 5 degrees to the horizontal.

Having regard to the evidence of the talk-down, the ground damage, and the damage to the aircraft, it is possible to obtain a fairly accurate picture of what happened up to within a few seconds of the aircraft hitting the ground and after the aircraft hit the ground. The important gap lies in the few seconds which elapsed after the talk-down was completed. The captain's explanation of the accident is that the flaps must have retracted from 45 degrees to 35 degrees during the last five seconds or so prior to the crash and that this caused the aircraft to sink and so hit the ground. In considering this explanation it was necessary first of all, if possible, to resolve the conflict between the evidence of the captain and first officer as to the landing lights. The Court had no doubt that the captain gave the order to switch on the landing lights and that this order was not carried out by the first officer and that the landing lights were accordingly not illuminated during the final approach. The order for flaps and the order for landing lights should, wherever possible, be separately given and separately acknowledged. However this may be, it is not possible to explain the first officer's failure to put on the landing lights by the confusion of the double order because the captain, if he is to be believed and on this matter the Court was prepared to accept his evidence, reiterated the order for landing lights. The Court found it difficult to understand how the captain could have been misled into thinking that the landing lights were on from the glare of the approach lights, but it was possible that the low cloud on the approach path led him into this mistake. The Court felt that if the order for landing lights had been given earlier and had been carried out the flight of the aircraft into low cloud might have been avoided. The advantage of giving the order for landing lights at an earlier stage is that if the order is not carried out or if the lights do not go on, there is time for the pilot to reconsider his position. The next point considered was if the flaps retracted from 45 degrees to 35 degrees, how this took place. The Court dismissed the suggestion that the flaps were never extended to 45 degrees for the reason that there is no evidence to support it. It was clear that the flaps could only retract by the operation of the flap selector switch. This is on the instrument panel next to the landing light switches immediately adjacent to the first officer's seat. The flap selector switch

is guarded on either side by a projection of metal. To operate the flaps to the down position the switch is moved in a forward motion. The switch being spring loaded from this position returns automatically when released to the neutral position which is vertical. To retract the flaps the switch is moved aft and on this side the switch is not spring loaded and only returns to the neutral position on being moved to the vertical. Prior to the accident, on a training flight, a pilot had the experience of the flap selector switch on the final approach springing into the retract position after full flap had been selected and the switch released. This caused B.O.A.C. to issue a warning to captains and first officers, to ensure that the flap selector switch is returned to the "off" position at all times. Since the accident three other B.O.A.C. pilots have reported similar malfunctioning of the flap selector switches which occurred prior to the accident. The Court did not consider that this malfunctioning of the flap selector switch was due to any mechanical defect in the system. The flap selector switch operated correctly if it was handled with care. The first officer testified that he did not allow the switch to move to the retract position and in fact asserted that he kept his fingers on the switch until he returned it to the "off" position. There was a further possibility that the first officer in a last-second attempt to switch on the landing lights in response to the captain's reiterated order for them inadvertently operated the flap switch. The first officer denies this and it was considered improbable in view of the different position, structure and movement of the two switches. Assuming, however, that the flaps retracted from 45 degrees to 35 degrees the next question considered was what caused them to retract. The possibility of the flaps retracting between first and second impact was canvassed, but having regard to the damage and the rate of retraction of 2 degrees per second the Court rejected this possibility. It was considered that contrary to the first officer's evidence the most probable explanation was that when operating the flap selector switch he allowed the switch to spring back from the extend position past the "off" position and that the strength of the spring did, as it had done on the other occasions, move the switch into the retract position which caused the flaps to move from 45 degrees to 35 degrees. If this did take place, the mechanism must at some point prior to the aircraft coming to rest have stopped retracting. It was considered that the probability is that this occurred with first impact when the rear spar was fractured and the torque tube put out of alignment.

The next step considered, in what came to be known as the "flap theory," was whether this caused or contributed to the accident. On the captain's account nothing unusual occurred until the last few seconds before impact. The question was therefore whether the flap retraction from 45 degrees to 35 degrees could have caused the sink which the captain sensed and resulted in the aircraft "falling out of his hands" as he described it. Tests were made in the air on a Stratocruiser by a B.O.A.C. pilot after the accident as to the effect of a flap retraction from 45 degrees to 35 degrees at varying speeds. The results of these tests, which were not controlled, were indeterminate and the Court did not find itself assisted by them. More valuable assistance came from the Test Pilot of Boeing Airplane Company. He produced a report from his Company made in response to questions asked by B.O.A.C. in relation to this accident. Graphs were produced which showed that the stalling speeds of this aircraft with flaps at 45 degrees and 35 degrees were very close. The evidence shows that this aircraft at no time prior to the accident approached these speeds. Graphs also showed that the lift co-efficient was not materially affected by the retraction of the flaps from 45 degrees to 35 degrees and that a retraction of the flaps from 45 degrees to 35 degrees would only require an increase of 2 degrees in the angle of attack to compensate for this retraction. The retraction of the flaps which would be at a rate of approximately 2 degrees per second would be gradual and the change is partially compensated by the left compensator trim tab which works in conjunction with the flap retraction gear. The Test Pilot's view was that the difference in handling characteristics of the aircraft caused by the retraction of the flaps from 45 degrees to 35 degrees was one which a careful pilot should be able to cope with.

After a close and careful study of the evidence the Court reached the conclusion that the retraction of the flaps from 45 degrees to 35 degrees did not cause or contribute to the accident.

Assuming that the retraction of the flaps was not associated with the accident, it became necessary to consider what was the cause of the aircraft hitting the ground 127 feet short of the threshold. In approaching this branch of this case the Court had perforce to discard the

captain's evidence as to what happened during the last few seconds before impact. The captain's approach was, on his own admission, high, and from the talk-down record, considered unduly high. In order to touch down in the position and at the point which he was aiming at it was necessary for him to make a steep final descent. The rate of descent has been calculated accordingly to a profile prepared in relation to the talk-down at 1260 feet per minute in the last 10 seconds before completion of the talk-down. This compares with a steady descent by the captain of the Constellation of 636 feet per minute. At what stage the aircraft went into reduced visibility due to cloud it was impossible to state with precise accuracy. It was probably, according to the first officer's evidence, in these conditions for a longer period than the captain stated. It was considered that the captain, owing to the reduced visibility into which the aircraft passed and the lack of landing lights, flared out too late and too severely, thereby causing the aircraft to sink too rapidly during the last few seconds. Flap retraction may have played a minimal part in the final sink, but in the opinion of the Court, owing to the captain's errors of judgment, the aircraft would, in any event, have hit the ground at about that point apart from any question of retraction of flaps.

The captain reported to the Meteorological Office at London Airport at 1520 hours on 24 December 1954, having telephoned for information about the weather at 1400 hours. The first officer had reported about noon on the same day. The flight had been scheduled to leave London at 1745 hours, but owing to a delay in waiting for a passenger to be flown from Manchester, the aircraft did not become airborne till 2158 hours. In the course of the flight the port undercarriage failed to retract and fuel had to be jettisoned prior to making a landing at 2245 hours. The take-off of the second aircraft from London Airport took place at 0120 hours and the accident happened at Prestwick about 0325 hours on 25 December. The captain had accordingly been on duty for about 12 hours and the first officer for a slightly longer period. These members of the crew had undoubtedly had a long and tiring day and the captain had throughout anxieties about the weather to be encountered at Prestwick and indeed had considered the possibility of several alternate airports for landing. His actual flying time was, however, approximately three hours. While the Court was prepared to believe that the captain would by 0320 hours on the morning of the 25 December be fatigued, it did not consider that he was so unduly fatigued as to endanger the safety of the aircraft. The captain himself disclaimed any feeling of tiredness at the time of the accident.

The Regulations of B.O.A.C. provide no maximum period of duty for members of the aircraft crew. It is left to the discretion of the captain to call for a stand-by crew. In the opinion of the Court consideration should be given by B.O.A.C. to Regulations providing for on-duty time limitations prior to departure from the airport and in the course of the flight. The Ministry of Transport and Civil Aviation had at present under consideration the question of the tours of duty by air crews.

