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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 comment from the aeronautical world. It is hoped that States will co-operate to the fullest extent permitted by their national laws in the submission of material for inclusion in future issues of this Digest. It is recognized that investigations take a diversity of forms under the variety of constitutional and juridical systems that exist throughout the membership of ICAO and that, for this reason, accident investigation presents one of the most difficult problems of standardization in international civil aviation. At the same time it is a most fruitful source of material for the attainment of the objectives of the Chicago Convention.

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

The ICAO Manual of Aircraft 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 an accident classification table and summary of reported accident causes in 1953. Future issues of the Digest will also contain a comparison with previous years.

Readers are requested to notify ICAO of any criticism of this Digest or any improvements that they can suggest.

ACCIDENT CLASSIFICATION TABLE AND SUMMARY OF REPORTED ACCIDENT CAUSES - 1953

This issue of the Digest contains three reports of aircraft accidents occurring in 1952 and thirty-three reports for 1953. In order to survey all the reports received by ICAO of accidents occurring in 1953, eight reports from Digest No. 4 have been included. In all, forty-one reports for 1953 are dealt with in this issue.

The Digest contains for the first 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 analysing techniques. Also the accidents reported in 1953, 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.

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 1953, contained in Digests 4 and 5, suggests that the following features are worthy of attention:

i) 44% of the accidents reported occurred during the en-route phase; of these, 50% were collision with terrain or water.

ii) 40% of the accidents reported occurred during the approach and landing stages and of these, 56% were collision with terrain or water.

iii) The remaining 16% of the accidents reported occurred during the take-off and climb stage.

iv) Of all the accidents, 55% were reported to have been probaly due to pilot error. However, caution should be exercised in accepting this figure, due to the many variations in the manner of defining pilot error, without due regard to the reasons set out in those accident summaries relating to pilot error. Examination of these accidents indicates that two were due to descent below minima, two deviating from established approach procedures five to flying into IFR conditions while on VFR, two to miscalculation of fuel, two to inattention to the fuel system, and two to turning too steeply and too low a height shortly after take-off during the critical climb phase. One of the last mentioned accidents was due to turning back to the aerodrome after engine trouble. Due to the undercarriage being down height could not be maintained; due to loss of airspeed; the other accident was due to loss of height while turning steeply shortly after take-off. One accident, involving the mid-air collision of two scheduled aircraft while en route, was found to be due to the failure of one aircrew to observe and avoid the other aircraft and to lack of alertness on the part of the other crew. (The report on this accident, which has caused considerable world-wide interest, is given in considerable detail in this Digest.) The remaining accidents in this class were ascribed to miscellaneous reasons.

It had been hoped that a classification of causes directly attributable to pilot error could have been included in this report, based on the classification set out in the ICAO Manual of Aircraft Accident Investigation, page 16. However, it has proved to be impossible to make any breakdown from the primary cause of "pilot error" on information supplied in many of the accident reports.

v) Four accidents which occurred because the aircraft were inadequately maintained, warrant special attention. In the first, the aircraft landed heavily and was damaged through lack of elevator control due to the loosening of the elevator control rod as the result of the absence of locking pins on the nut and bolt fixtures of the control links of the elevator bars. In the second, while the aircraft was en route and in IFR conditions, one engine failed due to faulty spark plugs causing excessively high operating temperatures and bearing loads by detonation and pre-ignition. Shortly afterwards, the second engine failed for similar reasons and the aircraft, unable to maintain altitude, collided with high terrain. In the third accident, reverse installation of controls caused loss of control; a very common cause of accidents in the past but one which is infrequent now. In this case, although the pilot checked his controls for movement before take-off, he did not, and was not called upon, to check them for correct direction of movement. This omission has been rectified in the State concerned by amendment of the regulations. In the fourth, an elevator failed while the aircraft was landing, causing loss of control. It was established that, due to poor maintenance and inspection, a hinge bolt fell out.

vi) It is interesting to note that only two accidents occurred during the "initial climb" phase.

vii) Special mention must be made of the four accidents included in this Digest which were brought about by severe turbulence. There is also one further suspected case, but sufficient evidence was not available to determine the cause with accuracy. Three of the accidents resulted in structural failure and one in failure to maintain altitude causing collision with high terrain. Report No. 10 in this Digest contains in considerable detail the investigation into one of the worst of these accidents and it will be noted that the Board of Inquiry put on record the following remarks: "The principal weather factors affecting this accident may be alleviated in the future by the installation of airborne radar. Development of equipment shows promise of meeting the problems of weather avoidance, weather probing and weather intelligence."

State Administrations are invited to notify ICAO on the usefulness of the Accident Classification Table and Summary, and to make any recommendation for improvement.

ACCIDENT CLASSIFICATION

1953

PHASE OF OPERATION	NO.	TYPE OF ACCIDENT	NO.	APPARENT CAUSE	NO.	DESCRIPTION	NO.	ICAO REF.	PAGE
Take-off Run	3	Collapse or retraction of undercarriage	1	Undetermined	1	-	1	AR/293	Page 34
				Aircraft inadequately maintained	1	Reversed installation of aileron control cables	1	AR/304	92
		Nose over	2	Engine failure	1	Partial power failure during take-off at night and failure of the pilots to interrupt the take-off early enough to prevent the aircraft from running off the runway.	1	AR/323	50
Initial Climb	2	Collision with terrain or water	2	Pilot error	2	Execution of steep starboard turn at too low an altitude after take-off	1	AR/273	Digest 4 Page 158
						Loss of height during steep turn with undercarriage down at unsafe altitude in in attempt to turn back to aerodrome after experiencing temporary loss of engine power	1	AR/305	132
Climb after Take-off	2	Aeroplane failure in flight	1	Turbulence in flight	1	Structural failure during flight through thunderstorm	1	AR/267	Digest 4 Page 151
		Emergency condition (immediate forced landing)	1	Engine failure	1	Sequence of mechanical failures resulting in emergency landing under adverse weather conditions	1	AR/319	109
En Route	18	Collision with terrain or water	9	Pilot error	6	Lack of technical experience in spraying operations	1	AR/296	57
						Aircraft was flown below prescribed minima	2	AR/284, AR/287	72 67
						Pilot continued VFR flight into unfavorable weather	3	AR/288, AR/302, AR/320	76 107 75
				Icing and turbulence in flight	1	Aircraft unable to maintain altitude	1	AR/289	21
				Aircraft improperly maintained	1	Both engines failed. Lack of compliance with proper maintenance standards	1	AR/303	64
				Undetermined	1	Turbulent conditions were reported in the area and recovered bodies showed signs of high impact forces	-	AR/307	95
		Collision with other aircraft	1	Pilot error	1	Failure to observe the other aircraft	1	AR/311	100
		Emergency condition (immediate forced landing)	5	Pilot error	3	Miscalculation of fuel requirements	2	AR/286, AR/295	18 27
						Inattention to fuel system causing engine failure due to fuel starvation	1	AR/272	Digest 4 Page 134
				Engine failure	2	Aircraft unable to maintain height	1	AR/300	97
						No. 4 engine torn from aircraft causing temporary loss of control. Aircraft subsequently landed safely	1	AR/318	129
		Aeroplane failure in flight	2	Turbulence in flight	2	Separation of right aileron tab motor during turbulence causing loss of control and failure of the right wing	1	AR/306	80
						Structural failure during flight through an intense frontal wave type storm of extremely severe turbulence	1	AR/314	36
		Undetermined	1	Aircraft lost at sea	1	-	1	AR/301	29
Landing Procedure	5	Collision with terrain or water	4	Pilot error	3	Pilot continued VFR flight into unfavorable weather	1	AR/308	115
						Pilot deviated from established approach procedure	2	AR/259, AR/315	Digest 4 Page 141 126
				Undetermined	1	-	-	AR/281	60
		Stall	1	Pilot error		Inattention to fuel system causing engine failure due to fuel starvation	1	AR/282	84
Final Approach	5	Collision with terrain or water	4	Pilot error	3	Pilot undershot runway on approach-to-land	2	AR/299, AR/275	25 Digest 4 Page 138
						Due to mishandling of controls left propeller was windmilling and right engine not developing sufficient thrust to reach runway	1	AR/276	Digest 4 Page 161
				Failure to compensate for wind	1	Lack of information on winds. Upper winds of greater intensity, causing the aircraft to collide with high terrain while making Radio Range approach (IFR)	1	AR/298	89
		Heavy landing	1	Propeller mechanism failure	1	Drag induced by propeller blades moving beyond the high RPM limit stop stalling aircraft.	1	AR/264	Digest 4 Page 144
Landing Run	4	Airplane failure in flight	2	Aircraft inadequately maintained	2	Loosening of elevator control rod due to absence of locking pins	1	AR/297	59
						Failure of elevator due to loss of elevator hinge pin	1	AR/322	119
		Overshoot	1	Pilot error	2	Improperly executed approach resulting in excessive speed and a landing too far down the runway	1	AR/261	Digest 4 Page 148
		Heavy landing	1			Misuse of controls after aircraft first touched down causing a series of bounces causing the nose section to be torn off.	1	AR/321	124
Missed Landing	2	Collision with terrain or water	2	Pilot error	1	Pilot continued VFR flight into unfavorable weather	1	AR/283	53
				Engine Failure	1	Right engine failed during missed approach manoeuvring	1	AR/316	113

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PART I

No. 1

Douglas DC-3, damaged following emergency landing at Gualeguaychú Airport on 18 March 1952. Argentina Accident Investigation Report No. 86. Released 12 June 1953

Circumstances

The aircraft, on a scheduled flight carrying 16 passengers, overshot the runway during an emergency landing at Gualeguaychú aerodrome (Entre Rios).

The aircraft commander had accumulated 4,100 hours of flying time and the co-pilot 1,600 hours.

Weather conditions on the route were bad: rain storm with severe turbulence, overcast sky with fracto-stratus clouds 4/8, ceiling 200/300 metres, and alto-stratus and alto-cumulus clouds 3/8, wind 18 km/h.

The aircraft was 15% damaged but the crew and the passengers escaped injury.

Investigation and Evidence

The investigation revealed that the aircraft left Buenos Aires (Ezeiza airport) for Paso de Los Libres-Resistencia-Sáenz Peña at 0654 hours on 18 March 1952 and encountered a rain storm with severe turbulence about 24 minutes after take-off.

While flying in the storm, the crew became aware of the smell of burning. When the radio operator found that the left generator indicated a discharge and the right one between sixty and seventy amperes, the captain gave the order to disconnect them.

The co-pilot opened the window and noticed that the right engine was on fire. The captain immediately, cut off the fuel and the ignition, feathered the propeller and operated the fire extinguisher. Following this action, the fire was extinguished.

The aircraft was flown on one engine as far as Gualeguaychú aerodrome in order to attempt a landing there. Flying time to that aerodrome was only about 25 minutes whereas turning back would have meant passing through the storm front again.

Flying under visual conditions and on one engine, the aircraft arrived at Gualeguaychú and passed over the aerodrome twice at an altitude of approximately 50 metres in order to attract the attention of the personnel and to frighten away some sheep which were on the runway.

Immediately afterwards, an approach was made and the aircraft touched down on the main wheels at about 150 metres from the approach end of the runway, with full use of the brakes throughout the landing run which was approximately 850 metres. The aircraft was on its tail wheel for 580 metres of this distance, however the aircraft could not be stopped and after overshooting the runway, the aircraft ran through the boundary fence, smashed a telephone pole, cut through another fence separating two roads, finally coming to rest on the far side of the second road, after breaking a third fence.

Cause

The Aircraft Accident Advisory Board concluded that the accident was due to pilot error during an emergency landing necessitated by malfunctioning of the battery-charging electrical system, probably caused by material defect or faulty maintenance. Bad weather and the presence of animals on the runway were contributing causes.

No. 2

Surrey Flying Services Ltd., York AVRO aircraft crashed near R.A.F. Airfield, Lyneham, on 27 November 1952. Ministry of Civil Aviation Report MCAP 115

Circumstances

The accident occurred towards the end of a positioning flight from Stansted to Lyneham prior to an intended flight with freight from Lyneham to Singapore.

Before departing from Stansted the captain telephoned the Meteorological Office at Lyneham and obtained the local weather situation. The en route flight to Lyneham was without incident and on arrival overhead a Ground Controlled Approach to Runway 07 was begun. The aircraft intercepted the glide path at 2,000 ft. and a normal talk-down approach was made until the 1/4 mile from touch-down position was reached. During the approach a normal descent was maintained with variations of up to 50 ft. above the glide path. At the 1/4 mile from touch-down position the aircraft's echo disappeared from the Tracker's Radar screen in a downward direction indicating a high rate of descent. At this time the captain, who was concentrating on the flight instruments, was warned suddenly by the co-pilot that there were trees ahead. The captain immediately pulled back the control column but was unable to prevent the aircraft striking the upper branches of trees and the ridge of steeply sloping ground approximately 140 yds. short of the touch-down point. The aircraft was severely damaged and three of the crew were slightly injured. There was no fire.

Investigation and Evidence

Prior to departure from Stansted, the captain telephoned at 0750 hours direct to the Lyneham Meteorological Office and was given the following meteorological conditions at Lyneham:-

> "Now 500 yards visibility and sky obscured. By 1100 hours an improvement to 1000 yds. and 8/8 St at 700 ft. is expected."

At the time of departure from Stansted the actual weather was:-

> "Overcast, mist. Continues slight drizzle. Visibility 1,400 - 1,500 yds. 8/8 St base 200 ft."

A flight plan was filed for Lyneham via Brookmans Park, Watford, Burnham and Compton at 5000 ft. under Instrument Flight Rules. The estimated elapsed time was 32 minutes with 3 hours 30 minutes endurance. Stansted and London Airport were given as alternatives.

The aircraft took off from Stansted at 0832 hours and proceeded according to Flight Plan. At 0900 hours the aircraft passed the Compton Fan Marker at 5000 ft. and was cleared by London Airways to descend to 3000 ft. on a QNH of 987 millibars. On passing through 4000 ft., clearance was given to change to Lyneham frequency 116.1 Mc/s. The working on this frequency is not electrically recorded but from a number of manually monitored logs, all of which agree in substance, a close reconstruction of the communications can be obtained.

At 0904 hours Lyneham Flight Information Service passed the following weather:-

> "Present weather. Fog. Visibility 600 yards. Sky not discernible. Surface wind 060° - 13 knots."

This was acknowledged by the aircraft and a Ground Controlled Approach was requested.

The GCA Director took control on the same frequency, 116.1 Mc/s, and passed clearance to descend to 2000 ft., QNH 992 millibars, runway in use 07, touch-down height 510 ft. This was in accordance with normal RAF practice. The captain, however, requestec QFE and was given QFE 975 millibars. This was set on the pilot's altimeters which were cross checked and showed no discrepancy. A warning was passed and acknowledged, to exercise caution on final approach due to the approach lights being well below the level of the runway. The cockpit checks for landing were completed and the aircraft was directed into a position about 7 GCA miles from touch-down on the final approach to Runway 07. (1 GCA mil = 5000 ft.) At this point the GCA talk-down controller took over and passed to the aircraft an amended QFE of 976 millibars. This was read back from the aircraft and was duly set on bo altimeters. The aircraft intercepted the glide path about 6 miles from touch-down and instru tions were passed to it to descend at 500 ft. per minute. The aircraft established the descen with the undercarriage locked down, 40° of the flap lowered and an rpm setting of 2850. The flap and rpm settings then remained unaltered throughout the approach and the boost settings were adjusted as necessary between 0 and +2 psi. The indicated airspeed was betwe 120 and 125 knots.

The following is the substance of the instructions which were given by the Talk-Down Controller during the remainder of the approach:-

"4 miles - 50 ft. too high, maintain 070°.

3 miles - Right 5° on to 570°, on the glide path.

2 miles - Left 5° on to 070° on the glide path, check wheels and flaps for landing, clear to land on this approach.

1 1/4 miles - Left 3°, nicely on the glide path.

1 mile - Right 3°.

3/4 mile - 3/4 mile from touch-down on the glide path.

1/2 mile - above glide path, 50 feet too high.

1/4 mile - Left 3°, clear to land talk-down out.

The captain stated that the last altitude he observed on his altimeter was 500 ft. and the last talk-down instruction that he remembers hearing was "3/4 mile - 50 ft. too high". He remained flying on instruments until he heard a shout from the first officer; when he looked up, saw trees ahead and pulled back on the control column. He never saw any approach light

The first officer stated that the last altitude that he observed on the starboard altimeter was 300 ft. at about 3/4 mile from touch-down. He then looked ahead expecting the visibility to be 600 yards. In spite of the correct functioning of the windshield wipers, however, he wa surprised that he could not see any approach lights. The last talk-down instruction that he remembered hearing at about this time was "50 ft. too high." He then saw trees ahead at an estimated range of 50 to 100 yds. and shouted a warning at the same time pulling back on the control column. The aircraft flew through the treetops which damaged the nose and shatterec the windshield. It then struck the ridge of steeply sloping ground, bounced, skidded and cam to a standstill. The crew, three of whom were slightly injured, left the aircraft through the broken starboard cockpit window and the astrodome.

The talk-down controller was following the aircraft's echo on an azimuth screen and passing instructions to the aircraft. His assistant, the GCA tracker, was tracking the aircraft in relation to the glide path. By means of a handwheel he fed any discrepancy from the glide path into an error meter on the talk-down controller's panel. In addition he called out the range of the aircraft from touch-down. The talk-down controller stated that throughout the whole approach the aircraft was never indicated as being below the glide path.

The tracker stated "at the range 1/4 mile from touch-down, the aircraft's echo descended rapidly and disappeared off my screen at a speed too fast to enable me to turn the handwheel to follow it."

Inspection at the scene of the accident showed that the approach to Runway 07 is over a valley with tree-covered ground rising steeply to a ridge which is about 130 yds. from the runway threshold. There are 15 sodium centre line approach lights, which were illuminated at the time of the accident; these are mounted on posts 30 ft. high at 100-yard intervals. They are situated in a clearing which is cut through the trees and in some case they are below tree-top level. With the exception of the last one, they are all below runway level.

The aircraft had first struck a tree situated about 15 yds. to the right of the extended runway centre line and 200 yds. from the runway threshold. This tree had been about 60 ft. high with the tree top about 10 ft. above the runway threshold level. The upper branches of the tree were broken off at about runway level. The aircraft then struck the ground on the top edge of the ridge which broke the undercarriage bouncing and skidding to a standstill 350 yards from the ridge facing the direction from which it had come. Pieces of the undercarriage and parts of cowlings lay along this 350-yd. line, but the aircraft remained substantially intact.

The theoretical touch-down point for Runway 07 is situated one GCA mile (5000 ft.) from the GCA van, and is approximately 10 yds. from the threshold of the runway. The angle of the GCA glide path is 3°. Under normal civil practice on a similar runway the touch down point would be situated approximately 220 yds. from the runway threshold; this would have the effect of increasing the glide path height by about 30 ft. The normal break off altitude (obstacle clearance limit) used at Lyneham for Runway 07 is 610 ft. (QNH) that is, 100 ft. above the touch-down point.

There was no mention of a warning to the pilot by GCA that he was approaching break off altitude. Furthermore both pilots stated that they did not receive any instructions regarding the break off altitude at any time during the approach. The talk-down controller was unable to give an assurance that he had passed a break off altitude warning during the talk-down.

Observations

1) No instrument approach charts for Lyneham were on board the aircraft at the time of the accident.

2) At Lyneham the visibility is observed over the airfield from the base of the control tower. There is a strong evidence that the actual visibility at the threshold to Runway 07 at the time of the accident was considerably less than the airfield visibility (500 yds) observed at 0915 hrs. The VHF/DF operator, who was in a vehicle 300 yds. from the touch-down point and was monitoring the talk-down, left the vehicle to look for the aircraft but failed to find it. He estimated the visibility to be 150 yds.

The two pilots have stated that immediately after escaping from the aircraft they estimated the visibility to be about 200 yds.

3) The QFE at Lyneham is calculated for a height of 457 ft. above sea level. The published airfield elevation is 513 ft. and the touch-down height for Runway 07 is 510 ft. A QFE so calculated would cause the pilot's altimeter to read 53 ft. at the touch-down point instead of 0 ft.

4) The ground formation close to the threshold of Runway 07 falls away rapidly and under certain conditions of wind is likely to cause a downdraught. It seems likely that on the flight considered in this report the aircraft was subjected to an increased rate of descent as a result of such a downdraught.

5) There was no clear pre-arrangement of the division of duties between the pilots during the approach. The co-pilot could have warned the captain when the aircraft was reaching critical altitude as indicated on the altimeters and thereafter assisted in the transition from instrument to visual conditions. Considering that no such pre-arrangement had been made, the captain did not pay due attention to his altimeter during the final stages of the approach.

6) The captain's knowledge of the weather situation was confined to the poor actual conditions at his proposed destination. The weather at his point of departure and first alternate was below his company's landing limits, and he had not obtained a forecast for his second alternate.

Discussion

The actual visibility during the approach was considerably less than the 600 yds. airfield visibility which had been reported to the aircraft. The operator's weather minima for this approach are 400 yds. visibility, 200 ft. cloud base. As the cloud base was on the surface the relevant minimum would have been 400 yds. actual visibility at a height of 200 ft.

The captain was, therefore, quite justified in attempting this approach on the information given to him; but as he did not have visual reference to the ground at an indicated altitude of 200 ft. he should have applied power and prepared to overshoot. If he had done this, even making maximum allowances for errors in altimeter reading and taking into consideration the effect of an increased rate of descent probably due to down draught, collision with the trees would have been avoided.

The apparent omission by the talk-down controller of the warning that the aircraft was approaching break-off altitude meant that the captain's attention was not drawn to his altimeter at a vital time. Also the fact that the controller continued the talk-down beyond this point undoubtedly gave the captain a false sense of security.

Conclusion

The accident occurred as a result of the captain's allowing the aircraft to descend below critical height during a Ground Controlled Approach without having visual reference to the ground.

The contributory causes were:

1) The captain was not warned by the talk-down controller that the aircraft was approaching break-off altitude.

2) The visibility at the threshold of Runway 07 was less than the airfield visibility which had been reported to the captain.

3) The aircraft was affected by a downdraught which caused it to sink below the glide path. The glide path at Lyneham allows for less obstacle clearance than is normal with a civil installation.

Recommendations

The report contained three recommendations directed to the Royal Air Force in regard to talk-downs. The fourth recommendation was as follows: that the attention of pilots is drawn to:-

a) their responsibility with regard to critical height;

b) the necessity for systematic flight instrument scanning during instrument approaches;

c) the need for systematic pre-arranged co-operation between the First and Second pilots during the transition stage from instrument to visual conditions.

ICAO Ref: AR/279

No. 3

Douglas DC-3 aircraft damaged at Rio Grande Aerodrome on 27 November 1952.
Argentina Accident Investigation Report No. 119 released 22 July 1953

Circumstances

On 27 November 1952 at approximately 0915 hours (local time) the aircraft was damaged while landing at Rio Grande aerodrome (National territory of Tierra del Fuego). The co-pilot who had logged 4,502:32 hours of flying time, was at the controls and the captain, who had logged 4,986:48 hours, was acting as co-pilot.

At the time of the accident the wind was strong, WSW 80/82 km/h, with gusts.

The aircraft was on a scheduled flight carrying only general freight. The crew were unhurt.

Investigation and Evidence

The investigation revealed that the co-pilot was at the controls while the landing was being carried out. After a first hard contact with the runway which made it necessary for the application of power to neutralize the effect of the impact, the landing operation was continued and the aircraft touched down in an abnormal manner, striking the ground with the propellers, damaging them and the front casing on the left engine.

According to statements made by the crew, the cargo aboard was well distributed and the total weight of the aircraft was below the maximum weight authorized for its operations.

Cause

The Board determined that the accident was due to an error on the part of the aircraft commander in failing to take correct measures at the proper time during landing by the co-pilot. A contributing factor was the fact that the landing was made with flaps unduly deflected and without taking the wind velocity into account.

ICAO Ref: AR/294

No. 4

KLM Douglas C-54B forced landed in the desert approximately 17 miles from Dhahran, Saudi, Arabia, on 1 January 1953

Government of Netherlands' Report

Circumstances

At 0905 hours (GMT) on 1 January 1953, the aircraft took off from Rome on a flight to Basra, part of a chartered flight from London to Karachi, carrying 56 passengers and 10 crew. Shortly before the aircraft arrived at Basra, the visibility, which had been very good during the day, deteriorated, falling below the minima laid down by the operator for landings at that aerodrome. It was reported at the same time that the visibility at Baghdad, the alternate, had dropped below the minima for that aerodrome also and the captain decided to divert to Dhahran. However, the aircraft ran out of fuel before that airport could be reached, and, at 2222 hours (GMT), the pilot was compelled to make a forced landing in the desert approximately 17 miles from the airport. A full moon provided good visibility and the emergency "wheels up" landing was successful. None of the occupants were injured and all were able to leave the aircraft without difficulty.

Investigation and Evidence

At take-off from Rome, the aircraft carried 15,930 lbs of fuel. The flight plan quoted a flight time to Basra of 10 hours 9 minutes and the fuel required as being 12,770 lbs. The fuel load also included a margin of 3%, 150 lbs for taxying and warming up the engines, 1,450 lbs for flying to the furthest alternate, 900 lbs for one hour of holding flight and 280 lbs as reserve, making a total of 15,930 lbs. This fuel load was considered as adequate for the flight.

Up to 1950 hours, the reports received by the aircraft did not indicate dubiety of landing at Basra. At that time, or shortly thereafter, weather reports were received which forecast that it would be impossible to land either at Basra or Baghdad within the operating limits laid down by KLM for those two aerodromes. The pilot-in-command then decided to fly through to Dhahran. Neither during the investigation, nor at the inquiry did it appear that this decision was not a wise one. The flight time from Rome was then 10 hours and 45 minutes.

The pilot-in-command however overestimated the quantity of fuel remaining, once it was clear that a landing could not be made at either Basra or Baghdad. Consequently, the following were also considered as errors:

a) his decision, after he decided to fly to Dhahran, not to fly directly to that aerodrome but first to approach Basra and hold over the aerodrome, descending to 500 feet;

b) his decision, not to attempt a landing when the aircraft was over Shaibah, where the moonlight gave good visibility and a visual landing appeared feasible;

c) his decision to put the aircraft into a climb, although the terrain did not so necessitate;

d) his failure to land at Kuwait aerodrome when there was not time to return to Shaibah although the co-pilot and the flight engineer had become concerned about the amount of fuel available for the flight to Dhahran, an insufficiency of which the pilot-in-command must have been aware;

e) his failure to warn Dhahran aerodrome earlier that owing to shortage of fuel, there was a serious risk of a forced landing having to be made;

f) the over-optimistic estimation, by the pilot-in-command, of the amount of fuel remaining.

The pilot-in-command was aware of the reading of the fuel level gauge. He disregarded this, however, and relied upon the information given him by the flight engineer who obtained such information by deducting from the amount of fuel on board prior to take-off, the total amount recorded by the fuel flowmeters as having been consumed by each of the four engines. Over Basra, the fuel level gauge initially indicated a smaller quantity of fuel remaining than was reported by the flight engineer. Although the accuracy of these fuel level gauges is far from satisfactory, in this critical fuel situation, it should have given, from the safety point of view, the least optimistic idea of the quantity of fuel remaining, as a basis for selecting the prudent course to follow.

When passing over Shaibah, the pilot-in-command calculated from the fuel flowmeters, that only the very small amount of 400 lbs of fuel remained for reaching Dhahran, i.e. 2 1/2% of the total fuel load. The fuel flowmeters may, however, have given a negative error of 2 1/2%. Moreover, no account was taken of the fact that when the aircraft is in an inclined attitude the total amount of fuel it carries cannot be drawn from the tanks.

Considering the fact that, even in the most favourable conditions, on arrival at Dhahran the aircraft would have only a small amount of fuel remaining in its tanks, the pilot-in-command in taking the decisions listed above in paragraphs a), b), c), and d), weighing the pros and cons of flying on to Dhahran, should have given his preference to the safer course.

As regards d) above, it should be noted that the risk involved in landing at Kuwait or Shaibah, under the circumstances, was certainly not weighed against the risk of continuing on to Dhahran with the added possibility of having to make a landing away from the aerodrome.

The fact that Dhahran aerodrome, which must have known that there was a possibility that the aircraft would have to make an emergency landing owing to lack of fuel, did not issue a warning earlier entirely fits in with the incorrect impression, still held by the pilot-in-command during the last part of the flight, regarding the amount of fuel remaining.

From the foregoing the inquiry concluded that the pilot-in-command did not take appropriate action to ensure the safety of the considerable number of persons on board and that he exposed the aircraft to a serious hazard. The inquiry noted to his credit, however, that he carried out the emergency landing successfully.

In judging the actions of the pilot-in-command, the following factors were taken into account. It was the opinion of the Board of Inquiry that the operating company's personnel involved were not made sufficiently aware of the fact that methods employed to determine the amount of fuel available should allow for a considerable degree of error. The flight engineer later doubted the reading of the fuel tanker, the co-pilot relied more on the fuel level gauge than on the fuel flowmeter and the pilot-in-command relied entirely on the fuel flowmeter. There was therefore a lack of unanimity among the crew. Furthermore, on a long distance flight made by the same aircraft a short time before, it was noted that all the fuel flowmeters combined gave a negative error of 3%. However, this fact was not known to the crew flying the aircraft on this occasion.

The investigation instituted a thorough inquiry into the methods adopted by the operator for measuring amount of fuel available and into the accuracy of the means used. This inquiry revealed that an inaccurate impression could be gained of the amount of fuel on board at take-off as the control of gauging-rods was inadequate. Furthermore, fuel gauges, the readings of which vary with the inclination of the aircraft, certainly do not appear to be precision instruments. Fuel flowmeters appear to be designed in such a manner that they are unreliable if there is any variation in the operation of the engines which affects the fuel consumption, yet the information these instruments provide is used to determine the amount of fuel remaining on board during flight. They do not appear to be sufficiently accurate to provide a reliable indication of the amount of fuel remaining, and certainly not after a considerable proportion of the original fuel load has been consumed. There appear to be many factors which make it necessary to use extreme care in calculating the estimated consumption.

Had all the points brought out in the above mentioned inquiry been brought to the attention of the pilot-in-command on 1 January 1953, he probably would not have shown such misplaced optimism. Nevertheless, even without the company giving detailed information concerning the accuracy of fuel flowmeters, a pilot-in-command, given the responsibility of making a long flight, should be aware of the fact that flowmeters are not accurate and he should allow a safety margin in his calculations on that account.

Conclusions

The unanimous findings of the Board of Inquiry were as follows:

1. The Company in training pilots-in-command and flight engineers, should make such personnel more fully acquainted with the possible misleading effects of instruments and should ensure that they realize that the error involved can be such as to have a bearing on the safety of operations.

2. More reliable fuel level gauges should be developed, particularly as regards the readings given when the fuel in the tanks is very low.

The pilot-in-command was compelled to extend the flight to a more remote aerodrome, at a greater distance than the aerodrome of destination or the designated alternate. Towards the end of this long flight, he over-estimated the amount of fuel still available. During the last part of the flight, owing to this inaccurate judgement, he took a series of unwise decisions which resulted either in unnecessary consumption of fuel or failure to avail himself of possibilities of making a landing. It is noted that the pilot-in-command was reprimanded by the management of the Company for his lack of caution and, in addition, was allowed to fly only in the capacity of second pilot for some time after the accident.

Taking all the foregoing into consideration, the Board approved the action of the Company in reprimanding the pilot-in-command in view of the serious failings on his part which are described above.

ICAO Ref: AR/286

No. 5

Associated Air Transport C-46F aircraft, crashed near Fish Haven, Idaho, on 7 January 1953. CAB Accident Investigation Report No. 1-0006. Released 31 December 1953

Circumstances

At approximately 0412 MST, 7 January 1953, an Associated Air Transport Curtiss C-46F aircraft, being operated between Seattle, Washington, and Fort Jackson, South Carolina, crashed approximately eight miles west of Fish Haven, Idaho. All 40 persons aboard, consisting of 37 passengers, all military personnel, and a crew of three lost their lives, and the aircraft was completely demolished.

Investigation and Evidence

The flight originated at Boeing Field, Seattle, Washington, with the first stop scheduled at Cheyenne, Wyoming.

Weather briefing of the crew by the United States Weather Bureau at Boeing Field, indicated en route weather to be, scattered to broken clouds to overcast with the tops estimatec at 12,000 feet and a Cheyenne Terminal Forecast of scattered clouds at 15,000 feet, visibility more than 15 miles. The weather briefing included a forecast of icing conditions in clouds and precipitation above 6,000 feet along the route, with cloud tops ranging from 10,000 to 14,000 feet MSL.

An IFR (Instrument Flight Rules) flight plan, filed by the captain and approved by the Civil Aeronautics Administration Air Route Traffic Control, Seattle, requested a cruising altitude of 13,000 feet to Cheyenne via Airways Green 2, Blue 12, Blue 32, Red 1 and Green 3, with a proposed true airspeed of 200 mph, estimated elapsed time five hours, with six hours and forty minutes of fuel aboard, alternate airport, Denver, Colorado.

The flight departed Boeing Field at 0050 and made the required position reports along the route, with no mention of any irregularities, reporting over Malad City at 13,000 feet, time 0358, and estimating Rock Springs at 0445.

There were no further radio contacts with the aircraft. All attempts to contact the flight by CAA radio stations and by other aircraft along and bordering the proposed route were unsuccessful. A widespread search for the missing aircraft was subsequently conducted under the supervision of Air Search and Rescue units of the United States Air Force.

Five days later, on 12 January 1953, at 1320 hours, the wreckage was sighted from the air by a Civil Air Patrol pilot. Two Air Force paramedics parachuted to the scene and immediately confirmed the aircraft's identity and determined that there were no survivors.

During their observation of the wreckage area, a strip of hard ice was noticed on the leading edge of the de-icer boot of a partially exposed wing. This piece of ice was adhering to the boot, parallel to the leading edge and was about three feet long and uniformly about 1-1/2 inches thick and about 3/4 inches wide. Both ends of this strip appeared to be blunt. No other ice was seen on the aircraft wreckage.

The investigation at the scene of the accident revealed that the initial impact occurred when the aircraft, travelling on a heading of about 340 degrees and nearly level longitudinally, struck a small pine tree at an altitude of approximately 8,545 feet, 45 feet south of an 8,500 foot east-west ridge, and continued 377 feet in a nearly level attitude where contact was made with two large pine trees. At this point several small bits of wreckage, including chips of propeller blades, were recovered. The aircraft continued on the same heading (340 degrees), striking another large pine tree 242 feet beyond and approximately 75 feet lower. From this point, the aircraft began to disintegrate as it continued down the slope at an approximate 50 degree angle shearing numerous trees. Contact with the ground was made at the base of the hill at the north end of a 93 foot ravine where the aircraft gouged three large holes in the ground.

The aircraft then continued up a 32 degree rise approximately 200 feet where the tail section came to rest. Several components of the wreckage continued over this hill approximately 350 feet. The wreckage was distributed over an area approximately 400 feet wide and 1,540 feet north from the point of initial impact.

Time of the crash was determined by impact-stopped watches as close to 0412.

Two oxygen bottles were found at the scene of the accident. Although the main valve on each cylinder was closed, both pressure gauges and output control valves were broken off. One bottle was completely charged, while the other, which was badly damaged, was partially discharged. Thus, it was evident that there was no shortage of oxygen supply.

Examination of the widespread and scattered wreckage yielded no clue or even suggestion that there had been structural or mechanical difficulty of any nature before impact. Further, the relatively flat angle of impact is indicative of partial control at the time the aircraft struck. There was no evidence of any fire or explosion before the crash.

Examination showed that both engines were rotating at the time of impact and that the propellers were in the cruising rpm range which definitely indicated that power was being developed at impact. Damage was so extensive that it was impossible to follow through on the continuity of all control systems; however, those portions of control systems that could be examined were found to be properly fastened and safetied.

The aircraft was equipped with wing de-icer boots but the cockpit unit controlling their use was not recovered. However, investigation disclosed that the de-icer boots were operative when checked at Boston on 4 January 1953, three days prior to the accident. Due to the forecasted icing conditions en route to Cheyenne, it is probable that the pilot checked the aircraft's de-icer equipment prior to departure from Seattle in accordance with standard operating procedure. Also, the propellers were equipped for de-icing, and the 20 gallon anti-icer tank, supplying the propellers, the carburettor and the windshields, was full of alcohol when the aircraft left Cheyenne for Seattle on 5 January 1953.

Had the flight continued on from Malad City at 13,000 feet, it would likely have entered the tops of the clouds over the mountains between Malad City and Bear Lake. During this short period that the flight would have been in the clouds, light rime ice and light to possibly moderate turbulence would have occurred. It is probable that the top portion of these clouds were predominately ice crystals, and that therefore sufficient water in the liquid state would not have been present to produce more than a light coating of ice. It seems likely that even this condition could have been flown over by an increase of altitude of not more than 500 feet. These conditions were verified by another flight that preceded the aircraft by only a few minutes without any difficulty. There was no request received from the flight for a higher altitude. (Any change of altitude would require clearance from Air Route Traffic Control.)

Since the above conditions did exist at the time the flight was in the area, it is likely that an involuntary descent was made into an area of increasing ice and turbulence which extended two or three thousand feet above the mountains. The mountains between Malad City and Bear Lake range from 8,000 feet to over 9,000 feet. The westerly winds were lifting the moist unstable air over those mountains, producing zero ceilings, moderate to severe turbulence, moderate to heavy icing and snow, with updrafts on the windward side of the slopes and down drafts on the leeward sides. Ground observers in that area, none of whom saw any aircraft, described conditions as a blizzard. This was a local condition resulting from the air flow over this mountain range.

The general weather conditions at 13,000 feet in the area were not conducive to carburettor ice. However, had any icing occurred, the prompt application of alcohol or heat should have eliminated this condition. Since icing became progressively worse at lower altitudes, there is a possibility that any appreciable delay in taking corrective action could have caused a forced descent into worsening conditions.

As mentioned previously, a strip of hard ice was found on the leading edge of the de-icer boot, parallel to the exposed upper surface of a wing. Although this ice was observed five days following the accident, there were strong indications that it had accumulated on the wing during descent. No ice was seen on the other exposed parts of the aeroplane and the absence of glazed ice or icicles on the boughs of trees is indicative that the wing ice had not formed following the accident. The configuration of the ice precludes the possibility of it having formed as a result of rain droplets after the crash. Furthermore, the blunt condition of both ends of the ice strip strongly suggests that it was the remaining portion of a larger ice layer on the leading edge which could well have been broken off during the crash. Since this ice was on the de-icer boot, it shows that ice was forming on the boots so rapidly during descent that action of the boots themselves was not sufficient to break off and remove the ice completely.

Investigation disclosed that the aircraft struck on a heading almost 100 degrees from its intended course. This gives rise to the belief that during the descent a rapid accumulation of ice on the top surfaces of the wings would have seriously impaired the lift of the aircraft and probably adversely affected controllability despite the fact that the de-icer boots could have been operating at the time. The aeroplane could not have maintained proper altitude much less climb had these conditions existed, even though maximum continuous power was being used.

It is well known that the rate of ice accretion and its quantity vary greatly under different conditions of temperature, moisture content, etc.

About 42 miles back from the crash site, over Malad City, the flight reported as being at 13,000 feet. The elapsed time from the Malad City report to the time of crash was about 14 minutes. Thus the ground speed over these 42 miles was about 180 miles per hour. Previous legs of the flight had been logged at ground speeds of 220 - 230 miles per hour. But the distance of the final segment, from Malad City, is short and the time determinations are subject to some error. Therefore, it may be presumed that the flight lost altitude while continuing straight ahead and on course at a somewhat reduced speed until shortly before the accident when a left turn was made. (The crash site was only about two miles from the centre of the airway.) This somewhat reduced speed can be accounted for by the fact that light to moderate turbulence existed at the cruising level and became worse at the lower altitudes. (The company's Operation Manual specifies a speed reduction to 140 mph through turbulence.)

The flight previously mentioned, also eastbound, and only a few minutes earlier, did encounter some turbulence in the area and this pilot avoided it by increasing his altitude from 13,000 feet to 13,500 feet.

The crash site was several hundred miles from Cheyenne, the point of next intended landing, far too distant to start a letdown.

The inquiry concluded from the evidence available that the aircraft encountered severe turbulence and the formation of heavy icing of the aircraft which precipitated its descent and subsequent crash. The inquiry was unable to state why the flight did not request and proceed to a higher altitude to clear the tops of the clouds. The reason for the initial descent is not known.

Probable Cause

The Inquiry determined that the probable cause of this accident was the inadvertent descent into an area of turbulence and icing which resulted in the flight's inability to regain a safe altitude.

ICAO Ref: AR/289

No. 6

Union of Burma Airways DC-3, crashed on approach-to-land at Mergui Aerodrome on 10 January 1953. D.C.A. Burma, Civil Aircraft Accident Report

Circumstances

The accident took place while the aircraft was approaching to land at Mergui Airstrip on Runway 01 on a schedule Rangoon-Tavoy-Mergui flight with 15 passengers and 3 crew. The port wing of the aircraft hit trees on its final approach and the aircraft landed heavily about 820 feet from the threshold of the runway. On impact with the ground, the starboard engine became detached from the aircraft and the aircraft ran along on its port wheels and starboard propeller approximately 270 feet and finally came to rest about 475 feet from the threshold and approximately 50 feet from the edge of the runway. Fire broke out on the starboard side, possibly due to severed fuel lines and electrical short circuits. The fire consumed the forward portion of the aircraft up to the main rear entrance door. The wings sustained damage but were not consumed by the fire. The crew and passengers were safely evacuated although two of the passengers sustained minor injuries. The fire fighting equipment at the aerodrome was totally inadequate and the local fire brigade with its 400 gallons of plain water could not save the aircraft.

Investigation and Evidence

The flight was routing to within 7 minutes of Mergui Airfield, when permission was asked by the aircraft to descend on course. On receipt of permission landing instructions were requested which were given as Runway in use 01; QNH, 29.85 inches; wind North 5 knots. At a height of 1,300 feet on the downwind leg the undercarriage was lowered and descent was continued until a turn was made on base leg when the flaps were half lowered. The height was then 800 feet. While lining up with the runway full flaps were applied and the tower was contacted for final clearance. The airspeed at this time was between 95 and 100 mph. A few minutes later, the aircraft struck trees and then the ground, finally finishing up approximately 475 feet from the end of the runway. Fire broke out on the starboard side of the aircraft but all passeng[illegible] and crew were able to escape. The aircraft was destroyed. Witnesses described the approach as low and banked steeply to the left. The ground level slopes at a gradient of 1 in 100 from the end of the runway.

Investigation showed that the lower portion of the starboard side of the aircraft brushed the top of a Betel palm 38 feet in height at a distance of 1543 feet from the end of the runway, then the port wing tip struck a forked tree branch 663 feet further on and another tree 35 feet in height 60 feet further on. The port undercarriage, port propeller blades, starboard undercarriage and propeller blades contacted the ground in that order, the aircraft then slid along the ground until it came to rest.

Probable Cause

The crash was attributed to an error of judgment on the part of the pilot, but there was nothing in the evidence to show what may have caused the error nor is there any evidence to show that the error was caused by negligence on the part of the pilot.

Recommendations:

1. That adequate means be provided at all airports for fire fighting.

2. That the engineers and other licensed personnel in the employ of the Union of Burma Airways be required to maintain their licenses in a current state.

3. That the first officers in the employ of the Union of Burma Airways be instructed on the correct procedure in case of emergencies.

4. That Union of Burma Airways lay down definite instructions as to the securing of passengers to their seats on take offs and landings.

5. That Union of Burma Airways make it compulsory that its pilots report personnally for briefing.

ICAO Ref: AR/299

No. 7

Junkers JU-52 aircraft crashed during a spraying flight near "El Chañar" (Gordillo Government Department, Province of La Rioja) on 15 January 1953. Argentina Accident Investigation Report No. 130 released 23 July 1953.

Circumstances

The accident occurred on 15 January 1953 at 1708 hours (local time) in the vicinity of El Chañar (Gordillo Government Department) while carrying out locust control spraying operations. The aircraft carried two crew members (a pilot and a mechanic) and one passenger. The occupants of the aircraft were not injured, but the aircraft suffered substantial damage (about 50%).

The pilot who was flying the aircraft had logged 3,790 hours of flying time, including 550 hours in the type of aircraft involved in the accident.

Investigation and Evidence

Between 4 and 7 January 1953 the aircraft was being readied at Tucumán aerodrome for transfer to La Rioja. On 6 January, it had been filled to capacity with 1,488 litres of fuel following which a 15 minute test flight was made. A slight leakage was discovered in No. 3 tank in the left wing, and the necessary repairs were carried out immediately.

On 12 January at 1500 hours the central and left motors were started preparatory to take off for La Rioja, but they were stopped when the flight was cancelled.

During the morning of 15 January, operating from Chamical aerodrome, the aircraft made a reconnaissance flight in the El Chañar district with a full load of locust spray. This flight lasted one hour and fifteen minutes. During the afternoon of the same day and in preparation for a fumigation flight, the mechanic made a thorough check of the aircraft, transferring seven litres of fuel from the left engine tank to the central engine tank because their consumption was uneven and in order that they should begin with the same quantity of fuel. Immediately following a five minute warming-up period, the aircraft took off at 1625 hours and reached the El Chañar area, completed its mission without incident, and started the return flight at 1700 hours. After four minutes of flight the right engine began to fail owing to lack of fuel. The mechanic switched over to the emergency tank after which the engine operated normally again. The pilot then stopped the central engine in order to save fuel. In the meantime the left engine started to fail and it also was connected to the emergency tank.

Faced with an emergency situation, the pilot searched for a field suitable for a landing but was unable to find any area that was clear of mountains or hollows. Complete failure of all engines, however, left the pilot no choice but to make a forced landing immediately. Nearing the ground, the aircraft first struck a cactus, then the wheels touched the ground and at the same time another larger cactus tore off the tip of the right wing. The aircraft then travelled along the ground for about forty metres, slewed round 150° following breakage of the landing gear strut, finally coming to a rest in that position with its nose facing west.

The weather in the area was: a few low clouds, unlimited ceiling, wind from "E" sector 10/15/km/h, and visibility 20 km.

The aircraft was not equipped with fuel level indicators.

From the evidence gathered at the investigation it was revealed that preparatory to carrying out the operation in which the accident occurred, in calculating the endurance the crew counted only the fuel consumed by the aircraft during the actual flying times of the various flights performed since the aircraft had been refuelled, without taking into account the consumption during the testing of the engines, the warming up of the engines on the taxiway, etc.

In fact, the pilot calculated 4:30 hours of flying time. To this figure had to be added the 15 minutes of the test flight which followed the refuelling at Tucumán aerodrome on 6 January, which gives a total of 4:45 hours. Deducting this from the endurance of the Junkers aircraft, which is 6 hours, theoretically leaves 1:15 hours flying time.

In making their calculations, the crew did not account for the fuel consumed for the following purposes: six starts with their "primings"; five "taxyings" to the take-off point; four post landing "taxyings" to the hangar area; five "engine stops" by closing the fuel selector valve with the resultant consumption of fuel in the pipeline and carburettors; and evaporation of gasoline because of the area and the hour of the work. All these operations used fuel equal to that required for approximately 1:05 or 1:10 hours flying time, or, theoretically, there remained five or ten minutes possible flying time. Also, account must be taken of the fact that at the time of the flight test at Tucumán aerodrome on 6 January a slight leakage had been detected.

Cause

The Inquiry concluded that the primary cause of the accident was negligence on the part of the crew in checking the fuel load and the fuel consumption, and that contributing causes were faulty maintenance and operation.

ICAO Ref: AR/295

No. 8

Skyways Ltd. Avro York aircraft missing in North Atlantic on 2 February 1953. Ministry of Transport and Civil Aircraft Accident Report CAP 119

Circumstances

The aircraft, engaged on a trooping flight from Stansted, Essex to Jamaica, tookoff from Lagens Airfield in the Azores to Gander, Newfoundland, at 2325 on 1 February 1953. The aircraft carried 33 passengers and six crew. "POMAR's" (Positional Operational Meteorological Aircraft Report's) were transmitted at approximately one hour intervals from 0010 hours on 2 February until dispatch of the last POMAR at 0425 hours when the position of the aircraft was given at 0410 hours as LAT 44° 32'N, Long 41° 38' W. At 0531 hours the radio operator on duty at Gander received an Urgency Signal from the aircraft giving the position at 0530 hours as LAT 46° 15'N, Long 46° 31'W. This was followed immediately by the distress signal "SOS, SOS, SOS de G-A" abruptly terminated at that point giving the impression that the transmitting station had gone off the air. No further communication of any kind was received from the aircraft and extensive sea and air searches failed to discover any trace of the aircraft or its occupants.

Investigation and Evidence

From the evidence of the "POMAR's" transmitted by the aircraft which were compiled hourly the first being timed 0010 hours on 2 February up to 0410 hours, the weather forecast for the flight was substantially correct. There were variable amounts of cloud stratiform in structure along the whole of the route the main tops being at between 7,000 feet and 8,000 feet. At 10,000 feet to which altitude the aircraft received permission to ascend at 0020 hours from Air Traffic Control, Santa Maria, the aircraft was flying above cloud. From 0410 hours onwards no further weather information was transmitted by the aircraft.

A notorial declaration made by the captain commanding a Trans-Ocean Airlines DC-4 aircraft which flew at 8,000 feet from Santa Maria, Azores to Gander about 3 hours later than the Skyway's aircraft, confirmed that the weather encountered en route was in the main such as would permit flying by Visual Flight Rules with occasional cumulus tops in which light rime icing was encountered. Throughout the whole flight no significant weather was encountered by this aircraft.

The synoptic situation indicated a ridge of high pressure extended across the track of the aircraft resulting in north westerly winds of a strength of 20 to 25 knots over the first half of the route decreasing in strength in the area of 42°N and gradually backing in the area of 47°N and increasing in strength. In such conditions it can be reasonably assumed that in the area in which and at the time at which the Distress Signal was sent there would be broken cloud with tops up to 8,000 feet. At 10,000 feet flying conditions should have been good without turbulence or risk of icing. The Court was satisfied that the cold front which was lying across Newfoundlan and moving eastward during the early hours of the morning of 2 February could not have reached or affected the weather in the area in which the last message was sent out.

There is no evidence of abnormality of any sort in what is known of the flight up to 0425 hours at which time the "POMAR" relating to 0410 hours was transmitted.

At 0531 hours O.A.C. Gander received a signal prefixed "X X X" from the aircraft giving the position at 0530 hours as LAT 46° 15'N, Long 46° 32'W. This message was described by the receiving operator in these terms "readability fair but distinct, sending good and speed of operating steady, normal and good, there did not appear to be any hurry or increase in operatin speed from the aircraft." This Urgency Signal which was incomplete in that it did not state the reason for sending it, was followed after a scarcely perceptible break by the Distress Signal "SOS, SOS, SOS de G-A" after which the transmission broke off abruptly. There was a decided increase in speed of operating as compared with the previous messages.

The Court attached no significance to the fact that the "POMAR" relating to the 0510-hour position was never transmitted. Transmissions of "POMAR's" must in practice be subject to delay for various reasons and on the flights from Stansted to Lagens and from Lagens toward Gander "POMAR's" were, in fact, sent out with a time lag of up to 25 minutes. Significance may, however, be attached to the fact that for the purpose of giving the 0530-hour position a recalculation must have been made which would not normally have been necessary. It is reasonable to assume, therefore, that trouble of some sort developed in the aircraft not less than two minutes before the transmission of the Urgency Signal. It seems unlikely that such trouble, whatever its nature may have been, was sufficient to produce a state of alarm among the crew of the aircraft until after the commencement of the transmission of the Urgency Signal. Such a signal is not one which indicates that immediate assistance is required. Had the crew been aware of a dangerous state of affairs it is reasonable to expect that the "distress" prefix would have been used at once or that an Urgency Signal giving the reason for sending it would have been sent out without waiting for the Navigating Officer to give the radio-officer the re-calculated position. The fact that the Urgency Signal so far as it went was transmitted at normal speed and was followed immediately by the Distress Signal transmitted at a greatly increased speed and broken off abruptly before completion leads to the conclusion that trouble developed in a sudden and violent manner.

The outstanding feature of the inquiry was the lack of evidence as to what caused the disaster. The number of possibilities was almost unlimited: among the possibilities none were preferred as probabilities. The choice of the topics which were discussed in the Report was not based upon any belief that in any one or combination of them the explanation of the disaster was to be found. The topics were discussed out of deference to the submissions of Counsel and to the witnesses whose evidence opened the matters before the Court.

The Possibility of Crew Fatigue: The Operations Manual of the Owners issued for the guidance of the Operators and their crews devotes an important paragraph to the question of Crew Fatigue. It lays down that no captain who is left to carry out his own time table (as was the captain in this case) should arrange a schedule which is liable to imperil the aircraft and its occupants through crew fatigue. The practice of the operators is to allow an absolute minimum of 9 hours rest after a flight of normal schedule, that is to say, when a flight does not entail more than 9 hours flying on one leg. On occasions when a flying time of 9 hours is required to be exceeded involving an elapsed time of more than 12 hours in any one day crew rest of not less than 12 hours is to be allowed.

The aircraft took off from Stansted at 1106 hours on 1 February and it was reasonably assumed that the crew came on duty not later than 1000 hours and probably as early as 0900 hours. This meant that by the time they reached Lagens at 1913 hours they had been on duty at least 9 hours and perhaps longer. The turn-round at Lagens occupied 4 hours 12 minutes during which time it was unlikely that any member of the crew had any time for recuperative rest. This carries the total of hours on duty to over 13 hours at the time of take-off from Lagens and to over 19 hours at the time of the distress signal. The total of hours on duty by the time the aircraft should have reached Gander would have been nearly 23 hours and there a landing in the dark under Instrument Flight Rules would have had to be undertaken.

The Report noted that it was for consideration whether operators of flights of this nature ought not to provide provisional schedules for the guidance of captains allowing for adequate periods of rest the duration of which should be related to hours on duty and not fo flying time.

On the Possibility of Icing: The Report indicated that in the evidence the Court did not think that the aircraft encountered icing. The Operations Manual of the Owners also contained the following:

"FLIGHTS IN ICING CONDITIONS.

Before commencing a flight, captains must carefully check their route forecast and should icing conditions be apparent alternative aerodromes must be available outside the icing belt. Where the aircraft is fitted with leading edge and engine de-icing equipment the captain must estimate the period of time where heavy icing conditions may exist; this should not exceed thirty minutes. If, after 30 minutes in heavy icing conditions, the captain has been unable to climb out of it, or there is no sign of clearance, the captain must turn back."

The Operators also issued the following supplementary instruction to cover the special trooping flights "Under no circumstances will any flight over any sector be commenced if any doubt exists as to its practicability." The Inquiry considered that these instructions could be regarded as reasonable and sufficient.

The Certificate of Airworthiness permitted the aircraft to fly in any conditions of icing for indefinite periods. As far as could be ascertained, no actual flight tests were ever carried out to determine whether or not some limitation should have been indicated in the Certificate to enable Operators to decide to what degree of icing it was safe to operate such an aircraft for prolonged periods.

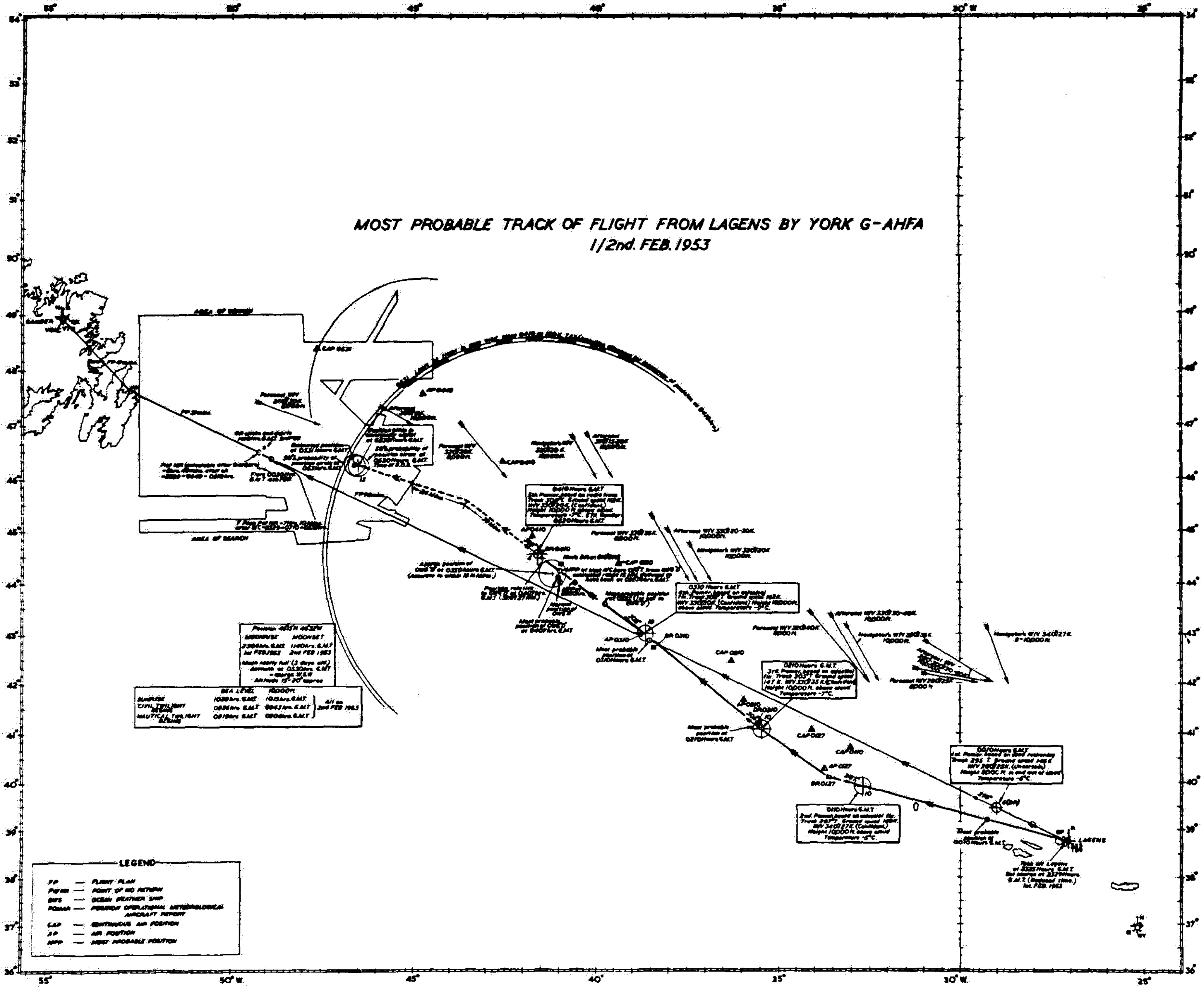
On the Possibility of Engine Fire: The Report indicated that the possibility of fire originating in the induction system could be disregarded but a development of such a nature should have been apparent to the pilot immediately through the noise of the back-fire which would lead him to look at once at his engine instruments. It was difficult to imagine an induction fire leading to so sudden and catastrophic a change in the situation as was indicated by the breaking-off of the Urgency Signal and the immediate sending of the distress signal.

In considering the possibility of engine fire, the Inquiry remarked that a potential contributory cause of such fires is the loss of lubricating oil. If this loss is detected in time the appropriate steps can be taken to prevent it leading to serious trouble. It is, therefore, important that the pilot should have every possible assistance in detecting any such loss. One valuable aid which under existing regulations is not mandatory is the oil-contents gauge associated with some sort of warning device. Reliance on the oil pressure gauges can lead to a dangerous situation in a number of combinations of circumstances, e.g., a loss of the oil through the feathering pipeline which may not be apparent from a reading of the pressure gauges until the point of starvation has been almost reached. The need for oil-contents gauges is the greater where the positioning, presentation of and night-lighting for the engine oil pressure and temperature gauges do not make for ready observation of changes in indications as was the case on this aircraft.

The engine fire extinguisher system on the aircraft appeared on the evidence to be satisfactory in circumstances when the engine fire drill which was contained in the Operations Manual and displayed in the cockpit is followed promptly and correctly and when there are no further complications, e.g., the propeller failing to feather. The Court of Inquiry was of opinion that a careful study should be made of the possibilities of transferring the contents of the methylbromide bottles from one adjacent engine to another so duplicating the fire extinguisher supply to any one engine.

The Court felt constrained to point out that the number of mechanical failures or combinations of such failures which could produce an engine fire is incalculable. So long as machines of such complexity exist those who entrust their lives to their performance cannot be guaranteed more than a reasonable standard of knowledge, skill and devotion to duty on the part of those who design, manufacture, test, operate, maintain or fly them. The Court was unable to detect any failure under these heads on the part of any of those responsible for the aircraft in any of those capacities.

Ditching: The York aircraft is a high-wing monoplane the whole of the fuselage of which is below the level of the main planes. In "ditching" it is unlikely that the aircraft could remain afloat for more than a few seconds after even a fully controlled descent on to smooth water. In a rough sea the aircraft would almost certainly break up almost immediately and it is extremely unlikely that any of the occupants who were alive when it touched the water would have any chance of using the escape hatches or of launching any of the six internally stowed dinghies provided for such emergencies.


MOST PROBABLE TRACK OF FLIGHT FROM LAGENS BY YORK G-AHFA
1/2nd. FEB. 1953
LEGEND
FP — FLIGHT PLAN
OWS — OCEAN WEATHER SHIP
POMAR — POSITION OPERATIONAL METEOROLOGICAL AIRCRAFT REPORT
CAP — CONTINUOUS AIR POSITION
AP — AIR POSITION
MPP — MOST PROBABLE POSITION
LAGENS
AREA OF SEARCH
55°
50° W.
45°
40°
35°
30° W.
25°

Recommendations

1. Steps should be taken by all operators to review the maintenance discipline in and about hangars. Such a failure as the omission to ensure that controls are locked against the possibility of damage caused by gusts of wind or the slip streams of other aircraft indicates a slovenly attitude on the part of a ground staff which can be corrected only by a tightening of discipline. (The report contained information on a pre-flight incident in which, while the aircraf was being towed, a powerful gust caught the elevators depressing them fully with such violence that the control column struck the blind flying panel breaking several instruments.)

2. Consideration should be given to the question whether it would be right to impose upon operators the duty of providing provisional schedules for the guidance of captains allowing for adequate periods of genuinely recuperative rest the duration of which should be related to duty time and the circumstances of the flight, e.g., type of aircraft, crew complement, noise level, climatic conditions, route characteristics, and not simply to flying time.

3. The whole subject of crew fatigue should receive study at an impressive level. This is not simply a question of establishing certain time standards based on medical opinion but involves an approach to the much more difficult problem of finding ways of preventing the subjective preference of individuals from accepting undesirable risks and so imposing the acceptance of the same risks upon others. The topic lies within the sphere of labour-relations as well as forming part of the proper subject matter of psychological studies. It is for consideration whether a Departmental Committee should be set up to investigate this important subject.

4. Consideration should be given to the desirability of strengthening or reinforcing Clause 40 in the "Compulsory Conditions" of Certificates of Airworthiness by imposing some limitations upon the permitted operation of an aircraft in terms of the degree and duration of icing to be expected.

5. Oil-contents gauges or some other reliable means of detecting loss of oil should be made a mandatory requirement on all public transport aircraft.

6. Study should be directed to the possibilities of transferring the contents of the methyl-bromide bottles from one adjacent engine to another.

7. Consideration should be given to the problem of providing external stowage for proportion of the dinghies carried together with an automatic or remotely-controlled means of inflation upon ditching, more especially on aircraft with poor ditching characteristics.

ICAO REF: AR/301

No. 9

Douglas DC-3 aircraft, damaged during take-off at Trelew Aerodrome, on 13 February 1953. Argentina Accident Investigation Report No. 115 Released 20 July 1953

Circumstances

On 13 February at about 1149 hours (local time), a Douglas DC-3 aircraft, which was operating a scheduled airline service, met with an accident at the Trelew (Gobernación del Chubut) Aerodrome.

At the time of the accident, the aircraft was being flown by the co-pilot who had logged 4,192:28 hours. The commander, who was performing the duties of co-pilot, had logged 5,780 hours of flying time.

The weather report indicated generally good weather with unlimited visibility, wind WSW 8/10 km/h, atmospheric pressure, 1,008.7 millibars, temperature 22°C, and relative humidity 50%.

The crew and the passengers were unhurt.

Investigation and Evidence

The investigation revealed that the aircraft was taking off from Runway 26 on the Trelew-Comodoro Rivadavia lap of its flight.

After travelling some 450 metres down the runway, it became evident that the right wing of the aircraft had a tendency to drop because of a lack of support from the landing gear strut on that side. At 490 metres, the right propeller began to touch the ground. This continued for a distance of some 40 metres after which the aircraft swerved to the right, dragging the wing on that side on the ground. The aircraft finally left the runway, breaking the left landing gear strut and stopping at a spot 700 metres from the point where it had left the runway, with the right hand assembly of the landing gear retracted in a normal manner inside the corresponding wheel well.

The left engine then caught fire as a result of broken fuel lines and possible sparks from the electric circuit or friction of the damaged parts. The fire destroyed a part of the central section of the wing and the landing gear wheel well on that side, and was finally extinguished by the aircraft crew and the aerodrome personnel.

Examination of the wreckage following the accident revealed that the right landing gear strut had retracted during the take-off run in spite of the fact that the control lever in the cockpit was in the "locked-down" position.

The crew members were in agreement in their statements that the mechanism for retracting the landing gear had not been touched and a thorough technical inspection revealed no failure in the retracting mechanism.

The investigations also revealed the mechanical possibility that the locking latch control lever could have been turned to the "locked-down" position after the releasing system had been used.

Probable Cause

Probable premature releasing of the landing gear mechanism during take-off or probabl failure in the landing gear retracting system during this operation.

ICAO Ref: AR/293

No. 10

National Airlines, Inc. DC-6 aircraft crashed in the Gulf of Mexico, 14 February 1953. CAB Accident Investigation Report File No. 1-0013. Released 27 May 1954. (Due to the very complete and important MET features of this accident, it has been given in considerable detail.)

Circumstances

The flight originated at Miami, Florida, for New Orleans, Louisiana with one stop scheduled at Tampa, Florida.

The flight departed Tampa at 1543 with 41 passengers and 5 crew. Gross weight was 78,580 pounds or 11,320 pounds less than the maximum of 89,900, and the aircraft's centre of gravity was located within the prescribed limits. At 1654 the flight advised Pensacola that it was reducing power because of turbulence and five minutes later requested Air Route Traffic Control clearance to descend from 14,500 ft. to 4,500. This was granted and at 1712, the flight advised Pensacola that it had reached 4,500 at 1710. A 1648 New Orleans special weather forecast was transmitted to the aircraft which acknowledged and there were no further radio contacts.

An attempt at 1718 to contact the aircraft was unsuccessful. The following day floating debris and 17 bodies were recovered from a fairly localized area in the Gulf of Mexico. The wrist watches on bodies were impact-stopped at 1710. There were no survivors.

Investigation and Evidence

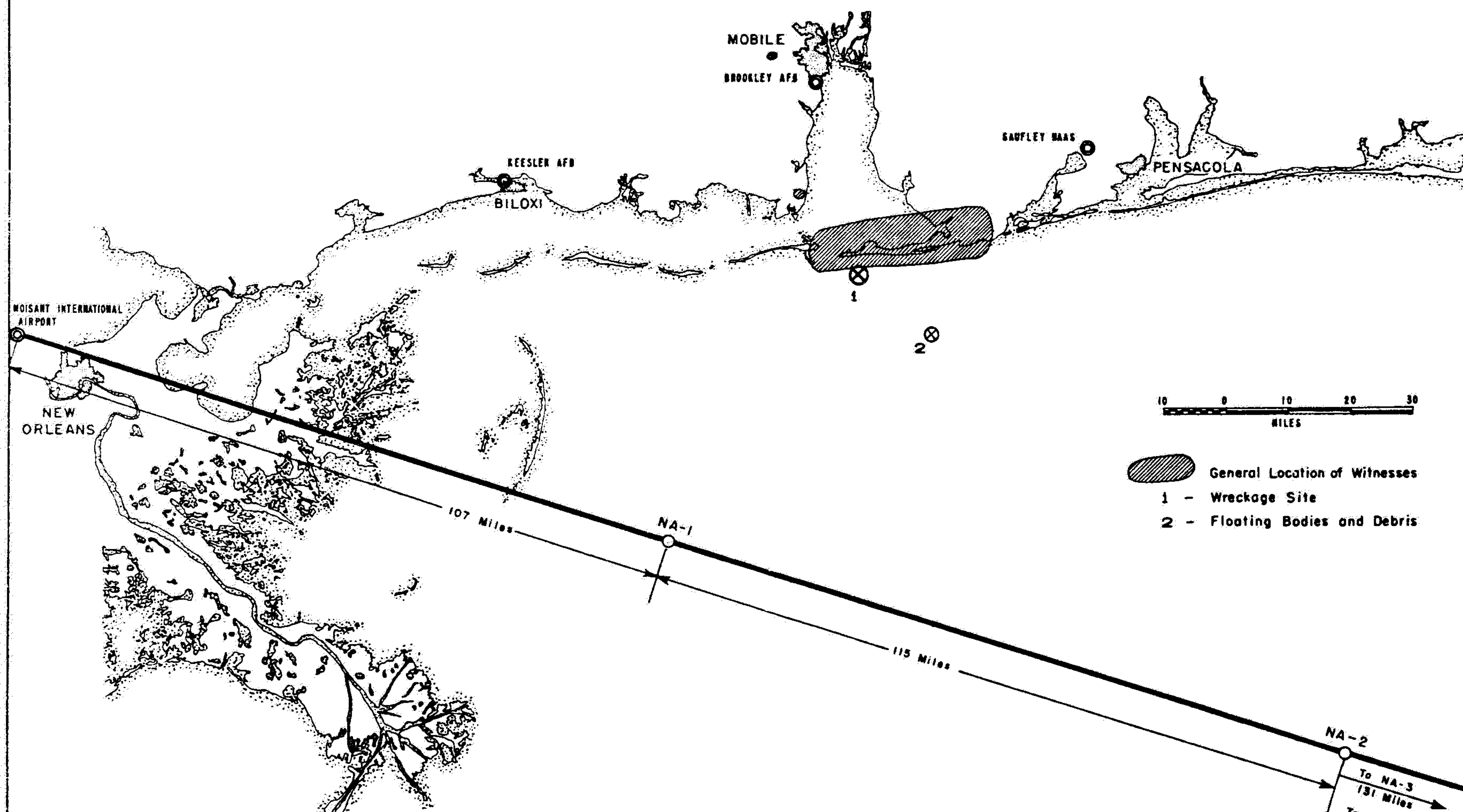
The flight plan, filed at Miami, specified a cruising altitude of 14,500 ft. IFR. Included among the weather data attached to the Captain's copy of the flight plan was a forecast of thunderstorms attended by moderate to severe turbulence in the vicinity of New Orleans. Meanwhile another National Airlines flight which left Tampa for New Orleans at 1311 landed at New Orleans at 1612 and at 1624 its captain sent the following message to Miami Flight Control and all company stations between New Orleans and Jacksonville, etc. "Flight 917 advises extreme turbulence all altitudes just east of New Orleans". This information was passed to the subject flight.

Part I - General

The floating debris recovered the day following the accident was carefully examined. This material consisted of hand luggage, personal belongings, and numerous diversified broken and torn fittings and furnishings from all sections of the cabin. Severe damage to many of these small articles, such as the extreme distortion of a lady's metal compact within a leather purse, indicated that the impact forces must have been of great magnitude. Early in this search there were false rumors of distress signals of a type that could have come from the aircraft's emergency transmitter (Gibson Girl). However, the emergency transmitter could not have been used except from a life raft; none had been inflated and condition of the bodies indicated clearly that no one had survived, even briefly. Two fully discharged CO_2 bottles of the aircraft's main fire extinguishing system were also floating among the debris. Their attached actuating cables were broken, thus indicating that they were discharged when thrown free at time of impact. None of the floating material showed any evidence of fire.

All of the seventeen recovered bodies had numerous fractures and a few bore marks of discoloration. These marks were first and second degree burns and were scattered over various parts of anatomies with no apparent pattern. The cause of these burns could not be determined with finality but competent medical opinion is that they were not electrical (lightning) but were possibly friction, or more likely, thermal as from exposure to a flash fire following impact.

ACCIDENT TO NAL DC-6, FEBRUARY 14, 1953 IN GULF OF MEXICO



Source: From U. S. Coast and Geodetic Survey - World Aeronautical Chart Mobile Bay (467)

When it became apparent that the actual wreckage site was not in the immediate vicinity of the recovered floating debris, an intensive organized search of the surrounding area in the Gulf was instituted. Aircraft of the company, the United States Coast Guard and surface craft of the Navy and Coast Guard as well as pleasure and fishing boats participated. The Navy did considerable diving at suspected locations. This search proved futile and was discontinued officially on 20 March 1953, after it appeared improbable that the wreckage could ever be located. But a group of the passengers' relatives elected to continue an unofficial search, and on 20 May commercial fishermen in their employ located a piece of wreckage. At the request of the Board, the Navy and the Coast Guard once more renewed their search and diving activities and in the subsequent days two separate wreckage areas were located. The main wreckage area was located at Latitude 30°10'25" North and Longitude 87°57'10" West, and contained fuselage parts, right wing parts and the Nos. 3 and 4 power-plants. The second area was located 2,100 feet to the northwest of the main wreckage on a bearing of 331°, and left wing parts and the No. 1 power plant were found in this area. Water depth at both places is about 50 feet and the distance from the Gulf shore is about 3.8 miles.

The floor of the Gulf in the vicinity of each of the wreckage areas was thoroughly explored by Navy and other divers. Several hundred dives, both by deep sea equipped divers and by shallow water equipped divers (frogmen) were made during the course of this work. It is estimated that about 75 per cent of the total structure was recovered from the two wreckage areas. Major components that were not recovered included the No. 2 power plant, the empennage, the left aileron, and a portion of the left wing from Station 60 near the fuselage outboard to about station 130. Since it was felt that the recovery of these components would shed additional light on the probable cause of the accident, the search activities were extended to a larger area in an effort to locate these parts. Sonar sweeps and dragging operations were employed in this operation. Except for one small part of the rudder leading edge, no portion of the major missing units was found.

All the recovered parts were transported to Brookley Air Force Base at Mobile where arrangements had been made to "reconstruct" the wreckage. The structure was carefully laid out in its relative form and the relationship of the different fractures with one another was carefully studied. The three power plants were torn down and the internal working parts were examined for evidence of failure.

Part II - Wreckage

Early in the investigation, it was believed that the corrosion problem would be severe. For this reason, arrangements were made to wash all wreckage with fresh water as soon as it was recovered from the Gulf. In addition, all important structural parts were carefully examined by technicians soon after they were recovered. As it developed, the anticipated corrosion problem did not materialize except for the magnesium engine parts, landing gear wheels, etc.

Examination of the three recovered power plants (Nos. 1, 3 and 4) indicated that there had been no operational failure of these engines or propellers. There was no evidence of fire in, or in the general proximity of, the power plants prior or subsequent to impact. The positions of No. 1 and No. 4 propeller blades at impact were 30° and 32°, respectively, whereas the No. 3 blade position was 53°. The No. 1 and No. 4 propeller blades were damaged in a similar manner, i.e., one blade broken, one blade bent and one blade only slightly damaged. On the No. 3 propeller, two of the blades were bent forward and one was bent aft slightly. The No. 3 and No. 4 engines had sustained severe impact damage on their lower cylinders, while the No. 1 engine had sustained similar damage but on the upper cylinders.

As indicated, the right wing and fuselage parts were all found in the main wreckage area. Severe water impact forces had disintegrated the right wing and fuselage into numerous small sections. The general condition of this wreckage indicated that the right wing and fuselage unit had contacted the water in a relatively flat attitude with no appreciable forward motion. The upper portions of the nacelles and fuselage including the cockpit area all retained their general contours. In general, direct water impact damage was confined to the lower sides of these two components, and the force application appeared to be predominantly in an upward direction, with very little, if any, indication of aft force application. The right flap and aileron were recovered, and these units were similarly damaged on their under surfaces. Since the tail section was not recovered, the fuselage material in the area of the separation of Fuselage Station 938 was carefully examined for evidence of a progressive type failure, but no such evidence was found. The fractures in this area all appeared to have resulted from the application of static type forces and no consistent directional pattern was apparent.

All of the left wing parts recovered were found in the second wreckage area located 2,100 feet from the main wreckage. A large section of the left wing panel from Station 130 to Station 558 was recovered as one unit reasonably intact. It was broken, torn and pierced in such a manner that there could not have remained any trapped air to contribute buoyancy. The center spar was in place in this section for the entire length. The front spare was in place out to approximately Station 460. The rear spar was in place from Station 280 out to Station 421. The upper surfaces of this entire wing panel unit had sustained severe hydraulic damage for its entire length, and those sections of skin panel still remaining in place were crushed downward toward the lower surfaces. The left landing gear was still attached to the spars at the inboard end. The outboard nacelle (No. 1) was still in place on the wing but its upper side had been crushed down severely by water impact forces. In general, the lower wing surface including the lower portions of both Nos. 1 and 2 nacelles was undamaged by water impact forces. Four other sections of the left wing were recovered in the same area and these parts had similar water damage on their upper surfaces. Various pieces of fabric, later identified as clothing by laboratory examination (Federal Bureau of Investigation Report dated 17 September 1953) were found entwined in several places inside the wing, on the No. 1 nacelle and on the No. 2 engine mount.

A close examination of the fractures at Station 130 on the left wing was made. Since the portions of the wing inboard from this station to the side of the fuselage were not recovered, the examination was necessarily confined to the fractures on the outboard side. This examination disclosed that the outboard portion of the wing had failed downward relative to the inboard portion. Further, no evidence of fatigue failure was found. Laboratory tests (U.S. Bureau of Standards Report, Reference No. 8.3/G-13732 of 17 September 1953) verified the preliminary findings. These tests further disclosed that the chemical composition and tensile strength of the material at the failed section met the original specifications for that metal.

A large number of instruments, switches and controls from the cockpit area were recovered. Most of these were in such a badly mutilated condition that it was not possible to make an accurate determination of their setting prior to the breakup.

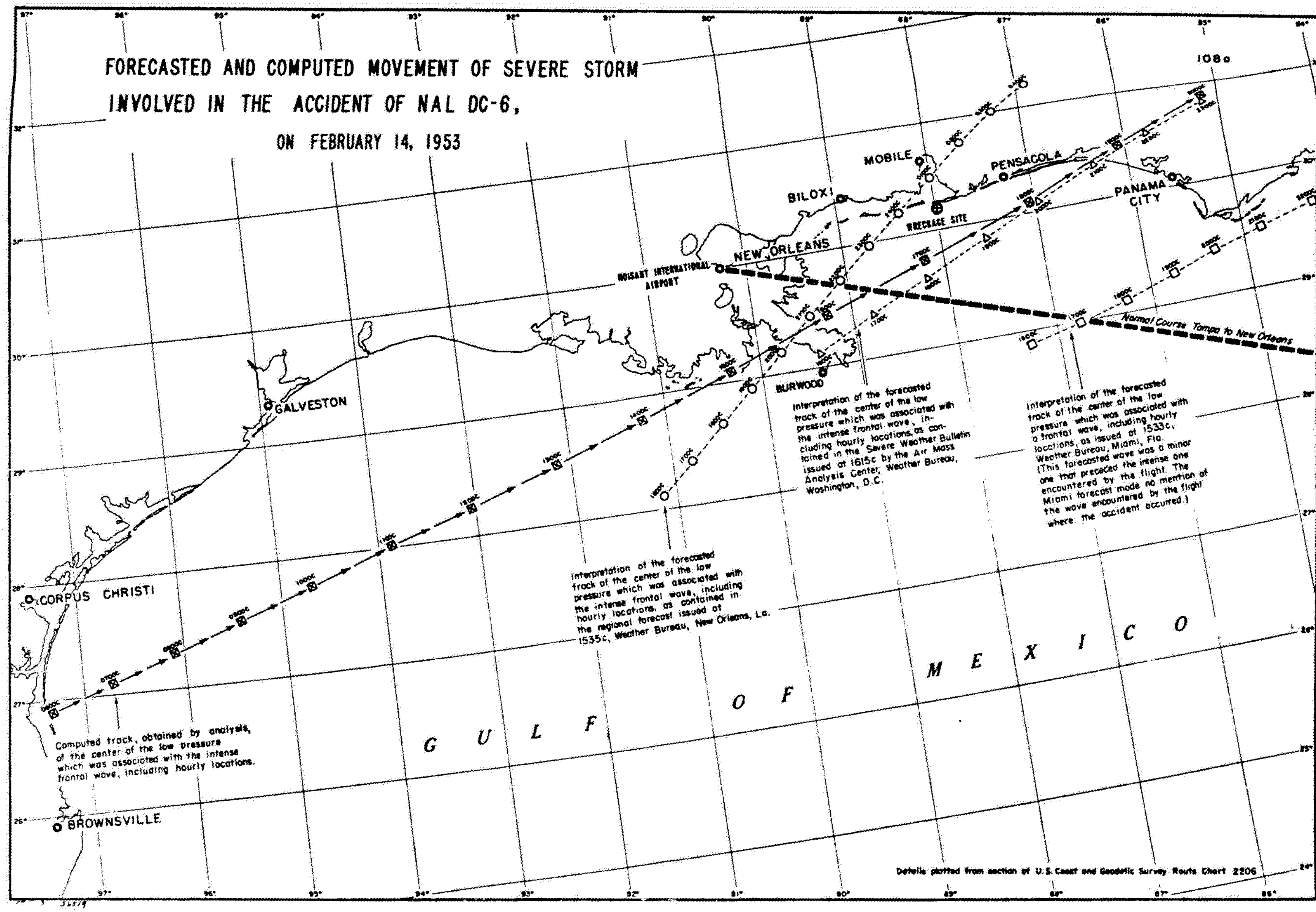
Two altimeters were recovered. The barometric scale on each altimeter was set at 29.61 inches, which was the New Orleans reading given the flight during the final transmission. Both the wing flap handle and the landing gear handle were rusted in the retracted position on their sectors and these positions were consistent with the observed damage to the wing flaps and landing gear.

All recovered control system components were examined for evidence of failure or malfunctioning prior to impact but no such evidence was found.

The damage to the hydraulic system, electrical system and oil system components was so extensive that nothing significant relative to the functioning of these systems prior to impact could be learned from an examination of the component parts. Numerous sections of cabin overhead panel, flooring, seat structure, etc., were recovered but an examination of these parts disclosed no significant evidence.

No evidence of fatigue failure was found in any of the numerous fractures examined. All of the fractures were of the general "static type" as distinct from the fatigue type.

No evidence of fire damage or combustible explosion damage was found on any of the recovered wreckage. The wreckage was examined for indications of lightning damage but none was found.


108a
FORECASTED AND COMPUTED MOVEMENT OF SEVERE STORM
INVOLVED IN THE ACCIDENT OF NAL DC-6,
ON FEBRUARY 14, 1953
MOBILE
PENSACOLA
PANAMA CITY
BILOXI
WRECKAGE SITE
NEW ORLEANS
MOISANT INTERNATIONAL AIRPORT
BURWOOD
GALVESTON
CORPUS CHRISTI
BROWNSVILLE
Normal Course Tampa to New Orleans
GULF OF MEXICO
Interpretation of the forecasted track of the center of the low pressure which was associated with the intense frontal wave, including hourly locations, as contained in the Severe Weather Bulletin issued at 1615c by the Air Mass Analysis Center, Weather Bureau, Washington, D.C.
Interpretation of the forecasted track of the center of the low pressure which was associated with a frontal wave, including hourly locations, as issued at 1533c, Weather Bureau, Miami, Fla. (This forecasted wave was a minor one that preceded the intense one encountered by the flight. The Miami forecast made no mention of the wave encountered by the flight where the accident occurred.)
Interpretation of the forecasted track of the center of the low pressure which was associated with the intense frontal wave, including hourly locations, as contained in the regional forecast issued at 1535c, Weather Bureau, New Orleans, La.
Computed track, obtained by analysis, of the center of the low pressure which was associated with the intense frontal wave, including hourly locations.
Details plotted from section of U.S. Coast and Geodetic Survey Route Chart 2206

Part III - Weather experienced by the previous National Flight

The captain of this flight testified that when he was approaching New Orleans (between NA-1 and New Orleans) at his assigned cruising altitude of 4, 500 feet, he experienced severe turbulence, coupled with heavy rain and heavy hail. He also testified that the aircraft's instrument panel intermittently shook so violently that the flight instruments were difficult to read. Another indication of the severe and abnormal weather is found in his statement that the turbulence was not of the violent updraft and downdraft type usually associated with well-developed thunderstorms. Rather, the gusts seemed to be more lateral; the captain stated, "The rudder was forced back and forth without changing direction of flight." He also stated that most of the passengers became airsick and "... we had more of a twisting whirling motion, too, which caused the aeroplane to shake and shudder from one side to another which is unusual in a normal thunderstorm." There was very little lightning and altitude was controlled within 1, 000 feet.

This captain also testified that shortly before he reached the worst of the weather, he discovered by radio fix that he was approximately 40 miles to the right of his course. Extreme changes in heading were necessary to get back on the course, and subsequent computation shows that the unusual and unexpected wind that he encountered must have been from a general southerly direction and in the order of 100 miles per hour. This drift occurred in the vicinity of NA-1.

Despite the highly unusual weather conditions as described by the captain of this flight, he reported to his company only "extreme" turbulence, and later, "severe" turbulence between NA-1 and New Orleans. The lost flight therefore received only the information that there was severe turbulence at all altitudes.

At New Orleans the captain of this previous flight had the aircraft inspected for possible damage caused by turbulence-induced stresses or hail. None was found.

Part IV - Witnesses

Early in the investigation it was believed that the flight was lost in the Gulf of Mexico not far from the mouth of Mobile Bay. Accordingly, statements were taken from a considerable number of persons in that area. There are 18 witness locations; at several of these there was more than one witness. A tanker was at anchor approximately a mile south of the mouth of Mobile Bay because of the heavy weather; statements were taken from 12 of its crew.

Of this large number of persons, 10 stated that they heard a low flying aeroplane. One of the 10, a woman, testified as to actually seeing an aircraft at low altitude, but could not identify it as to type. She believed that it was travelling from the northeast toward the southwest The majority of the 10 persons who claim to have heard an aeroplane believe that it was travelling from a generally northeast direction towards the southwest. The consensus of this witness evidence is that at or about 1710, the time of the accident, weather conditions were at their worst. The wind has been variously estimated as from 50 to 100 miles per hour. A lighthouse keeper at the mouth of Mobile Bay, accustomed to reporting weather conditions, stated that the wind reached "whole gale force", which by definition could mean up to 75 miles per hour. There is some diversity of testimony as to wind direction but the majority opinion is that it changed from easterly to westerly at about 1710.

There is no uniformity of opinion as to the intensity of rain in the area. Most of the witnesses state that it was "heavy", while others, a relatively short distance away, claim that there was little or no rain. None of the witnesses saw any hail.

One witness who was on the tanker thought that the wind was about 100 miles per hour, and stated that the visibility was so poor that he could barely see half of the ship's length (about 250 feet). This witness is one of the 10 who claim to have heard an aeroplane, and he believed it to be so low that he thought it might strike the vessel.

There is no uniformity of opinion relative to the amount of lightning and thunder. Some witnesses stated that both were heavy and frequent, while others declined knowledge of any thunder or lightning at all, and still others claimed to have heard thunder but saw no lightning. Crew members of the tanker believe that the seas were running about 25 feet high.

In reference to possible tornadoes, one witness, a commercial fisherman and therefore in all probability a fairly observant judge of weather who was at home about eight miles east-northeast of the crash site, stated that he looked out of the south window overlooking the Gulf and saw a tornado extending approximately half way down to the surface from the bottom of the cloud deck which he estimated to be 300 feet high. Another witness, a man of scientific background, believed that he heard the noise of a tornado (he had heard other tornadoes) but did not see it.

There was scattered property damage throughout this general area near the mouth of Mobile Bay. Some trees were leveled and a few structures were damaged. At nearby Fort Morgan, Alabama, a US Coast Guard lighthouse keeper reported their flag pole was bent over. This flagpole was of galvanized iron pipe three inches at base, tapering off to one and one-half inches at top, 45 feet above ground, and equipped with three 1/4 inch cable guy wires. Two of these wires broke and the pole was blown nearly down, bending at the base. The time was 1700 hours. It took 15 minutes from the time he first noticed the pole bending until it reached maximum deflection. He estimated the wind velocity to be 50 to 60 mph or greater. However, the damage was not as extensive as that generally caused by fully developed tornadoes.

In this connection it may be pertinent to point out that the development of this storm was under radar surveillance at the Keesler Air Force Base, Mississippi, approximately 60 miles west-northwest of the recovered wreckage. The radar manifestation showed that the storm was generally southwest of Keesler Air Force Base and lay across the direct route between Tampa and New Orleans, and that it reached its peak development from 1600 to 1700. The observer on duty stated that the echo was the most intense encountered by him in nearly two years of weather observation on radar scopes at Keesler Air Force Base.

A careful investigation was conducted of the possibility that the aircraft heard by 10 people may not have been the flight. Accordingly, examination was made of the movements of all aircraft, both civil and military, in the general area at the approximate time. One Navy aircraft, a Super DC-3 was in the area at about 1710, the time of the accident. It was en route from Jacksonville, Florida, to Saufley Field, Pensacola, Florida, and during its instrument letdown passed over the general area of the most easterly location of ground witnesses. The Navy pilot testified that the weather was unusually bad and that he descended to an altitude of about 1, 500 - 1, 000 feet in the above-mentioned area. He was unable to land and subsequently proceeded to, and landed at, Shreveport, Louisiana, via Mobile Alabama. During this flight in the Mobile area, he encountered severe turbulence at 4, 000 feet.

It may be that these witnesses did hear this aeroplane and later, learning of an accident, associated it with that accident. It is clear that this Navy plane was never closer than several miles to the accident site. This does not refute the possibility that more distant witnesses did hear the National DC-6.

Part V - Weather experienced by the flight

Weather reports for the Tampa-New Orleans route are made from land based stations, all located along the Gulf shore to the north of the direct route. On the day of the accident, there was no weather information supplied by any surface craft except one so far from the storm center that its report was not significant.

The crest and center of a very energetic, open wave, extra-tropical cyclone* was in the general area where the flight crashed at about the time of the crash. It has moved unexpectedly fast across the Gulf of Mexico from near Brownsville, Texas.

A cold air mass moved southward across the United States east of the Rocky Mountains during the period 11 - 13 February 1953, and as frequently happens, the cold front that preceded it became nearly stationary across the southern Gulf of Mexico and extended northwestward across Mexico and into western New Mexico. By the morning of 13 February, cyclogenes was indicated on the surface map in extreme northern Mexico near the boundaries of Arizona and New Mexico. This low pressure deepened and moved southeastward into central Mexico on the 13th. There are indications that new cyclogenesis occurred on the cold front during the early morning of the 14th west of Brownsville, and that it moved off the coast as an open wave low center between Brownsville and Corpus Christi about 0630. This latter open wave low center became the dominant one of the system and was accompanied by moderate winds and light to moderate rains in the Brownsville-Corpus Christi area but with no severe weather reported. From that time until it reached the Mississippi-Delta area, there were no weather reporting stations sufficiently close to establish accurately either its position or intensity.

The regional forecasts available to the flight at time of briefing at Miami were filed at 0933 and were for the period 1000 to 2200. These indicated the low center in the northwest Gulf area moving east-northeastward about 15 miles per hour and being located about 140 miles south-southwest of New Orleans at the time of intended arrival of the flight. Increasing cloudiness and lowering ceiling were forecast across the northern Gulf with light rain and scattered thunderstorms. However, over the land area from Mobile to southern Louisiana, occasional moderate to heavy thunderstorms with ceilings down to 400 feet were forecast, accompanied by moderate to severe turbulence in the build-ups of cumulus and cumulo-nimbus clouds with gusty surface winds to 50 miles per hour.

The latest weather reports along the coast showed light to moderate thunderstorms and rain showers from Mobile to New Orleans with ceilings mostly 300 to 600 feet. The next hourly sequence weather which was available at Tampa showed no important change in weather conditions along the coast.

At about the time of take-off of the flight from Tampa, new regional and terminal forecasts from Miami and New Orleans, were available at National Airlines' offices from Miami to New Orleans. In these new forecasts Miami had a wave located 100 miles south of Pensacola moving northeastward. New Orleans' forecast had the wave low center about 100 miles southwest of Grand Isle, moving into southern Alabama by 0400 of the 15th. The Miami forecast called for moderate to briefly severe turbulence in thunderstorms and the New Orleans forecas gave moderate to severe turbulence in thunderstorms through southern Louisiana and southern Mississippi. Terminal forecasts from New Orleans to Pensacola indicated heavy thunderstorm ceilings occasionally down to 300 feet and gusty winds to 60 miles per hour. At 1622 the Weathe Bureau, Miami, issued an amendment to their forecast as follows: "Add to clouds and weather, surface winds over waters and exposed coastal areas southerly 25 to 35 miles per hour becomin northerly over western Florida behind wave. Surface winds occasionally gusty in thunderstorm to 35 to 50 miles per hour". Also at about 1615, a severe Weather Bulletin was issued by the Weather Bureau analysis center in Washington DC, after consultation with its New Orleans office. That bulletin was received by the Miami Weather Bureau at 1619 and was delivered to CAA at 1629 who transmitted it on teletype Service A Circuit 8004 for general distribution at 1650. It was at this time that the National's Operations office received the Severe Weather Bulletin which was approximately 20 minutes before the accident. This bulletin read as follows: "Low center 2200Z (1600C) just north of Burrwood (Louisiana) will move to southwest Georgia by 0630Z (0030C) increasing thunderstorm activity extreme southern Alabama and Georgia and northwest Florida with locally severe thunderstorms, gusts with winds of 50-60 miles per hour, hail reaching the ground, more severe storms and severe turbulence aloft." Although these

* The term "extra-tropical cyclone" should not be confused with "tornado" or "hurricane". An "extra-tropical cyclone" originates in mid or northern latitudes, with an anti-clockwise circulation in the northern hemisphere. A "tornado" is a violent vortex of small diameter having a funnel-like shape. Its marine counterpart is a "Waterspout" often of far less energy. A "hurricane" is a cyclonic storm of tropical origin, rotating anti-clockwise in northern latitudes.

forecasts and the Severe Weather Bulletin were received by National Airlines in Miami, the evidence of record shows that no attempt was made to transmit any portion of them to the flight.

Between 1600 and 1630, the center of activity connected with the principal wave of the front moved close to land and crossed the southern portion of the Mississippi Delta and then continued out over Breton Sound. It was while this center was in that area that the severe weather was encountered by the previous flight between NA-1 and New Orleans.

The most severe weather of this system occurred in the vicinity and to the north of the apex of the wave. It was travelling east-northeastward between 50 and 60 miles per hour and appears to have not only been located at about the area of the crash but to have attained its most severe development during that period. The flight must have encountered unusually severe turbulence in that area. Weather conditions in general were such that waterspouts and/or tornadoes might possibly have existed.

Part VI - Dispatching

National Airlines does not maintain its own meteorological service; rather it depends on the US Weather Bureau for weather information. The National dispatchers were properly certificated, and the examination for that certificate demands some knowledge of basic meteorology. None of the dispatchers on duty at Miami on the day of the accident had taken any extensive courses in meteorology. However, company records disclose that both had been serving as flight dispatchers for a number of years, including the dispatching of flights over the route involved. Airline pilots such as this crew had had long experience in practical meteorology and thus were able to evaluate weather data as it pertains to flight. It therefore appears that the dispatchers' working knowledge of meteorology, together with the crew's practical knowledge, should have insured a proper evaluation of the weather data then available.

There was testimony at the hearing as to whether the crew of the flight had visited the Weather Bureau station at the Miami Airport on 14 February to be briefed on the weather en route. The three weather bureau meteorologists on duty at the station during the period involved stated that they did not recall briefing the crew. These meteorologists further stated that many pilots from several airlines are briefed daily and it is entirely possible that the crew of the flight could have been briefed by one of them. None of the three knew the captain or first officer. However, the evidence is clear that sequence reports, upper air winds and forecasts pertinent to the flight were on file at the weather station. This material was available to the company and the sequence reports, upper air winds and forecasts pertinent to the flight were on file in the company's operations office and available to the crew.

Weather conditions fast became worse over the western part of the route while the aircraft was in flight. The US Weather Bureau did not anticipate the severity or the rapid development of the storm system as it moved northeastward over the Gulf. It issued amended forecasts and the severe weather bulletins, at which time the flight was approaching the storm center. No weather Bureau advisory reports were given to Air Route Traffic Control (ARTC) for forwarding to en-route flights regarding the unexpected development and movement of this storm system.

The flight, however, did receive weather information supplied by the captain of the previous flight upon his arrival at New Orleans. As previously stated, the captain's message stated that he had encountered severe turbulence but that it appeared to be clearing west of New Orleans. Later the captain testified at the hearing that had he known the severity of the storm, he would not have returned into it. However, at the time he did not think to pass on this information to the following flight. Thus when the captain of the lost aircraft received this message, he may well have thought that conditions would be much better by the time he arrived at New Orleans.

Part VII - Aircraft Maintenance

All flight forms and maintenance records of the subject aircraft for a long period prior to the accident were studied and analyzed with care. Although a number of discrepancies were noted, none of these documents contained entries or items of apparent significance in connection with this accident.

Part VIII - Military Areas

There are several military danger areas along the Gulf coast and in the vicinity of the wreckage site. However, investigation disclosed that there was no military activity in these areas that could have endangered the flight near the time of the accident.

Analysis - Part I - Weather

The development of open wave extra-tropical cyclones on quasi-stationary cold fronts in the Gulf of Mexico area is rather a common occurrence during the winter and spring months However, in connection with the storm of 14 February 1953, an unusual complication of meteor ological factors simultaneously affected the northern Gulf area which resulted in a storm of remarkable severity including turbulence aloft. The following factors at the 500 millibar level (approximately 18,000 feet) during 11-13 February 1953, were important in the development of the 14 February storm:

1. A pressure trough extended from the northern plain states southward over Arizona, New Mexico and northern Mexico.

2. A pressure ridge lay along the Pacific Coast.

3. Another trough lay to the west of the ridge over the Pacific.

4. A small closed low of cold air aloft moved southeastward from the Pacific northwest to over Arizona.

5. A second tongue of cold air was moving southeastward over the United States from Montana.

As the cold air aloft reached Arizona, a low pressure center formed at the surface whi deepened and moved southeastward into central New Mexico. New cyclogenesis took place in eastern Mexico which became the principal low center and moved out into the Gulf north of Brownsville about 0630 of the 14th. In the meantime, the high level Pacific trough moved east ward to the coast and replaced the ridge that formerly existed there. The interior high level trough moved into Texas and was joined by the cold air low that had previously moved into Arizona. Also, as this trough moved to east Texas, it was further strengthened by the arrival of the cold air aloft from Montana. This produced a very steep temperature gradient aloft and reacted to form a jet stream of southwesterly wind with a maximum velocity of 75-100 knots trough southern Texas to Georgia. This condition was apparently directly related to the speed ing up of the wave cyclone over the Gulf to between 50 and 60 miles per hour. Also the inter-action of the cold, dry air to the north of the center and the moist, warm air of the Gulf waters deepened the low center and increased the severity of the accompanying weather. In fact, upp air analysis indicated that tongues of dry air aloft, at intermediate levels, moved into the area just north of the wave, which together with the high moisture content of the air below, was a very conditionally unstable situation. It appears that the energy from just such a situation was released in the Delta-Mobile area by means of frontal lifting which undoubtedly contributed to the very severe turbulence in that area.