Rescue Services

These functioned efficiently and promptly. The aerodrome services were in operation and assistance was obtained from local fire brigades. Doctors and ambulances were on the scene promptly and the services of ministers and priests were readily available. The Airport Police were supplemented by the Civil Police. So fierce was the fire that it was not finally extinguished till 0800 hours on 25 December. There was close and integrated co-operation between all the Services and full co-operation and assistance was obtained from the United States Air Force Services.

The aircraft was marked externally to show where access to the aircraft was easiest. While these marks would be of assistance to those engaged in Rescue Service, it would be of further assistance if some plainly marked instructions were given on the outside of the aircraft doors in order to show how these could easily be opened. The court approved a suggestion that a system of battery operated lighting should be installed on transport aircraft in order that in the event of failure of electrical power, passengers would be able in the event of an accident to see their way to safety.

Conclusions and Recommendations

The aircraft had been maintained in good condition and was properly equipped, fuelled and loaded for its flight from London to Prestwick. The engines functioned normally and there was no reason to believe that there was any failure of the equipment. There was no mechanical defect in the aircraft.

The crew were experienced and competent. The captain was a pilot of great experience who had familiarity with Prestwick. The first officer also had considerable experience in the position of co-pilot. Although nothing was disclosed in the evidence, the conclusion from the temperament of these two individuals may be that there was some lack of co-operation between them. There was nothing in the tour of duty to cause undue fatigue. B.O.A.C. should consider some limitation of the hours of duty of an air crew at an airport.

The flight proceeded normally up to the point where the G.C.A. talk-down began. The G.C.A. system worked normally and correctly. Any error in the glide path was minimal and had nothing to do with the accident.

The captain's orders to put on the landing lights were not carried out by the first officer. The landing lights would have enabled the captain to observe earlier the presence of low cloud into which the aircraft passed immediately prior to striking the ground.

Weather conditions were such that the captain's decision to land was correct. The weather minima of B.O.A.C. on Runway 31 at Prestwick are adequate to ensure the safe operation of aircraft.

The captain kept the aircraft unduly high on the final approach. His descent to the runway was abnormally steep and in order to correct his steep descent his flare out was too late and too severe. The aircraft passed through low cloud over the approach lights and owing to the absence of landing lights the reduced visibility took the captain by surprise and in the last few seconds he failed to appreciate how near to the ground he was.

The lighting at Prestwick was considered adequate, although this will be considerably improved when the Calvert Crossbar System of lighting is installed.

The G.C.A. system functioned correctly and the facilities provided gave reasonable and safe assistance to the aircraft. An effort should be made to institute complete ILS with glide path on either Runway 31 or 13 without further delay, if this has not already been done. The inter-departmental working of the Telecommunications Section of the Ministry should be looked into.

Improved marking of points of access to an aircraft should be introduced and battery operated emergency lighting to supplement the normal system should be made obligatory.

Probable Cause

Errors of judgment on the part of the captain in

a) starting his final approach to land at too steep an angle and

b) flaring out too late and too severely with the result that the aircraft sank and hit the ground short of the runway. During the flare out the aircraft passed through low cloud, thus reducing the captain's visibility. The accident was also contributed to by the failure of the first officer to carry out the order of the captain to put on the landing lights which prevented the captain from observing timeously the low cloud over the approach lights.

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PART II

AIRCRAFT ACCIDENT STATISTICS 1952, 1953, 1954

INTRODUCTION

GENERAL COMMENTS

1. This section of the Aircraft Accident Digest No. 6 contains statistics for the years 1952, 1953 and 1954 obtained largely from the ICAO Air Transport Reporting Form 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 a fairly complete picture of accidents in which public transport 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. When analyzing the Forms G (facsimile copy given on pages and) it has been found that in some cases there appears to be misinterpretation of the information required; in other cases the Forms have been filled in either incompletely or without regard to the instructions pertaining to this Form G. This lack of accuracy and uniformity, as well as the oft-observed inconsistencies between data reported on Form G and certain other Air Transport Reporting Forms, Form A in particular, has complicated the compilation of the tables in this Digest.

3. As this is the first time that statistics of this nature have been included in the Digest, States are invited to comment on the value of the material and to forward any recommendations for improvements. In particular, States are requested to notify any errors or omissions that may be observed and to file Air Transport Reporting Form G, if that has not already been done, so that improved and more complete information can be included in future Digests.

DESCRIPTION OF TABLES

4. Accident data has been recorded under the country in which the airline which suffered an accident is registered, and not in the country where the accident took place. Contracting States which were members of the Organization by August 1955, numbering 66, have been included in Tables B and C for the years 1952, 1953 and 1954.

5. The three tables compiled for each of the years 1952, 1953 and 1954 give the following information:

TABLE A Fatality rate by countries whose registered airlines had an accident causing a passenger to be killed on a scheduled flight.

TABLE B Aircraft accident summary by country of all operators engaged in public air transport registered in the 66 contracting States of ICAO.

TABLE C Aircraft accident summary by type of operation and by country.

PASSENGER FATALITIES 1925 - 1954

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
5 - YEAR PERIODS				
1925 - 1929	180	645	28	4
1930 - 1934	400	2 220	18	6
1935 - 1939	665	7 382	9	11
1940 - 1944	570	18 979	3	33
1945 - 1949	2 277	86 800	2.62	38
1950 - 1954	2 190	200 650	1.09	92
YEAR				
1945	247	8 200	3.01	33
1946	376	15 500	2.43	41
1947	590	18 900	3.12	32
1948	521	20 900	2.49	40
1949	543	23 300	2.33	43
1950	551	27 300	2.02	50
1951	443	34 400	1.29	78
1952	386	39 950	0.97	103
1953	360	46 500	0.77	129
1954	450	52 500	0.86	117

Exclusions: The People's Republic of China, U.S.S.R.

PASSENGER FATALITIES OCCURRING ON
SCHEDULED INTERNATIONAL AND DOMESTIC OPERATIONS
YEAR 1952

1952
TABLE A

Description	Country Total of Hours Flown	Number of Fatal Accidents	Number of Passengers Killed	Country Total of Passenger Kilometres	Fatality Rate per 100 Million Pass.-Kms.	Millions of Passenger-Kilometres per Fatality
	(thousands)			(millions)		
Total Scheduled Operations						
Belgium	63	1	12	344		
Brazil	343	2	13	1 279		
Cuba	27*	1	30	132*		
France	232+	1	33	1 910+		
India	119	3	15	389		
Iran	5	1	19	14		
Ireland	24	1	20	106		
Japan	6*	1	37	69+		
Netherlands	122	1	36	1 013		
Philippines	47	1	11	213		
Syria	1*	1	9	2*		
United States	2 935	5	140	25 025		
Venezuela	106*	2	11	285*		
All other countries	n.a.	-	-	9 169		
Total	n.a.	21	386	39 950	0.97	103
International Scheduled Operations						
Cuba	27*	1	30	70*		
France	232+	1	33	1 910+		
Iran	5	1	19	14		
Ireland	24	1	20	104		
Netherlands	119	1	36	1 007		
Syria	0.5	1	9	1*		
United States	496	3	94	4 867		
Venezuela	18*	1	2	171*		
All other countries	n.a.	-	-	6 581		
Total	n.a.	10	243	14 275	1.70	59
Domestic Scheduled Operations						
Belgium	32*	1	12	176		
Brazil	295*	2	13	1 085		
India	100*	3	15	280		
Japan	6*	1	37	69+		
Philippines	32	1	11	82		
United States	2 440	2	46	20 158		
Venezuela	88*	1	9	114*		
All other countries	n.a.	-	-	3 711		
Total	n.a.	11	143	25 675	0.56	180

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.

\+ Provisional data.
* Estimated data.
n.a. not available.

Exclusions: The People's Republic of China, USSR.