Barograph traces at stations in the Gulf area from southern Louisiana to western Florida, showed rapid and marked fluctuations indicative of the chaotic air movements aloft. Also further adding to those movements and to the complexity of the system there was indicati of a pressure dropline moving northeastward about 60 miles per hour and another line of pres-sure jump crossing the pressure dropline and moving east-southeastward about 32 miles per hour. The significance of these is that they indicated travelling waves on the frontal surfaces.

So far in this analysis only one wave on the front has been referred to although addition minor waves seem to have occurred. However, the other waves appear to have been at low levels as only one appears at the 850 millibar level (about 5,000 feet), and the most severe conditions in the storm occurred in a semicircular area mostly northward from the main wave crest. It was in that area and apparently very near the wave crest that the accident occurred.

Instead of the large updrafts and downdrafts that are frequently associated with thunderstorms and squall lines, the turbulence in this storm seems to have been in the nature of rapid, very sharp gusts of a chaotic nature. The Navy pilot at 4,000 feet, just west of Mobile and north of the crash site, estimated the gusts at 2-1/2 to 3 G's. There are indications that even more severe weather existed along the coast and offshore just south of Mobile.

Due to the many complex features of this 14 February storm, much study was necessary to arrive at a satisfactory analysis. Considerable information important to that analysis was not available to the forecasters at the time forecasts were made. It appears that between 1530 and 1630 errors in the movement and development of the storm were becoming apparent and that even though current forecasts included "severe turbulence", revised forecasts should have been issued by the Weather Bureau at New Orleans and Miami, particularly after the Severe Weather Bulletin had been received. Certainly the movement of the storm was not adequately covered by the current forecast at that time. A special advisory would have drawn attention to that development. Particularly, it appears that flight advisory Weather Service should have issued information to ARTC to be passed on to flights; on 5 June 1953, Weather Bureau offices were instructed by their Washington DC, headquarters to highlight such information.

In this situation pilots could have contributed much. It appears that the first pilot information that reached the weather bureau indicating unusually severe turbulence aloft was after the flight had crashed. The captain of the preceding flight did not give a full report of his difficulties.

As the word "severe" as applied to turbulence appears not uncommonly in weather forecasting, a study was made of the frequency of its use. During the two-month period, January and February, 1953, the Weather Bureau forecasting Service at Miami, Florida, and New Orleans, Louisiana, each prepared 236 scheduled weather regional forecasts. In the Miami series of forecasts, "severe turbulence" appeared 34 times, and in the New Orleans series of forecasts, the term appeared 18 times. Thus it appears that the word has acquired a connotation other than literal, as defined, by frequent usage. It may well be that weather bureau forecasters use the term when in doubt to be on the safe side. It is fully realized, of course, that any well-developed thunderstorm cell is a potential breeder of severe turbulence and also that the exact conditions within such a cell cannot be predicted with certainty. In any event, neither National's pilots nor dispatchers considered the word "severe" to mean what it was intended to mean by official definition.

Although the flight was dispatched in accordance with approved company procedures, a review of the company's dispatching policy would indicate that a closer monitoring of en-route flights would provide both the dispatchers and the crew with better current weather information whereby each could counsel with the other and arrive at a joint decision as to any change in plan affecting the safe conduct of flights.

Analysis - Part II - Structure

In studying the evidence, the immediate impression is of the suddenness of the accident. It is apparent that whatever difficulty manifested itself, occurred rapidly and was of such nature that the crew did not have an opportunity to communicate their predicament to ground personnel. Any probable cause arrived at must of necessity be consistent with this basic fact.

In arriving at the final probable cause, the Board considered many different possibilities. There was no evidence of in-flight fire, explosion or lightning strike in the wreckage recovered. Temporary blindness caused by intense lightning flashes could have temporarily created a confused condition in the cockpit; however, airline crews are thoroughly familiar with this and normally take precautions against such occurrences. Control system failure was considered but the examination of the recovered system components and a study of the circumstances surrounding the accident both serve to discount this possibility. Power failure would not ordinarily cause such a catastrophic accident unless an initial propeller blade failure resulted in serious structural damage and/or electrical or control system failure. Since the No. 2 engine and propeller were not recovered, this possibility was given careful consideration. The fuselage material and control system parts in the vicinity of the propeller plane on the left side were examined for propeller cutting marks, but none were found. Equipment failure must always be considered a likely possibility in an accident of this type. Had the flight experienced a total electrical power failure, radio equipment failure, or complete flight instrument failure while flying in turbulent instrument conditions, it is conceivable that a hazardous condition would result. However, no facts were developed during the investigation to indicate that equipment failure had actually occurred. The multiplicity of radio equipment, the availability of an emergency electrical source and past experience relative to the high level of reliability of the DC-6 flight instrumentation, all tend to preclude equipment failure or malfunctioning. It must be noted, however, that the crew of the proceeding flight had extreme difficulty in reading instruments because of turbulence-induced vibration.

In-flight structural failure was thought to be a likely possibility, and a detailed study of all available evidence was made in an attempt to substantiate or disprove its probability. While a number of puzzling, unexplainable points will probably remain, the Board was of the opinion that the preponderance of evidence indicated a structural breakup in flight prior to the initial water impact.

A number of significant factors led to the conclusion that an in-flight structural failure occurred. First of all, it was difficult, if not impossible, to explain the relatively great distance between the two wreckage areas unless it is theorized that the aircraft broke up in flight. Initially, it was thought that the left wing may have floated away from the main wreckage, or that underwater currents had drifted the wreckage to the separate location. However, a review of the facts indicated that this could not have been the case. Early in the investigation, the separation of the two wreckage areas was explained by reasoning that the aircraft contacted the water in a flat attitude with sufficient force to fail the left wing downward, and then the remaining portions ricocheted 2,100 feet to their final resting place. This theory was proferred by competent industry persons, and accordingly, the Board gave this possibility careful consideration and study. The extremely rough seas (waves variously estimated at 12-25 feet in height), the tendency of the aircraft to "bury itself" rather than bounce when under high downward accelerations such as would be required to separate the left wing panel, and the incredibility of the right wing fuselage unit bouncing nearly a half mile - are some of the reasons why this theory was discounted.

The dissymmetry of water impact on the left wing parts and on the right wing fuselage parts was another important reason for believing that the aircraft was not intact when it contactec the water. Had the aircraft been flown into the water in a near-level attitude, it would be much more reasonable to expect water damage on the lower surfaces of all major components. Furthe there would be evidence of the wing leading edge having crushed into the front spar, and a genera rearward deformation pattern of the wing box structure. Instead, the left wing sustained water damage on its upper side, and no evidence of leading edge crushing or wing box rearward deformation was observed. It is much more probable that the failing, rotating left wing mass contacted the water in such a manner that the upper surface only sustained major water damage. In any event, the Board believed that the dissymmetry of water damage was inconsistent with the theory that the aircraft was "flown into the water".

During the course of the investigation, the possibility of a structural failure of other components was also carefully considered. Since some of these components (notably, the tail section) were not recovered, the presence or absence of a failure of these units could not be directly established. However, using the facts available as developed during the investigation, the relative merits of each possibility could be determined and their probability assessed. It was of particular interest and importance to make a determination with regard to a failure of the tail section. The results of this evaluation led the Board to believe that the tail section did in effect separate, but that, in all probability, the tail failure followed, and was the direct result of, left wing failure.

A wing will fail when either its fatigue strength or its static strength is exceeded. The fatigue strength is related to repetitive gust and/or manoeuvre loads over a period of time, whereas the static strength involves the strength under the application of a single large gust or abrupt manoeuvre combination thereof. Fatigue was an important consideration early in the investigation, but the wreckage examination and the confirming laboratory tests clearly indicated that fatigue was not a factor in causing the separation of the left wing in flight. Accordingly it was apparent that the left wing failure could be attributed to loads which exceeded the static strength of the wing structure.

The Board made a detailed study of the strength characteristics of the DC-6 wing. No evidence was disclosed either during this study, the investigation or the subsequent public hearing to indicate that the DC-6 wing was deficient in static strength. On the contrary, the facts clearly indicate that adequate strength provisions had been incorporated into the design in accordance with the pertinent airworthiness portions of the Civil Air Regulations. In fact, it appears that in many instances additional strength had been provided in some parts and additional tests had been conducted above and beyond those required by the regulations. In this regard, it was developed that in addition to the normal stress analysis and proof test procedures which are generally used to substantiate a design, actual structural flight testing had been conducted to demonstrate the structural integrity of the aircraft. Six years of successful service experience is further proof that there are no significant deficiencies in the static strength of any major structural component.

At the public hearing held in connection with this accident, the Air Line Pilots' Association indicated its belief that the design gust load criteria were inadequate and recommended that consideration be given to increasing the severity of the gust load conditions. In particular, it urged that the DC-6 be strengthened for higher values of gust intensity. The Board studied this proposal and concluded that the facts developed during the investigation do not support such drastic action. It was emphasized that all aircraft design is essentially a compromise, and that the severity of the gust criteria (and all other design conditions for that matter) is adjusted to provide adequate strength provided normal airline operating procedures are followed. Additional margins of safety are incorporated for reasonable deviations from standard procedures. These design gust intensities have been determined on a statistical basis from a large number of experimental flights in turbulent conditions. They are not necessarily the highest gusts that could conceivably be encountered if the aircraft were flown into or very near, say, a tornado. Since the gust criterion has been in use, it has been monitored by the NACA with the co-operation of the airlines and CAA. Records from flight recorders installed in airline aircraft are continually being studied by the NACA to determine conformity with existing requirements and also to extend the general knowledge. These studies have indicated that the current requirements are adequate.

There is no doubt that weather was definitely a major factor in this accident. Studies made by the Weather Bureau, the NACA, and the Board's own meteorologist indicate that this particular storm was most unusual and that tornadic conditions may have been present. Reports received from the crew indicated that they were encountering severe turbulence. The testimony of the crew of the previous National Airlines' Flight verifies the unusual nature of the storm. The captain may not have realized the severity of the storm he was encountering until it was too late to take effective evasive action. Whether or not the aircraft became involved with a tornado vortex, the Board cannot say. Had this occurred, there is no doubt structural disintegration would have followed. However, the Board is inclined to believe that this did not occur. It appears more likely that the aircraft was upset by a sharp unsymmetrical gust and that in the recovery (or attempted recovery) gust loads combined with manoeuvring loads exceeded the strength of the left wing and caused it to fail downward. Past experience has shown that the real danger in encountering severe turbulence lies not in the possibility of structural damage from gusts alone, but, rather the danger is associated with loss of control, gust induced manoeuvres, excessive speed, stalling out and other related difficulties. In extremely turbulent conditions, the situation can rapidly get beyond the control of even the most skilled pilot. For this reason, the identifiable areas of intense turbulence are generally avoided by airline crews and more circuitous paths through or around the storm are flown.

It appeared that soon after arriving at the 4,500-foot altitude (the flight made a normal report of reaching this altitude) the aircraft became upset from its normal level attitude and that failure of the left wing occurred almost immediately thereafter. At the time of the left wing separation, the aircraft may have been upside down. The Board can only conjecture on the events that followed. Following the wing separation, it probably collided with the lower fuselage and/or the empennage. Either this collision and/or the abnormal manoeuvres following the left wing separation could have resulted in the detachment of the empennage. Clothing found entangled in the left wing could have come from the baggage compartment when the left wing struck the fuselage. The No. 2 power-plant quite probably was detached either during the initial wing failure or during the subsequent collision with the rear fuselage tail unit, and it fell free of the other components. The main portion of the aircraft without the stabilizing effect of the tail and left wing would fall with the longitudinal axis of the aeroplane in a relatively flat attitude, striking the water on the underside of the fuselage and the right wing at a high rate of descent. Also, the effect of the weight of Nos. 3 and 4 engines, fuel in the tanks, particularly outboard, and the existing turbulence could contribute to the right wing striking the water in a nearly horizontal attitude. The left wing then fell as a separate unit and struck the water on its upper surface predominantly. The tail unit fell separately and conceivably was broken into relatively small pieces.

The Board well realized that the sequence of events following the left wing failure as described in the preceding paragraph largely a matter of deduction. An examination of the missing components undoubtedly would shed additional light on the actual sequence. If at any time in the future the missing components are recovered, the Board indicated that it will conduct such an examination and will make such revisions and changes to this report as may be necessary.

In conclusion the Board wished to state that investigation of this accident had spared no known detail. It had been extraordinarily sweeping and painstaking by not only the Board but by other interests. From the record the Board can only conclude that the pilots in the case were beset by a most unusual complex of conditions beyond their control.

The principal weather factors affecting this accident may be alleviated in the future by the installation of airborne radar. Developmental equipment shows promise of meeting the problems of weather avoidance, weather probing and weather intelligence.

Probable Cause

The Board determined that the probable cause of this accident was the loss of control followed by the in-flight failure and separation of portions of the airframe structure while the aircraft was traversing an intense frontal-wave type storm of extremely severe turbulence, the severity and location of which the pilot had not been fully informed.

No. 11

Det Norske Luftfartselshap (SAS) DC-6 damaged on take-off at Lod Airport, Israel, 15 February 1953 (State of Israel Aircraft Accident Report No. 6)

(Inquiry held in accordance with the Procedures of Annex 13 to the Chicago Convention and the Manual of Aircraft Accident Investigation (Doc 6920-AN/855)

Circumstances

The aircraft, on a scheduled flight originating in Tokyo, took off from Lod Airport, Israel on the lod-Rome stage of its journey at 2303 GMT, 15 February 1953. During the take-off run partial engine failure was experienced. Emergency procedures to bring the aircraft to a stop were applied but the aircraft ran off the runway, the nose gear collapsed and the aircraft came to a standstill on its main gear and nose. The 30 passengers and 11 crew (5 off duty) were unhurt but the propellers and the nose section were extensively damaged.

Investigation and Evidence

At 2302 GMT on 15 February 1953, the aircraft, after a normal run-up and checks to 30 inches against the brakes started its take-off run. The take-off run had been calculated in accordance with instructions in the Flight Manual and was estimated at 1,400 metres. The runway in use was the principle runway 10-28 which is 2,360 metres long and 46 metres wide (7743 feet by 150 feet) with good condition asphalt surface. The western end of the runway is level for a short distance in continuation of the runway and there is no slope.

The Captain occupied the right seat and the first officer the left seat. With engines at 30" manifold pressure at the extreme easterly end of the runway, the first officer released the hydraulic brakes and gradually opened the throttles to approximately 52" of manifold pressure. The flight engineer then took over the throttles and brought them up to 53.5" manifold pressure with water methanol injection "ON". The first officer experienced some tendency of the aircraft to swing to the left.

The first sign of trouble occurred when the aircraft had travelled about 600 metres and No. 4 engine backfired. It was impossible to determine the severity of this backfiring but it was sufficiently marked to attract the attention of the captain and cause him to call out to the flight engineer "take care". The engine recovered. None of the crew regarded this backfiring as an abnormal incident. They had had considerable experience of backfires over the last year and in this flight there had been backfires on single engines at several take-offs since leaving Tokyo.

Nevertheless, whether through this momentary loss of power on No. 4 engine or through ignition defect or through other failure which cannot be determined without full examination of the engines, the aircraft did not reach its critical speed (96 knots) at the point on the runway where this speed should have been reached. With no wind and an all-up weight of 40,000 kgs. the critical speed should have been attained after travelling not more than 800 metres. However, the pilots were not at this stage seriously perturbed and this was readily understandable. In the first place, it is difficult at night to estimate distance covered on a runway. Furthermore, some prolongation of the run might have been expected from engine No. 4's backfiring. In the result, the first officer continued the run, expecting the captain to call out the critical speed at any moment, although the aircraft had traversed more than half of the runway and had already passed the point where it would normally have reached its safety speed (106 knots) and become airborne.

After about 1,200 metres had been covered and with the speed between 85 and 88 knots, No. 1 engine backfired. At this time both pilots were occupied with the tendency of the aircraft to swing to the left, which led the captain to order the first officer to "keep the course", and at the same time to apply right rudder himself. At about 1,500 metres with the speed between 90 and 100 knots, at least three out of the four engines severely backfired together. When this happened, the captain realized that the take-off must be interrupted and gave his orders accordingly. At the same time together with the flight engineer he reversed the propellers, and both he and the first officer applied the brakes. When this action was taken, the aircraft was about to run onto the new extension and therefore had little more than 440 metres of runway left.

It is clear that the decision to interrupt the take-off was taken too late to prevent the aircraft from overrunning the runway without use of the emergency brakes. The Company, after the accident, gave 800 metres as the distance required to stop the aircraft under the prevailing conditions. There is no doubt however, that the application of the brakes must have checked the speed considerably because the aircraft eventually came to rest with a comparatively slight jolt, sufficient to throw the luggage in the cabin forward, but not sufficient to cause any noticeable strain against seat belts or to inflict any hurt on passengers or crew. The absence of brake marks on the runway is somewhat surprising. The reversal of the propellers no doubt contributed to the reduction in speed, but did not have the braking effect which is normally experienced. This may have been due to instantaneous reversing with excessive power, and to the fact that the mechanical action of reversing lasts four seconds in which the aircraft had travelled 180 metres approximately. When it became apparent that the aircraft could not be stopped in time by normal means, the captain called for application of the emergency brakes, and simultaneously, the first officer turned the lever "ON" and then to "HOLD". As there was no response, he again turned the lever to "ON" and then to "HOLD". As there was again no response, he turned the lever to "ON" and back to "HOLD" two or three times.

The brake was applied when the aircraft was 50 to 100 metres from the end of the runway, but did not take effect and locked the wheels, until the aircraft was already off the runway, and the aircraft ran onto the soft ground beyond the runway end. The nosewheel collapsed and the nose section ploughed into the ground. The aircraft came to rest with its main gear about 39 metres from the end of the runway.

Probable Cause

The accident resulted from the following series of related causes:

1) The aircraft failed to reach its safety speed for take off after travelling approximately 1,900 metres on the runway, this was due to partial power failure during take-off.

2) The pilots failed to interrupt the take-off until there was insufficient runway left to bring the aircraft to a stop by normal braking and reversal of the propellers. This failure was attributable to the following circumstances:

a) The instruction by the Company of a supplementary engine handling procedure to remedy backfiring. The pilots' previous experience in following this procedure probably led them to believe that it would be effective on this occasion.

b) The difficulty of estimating distance at night.

c) The pilots' preoccupation with correcting the aircraft's course.

3) The pilots failed to apply the emergency brakes until it was too late.

Recommendations

1) That the operator cease the present use of the supplementary engine handling procedure during take-off and introduce measures to ensure that the take-off run is interrupted, in the event of backfiring, in sufficient time to bring the aircraft to a stop on the runway.

2) That the operator take all possible measures to prove that the power output during the take-off is not less than the power relative to the performance declared in the Flight Manual.

3) That the operator take measures to ensure closer familiarization with the operation of emergency brakes.

4) That the operator complete the section in the Flight Manual relative to engine failure during take-off.

ICAO Ref: AR/323

No. 12

Slick Airways Inc., C-46F, crashed near Bradley Field, Windsor Locks, Connecticut, U.S.A. on 4 March 1953. CAB Accident Investigation Report No. 1-0015. Released 22 September 1953

Circumstances

The aircraft, engaged on a cargo flight from New York with Chicago as its final destination, took off from New York International Airport at 0101 hours for Bradley Field, its first scheduled stop, with a crew of two. An IFR flight plan for this segment was filed and approved and the flight was continued to the Hartford radio range station where at 0139 hours the pilot advised the Bradley Approach Control that the aircraft was over Hartford at 0138 hours and that he would maintain 3,000 feet to the Bradley outer marker. This was acknowledged by the controller in the Bradley Field Tower who cleared the aircraft for instrument approach and then advised that number 6 runway was in use. Weather information given to the flight was "Wind indicating northeast calm, ceiling indefinite 500 feet, obscurement, visibility one and one-half miles, light rain and fog, altimeter setting 30.01 inches". The pilot was requested to report over the outer marker when inbound and was advised that the Bradley Field glide path was inoperative.

At approximately 0141, the pilot asked if the Bradley Field ILS localizer was also inoperative. He was told that the monitoring panel indicated normal operation of all components except the glide path. The pilot replied, "I believe my ILS is out momentarily and I will continue to make an ADF let-down".

The flight reported over the outer marker at 0144. The controller acknowledged and asked the pilot if the flight was inbound. The pilot replied "Roger" and the aircraft was cleared to land. The controller advised that the high intensity lights were on intensity 5 (maximum brilliance) and requested the pilot to let the tower know when he wished the intensity lowered. The pilot again acknowledged with "Roger". This was the last contact with the aircraft.

At approximately 0149, the controller requested the pilot to give the aircraft's position. Receiving no response, he then transmitted the following advisory: "If you are experiencing transmitter difficulties and have missed your approach you are cleared to reverse course, climb to 2,500 feet to the outer marker for another approach". Several other efforts were made to contact the flight, but to no avail.

Following the last contact with the tower, the aircraft was seen and heard flying low to the southwest of Bradley Field just before it struck trees and crashed short of the boundary of the field. Both occupants were killed.

Investigation and Evidence

After the pilot reported over the outer marker, an approach to the airport was continued, since the aircraft passed very low over the home of a witness, whose house is located near the approach end of Runway 6, about one-half mile west of the runway. Investigation disclosed that there were no other aircraft in the area at the time. Neither this witness nor two other witnesses saw the aircraft, but did hear it as it came near the field boundary on its first approach. The other two witnesses who heard the aircraft were on the east side of Bradley Field. Although there is some question as to which way the aircraft turned, the three witnesses were in agreement that the aircraft did make a turn.

Several other witnesses were found who both heard and saw the aircraft a few seconds before the accident. In general, the homes of this second group of witnesses are located about two miles southwest of Bradley Field. From the locations and observations of these witnesses, it is obvious that the pilot was attempting a second approach. The statements of these witnesses indicated that the aircraft was slightly left of a direct course between the outer marker and the end of Runway 6 and flew very low over the home of one of the witnesses, about seven-eights of a mile southwest of the airport boundary. These witnesses stated that the aircraft appeared to be proceeding northeast at an exceedingly low altitude with wings level; none of them observed it in a turn, and the aircraft was not on fire. A surge of power was heard almost simultaneously with the sounds associated with the crash. The eye witnesses reported that it was raining lightly at the time, but that there was no fog in the immediate area, witnesses estimating visibility to be in excess of one mile.

The left wing tip, the first portion of the aircraft to contact any ground object, struck a tree approximately 70 feet in height, and was torn off. The remaining portion of the wing then struck a second tree 112 feet further away, and was torn off. Cut branches and tree trunks revealed that the wings were relatively level upon initial contact with the trees. A 12-foot portion of the right wing panel, including the tip, was torn from the aircraft. As the aircraft cut a swath through the trees, it described a complete roll to the left. The right engine and wing stub dug into the ground when about 270 degrees of the roll had been completed; momentum carried the aircraft through the roll.

The captain's altimeter was found set at 30.00 inches and the co-pilot's at 29.99 inches. The wing flap control valve was in the "Up" position. The left main landing gear and tail wheel were down and locked; the right main gear was torn from the structure. Both landing lights were extended. The electronic equipment disclosed no evidence of failure prior to impact. Inspection of the propeller domes, segment gear, and markings on the shim plates indicated that the blade pitch angles of both propellers were 14 degrees positive pitch, or four degrees above the low pitch setting.

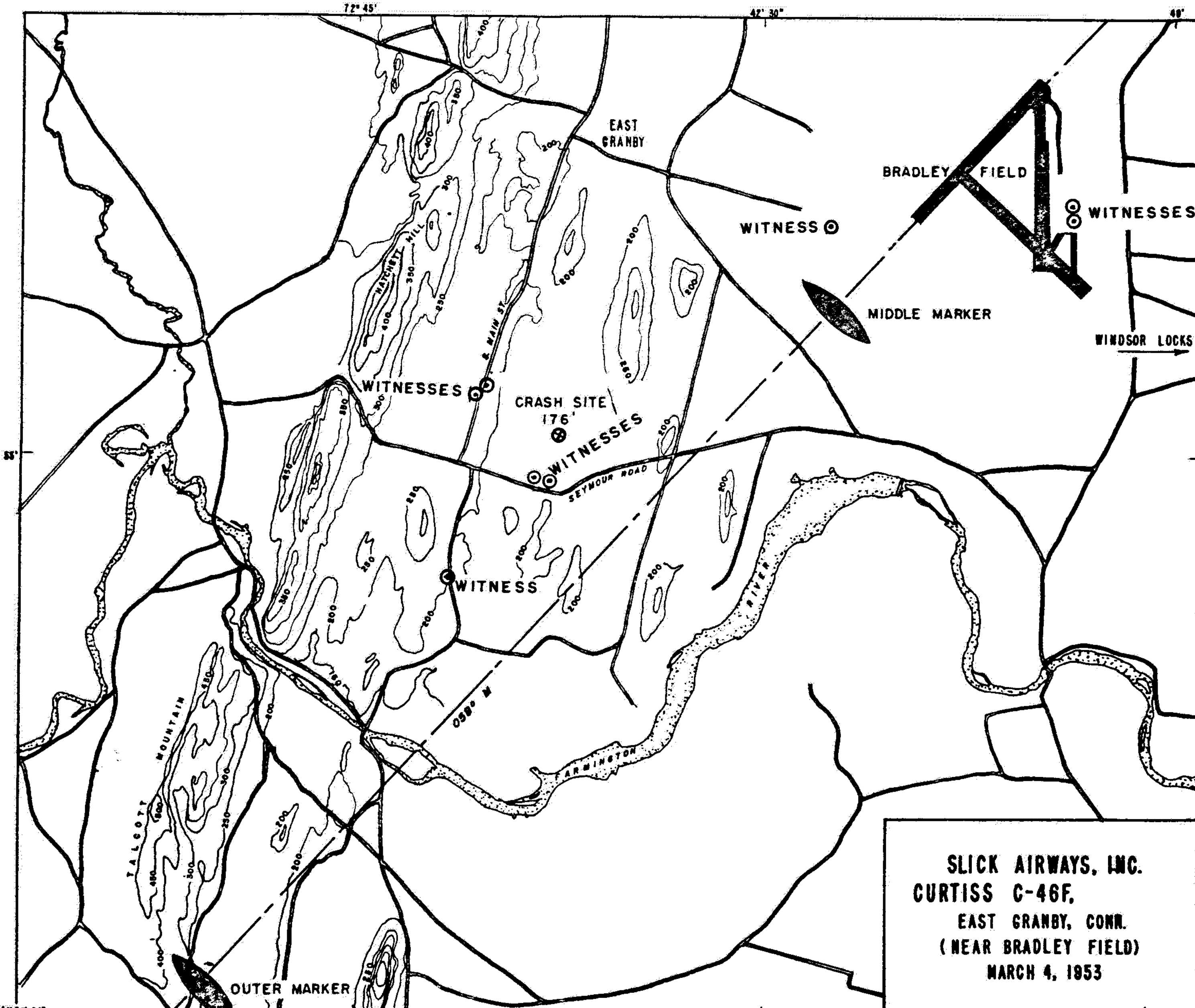
The wreckage disclosed no evidence of fire prior to impact, nor was there any indication of mechanical failure or malfunctioning of either the airframe or engines.

The CAA approved weather minima for ILS, ADF, or circling approaches to Bradley Field by Slick Airways flights were 500 feet ceiling and one-mile visibility.

The controller stated that after he did not hear from the flight for a time, he issued the instructions given earlier in the report, but received no acknowledgement. He testified that he did not specify the direction in which the pilot was to turn, for he did not know the position of the aircraft at that moment.

In the ADF approach to Bradley Field, a pilot should cross the outer marker locator at 2,500 feet MSL, proceed to the Weatogue intersection on a course of 238 degrees, make a procedure turn to the left (south), and return to the outer marker locator on a course of 058 degrees, crossing the locator at 1,740 feet MSL. After passing this point, the pilot would descend to not less than the minimum prescribed altitude of 500 feet above the ground. The timing of the approach at a normal rate of descent would bring the aircraft to minimum altitude about one mile from the end of the runway. Upon reaching minimum altitude, should the field not be in sight at the end of the specified time (dependent upon approach speed) a missed approach procedure should be executed and further clearance from the tower for another approach be requested. The missed approach procedure consists of climbing to 2,500 feet at MSL on a course of 058 degrees. It is noted that the missed approach procedure should be executed if the pilot is still on instruments. It would follow that his request for a second approach in such case would be for an instrument approach procedure.

It was deduced, from the fact that the aircraft passed very low over a house near the approach end of Runway 6 and the noted visibility was one mile or more, that the aircraft was low enough for the pilot to have had visual reference to the ground. Since reported weather conditions were equal to his circling minima, it was not improper for him to circle under the overcast in a second attempt to land. However, the more desirable method of making a second approach would have been to conduct a missed approach procedure and a new ADF instrument approach. A properly performed ADF procedure would probably have prevented the accident, even recognizing that the final approach would require precise control of the



SLICK AIRWAYS, INC.
CURTISS C-46F,
EAST GRANBY, CONN.
(NEAR BRADLEY FIELD)
MARCH 4, 1953

rate of descent, for its procedures are designed to prevent collision with ground hazards. The Board therefore questioned the pilot's judgment in this instance.

Upon missing the first approach, the pilot obviously did not follow a standard missed approach procedure. He did not advise the controller of the failure to make a successful approach, nor did he request further clearance. It is also evident that he did not execute a second ADF instrument approach, in view of the fact that there was insufficient time for such procedure between the time the flight passed over the outer marker, then the witness' house, and the reporting of the accident at 0150. It is known that the aircraft was at low altitude near the airport on the first approach and later at very low altitude immediately prior to the crash. The altitude at points between is unknown; the pilot could have remained low and tried to circle while under the cloud base, or he might have climbed before letting down to low altitude.

The take-off from New York, climb and cruise were all in warmer air in above freezing temperatures. During the descent approaching Bradley Field some turbulence, light to possibly moderate, was likely at the inversion level; otherwise little or no turbulence was indicated for the flight. Little or no icing is believed to have existed at the time the aircraft descended for an approach. However, conditions were favourable for carburettor and pitot tube icing if preventive measures were not taken by the pilot. Weather analysis indicated that the rain falling at the time of the accident was not freezing rain; this was borne out by witness' statements. In this connection, a pilot who landed at Bradley Field at 0120 stated that he encountered no ice, and thought temperatures too high for its formation. Several aircraft landing somewhat before this time did, however, accumulate ice.

The barometric pressure at Bradley Field was falling, and at the time of the accident was about .03 of an inch lower than the last setting given to the pilot. This would have resulted in the pilot believing, from his indicated altitude, that he was 30 feet higher than he actually was.

The last weather report for Bradley Field which was given to the flight showed an indefinite ceiling of 500 feet and visibility one and one-half miles. At 0210 the ceiling was reported as indefinite 300 feet, and visibility one mile. In this variable condition, it is quite possible that the flight had to descend to a very low altitude during the attempt to make a second approach if the pilot were attempting to maintain visual contact with the ground.

Probable Cause

The Board determined that the probable cause of this accident was that after missing his first approach to the airport, the pilot displayed poor judgment in attempting a circle under the overcast in rain and at night, rather than execute a standard instrument approach.

No. 13

Junkers JU-52 aircraft crashed on 10 March 1953 in the vicinity of "San Pedro de Colalao" (Tucumán Province). Argentina Accident Investigation Report No. 145. Released 5 August 1953

Circumstances

The accident occurred on 10 March 1953 at about 1815 hours (local time) in the mountains near the town of San Pedro de Colalao (Tucumán Province). The aircraft was on a locust-control spraying flight and carried two crew (a pilot and a mechanic) and three passengers. All but one of the occupants were killed and the aircraft was totally destroyed.

The pilot who was operating the aircraft had accumulated 5,032 hours of flying time up to 31 July 1948. Information on his subsequent activity up to the time of the accident was not available because it was not possible to locate his documents for that period. It was established, however, that he had 50 hours of familiarization flying time on the type of aircraft in which the accident occurred and 43 hours in fumigation work.

The mechanic who was flying as a member of the crew, did not hold a license issued by the competent technical authority, appropriate to these duties.

Investigation and Evidence

The aircraft, which was suitably equipped for locust-control operations, departed from Tucumán airport on 10 March 1953 at 1740 hours (local time) to carry out a spraying flight in the mountains located to the NW of the aerodrome. Besides the crew and passengers, 2,400 litres of gasoline, 180 litres of oil and 1,000 litres of liquid locust spray (DOC) of which the specific gravity is approximately 0.900 kg. per litre were carried. This gave a total weight of approximately 3,165 kg., 235 kg. less than the maximum capacity of the aircraft which was 3,400 kg.

After making two spraying runs, the pilot turned toward a ravine, repeating the operation. At that moment, a swarm of locusts was discovered in flight near the crop. The pilot began a run at a very low altitude and was making a left turn to follow the course of the ravine when the port wing struck a tree causing the aircraft to crash into the woods and to burst into flames.

The spot at which the accident occurred is in the mountains, some 90 km. from Tucumán airport and its elevation is in the neighborhood of 650 metres.

The meteorological report prepared on the basis of the weather conditions obtaining at Tucumán and Metan road: cloudy with high and low clouds (cumulo-nimbus especially in the mountains) ceiling 1,000/1,500 metres; visibility unlimited; wind west 8/10km/h. According to statements by witnesses at the scene, it was a very hot day without wind and with a clear sky.

Taking into account the fact that the aircraft was flying at the time in the lee of elevated terrain, the small amount of wind - if the air was not completely calm - could not have caused a down draft powerful enough to affect the course of the aircraft. Nor could it be presumed that convection caused a disturbance of such magnitude as to make the aircraft hit a tree, in view of the time at which the accident occurred (approximately 1815 hours, local time).

The theory that the pilot had been unable to see outside because he had flown into the cloud of locusts was discarded because of statements by witnesses, and even if this did occur, he must already have been at an extremely low altitude.

Undoubtedly, the aircraft entered the cloud of locusts, but it is believed that this occurred at the same time as the wing tip touched the tree, because the starboard engine, which was higher during the left turn, showed scarcely any trace of locusts, whereas there was more evidence of them near the central and port engines.

From the condition of the propellers it was determined that the engines were operating at the time of the accident. It was not possible, however, to ascertain how and when the pitch of the left propeller blades had been altered.

Probable Cause

The investigating authority attributed the accident to lack of technical experience on the part of the pilot in carrying out a spraying flight over mountainous terrain, resulting in his failure to allow adequate terrain clearance. Contributing factors were the type of operation, the nature of the area flown over and the type of aircraft used.

ICAO Ref: AR/296

No. 14

Fairchild twin-engined aircraft damaged on landing at Buenos Aires Airport on 16 March 1953. Argentina Accident Investigation Report No. 153. Released 12 August 1953

Circumstances

On 16 March 1953 at 1928 hours (local time), a Fairchild twin-engined aircraft carrying four passengers, made a heavy landing at Buenos Aires Municipal Airport. It was piloted by an airline transport pilot who had 2,589 hours of flying time.

The meteorological conditions were: partly cloudy, wind NE 15 knots and visibility 8/10 km. The aircraft was engaged on a sight-seeing flight although the aircraft was normally used for non-scheduled commercial transport.

The pilot and the passengers escaped injury although the aircraft sustained substantial damages as a result of the accident.

Investigation and Evidence

According to the pilot's statement, the aircraft took off from Mar del Plata Aerodrome for Buenos Aires Municipal Airport on 16 March 1953 and was in the approximate vicinity of Chascomus when the pilot discovered that the elevator control had ceased to function. He continued to operate the aircraft by means of the elevator turn tab control, and notified the airport control tower of the emergency. He was given a clearance and attempted to make a landing at Buenos Aires Airport. The landing was extremely violent, however, because of the lack of elevator control.

Inspection of the aircraft after the accident revealed that there had been a loosening of the elevator control rod, as a result of the absence of locking pins on the bolt and nut fixings of the control links of the elevator bars.

The investigating authority reached the conclusion that the accident was due to a hard landing, brought about by the loosening of the elevator control rod, as a result of faulty inspection and maintenance.

ICAO Ref: AR/297

No. 15

Transocean Air Lines, DC-4 aircraft, crashed near Alvarado, California, 20 March 1953. CAB Accident Investigation Report No. 10016. Released 14 October 1953

Circumstances

The flight departed Roswell, New Mexico for Oakland, California, at 1211 hours on 20 March 1953 carrying 30 military passengers and five crew. . The flight was routine and at 1819 the flight reported over the Newark California radio beacon at 11,000 ft. where it was held for 11 minutes. At 1827 the flight was cleared for straight-in range approach, to descend in the holding pattern to cross the Newark compass indicator at 3,500 feet and to report leaving each 11,000-foot level. These instructions were carried out and the flight reported being at 3,500 feet leaving the Newark compass locator at 1836. This was the last known radio contact with the flight and at approximately 1838 the aircraft crashed in a barley field. Impact and fire destroyed the aircraft and there were no survivors.

Investigation and Evidence

Prior to departure a DVFR (Defense Visual Flight Rules) flight plan was filed with ARTC (Air Route Traffic Control), indicating a flight to be flown at an altitude of at least 500 feet on top of clouds via Airways to Oakland, California. There was sufficient fuel on board for 10 hours and the flying time to Oakland was estimated to be six hours and 35 minutes. The gross weight of the aircraft at the time of takeoff was 63,817 pounds, which was within the allowable gross weight of 73,000 pounds and the load was properly distributed.

After departing Roswell the flight progressed in a routine manner and at 1451, when in the vicinity of Winslow, Arizona, the DVFR flight plan was changed to IFR (Instrument Flight Rules), still at least 500 feet on top of clouds.

At 1827, Oakland Approach Control cleared the flight for a straight-in range approach, to descend in the holding pattern to cross the Newark compass locator at 3,500 feet and to report leaving 8,000 feet, and subsequently report leaving each 1,000-foot level. At 1836, it reported being at 3,500 feet leaving the Newark compass locator inbound. This was the last known radio contact with the flight.

The aircraft crashed in a large flat field located three miles on a magnetic bearing of 323 degrees from the Newark compass locator and one and one-half miles northeast of the town of Alvarado, California. The surrounding terrain consists of flat farm land on which are a few scattered houses, fences, and trees. The elevation of the field is approximately 17 feet MSL.

The aircraft first struck the ground on its right wing tip and with the wing in a near vertical position, then cartwheeled and disintegrated.

The many pieces of wreckage were carefully examined and the major structural components including the flight control system were laid out in a manner to reproduce as closely as possible their original positions in the aircraft. This detailed examination revealed that no portions of the aircraft's structure failed prior to impact and that a structural failure or fire in flight had not occurred. No evidence of fatigue failure was found in any of the many fractures examined. All breaks appeared to have been caused by impact forces, with considerable ductility evident in all of the fractures. There was no evidence to indicate failure or malfunctioning of the primary control system.

The right aileron trim tab was in the "neutral" position. The needle of the pilot's aileron trim tab position indicator, however, was positioned at the extreme left wing "down" position. This pointer was bent and the wheel mechanism was also bent and immovable. The rudder trim tab setting was 10 degrees nose-left; this coincided with the setting of the rudder trim tab indicator in the cockpit. Both right and left elevator trim tabs were set one and one-half degrees nose-up. The aircraft carried both wing and propeller deicing equipment. Because of the extreme damage to the cockpit, it could not be determined whether these deicing systems were in operation at the time of the crash. All engines were delivering power when the accident occurred and there was no evidence of engine malfunctioning prior to impact.

Both wing fillets and all lower fuselage compartment doors were accounted for, and it was evident that these had not opened or become detached while the aircraft was in flight.

On the morning of March 20, 1953, a low pressure center was located in southeastern Montana and northeastern Wyoming. A cold front which was moving in an easterly direction extended from this low pressure center in a southwesterly direction across northwestern Arizona and the extreme southeastern portion of California. An occluded front which was lying off the coast of Oregon and Washington in the morning moved in a southeasterly direction and, at the time the accident occurred, was over the extreme northwest portion of California. Attendant to this synoptic condition, rain and snow showers were forecast in the frontal zone in Arizona with light to moderate rime ice between the 10,000 and 11,500-foot level east of the front and at the 4,500 to 6,000-foot levels west of the front. Light to moderate turbulence was expected over portions of the route involved and in the Oakland Bay area above an altitude of 5,000 feet. No severe weather of any type was forecast for the Oakland Bay area during the time the flight was expected to be there.

Eye witnesses of the accident stated that they estimated the cloud ceiling to be approximately 1,200 to 1,300 feet at the time of the accident, and that the aircraft was first observed beneath the overcast approximately one mile southwest of the scene of the accident. The aircraft was descending in a steep right wing low slipping attitude and it remained in this attitude until it contacted the ground. Wing lights were lighted, and all agreed that the engines appeared to be running normally and that they heard no unusual noises such as might be identified with a runaway propeller or backfiring. One witness, whose home is approximately 1,000 feet west-southwest of the point of impact, said that immediately following the explosion, which occurred when the aircraft struck the ground, numerous pieces of hard ice fell into his yard, the largest of which was rectangular in shape, approximately two inches thick, and bore evidence of having been attached to a surface on which there were rivets. According to witnesses, the flight path of the aircraft during its descent was slightly to the east of this witness's house.

Several pilots known to be flying in the area shortly before and after the accident reported that they encountered only mild turbulence and light icing above the 5,000-foot level. One pilot, who was holding over Newark at 8,000 feet approximately 35 minutes after the accident occurred, reported encountering severe icing conditions and mild turbulence with ice approximately three inches in diameter accumulating on antenna masts. He said that the ice began to melt when the 4,500-foot level was reached in the descent.

A company pilot was on board the Transocean aircraft to conduct a routine route check. He had considerable flying experience and ability and was known by his associates to insist that all flight crews adhere strictly to the company's regulations and the principles of safety. For passenger comfort, the chief pilot insisted that all descents be made at a rate of descent not greater than 400 feet per minute. Another company rule he insisted upon was that all fuel selector valves be put in the main tank to engine positions during all approaches for landings. It is not known where the chief pilot was seated in the cockpit when this aircraft was making the approach to Oakland; however, judging from the way in which he had conducted such checks in the past he normally would be sitting in either the co-pilot's seat or on the jump seat between the pilots.

Approximately three minutes elapsed between the time the flight was cleared to descend and the message that it was leaving 8,000 feet. This is not an unusually long period of time for the crew to begin descent after receipt of descent clearance as it is not known at what point in the holding pattern the aircraft received permission to descend. This holding pattern is a one-minute right elliptical track to be made southeast of the Newark compass locator on the east side of the southeast course of the Oakland range. If the aircraft was headed toward the southeast when the clearance was received the captain may have, for reasons of his own, elected to complete his turn and head northwest toward the compass locator before he began to descend. Since the wind at 7,000 feet was reported as from 280 degrees at 55 miles per hour, this may have further reduced the ground speed on the approach to the locator and may possibly justify the three minutes involved. Once the descent was started, the flight reported leaving each 1,000-foot level until the final report stating that it was over the Newark compass locator at 3,500 feet inbound at 1836. None of these reports indicated that the flight was experiencing any difficulty nor did it declare an emergency at any time. The descent was made from 8,000 feet to 3,500 feet in six minutes at an approximate rate of 750 feet per minute. Although the descent to this level was made at a rate almost double that which the Chief Pilot instructed the company's pilots to use with passengers aboard, 750 feet per minute is well within safe limits. It is possible that because the crew was being checked, the Chief Pilot purposely withheld criticism of their flying technique until the flight was completed.

All known facts indicate that the aircraft became uncontrollable almost immediately after the report of leaving 3,500 feet was made. One, the accident occurred at a point about three miles inbound from the Neward compass locator and about two minutes after the last report was made; this necessitated an abnormal rate of descent of approximately 1,750 feet per minute. Two witnesses agreed that the aircraft, when first seen beneath the clouds, was in a steep right wing low slipping attitude and that it remained in this attitude until striking the ground.

What caused the aircraft to become uncontrollable is not known. The possibility that aileron control may have become jammed was considered but is not supported by available evidence. The aileron trim tab control linkage is by means of cable between the cockpit control wheel and a point in the wing in front of the aileron trim tab. From that point back to the tab, the linkage is geared and rigid. Thus the finding of the right aileron trim tab in the neutral position after the accident indicates that it was so positioned immediately prior to the accident. The inconsistent position of the trim tab indicator could logically result from impact forces and progressive cable failure as the right wing sheared off.

The fact that ice fell to the ground adjacent to the scene of the accident, a large piece of which was identifiable by its contour as having previously been attached to an aircraft (most probably this one), indicates the probability that this aircraft had recently encountered a heavy icing condition. It is reasonable to assume that flying in weather where icing conditions were known to exist that the crew would have turned "on" both pitot heaters. If these heaters were not turned "on" or were malfunctioning, ice could accumulate at the orifices in the pitot heads and an erroneous indicated air speed would result. If the static vents were similarly closed and the crew did not detect it and change to the alternate source, erroneous readings of the rate of climb indicators and altimeters might also occur. If such were the case, loss of control of the aircraft could easily result in a stall and with the prevailing low overcast, it is doubtful if there would have been sufficient time to regain control before striking the ground.

Another possible cause of the accident could have been the accumulation of ice on the surfaces of the aircraft in sufficient magnitude to have caused loss of control since the flight had flown for a considerable period of time above 5,000 feet in an area in which icing conditions prevailed. It is also apparent that the loss of control did not occur until after the pilot had made his routine report over the Newark fan marker at 3,500 feet. Had the aircraft been subjected to such a heavy icing condition, the ice could not have dissipated during the short period of time involved in making the descent despite the warmer temperature below 5,000 feet and the proper functioning of the aircraft's deicer equipment. It is true that the amount of an ice accretion varies greatly not only with altitude but also in relatively short distances and times, as does its rate of accretion.*

Since the examination of the wreckage did not disclose any malfunctioning of the aircraft or its components prior to impact, the foregoing possibilities are worthy of consideration.

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* The detrimental effect of ice formation on aircraft performance has been the subject of long research and numerous studies. The National Advisory Committee for Aeronautics has prepared several such reports; four highly informative ones are NACA Technical Notes Nos. 1598, 2962, 2212, and 1084.

Although the Board could not state definitely that aircraft ice probably caused this accident, it was true that if the crew did not appreciate the seriousness of ice accretion and take preventive measures at once, the performance of the aircraft could have rapidly been reduced to a dangerous degree relative to control and stall speeds. It was recognized, however, that several other circumstances might have been involved, the evidence of which could have been destroyed by the impact and fire.

Probable Cause

The Board determined that the probable cause of this accident was the loss of control of the aircraft for reasons unknown, during its descent from the Newark compass locator.

ICAO Ref: AR/281

No. 16

Miami Airlines, Inc., Douglas DC-3, crashed near Selleck, Washington, on 14 April 1953. CAB Accident Investigation Report No. 1-0019. Released 23 February 1954

Circumstances

The flight which originated from the National Airport, Washington D.C., for Seattle, Washington via Wilkes-Barre, Cleveland, Chicago, Fargo, etc., at 0007 EST, 13 April departed Spokane at 0035 14 April, on an IFR flight plan to Seattle, Washington, carrying 22 military passengers and three crew. At 0207 the Seattle ARTC Centre received a report from the aircraft that an engine had failed and requested further clearance. This was given and at 0214, Approach Control heard the aircraft report that it was icing up and losing altitude. The last transmission was received at 0222, reporting that the flight was at 4,800 feet. The aircraft crashed at about the 3500-foot level of Cedar Mountain. Five passengers and the two pilots were killed.

Investigation and Evidence

Shortly after take-off at Chicago, the flight returned owing to rough operation of the left engine. The left magneto of this engine was replaced by a spare carried on the aircraft and the flight again departed at 1215 CST for Minneapolis, made a fuel stop there, and arrived at Fargo, North Dakota, at 1640 CST. The two pilots were relieved at this point. One of the relief pilots inquired about the availability of an engine mechanic, stating that one of the engines was spitting and coughing. When he was told it would take about 15 minutes to get a mechanic, he said to disregard it. The left engine started with some difficulty. The flight departed Fargo at 1748 CST and made fuel stops at Billings, Montana, and Felts Field, Spokane, Washington and the pilots did not report any mechanical difficulties over this segment.

The accident site was approximately 10 miles east of the Hobart fan maker (the last reporting point before Seattle), and on course to Seattle. The aircraft struck 150-200-foot trees while descending with wings level on a northwesterly heading. All 28 seats in the cabin (23 were occupied) were torn from their attachments.

The flaps were found in the "up" position and the landing gear was retracted. Wing deicer boots appeared to have been in operative condition. The left fuel selector was found in the "left auxiliary" position, and the right on "left main". Mixture controls were in the "emergency rich" position for the right engine and "auto rich" for the left. The right throttle was well forward at a high power position, and the left was full forward. The right propeller control was retarded and broken, while the left was found full forward. All components of the aircraft and powerplants were in the area of the impact site. Both engines were torn free of their mounts.

The engines were partially disassembled at the accident site. Both master rod bearings in the left engine had failed. The rear bearing had overheated, and the front bearing was seized on the crankshaft. The master rod assembly was dry and had evidently been subjected to excessively high operating temperatures. There were flakes of bearing material on the connecting rods, crankcase webs, and counterweight cheeks. Many metal particles were found in the main oil and scavenge pumps, main oil sump and the main oil screen. The front crankshaft plug assembly was free of any sludge deposits or other foreign material.

Upon inspection of the right engine, it was evident that the front and rear master rod bearings had failed rapidly. The bearing flanges had worked out beyond the crank throw faces, and several large pieces of bearing flange material were found between the crankshaft and crankcase webs. Both master rods showed evidence of having been subjected to excessively high operating temperatures, and the front rod had partially seized on the crankpin. Flying particles from the master rod bearings pitted the counter weights. The oil scraper ring of Nos. 1 and 12 pistons dropped below the cylinder walls, and portions of the piston skirts were broken. The front support plate, the front main bearing and crankshaft support coupling were discoloured from having been subjected to excessively high temperatures. This discoloration indicated a lack of lubrication of the front main bearing. The sludge cake in the front crankshaft plug was dry and brittle. As in the left engine, metal particles were found in the oil pump, oil screen, and sump, but not in as great an amount.

The No. 3 piston of the right engine indicated that detonation and preignition had taken place. The piston was burned completely through the skirt near the intake valve recess, as well as being burned on the top surface between the intake and exhaust valve recesses. The cylinder head and top surface of the piston had been severely pitted by flying metal particles.

The magneto, removed at Chicago and stored in the aircraft, was found in the wreckage. Upon being inspected and tested, it was found to be in satisfactory operating condition.

Inspection of the LS-87 spark plugs installed in the left engine revealed lead deposits on the core insulators, and a glazed condition on the insulator noses. Five rear row plugs had cracked core insulators. Electrode gap setting in all instances were in excess of limits set by the manufacturer. Examination of company maintenance records revealed that these spark plugs had been in use for 180 hours and 35 minutes.

The LS-87 spark plug is approved by the CAA for use in the R-1830 series engine with the restriction that they be used for a maximum of 120 hours of operation and then discarded, no reconditioned plugs to be used. This approval by CAA was based on information submitted by two irregular air carrier operators to the effect that they had experienced satisfactory results using the LS-87 plugs in R-1830 series engines, in lieu of full scale engine testing which is normally required by the CAA for confirmation of satisfactory operating of the plugs prior to approval. The engine manufacturer, as well as the Board, recommended to the CAA both prior t and following this accident, that the LS-87 spark plug not be used in this series engine. Further both Pratt and Whitney and the Wright Aeronautical Division have recommended to the Board following this accident that the LS-87 spark plug not be used in any engine manufactured by them due to the plug's marginal characteristics and the Board so advised the Administration. However, the limited approval was still in effect at the time of the report.

Company maintenance records further reflected that the spark plugs in the right engine had also been operated in excess of the normal maintenance inspection time. Inspection of the front plugs, type R-37S-1, revealed excessive electrode gaps, and four plugs were shorted internally. The rear spark plugs, type C-35S, showed evidence of excessive erosion of the ground and centre electrodes, and excessive gap settings.

The pilot was well informed on weather conditions, having been briefed at Fargo and Billings, and by telephone at Spokane. Unstable maritime air was flowing from the west across Washington, resulting in clear to partly cloudy skies in the valleys, and a generally overcast situation with snow showers over the mountains. VFR conditions existed en route up to the Cascade Mountains, following which the flight was on instruments most of the time. Occasional light to moderate turbulence and light to moderate icing were forecast. The forecast freezing level was 3,000 feet. Winds aloft at cruising altitudes were from the northwest at 20-30 knots. Snow showers were occurring at the scene when the accident occurred.

Investigation disclosed that the aircraft was over provisional allowable gross weight take-off from Billings (accountability for runway length, gradient, field altitude, and temperature) and over provisional gross weight for operation on the segment Billing-Spokane (accountability for terrain clearance considering theoretical engine failure). Although the provisional gross weight was exceeded in the above instances, the load was properly distributed with respect to centre of gravity limits.

Prior to this accident, numerous alleged violations with regard to provisional gross weight had been filed with the Civil Aeronautics Administration against the carrier and/or its pilots by CAA agents, but were later ruled not enforceable by CAA attorneys, since there appeared to be reasonable doubt that the carrier's personnel knew the proper method for obtaining the maximum provisional gross weight figures from graphs and other material carried on each aircraft. A simplified table for quick reference in obtaining maximum provisional gross weight was then obtained by the Airline, approved by the CAA, and company pilots were instructed in its use. The carrier was advised by CAA agents, prior to the accident, of the proper method for doing this, including use of the quick reference table. Testimony disclosed the pilots involved in this accident had received company instruction on the proper methods of such computation.

In reconstructing the sequence of events which led to this accident, available evidence indicated that the left engine failed, forcing the crew into single-engine operation. Following a short period at high power output, the right engine then failed. The fact that the left propeller was not fully feathered could be attributed to an attempt to restart the left engine after loss of power in the right.

The history of ignition malfunctioning and resulting rough engine operation and backfiring during the flight, the necessity for using carburetor heat and related higher operating temperatures following the high horsepower demand during take-off and climb out from Spokane, Washington, on the last segment of the flight, the absence of any sludge or foreign material in the front crankshaft plug assembly and evidence of detonation and preignition, are definitely indicative of the cause of the failure of the master rod bearings in the left engine due to the resultant excessively high operating temperatures and bearing loads.

There was considerable evidence that detonation and preignition had occurred in the right engine, and it was apparent that the engine failed quite rapidly while being operated in the high power range as the result of single-engine operation. The conditions were indicated by the burned piston, fused and eroded spark plugs, condition of the bearings, and other internal evidence. The poor condition of the spark plugs, evidenced by cracked core insulators and excessive erosion of the electrodes, indicated a susceptibility to detonation and preignition. This caused the failure of No. 3 piston and the master rod bearing due to excessively high temperatures and bearing loads.

In studying the physical evidence presented by the engines, maintenance records of the company on engines and airframe, and testimony with reference to the reporting and correction of items requiring maintenance, the Board concluded that the management had not exhibited a proper concern for maintaining aircraft in accordance with a high standard of airworthiness, but rather had been satisfied with acceptance of considerably lower standards.

In this connection, the Board was interested in knowing of enforcement action being taken or contemplated by the CAA, and addressed an inquiry to the Administrator of Civil Aeronautics. The Administrator advised by letter dated 25 January 1954 that the CAA had conducted an investigation of the carrier and that a number of maintenance and operational discrepancies were indicated with respect to this flight. Certain aircraft instruments were being used in excess of the allowable overhaul time; the radio equipment had been operated in excess of the maximum period specified in the carrier's Maintenance Manual; the pilot had not forwarded a revised flight manifest to the carrier's operations base upon departure from Spokane; and previous malfunctioning of the left engine had not been recorded in the flight log. Several alleged violations of Civil Air Regulations which occurred on other flights were also discovered, as well as a number of maintenance irregularities. The CAA concluded that a civil penalty should be imposed against the carrier; in determining the amount of such penalty, consideration was given to the fact that on 27 April 1953 the Airline voluntarily suspended operations for a period of 15 days. In view of this circumstance, and since the carrier's recent operations have indicated to the Administrator that they have been conducted in compliance with the provisions of Civil Air Regulations, it was concluded by the CAA that a compromise offer by the carrier of $2,000 would be satisfactory settlement of the alleged violations.

Probable Cause

The Board determined that the probable cause of this accident was the progressive failure of both engines, due to the lack of compliance with proper maintenance standards.

ICAO Ref: AR/303

No. 17

Western Airlines Inc., DC-6B aircraft, crashed in San Francisco Bay, California, on 20 April 1953. CAB Accident Report No. 1-0020. Released 1 December 1953

Circumstances

The flight originated at Los Angeles at 2100 hours bound for Oakland, California, with an intermediate scheduled stop at San Francisco. The aircraft carried 35 passengers and 5 crew. The flight was routine to San Francisco where 30 passengers deplaned. The aircraft took off at 2305 hours on a "Visual Trans-Bay" clearance with 5 passengers and five crew. Two minutes later, at 2307 hours, the flight called Oakland, advised that it was on a trans-bay clearance to the Oakland tower and requested further clearance to the airport. Oakland tower cleared the flight to enter the traffic pattern, and gave the wind west at 10 miles per hour. Acknowledgement was the last contact with the flight which crashed in the bay at about 2308. One passenger and a stewardess were rescued.

Investigation and Evidence

The weather observations for the San Francisco Bay area at about the time of take-off from San Francisco were:

San Francisco:

2300 - Measured ceiling 800 feet, broken clouds. Visibility 10 miles, wind west-southwest 7, altimeter setting 29.89.

2315 - (10 minutes after take-off): Measured ceiling 900 feet, broken clouds, visibility 10 miles, wind west-southwest 10, altimeter setting 29.88.

Oakland:

2300 - Measured ceiling 700 feet, overcast. Visibility 10 miles, wind, west-southwest 4, altimeter setting 29.89.

2312 - (7 minutes after take-off): Measured ceiling 800 feet, overcast. Visibility 10 miles, wind west-southwest 4, altimeter setting 29.89.

The flight was cleared direct to the Oakland tower, to remain clear of clouds at a minimum altitude of 500 feet. The clearance under which this flight departed San Francisco is known as "Visual Trans-Bay" and is used for traffic between San Francisco and Oakland. It is issued when the ceiling and visibility at both airports is less than 1,000 feet and/or three miles visibility and a minimum combination of ceiling and visibility (sliding scale) is required for its issuance. This procedure was established through the medium of a Joint Operations Letter Revised effective 10 April 1952, for the purpose of expediting traffic between San Francisco and Oakland. The applicable parts of this letter are as follows:

"1. GENERAL

The following procedures are established for the purpose of expediting the flow of trans-bay traffic between the Oakland and San Francisco Airports under certain IFR weather conditions. Control procedures will be applied in conformance with the ANC Manual of Operations, Procedures for the Control of Air Traffic, except for the deviations contained in these instructions.

2. CONTROL AUTHORITY

Authority for the control of trans-bay flights is delegated to the San Francisco and Oakland towers under the following conditions:

A. Visual Flights

(1) Whenever the ceiling or visibility is less than 1,000 feet and/or three miles, a clearance will be required for all trans-bay visual flights. Flight altitudes during these weather conditions shall not be more than 1,000 feet and not less than 500 feet.

(2) Trans-bay visual flights shall not be conducted under weather conditions less than the following sliding scale minima:

Ceiling	1,000 feet	minimum	visibility	1	mile
"	900 "	"	"	2	miles
"	800 "	"	"	3	"
"	700 "	"	"	4	"
"	600 "	"	"	5	"

4. MISSED APPROACH PROCEDURES - TRANS-BAY VISUAL FLIGHTS

A. In the event a trans-bay visual flight is unable to maintain visual contact with the land or water, such flights will immediately advise approach control at the destination airport and execute the following procedure:

(2) San Francisco to Oakland Flights: Proceed on a heading to intercept the northwest course of the Oakland range, climbing to missed approach altitude of 2,000 feet and hold northwest of the Oakland range station in a one-minute elliptical holding pattern, all turns west, of course."

Four minutes before the aircraft tookoff from San Francisco, the San Francisco tower called Oakland tower on the interphone and requested a trans-bay clearance for this flight. The Oakland tower replied by issuing the following clearance: "Western 636 is cleared to the Oakland tower via the direct route, remain 'clear of clouds'." The distance between the two airports is approximately 11.5 statute miles. Tower operators in both places stated that they could see the lights of the opposite airport clearly and distinctly at the time.

The flight tookoff at 2305, turned to its right in the direction of Oakland Airport and two minutes later reported to Oakland tower at 2307: "Oakland tower, this is Western 636, off San Francisco, Trans-Bay, landing instructions, over." The Oakland tower replied by issuing the following clearance: "Western 636, Trans-Bay cleared to enter traffic pattern, Runway 27 Right, wind west one zero." The flight acknowledged these instructions.

The Oakland surveillance radar detected the aircraft just as it was completing the right turn toward that airport and continued to observe it until it was within range of the six-mile scale at which time it was followed on the shorter range scope. At about 2308 tower operators in both Oakland and San Francisco saw a large orange coloured flash in the direction of the aircraft's track. The target disappeared from the radar scope at this moment and the radar operator marked its last position as 5.5 miles, on a bearing of 217° from the Oakland radar. Attempts to contact the aircraft by both San Francisco and Oakland towers were unsuccessful.

The Oakland tower immediately alerted the San Francisco Coast Guard station and the Alameda Naval Air Station. The Coast Guard quickly dispatched two helicopters and three airplanes to the area, the helicopters being guided by Oakland radar. They illuminated the scene with landing lights and directed the aircraft to a position over the overcast directly above the floating debris from which flares were dropped. The fixed wing aircraft came below the overcast and reported its base as 500 to 600 feet above the water, with visibility restricted to approximately two miles. A helicopter pilot reported that visibility below 300 feet was 12 miles or better and that he could clearly see the lights on both sides of the bay. One stewardess and a male passenger were rescued by a Coast Guard boat and six bodies were recovered by Coast Guard and naval vessels. Bodies of the captain and the flight engineer were not found.

The surviving stewardess stated that she was seated in the aircraft's lounge at the time of take-off from San Francisco, and that the take-off appeared to be normal in all respects. She did not notice whether the "No Smoking" sign was on or not. When about five minutes out she sensed what she thought was the beginning of a gradual descent. She said that she thought the aircraft had some degree of flap owing to the sound of the slipstream, and at this time she heard a decrease in power such as she was accustomed to hearing in the course of a normal landing. She then heard and felt what she presumed to be the nose wheel striking the runway though she thought it was too soon to be landing at Oakland. The stewardess was in the water for about one hour before her rescue.

The surviving passenger stated that the take-off from San Francisco was normal and that he could see the lights on both sides of the bay. When over the water, the aircraft banked to the right and headed for Oakland. After about two minutes, he was still looking at the lights ashore and judged the aircraft to be about 500 feet high. Then, the next thing he noticed was that "we were about 20 feet off the water - and it appeared that we were below the lights, like we were under them." In "maybe 15 seconds" the aircraft was down about 10 feet. Following this, he unfastened his seat belt and stood up, whereupon the crash occurred, accompanied by a blinding flash. He also stated that the flight was well below the clouds at all times and that the surface of the water appeared smooth. According to the witness, no turns nor abnormal manoeuvres were made after the right turn to get on course. The wings were level with the nose slightly down. There was no backfiring nor coughing of the engines and they were all running smoothly at the time of impact. He estimated that he was in the water about 50 minutes before his rescue.

Complete disintegration of the cabin allowed the stewardess to step out of the rear section of the cabin and into the water, and the passenger was thrown out as the cabin broke open on impact.

The rescuing helicopters reported that at 2330 there were scattered to broken clouds in the area of the crash scene at about 400-500 feet, and that it was necessary to descend from their cruising altitude of 600 feet in order to stay clear of clouds at which altitude the visibility was about two miles. In the immediate vicinity of the crash scene, at altitudes of 300 feet and below, visibility improved and lights on both sides of the Bay were plainly visible. The air was smooth below the overcast.

Crews of other flights operating trans-bay within the hour before and after the accident reported ceilings varying from 400 to 1,000 feet and visibility 12-15 miles.

From the testimony of the two survivors, it is apparent that the accident resulted from the pilot's failure to maintain sufficient altitude to avoid contact of the aircraft with the water. The precise reason or reasons for the pilot's action or lack of action in allowing the aircraft to descend into the water is a matter of conjecture. However, there were several pertinent conditions and circumstances that can be considered as contributory factors. These were the type of operation being conducted, the weather conditions that existed over the bay and the sensory illusions that can occur under certain conditions.

The type of operation being conducted was somewhat of a special nature wherein flights between the Oakland and San Francisco Airports are permitted to fly at altitudes below the minima normally prescribed for scheduled airline operations and also below the normal Visual Flight Rule weather minima. This has been authorized to expedite traffic between these two airports in view of the short distance involved and the fact that such flights are made entirely within controlled airspace. Special procedures have been established in the form of sliding scale minima for various combinations of visibility and ceiling values. Also, aircraft must remain clear of clouds and fly not less than 500 feet above the surface. If unable to remain clear of clouds at 500 feet or if unable to maintain visual contact with the surface, such flights are required to climb to 2,000 feet, intercept the northwest course of the Oakland range and hold for clearance to make a standard instrument approach. It is evident that, at the time of the subject flight, the cloud base was lower than 500 feet over portions of the bay area. Reports indicate that the ceiling in the area of the accident was approximately 400 feet. It was also found that the visibility was at least 12 miles at an altitude of 300 feet.

It therefore appears that in proceeding over the bay, the subject flight encountered a cloud condition lower than indicated from pre-flight reports and that the pilot, endeavoring to stay clear of clouds as required for this operation, descended below the minimum altitude of 500 feet. In doing so, the pilot may have lost visual reference to the surface both with respect to the lights on shore and to the surface of the water. As the waters of the bay were reported as smooth, a condition existed that made it extremely difficult if not impossible to judge distance above the water especially as it was at night and when no other means of reference were available for visual orientations.

In this connection, the third condition enters the then existing situation. This is a condition wherein an erroneous belief of an aircraft's altitude can occur when attempting to maintain orientation by means of visual reference to distant lights. In this case the aircraft was approaching the shore some five miles distant where there were numerous lights. But the concentration of the much stronger lights at the airport proper could well cause that cluster of lights to appear as a single foci, and thus bring into being the condition so aptly described by P.P. Cocquyt's* "The Sensory Illusion of Pilots". Therein, the author explains the condition necessary to cause a pilot to believe that he is higher than he really is, and so invite quick disaster if at extremely low altitude, as was the case in the subject flight. Briefly, the error in estimate of altitude stems from the fact that a nosed-up attitude of the aircraft causes a distant light or concentration of lights to appear lower (and the aircraft thus higher), and vice versa. This simple false illusion has demonstrably caused a number of accidents, and many near-accidents, under conditions of light and weather similar to those being encountered by the flight. Refraction, and apparent displacement, of lights through windshields, with many conflicting and confusing reflections, is another element that may have been involved. Another contributory factor could have been the unlighted water surface offering little or no visual stimuli for estimating altitude.

Notwithstanding the points mentioned above, there remains the fact that the pilot had two altimeters in the cockpit. It was disclosed that prior to landing at San Francisco the flight received and acknowledged the San Francisco barometric pressure of 29.90 inches. There was no appreciable change in pressure between this time and the time of departure from San Francisco when both airports reported the pressure at 29.89 inches. Therefore, it can be concluded that there was no possibility of erroneous altimeter setting existing as a factor in the accident. Why the pilot did not refer to the altimeter is unknown. There also arises the question as to why the pilot did not follow the prescribed procedure of climbing to 2,000 feet and intercepting the northwest leg of Oakland range when he found it impossible to maintain visual contact at 500 feet.

In reviewing this accident, the Board concluded that the crew was definitely qualified to operate the aircraft. The evidence is conclusive that the aircraft was in an airworthy condition. It is, therefore, reasonable to assume that in the conduct of the flight the pilot permitted the aircraft to descend into the Bay under a low and spotty overcast while maintaining visual reference to the distant shore, in the belief that he still was safely above the water. Obviously the pilot must have been misled by some form of optical illusion relative to altitude.

With regard to Trans-Bay Operations, the Board, subsequent to this accident, inquired of the Administrator regarding the adequacy of the procedures prescribed for visual contact flight, particularly with respect to 4-engine aircraft. The Administrator had advised that this matter had been reviewed and re-evaluated both by the CAA and by a joint industry and CAA

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* See Digest No. 4, page 165

group since the accident and they have concluded that the procedures in effect insure a reasonable degree of safety consistent with normal standards*.

Nevertheless, the Board included in its report the opinion that this operation requires special attention to insure that no relaxation of safety standards occurs in the conduct thereof, and further, now has under active consideration the present regulation and procedures to determine whether any additional measures are required to insure an adequate margin of safety in trans-bay operations.

Probable Cause

The Board determined that the probable cause of this accident was the pilot's action in continuing descent below the 500-foot prescribed minimum altitude until the aircraft struck the water. A probable contributing factor to the aircraft striking the water was the sensory illusion experienced by the pilots.

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* Section 61.261 of the Civil Air Regulations governing minimum flight altitudes specifies a minimum of 1,000 feet for VFR (Visual Flight Rules) operations "Provided that other altitudes may be established by the Administrator for any route or portion thereof where he finds, after considering the character of the terrain being traversed, the quality and quantity of meteorological service, the navigational facilities available, and other flight conditions, that the safe conduct of the flight permits or requires such other altitudes."

This deviation authority has been exercised in four cases by the Administrator in authorizing lower VFR flight altitudes for the following routes:

1. Forth Worth and Dallas, Texas (day and night)
2. Spartanburg and Greenville, South Carolina (day and night)
3. Winston-Salem and Greensboro, North Carolina (day and night)
4. San Francisco and Oakland, California (day and night)

No. 18

American Air Transport, Inc., C-46F, crashed on Cedar Mountain near Selleck, Washington, on 23 April 1953. CAB Investigation Report No. 1-0045. Released 10 November 1953.

Circumstances

The aircraft was engaged on a ferry operation (positioning flight) from Columbia, South Carolina to Seattle, Washington with a crew consisting of two pilots with two company pilots riding as passengers. The aircraft departed Columbia 1305 EST 22 April 1953 and arriving at Cheyenne at 1835 MST the same day. At Cheyenne, the two relief pilots took over, the previous pilots now riding as passengers and the aircraft took off at 2043 MST. The flight proceeded uneventfully and at 2254 the Boise radio cleared the aircraft to the Seattle range maintaining 12,000 feet. Near Yakima, Washington, the aircraft was cleared for descent to 10,000 feet and on reporting over Yakima at 0026, was further cleared to descend to and to maintain 8,000 feet. The aircraft contacted Seattle Centre at 0047 and reported over Easton at 8,000 feet inbound to Boeing Field. Seattle Centre thereupon issued the following clearance: "NECTAR ONE SIX NINE THREE METRO YOU ARE CLEARED TO CROSS HOBART AT 8,000 SEATTLE AT OR ABOVE 4,000 MAINTAIN 4,000 NO DELAY EXPECTED CONTACT SEATTLE APPROACH CONTROL OVER HOBART FOR FURTHER CLEARANCE OVER."

The controller in the Seattle Centre who was handling this flight was at his control board, about four feet from a loud-speaker installed on top of the unit. The read-back of the clearance by the pilot of the aircraft seemed to the controller to be as follows: "ROGER, CLEARED TO ----- (distinct pause involving a lapse of three or four seconds) CROSS THERE FOUR THOUSAND OR ABOVE THE RANGE STATION, AH, FOUR THOUSAND, REPORT HOBART TO YOU." A correction, "NEGATIVE REPORT HOBART TO SEATTLE APPROACH CONTROL," was then immediately transmitted. The pilot replied, "HOBART TO SEATTLE APPROACH CONTROL ROGER". These contacts were made at approximately 0048. There was no record of further transmission from the aircraft.

When the pilot failed to report over Hobart, and the flight became overdue at Seattle, controllers in the Seattle Centre and Boeing Field tower attempted to contact the flight, but without success. Search and rescue activities were then instituted. The crashed aircraft was found the next day and the two passengers who survived were rescued.

Investigation and Evidence

A two-way belt recorder was installed in the Seattle Centre. A play-back of the recording revealed that transmissions to and from the aircraft had transcribed very clearly. It was learned that incoming signals to the unit were recorded while in the electronic circuit and not after being broadcast in the room by the loud-speaker; therefore, any extraneous noises in the control room were not reflected in the recording. The transcription revealed that the correct content of the clearance read back to the Centre, as opposed to the controller's initial impression, was (pause indicated by dashes): "ROGER THIS UH NINE THREE METRO IS CLEARED TO - UH --- HOBART --- TO- CROSS THERE FOUR THOUSAND OR ABOVE ----- THE RANGE STATION AH FOUR THOUSAND AND WE'RE TO REPORT TO YOU AT UH HOBART OVER". The subsequent corrective message and the pilot's acknowledgment were the same as reported in the previous section. The controller testified that transmissions from the aircraft were clear and easily readable.

The aircraft first struck a large tree located approximately 210 feet east of the crest of Cedar Mountain at about the 4,000 foot level. The aircraft was on a heading of approximately 270 degrees at impact and was on course. The wreckage was scattered along a 950 foot swath on both sides of the crest.

Examination of the wreckage revealed no evidence that any malfunction or failure of any component part of the aircraft had occurred prior to impact.

A company official stated that the captain had flown to Seattle approximately fifteen times in the past year, while the first officer had flown there only three or four times. It was unknown how many of these trips were made with IFR conditions existing in the Seattle area.

Another company official testified that he had known the captain for several years and had flown with him numerous times. He advised that the captain was in the habit of handling all radio contacts, and always read back clearances in a crisp and positive manner.* Based upon his familiarity with the captain's voice, he stated that after hearing a copy of the recording, he was positive that the pilot talking to Seattle Centre was the captain.

A close relative of each pilot also listened to the copy of the recording. They advised that they could detect only one pilot's voice, and identified it as the captain's.

A Jeppesen chart recovered at the accident scene indicated the minimum en-route altitude between Ellensburg and Seattle at 8,000 feet. A Seattle Boeing Field low frequency approach plate also recovered at the scene showed that the minimum altitude between Ellensburg and the Hobart fan marker was 8,000 feet, and descent to a minimum en-route altitude of 4,000 feet was permitted between Hobart and the Seattle radio range station. Investigation and testimony revealed that these altitudes were established by the Administrator, and were currently in effect. It was the controller's responsibility not to authorize flight below minimum en-route altitude.**

Civil Air Regulations Part 60 states that a pilot is not to descend below prescribed minimum en-route altitude.*** This requirement was also reflected in the operations manual of the company. Pilots were required to be familiar with pertinent Civil Air Regulations and the Operations Manual.

It was found that oxygen was available for the pilots and passengers, as shown by the pre-flight check of the aircraft at Columbia. The oxygen supply for the pilots was sufficient for about four hours on demand-type supply, which could also be supplemented by a constant-flow system available from the cabin. The captain of the first part of the flight testified that his portion of the flight was conducted between 2,000 and 5,000 feet above the ground and use of oxygen was therefore unnecessary. Neither he nor the other relief pilot used oxygen between Cheyenne and the place of the accident. When the flight was over Malad City, he went forward for about 10 minutes and spoke to the pilots; no mention was made of fatigue in the course of the conversation. The aircraft was at 12,000 feet, to the best of his recollection, and neither of the pilots was using oxygen.

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* Standard voice procedure does not require that clearances or other messages be read back by the pilot unless specifically requested by the controller.

** "ANC Procedures for the Control of Air Traffic. 2.0401 Minimum Altitudes: A controller shall not assign nor authorize flight at an altitude along any route below the minimum IFR altitudes established by the Administrator for such route. Where a minimum IFR altitude has not been established, a controller shall not assign nor authorize flight at an altitude known to be lower than the minimum safe altitude as prescribed by Civil Air Regulations (60.17)."

*** "CAR Section 60.17. Minimum Safe Altitude: d) IFR Operations. The minimum IFR altitude established by the Administrator for that portion of the route over which the operation is conducted. Such altitude shall be that which the safe conduct of the flight permits or requires, considering the character of the terrain being traversed, the meteorological services and navigational facilities available, and other flight conditions ...."

The accident report indicates that investigation showed that the pilot misunderstood his clearance, as evidenced by the two errors he made in the read-back: 1) The belief that crossing altitude at Hobart was to be 4,000 feet rather than 8,000 feet, as stated in the clearance, thus indicating to him that he was to descend to 4,000 feet before reaching Hobart and (2) to report to Seattle Centre over Hobart rather than Seattle Approach Control as specified in the clearance. The controller stated that he did not detect the first error; the second error was caught and corrected. The read-back, as the controller stated he heard it, therefore, had quite a different meaning from that which was conveyed to the pilot. Failure to detect the error was a contributing factor to the accident. The contacts were made under a routine situation and there was nothing to indicate why the controller did not detect all of the message, other than the normal noise level in the room.

The prescribed minimum en-route altitude for this segment was 8,000 feet. Civil Air Regulations and the company Operations Manual place the responsibility on the pilot to maintain minimum en-route altitude. Even if he felt that he understood the clearance correctly, he should not have descended, for the flight had not yet arrived over Hobart, and descent before reaching Hobart was contrary to provisions of the company Operations Manual, Civil Air Regulations, and minimum en-route altitude as established by the CAA.

With regard to the captain's familiarity with the minimum altitude requirement over this segment, it will be recalled that testimony disclosed that he had flown to Seattle approximately 15 times during the past year. The charts found in the wreckage were mandatory navigation equipment. It was not understood why he did not refer to his charts for minimum en-route altitude information, as a check against the clearance and his knowledge of the route, unless his physical condition caused him to overlook it.

It was noted that the captain and the first officer were passengers in the aircraft or had been actually flying it for almost 13 hours. It will also be recalled that the flight was at 12,000 feet for some time. Since the captain travelling as a passenger on the latter part of the flight testified that the pilots were not using oxygen at the time he was talking to them when at 12,000 feet over Malad City (about two-fifths of the distance between Cheyenne and Seattle), it might indicate that oxygen was not used throughout the flight. If the flight from Cheyenne to Yakima was made without using oxygen, it is possible that in this period of over four hours at 12,000 feet, the pilot would have experienced some loss of mental alertness which, in general, cannot be detected by the individual, these effects have been observed in aero-medical studies of oxygen want (anoxia or hypoxia). McFarland has pointed out that "oxygen want has a progressive and insidious effect on the central nervous system that will impair an airman's performance and influence the safety of flight. Laboratory studies have shown that mental deterioration, such as loss of memory and judgment, may significantly impair performance at altitudes similar to those at which several air transports have crashed into mountains. Illustrations can be given of airmen who have jeopardized the safety of flight at altitudes between 10,000 and 15,000 feet by not using their supplementary oxygen.* The accident occurred approximately one-half hour after passing Yakima; it is possible that the effects of oxygen want might have been partially ameliorated during this period at 8,000 feet and lesser altitudes.

Probable Cause

The Board determined that the probable cause of this accident was the pilot's misunderstanding of the clearance, failure to check en route altitude against available charts, and descent below prescribed minimum en route altitude. The fact that the controller did not detect the first of two errors made by the pilot was a contributing factor.

* McFarland, R.A., Human Factors in Air Transportation; McGraw-Hill Book Company, Inc., New York, 1953, pp. 155-156.

ICAO REF: AR/284

No. 19

Canadian Pacific Air Lines Ltd., Consolidated PBY-5A aircraft sustained substantial damages while landing at Prince Rupert, British Columbia, on 11 May 1953. Department of Transport, Canada, Summary Accident Report Serial No. 53-14

Circumstances

At 1147 PST on 11th May, 1953, the aircraft took off from Sandspit on a scheduled flight to Prince Rupert, B.C. with sixteen passengers and a crew of three.

The flight was made via Banks intersection to Prince Rupert without incident. However, during the landing at Prince Rupert the aircraft was seen to skip and then bounce twice. In the first bounce the aircraft nosed up and down 15° - 20° and in the final bounce 30° - 35°. The final impact demolished the portion of the hull forward of the wings and the aircraft is considered to be beyond repair. As a result of the accident one passenger is missing and one crew member was killed.

Investigation and Evidence

A Certificate of Airworthiness had been issued for the aircraft. Evidence indicates that prior to the landing the passengers moved to the rear of the aircraft thereby causing the centre of gravity to move aft of the rear limit. The load sheet, which was prepared before the flight, seated the passengers in such a manner that the position of the centre of gravity of the aircraft would have fallen within the limits permitted, had this seating arrangement been followed.

The pilot-in-command held a valid Airline Transport Pilot Licence and a valid instrument rating. He had accumulated a total of about 6,700 hours of flying time of which about 1,730 hours had been acquired on Consolidated PBY-5A type of aircraft.

The co-pilot held a valid Airline Transport Pilot Licence and a valid instrument rating. He had accumulated a total of about 4,500 hours of which about 100 had been acquired on Consolidated PBY-5A type of aircraft.

It was stated that during the landing, which was made into wind, a normal round-out was made. A witness who watched the landing stated that after the first skip, the aircraft bounced twice, the second bounce being more severe than the first. The action taken by the Pilot-in-Command after the first skip was to push the control column fully forward and keep it there.

The airspeed just prior to the first contact with the water was stated to have been 105 mph.

About 20 minutes before landing local weather information was passed by radio to the aircraft. The ceiling was given as 3,000' - 4,000' overcast with visibility 15 miles, wind south-east at 20 m.p.h. gusting to 30 m.p.h. The water conditions were described by the pilot-in-command as a 12" - 18" chop on the water.

Weather is not considered to have been a factor in the accident.

Probable cause

It would appear that through misuse of the controls in the air after the aircraft touched down on the water, it bounced several times, the final bounce being so severe that the nose section was torn off.

ICAO Ref: AR/320

No. 20

Delta Airlines, Inc., Douglas DC-3, crashed near Marshall, Texas, on 17 May, 1953. CAB Accident Investigation Report No. 1-0030. Released 31 December 1953

Circumstances

The Flight departed Dallas, Texas at 1310 hours for Atlanta, Georgia, with a stop scheduled at Shreveport, Louisiana. The aircraft was cleared on a VFR flight plan and carried 17 passengers and three crew.

At 1408, in the vicinity of Marshall, Texas, the flight made a routine radio contact with Delta's Shreveport station, during which it was given the Shreveport altimeter setting of 29.78. At this time the flight advised it was changing over to the Shreveport Control Tower frequency. At about 1412, four minutes later, the flight called the Shreveport Control Tower, which cleared it to make a right-hand turn for landing approach to Runway 13 and gave the wind as southeast 10 miles per hour. The flight acknowledged this message and requested the Shreveport weather which was transmitted as dark scattered clouds at 1,000 feet, ceiling estimated 4,000 feet, overcast at 20,000 feet, visibility 10 miles, thunderstorm light rain shower. The tower also advised of a thunderstorm approximately 15 miles west of Shreveport. This transmission also was acknowledged by the flight.

At 1416 the Shreveport Control Tower asked the flight to give a position report. No reply was received, and a number of unsuccessful attempts were then made to contact the flight. At 1428 the tower was advised that an aircraft had crashed near Marshall, Texas. Only one passenger survived.

Investigation and Evidence

The wreckage was located approximately 13 miles east-southeast of Marshall, Texas, one-half mile south of Highway 80 in a heavily wooded area. Broken tree limbs, markings on the ground, and distribution of the wreckage indicated that the aircraft first struck the trees while in a shallow angle of descent, under power, in approximately wing-level attitude and on a 50-degree heading. It continued ahead, cutting a swath through trees for a distance of approximately 500 feet, struck the ground, skidded, and came to rest in a mass of wreckage 870 feet from the point of initial contact with the trees. The aircraft partially burned following impact. There was no evidence found at the scene of the accident to indicate fire in flight or collision with any object, other than the trees, prior to impact, and no evidence of hail damage.

Both engines and propellers were examined. Indications were that both engines were delivering power at the time of impact, and that both propellers were in low pitch range.

Sequence weather reports, issued by the United States Weather Bureau at 1230 and available to the crew at the company's office, indicated good visibility en route to Shreveport with cloud layers ranging from scattered to overcast with bases 1,000 feet or higher. Thunderstorms were indicated to the south of the route from Longview to Shreveport. Pilot reports showed a heavy thunder storm 40 miles south of Shreveport with moderate to heavy turbulence and hail one-fourth inch in diameter. One pilot reported hail damage. The regional forecast indicated widely scattered thunderstorms in northeast Texas with bases about 2,000 feet and tops to 30,000 feet. The terminal forecasts for Tyler and Longview, Texas, were for broken clouds at 2,500 feet, occasionally becoming overcast at 2,500 feet, moderate thunder showers after 1400 and possibly hail with gusts to 50 miles per hour after 1800. The terminal forecast for Shreveport indicated broken clouds at 2,000 feet occasionally becoming overcast at 2,000 feet with moderate thunder showers after 1430 and possible hail with gusts to 50 miles per hour after 1800. Moderate to heavy* turbulence was forecast at all levels in the vicinity of thunderstorm activity. Also available to the flight before departure was this severe weather forecast: "There is a possibility of a few tornadoes in north-east and central Louisiana and west central Mississipi this afternoon until 9:00 p.m.".

At departure from Dallas these latest weather sequence reports and terminal weather forecasts, together with winds aloft for the Dallas-Atlanta area, were attached to the flight's clearance, as were the severe weather forecast and pilot reports previously mentioned.

During the flight VFR conditions with good visibility prevailed from Dallas to Marshall. East of Marshall occasional thunderstorms existed and it appears that ceiling in some of the heavier storms was near the surface with tops probably at 30,000 to 35,000 feet. One of these storms was on course between Marshall and Shreveport. Information from witnesses both on the ground and in the air indicate that the thunder storm was plainly visible from the west side but did not look nearly as severe as it did from the east and northeast sides. Witnesses also indicate that the storm was local in extent and could have been flown around; in fact another flight did go around it. Delta's aircraft was seen by several witnesses to fly into the storm.

Investigation discloses that the thunder storm was first noted south of Marshall, moving rapidly northeastward. During that time it was picked up as an intense echo on the radar scope at Barksdale Field. A U.S. Air Force reconnaissance flight was then dispatched to reconnoiter the storm to determine its probable severity. An Air Force C-47 with two pilots departed from Shreveport at 1340, about 35 minutes before the accident.

They proceeded westward in the direction of Marshall, Texas, toward the thunderstorm, and observed weather conditions over the Shreveport area to be 3,000 to 5,000 feet, scattered to broken clouds; visibility unlimited. However, as the C-47 approached the storm area, the ceiling began to slope steeply downward in the proximity of the storm. The estimated height of the base of the storm cloud varied from approximately 1,000 feet at the outer edges to zero feet near the centre. Heavy rain and severe cloud-to-ground lighting were observed in the thunderstorm. The Air Force aircraft then skirted the storm to the north and west, and while flying at an altitude of approximately 2,500 feet MSL on a southwesterly heading, the captain observed a Delta DC-3 approximately one-half mile south, and at about the same altitude, headed on a straight easterly course toward the storm. In fact, he watched the Delta aircraft, in what appeared to be normal cruising attitude, enter the storm and disappear at about 1415. At no time did the Delta flight request an Instrument Flight Rules clearance.

The Air Force pilot testified that at all times he flew visually and that he was able to stay clear of the thunderstorm. Once when he approached quite close, while on the east side, moderate turbulence was encountered. He turned away stating that the storm looked too severe to probe with safety. At one time while skirting the storm he noted a "snout" form under the cloud, disappear, then form again, suggestive of a tornadic development, extending from the cloud base but not reaching the ground. He also stated that on the east side the storm was as black and threatening as any he had ever seen, but on the west side, the side that the sun was shining on, it looked much less threatening although heavy cumulus and rain could be seen. Other witnesses on the ground near Marshall testified that the storm was quite severe. Some stated that they observed the Delta aircraft proceeding in an easterly direction toward the storm in straight and level flight. Others testified as to the intensity of the storm. They stated that there was very heavy rain with hail for a very short period of time, and that the wind seemed to be quite strong. There was no evidence, however, in the vicinity of the crash, of any characteristic tornado effect such as the uprooting of trees or damage to property. The one surviving passenger, who was on her initial flight, stated that the flight seemed normal and that she was asleep most of the trip. She had her seat belt fastened when the aircraft entered the storm area, and her last impression was that the left wing of the aeroplane was down; she remembers nothing further until after being rescued.

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* The Weather Bureau interprets "heavy turbulence" as: "Usually associated with the interior of thunderstorms either frontal or isolated. Difficult to maintain flying altitudes".

The company's operations manual, with which the captain should have been familiar, sets forth:

"5032.3 Completion of schedules takes third place and is considered of major importance after safety and passenger comfort.

5032.4 It is the policy of Delta Air Lines to circumnavigate thunderstorms in so far as practicable.

5032.5 It is the policy of Delta Air Lines to avoid flight through turbulent air by variation of altitude, or course, or both.

If impracticable to avoid such flight, the effect of turbulence shall be lessened by reduction of speed."

The thunderstorm was entered with no known change of altitude (from 2,500), and with no apparent attempt to change course. About 1412, with Shreveport only 21 miles ahead, and reporting good ceiling and visibility, the captain evidently elected not to by-pass the storm and to remain VFR which he could have done, but flew directly into it, and in so doing acted contrary to Civil Air Regulations, as well as to company directives. The crash occurred about six miles beyond his point of entering the storm and only some two miles from its eastern, or far, edge.

The thunderstorm in which the crash occurred was very active at the time the flight went into it, elliptical in shape, and about ten to twelve miles in extent. Heavy to severe turbulence was indicated to have existed, including vortices which apparently did not become mature tornadoes. This was not known by the captain of the Delta flight and he may have believed that the storm did not look too severe. Although he may have further believed that the Air Force plane had come through it, he should have known that the storm was local and could be by-passed (it was visible to him), and that pilots had already encountered heavy thunderstorm with heavy turbulence and damaging hail in the general area. He was getting into a thunderstorm area which farther to the east had been forecast to possibly develop tornadoes, and it had been suggested to him by ground personnel to by-pass the storm to the north. In view of these known facts there appears to be no logical reason why the captain did not alter his course to avoid the storm, in as much as company instructions required him to by-pass thunderstorms when practicable.

The exact nature of the conditions within the storm cannot be determined. However, it is known that the storm appeared to be a very severe one, with zero ceiling conditions and extremely heavy rain accompanied by hail, with strong, gusty surface winds and sharp cloud-to-ground lightning. These factors are indicative of other conditions such as extreme turbulence accompanied by violent updrafts and downdrafts. It is known that turbulence, if sufficiently severe, is capable of rendering an aircraft uncontrollable. Instruments have been known to vibrate and fluctuate, even in a shock-mounted panel, so violently that they become unreadable. Although investigation disclosed no evidence of lightning strike, there may be the possibility that lightning flashes temporarily blinded the crew members, since cloud-to-ground lightning of strong intensity was seen by air and ground witnesses.

The aircraft's attitude, level laterally and in a slight descent with power being developed when it struck, does not necessarily eliminate the possibility of lost control.

Considering the possibility that the pilot, after encountering instrument flight conditions at his altitude, was descending to establish visual contact, it may be assumed that the pilot was faced with a combination of various hazardous conditions, described above, lost control of the aircraft and was unable to effect recovery in time to prevent impact with the trees.

The Board noted that the forecasting of thunderstorm severity and behaviour is far from being an exact science, and that scheduled flights must frequently traverse undeterminable conditions. But it has long been held to be good practice to skirt thunderstorms when possible, either laterally or vertically, or both. This is of paramount importance when tornadoes are possible.

Probable Cause

The Board determined that the probable cause of this accident was the encountering of conditions in a severe thunderstorm that resulted in loss of effective control of the aircraft, and the failure of the captain to adhere to company directives requiring the avoidance of thunderstorms when conditions would allow such action.

No. 21

Resort Airlines Inc., C-46-F, crashed near Des Moines, Iowa, on 22 May 1953. CAB Accident Investigation Report No. 1-0034. Released 17 March 1954.

Circumstances

The aircraft, engaged on a ferry flight (positioning flight) from Cheyenne, Wyoming to Chicago, took off from Cheyenne at 0132 on 22 May 1953. The flight departed on an instrument flight plan to fly at 7,000 feet. Routine position reports were made and in the last position report, at 0327, the flight reported over Omaha at 7,000 feet, estimating over Des Moines at 0409. At 0412 the pilot again contacted Omaha and requested a change of altitude to 3,000 feet. This request for descent was refused due to another aircraft proceeding at 2,600 feet between Des Moines and Omaha. The flight was given the latest weather information between Omaha and Chicago and the Des Moines 0327 weather. There were no further radio contacts. The aircraft disintegrated in flight whilst flying in a thunderstorm at approximately 0413 hours. Both pilots, the sole occupants, were killed.

Investigation and Evidence

Numerous pieces of the tail surfaces and the right outer wing panel were found scattered over a considerable area. Prior to impact, the right aileron front and centre fuel tanks, and portions of the leading edge and lower surface skin near the root separated from the right outer wing panel.

The main wreckage consisted of the fuselage, left wing, centre section, movable surfaces from the left tip to the right end of the centre section, power plant installations, right horizontal tail, and parts of the left horizontal and vertical tails. Damage to the structure and markings on the ground indicated that this assembly struck while in near-vertical descent, with the nose of the aircraft and right end of the wing centre section striking almost simultaneously. Ground impact shattered the fuselage and the wing centre sections and fire following impact melted considerable portions of the wreckage but the left outer wing panel received relatively minor damage.

Examination of the right outer wing wreckage disclosed that the upper surface attach angle failed in tension and bending. The lower surface buckled in compression along a chordwise line several feet outboard of the lower attach angle. Downward buckling of the right outboard flap and downward deformation of the rear fuel tank, which remained in the wing, were observed. The outer panel leading edge from the attach angles to a point approximately nine feet outboard was severely damaged and much of the deicer boot in this area was missing. There was evidence that battering of the leading edge near the root was due to contact with some object or portion of structure not associated with the wing.

Evidence of one item of malfunctioning prior to disintegration was found. This occurred at the attachment of the right aileron trim tab motor to the support bracket. At this point, two studs in the bracket acted as trunnions about which the tab motor pivoted. The outboard trunnion had backed out of the threaded sleeve in the bracket without stripping any threads; it was not found. The tab motor had then rubbed against the inner surface of the outer support arm and gouged the inner surface of the inner support arm; this damage indicated that the tab motor had been insecure for a considerable period of time after the outboard stud was lost, since the threads of the outboard insert were coated with a rust colored deposit approximately two-thirds the length of the length of the insert. Some of the threads were worn and rounded. When the tab motor separated from the support bracket, the inboard trunnion was bent approximately 15 degrees. The safety wire through the drilled head of this trunnion was broken at about the point where it would normally be anchored to the support bracket by means of a drilled hole. The remaining trunnion was found backed out by one turn and had a loose fit in the threaded sleeve. The threads in this trunnion and its sleeve were clean and in good condition. The support bracket was still bolted to the rear face of the rear spar.

Directly above the tab motor support bracket, a hole approximately 18 inches long had been punched through the top skin of the wing from the interior. This damage was caused by the tab motor, obviously before the right aileron separated from the wing panel. The tab motor was not found.

Portions of the left stabilizer, elevator, and spring tab remained attached to the fuselage. The stabilizer failed downward along a diagonal line extending aft and outward from the attach angles at the leading edge and rotated through nearly a 180 degree arc until the lower surface of the stabilizer struck the bottom of the fuselage with sufficient force to produce pronounced deformation of the fuselage.

The leading edge of the left stabilizer was flattened rearward and downward through most of its length in a manner which indicated that it was caused by impact with some object other than the fuselage, and that it occurred before the stabilizer failed downward. There were numerous cuts and abrasions in the leading edge deicer boot.

Evidence presented by four detached portions of the left horizontal tail indicated that they were snapped off by inertia forces when the stabilizer struck the bottom of the fuselage. Just inboard of the second hinge from the tip, one of the detached pieces of the elevator had a hole punched through both the top and bottom skin by a gray-painted object entering from above and moving rearward. Since the gray-painted portions of the aircraft consisted of the wing, the horizontal tail surfaces and parts of the fuselage, the direction in which the hole was made indicated that it could have resulted only from impact with a portion of the right wing.

All balance weights for the elevator tabs, except one, were still attached. The left elevator flying tab weight was torn off by interference with the edges of the elevator cutout for the balance weight horn.

Six pieces of the vertical tail surfaces were found scattered over a wide area. The dorsal fin, the lower half of the rudder, and the lower third of the rudder spring tab were found at the main wreckage site. The upper half of the rudder trim tab was not found. The top half of the rudder, extending from the tip to midway between Nos. 2 and 3 hinges, had its rudder balance weight still firmly attached.

A wide trough-shaped depression, centered approximately two feet below the tip of the fin, extended rearward from the leading edge on the left side. In this area there were numerous tears in the skin, scratches running rearward, and several black-smudged areas on the exterior surface. A sliver of black and tan deicer boot rubber six and three-quarters inches long was found wedged in one of the tears in the stabilizer or fin deicer boots or in the re - covered portions of the right wing deicer boots. Therefore this sliver probably came from the unrecovered portion of the boot. The left side of the detached portions of the rudder bore numerous black smudges in the area aft of similar markings on the fin.

In the cockpit, the throttles were found advanced halfway, both propellers advanced one-fourth of the travel from low rpm, trim tabs neutral, left mixture controls in cruising lean, right mixture control in full rich, left magneto switch "off", and right magneto switch "on". Safety belt buckles for both pilots were found fastened; the belts were destroyed by fire. One clock had been stopped at 4:12 and the captain's watch was stopped at 4:13. Both altimeters were set at 29.76 inches. No reading could be obtained from the air speed indicator. The VOR frequency selector was found set on 113.1 mg (Des Moines frequency) and the bearing indicator showed 88 degrees. The left ADF was in "antenna" position and the tuning control was found at 212 kilocycles (Des Moines frequency); the right ADF was on the 200-400 kilocycle band and the "antenna" position, but no reading on the frequency could be determined.

Company maintenance records pertaining to the aircraft disclosed no discrepancies. All CAA airworthiness directives and notes applicable to the aircraft and engines had been complied with. The aircraft was currently certificated.

Examination of the engines and propellers revealed no indication of malfuntioning or failure in flight.

Investigation relative to communication with the flight revealed that all radio contacts were routine and no emergency was declared by the pilot. There was no request for Flight Advisory Weather Service (FAWS) assistance.

A cold front extended from west to east across central Colorado, Kansas, and Missouri, thence northward into southern Ohio, northwestern Pennsylvania, and Canada. A low pressure centre and active frontal wave was in central Kansas, moving eastward. Showers and thunderstorms were occurring north of the front, from a wave apex eastward.