1953
TABLE A

PASSENGER FATALITIES OCCURRING ON SCHEDULED INTERNATIONAL AND DOMESTIC OPERATIONS

YEAR 1953

Description	Country Total of Hours Flown	Number of Fatal Accidents	Number of Passengers Killed	Country Total of Passenger Kilometres	Fatality Rate per 100 Million Pass.-Kms.	Millions of Passenger-Kilometres per Fatality
	(thousands)			(millions)		
Total Scheduled Operations						
Australia	294	1	11	1 472		
Belgium	72	2	42	448		
Bolivia	16+	1	25	32*		
Brazil	375+	2	13	1 483		
Canada	210	1	1	1 425		
Chile	25+	1	4	95+		
Costa Rica	16*	1	6	33*		
Egypt	10	1	1	32		
France	241+	4	41	2 157+		
India	115	2	23	386		
Italy	37	1	15	229		
Pakistan	11*	1	12	42		
Thailand	12	1	4	31		
Turkey	26*	1	5	66		
United Kingdom	406+	3	69	2 308		
United States	3 198	5	88	29 212		
All other countries	n.a.	-	-	7 049		
Total	n.a.	28	360	46 500	0.77	129
International Scheduled Operations						
Australia	41	1	11	332		
Belgium	34	2	42	227		
Brazil	28+	1	10	204		
Egypt	3	1	1	21		
France	241+	4	41	2 157+		
Pakistan	9*	1	12	36		
United Kingdom	305+	2	45	2 066		
United States	497	1	2	5 458		
All other countries	n.a.	-	-	5 309		
Total	n.a.	13	164	15 810	1.04	96
Domestic Scheduled Operations						
Bolivia	15*	1	25	30*		
Brazil	347+	1	3	1 279		
Canada	164	1	1	994		
Chile	23+	1	4	85+		
Costa Rica	2*	1	6	4*		
India	100*	2	23	256		
Italy	16	1	15	52		
Thailand	6	1	4	8		
Turkey	24*	1	5	62		
United Kingdom	101+	1	24	242		
United States	2 701	4	86	23 754		
All other countries	n.a.	-	-	3 924		
Total	n.a.	15	196	30 690	0.64	157

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.

\+ Provisional data.
* Estimated data.
n.a. not available.

Exclusions: The People's Republic of China, USSR.

PASSENGER FATALITIES OCCURRING ON
SCHEDULED INTERNATIONAL AND DOMESTIC OPERATIONS
YEAR 1954

1954
TABLE A

Description	Country Total of Hours Flown	Number of Fatal Accidents	Number of Passengers Killed	Country Total of Passenger Kilometres	Fatality Rate per 100 Million Pass.-Kms.	Millions of Passenger-Kilometres per Fatality
	(thousands)			(millions)		
Total Scheduled Operations						
Argentina	55	1	21	333+		
Brasil	435*	2	17	1 720+		
Canada	213	1	31	1 624		
Colombia	120*	2	39	426+		
Czechoslovakia	10*	1	11	7*		
Italy	45	1	16	307		
Laos	3*	1	26	8*		
Mexico	200*	1	15	1 399*		
Netherlands	151	2	37	1 362		
New Zealand	56	1	3	237+		
Peru	20*	2	30	86*		
Philippines	39	1	7	127+		
Switzerland	49	1	3	447		
Turkey	15*	2	22	60*		
United Kingdom	398*	5	107	2 441+		
United States	3 224	2	16	33 020		
Viet Nam	8+	2	49	153*		
All other countries	n.a.	-	-	8 743		
Total	n.a.	28	450	52 500	0.86	117
International Scheduled Operations						
Colombia	15	1	21	129+		
Italy	30	1	16	254		
Netherlands	148	2	37	1 353		
Philippines	6	1	7	37+		
Switzerland	49	1	3	447		
United Kingdom	290*	5	107	2 147+		
Viet Nam	2+	1	47	7*		
All other countries	n.a.	-	-	13 476		
Total	n.a.	12	238	17 850	1.33	75
Domestic Scheduled Operations						
Argentina	35	1	21	152+		
Brasil	400*	2	17	1 485+		
Canada	167	1	31	1 116		
Colombia	105*	1	18	297+		
Czechoslovakia	7*	1	11	4*		
Laos	0.4*	1	26	1*		
Mexico	135*	1	15	965*		
New Zealand	45	1	3	144+		
Peru	20*	2	30	86*		
Turkey	14*	2	22	55*		
United States	2 721	2	16	26 986		
Viet Nam	6+	1	2	146*		
All other countries	n.a.	-	-	3 213		
Total	n.a.	16	212	34 650	0.61	163

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.

\+ Provisional data.
* Estimated data.
n.a. not available.

Exclusions: The People's Republic of China, USSR.

1952

TABLE B

CONTRACTING STATES OF ICAO

AIRCRAFT ACCIDENT SUMMARY FOR 1952

OF ALL OPERATORS ENGAGED IN PUBLIC AIR TRANSPORT

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	7	-	-	-	-	-	-	-	-	-		51 775	51 775
✓ Australia	4	1	-	1	70	1	-	16	-	-			293 391
Austria	noa	noa	noa	noa	noa	noa	noa	noa	noa	noa			
✓ Belgium	1	1	12	-	-	3	-	-	-	-		71 056	
Bolivia	-	-	-	-	-	-	-	-	-	-			
✓ Brazil	6	3	13	10	9	12	4	-	-	-			351 249
Burma	-	-	-	-	-	-	-	-	-	-			
✓ Canada a/	1	1	-	-	-	1	-	-	-	-			254 199
Ceylon	-	-	-	-	-	-	-	-	-	-			
Chile	-	-	-	-	-	-	-	-	-	-			
China (Taiwan) b/	-	-	-	-	-	-	-	-	-	-			
Colombia	-	-	-	-	-	-	-	-	-	-			
Cuba	1	1	30	4	-	7	-	-	-	-			
Czechoslovakia	-	-	-	-	-	-	-	-	-	-			
Denmark	-	-	-	-	-	-	-	-	-	-			
Dominican Rep.	-	-	-	-	-	-	-	-	-	-			
Ecuador b/	-	-	-	-	-	-	-	-	-	-			
Egypt	-	-	-	-	-	-	-	-	-	-			
El Salvador	noa	noa	noa	noa	noa	noa	noa	noa	noa	noa			
✓ Ethiopia	-	-	-	-	-	-	-	-	-	-			
✓ Finland	-	-	-	-	-	-	-	-	-	-			15 152
France	3	2	47	2	2	7	-	-	-	-			
✓ Greece	-	-	-	-	-	-	-	-	-	-			
Guatemala	-	-	-	-	-	-	-	-	-	-			
Haiti	-	-	-	-	-	-	-	-	-	-			
Honduras a/	-	-	-	-	-	-	-	-	-	-			
Iceland	-	-	-	-	-	-	-	-	-	-			
India	4	3	15	12	-	5	3	4	-	-			
Indonesia	-	-	-	-	-	-	-	-	-	-			
Iran	1	1	19	-	-	4	-	-	-	-			
Iraq	-	-	-	-	-	-	-	-	-	-			
✓ Ireland	1	1	20	-	-	3	-	-	-	-	19 615	25 634	
Israel	-	-	-	-	-	-	-	-	-	-			
Italy	-	-	-	-	-	-	-	-	-	-			
Japan a/	1	1	37	-	-	-	-	-	-	-			
Jordan	-	-	-	-	-	-	-	-	-	-			
Korea	-	-	-	-	-	-	-	-	-	-			
Laos a/	-	-	-	-	-	-	-	-	-	-			
✓ Lebanon	2	-	-	-	-	-	-	-	-	-		19 545	20 217
Liberia	-	-	-	-	-	-	-	-	-	-			
Libya a/	-	-	-	-	-	-	-	-	-	-			
Luxembourg	noa	noa	noa	noa	noa	noa	noa	noa	noa	noa			
Mexico	1	1	-	22	-	-	-	-	3	-			
✓ Netherlands	2	1	36	1	34	9	1	10	-	-	48 751	140 280	
✓ New Zealand	2	-	-	-	2	-	-	2	-	-	14 205	10 049	58 376
Nicaragua	-	-	-	-	-	-	-	-	-	-			
Norway	1	1	8	-	18	3	-	-	-	-			
✓ Pakistan	2	1	-	-	-	1	-	2	-	-	9 017	17 283	
Paraguay	noa	noa	noa	noa	noa	noa	noa	noa	noa	noa			
Peru	-	-	-	-	-	-	-	-	-	-			
Philippines	3	2	11	16	-	4	-	-	-	-			
Poland	-	-	-	-	-	-	-	-	-	-			
✓ Portugal	-	-	-	-	-	-	-	-	-	-			7 268
✓ Spain	-	-	-	-	-	-	-	-	-	-			45 791
✓ Sweden	17	2	1	-	-	-	1	-	1	-	22 550 d/ f/	50 750 d/	55 500 d/
Switzerland	-	-	-	-	-	-	-	-	-	-			
Syria	1	1	9	-	-	16	-	-	-	-			
✓ Thailand	2	-	-	-	3	-	-	2	-	-	8 379	13 231	13 231
Turkey	-	-	-	-	-	-	-	-	-	-			
Un.of S.Africa	1	-	-	-	14	-	-	5	-	-			
✓ United Kingdom g/	32	5	37	1	201	9	1	65	1	-			
h/	(17)	(5)	(37)	(-)	(198)	(8)	(-)	(63)	(1)	(-)	(132 673)		(324 640)
United States i/	62	10	173	49	1 029	20	4	208	18	11			
✓ Uruguay b/	-	-	-	-	-	-	-	-	-	-			5 898
Venezuela	2	2	11	-	-	4	-	-	-	-			
Viet Nam b/	1	-	-	-	-	-	-	-	-	-			
Total for 66 States	161	41	479	118	1 382	109	14	314	23	11			
TYPE OF OPERATION													
Scheduled International	32	12	243	7	334	38	3	93	2	-			
Scheduled Domestic	80	18	143	83	838	36	10	149	18	11			
Non-Scheduled International	13	7	70	-	154	13	-	30	-	-			
Non-Scheduled Domestic	19	2	8	22	46	3	-	11	3	-			
Non-Revenue	14	1	1	4	8	1	1	31	-	-			
Indeterminate	3	1	14	2	2	3	-	-	-	-			
Total Operations	161	41	479	118	1 382	109	14	314	23	11			