The latest weather reports showed clear to scattered high clouds from Cheyenne to central Nebraska and a scattered to overcast condition from central Nebraska to Chicago, with scattered thunderstorms whose bases were at 3,000 - 4,000 feet. Forecasts indicated that a squall line in central Nebraska was moving eastward and would be accompanied by thunderstorms extending into southwestern Iowa. In south central and extreme southeastern Nebraska, the thunderstorms were expected to be locally severe with occasional hail, severe turbulence aloft, gusts 55 to 65 miles per hour, and the possibility of a few tornadoes.

Study of weather conditions along the route indicated that the visual flight rule conditions existed to about North Platte, after which the flight encountered intermittent instrument conditions and scattered thundershowers. The instability line moved more rapidly than anticipated, and crossed into Iowa by the time the aircraft reached that State. The thunderstorm which the flight encountered near Des Moines was connected with the line of instability. It is probable that the aircraft was in clouds at 7,000 feet, and therefore, the pilots would have found it difficult if not impossible to ascertain, from observation alone, that they were entering such a violent storm area.

Through weather information given to them at Cheyenne and while en route, the crew had warning of thunderstorm activity, severe turbulence, hail, and possible tornadoes. Although the most severe conditions were forecast for southern central and southeast Nebraska, these warnings should have alerted them to the possibility of thunderstorm activity in a wider area. Two westbound flights avoided the more severe storm areas in the vicinity of Des Moines without difficulty. The storm in which the aircraft disintegrated was located on a squall and pressure jump line. It has been found that squall clouds forming on a pressure jump line are often accompanied by violent turbulence of such severity that loss of control can be experienced.

When disintegration of the aircraft occurred, the high wind from the northeast carried the less dense pieces of wreckage to the southwest. The mingling of parts from various components of the aircraft indicated disintegration of the wing and tail surfaces within such a short interval of time that the sequence of disintegration was not apparent from the wreckage distribution alone.

Damage to various pieces of wreckage appeared to be the more reliable basis for ascertaining the sequence of failure. The flattening of the left stabilizer leading edge, the hole punched through the left elevator by a gray-painted object entering from above and driving rearward, the trough-shaped depression, tears and scratches on the left side of the fin due to an object moving rearward, and the sliver of deicer boot rubber found in one of these tears, all indicated impact by some portion of the aircraft prior to a failure of the tail group. Only the detached right wing panel could have caused this damage, since no other part forward of the tail surfaces separated from the aircraft in flight.

The manner in which the failure of the right wing occurred was therefore significant. It was learned in study of the wing that the failure occurred due to compression buckling of the lower surface several feet outboard of the splice angles, accompanied by tension and bending failure of the upper surface in the splice angle. This combination indicated that the lower surface buckled first under loads which were in excess of the design strength of the wing.

Since the airplane was lightly loaded, it was apparent that the wing failure could not be attributed solely to down gusts with the airplane operating at cruising speed. Excessive air speed and in all probability manoeuvring loads in combination with the gusts would have been necessary. These could have resulted from loss of control in the severe turbulence.

Progressing from failure of the right wing panel to the cause of its failure, analysis of the evidence presented by portions of the right tab motor assembly indicated that in all probability the outboard trunnion had been lost for some time. Under normal operating conditions, the remaining trunnion and interference with the tab motor bracket were evidently sufficient to retain the motor in place. However, when the aircraft met the extreme turbulence of the thunderstorms, the loads on the trim and balance tab were probably great enough to force the tab motor out of the housing and as evidence shows, it was displaced and pierced the wing. Displacement of the tab motor from its normal position, and interference with other parts inside the wing would have actuated the tab in an erratic manner. This in turn would have produced a strong tendency to erratic rolling of the aircraft. This tendency to roll erratically, in conjunction with the extremely turbulent weather conditions, very likely caused loss of control and subsequent overloading of the wing to point of failure.

As a result of this accident, an Air Carrier Maintenance alert bulletin, No. 145, was issued on 21 August 1953, notifying operators of the importance of an inspection of the aileron, rudders, and elevator tab motor trunnions.

Probable Cause

The Board determines that the probable cause of this accident was separation of the right aileron tab motor from its support bracket, due to loss if its outboard trunnion, while the aircraft was in the severe turbulence of a thunderstorm. These conditions resulted in a tendency to roll erratically, and in conjunction with the extreme turbulence, caused loss of control and subsequent overloading of the wing to the point of failure.

ICAO REF: AR/306

No. 22

Meteor Air Transport, Inc. DC-3 aircraft crashed on the east side of Lambert Field, St. Louis, Missouri, on 24 May 1953. CAB Accident Investigation Report No. 1-0029. Released 13 October 1953

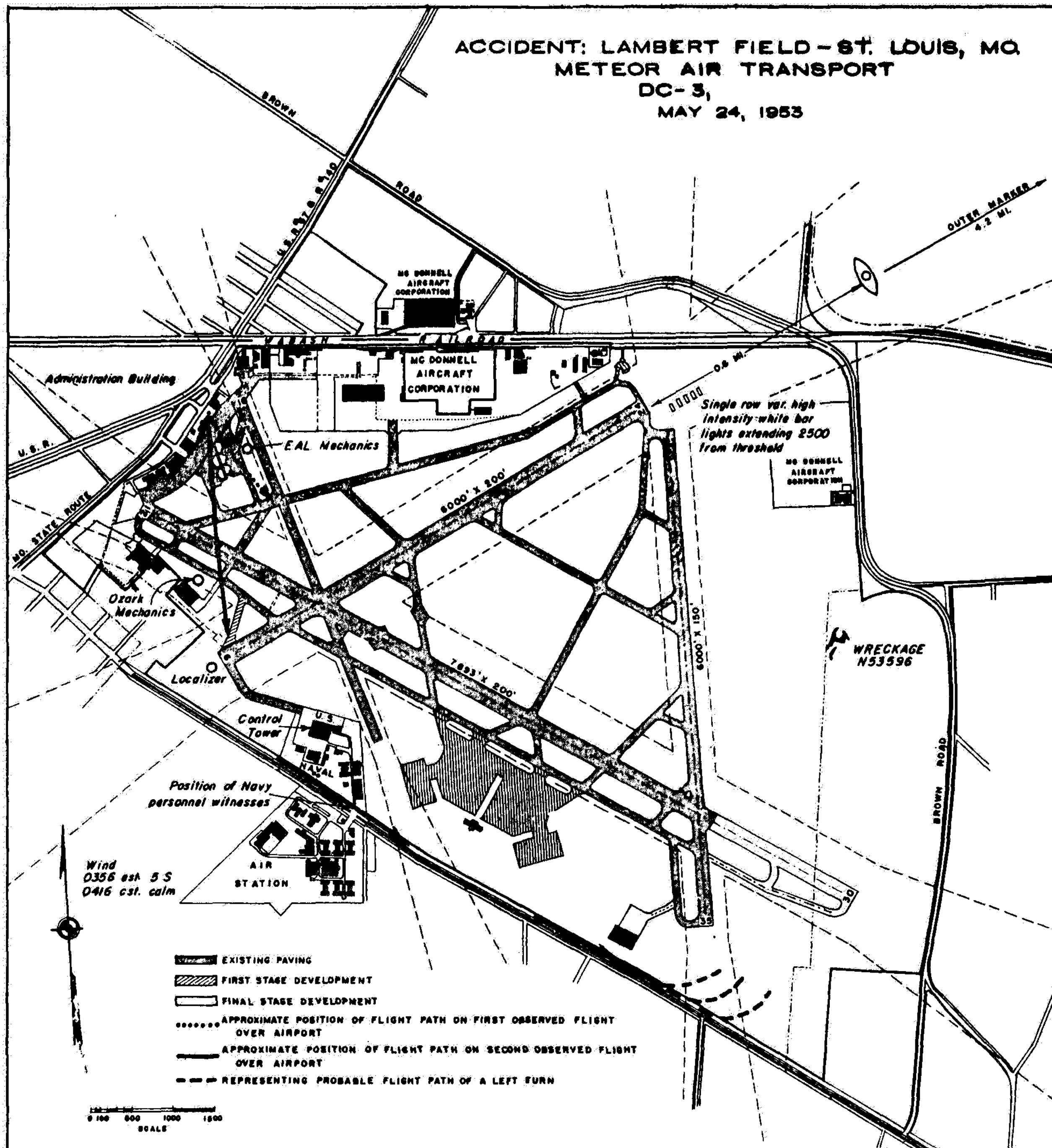
Circumstances

The aircraft engaged in a non-scheduled flight from Teterboro, New Jersey, to Oklahoma City, Oklahoma, transporting a Pratt and Whitney R-2800 engine and four company employees, departed Teterboro at approximately 2300 hours on 23 May 1953. The flight which was cleared on a VFR flight plan with an estimated flight time of six and one half hours, filed an instrumental flight plan en route which was approved. Whilst making an approach to land at St. Louis, the aircraft was seen to descend to 200 ft. south of the field and then start a climbing turn into the overcast. The aircraft crashed on the east side of the field while being manoeuvred beneath the 400 ft. ceiling preparatory to effecting a landing and six of the seven occupants were killed. There was no fire.

Investigation and Evidence

The flight proceeded in a routine manner and reported over Terre Haute, Indiana, at 0259, 24 May, and at 0324 the following clearance was given to Vandalia radio for delivery to the flight: "ATC clears N 53596 to the Alton intersection to cross Alton at 3,000, Maintain 3,000, no delay expec ted, contact approach control approaching Alton." At 0357, the aircraft made its initial contact with the St. Louis Tower with the information that it was approaching Alton intersection at 3,000. In reply to an inquiry, the aircraft advised the tower that it carried ILS equipment and was recleared to the ILS Outer Marker to maintain 3,000 with no expected delay and to report when over the Alton intersection. The flight was given the current St. Louis weather: ceiling measured 400 overcast, visibility 3 miles, fog and smoke, altimeter 29.93. It was cleared for an ILS approach to Runway 24 or 12, wind south variable 5, to report leaving 3,000, passing Alton and the Outer Marker. The aircraft reported leaving 3,000 at 0408, passing Alton intersection at 0410-1/2 and inbound over the Outer Marker at 0414. While the controller was watching the approach end of Runway 24 expecting the aircraft to come into view at any moment, a surging of engines was heard; and almost simultaneously a message was received from the flight stating that it was over the field with an engine out. The time as noted by the controller was 0415 at which time all runway and approach lights were turned up to full intensity and the standby emergency alarm sounded. The pilot of the aircraft was advised that the surface winds were calm and to use any runway he could make. Shortly thereafter, the controller for the first and only time observed the aircraft at a position south of the field flying on a southeasterly heading above Natural Bridge Highway which runs parallel to Runway 12. The altitude of the aircraft was estimated at 300 feet and it appeared to be descending with the landing gear in a down position. Upon reaching an altitude of 200 feet, according to the controller, it started a climbing left turn and disappeared in the overcast.

The aircraft was observed by competent witnesses to twice approach the airport below the overcast from the north and disappear, headed in a southerly direction. These witnesses were all located in the vicinity of the Administration Building at the northwest corner of the airport. All stated the engines appeared to be functioning normally. The aircraft was also observed by three Navy guards located at the Navy entrance on Natural Bridge Highway just south of the tower on the south side of the airport who stated they got a fleeting glimpse of the aeroplane as it passed overhead in a southeasterly direction. They stated that during this period they noticed that the left engine was either windmilling or feathered. It must have been shortly thereafter that the tower controller observed the aircraft at a position south of the field flying on a southeasterly heading above Natural Bridge Highway. Whether or not the message from the pilot to the controller, that he was over the field and had an engine out, was received before or after the aircraft was first observed over the field in the vicinity of the administration Building could not be determined.


ACCIDENT: LAMBERT FIELD – ST. LOUIS, MO.
METEOR AIR TRANSPORT
DC-3,
MAY 24, 1953
BROWN ROAD
OUTER MARKER 4.2 MI.
MC DONNELL AIRCRAFT CORPORATION
WABASH RAILROAD
Administration Building
U.S.R.
E.A.L. Mechanics
Single row var. high intensity white bar lights extending 2500 from threshold
6000' X 200'
MO. STATE ROUTE
Ozark Mechanics
Localizer
7693' X 200'
6000' X 150
WRECKAGE N53596
Control Tower
U.S. NAVAL AIR STATION
Position of Navy personnel witnesses
Wind
0356 est. 5 S
0416 est. calm
EXISTING PAVING
FIRST STAGE DEVELOPMENT
FINAL STAGE DEVELOPMENT
APPROXIMATE POSITION OF FLIGHT PATH ON FIRST OBSERVED FLIGHT OVER AIRPORT
APPROXIMATE POSITION OF FLIGHT PATH ON SECOND OBSERVED FLIGHT OVER AIRPORT
REPRESENTING PROBABLE FLIGHT PATH OF A LEFT TURN
SCALE

The survivor of the accident testified that, from his seat in the rear of the cabin, he saw the lighted sign on the McDonnell Aircraft Factory located on the north side of the field, both times they passed across the airport. He further stated he believed both engines functioned normally throughout the circuits of the field and that the only change in power that he recognized was when the aircraft climbed slightly when crossing the field the first time. He stated also that, a short time before the crash, the aircraft "trembled" twice in rapid succession, there was no recognizable change in power at that time, and the aircraft continued flying in level flight. He said, "I made a statement to my mechanic friend that it felt like it was going to stall." A few seconds later the aircraft again "trembled" and the right wing dropped. The crash followed immediately. The aircraft struck the ground on an undeveloped portion of the airport approximately 1,950 feet east of the mid-point of the north-south runway which is itself located on the eastern side of the airport proper.

Upon examining the wreckage, the landing gear was found in the fully extended and latched position, the wing flaps fully retracted, elevator trim slightly nose-high and rudder trim neutral. Cockpit damage was so extensive that readings of cockpit instruments were meaningless. The two altimeters were found lying on the ground away from the main wreckage where they had been thrown by the impact. The altitude needles were both inoperative due to damage to the gearing. However, the barometer settings were found at 29.90 and 29.96 inches, respectively.

The aircraft came to rest practically level both laterally and longitudinally. Since the four tanks located in the centre section were undamaged and no leakage from the system existed, reasonably accurate measuring of the fuel in the tanks was possible. The following amounts of fuel were found:

80 gallons - left main tank
70 gallons - right main tank
40 gallons - left auxiliary tank
10 gallons - right auxiliary tank.

Examination of the fuel system disclosed that the selector valve for the left engine was on the left main tank containing 80 gallons of fuel, while the selector valve for the right engine was on the auxiliary tank containing 10 gallons of fuel. The position of the cockpit control for the right engine selector valve was found to be jammed in the right auxiliary tank position, which is in agreement with the position of the selector valve. Due to this agreement and the nature of the ground impact damage, which merely relieved the rigging loads in the cables between the cockpit control and the valve, it is apparent that the right engine was being fed from the right auxiliary fuel tank immediately prior to the time of impact. No evidence was found during an examination of the wreckage to indicate that the aircraft was not in an airworthy condition at the moment of impact with the ground.

An examination of the engines, propellers and their accessories indicated that both power-plants were operable prior to impact. This was further substantiated by normal operation of both carburettors when flow tested and by satisfactory bench tests of propeller feathering pumps, fuel boost pumps, propeller governors and engine fuel-driven pumps. The carburettor fuel strainers were found free from all foreign material. Upon removal of the carburettor from the left engine, it was noted that the main fuel supply line from pump to carburettor, the fuel regulator and the fuel transfer line were filled with gasoline. However, when the carburettor was removed from the right engine, the pump to carburettor and transfer lines were empty and the regulator contained less than a gill of gasoline.

It was determined that the aircraft's gross weight at take-off was 26,523 pounds, which was 1,323 pounds more than the approved take-off weight of 25,000 pounds.*

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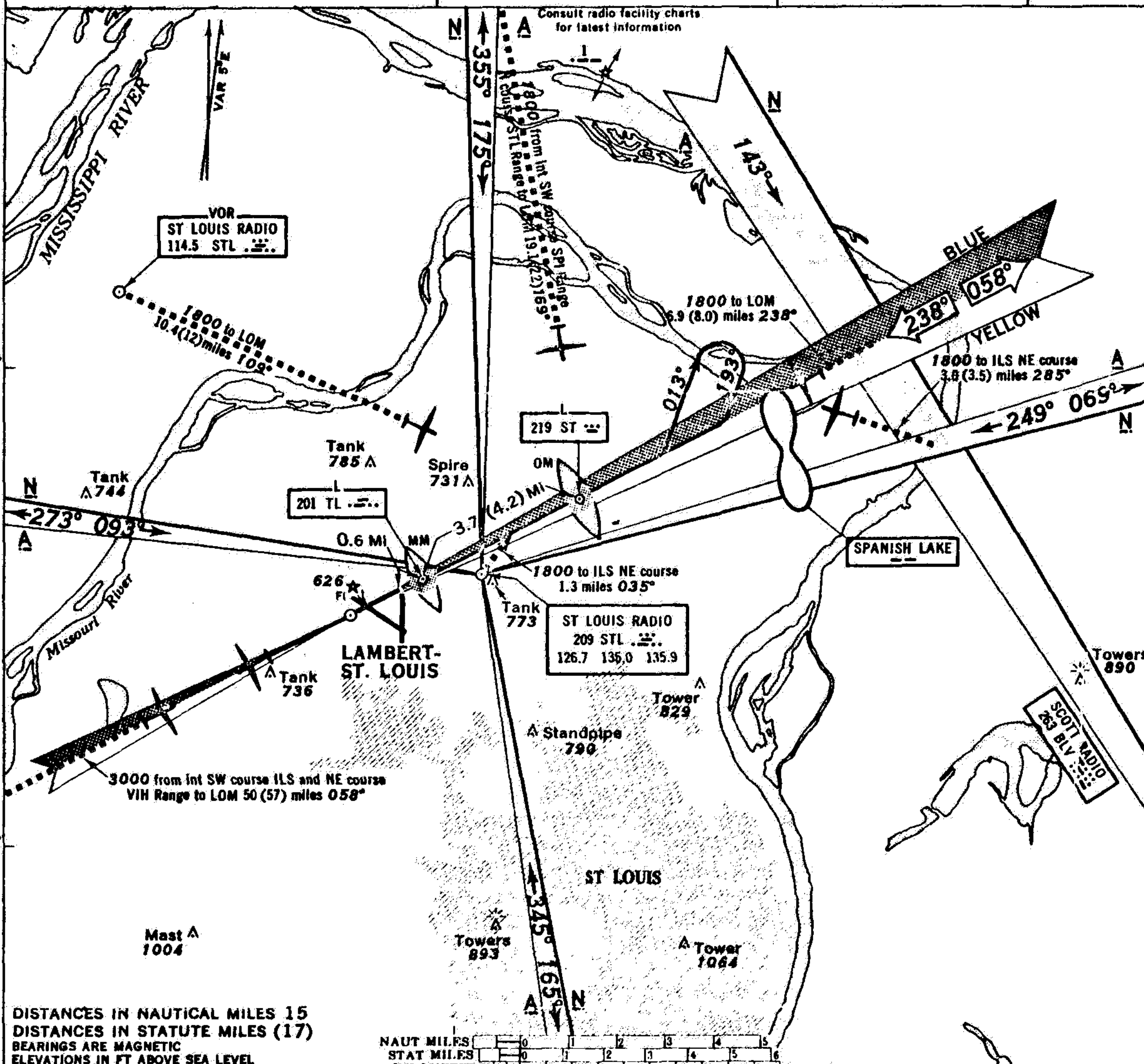
* The specifications for this model aircraft, issued by the CAA, limit the gross weight for carriage of passengers, or passengers and cargo, to 25,200 pounds, and to 26,900 pounds for cargo only.

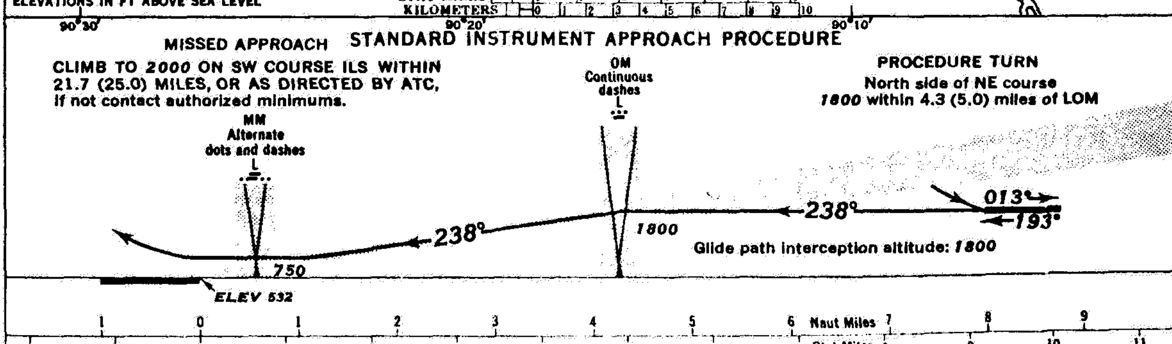
INSTRUMENT APPROACH
CHART - ILS

MINIMUM SAFE ALTITUDES
100 Nautical Miles 2800
25 Nautical Miles 2100

LAMBERT-ST. LOUIS AIRPORT
ST. LOUIS, MO.

ST LOUIS APPROACH CONTROL	LAMBERT-ST LOUIS LOCALIZER	LAMBERT TOWER	ELEV
209 118.3 126.18	Z 110.3 I•• STL	278 118.3 126.18	558





MINIMA FOR MILITARY USE ONLY

LANDING		MIN ALT	CEIL	VIS		MIN ALT	CEIL	VIS
STRAIGHT-IN	DAY	958	400	1	NIGHT	958	400	2
CIRCLING		1058	500	1½		1058	500	2

RATE OF DESCENT - FEET PER MINUTE

KNOTS	90	110	130	150	M.P.H.	100	120	140	160	180
	440	535	630	730		420	505	590	675	760

PRICE FIVE CENTS

55091

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30 JAN. 1953

AL-360-ILS

However, the fact that the aircraft was overloaded approximately 1,323 pounds upon departure from Teterboro is not considered significant in this accident since consumption of fuel en route reduced the weight to well under the approved gross maximum upon its arrival at St. Louis.

The flight from Teterboro to the St. Louis ILS Outer Marker appears to have been routine; however, the movements of the aircraft after leaving the Outer Marker to the point of impact are not clear. The fact that the tower asked and the flight acknowledged that it was equipped to make an ILS approach does not definitely indicate that this kind of an approach was attempted. To the contrary, three significant facts indicate that such an approach either was not made, or, if started, was abandoned. First the tower controller, after clearing the flight to make an ILS approach, watched the approach end of Runway 24 but the aircraft never came into his view. Second, the aircraft was never observed over the airport on an ILS localizer course. It is difficult to understand how an off course error of such magnitude could have been made in such a short distance. Third, witnesses who were in the vicinity of the Administration Building on the north side of the airport twice observed the aircraft fly over them in a southerly direction at approximately right angles to Runway 24, the ILS runway.

The two witnesses on the north side of the field said that both engines were functioning normally each time the aircraft passed over them. However, the two Navy guards who were on the south side of the field thought that the left engine was inoperative when they observed the aircraft. It is believed, however, that these latter witnesses who had only a fleeting glimpse of the aircraft almost directly overhead in the haze and smoke were in error and that due to an optical illusion thought that this engine's propeller was turning only slowly. Testimony of the survivor, the company's Chief of Maintenance, clearly indicated that both engines were functioning normally until the final left turn at which time the aircraft trembled and the right wing dropped. This witness' testimony seems far more credible than that of the Navy witnesses on the ground since he was sitting in the cabin and was in a position to hear the sound of the engines clearly.

Therefore, it is apparent that the pilot did not experience any mechanical difficulties with either engine during the circling of the airport prior to the accident. More probably he elected to remain visually in contact with the airport rather than execute a missed-approach procedure; and that since the ceiling was below the authorized minimum of 500 feet prescribed for a circling approach, he reported having an engine out. This indicated a possible emergency to the tower controller who then cleared the flight to land on any runway.

There is no logical reason why the supply of fuel to the right engine should have been taken from the auxiliary tank with only 10 gallons of fuel available when the right main tank still contained approximately 70 gallons. The only conclusion that can be reached is that during the times the pilots changed positions in the cockpit prior to reaching St. Louis, the change over from auxiliary to main tank was overlooked. If there had been any surges in power, the pilots would have immediately discovered the cause and would have turned the handle of the fuel selector valve to the right main tank.

Because the carburettor and related fuel lines of the right engine contained little or no fuel and only about 10 gallons of fuel remained in the tank being used, the Board concluded that during the final left turn the outlet of the fuel tank became unported allowing air to enter the line, and that immediately following this turn the engine suffered a critical loss of power due to fuel starvation. The Board further concluded that the loss of power from this engine, together with the reduced airspeed of the aircraft at the time, caused the right wing to drop and the aircraft to settle at an altitude too low to effect recovery.

Probable Cause

The Board determined that the probable cause of this accident was mismanagement of fuel resulting in loss of power and control while circling the field preparatory to an approach for landing.

No. 23

Douglas DC-4 aircraft crashed on approach to land at Córdoba Airport on 17 June 1953. Argentina Accident Investigation Report No. 173. Released on 2 September 1953

Circumstances

On 17 June 1953 at 1930 hours (local time), a Douglas DC-4 aircraft met with an accident approximately 12 km. north of the Córdoba airport while an approach to land. The aircraft carried 7 crew and 34 passengers.

The pilot in command of the aircraft had a total of 14,000 hours of flying time and the co-pilot 5,300 hours.

The pilot in command and the co-pilot suffered superficial injuries as a result of the accident, but the remainder of the crew and the passengers were uninjured. The aircraft was totally destroyed.

Investigation and Evidence

The investigation revealed that the aircraft left Santa Cruz de la Sierra (Bolivia) on a scheduled airline flight and landed without incident at Salta 2 hours and 30 minutes later.

It took off from Salta airport for Córdoba at approximately 1645 hours (local time). At take-off the aircraft was carrying a total load of 3,512 kg.

The route forecast as far as Marcos Juarez was as follows: partly cloudy, visibility 15 km., strato-cumulus cloud 7/8ths at 800m., alto-cumulus 3/8ths at 3,000m., upper wind 20° 13/15 knots.

The aircraft contacted Córdoba airport control tower at 1856 hours (local time) and was cleared to enter the airport zone.

At 1925 hours (local time) it passed over the radio beacon and the control tower provided the following weather information: horizontal visibility 6 km., average height of cloud 250 metres, pressure for altimeter correction 30 inches, surface wind SE, 10 to 11 knots.

The approach to the airport was begun under IFR conditions, at an indicated speed of 140 mph and at an altitude of 5,100 feet above the radio range (the requirement is 4,400 feet). The aircraft flew a course to the north for 1 minute 50 seconds, with 15° flaps and then, continuing the descent, it turned to the right on a 45° course, flying in this direction for 1 minute more. The altitude just before the turn was 3,100 feet. It then turned to the left on a course of 225°. When the aircraft direction finder indicated 40° to the left, the compass was set at 180° and the direction finder maintained at 0°. At that moment, according to the evidence, the instruments indicated an altitude of 2,980 feet. The aircraft flew at this altitude for 30 seconds, and the engine speed was reduced for landing. It continued to descend for another minute 20 seconds until the altimeter indicated 2,200 feet. At that instant, according to the statements made by the pilot-in-command and the co-pilot, the aircraft came into contact with the ground. The aircraft was finishing the final straight-in approach to the airport and was aligned exactly with runway 17.

An inspection by the investigating board at the scene of the accident established the following:

The terrain, 12 km. north of Córdoba airport, is 150 metres higher than the airport itself. It slopes gently to the south and is flat and almost clear of obstacles.

The first impacts made by the tips of the propellers, beginning with the inner port propeller, occurred fifty metres beyond the point of the first impact; the fuselage, the engines, and the central section of the wings were dragged along, bending the propellers and tearing them off with the reduction gears and parts of the upper engine crankcases, the engine cowlings and the lower electrical radio equipment which was scattered over an area from 50 to about 350 metres beyond the point of first impact. At 400 metres, the aircraft crashed through a roadway fence, breaking the right wing and stopping some 70 metres farther on, where it burst into flames as a result of broken fuel lines. It was not possible to use the fire extinguishers owing to the haste with which the occupants left the cabin, nor to use the airport safety equipment because of the distance and difficulty of access to the scene of the accident.

Further evidence established that when the approach was half completed, the pilot decided to continue his instrument approach using the radio range only, since the crew had at no time been able to tune in to the "C" marker beacon although the equipment on the aircraft was operating properly. The approach procedure in this case is to descend to the critical height of 150 metres and, if the runway cannot be seen, to break-off and head for the alternate aerodrome.

On commencing the final approach, the pilot continued his descent with the intention of reaching the critical height and then breaking off. Since he was unaware of his distance from the aerodrome and of the elevation of the terrain over which he was flying, impact with the ground, while the altimeter indicated 2,200 feet, was completely unexpected.

The crew of an aircraft which had landed a few moments earlier reported that although the "C" marker beacon was not sending a distinct signal, they had been able to pick it up.

Since it was evident that the accident was caused by the fact that the aircraft had been unduly deflected toward the north during the instrument approach, the investigation attempted to discover the reasons for that deflection. The following probable factors were considered:

1) An analysis of the approach manoeuvre indicated that it had been started at a greater altitude than that prescribed by the instrument approach procedures. This in itself would result in a steeper descent on the northern course, and it is possible therefore that the speed of 140 miles per hour was exceeded by 5 or 10 knots, particularly since the landing gear was retracted and tail wind was not taken into account in timing the manoeuvre.

2) The co-pilot stated that he called the time on his stop-watch, using the small second-hand because the large one was not working properly. This was confirmed by the Investigating Board. Since the co-pilot was wearing the watch on the left wrist and working constantly with that hand in trying to tune in the "C" marker beacon, his time readings may have been inaccurate with the result that the total time may have been exceeded by a few seconds.

3) The possibility of upper wind of an intensity greater than that registered on the surface.

This theory was accepted, taking into account the fact that two fronts of the "upper cold front" type occurred at Córdoba on 17 June 1953.

The first passed between 1300 and 1400 hours, local time, and was of limited activity causing an increase in medium and high clouds with a wind shift from the NE to the SE sector at a velocity of 5/12 knots. The second front reached Córdoba at 1700 hours local time with normal activity and with centres of instability accompanied by rain and an electric storm. The velocity of this second front was approximately 57 km/h and it moved towards the NE. At 1925 hours local time, the upper wind at 1,500 m. above the tower was estimated to be at 180° and approximately 25/30 knots.

ICAO Ref: AR/298

No. 24

Western Airlines, Inc., Douglas DC-3A, crashed shortly after take-off on the Los Angeles International Airport, California, on 29 June 1953 - CAB Accident Investigation Report No. 1-0039. Released 8 February 1954

Circumstances

The aircraft was engaged on a local routine test flight following a major overhaul. The aircraft was cleared by the tower at Los Angeles International Airport at 1723 hours, for take-off on Runway 25R for local VFR flight. There were two crew and a company aircraft inspector on board.

On take-off run at 1725 hours, just when becoming airborne, and near the intersection of Runway 25R with Runway 22-4, it appeared that control of the aircraft had been lost. The right wing dropped and struck the ground. The aircraft was then 15-20 feet high and the right wing remained down and the tail rose. It then veered to the right of the runway, cartwheeled over its nose, and came to rest upside down. Fire broke out a few seconds later in the forward portion of the fuselage.

The two crew members were injured and the inspector killed.

Tower personnel had alerted emergency equipment when the aircraft first appeared to be in trouble, and fire apparatus arrived at the scene within a few minutes and extinguished the fire.

Investigation and Evidence

Examination of marks on the runway showed that first contact by the right wing tip was 1,879 feet from the take-off end of Runway 25R. This mark was 68 1/2 feet long. Forty feet beyond, another wing mark started and continued for 36 feet. There were no runway markings for the next 399 1/2 feet. At that point another wing mark started, continuing for 335 feet.

The aeroplane came to rest inverted, about 950 feet from the point where the right wing tip first contacted the runway, or about 2,830 feet from the take-off end of Runway 25R.

During initial examination of the aircraft the captain suggested that the difficulty may have been in the aileron control. This coupled with the observed behavior of the aircraft during the take-off run, pointed to an isolation of the trouble in the aileron control system. Accordingly, it was studied throughout for defect.

An immediate inspection was made of the flight control cables. All cable attachments to the aircraft control surfaces were found attached and safetied. There was no evidence that normal movement of the controls had been impaired prior to impact.

The aileron trim tab control drum of the right wing was found with its cable attached to the centre of the drum and with four loops of this cable on both sides of the centre, corresponding with the control trim tab being in neutral. Similarly, the rudder and elevator control trim tabs were observed to be in neutral positions. This corresponded with their indicated positions on the control pedestal.

Further examination of the control system revealed that the aileron control cable within the control column housing had been reversed.

Specifically, the replacement pulleys, one aluminum and one micarta, located at the elbows of both control columns, had been transposed during assembly. The correct position of these pulleys is, aluminum pulley aft, micarta pulley forward. Over each of these pulleys passes a control cable. The ends of these cables attach to ends of a bicycle-chain that runs over a sprocket attached to the shaft of the control wheel. The aforementioned pulleys being transposed, the assembly mechanic from then on correctly following a diagram in the Overhaul Manual, fastened the cable passing over the micarta pulley to the upper end of the bicycle chain and the one passing over the aluminum pulley to the lower end of the chain. The above mentioned error resulted from the mechanic assuming that the diagram was of the captain's left side looking forward. Although this diagram was ambiguous in that it did not illustrate graphically which wheel was depicted nor the direction from which it was viewed, instructions applicable to the diagram indicate that it referred to the co-pilot's wheel looking aft. The result was a reversed motion of the ailerons.

Investigation disclosed that the mechanic was unaware of having made a mistake during the assembly and subsequently initialed the item on the Plane Overhaul Record as having satisfactorily completed the work.

Both control columns were installed in the aircraft a few days later by the same (assembly) mechanic, who then went on vacation. The company inspector (who was killed in the accident) signed off the Plane Overhaul Record indicating that he was satisfied with the work.

The next step in the overhaul procedure was the rigging, or connecting and adjusting, of the entire control system. This was done and likewise signed off by another mechanic, a rigger, on the Plane Overhaul Record as having been completed satisfactorily. In addition, the same (deceased) company inspector signed off the Plane Overhaul Record again indicating that he was satisfied.

The next step was to check full travel of controls against full travel of control surfaces. A mechanic in the cockpit moved the controls while the travel of the control surfaces was observed by another mechanic and the (deceased) inspector standing on the ground.

All controls and control surfaces moved freely and with full travel. (Actually the normal aileron control, or wheel rotation, was reversed in relation to the aileron motion but this went unnoticed). This phase of the work was also signed off by the inspector.

Before the subject flight was started, the captain made a "walk around" visual inspection of the aircraft. This type of inspection did not, and could not, reveal the abnormality in the aileron control system. Upon boarding the aircraft, the captain went through his cockpit check list. This included moving all controls to ascertain if they moved freely and fully. It did not include a check of the proper direction of control surface travel in relation to the control wheel. This latter check was not then required of flight crews.

Accordingly, take-off was started with the crew unaware of the aileron system being improperly connected.

The Board, after careful consideration of all the facts developed in this investigation, concluded that had the proper functional checks been made by either the mechanic or the inspector, the improper installation of the aileron controls would have been detected. This functional check is a required item in both installation and inspection, with which the personnel involved were well acquainted. All were certificated mechanics and had considerable experience in working on DC-3 type aircraft. Of course, had the company's maintenance procedures been more explicit, it is unlikely that the assembly mistake would have been made.

The crew were regularly scheduled line pilots and according to normal DC-3 flight operating procedures were required to check for free and full travel of the controls only. This was accomplished; however, had they been sufficiently alert while acting as a test crew during the pre-flight inspection of the aircraft, the reversal of the controls should have been detected.

On 3 July 1953, four days after the accident, Western Air Lines, in revision No. 132 of 3 July 1953, of their DC-3 Overhaul (Maintenance) Manual specified that checks be made by maintenance, inspection and flight crews of not only free and full travel of controls, but direction of the control surface travel relative to movement of the cockpit controls.

Probable Cause

The Board determined that the probable cause of this accident was reversed installation of aileron control cables and pulleys, and failure of the inspection department to detect this mistake.

ICAO Ref: AR/304

No. 25

Transocean Air Lines Douglas DC-6A, crashed in the Pacific Ocean on 12 July 1953. CAB Accident Investigation Report No. 1-0052. Released 12 March 1954

Circumstances

The flight departed Wake Island at 0658 hours on 12 July 1953 for Honolulu carrying 50 passengers and eight crew. An IFR flight plan was filed indicating a rhumb-line course to Honolulu at a cruising altitude of 15,000 feet at a true airspeed of 236 miles per hour. At 0829 the flight made its last known radio contact reporting its position as 19° 48' north latitude 171° 48' east longitude, and cruising at 15,000 feet between cloud layers. Since the flight did not report over its next scheduled reporting point, an alert was declared by Wake Island ARTC at 1001 hours. At approximately 0608 hours on 13 July 1953, a considerable amount of floating debris was sighted at 19° 49' north latitude and 172° 25' east longitude. Several bodies were recovered. There were no survivors.

Investigation and Evidence

It is believed that the aircraft crashed approximately 12 minutes after its last position report and about 45 miles east of this position. The daily drift is estimated to be approximately 25 miles westerly. The ocean at this point is about 2 miles deep. No primary structure of the aircraft was recovered; therefore, it was not possible to determine if a structural or mechanical failure of the aircraft occurred in flight. An examination of the recovered bodies and wreckage definitely indicated that the aircraft crashed with a high impact force. On the recovered material there was no evidence of fire in flight.

Inspection of the five life rafts recovered revealed that the one found inflated had become inflated because of impact forces. The other four rafts were damaged and had not inflated when found. None of the six life jackets recovered had been used; all were in working order.

The aircraft had received routine servicing on both the west and eastbound flights. There was no record of any mechanical troubles having been reported by the crew on either of these flights. Interviews with ground personnel at Guam and Wake and an examination of company records revealed nothing which would indicate that the aircraft was unairworthy when it departed Wake Island. All CAA communications facilities were operating normally.

The possibility of sabotage was considered. An investigation which included a security check of every passenger was made by the Board's investigator with the co-operation of the local and federal authorities at Guam. No evidence of sabotage was found.

In aircraft of this general type where the fuel carried aboard is distributed over almost the entire wing span, it is customary for the aircraft designer to utilize the relieving effect of this dead weight in the basic design of the structure. All sequences of fuel loadings and usage are considered and optimum sequence is determined. Accordingly, it is extremely important that the manufacturer's recommended procedures be followed in order that the design limitations will not be exceeded in any particular flight condition. During the investigation this phase of the subject was thoroughly explored. It was determined that the fuel had been properly loaded aboard at Guam in accordance with CAA approved fuel weight distribution charts and instructions and that the crew had been thoroughly trained in the recommended in-flight fuel management procedures.

The synoptic weather on 12 July 1953 was as follows: An elongated high pressure area lay from Wake Island to Honolulu. The crest of the pressure ridge was to the north of the intended route of the flight. As a result easterly winds existed along the route from the surface to high altitudes with the winds at the flight's cruising altitude of 15,000 feet averaging 15 knots. The freezing level was also at approximately this altitude. In this latitude with pressure conditions as described, waves which consist of pressure troughs form in the pressure field aloft and these troughs move in a westerly direction. Where a decided trough exists from the surface to 30,000 feet or higher, the cumulus clouds near the trough build up and form cumulo nimbus clouds and thunderstorms, the tops of which reach 20,000 to 30,000 feet or higher. These are usually accompanied by moderate to heavy turbulence. Although two such waves were present in the pressure field between Wake Island and Honolulu on the day of the accident, only one could have affected the subject flight since the other was east of 180 degrees of longitude. The wave which lay along the route was developing into a high level cyclonic circulation. Cumulus clouds were gradually developing in the vicinity of the flight's path with tops mostly under 15,000 feet but with scattered peaks reaching approximately 20,000 feet. Some lightning was present in these clouds.

Subsequent to the accident and public hearing, the Board received a statement from the captain of a westbound Pan American World Airways flight which was flying at an altitude of about 8,500 feet and approximately 30 miles north of the course of the eastbound Transocean flight. This statement indicated that an extensive thunderstorm area accompanied by heavy turbulence was encountered.

When the captain and his flight crew were briefed by the Weather Bureau personnel at Wake prior to departure, a flight folder was furnished to them. This folder consisted of an aerodrome forecast sheet, cross section profile chart, surface chart, 700 mb prognostic chart and a 500 mb chart. According to the meteorologist, the crew was thoroughly briefed on each of these documents as well as terminal forecasts and pilot's reports. This information indicated that cumulus clouds with tops generally below 10,000 feet might be expected in Zones I and II (170°E to 180°E) with the tops of some clouds reaching 14,000 feet between 175°E and 180°E. In-flight reports indicated and occasional build up to 20,000 feet. No turbulence of importance was indicated.

The fact that the aircraft struck the water with a high impact force indicates that the crew lost control of the aircraft prior to impact. The flight last reported flying at the planned cruising altitude of 15,000 feet and nothing was said in this report to indicate that any difficulty was being experienced.

From an analysis of the weather conditions it appears that the flight probably encountered light to moderate turbulence during the climb to cruising altitude. For the first hour the flight should have been in the clear after which it was reported to have been between cloud layers. Relatively smooth air should have existed unless the flight encountered one of the local thunderstorms which appear to have been located along the flight course. However, there is insufficient information to determine definitely whether the more extensive thunderstorms reported north of the course extended far enough southward to have been intercepted by the subject aircraft. If the flight did penetrate an extensive thunderstorm area or one of the isolated thunderstorms, moderate to heavy turbulence would have been encountered.

Probable Cause

The Board is unable to determine the probable cause of this accident from the available evidence.

ICAO Ref: AR/307

No. 26

Air France Constellation made forced landing on the sea near Fethiye, Turkey, on 3 August 1953. Report 149 Journal officiel de la République française - Annexe administrative, 16 March 1954

Circumstances

The aircraft, on a scheduled flight from Orly to Teheran with stops at Rome and Beyrouth, departed from Orly at 1838 hours GMT and after landing at Rome at 2125 took off again at 2232 for Beyrouth with 8 crew and 34 passengers. At 0210 No. 3 engine broke away from the aircraft following violent vibration. Violent vibrations continued and height could not be maintained. The aircraft was "ditched" 6 miles from Fethiye point, between "Kizil Ada" and "Idris Burnu", and 1.5 miles from the coast.

Thirty passengers and the eight crew were saved; four passengers were drowned.

Investigation and Evidence

The flight was uneventful until 1205 when, at an altitude of 17,500 feet slight vibrations were noticed. However, as the instruments were registering normal conditions, no action was taken. Three minutes later, the flight engineer noticed a 40 point fall in the fuel flow to No. 3 engine. Attributing this to icing, he set the propeller at fixed pitch and turned on the fluid de-icer. The fuel flow rose to its normal value but the vibrations continued without increasing. A few minutes later the flight engineer noted that the fuel flow needle was oscillating between 570 and 620, and that the B.M.E.P. indications were becoming less regular. However, the temperature and manifold pressure remained normal and synchronization was not affected.

At 0210 a violent knocking was heard followed by an explosion, and the aircraft suddenly slipped to the right, rapidly losing 1,000 feet. No. 3 engine was then found to have broken away from the aircraft. The violent vibrations increased, level flight became impossible, and the aircraft began to lose altitude at the rate of 300 to 500 feet per minute. Fearing an airframe breakup, an S.O.S. was sent at 0213 giving the approximate position.

At 0214, No. 4 engine was feathered, it being considered the cause of the vibration. As the vibration continued as before, action was taken to unfeather No. 4 engine but, due to a defect in the throttling device, this was unsuccessful.

At 0215, the height was approximately 12,500 feet. Engines 1 and 2 were operating normally. At the time No. 3 engine broke loose, the aircraft was 70 miles beyond Rhodes, the airspeed was 145 knots and it was decided to proceed to Cyprus for an emergency landing; however, due to excessive vibration, the aircraft was losing height at the rate of 800 to 1,000 feet per minute and it was, therefore, decided to turn on to a heading of 20° in order to reach the coast as soon as possible.

As it was still dark and as the presence of particularly dangerous terrain ruled out any attempt to search for a suitable landing spot, the pilot-in-command decided to ditch the aircraft alongside the coast since height could not be maintained. At 0222, an S.O.S. was transmitted giving an approximate position and all necessary arrangements were made for the ditching. The rate of descent was now 1,000 feet per minute and the vibrations had become so intense that a complete failure of the airframe was feared at any moment.

At 0228, the aircraft was landed without flaps as near as possible to a lighthouse near the coast. With the speed at 125 nm during the flare-out, the aircraft was held with the tail very low at about three metres from the surface of the sea until contact. The effectiveness of the controls as regards vertical, directional and lateral stability during this manoeuvre were respectively good, mediocre, and weak.

In spite of a calm sea and a well executed "ditching", the aircraft which had touched down tail first, was picked up by a swell which it managed to ride without becoming submerged, the aircraft then pitched forward gently, the wing under surface struck the water, and breaking was fast and even. The scene of the ditching was approximately 2 nm from the coast and the lighthouse. After the ditching, the aircraft floated about two hours and then sank. The tail of the aircraft from behind the passenger-loading door broke away 10 minutes after the impact.

In view of the absence of any material evidence (the wreckage of the aircraft sank in about 100 metres of water) the technical investigation was based solely on the evidence given by the crew, the history of previous failures of a similar nature, and history of the parts suspected of failure.

Although the technical information provided by Air France did not definitely prove that any equipment was defective, the circumstances of the accident and its similarity to earlier ones was considered sufficient support in the theory that the breaking away in flight of the No. 3 engine and the loss of control of the No. 4 engine was due to propeller blade failure in No. 3 engine.

The similarity to two previous accidents concerning a DC-6 on 27 August 1950 in Colorado, and a Constellation on 23 March 1952 at Bangkok, in both cases of which the inside right engine broke free in flight following the failure of a propeller blade, indicated similar conditions leading to the present accident.

Probable Cause

The probable cause of this forced ditching was failure in flight of a propeller blade resulting in the separation of No. 3 engine from the aircraft and the loss of control of No. 4 engine. The cause of the blade fracture cannot be determined.

Rescue Operations

The rescue and evacuation operations were largely facilitated by the coolness and excellent discipline of the crew and the non-technical personnel on board; the hostess' control over the passengers was such that at no time was there any panic inside the cabin.

All instructions regarding allocation of tasks and stationing of flight personnel were scrupulously carried out. Panic was thus avoided and the aircraft was completely evacuated within 10 minutes.

The first mechanic left the aircraft by the forward left cabin emergency exit, since exit through the crew door was no longer possible; the co-pilot and the pilot-in-command followed the same route and took shelter on the left wing.

The radio operator, the hostess and the two stewards were stationed at the passenger loading door and helped the passengers to leave the aircraft. The hostess' instruction not to break the seals on the bottles of CO_2 serving to inflate the life jackets until outside the aircraft was followed by all the passengers. The radio operator got into the water and made sure the seals were broken.

As soon as evacuation was completed, the radio operator, who was an excellent swimmer, received permission from the pilot-in-command to leave the wreck in order to seek help.

Later a few passengers and the crew members started to swim, some towards the coast and others towards the lighthouse; some remained in the water for several hours; in the end, only the pilot-in-command of the aircraft, the co-pilot and some ten passengers were left with the aircraft.

The pilot and co-pilot were on the left wing with some of the survivors; the hostess was on the right wing with one passenger and her baby. The pilot-in-command lit the electric lamps on the life jackets and the survivors signalled in the direction of the lighthouse while awaiting rescue.

A few minutes later, the first pilot noted that the fuel was spreading beyond the trailing edge of the left wing; fearing that this might hamper evacuation, he ordered everyone to leave the wreckage.

This order was not followed entirely and immediately because some of the passengers were afraid to get into the water.

The pilot-in-command, the co-pilot and the mechanic and some passengers got into the water and reached the coast after about an hour of swimming.

A small boat rowed by the lighthouse keeper reached the scene of the ditching shortly after the aircraft sank. The hostess, the baby she had saved and four passengers including the mother of the baby were taken by the keeper aboard the boat.

As soon as he returned to the lighthouse the keeper notified the port authorities.

By this time it was daylight. The authorities arrived in a motor boat and picked up some of the survivors. This motor boat and another boat remained in the area for about an hour and picked up several passengers who were still swimming.

While swimming towards the coast with other persons and crew members, the radio operator saved a passenger who was in trouble; all those who reached the shore were picked up by the motor boat and the other boat.

Ashore, the crew counted the survivors: four passengers were missing - their bodies were found floating, wearing inflated life jackets and they were picked up by the motor boat and sailors from the port of Fethiye.

ICAO Ref: AR/300

No. 27

United Airlines Inc. and American Airlines, Inc., Convair aircraft, collided over Michigan City, Indiana, 26 August 1953. CAB Investigation Report No. 1-0067. Released 26 April 1953

Circumstances

At about 1917, 26 August 1953, a United Airlines Convair 340 and an American Airlines Convair 240,* both operating in scheduled passenger service, collided at approximately 10,800 feet altitude in the vicinity of Michigan City, Indiana. A hole was torn in the fuselage of each aircraft and instantaneous decompression occurred in both. One passenger of United indicated that he had a neck injury; no other occupant of either aircraft was injured. Both aircraft made emergency landings, United landing at South Bend, Indiana, and American landing at Chicago Midway Airport.