NOTES: Source of Data: Air Transport Reporting Form G filed by countries indicated with a ✓.
All other country data collected from outside sources.

noa - No Civil Aviation.
a/ Country became a Contracting State in 1953
b/ Country became a Contracting State in 1954.
c/ Country became a Contracting State in 1955.
d/ Includes Country's share in Scandinavian Airlines System (SAS).
e/ Data for scheduled operations only. The last column includes hours flown by all scheduled operators.
f/ Excludes helicopter landings.
g/ Data refer to airlines registered in the United Kingdom and its dependencies.
h/ United Kingdom only.
i/ Data for scheduled operators only. (Excludes Alaskan carriers).

CONTRACTING STATES OF ICAO

AIRCRAFT ACCIDENT SUMMARY FOR 1953

OF ALL OPERATORS ENGAGED IN PUBLIC AIR TRANSPORT

1953
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	nca	nca	nca	nca	nca	nca	nca	nca	nca	nca			
✓ Argentina	5	-	-	-	-	-	-	-	-	-		56 396	
✓ Australia	4	2	12	-	6	9	-	3	-	-	64 813	108 772	293 010
Austria	nca	nca	nca	nca	nca	nca	nca	nca	nca	nca			
✓ Belgium	3	3	42	-	11	5	3	-	-	-			
Bolivia	1	1	25	-	-	3	-	-	-	-			
✓ Brazil d/	10	3	13	1	2	12	6	4	-	-	146 944	225 046	389 489
Burma	1	-	-	-	15	-	-	3	-	-			
✓ Canada d/	6	1	1	-	7	1	-	-	-	-	131 118	207 497	263 172
✓ Ceylon	-	-	-	-	-	-	-	-	-	-			5 654
✓ Chile	1	1	4	-	-	3	-	-	-	-			
China(Taiwan) a/	-	-	-	-	-	-	-	-	-	-			
Colombia	2	-	-	-	25*	-	-	3*	-	-			
Cuba	-	-	-	-	-	-	-	-	-	-			
Czechoslovakia	-	-	-	-	-	-	-	-	-	-			
Denmark	-	-	-	-	-	-	-	-	-	-			
Dominican Rep.	-	-	-	-	-	-	-	-	-	-			
Ecuador a/	-	-	-	-	-	-	-	-	-	-			
✓ Egypt	1	1	1	-	1	1	-	1	-	-			
El Salvador	nca	nca	nca	nca	nca	nca	nca	nca	nca	nca			
Ethiopia	-	-	-	-	-	-	-	-	-	-			
✓ Finland	-	-	-	-	-	-	-	-	-	-			16 117
✓ France b/	9	5	41	6	119	17	7	28	-	-		351 300	351 300
Greece	-	-	-	-	-	-	-	-	-	-			
Guatemala	1	1	-	-	-	2	-	-	-	-			
Haiti	-	-	-	-	-	-	-	-	-	-			
Honduras	1	1	-	-	-	3	-	-	-	-			
Iceland	-	-	-	-	-	-	-	-	-	-			
India	9	3	23	-	6	11	1	13	-	-			
Indonesia	1	-	-	-	-	-	-	-	-	-			
Iran	1	-	-	-	6	-	1	2*	-	-			
✓ Iraq	-	-	-	-	-	-	-	-	-	-			
✓ Ireland	1	-	-	-	-	-	1	1	-	-	21 213	25 566	
Israel	-	-	-	-	-	-	-	-	-	-			
✓ Italy	1	1	15	-	-	4	-	-	-	-	16 919	24 752	38 428
Japan	-	-	-	-	-	-	-	-	-	-			
Jordan	-	-	-	-	-	-	-	-	-	-			
Korea	-	-	-	-	-	-	-	-	-	-			
Laos h/	1	-	-	-	-	-	-	-	-	-			
✓ Lebanon	1	-	-	-	-	-	-	-	-	-		9 946	29 016
Liberia	-	-	-	-	-	-	-	-	-	-			
Libya	-	-	-	-	-	-	-	-	-	-			
Luxembourg	nca	nca	nca	nca	nca	nca	nca	nca	nca	nca			
Mexico	3	2	20	-	-	1	-	-	-	-			
✓ Netherlands	2	-	-	3	81	-	1	4	2	5	53 695	153 435	
✓ New Zealand	2	1	2	-	-	1	-	4	-	-	55 833	64 608	
Nicaragua	-	-	-	-	-	-	-	-	-	-			
✓ Norway	1	1	3	-	-	1	-	-	-	-			46 150 g/
✓ Pakistan	3	2	13	3	4	5	2	2	-	-	8 301	15 384	
Paraguay	nca	nca	nca	nca	nca	nca	nca	nca	nca	nca			
Peru	-	-	-	-	-	-	-	-	-	-			
✓ Philippines	6	-	-	-	-	-	-	1	-	-	31 110 j/	54 020	54 020
Poland	-	-	-	-	-	-	-	-	-	-			
✓ Portugal	-	-	-	-	-	-	-	-	-	-			7 347
✓ Spain	1	1	22	5	1	1	2	2	-	-	6 974	9 361	50 914
✓ Sweden	15	1	-	-	-	2	-	-	-	-	28 771a/g/	58 511 g/	59 100 g/
✓ Switzerland	-	-	-	-	-	-	-	-	-	-			
Syria	-	-	-	-	-	-	-	-	-	-			
✓ Thailand	2	1	4	-	-	2	-	2	-	-	8 703	13 450	13 450
Turkey	1	1	5	16	-	1	-	-	-	-			
✓ Un.of S.Africa	26	2	-	-	1	2	-	-	-	-			65 187 f/
✓ United Kingdom g/	25	6	102	7	164	22	1	44	1	1	230 507	468 119	486 873
h/	(14)	(4)	(94)	(7)	(164)	(15)	(1)	(43)	(1)	(-)	(161 940)	(343 798)	(362 552)
✓ United States i/	48	12	113	40	1 094	27	5	151	4	-	1 998 845	2 730 766	3 339 720
✓ Uruguay a/	-	-	-	-	-	-	-	-	-	-			7 898
Venezuela	-	-	-	-	-	-	-	-	-	-			
Viet Nam a/	2	-	-	-	-	-	-	-	-	-			
Total for 66 States	197	53	461	81	1 543	136	30	268	7	6			
TYPE OF OPERATION													
Scheduled International	34	17	164	25	482	51	14	89	7	5			
Scheduled Domestic	80	17	190	32	931	50	10	131	-	1			
Non-Scheduled International	9	3	34	3	86	9	2	18	-	-			
Non-Scheduled Domestic	50	10	50	21	11	15	2	7	-	-			
Non-Revenue	10	3	23	-	8	5	2	10	-	-			
Indeterminate	14	3	-	-	25	6	-	13	-	-			
Total Operations	197	53	461	81	1 543	136	30	268	7	6			