Investigation and Evidence

Evidence indicated that United's flight 314 took off runway 22L of Chicago Midway Airport at approximately 1858 on a VFR flight plan to Cleveland, Ohio, via airways Red 12, Red 55 and Green 3. Cruising altitude was to be 11,000 feet. There were 27 passengers and three crew. The captain and first officer of the United Airlines aircraft stated that after takeoff, they climbed straight ahead and reduction to climb power was made at 400-500 feet altitude. Climb was continued on this heading for about another one-half minute, when a left climbing turn to a southerly heading was made and another left climbing turn to an easterly heading was made at about 2,000 feet. The aircraft was then climbed on a 90-degree course across the lake shore and the southern tip of Lake Michigan. The course was modified to 100 degrees while crossing the lake and at about 9,000 feet, in order to proceed toward Goshen, Indiana, with the intention of passing slightly to the south of South Bend. Reaching the top of the haze level at about 9,000 feet, the captain shortly thereafter put the aircraft on automatic pilot and continued to climb to 11,300 feet, then descended at approximately 500 feet per minute to establish cruising speed. The descent was discontinued upon reaching 10,800 feet, and the flight leveled off. During part of the descent and the subsequent level flight the first officer was in the process of setting up cruise power. While cruise power was being set by the first officer in level flight, the captain caught a glimpse of the other aircraft in front of him an instant before collision and, in an effort to pass under American, rolled the pitch control of the automatic pilot forward, almost at the moment the two aircraft made contact. The top of United's fuselage over the right side of the cockpit struck the lower portion of American's fuselage slightly forward of the tail group as United passed under the climbing American aircraft from left to right. An attempt was made to declare an emergency, but the radio was inoperative due to collision damage. The United aircraft remained fully controllable, and a normal landing was accomplished at South Bend.

Evidence further indicated that at the time United took off, American airlines flight 714 was in run-up position immediately adjacent to Runway 22L. The captain had filed a VFR flight plan via airway Red 12 to cruise at 11,000 feet to Willow Run Airport, Ypsilanti, Michigan. There were 3 crew and 24 passengers. Both flights had the same scheduled departure time - 1845 - but were slightly late owing to passenger delays.

The precise departure time of American could not be positively established; the first officer (sitting in the right seat) made the take-off probably within one or two minutes after United's departure. He stated that a left climbing turn was made after climbing straight ahead to an altitude of 1,000 feet and the turn was discontinued upon reaching a heading of approximately 90 degrees, but climb was continued as the aircraft crossed the southern tip of Lake Michigan. He planned to overhead the South Bend radio range prior to changing course. The aircraft was still climbing when the collision occurred. Instantaneous decompression followed, but the aircraft was fully responsive to controls. An emergency was immediately declared by radio at

* Hereafter referred to as "United" and "American".

about 1917 and the aircraft returned to Chicago Midway Airport. The captain took over the controls near Chicago and landed without further incident.

Early in the investigation it was disclosed that the take-off time reported indicated a take-off sequence which was at variance with information given by two air traffic controllers, the pilots, and an American passenger. American's communications office received a message from Flight 714 reporting that they were off the ground at 1857; this message was time-stamped as having been received at 1902. United's communications records reflected that their Flight 314 reported being airborne at 1858 and the message was time-stamped 1900. Thus it appeared, from the content of the messages, that American took off first. On the other hand, one controller stated that he cleared United into take-off position at 1856, observing the time, cleared United for take-off at 1857, and changed positions with another controller when United was in its take-off run. When he cleared United for take-off, the controller noted there was an American Convair "sitting behind the United on the ramp". The second controller took over the local control position at 1857 and estimated that he cleared American for take-off at 1901. He did not observe the time he took over the position, nor the time he cleared American for take-off. No other aircraft took off between the two flights involved. Both flights were on VFR flight plans. The tower does not make tape recordings in VFR weather, nor do the controllers keep any log on aircraft movements under VFR conditions. The two controllers were positive that the two flights they cleared were United Flight 314 and American Flight 714.

The United captain testified that as they turned from run-up position onto Runway 22L, he observed an American Convair behind them. When United arrived at run-up position, there were no aircraft ahead of them. Further, he did not recall seeing any other aircraft behind the American Convair. Just after he applied take-off power, he overheard an American flight requesting clearance into take-off position, and some time before leaving tower frequency heard this American flight cleared for take-off.

The United first officer stated that while they were taxiing to run-up position, he did not hear or see any American Convair takeoff. No other aircraft preceded them in take-off. He testified that he saw an American Convair behind them as they moved into take-off position, and during their take-off run heard an American Convair cleared into take-off position. He did not hear this aircraft cleared for take-off. The first officer stated that he transmitted the message relating to take-off time about one and one-half minutes after becoming airborne, but he did not recall having looked at the aircraft's clock or his watch at that time.

American's captain testified that they were delayed about eight minutes by another aircraft ahead of them in the "number one spot warming up". He did not know what make aircraft it was nor the company which operated it. He did not see this aircraft takeoff, as he was engaged in preflight checks. American's time of take-off was transmitted to company communications by the captain. He testified that the transmission was made about five minutes after becoming airborne, when they were about over the lake shore.

The American first officer saw an aircraft precede them into take-off position, but he was unable to further identify it. He did not recall if there were any other aircraft waiting behind them.

An American passenger sitting on the left side testified that he saw no other aircraft behind the American flight; however, the one aircraft which preceded them in take-off was described by him as a United twin-engined aircraft which he tentatively identified at the time as a Convair or Martin, but definitely not a DC-3.

Company records of both airlines relative to aircraft departures and arrivals were checked by a Board investigator. No American Convair other than the flight involved tookoff in the immediate pertinent period; United had no other Convair take-offs; therefore the two aircraft involved could not be confused with another flight operated by either company. It was found that no arriving aircraft was parked in the vicinity of aircraft standing by for take-off.

The United pilots testified that an indicated airspeed of 135-140 knots (155-161 mph) was maintained from shortly after take-off until the peak of the climb (11,300 feet). In the descent, speed built up to 170 knots (196 mph) with a rate of descent of about 500 feet per minute until leveling off at 10,800 feet. The first officer seated on the right side, stated that he looked to the right after the captain gave a hand signal to reduce to cruise power during the descent. Seeing no other aircraft, the first officer directed his attention within the cockpit and began setting up cruise power, and was so engaged at the time of the accident. He estimated that the time interval during which he was changing power was approximately 30 to 45 seconds. Indicated air speed remained at about 170 knots.

The captain testified that he was alert for other aircraft during the flight, but saw none until an instant before the collision. The first officer testified in the same vein, except that he did not see American in flight at any time before the accident. Both pilots of American similarly testified that they were vigilant but did not see United at any time before collision. The pilots of both aircraft stated that they were not engaged in duties during climb which diverted their attention from outside the cockpit for more than a few seconds at a time.

The first officer, flying from the right, stated that he climbed American's Convair at 500 feet per minute with an indicated air speed of 180 mph (156 knots)* to the 10,000-foot level, whereupon air speed was reduced to 170 mph (148 knots). The aircraft was still in climb when the collision occurred.

Three United passengers in window seats on the right side aft of the wing testified that they saw the other aircraft off to their right shortly before the collision. One of these stated she saw American for an estimated five or six seconds and that it was initially slightly above, ahead and "only yards away" to the right. Further than this, she was unable to give an estimate of the lateral or vertical separation of the two aircraft. The outlines of American were clearly discernible but she was not sure that she saw any position lights. The two aircraft converged at an acute angle, and American was lost to her sight a few moments before collision. Signed statements of three other United passengers indicated that they saw the tail position lights of American a moment before impact.

A passenger on American, an aeronautical engineer, was in the second window seat from the front, left side, and testified that he saw United off to the left at about the 8 o'clock position (left and rear), several hundred feet higher, perhaps a mile away, and apparently in descent. American was continually in climb, to the best of his knowledge. He tentatively identified the other aircraft as a Convair upon first seeing it and thought that it would pass well to the rear and under American. He initially saw the right front quarter of the other aircraft, but owing to convergence of their courses, this changed to almost a head-on view just before collision, with United closing on American from the left and rear. He estimated that the longitudinal axes of the two aircraft were inclined toward one another about 10-15 degrees during the period of closure. It also appeared that the other aircraft was in level flight prior to collision. He estimated that he had United in sight for perhaps two minutes; about three to five seconds before the accident, he believed that collision was inevitable. It seemed to him that United's speed was greater before collision.

Of the other American passengers, two indicated that they caught a glimpse of lights or metal of the other aircraft to their left an instant before collision.

The accident occurred during the twilight period about 35 minutes after sunset and 10 minutes after moonrise, corrected for the 11,000-foot level over Michigan City. It was dusk, as civil twilight ended about three minutes before collision, but the western sky was still lighted to a considerable degree.

Neither crew knew that another company had a flight operating at the same scheduled time, over the same route. The cruising altitude selected by each captain was a coincidence.

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* United's air speed indicators were calibrated in knots; those of American in miles per hour.

As both aircraft were on VFR flight plans, CAA Air Route Traffic Control was not responsible for providing en-route separation.

Investigation revealed that the required position lights on both aircraft were in the "flashing" position from time of take-off. Neither aircraft was equipped with a high-intensity rotating anti-collision light, but both companies were in the process of equipping their fleets with it.*

U.S. Weather Bureau reports reflected that the haze was relatively light and the top of the haze in the Chicago-Michigan City area was between 9,000 and 10,000 feet. The pilots also testified that the haze was light, and that it did not appreciably affect their ability to see several miles. The United pilots stated that the top of the haze was reached at about 9,000 feet, while the American pilots noted that they passed above the haze at about 10,000 feet. Ceiling and visibility were unlimited above the haze.

Occupants of both aircraft were in general agreement that impact was not particularly severe. This was borne out by examination of the relatively moderate structural damage to both aircraft. Damage to each aircraft was examined with the primary view of determining the relative positions of both at the instant of impact.

The right front top section of the cockpit of United's Convair 340 was partially flattened, and the skin was crumpled. The right clear-view cockpit window, located between the right front windshield and the first officer's side window was "crazed" over its entire area, but the glass remained intact in the frame. Scuff marks on the upper skin of the fuselage were at an angle of approximately 43 degrees, measuring clockwise from the nose and relative to the fuselage centerline. The crushed area extended rearward 32 inches, at which point the top skin began tearing from the aircraft. A strip of top fuselage skin and sections of several stringers several feet long were torn free of the aircraft. As the fuselage skin was ripped, it ruptured outward as a result of instantaneous decompression. The ILS, VHF and HF radio antennas were torn off. The left wing skin of the United aircraft had a gash approximately two feet outboard of the landing light and about five inches above the leading edge centerline. A deep gouge was found in the leading edge of one blade of the left propeller as a result of impact with a flying metal object. No other propeller or power plant damage was found. Lighting and radio wiring in the cockpit was severed. The cockpit, front cabin, and lavatory doors were torn from their hinges by decompression forces. Sections of the removable aisle flooring were lifted and displaced, but were held in their generally normal position by the floor carpet. Other damage in the cabin area was minor.

Impact damage to the American Convair 240 extended along the lower surface of the fuselage from the forward edge of the left rear service door rearward 154 inches. The hole across the fuselage measured 86 inches at its wides point. Four bell formers were torn, twisted, bent, and compressed upward. Three fuselage formers aft of the skin puncture were bent and broken. The passenger cabin was not damaged. Collision left a scuffed area impregnated with blue paint or lacquer in the general area of the hole in the fuselage. The abrasions made diagonal lines which were consistent in direction; the angular measurement of these lines relative to the aircraft centerline was 116 degrees, measured counterclockwise. The angle of convergence of the two aircraft at the moment of collision was therefore about 21 degrees. The ragged edges of skin were forced outward by decompression.

None of the propellers contacted any airframe structure; damage to both aircraft was caused by contact of the two airframes alone.

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* In order that operators could evaluate more thoroughly this and other systems of aircraft exterior lighting, the Board promulgated Special Civil Air Regulations Nos. SR-361 effective 1 March 1951, SR-390 effective 1 January 1953, and SR-392 effective 16 May 1953. A notice of proposed Rule Making was also circulated to the industry on 10 November 1953 which would require installation of anti-collision lights to be used between sunset and sunrise, on all aircraft over 12,500 pounds maximum certificated gross weight not later than 30 September 1954. A decision on the proposed amendment to pertinent parts of the Civil Air Regulations will be made at a later date following consideration of all comments.

Examination of both aircraft and their maintenance records disclosed no evidence that either aircraft was not airworthy at take-off. The records indicated that the gross weights of the two aircraft were less than the authorized maximums and that the useful loads were properly distributed. The pilots testified that no malfunctions were experienced prior to the accident. Both companies, their aircraft, and the pilots were currently certificated.

Cockpit visibility photographs, showing the field of vision available to each of the four pilots, were taken. A special panoramic camera was so positioned in each of the four instances that its two lenses were at the level of the individual pilot's eyes.

The United captain, from his particular seat position, could see about 90 degrees to the right from dead ahead, at which limit he could see 10 degrees down and 5 degrees up.* The glare shield caused a considerable obstruction to downward and forward vision, varying from a maximum 13 degrees down from dead ahead to a minimum of 5 degrees where a line of sight across the right edge of the glare shield would pass through the first officer's clear-view window. The compass housing also offered a restriction about 10 degrees wide; the top of the housing was about at eye level.

The United first officer, without moving his body could see to the right about 25 degrees aft of abeam. At the rear still of his side window, the limits were about 20-25 degrees down and 12 degrees up. His maximum downward visibility from this seat position was 37 degrees, at the mid point fore and aft of the bottom sill of his side window. His maximum downward angle through the clear-view window was about 30 degrees.

The American captain, from his seat position would have been able to see about 105 degrees to the left from dead ahead and at the rear sill of the left side window, about 20 degrees up and 20 degrees down. Seventy-five degrees left of dead ahead (left side window), he had a range of 30 degrees either up or down. The range would have been at a minimum when 15 degrees left of dead ahead, the limits there being 25 degrees up and 12 degrees down.

The American first officer could see 95 degrees to the left of dead ahead. At the rear sill of the captain's side window, he would have been able to see upward only about 5 degrees from eye level and 10 degrees downward. Looking through the captain's forward windshield, he would have had a range of 7 to 12 degrees upward, owing to the shape of the windshield, and could have seen downward 6 to 8 degrees. From his seat position, the compass housing was about 8 degrees wide and the top was just below his eye level. He could see about 27 degrees upward and 15 degrees downward when looking straight ahead through his own forward windshield.

The training programmes of both companies and the training given to each pilot were examined during the course of the investigation. As a result of this review, the Board has no criticism of the programmes or training given to the pilots involved.

Analysis. - Although there is a question as to the exact time each aircraft departed Chicago, evidence indicated that United tookoff first and American followed a short time later. In considering the evidence regarding the initial lead of United, it is believed that the flights tookoff within one or two minutes of each other. Therefore at the time American tookoff, United had an appreciable lead in altitude and total distance traversed, with both proceeding toward South Bend.

American cut down the lead and west of Michigan City, passed to the right of United but at lower altitude. United then closed the gap created by American's passage, since the speed United

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* The visibility angles given above are approximate, as there are variations at any point due to the shape of the windows and objects which obstruct portions of the panes; further, these angular limits do not give consideration to the restriction offered by the other pilot. These values are restricted to the particular eye level of the individual pilot, and if the body were moved, the above figures would not be valid for the new situation. The attitude of the aircraft also affects the field of vision at any given time; e.g., the downward field of vision is increased when an airplane is diving.

built up in descent and maintained in the short period of level flight exceeded American's speed. Since United had the greater speed for such a short period of time, the American flight could not have moved very far ahead.

There are many factors to consider in analyzing this accident, such as visibility in haze, the twilight condition, improved natural light as both aircraft climbed, conspicuity of both in the twilight period during climb, the effectiveness of the aircraft position lights, vigilance of the pilots, cockpit visibility, and relative positions of the two aircraft at various stages of their flights. Considering the amount of separation when at the lower altitudes and in the haze, the Board would hesitate to state that United could have been sighted by American's pilots (and vice versa) during their climb through the haze. However, after careful consideration of the evidence, the Board must conclude that had the pilots of both aircraft been maintaining the proper lookout, especially after passing above the haze level and when the separation of the two aircraft lessened, one or more of the pilots should have been able to see the other aircraft in sufficient time to alter course before the situation became critical.

Study of United passenger statements and cockpit visibility photographs indicated that the American captain should have been able to see United before he drew abreast, by looking off to his left, upward, and forward, since United was within his normal forward field of vision. He should also have been able to see United when American was abreast since he, like the United passengers, had a practically unobstructed view to his left. It is also possible that the American first officer could have seen United as they passed, although United could conceivably have been in a blind spot to him owing to the roof of the cockpit. Up to the time American passed, had its pilots seen United, it would not necessarily have caused them any concern or necessitated a radical change in heading since it would not have appeared to them that the aircraft were on converging courses; however, they would have known that another aircraft was in the same area and proceeding in the same general direction.

After American drew ahead, it became increasingly difficult for its pilots to see United. The American first officer, in the right seat, could not have seen it for long, if at all; the American captain would have been able to see United for a time, but would have found it difficult, if not impossible, to see United as the two aircraft converged in the last moments before collision.

At the time American drew abeam of United, the United first officer should have been able to see the other aircraft to his right at slightly lower altitude, had he been exercising proper vigilance. When he scanned the area just before setting up power, American was a little lower, somewhat to the right, and probably slightly ahead; he should have been able to see it at that time; after this his attention was directed within the cockpit.

The United captain seemingly had an opportunity to see American, both during descent and level flight. American was ahead, below, and to the right. The courses were converging and American was climbing. This combination of convergence and climb resulted in American progressively getting in a more difficult position to be seen by the United captain. In addition, no clear line of sight was available to him, as was the case with the American passenger who looked back with an unobstructed view of the United to the left, rear and above for the captain's seat was adjusted to a low position and the glare shield and forward fuselage structure restricted his view downward and to the right. Therefore, paradoxical as it might seem, American had to be at or near his level before he could, with certainty, have seen the other aircraft in the final period of level flight when the two aircraft were converging in both the vertical and horizontal planes.

Since the collision occurred at dusk there was less natural light available and the two aircraft were not as conspicuous as in full daylight; aircraft lighting was not as effective as it would have been a little later during the hours of darkness; further, cockpits are products of design compromises and blind spots are not completely eliminated. Nevertheless, the circumstances of the passage were such in this case that all of the pilots should have been able to see the other aircraft at some time; the American pilots prior to the time they passed ahead, the first officer of United at least when American was abeam and until he set up power and the United captain when the American was abeam to slightly ahead.

During VFR flight, pilots alone are responsible, under Civil Air Regulations, for maintaining separation from other aircraft. Therefore, the Board cannot find but that both American and United were responsible, in different degrees, for the situation which resulted in the collision, as they apparently did not exercise the highest degree of care.

It would have been desirable for the companies to have provided a means by which their pilots were advised of flights by different carriers scheduled to operate over the same route, at the same altitude, and at the same time.

For many years the standard method of making aircraft distinguishable under limited visibility conditions or during the hours of darkness had been by use of navigation lights. In the past decade, it has been recognized that conspicuity of aircraft during the hours of darkness could be inproved and indeed has been improved, through regulations promulgated by the Board, to provide greater conspicuity. Experiments in recent years have pointed to the desirability of adding a high-intensity rotating light to the flashing position lights. Evaluation of this light has shown that safety in flight can be materially increased if aircraft are so equipped. At the present time installation of the high-intensity rotating (or anti-collision) light is made by the operator on a voluntary basis. The voluntary programme has indicated relatively unsatisfactory progress. Accordingly, a proposed change in Civil Air Regulations in presently under consideration.

This proposed change is one of the projects under active consideration in the prevention of air collisions. Items such as improved cockpit visibility, the reduction of cockpit duties that tend to distract the attention of pilots from maintaining the necessary lookout to keep clear of other aircraft, the feasibility of aircraft separation at higher altitudes by traffic control, and examination of pilot incident reports, are also under active study by the appropriate governmental agencies in collaboration with the aviation industry.

Probable Cause

The Board determined that the primary cause of this accident was the failure of the United crew to observe and avoid the American aircraft while overtaking it on a converging course from the left and rear. However, the American crew demonstrated a lack of alertness in not observing United prior to passing and while abeam.

ICAO Ref: AR/311

No. 28

Regina Cargo Airlines, Inc. Douglas DC-3, crashed near Vail, Washington, 1 September 1953. CAB Accident Investigation Report No. 1-0071. Released 22 January 1954

Circumstances

The aircraft took off from Monterey, California, at 1408 hours on 1 September 1953 on an IFR flight plan for McChord Air Force Base, with 19 military passengers and two crew. At 1820 the flight cancelled its IFR flight plan, advising that it would complete the trip on VFR with an estimated time of arrival over Toledo at 1842. This was the last radio contact with the aircraft which crashed 26 miles short of its destination. There were no survivors.

Investigation and Evidence

The flight's estimated ground speed from Portland to Toledo was 164 miles per hour and the crash scene is 16 miles north of Toledo and about 26 miles short of the destination. A continuation of the same course at this ground speed indicated a crash time of 1848. The hill struck is the highest point between Toledo and McChord Air Force Base and is approximately 3,000 feet above MSL. The aircraft struck in level flight at approximately the 2,600-foot level on Airway Amber 1. At the time of impact the heading was 360 degrees magnetic while the airway's course is 355 degrees magnetic. Investigation revealed that both the captain and the co-pilot had flown over the region several times during the past few months, and that the aircraft and captain's flight kit contained aeronautical charts of the region which show elevations along the airway.

The weather was generally overcast with layers of stratus clouds with a 4,500 foot ceiling reported in the Portland area, lowering to 1,500 feet at McChord Air Force Base. Fifteen miles west of the crash, there were breaks in the overcast through which the aircraft could have descended contact. The actual 1730 weather conditions given to the flight by Portland radio while over Portland were, Portland, 4,800 feet measured, overcast, visibility 15 miles, altimeter 30.05 inches; - Toledo, 2,200 feet estimated, broken clouds, overcast at 3,500feet, visibility 20 miles, altimeter 30.08 inches; - McChord, scattered clouds at 1,500 feet, overcast 3,000 feet, visibility 1-1/2 miles, very light drizzle, altimeter 30.06 inches. Temperatures were high enough to preclude wing ice formation in flight.

An Air Force pilot was flying a small civil aircraft northbound from Eugene, Oregon, about 100 miles south of Portland, to Tacoma at about the time of this Accident. Actually he passed over a point about 15 miles west of the accident site at about 1800, about 45 minutes before the accident. He described the weather in the direction of the site as fog and showers on the hill tops. This pilot was well qualified and he was familiar with the terrain near McChord Air Force Base. He offered the opinion that visual flight from the crash site to McChord would not have been possible at that time. His flight was entirely visual and he was able to see the ground at all times from his altitude of about 1,000 feet MSL. However, because of the low ceiling and visibility he landed at an airport a few miles to the west of where he had intended to land, a small airport near McChord. The ground witness, a workman about half a mile away on the opposite side of the ridge when the aircraft crashed and who heard the noise of impact, described the weather at the time as rain with clouds on the trees.

Examination of the engines and propellers indicated power development and inspection of the propeller domes revealed a cruise pitch position of the blades at the time of impact. The gross weight of the aircraft at time of take-off was 25,052 lbs; its allowable weight was 25,346 lbs. The aircraft's C.G. was located within prescribed limits. There was ample fuel aboard.

There appears to be factor entering into this accident other than an attempt to fly visually at too low an altitude during instrument weather. Between Toledo, which was about 16 miles south of the crash site, and McChord, about 26 miles ahead of it, the ground on the airway is relatively low, except at the crash site. There a ridge of high land projects westward from much higher land to the east, and not only extends into the airway, but crosses it. It was close to the summit of this range where the aeroplane struck.

A logical surmise, therefore, as to just what caused the pilot to be so low is that he must have believed himself to be somewhat closer to his destination than he actually was, and was attempting to fly visually in intermittent instrument conditions. Had he been a few miles farther to the north, he could have continued level or even made a descending flight to McChord without encountering any obstruction. At the time that the aeroplane struck, it is highly likely that the hillside was entirely obscured by cloud, so that it would have been impossible to fly by visual reference. Moreover, the captain did not ask for a change of flight plan back to an assigned instrument altitude which would have allowed the flight to proceed safely.

Furthermore, had the captain referred to the aeronautical charts, which were on board and readily available prior to or at the time the flight plan was changed to VFR, he would have had knowledge of the height of the terrain and any prominent elevations between Portland and Tacoma, particularly beyond Toledo. Either the captain did not refer to those charts or he relied upon his knowledge of the terrain, possibly believing that he was beyond the ridge.

The 1830 weather transmitted on range frequencies at about 1845 gave McChord conditions, including the altimeter setting, about the same as at 1730. The weather was not conducive to abrupt pressure changes. There is no way of ascertaining if the captain received this last information.

Probable Cause

The Board found that the probable cause of this accident was the pilot's attempt to continue flight under the provisions of Visual Flight Rules during instrument conditions.

ICAO Ref: AR/302

No. 29

Northwest Airlines, Inc., Lockheed Constellation, burned following an emergency landing at McChord Air Force Base, Tacoma, Washington, on 6 September 1953. Civil Aeronautics Board, Accident Investigation Report No. 1-0073. Released 19 July 1954

Circumstances

The flight departed Seattle-Tacoma Airport on a scheduled flight to Chicago, Illinois at 0148 hours with 26 passengers and six crew. Just after take-off No. 3 propeller oversped. Attempts by the flight engineer to correct this condition were unsuccessful and feathering was started. The propeller continued to rotate at 400 rpm. Upon reaching 5,000 feet No. 4 engine had to be feathered owing to severe loss of oil and an emergency was declared and an immediate forced landing at McChord Air Force Base was decided upon. The flaps would not extend hydraulically and only 15-20 turns manually, and only the right main gear extended fully and locked down. On landing the aircraft veered off the runway to the left and burst into flames. Previously alerted fire apparatus already standing by, kept the fire from spreading while all passengers and four of the crew left quickly by the main cabin door, the door sill being five or six feet above the ground. The captain and flight engineer left by the cockpit crew door after ascertaining that the cabin was empty. All 32 occupants were clear within an estimated two minutes. There were no fatalities although several persons were treated for burns. The aircraft was practically destroyed by fire.

Investigation and Evidence

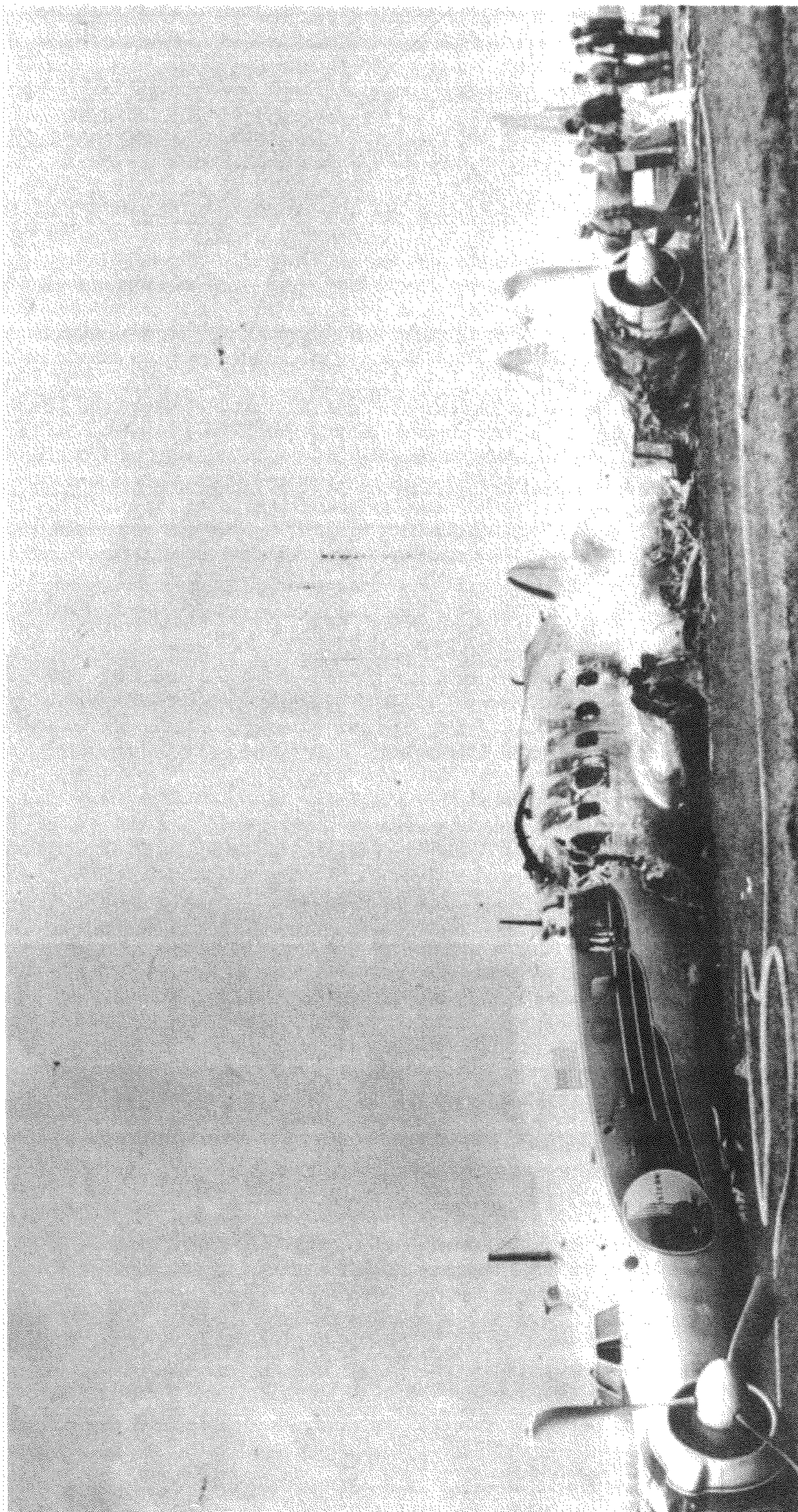
The weather at Seattle-Tacoma Airport during take-off was: ceiling 200 feet, 1/4 mile visibility. The gross weight on take-off was 105,839 pounds; maximum allowable for take-off 116,740 pounds; maximum allowable for landing 98,500 pounds. Examination of the burned aircraft and subsequent tests revealed the following:

Two of the legs supporting the oil seal front adapter of the No. 3 propeller shaft had fractured and the fragments of metal from this failure had penetrated the governor pad oil screen with the failure occurring at the oil inlet passage. This allowed the passage of metal particles into the governor oil passages and valves. Foreign material holding open the low pressure relief valve would cause loss of propeller control.

Of the 40-gallon oil supply for No. 4 engine at the time of take-off only about two gallons remained. The reason for this depletion could not be determined. Tests with the same power-plant, both on a test stand and in the air mounted in a similar aircraft in the same (No. 4) position, with the oil adulterated with increasingly large amounts of water, failed to produce foaming or abnormal oil depletion.

Examination of the wing flap hand cranking mechanism revealed no failure or malfunction which could have produced the reported binding and prevented hand cranking movement beyond 15 or 20 turns at the time of attempting emergency extension. Whatever obstruction may have been present, if any, must subsequently have been removed, for the wing flaps were found hydraulically extended approximately 8 inches (approximately 100 turns of the crank).

For better understanding of the operation of the wing flaps and landing gear, it is desirable at this time to describe briefly the hydraulic system of the aircraft in question. Each of the four engines drives a hydraulic pump. Those on Nos. 1 and 2 engines furnish jointly (or individually in the event of failure of either No. 1 or No. 2 engine) hydraulic pressure to supply boost for the aircraft's flight controls, and for certain other purposes. This is known as the primary hydraulic system.



Pumps on Nos. 3 and 4 engines furnish jointly (or individually in the event of failure of either No. 3 or No. 4 engine) hydraulic pressure to effect wheel braking, nose-wheel steering, wing flap motion, landing gear extension or retraction, and for certain other purposes. This is known as the secondary hydraulic system. It can supplement the primary hydraulic system, but the reverse is not possible. If Nos. 3 and 4 engines are inoperative, there is no means of obtaining nose-wheel steering; wing flaps must be cranked down manually, and the landing gear must be lowered with the hydraulic hand pump. It is therefore apparent that the only source of pressure available in the secondary system of the aircraft during its emergency was the hydraulic pump driven by the windmilling No. 3 engine. The result was an abnormally low volumetric output.

A small internal leak was found in the landing gear selector valve when in the "neutral"" position. The leak was caused by an improperly seated poppet valve which permitted flow from "pressure" port to "down" port. Since the "down" port is connected internally to "return" port when selector valve is in "neutral" a leakage path was provided between pressure and return lines. This leakage at the landing gear selector valve prevented normal flap extension, due to insufficient hydraulic pressure.

With the flap control remaining in the "take-off" position and with the flaps retracted, the existing hydraulic pressure of 1,000 to 1,000 psi, and the reduced output of the No. 3 pump, an abnormally slow extension of the landing gear resulted.

It would have required an estimated two or more minutes to extend and lock all three landing gears and extend flaps to "take-off" position, with the small quantity of hydraulic fluid being pumped by the windmilling No. 3 engine. It was only approximately 30 seconds from actuation of the landing gear control for gear extension to the touchdown.

An extension of the landing gear prior to breaking out of the overcast was not attempted due to the captain's decision to keep the aircraft's drag to a minimum during the instrument approach with two engines inoperative on one side. The windmilling No. 3 propeller was producing added drag. Once below the overcast, when he attempted to extend the landing gear, only the right main gear extended and locked. The left main gear and nose gear extended, but not far enough to lock in the down position and were forced upwards by contact with the runway.

There was no evidence of structural failure in the airframe, or control malfunctioning, prior to impact, nor any indication of other than normal operation in Nos. 1 and 2 power-plants.

In regard to weather conditions during the approach and landing at McChord Air Force Base; the ceiling and visibility were 700 feet overcast and five miles, respectively. These values were in excess of all pertinent minima.

In the analysis of the facts surrounding this accident, it is important to remember that the overall time interval from take-off (at 0148) to crash, was 43 minutes. During the final 20 minutes of flight, emergency factors multiplied rapidly. These were, delay in establishing a usable GCA channel with McChord Air Force Base, inability to extend flaps to take-off position, difficulty of aircraft control, knowledge that the diminished secondary hydraulic pressure meant slow landing gear extension, low ceiling at McChord causing the captain's decision against early gear actuation, and the choice to be made between restarting either No. 3 or No. 4 engine. All these factors placed a heavy burden on mental pressure on the captain. The take-off was under weather conditions such that, although within minima, the flight must have been on instruments at once, shortly before No. 3 propeller gave trouble. After unsuccessful attempts to control its overspeeding, only partial feathering was accomplished due to structural failure in the propeller control. Fifteen minutes later, after the aeroplane had reached 5,000 feet, No. 4 propeller was feathered because of drastic oil loss from No. 4 engine.

The crew was then faced with the process of establishing a usable frequency for GCA communication and performing the requirements for an instrument approach while hampered by an unusual combination of mechanical difficulties. Some time was consumed working through the McChord tower in settling upon the emergency frequency of 121.5 with which the aircraft was equipped.

Prompt and commendably efficient action by airport crash personnel enabled the flight crew to take immediate correct measures for getting the passengers out of the aircraft. Conditions were critically hazardous, with fire surrounding the aircraft and the constant possibility that it would spread or that an explosion would occur. Weather was an important factor in the accident. Conditions at the take-off point (ceiling 200 feet - visibility one-fourth mile) prevented an immediate return after shutting down No. 3 engine.

The captain testified that he decided not to dump fuel for the emergency landing at McChord, due to the fire hazard during necessarily continuous radio operation with GCA, as well as the time element involved. The CAA-accepted manual requires that all radio equipment and all unnecessary electrical equipment be turned off while dumping fuel. With reference to the unsuccessful attempt to increase hydraulic pressure by unfeathering No. 3 propeller during final approach, rather than No. 4 propeller, the captain stated that he decided against the latter because of the danger of engine fire or other hazard that could result from the nearly exhausted oil supply for that engine.

The captain testified that he elected not to lower the landing gear earlier because of the increased drag and the resultant adverse effect on aircraft performance. He said he chose not to put it down prior to breaking out of the overcast because there was no possible way of retracting it even if a go-around had been possible. Shortness of time precluded manual extension of the landing gear, since this is a rather lengthy process requiring several hundred pump strokes.

Following this accident the manufacturer of the aircraft issued a Service Bulletin recommending that certain changes be made in the hydraulic system of Constellations now in service and prepared the necessary changeover kits, and the company will incorporate these changes in all future Constellations. The change, in brief, allows the flight engineer to draw hydraulic pressure from the primary system for the secondary system.

Probable Cause

The Board determined that the probable cause of this accident was a sequence of mechanical failures resulting in an emergency landing under adverse weather conditions with insufficient hydraulic pressure in the secondary system to extend fully the landing gear in the time available. A contributing factor was the design of the hydraulic system which did not permit use of the available pressure in the primary system for that purpose.

Fire Aspects (Excerpts from the NFPA Quarterly, January 1953)

Air Base Fire Department equipment had been alerted by the control tower and was on stand-by duty when the aircraft touched down. Gear failure followed dropping the left wing to the runway and ultimately dragging the aircraft off the pavement. A large spill of fuel occurred simultaneously with the impact and at least 3,500 of the 4,300 gallons of the fuel aboard were consumed in the fire despite prompt fire control.

The combined agent technique of crash fire fighting, recommended by the NFPA in Standard No. 403, was used. Foam was applied by the crash truck turret, in the area of the rear cargo door through which 26 of the passengers made their escape. Hand lines of foam were used around the fuselage door. Low pressure carbon dioxide (6,000 lbs) was used to control the severe fire in the area while two other foam trucks blanketed the burning fuel spills with foam and also blanketed both sides of the fuselage. Additional water supplies were furnished the crash trucks from pumpers relaying from the nearest hydrant 800 feet away. Limitations in personnel and lack of complete radio equipment on the emergency apparatus were handicaps in the full utilization of the available equipment. Tacoma and Lakewood fire departments sent three pumpers and 14 men to the scene. Total time required to accomplish total extinguishment was 30 minutes. Only 2 of the 30 occupants suffered major burns and 21 had no burns at all including the 4 crew members who evacuated through the right front cabin escape hatch.

ICAO Ref: AR/319

No. 30

TACA de Honduras, DC-3 aircraft crashed into mountain 5 kilometers from San Andrés Aerodrome on 8 September 1953. Report by the Directorate of Civil Aviation, Honduras

Circumstances

The flight which departed from San Pedro Sula airport on an extra flight with cargo for the San Andrés Mine, took off at 1242 hours on 8 September. The load was properly distributed with the centre of gravity on take-off, within the authorized limits. At 1316 hours, following the first and only attempt to land at San Andrés Aerodrome, the aircraft crashed into a nearby mountain approximately 5 kilometers from the aerodrome. Fire broke out on impact and the aircraft and cargo were completely destroyed. The three crew, who were the only persons on board, were killed.

Investigation and Evidence

According to witnesses the aircraft began its approach to San Andrés aerodrome at about 3,000 to 3,400 feet. The approach was made on the right hand traffic pattern and landing gear and flaps were lowered. During the final approach and while at an altitude slightly above normal for a landing, the aircraft was nosed down with the apparent intention of getting on the runway. Upon failing to do so, the landing gear was retracted but the flaps left extended, while power was applied to the engines. The aircraft continued to fly the length of the runway maintaining an altitude of about 50 feet above the runway. There were no obstacles on the runway that could have prevented landing.

When the aircraft passed over the TACA Building, witnesses noted that heavy black smoke was coming from the aircraft, the exact source of which they were unable to determine. The aircraft continued its flight toward the narrow canyon to the northeast of the aerodrome and at a spot about 5 kilometers away, where the canyon widens, the aircraft began a sharp 180° turn to the left, presumably with the intention of leaving the canyon in the opposite direction in order to land at one of the nearby aerodromes. The aircraft completed about 150° of the turn but at that point, the steep turn became a sort of spin and the aircraft crashed into the mountainside.

According to available weather reports the meteorological conditions at the time of the accident were generally good: visibility unlimited and little cloud. It was pointed out, however, that there was no accurate wind direction and velocity indicator at San Andrés, and that the reports were drawn up by inexperienced personnel. With the lack of adequate instruments, wind conditions cannot be reported accurately. The wind on that day was rather variable between calm and 10-12 miles from the north. The topographical conditions at San Andrés are such that often there are sudden gusts of air which can only be measured with accurate instruments.

According to the TACA radio operators the pilot of XH-TAR made no contact with ground stations.

Examination of the wreckage disclosed that the cylinder head No. 12 on the right engine was missing. The engine also showed clear signs of having been subjected to intense internal heat with no indication that it had been exposed to the fire following the crash. It was assumed that the right engine failed at some time during the flight.

The inquiry on examining all the facts brought out in the investigation decided that they did not afford a clear explanation for the accident, but a logical reconstruction of the events and a careful analysis of the results of the investigation lead the inquiry to the following conclusions:

It was assumed that engine failure did not occur during the en-route, initial or final approach to land otherwise the pilot would have been left with no other choice but to land since a DC-3 with only one serviceable engine and a gross weight of 25,642 lbs could not get out of the canyon ahead.

Although it appeared to some of the witnesses that the altitude of the aircraft during the approach was high, it was noted that the pilot had, on several earlier occasions during final approach-to-land at this aerodrome, encountered gusts which lifted the aircraft so that it was necessary to dive in order to reach the runway.

It was assumed that the pilot was faced with the same situation on this approach. He nose-dived in an attempt to reach the runway, but realizing that the approach would be too steep to permit a safe touch down on the runway, he prepared to carry out a missed landing procedure.

The assumption that partial engine failure occurred after the attempt to land and that full engine failure did not occur until the aircraft was in the turn appeared valid to the inquiry for the following reasons: the pilot would not have attempted a steep turn such as the one almost completed in the La Bufa canyon with low air speed and a heavily laden aircraft with complete engine failure on one side. The pilot had made this type of turn in the narrow canyon on other occasions, but with both engines operating at maximum power. Presumably, the pilot considered that the malfunctioning engine would last at least until he got out of the canyon. Unfortunately it failed during the turn, precipitating a stall. There was no evidence that the cargo moved during the last turn, however, the enquiry considered that, because of the speed of the manoeuvre, it was possible that some drums of oil and gasoline (part of the cargo) broke the ropes, which were relatively too light to withstand any violent movement thereby aggravating the conditions.

Therefore, it appeared that the cause of the accident was that, on failure in an attempt to land, the pilot endeavoured to regain full power from both engines for missed approach procedure. However, the right engine did not fully respond and sufficient speed could not be obtained to complete as sharp a turn as was necessary to get out of the canyon since it was impossible to obtain altitude to clear the canyon.

Probable Cause

Failure of the right engine when the pilot wished to obtain maximum power from both engines after a missed landing.

ICAO Ref: AR/316

No. 31

American Airlines, Inc. Convair 240 crashed at Municipal Airport, Albany, New York, on 16 September 1953. Civil Aeronautics Board, Accident Investigation Report No. 1-0080, Released 19 March 1954.

Circumstances

American Airlines' flight of 16 September 1953 was a scheduled operation between Boston, Massachusetts, and Chicago, Illinois, with intermediate stops including Hartford, Connecticut, and Albany, New York.

At the time the flight clearance was issued, the weather en route to Albany was good and the conditions at Albany were above minima. The portion of the flight to Bradley Field was without incident and the aircraft arrived there at 0657.

At Bradley Field, the captain reviewed the latest weather reports and was advised that Bradley Field had been added to his flight clearance as a second alternate in addition to Syracuse because the weather at Albany at this time was below the company's landing minima* but was forecast to improve to within limits by the time the flight arrived there. The special Albany 0642 weather report available to the captain at this time was: ceiling indefinite zero, sky obscured, visibility zero, fog. The en-route weather was clear. The aircraft on landing struck two of three radio towers located 3.1 miles southwest of the Albany Municipal Airport, Albany, New York, and crashed at approximately 0834 hours on 16 September 1953. All three crew members and 25 passengers on board were killed; the aircraft was destroyed by impact and fire.

Investigation and Evidence

Departure from Bradley Field was made at 0714. Immediately before departing, the flight advised the tower it was proceeding to Albany VFR. At 0737, a message from the company's dispatcher at New York was relayed to the captain through the company radio at Albany as follows "If Albany still below limits on your arrival, if OK with you, suggest hold vicinity until at least 0830 EST. Expect Albany to have limits 0730 - 0800 EST. Advise fuel on board when over Albany." The flight acknowledged and advised, "We will hold." At 0740, the flight reported to Albany Approach Control that it was over Montgomery Ward, and in-range visual check point, VFR, and requested a clearance of at least 500 feet on top of clouds to the Albany Range Station. This request was approved and the flight was cleared to maintain at least 500 feet on top and to hold north of the Range Station. The 0739 Albany special weather report given to the flight was: "ceiling indefinite, 100 feet, sky obscured, visibility 1/4 mile, fog, wind west-southwest one mile per hour." The flight reported over the Range Station at 0742. During the holding period the number of aircraft in this pattern varied from six to nine.

The special Albany weather report issued at 0750 indicated thin obscurement, ceiling estimated 4,000, overcast, fog, visibility 3/4 mile. At 0753, the first of the aircraft in the holding pattern, was cleared for an instrument approach to Runway 19. At 0800, this aircraft missed its approach and was immediately cleared to climb toward the south and to again remain at least 500 feet on top of clouds. A second aircraft which was holding was then cleared to make a similar approach and it too was forced to execute a missed approach procedure. At 0816, an instrument approach and a landing on Runway 19 were successfully completed by one of the holding aircraft.

Immediately following this landing, the American Airlines flight was cleared to make an instrument approach to Runway 19. Three minutes later the flight advised the tower that its

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* The company's ceiling and Visibility Instrument Landing minima at Albany, N.Y., for Convair aircraft are: regular straight-in landing Runway 19 - ceiling 400 feet, visibility 1 mile, day or night. Other approaches to Runway 19 or all other runways - ceiling 600 feet, visibility 1 mile day and night.

approach was being abandoned because the aircraft's flaps could not be lowered. It was then still at least 500 feet on top of clouds and was advised by the tower to remain there until further advised. At approximately 0830, the following message was transmitted from the Albany Tower: "All aircraft holding Albany. It now appears to be pretty good for a contact approach from the west. It looks much better than to the north."

Immediately following this message, the flight was asked by the tower if it would accept a contact approach from the west for a landing on Runway 10. After requesting and receiving current weather including altimeter setting (29.74) and the length of Runway 10 (4,500 feet) the flight stated it would accept a contact approach. Clearance was then issued the flight to make a contact approach to Runway 10. Acknowledgement of this clearance was the last radio contact with the flight. At approximately 0934, the flight struck the radio towers and crashed.

The weather reported at the time of the accident was thin scattered clouds at 500 feet, ceiling estimated 4,500 feet, broken clouds, visibility 1-1/2 miles, fog.

Investigation revealed that the right wing of the aircraft struck the centre tower of three radio towers at a point 308 feet above ground followed immediately by the left wing striking the end (easterly) tower 293 feet above ground. These towers, located 3.1 miles southwest of the airport, are spaced in a line 266 feet apart on a true bearing of 234 degrees with their tops 370 feet above the ground and about 690 feet above sea level.

7 feet of the outer panel of the right wing including the right aileron and control mechanism from the centre hinge outboard together with 15 feet of the left outer wing panel and aileron separated from the aircraft at this time. Following the collision with the tower, ground impact occurred a distance of 1,500 feet beyond and on a true bearing of 52 degrees from the tower last struck. First ground contact was made simultaneously by the nose and the left wing with the aircraft partially inverted. Impact forces and the ensuing fire destroyed the major portion of the aircraft.

The landing gear control handle attached to the locking quadrant was found in the "down locked" position. Inspection of the landing gear revealed that it was down and locked at impact.

It was determined that the flaps were in the "full up" position at impact. The wing flap selector valve and electrical solenoid showed a minimum of external damage. Examination of the solenoid assembly disclosed that the plunger shaft between the selector valve and solenoid had failed due to fatigue at approximately the last thread of the attach end to the solenoid. This type of failure would not permit the pilot to lower the flaps and the flap selector valve could not be positioned manually from the cockpit.

It was determined that at the time of the accident there was sufficient fuel on board for the aircraft to have flown to either of its alternates with the required reserve.

The subject radio towers were erected in 1948 with the approval of the CAA and the Federal Communications commission. All three towers were hazard-painted and lighted in accordance with accepted standards. The lighting system included a light-sensitive device to assure automatic operation during periods of restricted visibility. These lights were on at the time of the accident.

Runway 19 is 5,000 feet long and is used when a straight-in approach is to be made using the low frequency range. The straight-in approach to this runway or its reciprocal, Runway 1, is over relatively flat terrain. Runway 19 is also aligned with the Instrument Landing System. Although ILS was in operation at this date, it had only been approved by the CAA a short time prior to 16 September and the captain had not received his company's authorization to use it.

Runway 10 is 500 feet shorter than Runway 19 and its approach is over irregular terrain. The elevation of the airport is 288 feet above sea level.

According to qualified witnesses the Convair 240 can be landed on Runway 10 without flaps and under similar conditions of load, surface wind, density altitude, and runway slope. Also, these aircraft can be stopped within 3,500 feet of runway distance provided both brake pressure and reverse propeller thrust are applied.

In an effort to determine as accurately as possible the flight path of the aircraft during its approach, may persons were interviewed. From statements of those persons who were considered to have actually seen or heard the aircraft, it was determined that the approximate following pattern was flown: The aircraft was first observed approximately one-half mile west of the airport on a southerly heading flying at about 2,000 feet. Near the south boundary of the airport it turned right toward the west and disappeared into or above a fog bank. It is believed that after flying this direction a short time, the aircraft again flew toward the south. This direction was held for a few miles, after which a wide circular right turn was begun and terminated on a heading slightly south of east. This latter heading was continued until the aircraft collided with the radio masts.