NOTES: Source of Data: Air Transport Reporting Form G filed by countries indicated with a ✓.
All other country data collected from outside sources.

* Estimated.
nca - No Civil Aviation.
a/ Country became a Contracting State in 1954.
b/ Country became a Contracting State in 1955.
g/ Includes Country's share in Scandinavian Airlines System (SAS).
d/ Data for scheduled operations only. Data for Canada given in the last column includes hours flown by all scheduled operators.
a/ Excludes helicopter landings.
f/ Does not include 2564 hours flown by aerial work organizations.
g/ Data refer to airlines registered in the United Kingdom and its dependencies. Data for dependencies incomplete for number of landings and hours flown.
h/ United Kingdom only.
i/ Data for 20 scheduled operators only. Hours flown are by all operators engaged in public air transport. (Excludes Alaskan carriers).
j/ Excludes PAL non-scheduled and non-revenue landings which are not available.
k/ Excludes all domestic flights in Indo-China.

1954
TABLE B

CONTRACTING STATES OF ICAO

AIRCRAFT ACCIDENT SUMMARY FOR 1954

OF ALL OPERATORS ENGAGED IN PUBLIC AIR TRANSPORT

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	3	1	21	-	26	4	-	1	-	-			
Australia	6	2	-	-	13	5	-	6	-	-			
Austria	noa	noa	noa	noa	noa	noa	noa	noa	noa	noa			
Belgium	3	-	-	-	49	-	-	6	-	-			
Bolivia	-	-	-	-	-	-	-	-	-	-			
Brazil	5	2	17	8	66	4	-	9	-	-			
Burma	1	-	-	-	-	-	-	-	-	-			
Canada	4	1	31	2	14	4	-	7	1	-			
Ceylon	-	-	-	-	-	-	-	-	-	-			
Chile	1	-	-	-	26	-	-	2	-	-			
China (Taiwan)	1	1	4	-	-	2	-	-	-	-			
Colombia	7	2	39	-	-	12	1	1	-	-			
Cuba	-	-	-	-	-	-	-	-	-	-			
Czechoslovakia	1	1	11	-	-	4	-	-	-	-			
Denmark	-	-	-	-	-	-	-	-	-	-			
✓ Dominican Rep.	-	-	-	-	-	-	-	-	-	-			
Ecuador	-	-	-	-	-	-	-	-	-	-			
✓ Egypt	2	1	-	-	1	1	-	2	-	-	2 046	10 284	
El Salvador	noa	noa	noa	noa	noa	noa	noa	noa	noa	noa			
Ethiopia	-	-	-	-	-	-	-	-	-	-			
✓ Finland	2	1	-	-	-	1	-	-	-	-			
France	22	5	13	-	155	14	2	3	-	-			81 980
✓ Greece	-	-	-	-	-	-	-	-	-	-			
Guatemala	1	-	-	-	7	-	-	2	-	-			
Haiti	-	-	-	-	-	-	-	-	-	-			
Honduras	1	1	-	-	-	3	-	-	-	-			
Iceland	-	-	-	-	-	-	-	-	-	-			
India	8	1	-	8	7	3	3	16	-	-			
Indonesia	-	-	-	-	-	-	-	-	-	-			
Iran	2	-	-	-	-	-	-	-	-	-			
Iraq	-	-	-	-	-	-	-	-	-	-			
✓ Ireland	1	-	-	-	-	-	-	-	-	-	19 286	23 434	
Israel	2	-	-	-	-	-	1	-	-	-			
✓ Italy	1	1	16	-	6	10	-	-	-	-	18 818	29 498	46 269
✓ Japan	-	-	-	-	-	-	-	-	-	-			
Jordan	-	-	-	-	-	-	-	-	-	-			
Korea	-	-	-	-	-	-	-	-	-	-			
Laos a/	1	1	26	-	-	3	-	-	-	-			
✓ Lebanon	-	-	-	-	-	-	-	-	-	-			24 056
Liberia	-	-	-	-	-	-	-	-	-	-			
Libya	-	-	-	-	-	-	-	-	-	-			
Luxembourg	noa	noa	noa	noa	noa	noa	noa	noa	noa	noa			
Mexico	3	1	15	-	-	3	-	-	-	-			
✓ Netherlands	2	2	37	-	21	12	-	7	-	-	59 770	175 444	
✓ New Zealand	5	3	5	12	15	2	1	5	-	-	45 682	50 980	66 991
Nicaragua	1	-	-	-	-	-	-	-	-	-			
✓ Norway	-	-	-	-	-	-	-	-	-	-			48 400
Pakistan	1	-	-	-	8	-	-	3	-	-			
Paraguay	noa	noa	noa	noa	noa	noa	noa	noa	noa	noa			
Peru	2	2	30	-	-	3*	-	-	-	-			
Philippines	6	1	7	-	-	10	-	-	-	-			
Poland	-	-	-	-	-	-	-	-	-	-			
✓ Portugal	-	-	-	-	-	-	-	-	-	-			8 945
✓ Spain	-	-	-	-	-	-	-	-	-	-			58 183
Sweden	1	-	-	-	35	-	-	8	-	-			
✓ Switzerland	1	1	3	-	-	-	-	-	-	-	25 795	48 889	
Syria	-	-	-	-	-	-	-	-	-	-			
✓ Thailand	-	-	-	-	-	-	-	-	-	-			13 797
Turkey	2	2	22	3	-	7	3	-	-	-			
Un.of S.Africa	1	-	-	-	-	-	-	-	-	-			
United Kingdom b/	32	5	107	6	281	18	12	63	-	-			
United States c/	62	6	16	18	1 381	10	5	213	3	-			
✓ Uruguay	-	-	-	-	-	-	-	-	-	-			8 728
Venezuela	1	1	-	-	-	2	-	-	-	-			
Viet Nam	3	2	49	-	-	3	-	-	-	-			
Total for 66 States	198	47	469	97	2 111	140	28	354	4	-			
TYPE OF OPERATION													
Scheduled International	49	14	238	2	757	60	8	120	1	-			
Scheduled Domestic	76	21	212	41	1 270	52	9	272	3	-			
Non-Scheduled International	6	5	13	6	-	14	3	-	-	-			
Non-Scheduled Domestic	13	2	2	8	3	2	3	21	-	-			
Non-Revenue	12	3	4	-	6	8	1	24	-	-			
Indeterminate	42	2	-	-	75	4	4	17	-	-			
Total Operations	198	47	469	97	2 111	140	28	354	4	-			

NOTES: Source of Data: Air Transport Reporting Form G filed by countries indicated with a ✓.
All other country data collected from outside sources.

* Estimated
noa - No Civil Aviation.
a/ Country became a Contracting State in 1955.
b/ Data refer to airlines registered in the United Kingdom and its dependencies.
c/ Data for scheduled operators only. (Excludes Alaskan carriers).

CONTRACTING STATES OF ICAO

AIRCRAFT ACCIDENT SUMMARY FOR 1952

OF ALL OPERATORS ENGAGED IN PUBLIC AIR TRANSPORT

BY TYPE OF OPERATION

1952

TABLE C

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												
Cuba	1	1	30	4	-	7	-	-	-	-		
France	1	1	33	-	-	4	-	-	-	-		
Iran	1	1	19	-	-	4	-	-	-	-		
∮ Ireland	1	1	20	-	-	3	-	-	-	-	16 423	23 554
∮ Lebanon	2	-	-	-	-	-	-	-	-	-		19 545
∮ Netherlands	2	1	36	1	34	9	1	10	-	-	42 218	122 650
∮ Pakistan	1	-	-	-	-	-	-	-	-	-	5 142	11 028
∮ Sweden	3	1	-	-	-	-	-	-	1	-	9 060 b/	33 370 b/
Syria	1	1	9	-	-	16	-	-	-	-		
∮ United Kingdom a/	7	1	-	-	71	-	-	31	1	-		
d/	(4)	(1)	(-)	(-)	(71)	(-)	(-)	(31)	(1)	(-)	(81 447)	(257 687)
United States e/	11	3	94	2	229	9	2	52	-	-		
Venezuela	1	1	2	-	-	1	-	-	-	-		
Total for 12 States	32	12	243	7	334	53	3	93	2	-		
SCHEDULED DOMESTIC OPERATIONS												
∮ Argentina	7	-	-	-	-	-	-	-	-	-		
∮ Australia	3	-	-	1	24	-	-	10	-	-	116 803	187 724
∮ Belgium	1	1	12	-	-	3	-	-	-	-		62 833 f/
∮ Brazil	6	3	13	10	9	12	4	-	-	-	89 551	114 634
∮ Canada	1	1	-	-	-	1	-	-	-	-	9 768	7 015
India	3	3	15	12	-	5	3	-	-	-		
Japan	1	1	37	-	-	-	-	-	-	-		
Philippines	3	2	11	16	-	4	-	-	-	-		
∮ Sweden	3	-	-	-	-	-	-	-	-	-	3 490 b/	5 130 b/
∮ Thailand	1	-	-	-	1	-	-	1	-	-	5 663	6 190
∮ United Kingdom a/	6	-	-	-	12	-	1	2	-	-		
d/	(2)	(-)	(-)	(-)	(12)	(-)	(-)	(2)	(-)	(-)	(51 226)	(52 981)
United States e/	44	6	46	44	792	8	2	136	18	11		
Venezuela	1	1	9	-	-	3	-	-	-	-		
Total for 13 States	80	18	143	83	838	36	10	149	18	11		
NON-SCHEDULED INTERNATIONAL OPERATIONS												
∮ Australia	1	1	-	-	46	1	-	6	-	-	16 019	38 618
∮ Pakistan	1	1	-	-	-	1	-	2	-	-	400	1 783
∮ United Kingdom a/	9	4	37	-	101	8	-	20	-	-		
d/	(7)	(4)	(37)	(-)	(101)	(8)	(-)	(20)	(-)	(-)		(8 090)
United States e/	2	1	33	-	7	3	-	2	-	-		
Total for 4 States	13	7	70	-	154	13	-	30	-	-		
NON-SCHEDULED DOMESTIC OPERATIONS												
Mexico	1	1	-	22	-	-	-	-	3	-		
∮ New Zealand	2	-	-	-	2	-	-	2	-	-	14 205	10 049
Norway	1	1	8	-	18	3	-	-	-	-		
∮ Sweden	10	-	-	-	-	-	-	-	-	-	6 455b/g/	9 375 b/
∮ Thailand	1	-	-	-	2	-	-	1	-	-	251	434
∮ Un. of S.Africa	1	-	-	-	14	-	-	5	-	-		
∮ United Kingdom a/	3	-	-	-	10	-	-	3	-	-		
d/	(1)	(-)	(-)	(-)	(7)	(-)	(-)	(1)	(-)	(-)		(963)
Total for 7 States	19	2	8	22	46	3	-	11	3	-		
NON-REVENUE OPERATIONS												
India	1	-	-	-	-	-	-	4	-	-		
∮ Sweden	1	1	1	-	-	-	1	-	-	-	3 390 b/	2 320 b/
∮ United Kingdom a/	7	-	-	1	7	1	-	9	-	-		
d/	(3)	(-)	(-)	(-)	(7)	(-)	(-)	(9)	(-)	(-)		(21 299)
United States e/	5	-	-	3	1	-	-	18	-	-		
Total for 4 States	14	1	1	4	8	1	1	31	-	-		
INDETERMINATE OPERATIONS												
France a/	2	1	14	2	2	3	-	-	-	-		
Viet Nam	1	-	-	-	-	-	-	-	-	-		
Total for 2 States	3	1	14	2	2	3	-	-	-	-		

NOTES: Source of Data: Air Transport Reporting Form G filed by countries indicated with a ∮.
All other country data collected from outside sources.

a/ Includes accident data for all airlines other than Air France.
b/ Includes Country's share in Scandinavian Airlines System (SAS).
c/ Data refer to airlines registered in the United Kingdom and its dependencies.
d/ United Kingdom only.
e/ Data for scheduled operators only. (Excludes Alaskan carriers).
f/ Includes scheduled international operations.
g/ Excludes helicopter landings.