While in the circular right turn, the aircraft flew over the eastern side of an Army Depot located approximately 11 miles southwest of the airport. At this point the aircraft was observed by witnesses on the ground to be flying at a low altitude and one witness saw its landing gear extend. These witnesses stated that they could distinctly hear the noise made by the aircraft's engines and that they appeared to be functioning normally. Ground visibility in this area was approximately three miles limited by haze and fog and there appeared to be a dense fog to the northeast in the direction of the airport. Witnesses who were closer to the radio towers said that when they saw it, the aircraft was flying very close to the tree tops and only appeared between patches of fog. Several witnesses in this area said that the aircraft appeared to be "rocking" from side to side and that the engines sounded as though they were "sputtering". The fog in this area (near the towers) was quite dense and ground visibility was poor. A witness who did not see the aircraft hit the towers but did see it fall to the ground said that the upper one-third of the towers was completely obscured by fog. A sound believed to be a surge of engine power was heard immediately prior to the crash.

Several factors had to be considered by the captain at the time he decided to execute a contact approach to Runway 10. The result of these considerations could have been the basis for his decision, and also could have had a decided bearing on the manner in which the approach was executed.

When the flight arrived at Albany, it was necessary because of a low ceiling and restricted visibility, to hold, together with a number of other aircraft, at least 500 feet on top of clouds north of the Albany Range Station. Weather conditions were changing rapidly and were expected to improve sufficiently in a short time to permit landings. A few minutes after the flight entered the holding pattern, two of the aircraft were cleared, in turn, to make standard instrument approached to Runway 19. Both of these aircraft, however, executed missed approaches because they were unable to establish visual reference with the ground within their authorized minima. A third flight, however, made a landing, whereupon the American Airlines flight was cleared to make the same type of approach. This was abandoned because the wing flaps could not be extended and since the flight was still 500 feet on top, it continued in the No. 1 position in the holding pattern.

Approximately ten minutes after abandoning the instrument approach, the flight was informed by the tower that the weather was clearing to the west and was asked if it would accept a contact to Runway 10 from that direction. After requesting and receiving current weather, altimeter setting, and length of Runway 10 the captain replied in the affirmative. His specific request for the length of this runway was undoubtedly made to ascertain higher approach speed and additional landing roll. His acceptance of this runway indicated that he was fully satisfied that a safe landing could be made.

At the time the captain accepted this contact approach, it appears to have been a reasonable decision; the weather was clearing to the west of the airport and the bases of the scattered clouds were reported at 500 feet. Why the captain decided, in executing the approach, to fly in a general southerly direction and then make a wide right-hand turn to align with the runway is not known. It is entirely possible that from his position in the holding pattern, the weather in that area appeared to be better.

The course which the pilot chose carried the flight into intermittent areas of fog and haze. Confronted with these conditions the captain should have pulled up and discontinued the approach, however, he flew the aircraft at an extremely low altitude probably in an effort to maintain or regain visual flight and to be able to touch down as near the approach end of the runway as possible.

Rolling turns were made along the flight path in an apparent effort to enhance forward visibility. Undoubtedly it was the execution of these turns which caused ground witnesses to say the aircraft was rocking from side to side.

The fact that the aircraft's omni bearing selector was set to 99 degrees indicates that this instrument might have been used during portions of the approach as a check for runway alignment. However, it is apparent that during the latter portion of the approach the aircraft was flying so low that the crew could not have devoted much of their attention within the cockpit.

Because of these conditions it is probable that the aircraft continued the wide right turn past the desired heading to the runway and onto a heading which resulted in collision with the towers. The engine sound which witnesses described as a surge of power immediately prior to the collision may have been a sudden application of throttle by the pilot in an effort to avoid the towers. It is also possible that witnesses misinterpreted this sound because none were familiar with aircraft, engine, and propeller noises at low altitudes.

The Board viewed with concern the practice of some aircraft operators of making contact approaches to airports during very poor weather. It was intended that this matter be investigated further to determine whether some limitations upon contact approaches should be made in Part 60 of the Civil Air Regulations. A contact approach is made as an alternative to the instrument approach specified by the Administrator in order to expedite the flow of traffic. The need for some such alternative approach procedures, particularly in areas of high traffic density, was recognized. However, the Board considered whether such alternative approach procedures should be explicitly specified by the Administrator and adhered to by all pilots under weather conditions less than the minima spècified for VFR approach and landing.

Probable Cause

The Board determined that the probable cause of this accident was that during the execution of a contact approach, and while manoeuvring for alignment with the runway to be used, descent was made to an altitude below obstructions partially obscured by fog in a local area of restricted visibility.

ICAO Ref: AR/308

No. 32

Resort Airlines Inc. C-46F aircraft crashed during landing at Standiford Airport, Louisville, Kentucky, on 28 September 1953 Civil Aeronautics Board Accident Investigation Report No. 1-0079

Circumstances

The flight operating between North Philadelphia, Pennsylvania, and Louisville, Kentucky, departed North Philadelphia Airport at 1303 hours with thirty eight passengers and a crew of three. The flight was normal and in good weather and, in the vicinity of Standiford Airport, landing instructions were requested and the aircraft was cleared for landing on Runway 24.

The approach was normal until the "flare out" when the aircraft ballooned slightly, power was applied and at about 500 feet farther on entered a steep climb. The aircraft then yawed to the left and climbed with a steadily increasing angle of attack until it reached an altitude of about 300 feet, when it stalled, falling off to the left, and struck the ground on the nose and left wing.

The fuselage burst open on impact and a number of occupants were thrown free. Fire broke out upon impact but was extinguished by the airport fire fighting equipment. There were twenty-five fatalities including the crew of three, and sixteen passengers received serious injuries.

Investigation and Evidence

The three controllers in the tower as well as several witnesses on the ground saw the left elevator dangling during the climb. A number of these witnesses testified that the approach to landing was normal and the wheels had almost touched the runway when power was applied. All the witnesses were in agreement that the aircraft entered a steep climb, which culminated in a stall, and stated that it was apparent that something was wrong with the left elevator, as it appeared to be hanging down. None of them saw anything fall from the aircraft.

Statements were obtained from surviving passengers who advised that prior to landing the seat belt sign came on and the stewardess went through the cabin to ascertain that all passengers had their seat belts fastened. They also stated that, to their knowledge, there was no abnormal operation or malfunction of the aircraft at any time during the flight until the flare-out for landing at Standiford Airport.

Board investigators ascertained that the aircraft struck the ground approximately 50 degrees nose down with the left wing depressed approximately 30 degrees and coming to rest on a heading of about 140 degrees. The wreckage was localized to the left of Runway 24. Both wing flaps were found in the full-down position. The manner in which the main landing gear was torn off indicated that it was in down and locked position at impact. Examination of the engines and propellers indicated no malfunction. All passenger seats were torn from the floor with the exception of three unoccupied seats in the rear of the cabin.

Although a thorough examination was made of the wreckage, investigation was primarily centered on the empennage group in view of the obvious structural failure of the left elevator. Examination of the flight control systems revealed no evidence of malfunction or failure prior to impact. The right stabilizer and elevator, as well as the vertical fin and rudder, were undamaged. The left horizontal stabilizer was buckled upward at two stations but was still attached to the fuselage. The inboard two-thirds of the left elevator was found still attached to the stabilizer by hinges Nos. 3 and 4 (numbering the hinges 1 through 4 from left outboard to left inboard). The outboard third of the left elevator was found in the immediate area.

Examination of the left elevator and its hinge fittings, details of which will follow, indicated that the No. 1 hinge bolt worked free from the hinge fitting and thus resulted in the outboard third of the elevator being unsupported. This section then bent downward during flight at No. 2 hinge station;

therefore, the hanging portion of the elevator observed by witnesses was this outer third of the left elevator.

Both the elevator and stabilizer portions of the No. 1 elevator hinge bracket were attached to their respective surfaces but the No. 1 hinge bolt was missing. This bolt was found inside the crumpled leading edge of the left elevator tip, but the nut and cotter pin could not be found. Since the bolt had not failed it was evident that the nut had backed off, allowing the bolt to work out.

Upon examining this steel bolt, an AN5-13 type, it was ascertained that it was not specified for this installation. The proper type bolt was NAS55-14. The bolt was severely worn about the shank and the portion most reduced in diameter was found to be that section which bore on the steel bushing installed in the inboard lug of the hinge fitting. Laboratory examination showed that wear on the bushing and the bolt shank matched, proving that this bolt was the last one installed in No. 1 hinge bracket. The wear and markings on the bolt shank and the hinge bushing indicated that the bolt had been loose in the bracket for a conservatively estimated 50-100 hours of flight.

The cotter pin hole of the bolt was clean and microscopic examination of the hole showed no noticeable distortion of the hole other than a small deformed area at one end. This distortion indicated that a cotter pin had been installed at some time. A flake of brass was found in the hole, but no brass deposit was found at either end of the hole. A laboratory report stated that its presence could have been an indication that a brass cotter pin had been used at some time. Since only one small particle of brass was found, it appears improbable that a brass cotter pin was installed during the pertinent period.

When the interposer and left stabilizer bracket for No. 3 elevator hinge were removed for laboratory examination, a brass cotter pin was found securing a nut on the vertical bolt in the interposer block. All other cotter pins were of steel. The maintenance Company's personnel (who conduct maintenance on the airline's aircraft) stated that they do not use brass cotter pins and none had been purchased by the Company for five years. The Airlines likewise has standing instructions that only steel cotter pins are to be used.

Laboratory examination of the steel bushings in No. 1 hinge bracket revealed, through hardness tests, that they did not meet the minimum required 125,000 psi tensile strength by 40,000 psi. Being softer, they were more subject to battering and wear by the bolt. The holes of both bushings were beaten out of round.

There are four elevator hinge bracket assemblies on each elevator. Upon disassembly, it was found that the bolts installed in the right elevator were of the specified type, but all four on the left elevator were not.

The correct bolt to be used on all certificated C-46 aircraft was specified in CAA Airworthiness Directive 47-51-2, which was in force at the time the elevators were last overhauled. The correct and incorrect bolts are so nearly alike that it is difficult to tell them apart by cursory inspection except for the designations on the head.

The incorrect bolt was shorter than the correct bolt by one-eighth of an inch and its tolerance permitted a smaller diameter than the approved type bolt. Being shorter, the improper bolt installed in No. 1 hinge had less grip length and several threads rested on the bushings of the hinge bracket. The approved bolt, if used, would have had a tight fit in the assembly; the diameter of the non-approved bolt could have resulted in greater clearance than desirable and thus induced greater vibration loads on the assembly.

Examination of the interposer ball bearings of the elevator hinge assemblies disclosed that only one of the four bearings on the left side was of the approved type. This is a self-aligning bearing, type KS5. The three incorrect type bearings were type K-5, a non-self aligning bearing. All four bearings for the right elevator were the approved type.

Overhaul and maintenance on the Airlines' C-46 aircraft was conducted under contract with the carrier by a maintenance company, in addition to other CAA-approved repair stations which handled minor maintenance on a contractual basis. The records of all work performed by these agencies were forwarded to the headquarters of the Airline for review to ascertain that the work had been performed in compliance with their continuous maintenance and inspection procedures. Maintenance checks were to be performed at intervals of 70 hours for a No. 1, 125 hours for a No. 2, 250 hours for a No. 3, 500 hours for a No. 4, and 1,000 hours for a No. 5.

The Airline's maintenance manual prescribed that the elevators were to be removed and overhauled at each 2,000 hours interval. At overhaul the interposer, bearings and fittings for the elevators were to be removed and inspected. These items were to be replaced as necessary and new bolts and cotter pins were to be installed at each elevator overhaul.

The maintenance manual further prescribed that empennage control surfaces were to be checked for security and attachment on all numbered checks. On all checks above a No. 1, the manual required inspection of all elevator fittings, attachments, and component parts.

With regard to pre-flight checks the maintenance manual prescribed that the fuselage and empennage were to be inspected for structural damage.

Between July 8 and 11, 1953, the maintenance company conducted a No. 3 inspection of the subject aircraft at San Antonio. This included removal and overhaul of the elevators owing to time requirements. Since this was the last overhaul of the elevators before the accident, the records of the overhaul were given careful study and personnel involved in the overhaul of the elevators were questioned regarding the work they performed. It was ascertained that the right and left elevators were both removed but there was only one work and parts replacement sheet. Testimony indicated that the repairs and replacements listed on this sheet related only to the right elevator. Although a work sheet for the left elevator would normally have been completed to accompany the elevator overhaul sheet, none was found. None of the mechanics or inspectors had any recollection of having done any work or completed any inspections on the left elevator.

After the overhaul was completed, the aircraft underwent a pre-flight inspection before being test flown. This was accomplished by the maintenance Company's mechanics and inspectors and included inspection of the elevator and fittings for proper attachment and safety.

In view of the fact that investigation disclosed a number of discrepancies in the left elevator, namely: non-approved bearings, non-approved bolts, and a brass cotter pin, these discrepancies were either the result of improper attention to assembly and inspection of the left elevator by the maintenance Company's personnel, or the left elevator was worked on by some other agency between the time of this overhaul and the day of the accident. Therefore, the Airlines maintenance records relating to this aircraft were carefully searched and a number of personnel who were involved in the maintenance of the aircraft, were interviewed for any information on further work on the left elevator after 11 July. These reviews of the maintenance records and the interviews failed to reveal any indication of additional work on the left elevator. Further, the carrier's accounts applicable to the aircraft were carefully checked for bills from any source for work on the left elevator. This check also proved negative. The Airlines furnished the Board with an affidavit stating that no work was performed on the left elevator of the subject aircraft since the date of the last No. 3 inspection at San Antonio.

The maintenance Company had also overhauled the elevators in June 1952. The records reflected the left elevator serial number as 2-65M. During inspection of the left elevator at the accident site, it was ascertained that the left elevator bore this same serial number. This therefore negated the remote possibility that there was replacement or removal of the left elevator after the No. 3 inspection at San Antonio in July 1953.

Following the No. 3 inspection, the aircraft underwent three No. 1's, two No. 2's and one No. 5 inspections in the 412 hours it acquired to the time of the accident. The No. 2 and No. 5 inspections were conducted by the maintenance Company and one of the No. 1's by another approved repair station. The last numbered inspection was a No. 2 only 53 flight hours before the accident. No. 2 inspections include examination of the elevators, including the hinge bolt assemblies. Several work items on the elevators were performed during this last No. 2 check, but none of these items related to the hinge assemblies. A review of the records for these checks and testimony indicated that no discrepancies were found in inspections of the left elevator. If the No. 1 hinge bolt had begun to wear to an appreciable degree at the time of these inspections, it should have been found.

Between 11 July and the day of the accident the aircraft underwent almost daily pre-flight inspections. These pre-flight records were reviewed by Board investigators. Of the last six pre-flight inspectors, two were signed by the captain, the latter prior to departure from North Philadelphia. None of the pre-flight inspections reviewed contained a report of discrepancy on the left elevator. The Airlines pre-flight inspection forms included an item that the elevators are to be inspected for structural damage, distortion, and security of attachment.

As the cotter pin and the nut were not recovered, there are four possibilities with regard to the cotter pin: (1) it is possible that it was not installed at the time of the San Antonio overhaul, (2) not properly installed which would have permitted it to work out, (3) correctly installed but later removed by an unknown party, or (4) properly installed but worn away by the nut. This last possibility is considered the most probable staring point of this sequence.

Owing to the deep circumferential grooving of the hinge bolt, were on the bore of the steel bushings in the elevator fitting lugs, and wear on the faces of the inboard lug, it is apparent that the hinge bolt was subjected to vibrational pounding over a considerable period of time. It is probable that during this period the nut was safetied by a cotter pin. The pounding would have included a very large number of small torque loadings of the nut which would have tended to wear away the cotter pin. It appears probable that a steel cotter pin was in place during this period, for a brass cotter pin would have coated the cotter pin hole with particles of brass.

The nature of the hinge bolt grooving and wear on the fitting indicated that the bolt worked out very shortly after the nut started backing off, and further, that the nut backed off very shortly after it was no longer safetied. In light of this evidence it is highly improbable that the cotter pin was missing for a long period of time. Any numbered check or pre-flight inspection which failed to disclose the excessive wear of the hinge fitting or absence of the cotter pin, if it were missing at any of those times, must have been performed in a perfunctory manner.

Calculations entered in the record indicated that with the tip hinge bolt missing, the elevator could be expected to fail in smooth air at the second hinge from the tip due to loads resulting from elevator deflections within the normal operating range at all speeds from cruise to approach. It can therefore reasonably be deduced that the hinge bolt did not work from the hinge until the latter part of the flight from North Philadelphia to Louisville, and the flare-out for landing was the first moderately large elevator deflection after the bolt freed itself from the hinge fittings.

Many factors combined to produce the large amount of wear on the No. 1 hinge bolt, bushings, and lugs. Although the relative influence of these factors cannot be determined exactly, it appears that the use of the improper bold contributed to accelerated wear in two ways. First, since the threads of the bolt extended into the inboard bushing, the bearing area was appreciably reduced and bearing stresses were increased for any given load. Secondly, the permissible smaller minimum diameter of the incorrect bolt can result in larger clearances that are desirable, with the result that vibration produces larger bearing loads. Another factor in the excessive wear in the assembly was the use of steel bushings with a lower tensile strength and hardness than that specified. Still another appears to have been the use of the improper bearing; the K-5 type is a rigid bearing whereas the specified KS5 is a self-aligning type. The wear pattern showed misalignment of the fittings; bearing stresses would thus be higher than when a self-aligning bearing was used. The worn condition of the parts indicated that there was insufficient torquing of the nut on the hinge bolt to clamp the bearings tightly enough between the steel bushings to prevent relative rotation between these parts; all rotation should take place within the bearing. In addition to these, several other variables affected the service time which would have been required to produce the amount of wear. Among these are engine roughness, propeller disturbances, weather conditions, surface conditions of the airports from which the airplane was operated, and technique of the flight crews.

With such a large number of variables, it is impossible to determine with any degree of accuracy how long the wear progressed. However, a reasonable estimate appears to be a service period of 50-100 flight hours. In any event, it is obvious that excessive wear of the No.1 hinge should have been detected in pre-flight inspections.

In view of the above discussion, a probable sequence of events can be established. It appears that accelerated wear in the tip hinge was the result of a combination of non-conformities and other factors. This probably caused the nut to work on the hinge bolt and wear away the cotter pin until it separated and worked out of the cotter pin hole. This probably occurred during the flight from North Philadelphia. With the nut no longer safetied, vibration quickly caused it to back off the hinge bolt and the bolt worked out of the hinge fitting. The bolt probably worked out as the aircraft was approaching Louisville. When the crew applied up elevator in the flare-out for landing, the resultant down load on the left elevator was sufficient to cause downward failure in line with the second hinge from the tip. The balance area of the elevator ahead of the hinge line on the failed portion then interfered with the second hinge bracket and jammed, preventing the pilots from applying down elevator to counteract nose-up pitch of the aircraft. Application of power produced a steep climb which terminated in a stall and the crash.

In view of the importance that the proper hinge bolts be installed, the CAA conducted a survey on all commercially operated C-46 aircraft immediately following the accident. It was found that a number of C-46's including one owned by Resort Airlines did not have the specified NAS-55 hinge bolts installed at all hinge positions. In all cases where improper bolts were installed at various hinge positions, it was found that the most wear had occurred at the outboard hinges. Although this special inspection covered all control surfaces and systems, unsatisfactory conditions were found only in the elevators and hinges.

Probable Cause

The Board determined that the probable cause of this accident was structural failure of the left elevator in flight, causing loss of control. This structural failure was brought about by the left outboard hinge bolt backing out of the assembly. The underlying cause was improper maintenance which resulted in the installation of hinge bolts and bearings not meeting specifications, and inadequate inspection which failed to detect this condition.

No. 33

Pacific Western Airlines Ltd., DH. DHC-2 aircraft crashed in mountainous terrain 18-1/2 miles north of Squamish, British Columbia, on 19 October 1953. Department of Transport Canada, Summary Accident Report, Serial No. 53-31

Circumstances

At 1137 hours PST on 19th, October, 1953, the aircraft took off from Vancouver for Gunn Lake, B.C., having cleared the Tower in the usual manner. There was no further radio contact with the aircraft - radio reception was said to have been poor.

At about 1430 hours the aircraft left Gunn Lake for Vancouver its take-off having been delayed slightly in order to bring a seriously injured man to Vancouver. There were altogether 5 persons on board the aircraft. When the aircraft became overdue preliminary inquiries were made and then at about 1740 hours PST the RCAF Search and Rescue Organization were notified that the aircraft was missing. At about midday the following day the missing aircraft was sighted by a company aircraft which was taking part in the search. When the rescue party arrived at the scene of the accident it was found that all of the occupants had been killed in the crash and the aircraft had been destroyed and partly consumed by the fire which ensued.

Investigation and Evidence

A Certificate of Airworthiness which was valid at the time of the accident had been issued for the aircraft. No evidence was found of malfunctioning of either the aircraft or equipment.

The pilot held a valid Senior Commercial Pilot Licence and was stated to have accumulated about 4000 hours of flying time. It was estimated that he had made about 30 flights over the route in the previous three months. During the month of October he had acquired about 52 hours of flying time.

The weather prognosis for 19th October, 1953, for the period 0800-2000 hours PST, showed that there was an occlusion lying on a line between Sitka and Sandspit and south followed by a secondary cold front 200 miles further west. The occlusion was expected to move east of a line between Fort Nelson - Dog Creek and south west at 2000 hours PST. A deep depression was 200 miles south west of Yakutat and was expected to move to 100 miles west of Yakutat at 2000 hours PST and begin to fill. The air mass following the secondary front was expected to be moist and unstable.

The Vancouver terminal forecast for the period 0800-2000 PST was 8000' overcast, 4000' scattered, visibility 6 miles becoming at 1800 hours PST, 8000' overcast, 3000' broken, visibility 6 miles with light rain, wind south east 15 mph.

The weather conditions at Gunn Lake were 8-10,000' scattered, visibility unlimited, wind calm. This information was obtained by a telephone call to Gunn Lake and was given to the pilot before his departure from Vancouver. In addition the weather at Alta Lake, which was on the aircraft's route, was reported as low stratus in the valley and this too was given to the pilot prior to his departure from Vancouver.

It was stated that the pilot expected the weather to deteriorate before the return flight from Gunn Lake to Vancouver.

It was estimated that the time of the accident was about 1530 hours PST. A synoptic chart projected to the time of the accident revealed that at this time the occlusion would be lying approximately over the place where the accident occurred.

Examination of the area around the scene of the accident indicated that the aircraft was on a northerly course when it crashed. It would thus appear that the aircraft had turned back.

Probable Cause

Through the continuation of VFR flight into deteriorating weather conditions at too low an altitude in mountainous terrain the aircraft crashed into the trees on the side of a mountain, after having made a turn in a narrow canyon in what appears to have been an attempt to return to the wider canyon to the north.

ICAO Ref: AR/321

No. 34

British Commonwealth Pacific Airlines, Ltd., Douglas DC-6 aircraft, crashed near Half Moon Bay California, on 29 October 1953. Civil Aeronautics Board Accident Investigation Report No. F-112-53, Released 15 June 1954

(This accident was investigated in accordance with the ICAO Standards and Recommended Practices of Accident Inquiry, Annex 13. An accredited representative of the Australian Government, the State of Registry, together with representatives of the carrier involved, participated in the investigation and public hearing.)

Circumstances

The flight, scheduled between Sydney, Australia, and San Francisco, California, left Honolulu for San Francisco at 2259 hours on 28 October, carrying 11 passengers and 8 crew. The flight was routine to San Francisco after leaving the vicinity of Honolulu. While carrying out an approach on San Francisco airport, the aircraft crashed approximately 7-1/2 miles southeast of the town of Half Moon Bay in mountainous terrain.

The aircraft was totally destroyed and there were no survivors.

Investigation and Evidence

The Aircraft had initially struck and topped several large redwood trees, continued across a narrow ravine and crashed against the side of a steeply rising slope approximately one-half mile beyond the first tree struck. The elevation of this tree at the point of contact was 2,020 feet MSL. First contact was made by the left wing, at which time 13 feet four inches of the wing, inboard from the tip, was severed. The severed portion of the wing was found 475 feet beyond the tree in a northeasterly direction. The left stabilizer, also sheared in flight, was located about 300 feet farther north. The main wreckage area, at an elevation of about 1,950 feet MSL, was approximately one-fourth mile farther to the north. It was determined the aircraft was flying on an approximate heading of northeast by north when it first struck the trees.

Examination revealed the landing gear was down and locked at impact. From impact impressions in the left flap as well as an extended flap actuator piston, it was determined the flaps were extended between 15 and 20 degrees.

As far as could be determined from an examination of the damaged engines and components, there was no indication that a malfunction or failure had occurred prior to impact. The aircraft was in an airworthy condition according to the laws of the Australian Government when it departed Sydney.

Two communication receivers were found tuned to 278 kc., the frequency of the San Francisco tower. The marker beacon receiver hi-lo switch was in the "hi" position. The ADF receivers were so badly damaged it was impossible to determine their settings. One altimeter was recovered with a barometric setting of approximately 30.12; the latest setting given the flight was 30.14. This difference amounts to approximately 20 feet of altitude. A clock was impact stopped at approximately 1640 (0840).

CAA navigation and landing facilities in this area were given careful investigation. A thorough flight check was given the facilities by a CAA patrol aircraft as soon as possible after the crash; no discrepancies could be found. Maintenance and daily inspection reports indicated normal operation during the time the approach was being made. The pilot of a scheduled flight from Honolulu who landed a few minutes prior to the accident, stated that during his approach the Half Moon Bay Fan Marker, the Belmont Fan Marker and the ILS system gave normal aural and visual indications. Because of information received from a scheduled pilot that an overlap of the aural and visual signals of the Half Moon Bay Fan Marker and the Belmont Fan Marker had been experienced by him four or five years prior, a flight check was made by BCPA using their DC-6 with identical radio equipment to the aircraft involved. A CAB investigator was on board as an observer and the purpose of the flight was to simulate as nearly as possible the flight of VHBPE from the point of starting descent some 71 nautical miles southwest of Half Moon Bay. The radio navigational facilities were checked throughout this flight and neither the alleged overlapping nor any other discrepancies were revealed.

Voice communications received from the crew prior to the crash were made in a normal manner and at no time did personnel receiving them suspect concern or excitement. The last transmission, "Southeast, turning inbound", was made less than three minutes prior to the crash.

Investigation disclosed that BCPA flights were approved by CAA and by company procedures to make three types of instrument approaches to San Francisco: One radio range approach and two ADF approaches. The standard ADF approach from the southwest is over the southwest leg of the San Francisco low frequency radio range station to the range station at a minimum altitude of 3,000 feet, then outbound on the southeast leg at a minimum altitude of 2,000 feet followed by a left descending turn after passing the Belmont Fan Marker, then crossing the ILS outer marker inbound at 1,660 feet. The compass locators of the outer and middle markers are used in the latter part of the approach. The other ADF approach permitted a direct course from the Half Moon Bay Fan Marker to the ILS outer marker, a distance of 13.8 statute miles and at a minimum altitude of 3,500 feet. BCPA flight crews were not trained to make an ILS approach but when such approach was given they would accept it and use one of the ADF procedures. This latter was approved by CAA.

Witnesses agreed the crash site and surrounding terrain were covered by a dense fog and the aircraft could not be seen in flight. Also the aircraft, when heard, was flying very low with the engines sounding normal. One witness, located one and one-half miles south of Half Moon Bay near the coast, stated that from the sound, the aircraft seemed south of his position, flying from west to east, and that he heard it crash between one and two minutes after it passed his position. Witnesses who were cognizant of the time and who heard the crash were able to establish the accident as having occurred between 0842 and 0845. Also, witnesses near the crash site substantiated that the course of the aircraft immediately prior to impact was northeast, and that the impact was accompanied by at least one large explosion.

Weather conditions existing at the time of the accident were caused by a weak surface low pressure trough extending from Sacramento and the Bay area south-southeast to Monterey Bay with a high pressure area off the coast. This pressure gradient caused a stratus overcast with its base approximately 1,200 feet and its top about 2,500 feet. This condition also extended westward over the Pacific Ocean for several hundred miles, with varying degrees of cloud coverage. The freezing level was 12,000 feet. The fog and stratus overcast were clearing inland toward the coast and within a short time after the accident, clearing conditions existed at the San Francisco Airport. Good visibility prevailed both above and below the overcast in the instrument approach area and at the airport itself. The mountains to the west and the crash area at an altitude of 1,950 feet were covered by dense fog completely obscuring the terrain.

The flight was conducted in accordance with an IFR clearance but was above clouds and the pilots apparently were not required to fly actual instruments for any appreciable length of time. The weather in the San Francisco area presented no adverse flight conditions such as turbulence or icing; however, visual reference with the ground was precluded by the overcast as far as is known, and an instrument approach was required.

As the flight neared the coast, it was given its approach clearance which was acknowledged and repeated back. This clearance required the flight to maintain at least 500 feet above all clouds from the Half Moon Bay Fan Marker to the ILS outer marker. The accident site was between these two points. It is obvious the flight did not maintain at least 500 on top and descended in weather conditions which precluded visual reference to the ground.

The flight reported over the Half Moon Bay Fan Marker at 0839 and then reported, "Southeast, turning inbound", at approximately 0842. The crash took place between 0842 and 0845. It seems impossible in this time interval for the flight to have flown from the Half Moon Bay Fan

Marker to the ILS outer marker, made the required turn and returned to the crash site, assuming a normal speed. This is especially true considering that a part of the distance was flown with the landing gear down and 15 degrees of flaps extended. Thus it is likely that when the pilot reported "Southeast turning inbound", his actual position was southwest of the airport. It is therefore probable that the captain after reporting over Half Moon Bay either saw the terrain momentarily through an unreported break in the overcast or because of a radio navigational error became convinced that his position was farther northeast, and started to let down over what he believed was the proper area for this descent.

Probable Cause

The probable cause of this accident was the failure of the crew to follow prescribed procedures for an instrument approach.

ICAO Ref: AR/315

No. 35

Pan American Airways, Inc., Boeing 377 forced Landed on Johnston Island after Loss of Engine and Propeller on 6 December 1953. Civil Aeronautics Board Accident Investigation Report No. 1-0091 Released 19 July 1954

Circumstances

The flight scheduled from San Francisco to Tokyo, took off from Honolulu International Airport for Wake Island at 0847 hours on 6 December 1953, with 35 passengers and seven crew. The flight was routine until 1235, three hours forty-eight minutes after departure, when the crew felt an unusual vibration. At the time, the flight was at 10,000 feet in clear weather and smooth air. The vibration built up rapidly and within a minute culminated in an explosive noise and violent jerk. The aircraft went out of control in a right descending turn accompanied by violent buffeting. Control was regained. The aircraft was able to maintain altitude and landed at Johnston Island at 1532 without further damage.

Investigation and Evidence

The captain had left the cockpit sometime earlier than the incident and the first officer was occupying the right seat. He noted the vibration and immediately ordered all propeller spinners checked, disconnected the automatic pilot, and flew the aircraft manually. Control surface boosters were not turned on after the automatic pilot was disconnected. The flight engineer and second officer (who was navigating) checked from B compartment, forward of the cabin, but did not observe any of the engines running roughly or propeller spinners wobbling. The flight engineer returned to his station and attempted to detect the trouble; none of the engine instruments showed abnormal readings and he was unable to isolate the source of the vibration.

At the first sign of abnormal operation the captain hurried back to the cockpit. As he reoccupied the left seat, he glanced over his shoulder at the flight engineer's panel to see if he could detect the trouble. No. 4 engine and propeller fell away at that moment; simultaneously, violent buffeting began.

The steward had come forward to report unusual vibration in the galley and saw a flash of fire as No. 4 engine tore out; he and the second officer called to the flight engineer that No. 4 was gone.

The buffeting continued during the diving turn to the right. The master fire warning light came on and the fire warning bell sounded; there was no further evidence of fire thereafter, so CO_2 was not used. Power was reduced on the left engines. Full left aileron and rudder tabs were rolled in. Wing flaps were extended about 15 degrees to reduce buffeting, but were found ineffective; they were therefore retracted. The combined efforts of both pilots were used to apply full left aileron and rudder, but the right wing would not come up. At this time, ditching appeared imminent.

In an effort to raise the right wing and bring the aircraft under control, the captain ordered fuel dumped from No. 4 tank. The aircraft continued to lose altitude while 2,500 pounds of fuel were dumped, and control was eventually regained. Altitude was temporarily stabilized at 3,700 feet, then the aircraft again settled slowly until the power and air speed combination was found which would arrest descent and still permit control with the least buffeting. Heading was controllable within 20 degrees at 145 knots indicated air speed and descent was checked at 2,300 feet.

The first officer had been able to transmit a "Mayday" shortly after the engine and propeller tore out. A little later, before descent was arrested, he reported their position to Honolulu and advised the purser over interphone to prepare the passengers for a water landing. Steps had already been taken by the cabin attendants, in accordance with company emergency procedures, to assist passengers in preparation for ditching.

From time to time, Honolulu was advised of progress in coping with the emergency. At 1245 the flight advised Honolulu they were attempting to reach Johnston Island.

The Search and Rescue organization was immediately alerted after the "Mayday". Two aircraft were dispatched from Honolulu and an Air Force aircraft left Johnston Island. Interception was made at 1418 by the Air Force aircraft approximately 140 miles northwest of Johnston Island. Surface craft in the vicinity of Johnston Island were alerted as the flight approached.

The Flight was able to maintain 2,300 feet to Johnston Island and landed at 1532, two hours and 56 minutes after the engine and propeller fell free.

Weather was not a factor in this accident. The forecast was for clear weather throughout, with scattered cumulus along the course well below flight level. The crew stated that no adverse weather was encountered, and turbulence was light.

Since there was a malfunction in the No. 4 power package, followed very quickly by failure which caused the engine and propeller to rip out, the investigation was centered on ascertaining the nature of the malfunction and reason for the failure.

Investigation by the Board and testimony given by engineers from Pan American, Boeing Airplane Company, and Hamilton Standard Propeller Division disclosed that loss of the engine and propeller could have been caused by (1) failure of the engine mount, (2) sudden stoppage or seizure of the engine, (3) an unbalanced or otherwise defective propeller, or (4) a combination of these. Since the engine and propeller fell in deep water and could not be recovered, there was no opportunity to examine them.

During investigation of the first possibility above, it was found in examination of the No. 4 engine mount that the top portion of the engine mount ring was missing. Laboratory examination of the remainder of the ring, an attach fitting, and a portion of a buckled support tube did not reveal any evidence of fatigue failure. This study showed that all fractures apparently had been caused by loads in excess of the design strength. From examination of these pertinent parts and the engine mount in general, it appeared that separation of the engine from the aircraft was downward and to the right.

Loss of No. 4 engine exposed to the air stream the large flat plate area of the fire wall to which the oil cooler remained attached. This created drag and buffeting of such proportions that control could not be regained until dumping of fuel from the No. 4 wing tank made it possible to raise the wing.

The fuselage skin on the right side above the lounge door was damaged by a piece of engine cowling. The skin was abraded, with a slight amount of buckling. There was a triangular tear approximately eight square inches in area at Station 806, just forward of the window above the door. Three circumferential members and three stringers in this area were damaged, but there was no structural failure. There were two small tears in the top skin of the right wing at Stations 213 and 219; the tears were 1-1/4 and 2-3/4 inches long.

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

Investigation of the third possibility, that of propeller failure, revealed that the engine mount on this aircraft showed several points of similarity with another mount from which No. 1 engine was wrenched out in flight. In this comparative case, a B-377 of another carrier over Glenview, Illinois, on January 25, 1950, the engine and propeller were recovered and it was found that a propeller blade failure had occurred, causing the engine to fall free. In another case, a Pan American B-377 landed at New York International Airport on March 29, 1951, after unusual vibration was experienced in flight. After landing the No. 1 engine was found drooped in the nacelle and No. 1 propeller had lost 12-1/2 inches of one blade. There have been two other B-377 cases in which the engine and propeller were not recovered for study, but their engine mounts showed points of similarity with the mount in the Glenview incident.

Pan American officials stated that the hollow blade steel propeller was installed on its B-377 aircraft.

The hollow blade steel propeller, by the nature of its construction, is susceptible to external damage and therefore requires exacting inspection and maintenance.

A nickel-plated hollow steel blade for B-377 aircraft, manufactured by Hamilton Standard, was certificated by the CAA for air carrier operation on September 14, 1953. This blade, while slightly heavier owing to the plating, has shown promise in being considerably less subject to damage by foreign objects such as stones and debris. It is of the same design as the unplated blade, but improvements have been incorporated in it to lessen or eliminate other difficulties, such as corrosion.

Presently, there is no solid-type propeller blade available for B-377 aircraft.

Pan American decided to retire the unplated hollow steel blades in favor of replacement with the nickel-plated type, since it was felt that the new blade would give better service. This program of replacement started early in 1954, and the carrier anticipates that replacement on its B-377 fleet will be accomplished during 1955. In the meantime, the improved procedures relative to the hollow steel blade will remain in effect.

Pan American has also been testing several vibration pickup units, the purpose of which is to give early warning of excessive vibration in a power plant. This permits the flight engineer or pilot to identify the malfunctioning engine or propeller and to take it out of operation by feathering the propeller before serious damage occurs. The results of this testing program have proved promising and the carrier plans early installation of such units on its aircraft. A similar unit to detect unusual amounts of vibration in the power plant is being developed by Hamilton Standard.

The Board commended the crew for the efficient manner in which they handled a most difficult situation. The immediate transmittal of distress signals, the preparation of passengers for possible ditching, and the dumping of fuel, as needed, were all accomplished with praiseworthy precision.

Probable Cause

The Board determined that the probable cause of this accident was a propeller blade failure resulting in an unbalanced condition which tore No. 4 engine from the mount.

No. 36

Indian Airlines Douglas DC-3 aircraft, crashed shortly after take-off at Nagpur, India, 12 December 1953. Government of India Report

Circumstances

The aircraft, an Indian Airlines DC-3, took off from Nagpur Airport at 0325 hours on December 1953 carrying 4 crew, ten passengers and mail. After a normal take-off, the aircraft was seen to turn to the left and disappear from view after losing height at a steep angle. The aircraft crashed in a field within 4,000 feet of the aerodrome and caught fire. The captain was the only survivor, escaping with serious injuries.

Investigation and Evidence

At 0325 hours, after obtaining permission from control, the aircraft started its take-off run and became airborne in the normal manner somewhere near the intersection of runways 27 and 33. The captain of another aircraft who had moved to the beginning of runway 27 for his turn for take off, watched the take-off of the aircraft and noticed that it became airborne normally but swung to the left when at a height of about 10 or 15 feet. It then climbed steeply on a straight course until it had well passed the end of the runway, and reached a height of about 100 to 150 feet. Thereafter it turned sharply to the left and lost height, disappearing in the dark. A blaze was then observed from the direction in which it had disappeared.

Fortunately, the captain of the crashed aircraft survived and was in a position to make a clear statement on the events that led to the occurence. He stated that he commenced the take-off after satisfying himself of the performance of both the engines by ground testing them. The take-off was made with both throttles advanced to 45" of manifold pressure and with the co-pilot's hand on the throttles. The landing lights were "on". The take-off run was normal and the aircraft was airborne at 85 miles an hour. However, at a height estimated by him to be 10 to 15 feet and at a speed of nearly 100 miles an hour, the left engine "suddenly cut dead", causing the aircraft to swing to the left. The swing was checked and the aircraft was flown parallel to the runway. After about three seconds from the time of the engine failure it picked up again and the aircraft climbed steeply at 120 miles an hour without any difficulty, and gained 100 to 150 feet with both engines at 45" manifold pressure. The aircraft by this time had flown over the end of the runway. Thereafter the pilot decided to return to the aerodrome with the idea of landing on runway 33 or 27 in order to have the engine checked, and, therefore, started a gradual turn to the left. After the commencement of the turn the left engine "went off" again. The throttle of the right engine which was at 45" manifold pressure was advanced further but not to its full limit. The pilot levelled the aircraft laterally as he did not want to continue a steep turn on one engine. He noticed that the aircraft had lost a "lot of height". The pilot had intended to increase the right engine power still further, but at that time the right engine fire warning came on. He then heard a "bang", which he thought came from the right side of the aircraft. He therefore throttled back the engine. More height had been lost by that time. The pilot then lifted his hand to feather the left engine, but was "undecided", whether to feather it or not as the engine had picked up once previously. Further considerable height was again lost. Instead of feathering the propeller, the pilot switched on the port landing light, the landing lights having been switched "off" on leaving the ground. He then found himself "almost" on the tree tops in a tail-down attitude at a speed of 105-110 miles per hour. He therefore decided to land. He was under the impression that the landing gear was up, as after getting airborne he had asked for the gear to be raised and had seen the co-pilot lean over for this purpose. He had not at any time asked that the undercarriage should be lowered.

The pilot then pulled back both the throttles half way and at the same time felt a scraping sound. He does not remember the aircraft coming to a stop but recalls forcing himself out of the aircraft through a window and subsequently being helped by persons who had arrived at the scene.

There is no doubt that after getting airborne the left engine lost power, which caused the swing. This swing was, however, corrected and the fact that the aircraft was able to climb away steeply and also keep a straight course shows that the port engine revived within a few seconds of its failure.

It was evident that the captain did not follow the procedure recommended in the Operations Manual of Indian Airlines Corporation, Line 5, when the engine failure occurred, possibly because the engine had revived again. The procedure under such circumstances is to throttle back the live engine and land straight ahead. This could have been done in this case as there was a sufficient length of runway available in front to land and pull up even with the wheels down, and certainly with the wheels up.

It appears that the landing gear was not retracted soon after getting airborne as it should have been done and this omission on the part of the pilots must have resulted in a poor climb performance, in spite of the fact that both the engines were developing the required power. If it had not been retracted before the power was lost, it should definitely have been retracted at the time of the power loss or as soon as possible after that, unless, of course, it was intended to land straight ahead with the wheels down. As the captain says, he may have called for "gear up" soon after getting airborne, as is normally done, but the copilot may not have done it, possibly being confused when the swing occurred. After that, even though the engine revived, the fact that the gear was down was apparently overlooked by both the pilots.

During the initial climb with both the engines developing the required power, the "predominant desire" of the captain was to get the airfield in sight again in case the left engine failed again. It also appears that the captain felt that the aircraft, loaded as it was, would not maintain or gain height on one engine. All his subsequent actions, and particularly his omissions to attend to certain vital duties necessary under the circumstances, are attributable to this state of mind of the pilot.

With the desire to turn towards the airfield "predominant" in his mind, the captain discontinued the climb and made a turn to the left at a low and unsafe altitude. It seems that in taking a decision to turn to the left, though he felt that the left engine was "unreliable", the advantage of keeping the airfield in sight from his left hand seat outweighed the advantage of turning towards the more reliable (right) engine. An in-board engine failure in a turn would ordinarily cause considerable loss of height.

It is not certain whether, as the pilot says, the port engine failed again during the turn, but some height and speed were certainly lost in this turn, bringing the aircraft closer to the ground. Under these circumstances, i.e. when the forward speed was only about 105 miles an hour and the aircraft was "almost over the tree tops", losing height at a rapid rate, the starboard engine fire warning light came on. Faced with this situation the pilot thought it advisable to put the aircraft down straight ahead and therefore throttled the engines half way back.

With the speed already low, the aircraft must have dropped in a nose-down attitude as soon as the engines were throttled back, a phenomenon which is normally to be expected under such circumstances.

It appears that the captain was perplexed by the temporary failure of the left engine during take-off. The reaction of the pilot to these circumstances may be attributed to:-

(1) a fear that this aircraft could not maintain height or climb-on one engine with the load it carried; and

(2) lack of sufficient intensive checks for emergency procedures during the past twelve months, which, if carried out, might have given the pilot confidence apart from practice, enabling him to deal coolly with an emergency of this nature.

The symptoms of loss of power as described by the pilot are consistent more with a defect in the fuel system than any other failure of mechanical parts of the engine. The port engine which had been thrown clear of the fire was, however, stripped and examined thoroughly. There was no evidence of any mechanical defect or internal fire in it.

The possibility of this engine having cut out completely due to ignition trouble is very remote. This could only happen if both the independent ignition systems had failed. Considering the fact that the pilot had ground tested both the engines, (this ground test includes the testing of the engine on each magneto), the failure of both the ignition systems soon after is extremely unlikely. Whatever components of the ignition system were recovered from the wreckage were, however, examined, but no defect was detected.

As some defect in the carburetion and its related fuel system was the most likely explanation for the intermittent loss of power, a detailed examination of the complete system from the fuel tanks to the combusion chambers was attempted. Most of the fuel lines had been destroyed by fire, but there was evidence that the left main tank was selected to the left engine and the right main tank to the right engine. The fuel valve itself of the left engine could not be recovered but the right valve was found to be fully open and connected to the right main tank. The cross feed valve was found to be off. The left fuel pump and its drive were mechanically sound. Both the injectors were bench tested and found to be satisfactory, in spite of some damage caused by the impact. The fuel strainers in the fuel system and in the injectors were found clear. A few ounces of fuel were recovered from the left injector.

As already observed, both the suspected left engine and the right engine were rotating at the same speed, and as the pilot says, with the throttles about half-way at the time the propellers first cut the ground. This would indicate that any trouble that caused loss of power of the port engine had cleared itself at the time of impact. An examination therefore of the engines and their related accessories cannot be expected to give any indication of a defect, unless there was evidence of physical restriction which would obstruct the amount of flow causing intermittent failure. No such evidence was, however, found. But this does not rule out the possibility of the symptoms of power failure described by the pilot. An air or vapour lock in the system may cause a temporary engine cut. In such cases, the use of the wobble pump helps to maintain the fuel supply. There is, however, no evidence that the wobble pump was used, nor is there any evidence to show whether the fuel pressure dropped at the time of the engine cut.

Although the pilot noticed the starboard engine fire warning light come on, there is in fact no evidence of fire having broken out in that engine till the aircraft hit the bund. There have been numerous occasions in the past when a false fire warning was given by the type of the warning system installed on this aircraft. The warning light would come on as a result of short circuit in the system or a defect in the switch. Although a modification has been recently carried out in the fire warning system of Dakotas by Indian Airlines Corporation, Line 5, with a view to reduce the chances of false alarm, such a chance cannot be said to have been altogether eliminated, as shown on the present case.

The aircraft was loaded at Nagpur to 25,797 lbs., 403 lbs. less than the authorized maximum all up weight of 26,200 lbs. A doubt has been expressed as to whether a Dakota aircraft with one engine inoperative is able to climb or even maintain height with this all up weight. The evidence on the point is conflicting. The chief Inspector of Flying, Civil Aviation Department, said that it could, but the Chief Pilot (Training), Indian Airlines Corporation, Line 5 doubted it and has deposed to two tests on Dakotas carried out after this accident. It was also found from the tests that the performance of the two aircraft varied to some extent. The Senior Scientific Officer, Civil Aviation Department, recommended that "tests should be carried out on a fleet of Dakota aircraft for determining their exact performance". It will then be possible to determine up to what weight the present Dakotas can be safely loaded for single engine operation.*

The aerodrome crash tender could not reach the scene of the accident as unfortunately its clutch plate burnt out on the way while crossing a "nullah". The fire engine which came later from the city however, succeeded in reaching the spot quickly in spite of the difficult terrain,

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* Secretariat Note: An Indian Airlines DC-3 aircraft crashed on 25 February 1954 during continued tests to determine the cause of the above crash. The crew of three were killed. The co-pilot was a brother of the Indian Government's inspector of accidents who was directing the tests.

and commenced fire fighting action. When its supply of water and foam was exhausted, it was replenished from the aerodrome crash tender. But the magnitude and intensity of the fire as a result of the bursting of fuel tanks was such that it took considerable time before it could be controlled.

Probable Cause

Loss of critical height during a steep left hand turn, with the under carriage down, executed by the pilot at an unsafe altitude in an attempt to return to the aerodrome, after experiencing a temporary loss of power of the left engine soon after getting airborne. A false right engine fire warning precipitated the attempt at a forced landing.

Recommendations

(i) Checks for proficiency in instrument flying and emergency procedures should be made a mandatory requirement for the renewal of the licences of pilots engaged on scheduled air transport services.

(ii) Some infallible mechanism should be devised whereby false fire warning may be completely eliminated. Till then the attention of the pilots should again be drawn to the fact that the fire warning light is sometimes a false alarm, and does not necessarily indicate that a fire has actually broken out.

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PART II

PUBLICATIONS AND REPORTS

SECTION I

THE MOUNTAIN WAVE

A SUMMARY OF AIR FORCE SURVEYS IN GEOPHYSICS, NO. 15

By C.F. Jenkins

Geophysics Research Directorate
Air Force Cambridge Research Center
Air Research and Development Command

(The following two reports have been reproduced by kind permission of the Flight Safety Foundation, Inc., 471 Park Avenue, New York 22, New York)

FORECASTING THE MOUNTAIN WAVE

1. Introduction

The purpose of this report is to give the field weather forecaster the latest and most accurate available information on the structure of the mountain wave, the hazards of flying the wave and the methods of forecasting the wave. The importance of the best possible forecast of a wave condition cannot be stressed too strongly, because it involves the most dangerous of flight conditions.

With regard to flight operations, the extreme turbulence, vertical currents and altimetry errors encountered in the wave combine to form very hazardous flight conditions. The present flight minimums are considered to be inadequate under wave conditions. Indeed, some accidents that have been attributed to pilot error, for lack of any other obvious cause, might have been prevented had the pilot been properly informed of the extreme hazards in flying a strong wave.

2. Description of the Wave

Figure 1 is a cross section describing the conditions generally associated with a typical wave.

The dot-filled arrows indicate the position, relative to the mountains, where strong downdrafts occur. The solid arrows indicate the updraft area.