1953

TABLE C

CONTRACTING STATES OF ICAO

AIRCRAFT ACCIDENT SUMMARY FOR 1953

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												
✓ Australia	1	1	11	-	-	8	-	-	-	-	1 416	9 329
✓ Belgium	3	3	42	-	11	5	3	-	-	-		
✓ Brazil	1	1	10	-	-	7	-	-	-	-	6 837	25 414
✓ Canada	1	-	-	-	7	-	-	-	-	-	17 904	41 493
✓ Egypt	1	1	1	-	1	1	-	1	-	-	1 846	12 154
✓ France a/	7	4	41	6	119	14	7	23	-	-		328 300 b/
✓ Ireland	1	-	-	-	-	-	1	1	-	-	16 512	21 119
✓ Lebanon	1	-	-	-	-	-	-	-	-	-		9 946
✓ Netherlands	1	-	-	3	25	-	1	4	2	5	45 653	130 738
✓ New Zealand	1	-	-	-	-	-	-	4	-	-	1 367	10 172
✓ Pakistan	1	1	12	-	-	5	-	-	-	-	3 839	8 490
✓ Sweden	1	-	-	-	-	-	-	-	-	-	10 290 g/	37 030 g/
✓ United Kingdom d/	7	3	45	-	122	11	-	22	1	-	115 165	286 263
g/	(5)	(2)	(37)	(-)	(122)	(6)	(-)	(22)	(1)	(-)	(107 119)	(260 266)
✓ United States f/	7	3	2	16	197	-	2	34	4	-	126 543	444 158
Total for 14 States	34	17	164	25	182	51	14	89	7	5		
SCHEDULED DOMESTIC OPERATIONS												
✓ Argentina	5	-	-	-	-	-	-	-	-	-		
✓ Australia	2	-	-	-	3	-	-	3	-	-	10 456	11 447
Bolivia	1	1	25	-	-	3	-	-	-	-		
✓ Brazil	9	2	3	1	2	5	6	4	-	-	140 107	199 632
Burma	1	-	-	-	15	-	-	3	-	-		
✓ Canada	5	1	1	-	-	1	-	-	-	-	113 214	166 004
✓ Chile	1	1	4	-	-	3	-	-	-	-		9 100
India	3	3	23	-	-	11	1	-	-	-		
✓ Italy	1	1	15	-	-	4	-	-	-	-	12 412	15 197
✓ Pakistan	1	-	-	-	-	-	-	-	-	-	2 067	2 537
✓ Philippines	3	-	-	-	-	-	-	-	-	-	27 030	32 492
✓ Sweden	1	-	-	-	-	-	-	-	-	-	3 700 g/	5 240 g/
✓ Thailand	2	1	4	-	-	2	-	2	-	-	5 750	6 108
Turkey	1	1	5	16	-	1	-	-	-	-		
✓ United Kingdom d/	7	1	24	7	14	3	1	3	-	1	85 448	106 671
g/	(2)	(1)	(24)	(7)	(14)	(3)	(1)	(3)	(-)	(-)	(54 821)	(57 584)
✓ United States f/	37	5	86	8	897	27	2	116	-	-	1 866 168	2 184 077
Total for 16 States	80	27	190	32	931	50	10	131	-	1		
NON-SCHEDULED INTERNATIONAL OPERATIONS												
✓ France	2	1	-	-	-	3	-	5	-	-		9 000
Indonesia	1	-	-	-	-	-	-	-	-	-		
✓ Netherlands	1	-	-	-	56	-	-	-	-	-	2 989	13 516
✓ Pakistan	1	1	1	3	4	-	2	2	-	-	562	2 007
✓ United Kingdom d/	4	1	33	-	26	6	-	11	-	-	403	11 895
g/	(4)	(1)	(33)	(-)	(26)	(6)	(-)	(11)	(-)	(-)		(9 425)
Total for 5 States	9	3	34	3	86	9	2	18	-	-		
NON-SCHEDULED DOMESTIC OPERATIONS												
✓ Australia	1	1	1	-	3	1	-	-	-	-	52 941	87 996
India	1	-	-	-	6	-	-	3	-	-		
✓ New Zealand	1	1	2	-	-	1	-	-	-	-	13 681	9 641
✓ Norway	1	1	3	-	-	1	-	-	-	-	120	47
✓ Philippines	3	-	-	-	-	-	-	1	-	-		1 675
✓ Spain	1	1	22	5	1	1	2	2	-	-	6 636	8 009
✓ Sweden	11	1	-	-	-	2	-	-	-	-	12 085 g/	13 625 g/
✓ Un.of S. Africa	26	2	-	-	1	2	-	-	-	-		20 759
✓ United Kingdom d/	3	1	-	-	-	2	-	1	-	-	15 299	19 229
g/	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)		(951)
✓ United States f/	2	2	22	16	-	4	-	-	-	-	4 407	13 933
Total for 10 States	50	10	50	21	11	15	2	7	-	-		
NON-REVENUE OPERATIONS												
Iran	1	-	-	-	6	-	1	2*	-	-		
Mexico	1	1	20	-	-	-	-	-	-	-		
✓ Sweden	2	-	-	-	-	-	-	-	-	-	2 381	1 711
✓ United Kingdom d/	4	-	-	-	2	-	-	7	-	-	791	17 665
g/	(3)	(-)	(-)	(-)	(2)	(-)	(-)	(7)	(-)	(-)		(15 572)
✓ United States f/	2	2	3	-	-	5	1	1	-	-		81 425
Total for 5 States	10	3	23	-	8	5	2	10	-	-		
INDETERMINATE OPERATIONS												
Colombia	2	-	-	-	25	-	-	3	-	-		
Guatemala	1	1	-	-	-	2	-	-	-	-		
Honduras	1	1	-	-	-	3	-	-	-	-		
India	5	-	-	-	-	-	-	10	-	-		
Laos	1	-	-	-	-	-	-	-	-	-		
Mexico	2	1	-	-	-	1	-	-	-	-		
Viet Nam	2	-	-	-	-	-	-	-	-	-		
Total for 7 States	14	3	-	-	25	6	-	13	-	-		

NOTES: Source of Data: Air Transport Reporting Form Q filed by countries indicated with a ✓.
All other country data collected from outside sources.

* Estimated.

a/ Domestic scheduled operations are combined with international scheduled operations.
b/ Includes some non-scheduled and non-revenue data for airlines other than Air France.
g/ Includes Country's share in Scandinavian Airlines System (SAS).
d/ Data refer to airlines registered in the United Kingdom and its dependencies. Data for dependencies incomplete for number of landings and hours flown.
e/ United Kingdom only.
f/ Data for scheduled operators only. (Excludes Alaskan carriers).
g/ Excludes helicopter landings.

CONTRACTING STATES OF ICAO

AIRCRAFT ACCIDENT SUMMARY FOR 1954

OF ALL OPERATORS ENGAGED IN PUBLIC AIR TRANSPORT

BY TYPE OF OPERATION

1954
TABLE C

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												
Belgium	2	-	-	-	49	-	-	6	-	-		
Burma	1	-	-	-	-	-	-	-	-	-		
Canada	1	-	-	2	14	-	-	7	-	-		
Colombia	1	1	21	-	-	9	-	-	-	-		
✓ Egypt	2	1	-	-	1	1	-	2	-	-		
France	8	-	-	-	155	-	-	-	-	-		
✓ Ireland	1	-	-	-	-	-	-	-	-	-	16 512	21 119
✓ Italy	1	1	16	-	6	10	-	-	-	-	6 076	14 687
✓ Netherlands	2	2	37	-	21	12	-	7	-	-	49 607	147 664
Philippines	1	1	7	-	-	10	-	-	-	-		
✓ Switzerland	1	1	3	-	-	-	-	-	-	-	25 795	48 889
United Kingdom a/	20	5	107	-	278	18	8	54	-	-		
United States b/	7	1	-	-	233	-	-	44	1	-		
Viet Nam	1	1	47	-	-	-	-	-	-	-		
Total for 14 States	49	14	238	2	757	60	8	120	1	-		
SCHEDULED DOMESTIC OPERATIONS												
Argentina	2	1	21	-	26	4	-	1	-	-		
Australia	4	1	-	-	6	2	-	1	-	-		
Belgium	1	-	-	-	-	-	-	-	-	-		
Brasil	5	2	17	8	66	4	-	9	-	-		
Canada	1	1	31	-	-	4	-	-	1	-		
Colombia	1	1	18	-	-	3	-	-	-	-		
Czechoslovakia	1	1	11	-	-	4	-	-	-	-		
India	2	-	-	-	7	-	-	4	-	-		
Laos	1	1	26	-	-	3	-	-	-	-		
Mexico	1	1	15	-	-	3	-	-	-	-		
✓ New Zealand	3	1	3	12	15	-	1	5	-	-	43 721	47 104
Pakistan	1	-	-	-	8	-	-	3	-	-		
Peru	2	2	30	-	-	3*	-	-	-	-		
Turkey	2	2	22	3	-	7	3	-	-	-		
United States b/	47	5	16	18	1 142	10	5	149	2	-		
Venezuela	1	1	-	-	-	2	-	-	-	-		
Viet Nam	1	1	2	-	-	3	-	-	-	-		
Total for 17 States	76	21	212	41	1 270	52	9	172	3	-		
NON-SCHEDULED INTERNATIONAL OPERATIONS												
France	5	5	13	-	-	14	-	-	-	-		
United Kingdom a/	1	-	-	6	-	-	3	-	-	-		
Total for 2 States	6	5	13	6	-	14	3	-	-	-		
NON-SCHEDULED DOMESTIC OPERATIONS												
Argentina	1	-	-	-	-	-	-	-	-	-		
India	5	-	-	8	-	-	3	12	-	-		
✓ New Zealand	2	2	2	-	-	2	-	-	-	-	1 699	2 269
United Kingdom a/	3	-	-	-	3	-	-	5	-	-		
United States b/	2	-	-	-	-	-	-	4	-	-		
Total for 5 States	13	2	2	8	3	2	3	21	-	-		
NON-REVENUE OPERATIONS												
Australia	1	1	-	-	-	3	-	4	-	-		
Canada	1	-	-	-	-	-	-	-	-	-		
China (Taiwan)	1	1	4	-	-	2	-	-	-	-		
India	1	1	-	-	-	3	-	-	-	-		
United Kingdom a/	2	-	-	-	-	-	1	4	-	-		
United States b/	6	-	-	-	6	-	-	16	-	-		
Total for 6 States	12	3	4	-	6	8	1	24	-	-		
INDETERMINATE OPERATIONS												
Australia	1	-	-	-	7	-	-	1	-	-		
Canada	1	-	-	-	-	-	-	-	-	-		
Chile	1	-	-	-	26	-	-	2	-	-		
Colombia	5	-	-	-	-	-	1	1	-	-		
Finland	2	1	-	-	-	1	-	-	-	-		
France	9	-	-	-	-	-	2	3	-	-		
Guatemala	1	-	-	-	7	-	-	2	-	-		
Honduras	1	1	-	-	-	3	-	-	-	-		
Iran	2	-	-	-	-	-	-	-	-	-		
Israel	2	-	-	-	-	-	1	-	-	-		
Mexico	2	-	-	-	-	-	-	-	-	-		
Nicaragua	1	-	-	-	-	-	-	-	-	-		
Philippines	5	-	-	-	-	-	-	-	-	-		
Sweden	1	-	-	-	35	-	-	8	-	-		
Un.of S.Africa	1	-	-	-	-	-	-	-	-	-		
United Kingdom a/	6	-	-	-	-	-	-	-	-	-		
Viet Nam	1	-	-	-	-	-	-	-	-	-		
Total for 17 States	42	2	-	-	75	4	4	17	-	-		

NOTES: Source of Data: Air Transport Reporting Form G filed by countries indicated with a ✓.
All other country data collected from outside sources.

* Estimated.

a/ Data refer to airlines registered in the United Kingdom and its dependencies.
b/ Data for scheduled operators only. (Excludes Alaskan carriers).

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INTERNATIONAL CIVIL AVIATION ORGANIZATION

FORM G

AIR TRANSPORT REPORTING FORM
AIRCRAFT ACCIDENTS

COUNTRY..................... 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 resported.
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

List of Laws and Regulations of the Contracting States containing provisions relating to "Aircraft Accident Investigation"

(Amendments to list in Digest No. 5)

1. Add

ARGENTINA

1954 enero 8	Ampliación Núm. 1 de las Directivas Generales para la Investigación de Accidentes de Aviación aprobadas por Resolución Núm. 100 (S.A.C.) del 9 de octubre de 1952.
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.

CANADA

1954 Nov. 23	The Air Regulations, Order in Council P.C. 1954-1821: Part VIII. - Div. III. Accidents and Boards of Inquiry.
	(The Air Regulations, P.C. 2575, 24 May 1951 - Part VIII - Sec. 3. - Accidents and Boards of Inquiry - page 178 - shall be deleted

CEYLON

1955 May 4	Civil Air Navigation Regulations:
	Chap. XVI. - Accident Enquiry (Reg. 260-271).

CHINA (TAIWAN)

1953 Oct. 21	Civil Air Regulations No. 102 - Accident Reporting and Investigation.
	(The Regulations relating to civil aircraft accidents of 16 October 1947, under China - page 179 - shall be deleted).

ECUADOR

1954 julio 8	Reglamento de Aeronáutica Civil del Ecuador, Núm. 7:
	Título II. - Parte 8. Investigación y encuesta de accidentes de Aviación.

IRELAND

1953 April 27	The Investigation of Accidents (Direction of Formal Investigation) Order, 1953.

ITALY

1953 June 10	Ministerial Circular No. 5017/L - Removal of the wreckage in aircraft accident.

SWEDEN

Civil Aviation Regulations (BCL) - Operational Regulations (D): Aircraft Accident Inquiry - ICAO Annex 13.

UNITED KINGDOM COLONIES

ADEN

1954 The Civil Aviation (Investigation of Accidents) Regulations (G.N.125/54).

BRITISH HONDURAS

1953 Dec. 19 Air Navigation (Investigation of Accidents) Regulations, 1953(S.I.-1/54).

(The Air Navigation (Accidents) Regulations (S.R.O. No. 41/1939), dated 17 May, 1939 - page 183 - shall be deleted).

SARAWAK

1953 The Air Navigation (Investigation of Accidents) Regulations, (G.N. S 6/54).

(Air Navigation (Investigation of Accidents) Regulations, 1949, G. N. S. 62/49 - page 184 - shall be deleted).

TRINIDAD

1954 Air Navigation (Investigation of Accidents) Regulations, 1954. (G.N. 205/54).

(The Air Navigation (Investigation of Accidents) Regulations, 1940 - page 185 - shall be deleted).

UNITED STATES OF AMERICA

1954 Public Notice PN 8 - Delegations of final authority related to substantive program matters, (as issued, effective October 27, 1954, 19 F.R. 7418):
Sec. 7. Director, Bureau of Safety Investigation.

1955 Public Notice PN 9 - Statement of Organization, (as issued, effective July 8, 1955, 20 F.R. 4194):
Sec. 6.1-6.5 - Bureau of Safety Investigation
Sec. 12.2 - Bureau of Safety Investigation

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.

2. Corrections, modifications and deletions.

Under Australia (Reg. 270-274) shall read (Reg. 270-311) instead.

Egypt Notice to Airmen No. 5A/1951 shall be deleted.

Japan Law No. 231 of 1952 shall read as follows:
1952 July 15 - Civil Aeronautics Law No. 231, as amended up to 1/4/54.

Under Spain Decree of 12 March 1948 shall read as follows:

1948 marzo 12 Decreto - Investigación de accidentes y auxilio de aeronaves.

United Kingdom Colonies the following shall be deleted:
Kenya, Tanganyika and Uganda.

U.S.A. For (as issued, effective January 1, 1954, 19 F.R. 2133) under Public Notice PN 7 - 1954, there shall be substituted the following: (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).

- 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* Combined Meteorological Tables for International Air Navigation.

INTERNATIONAL STANDARDS AND RECOMMENDED PRACTICES are adopted by the Council in accordance with Articles 54, 37 and 90 of the Convention on International Civil Aviation and are designated, for convenience, as Annexes to the Convention. The uniform application by Contracting States of the specifications comprised in the International Standards is recognized as necessary for the safety or regularity of international air navigation while the uniform application of the specifications in the Recommended Practices is regarded as desirable in the interest of safety, regularity or efficiency of international air navigation. Knowledge of any differences between the national regulations or practices of a State and those established by an International Standard is essential to the safety or regularity of international air navigation. In the event of non-compliance with an International Standard, a State has, in fact, an obligation, under Article 38 of the Convention, to notify the Council of any differences. Knowledge of differences from Recommended Practices may also be important for the safety of air navigation and, although the Convention does not impose any obligation with regard thereto, the Council has invited Contracting States to notify such differences in addition to those relating to International Standards.

PROCEDURES FOR AIR NAVIGATION SERVICES (PANS) are approved by the Council for worldwide application. They comprise, for the most part, operating procedures regarded as not yet having attained a sufficient degree of maturity for adoption as International Standards and Recommended Practices, as well as material of a more permanent character which is considered too detailed for incorporation in an Annex, or is susceptible to frequent amendment, for which the processes of the Convention would be too cumbersome. As in the case of Recommended Practices, the Council has invited Contracting States to notify any differences between their national practices and the PANS when the knowledge of such differences is important for the safety of air navigation.

REGIONAL SUPPLEMENTARY PROCEDURES (SUPPS) have a status similar to that of PANS in that they are approved by the Council, but only for application in the respective regions. They are prepared in consolidated form, since certain of the procedures apply to overlapping regions or are common to two or more regions.

The following publications are prepared by authority of the Secretary General in accordance with the principles and policies approved by the Council.

ICAO FIELD MANUALS 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.

ICAO CIRCULARS make available specialized information of interest to Contracting States.

EXTRACT FROM THE CATALOGUE
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June 1951. 116 pp. $0.15

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31-AN/26 — Aircraft Accident Digest No. 3.
1952. 190 pp. $1.00

38-AN/33 — Aircraft Accident Digest No. 4.
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