There are cloud types shown in Fig. 1 which are peculiar to the mountain wave. These are the cap (foehnwall), rotor or roll, lenticular and mother-of-pearl clouds.

The cap cloud hugs the tops of the mountains and flows down the leeward side with the appearance of a waterfall. This cloud is dangerous because it hides the mountains and is in the strong downdraft area on the lee side of the peaks. The downdrafts can be as strong as 5, 000 feet per minute.

The rotor cloud, which looks like a line of cumulus or fracto-cumulus clouds parallel to the ridge line, forms on the lee side with its base at times below the mountain peaks and its top extending considerably above the peaks, sometimes to twice the height of the highest peaks. The rotor cloud may extend to a height where it merges with the lenticulars above, extending solidly to the tropopause. While often appearing very harmless, the rotor cloud is dangerously turbulent with updrafts of up to 5, 000 feet per minute on its leading edge, and equivalent downdrafts on its leeward edge. There is a constant boiling motion in and below this cloud. In overall shape and location, it is effectively a stationary cloud constantly forming on the windward side and dissipating to the lee.

The lenticular or lens-shaped clouds, which appear in layers sometimes extending to 40, 000 feet, are relatively smooth. The tiered appearance of these clouds is consistent with the smooth laminar flow in this section of the wave. The tiered type of structure is due to the stratified characteristic of humidity in the atmosphere and the lifting effect of the wave on the whole depth of the atmosphere. These lenticular clouds, like the rotor, are stationary, constantly forming on the windward side and dissipating to the lee.

At time, severe turbulence is again encountered above the extremely smooth lenticulars. The turbulence layers above and below the lenticular levels are comparable to ball bearings, allowing the atmosphere between to flow through at very high speeds. Occasionally, a breakdown of the laminar flow sets off the formation of severe turbulence throughout the whole depth of the wave. When this happens, the highest lenticular clouds show very jagged, irregular edges rather than the normal, smooth edges. The juxtaposition of very turbulent and very smooth flow is typical in the wave.

In most cases, the clouds tilt toward the mountain range as ascent is made through the layers from the rotor cloud to the highest lenticular layers. As a consequence of this tilting, the streamlines are packed close together in the downdraft side of the rotor. Thus, the wind speed is considerably increased in this area and local jets form, introducing an additional flight hazard.

The dimensions of the wave can be tremendous. In the Sierra Nevadas, for example, the wave clouds can extend several hundred miles parallel to the ridge lines with a well-defined leading edge to the clouds. The wave clouds are visible from great distances and can provide the pilot with a warning of the existence of wave conditions.

There may be several wave crests or there may be only one. The amplitude and intensity of the waves decrease as you go downstream. The distance of the first wave crest from the mountain peaks varies with the wind speed, the type of wind profile and the lapse rate.

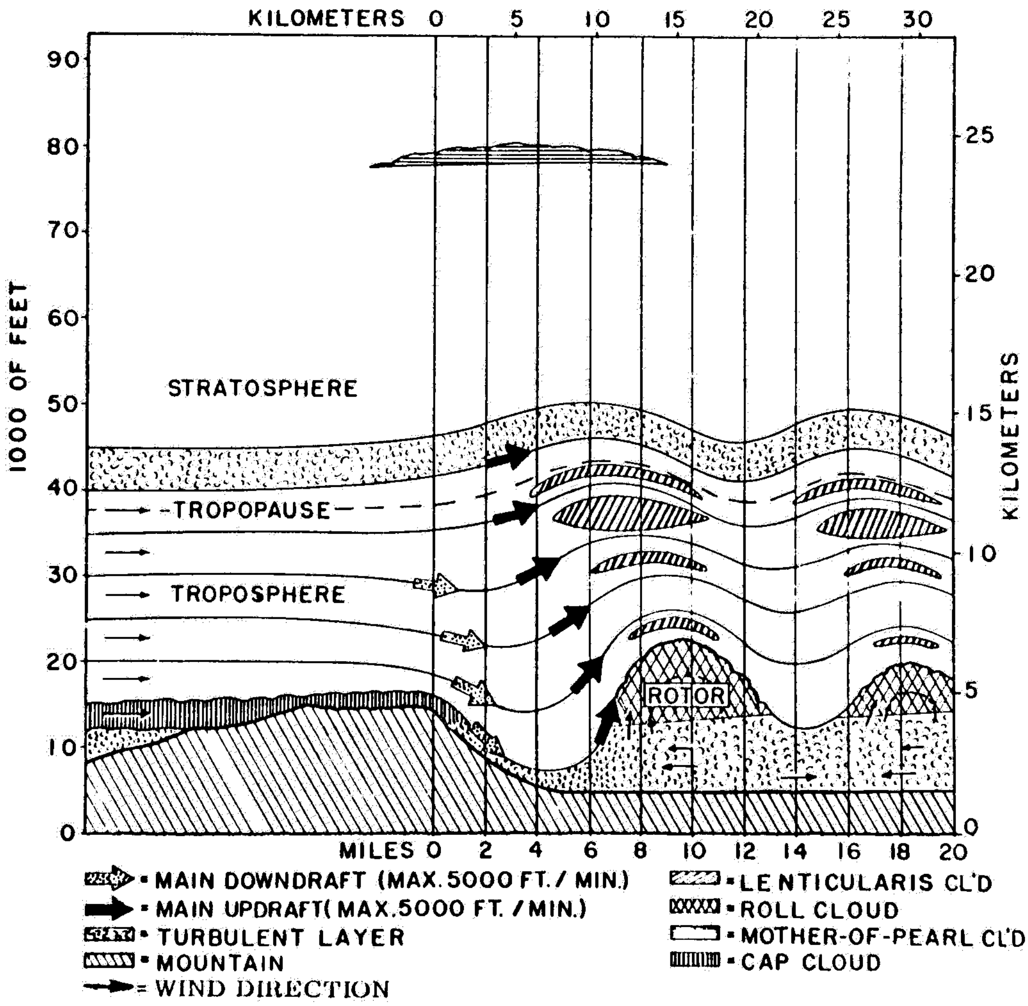

Fig. 1. Cross section of conditions associated with a typical wave.

The roll cloud may be present anywhere from a position immediately to the lee of the mountain peaks to a distance ten miles downwind. With a long wavelength, one might naturally assume that the lift zone ahead of the rotor cloud would taper off gradually. This, however, is not true. The updraft area is just as sharply defined as in shorter wavelength cases.

While the overall context of the cloud formation is stationary over a considerable period of time, the clouds can change position, shape and structure in an extremely short time and there is continuously a considerable amount of motion in and around the clouds. Extensive clouds can form or dissipate in a matter of seconds.

There are times when the wind is favorable for a wave condition, but there is not enough moisture present for the clouds to form. This cloudless or "dry wave" gives just as much turbulence as when clouds are present, but none of the warning features that the clouds provide are present.

The strength of the flow during a strong wave may be from 90 to 150 knots in the upper troposphere. During the winter months, over a range like the Sierra Nevadas, waves can be expected on an average of 8 to 10 days in each month, with 2 or 3 strong waves included.

Figure 2 is an "ideal wave" picture taken from the ground. The mountains are to the right and the flow from right to left. The foehnwall hides the Sierra Nevada mountain peaks to the right. The rotor cloud appears in the lower center portion of the picture with the lenticular clouds fanning out above.

Figure 3 is a picture taken from above the same wave. This picture shows the horizontal extent of the rotor cloud and the tops of this cloud merging with the lowest lenticular layers. Several lenticular layers can be seen to the right of the picture. The slopes of the Sierras are visible in the lower right-hand portion of the picture.

Figure 4 shows the range to the right with the downdrafts striking the floor of the valley, kicking up dust and carrying it up into the rotor cloud zone. This is a rather unusual long wavelength case with the rotor zone very far back from the peaks. The dust shows how the flow hugs the surface and then rises sharply just in advance of the rotor up to 30,000 feet.

Figure 5 is a picture taken on a day when there was extreme turbulence at high levels. The high lenticulars in this case show very rough edges. Fragments of clouds moved rapidly across the wave showing turbulent motion.

Figure 6 shows many heavy lenticular layers blanketing the sky. The smooth texture and well-defined edges of the clouds indicate the laminar motion.

Figure 7 is a good shot of the foehnwall. It shows the complete coverage of the mountain peaks which this cloud affords. In this picture, the wind flow is from left to right.

3. Features leading to a Wave Condition

A wave condition affecting flight operations arises with a component of the wind at a speed of 25 knots or more at the mountain-top level flowing perpendicular to the mountain range. The actual wind direction can vary somewhat (with 50° being the maximum deviation from the perpendicular) and still cause a wave, but the strongest waves occur with a strong, perpendicular flow. The stronger the flow, the more severe the effects to be expected on the leeward side.

Any mountain range with crests of 300 feet or higher can produce a wave. Over low mountains the wave effect can be felt up to a height twenty-five times that of the range. The intensity of the wave is, in part, a function of the mountain height and the degree of slope of the mountain range, as well as the strength of the flow.

Fig. 2 Typical wave clouds from below (wind from right to left)

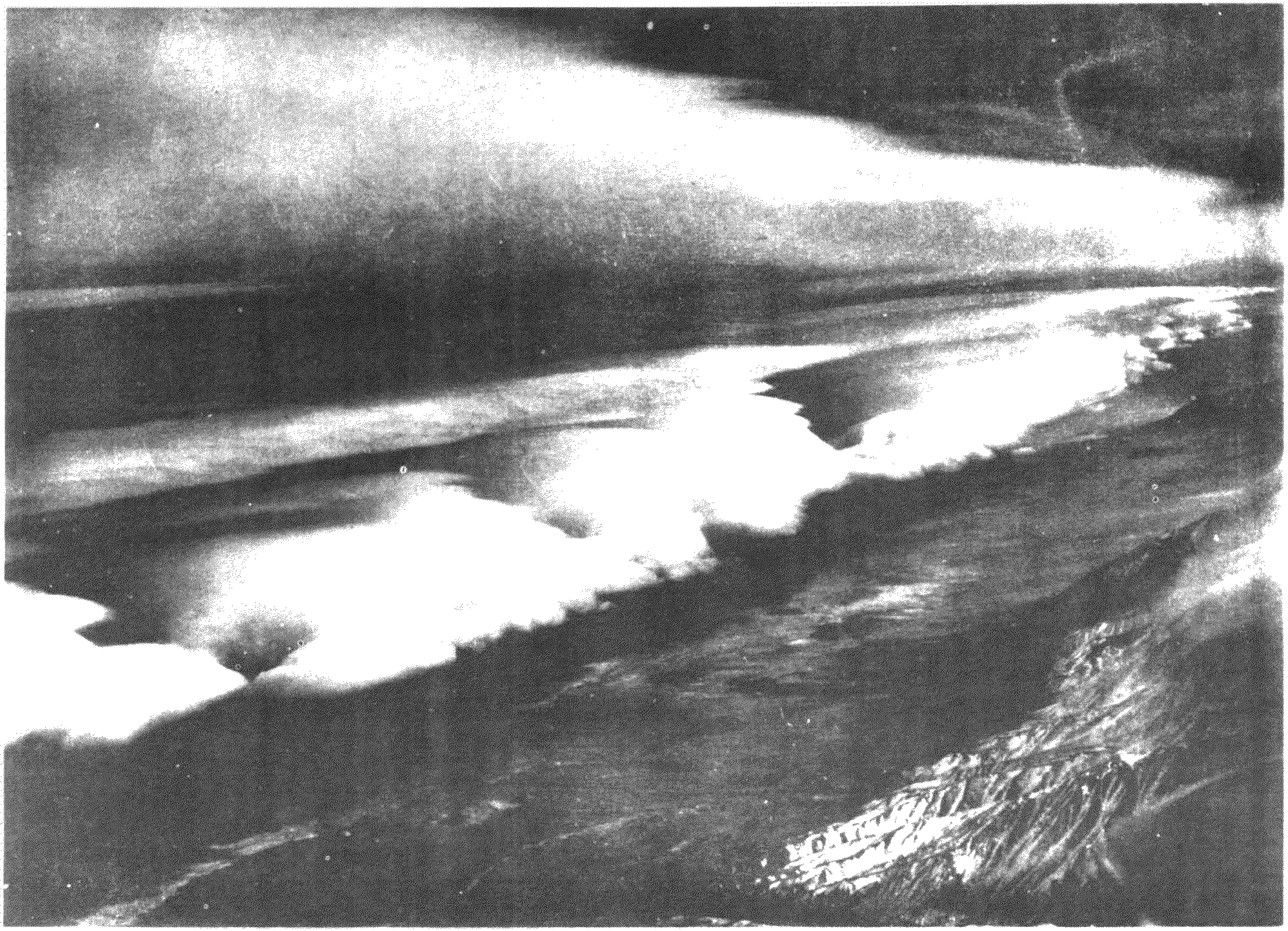

Fig. 3. Typical wave clouds from above (wind from right to left).

Fig. 4. Long wavelength case - dust lifted to 30,000 ft.

Fig. 5. High-level turbulence (39,000 feet) shown by fragmentation of high lenticulars.

Fig. 6. Heavy smooth-textured lenticulars.

Fig. 7. The foehnwall (wind from left to right).

There should be a rapid increase in the wind speed with altitude in the level of the mountain range and for several thousand feet above, with a steady strong flow up to the tropopause. The character of the wave varies with different wind profiles. A very strong increase of wind with height can eliminate the wave, leaving only stagnant air in the valley. Frequently, when a strong wave forms, the jet stream, or zone of strongest wind flow, moves southward to a position in the neighborhood of the range.

In the western United States where these waves have been most frequently observed, it has been noticed that the strongest waves develop when there is a cold front approaching the mountains from the north-west and/or a trough aloft approaching from the west. This produces a strong westerly flow over the mountain ranges which have a north-south orientation.

4. Flight Conditions in the Wave

The most dangerous features of the wave are the turbulence in and below the rotor cloud and the downdrafts just to the lee of the mountain peaks, and to the lee of the rotor cloud. The downdrafts to the lee of the rotor, and the updrafts below it, can carry a plane into the rotor cloud while a pilot is attempting to pass above or below this cloud. The best procedure for one caught in the rotor cloud is to nose down to pick up speed and to attempt to reach the updraft area in advance of the rotor to regain altitude.

These dangers cannot be stressed too much. A pilot without specific and considerable experience in flying the wave should not attempt a flight through such conditions.

A combination of the winter temperature error and the wave error in the altimeter reading, together with the strong downdraft conditions near the peaks and the fact that they are hidden most of the time by the cap cloud, make it very likely that a plane at minimum clearance altitude would fly into the mountain peaks.

From calculations and instrument considerations, it has been shown that altimeter errors are associated with the wave conditions. Since the wave is principally a winter phenomenon, the temperature error in the altimeter reading contributes to an overestimation of the flight altitude. The maximum total error possible has been computed to be about 1,000 feet. Altimeter errors as high as 2,500 feet near the mountain peaks have been claimed by pilots although this seems as extreme figure. Data are not yet available to prove or disprove these figures.

5. Tips on Flying the Wave

The following rules of flight have been suggested to pilots for flights over mountain ranges when wave conditions exist. It would be good to keep these procedures in mind when clearing a plane for such a flight.

1. If possible, fly around the area when wave conditions exist. If this is not feasible, fly at a level which is at least 50 percent higher than the height of the mountain range.

2. Do not fly high-speed aircraft into the wave. Particularly, do not fly downwind. Structural damage may result.

3. Avoid the rotor cloud.

4. Avoid the foehnwall area with its strong downdrafts.

5. Avoid high lenticular clouds if the edges are very ragged and irregular, particularly if flying high-speed aircraft.

6. If necessary, updraft areas, especially the one in front of the rotor cloud, may be used as an aid in gaining the altitude necessary to pass through the downdraft area and cross the mountain range.

7. Do not place too much confidence in pressure altimeter readings near the mountain peaks.

6. Forecasting the Wave

Normal forecasting techniques can be employed in forecasting the upper winds when the stability and direction of flow are expected to be favorable for a wave condition. In the Sierras, the technique employed is to decrease the 10,000-foot wind forecast by one fourth and increase the 18,000-foot wind by one third to account for the local effect of the crest line (10,000 feet being below the level of the ridges, and 18,000 feet being above).

To apply forecast techniques to other ranges, especially when ranges have a different orientation, local studies should be made to determine the characteristics of the flow in the area concerned and thus learn the local forecast rules to be applied.

In the Sierras, it was found that a well developed wave would form with a wind speed of 25 knots or more normal to the range line at mountain-top level. This is probably a good threshold value to apply in any mountain range. Certainly wind speeds of greater than 25 knots will create some disturbance to the lee of any mountain barrier. As previously stated, the mountain heights above surrounding terrain, the leeward slope of the mountains, and wind profile are all factors in determining the intensity of the wave.

One should look for an increase in the horizontal temperature gradient aloft north of the mountain range providing a thermal wind increase over a period of 12 to 18 hours before wave formation.

This study was conducted in the Sierras, but the same type of wave has been observed all over the world, and sailplane pilots have made use of these waves as an aid in soaring for years.

While the information contained in this report may not be the final work in preparing the forecaster to handle every forecasting problem connected with wave patterns in mountain ranges, it is hoped that it will provide a basic understanding of what the wave is and what is necessary in the way of atmospheric conditions for its formation.

To summarize the weather conditions under which a wave will form, the following requisites are considered to be necessary in the case of any mountain range.

1. Wind flow normal to the range and with a speed of 25 knots or more at mountain-top level.

2. A wind profile which shows an increase in wind speed with altitude near mountain-top level and a strong steady flow at higher levels extending up to the tropopause.

3. An inversion or stable layer somewhere below 600 mb.

With a mountain range which extends north and south, the approaching cold front and/or north-south trough aloft should be considered as a probable igniting factor for the wave.

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FLIGHT ASPECTS OF THE MOUNTAIN WAVE

A SUMMARY OF AIR FORCE SURVEYS IN GEOPHYSICS NO. 35

By J. Kuettner
C.F. Jenkins

AFCRC Technical Report 53-36

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(This is a sequel to
THE MOUNTAIN WAVE.)

FLIGHT ASPECTS OF THE MOUNTAIN WAVE

Abstract

The great number of unexplainable collisions of aircraft with mountains has resulted in a comprehensive meteorological study of air flow over mountain barriers. This survey is based on an intensive investigation of the flow pattern in the Sierra Nevada mountains of western United States. Flight through the mountain wave, a phenomenon associated with strong flow across a ridge of mountains, is described from a pilot's point of view. An example of an attempted wave flight is analyzed. Many striking features of the mountain wave, which were observed by the use of instrumented sailplanes whose locations were determined by optic and electronic tracking equipment and supplemented by time-lapse motion pictures, are presented. These include certain typical cloud formations usually associated with the wave, thus making it recognizable to the pilot. Violent updrafts, downdrafts, turbulence and altimeter errors encountered in a wave are shown to make flying hazardous and indicate that more realistic flight minima should be observed.

Introduction

In the past, some very experienced pilots and crews have been lost in air accidents due to unexplained circumstances. These mishaps apparently occurred for no reason other than miscalculated positions, with subsequent flight directly into the mountains while on IFR. In some cases these occurrences were almost unbelievable, considering the vast flying experience possessed by the crews involved. How could they have happened? All too often, after a thorough investigation had been made, the inevitable answer was: Pilot Error.

Atmospheric research has advanced some ideas as to the possible causes of such accidents. In fact, quite a few of the accidents which have been attributed to pilot error, for lack of any other obvious cause, might have been prevented had the pilots been properly informed of the hazards in flying a strong mountain wave. A mountain wave is a disturbance of the atmosphere set up by mountain barriers and characterized by a wave-like airflow in which severe turbulence, vertical currents, and altimeter errors combine to form dangerous flight conditions.

Preliminary results of the "Mountain Wave Project" confirm that the conventional conception of the wind flow pattern over mountain ranges is in error. This is particularly true when a strong flow exists perpendicular to the ridge lines, as required for the formation of a mountain wave.

It is intended that this survey provide pilots with a more complete picture of the wave and with a detailed description of its structure.

Let us first accompany a pilot as he attempts to traverse a strong mountain wave without sufficient knowledge of its characteristics. A great deal of flight experience in the study of such waves has been incorporated here in an attempt to give pilot readers a feeling of what they might encounter were they unaware of the experiences to be expected. Later in this report the wave phenomenon will be explained as to its formation and features.

An In-Flight Encounter With a Mountain Wave

Let us suppose you are fighting strong head winds at 10,000 ft altitude in a moderate-speed aircraft. Two hundred miles ahead on your flight course is X-Mountain.

There are not many clouds around and visibility is very good. The air is smooth up here although in the lower layers it is quite turbulent. You are flying with a slight drift correction. Some time ago you spotted a long white cirrus band over the horizon far ahead. At about 100 miles from X-Mountain you notice that this cloud bank seems to extend just along the mountain range although at a much higher level than the peaks of the range. Apparently it does not move despite strong upper winds. The summits of X-Mountain cannot be seen. They are covered by a flat white cloud blanket.

Every minute you can see more details. The high cirrus cloud ahead consists of a few parallel banks extending from right to left, normal to the wind. As you approach this cloud it does not look as white and harmless as it looked from 200 miles away. There are dark, dense parts in it and you would not dare to guess how high it is. You would not even call it a cirrus cloud any more. It looks more like a big altocumulus cloud. You can see that this cloud is composed of a number of layers staggered vertically like pancakes. The leading (upwind) edge appears quite sharp and seems to follow every bend in the long mountain range.

Farther upwind blue sky extends over the flat cloud blanket ("cap cloud") which covers the mountain tops. The high cloud extends only downwind of the mountain range. It is a so-called "lee cloud."

You are now 50 miles from X-Mountain. Climbing slowly you should be able to pass below the high altocumulus cloud and then above the cap cloud and X-Mountain. There is a wide gap of blue sky between these two cloud layers, and except for some long lines of cumulus clouds under the high cloud bank, you do not expect any clouds at all on your flight path and head directly into this gap.

Apparently there are two of these cumulus lines extending from right to left just this side of the mountain range. They look so harmless that you really do not worry about penetrating them. The row nearer you consists only of some broken ragged cloud pieces ("fracto-cumulus"). They seem to be just about as high as the mountain tops and the cap cloud. The cloud line nearer the mountain range looks much more dense and builds up higher than the cap cloud over the mountains, although it is certainly not comparable in depth to the big shower clouds you had to penetrate sometimes. None of the cumulus clouds here gives any indication of precipitation.

As you cannot estimate how much space exists between X-Mountain and the cumulus lines, you have to decide now if you want to pass beneath, above, or through the cumulus clouds. Had you heard about the "Mountain Wave" earlier you would have made up your mind a long time ago. You would know by now that the harmless cloud picture ahead displays all indications of impending danger. Now you have to learn it the hard way!

You decide to continue your flight towards the cloud gap by climbing steadily. You will probably pass through the first tiny cumulus line which is now only a few miles ahead. Fixing your eyes on some of the cloud fragments you notice that they show strong rolling motion. You remember having heard of a "roll cloud" and anticipate some turbulence.

Upon contact with the first cloud pieces, your ship banks steeply and you are thrown against the ceiling of your cockpit. You have your hands full to regain control of the plane and you do not find any time to watch your altimeter or rate of climb indicator. Nevertheless, you feel that the ship is climbing and descending rapidly in what you would call severe turbulence. This dance lasts only one or two minutes then suddenly the air is smooth again and you have a good rate of climb. You have passed the first roll cloud and have time now to fasten your shoulder straps and to think your situation over. Looking upwards you notice that the high cloud is now huge and compact, completely shading the countryside. Your decision to climb over the cumulus lines seems justified by your first experience.

The rate of climb is unusually good after passing the first roll cloud. You can already see over the next cloudline, which seems to be 5 to 10 miles ahead, and you should have plenty of height to clear even the highest cloud tops of this roll cloud. With the air quite smooth you are confident that you are out of trouble by now. Looking down at the valley floor you notice that jet-like dust streaks indicate strong surface winds. Your progress is slow. Apparently the upper winds are very strong. As a consequence you have to change your drift correction to stay on course.

Now you are high enough to look down on the next roll cloud. The cap cloud over X-Mountain ahead is snow-white in the brilliant sun. It seems to pour down the mountain slope like a cloud waterfall. Farther upwind the cap cloud merges with the horizon and it is hard to estimate whether you are higher than this cloud layer or not. The huge altocumulus cloud above is even darker now. The leading (upwind) edges of the different pancake layers are staggered toward the wind. The highest one is still far ahead and shows a brilliant white rim. Now you can see the profiles of the staggered layers. They are lens-shaped and you remember having heard meteorologists say that so-called "lenticular clouds" occur frequently over mountains.

Something unexpected must have happened suddenly. The roll cloud ahead has started to build up quickly in front of you. Looking downwards you notice that the plane does not seem to be making any headway. Now the first cloud drifts by under the plane. If the cumuli continue to rise that way you are not sure that you can make it.

A glance at the rate of climb indicator reveals what is going on: the ship is falling at over 2,000 ft/min in completely smooth air. What you need now is ground speed. With the nose down and full power, clouds seem to shoot by underneath the plane but the ground still does not show noticeable movement. The rate of descent is now 2,500 ft/min. A big cumulus turret builds up ahead and engulfs the plane within seconds. You have fallen from above into the roll cloud.

What follows is no longer controlled instrument flight. Heavy gusts make all the instruments dance. The speed drops down, then shoots up, the rpm's are changing rapidly and the engine is howling. Several times you hang in your belt without the slightest idea of attitude. You have not encountered anything like this before. You recall a thunderstorm flight which scared you to death but the turbulence was nowhere near this bad.

Suddenly you dropout of the cloud base and the view excites you: everything seems to have changed. X-Mountain looks down on you like a big barrier, the clouds sweeping down its slopes with visible speed and dissipating just in front of you. You are about ready to turn back when your plane is lifted with enormous power. In heavy vertical gusts your rate of climb jumps to 1,000 ft/min., later to 2,000 ft/min. The leading edge of the cumulus line is now just above you. To avoid being pulled back into the roll cloud you push the nose down. Apparently you now have a good ground speed and the ship is climbing fast just in front of the cloud line which looks like a long railroad train.

Suddenly the gusts die out. The air becomes smooth as glass. But your rate of climb is now 2,500 ft/min. You are stunned by the fact that such extreme degrees of smoothness and turbulence can coexist so closely in the atmosphere. Looking back after a few minutes you notice that you are already higher than the top of the cloud. You are now flying at a safe level. That should be enough finally to cross X-Mountain and the cap cloud. Your altitude is 3,000 ft over X-Mountain and probably 2,000 ft over the cap cloud. There is no roll cloud line ahead now and you have reason to believe that you are out of trouble.

The foot of X-Mountain lies just below you. The trailing edge of the cap cloud is only one mile ahead. The cloud mass pouring down the mountain slope and dissipating is a fascinating spectacle. The upwind edge of the high lenticular cloud is directly overhead, maybe between 30,000 and 40,000 ft.

The ship makes good headway now but the updraft is slowly tapering off and you have to use more power to keep altitude and ground speed.

High as you are above the low-level clouds you feel almost -- but not quite -- safe. This completely smooth air has proved treacherous before and you are not sure what it has in store for you this time. The crestline of the mountain is not yet passed and ground speed seems to drop again. After another minute the low clouds look nearer. There has been no indication of what your altimeter and rate of climb now reveal: you are falling again at 1,000 ft/min, and full throttle does not help. You feel if you can go another mile upwind you should be through.

But once more there is this unfortunate combination of a jetlike headwind and a strong downdraft. You have been running through several consecutive up and down-draft areas. This is indeed the pattern of an atmospheric wave. In another minute you will know if you can pass X-Mountain. The cloud waterfall is directly beneath the plane now.

But in front of you the cap cloud climbs fast. The air is still quite smooth, but now you are falling at about 3,000 ft/min. Three thousand feet per minute? That means you will crash into the mountain within another minute. What does your altimeter show? A thousand feet above the highest peak of X-Mountain. But now you can see a mountain peak through the cap cloud. That is certainly not 1,000 ft below you. It is just about your present height. Is the altimeter wrong? Only a quick decision will save you. Turn back.

While you bank in a steep left turn the air becomes hazy. A glance at the instrument panel and the mountains shows that you are falling at almost 4,000 ft per minute into the lower end of the cloud waterfall. Suddenly a terrific gust banks the airplane into a steep right turn towards the mountain. For a moment you see the rocks of the mountain rapidly coming nearer. Then you succeed in maneuvering the plane away from the stone wall.

You are right in the foot of the cloud waterfall which looked so smooth from above and the airplane shoots with an enormous tailwind 1,500 ft over the valley floor. As the heavy gusts diminish you look back on the towering mountain range and the cap cloud which only a few minutes ago lay under your feet.

In a matter of minutes you have passed under the two roll clouds and the nightmare is over. You decide to do what you should have done in the first place; change your flight course, flying around X-Mountain and avoid traversing a full-scale "Mountain Wave."

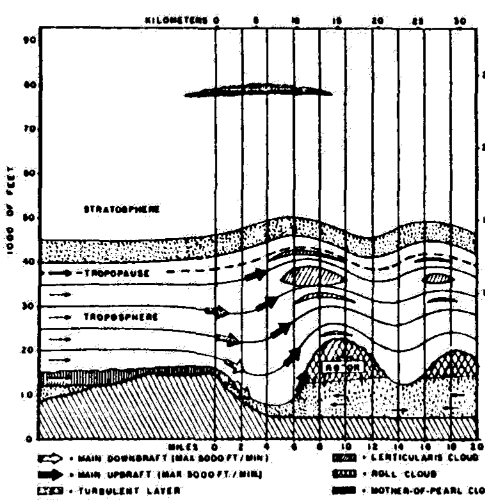

Fig. 1. A cross section of a mountain wave.

The foregoing probably describes a typical mountain wave experience. In this case, the pilot encountered a very powerful wave, but with the favorable factor of good visibility which enabled him to recognize cloud types and thus orient himself and maneuver the ship out of immediate danger. It is conceivable that the situation would have been more serious if the wave were very dry, with no clouds to give any indication of hidden danger; or on the other hand, if the mountain were completely obscured by a massive cloud layer.

The Mountain Wave Project

To investigate this type of airflow, the "Mountain Wave Project" was implemented under the joint sponsorship of the Geophysics Research Directorate of the AF Cambridge Research Directorate of the AF Cambridge Research Center and the Office of Naval Research. It was conducted by the University of California Soaring Association and several government and private organizations.* The field tests were carried out during 1951-1952 in the Sierra Nevada mountain range in California under the direction of the Geophysics Research Directorate.

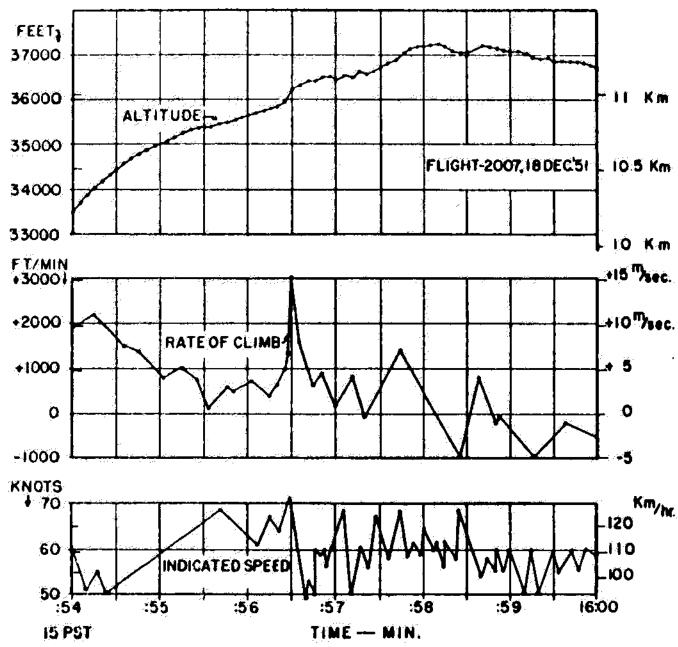

Fig. 2. High level turbulence encountered between 36,000 and 37,000 ft by one of the project gliders. This is a six-minute flight record of the glider instruments. Note the enormous changes in rate of climb.

Specially instrumented sailplanes were used to trace the streamlines and the temperature and pressure field in the neighborhood of the mountain range when a strong flow existed perpendicular, or nearly perpendicular, to the ridge lines. Conditions were investigated up to a record height of 44,500 ft by use of these sailplanes which were tracked by radar, Raydist and cinetheodolites. Time-lapse cameras took motion pictures of the associated cloud structures from the ground to supplement the data taken by the sailplanes. Meteorological stations were established on both sides of the mountain range from the valley floor up to an elevation of 9,000 ft.

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* These included the U.S. Weather Bureau, the Air Weather Service, the Naval Ordinance Test Station at Inyokern, the Hastings Instrument Company, the Symons Flying Service, the Institute of Numerical Analysis, the Air Force Lookout Mountain Laboratory, and others.

Gliders were preferred to powered planes or balloons in this project because of their small sinking rate, low speed, maneuverability, and accuracy of calibration. They can remain aloft for many hours traversing the wave, using updraft areas to gain altitude and, due to their low speeds, can be used to investigate the structure of severe turbulence which higher-speed, conventional aircraft try to avoid.

The Invisible Mountain Wave

There may be times when meteorological conditions are favorable for the creation of a mountain wave, but the lack of moisture in the atmosphere prevents the formation of clouds. This cloudless or "dry" wave is rare but can approach the waves previously discussed in turbulence. It can be dangerous even to pilots experienced in mountain wave flying, since it lacks the warning features that the recognizable clouds in most waves will provide.

Most serious is the case where the wave flow is completely obscured by a thick overcast with low ceiling. The wave is present and might be powerful but it is hidden to the pilot who is occupied with instrument flying. Additional hazards are present in the form of precipitation and icing. In the opinion of the authors it is practically impossible to penetrate the lower parts of a strong rotor cloud in controlled instrument flight. The majority of accidents in the mountain wave has occurred under these conditions.

The Mechanism Forming A Mountain Wave

The phenomenon of the mountain wave is essentially the same as the flow of water over a barrier which forms rapids and waves downstream. However, the fact that the atmosphere is a gas and that temperature, humidity and wind are changing with height introduces considerable modifications. In the air-flow model described in Fig. 1 the troposphere consists of two layers. They are separated by a temperature inversion on top of the cap cloud. Consequently, at least two processes work simultaneously:

a) A "spill-over" of the lower layer which shoots down the mountain slope with increasing speed after passing the crestline, at the same time sweeping away pockets of old stagnated air in the valley. It then jumps up into the rotor clouds in a manner related to the hydraulic jump of water.

b) An internal lee wave in the upper layer which forms in the wake of the mountain barrier and over the rotor zone.

The interaction of these two effects probably determines the height and position (with respect to tne mountain) of the rotor cloud, as well as the amplitudes of the waves. Complications are introduced by the change of winds with height, and further, by the existence of the stratosphere, basically a third atmospheric layer.

Meteorological Conditions Favoring a Mountain Wave

As previously stated, a favorable condition for the formation of a wave is for the wind at the mountain-top level to flow perpendicular to the mountain range. Actually, the wind direction can vary somewhat (50° being the maximum deviation from the perpendicular) and still cause a wave, but the most intensive waves occur with a strong, perpendicular flow. The stronger the flow, the more severe are the effects to be expected on the leeward side. There is a minimum of waves in summer and a maximum in winter. During the latter season, for example, over a range like the Sierra Nevada, waves can be expected during one out of four days with two or three strong waves per month included.

In the western United States where these waves have been frequently observed, it has been noticed that the strongest ones develop when there is a cold front approaching the mountains from the northwest and a trough aloft approaching from the west. This produces a strong westerly flow over the mountain ranges which have a northsouth orientation.

In accordance with the two-layer model of Fig. 1 there is generally a stable layer or temperature inversion present on the windward side of the range up to an altitude slightly above the peaks. A prefrontal area usually includes this condition. The top of this stable layer is just above the cap cloud and dips to its lowest level at a point directly over the downwind foot of the mountain. In the valley the winds are frequently parallel to the mountains or even reversed. Without this stable layer, convective instability would tend to break up the wave pattern.

The most favorable wind profile for the existence of a high wave has winds exceeding 25 knots at the mountain top level. There is usually a rapid increase in the wind speed with altitude in the level of the mountain range and for several thousand feet above with a strong, more uniform, flow up to the tropopause or higher. The character of the wave varies with different wind profiles. An exceptionally strong increase of wind with height (perhaps from 40 knots at mountain top to 100 knots 5,000 ft. higher) can eliminate the wave, leaving only stagnant air in the valley. A strong wave frequently is associated with the jet stream, the zone of strongest wind flow, when the latter is located in the neighborhood of the range. The strength of the flow during such a strong wave may be from 75 to 150 knots in the upper troposphere. In this case one has to watch out for high-level turbulence.

The same type of wave pattern as found in the Sierra Nevada has been observed all over the world. In fact, sailplane pilots have made use of these waves as an aid in soaring on all continents for years.

The following is a summary of the meteorological criteria which should serve to alert a pilot to the probability of a mountain wave:

a) Wind flow perpendicular to the range line and with a speed of more than 25 knots at mountain top level.

b) A wind profile which shows a strong consistent flow extending several thousand feet above the mountain tops, or an increase in speed with altitude.

c) An inversion or stable layer somewhere between the mountain tops and the 600 millibar level.

The Hazards of the Wave

The most dangerous feature of the wave is the combination of downdrafts, jet-like winds, horizontal turbulence and altimeter errors. These dangers cannot be stressed too highly. Pilots, even those with considerable experience, should avoid direct flights upwind through a full scale mountain wave, either by circumnavigating the area, delaying the flight, or flying at extremely high altitudes.

The downdrafts to the lee of the rotor, and the updrafts below it can carry a plane into the rotor cloud while a pilot is attempting to pass above or below this cloud. The best procedure for one caught in the rotor cloud is to nose down to pick up speed and attempt to reach the updraft area in advance (upwind) of the rotor to regain altitude. If the aircraft approaches the crestline of the mountains from the downwind side with insufficient height it will be practically impossible to climb through the jet-like currents near the mountain slope. These conditions, plus the fact that the peaks are hidden most of the time by the cap cloud, make it very likely that a plane fighting strong headwinds at minimum clearance altitude would fly into the mountain peaks.

As the barometric pressure is considerably disturbed in the mountain wave, altimeter errors are associated with the wave conditions. Since the wave is mostly a winter phenomenon, the temperature error in the altimeter reading, frequently neglected by pilots, contributes to an overestimation of the flight altitude. The maximum total error possible has been estimated to be about 1,000 ft. However, altimeter errors as high as 2,500 ft. near the mountain peaks have been claimed by pilots, although this seems an extreme figure.

Data are not yet evaluated to prove or disprove these figures. At a certain level the maximal positive "altimeter error," indicating greater than actual altitude, can coincide with the downdraft area immediately to the lee of the mountain range, leading to very hazardous conditions. Under wave conditions pilots should not place too much confidence in their altimeter readings.

Pilots who have the greatest experience in both soaring and flying under wave conditions relate that they consistently lost all control for short periods while under the influence of the roll cloud. They report that they have experienced more hazardous flight conditions in the wave than they have encountered in any thunderstorms. In fact, effective gust velocities measured in the sailplanes at heights up to 40,000 ft. were of the order of 40 ft/sec. This is more than has been measured in the extensive Air Force-Weather Bureau Thunderstorm Project. In wave flight, full controls have to be used to maintain a heading.

Although vertical displacements of aircraft flying downwind through the waves are generally moderate, the turbulence effects may be worse. Estimates show that high speed aircraft (jet class) flying downwind through the rotor zone would experience accelerations which can be structurally dangerous.

RULES FOR FLYING THE WAVE

The following rules of flight are suggested to pilots for flights over mountain ranges when wave conditions exist:

a) If possible, fly around the area when wave conditions are indicated. If this is not feasible, fly at a level which is at least 50 percent higher than the height of the mountain range.

b) Do not fly high speed aircraft into the wave; particularly, do not fly downwind. Structural damage may result.

c) Avoid the rotor (roll) cloud.

d) Avoid the cap cloud (foehnwall)* area with its strong downdrafts.

e) Avoid high lenticular clouds if the edges are very ragged and irregular, particularly if flying high.

f) If flying against the wind, updraft areas, especially the one upwind of the rotor clouds, may be used as an aid in gaining the altitude necessary to pass through the downdraft areas and cross the mountain range.

g) Do not place too much confidence in pressure altimeter reading near the mountain peaks.

h) Avoid penetrating a strong mountain wave on instrument flight.

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* "Foehn" is the meteorological term for the air current descending from a mountain range.

ACKNOWLEDGEMENTS

Acknowledgement is made to the following for their assistance in gathering and interpreting the data and results included in this survey:

The Meteorology Department, University of Los Angeles; the Southern California Soaring Association; the Symons Flying Service of Bishop, California; the Los Angeles Forecast Center; and the Scientific Services Division of the United States Weather Bureau.

The services of Mr. Paul James, Technical Editor of the Resources Management Branch, Geophysics Research Directorate, are acknowledged.

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PART II

SECTION 2

EXCERPTS FROM SAFETY BULLETINS

SAFETY EMPHASIS

"The Governmental safety authorities should devote increasing emphasis to singling out and attacking the really key factors and problems that have the greatest impact upon the safety of air operations. This will involve statistical and other investigations to isolate major safety and hazard-generating factors in aircraft, airmen, operations, and facilities; the solicitation of the opinions of industry and aviation organizations on the nature of such problems, and their cooperation in developing solutions; the pooling of the results of research and experience bearing upon these problems; and the open-minded exploration of fresh approaches to their solutions."

(The President's Air Coordinating Committee, May, 1954)

INJURIES IN TURBULENT AIR

Accident reports during a twenty-month period from May 1952 through December 1953 show that in air carrier operations, six crew members and 51 passengers were injured when flights encountered turbulent air. Although the seat belt sign was 'on' in almost every instance, all passengers had not fastened their seat belts when the severe turbulence was encountered. On many flights there are inadequate checks of belts by cabin attendants. Often no check is made. A passenger would rather be disturbed enough to answer a question about his belt than be carried off to surgery !

In one recent case after the seat belt sign was 'on' a passenger got up as the airplane entered turbulence. The cabin attendant released her belt, walked down to tell the passenger to be seated. Result: A broken leg.

The following letter is from a Vice President of Operations to his pilots:

"The increase in speed in modern aircraft has been accompanied by an increase in the number and severity of passenger and attendant injuries resulting from turbulence. Some of these occur in clear air turbulence. Others occur in frontal or thunderstorm areas where turbulence is known to exist.

In practically all cases the seat belt was not fastened. Generally, this was because the sign was not on, or had not been on long enough for the attendants to check the belts. In several cases, there was a passenger in the lavatory who did not have time to return to his seat. In other cases, the passenger had unfastened his belt.

Attendants were injured while checking seat belts, checking lavatory for passengers, or administering to sick passengers. In most instances the seat belt sign was on, but 'No Smoking' sign was off.

Six attendants were on the injured list for a total of 159 days last year. This emphasizes the need for taking all possible precautions against injuries caused by turbulence.

Recommended procedure:

1. Turn seat belt sign on in time to permit attendants to check belts and for passengers in lavatories to return to seats.

2. Attendants check passenger seat belts as quickly as possible after light comes on.

3. Keep seat belt sign on while flying in areas of possible turbulence, even though no turbulence is being experienced.

4. Attendants should remain in seat as much as possible, even though the 'No Smoking' sign is off. Perform only necessary duties. Check with captain on possibility of turbulence."

Flight Safety Foundation

V_1, V_2

"Several general conclusions can be drawn which apply to emergencies where one engine fails during the take-off.

1. Stop the take-off if engine failure occurs before V_1.

2. Continue the take-off if engine failure occurs after V_1. (The exception to this rule occurs when there is known to be considerable excess runway (1,000 feet) above that required to accelerate to V_1 and stop, for the actual conditions of the take-off. Under these conditions, if V_1 has been exceeded by not more than 5 miles per hour, the airplane is not more than 15 feet above the runway and the gear has not yet been retracted, the pilot may safely elect to land and stop. In general, however, take-offs in which engine failure occurs after V_1 are committed to proceed with the take-off.)

3. Hold the airplane on the ground until the V_2 safety speed is reached.

4. Hold the airspeed at the V_2 safety speed during the engine-out climb until all obstacles are cleared.

5. Hold the flaps at take-off setting until all obstacles are cleared.

6. Increase airspeed above V_2 before the flaps are raised."

(CAA Aviation Safety Release #386)

FLOATABLE SEAT CUSHIONS

APB 53-25 called attention to the usefulness of pillows to provide buoyancy in accidents involving evacuation problems on water. (Since 1946 there have been 16 such, 8 non-skeds, 8 skeds in U.S. airline operations making 150 passenger fatalities 15 pilot fatalities. Several of these occurred in bodies of water adjacent to airports on landing or take-off with no time to prepare for the emergency.)

The Douglas Aircraft Co. has issued report No. SM-14934 on "Use of Aircraft Seat Cushions As Life Preservers". It says:

"INTRODUCTION: Two commercial aircraft crashes in water occurred during 1953 which bore distinct similarities. In each instance, seat cushions floated to the surface as the plane sank. In the first crash, one of the cushions enabled a stewardess, who did not know how to swim, to remain afloat for approximately one hour until rescued. In the second crash, floating seat cushions were reported by searching ships. Investigation of the seats involved in both accidents showed that their cushions were enclosed in an upholstery cover that had been fastened to the seat with five snaps across the front seat structure.

DISCUSSION: Since we may assume that the value of a seat cushion as a life preserver was not realized by passengers in the two crashes, it is further assumed that the seat cushions must have come loose either by their own inertia or by disintegration of the seats. The use, by the stewardess, of a cushion to save her life proves that they could be a valuable life preserver on continental flights which are not normally equipped with life jackets. They will also serve as a valuable adjunct to the emergency equipment provided by law on overwater airplanes. This extra function can be acquired at no increase in the weight of the airplane. Nor is extra cost involved if the cushion covers are originally designed for quick detachability.

To advance the idea that seat cushions can become valuable life preservers, it was necessary to establish buoyancy values of a typical cushion. A test program, therefore, was initiated involving laboratory tests, which were followed with ocean tests accomplished by swimmers in the rough surf off the California coast.

CONCLUSIONS: An upholstered Douglas dayplane seat bottom cushion will support 13 lbs. in water for at least 72 hours under laboratory conditions. It reached a steady state in buoyancy after three hours of immersion. A similar cushion, modified by replacing the bottom inch of latex foam with one inch of closed cell, foamed vinyl, will support 26 pounds in water for at least 28 hours under laboratory conditions, reaching a steady state of buoyancy after three hours immersion. However, since the unmodified cushion contained adequate buoyancy for one person, a modification to gain increased support is considered unnecessary.

The buoyancy of the cushion in combination with the human body will enable a non-swimmer to remain afloat for at least 24 hours. The conclusion is reached, therefore, that a seat bottom cushion, similar to the one tested is a good life preserver if it is easily removable."

INCIDENTS OF ATMOSPHERIC CONTAMINANTS IN CARRIER AIRCRAFT JANUARY 1 - JUNE 30, 1953

"Ninety-three incidents in which smoke or other atmospheric contaminants occurred in U.S. Civil air carrier aircraft were reported in the Summaries of Daily Mechanical Reports - CAR 61 and 41 - for the period January 1 - 30 June, 1953 (Table 1) from CAA Aviation Toxicology Bulletin No. 8, July 1953.

TABLE I

Source of Smoke or Other Atmospheric Contaminants	Number of Incidents	Per Cent of Total
Radio and electronic equipment	36	39
Other electrical equipment	26	28
Ventilation or pressurization system	13	14
Heater	9	10
Hydraulic fluid	4	4
Miscellaneous	4	4
Unidentified	1	1
Total	93	

Tabulation of Incidents of Smoke or Other Atmospheric Contaminants According to Place of Occurrence.

TABLE II

Source of Smoke or Other Atmospheric Contaminants	Total	Ground	Air	Unscheduled Landing
Radio and electronic equipment	36	4	32	5
Other electrical equipment	26	8	18	8
Ventilation or pressurization system	13	5	8	2
Heater	9	1	8	5
Hydraulic fluid	4	0	4	4
Miscellaneous	4	0	4	1
Unidentified	1	0	1	1
Totals	93	18	75	26

"Additional information regarding these incidents follows:

(a) Radio, electronic and other electrical equipment: These incidents are similar both as regards total number and general pattern to these occurring in previous six months periods.

(b) Ventilation or pressurization system: Twelve of the 13 incidents (which occurred on a single model airplane) were caused by failure or malfunction of the compressors or related equipment causing smoke or oil to enter the ventilating ducting. In the remaining incident, newspaper presumably entered the supercharger intake.

(c) Heater: These cases involved the presence in the heater, ducting or other parts of the heater of oil (2 cases), paper (1), rubber (2), shellac (1) and sealant (1). Of the two remaining cases, one was due to imperfect combustion and the other to insufficient burnout time.

(d) Hydraulic fluid: Two of these cases involved the leakage of hydraulic fluid into the heater ducting. One case involved spillage of hydraulic fluid into the inverter compartment during the refilling of the hydraulic supply tank. In the remaining case a fine mist of hydraulic fluid came from a hydraulic valve.

(e) Other: The case listed under Miscellaneous involved 'vapor' coming from a clogged vent which served as a drain for the vacuum pump and galley drain. The case under Unidentified was smoke in the cockpit from an unknown source."

SAFETY RATES FOR U.S. CERTIFICATED AIR CARRIERS AND U.S. LARGE RATE IRREGULAR AIR CARRIERS INCLUDING MILITARY CONTRACT PASSENGER OPERATIONS IN 1953

The U.S. air carrier safety rates in all passenger services for the calendar year 1953, including military contract passenger operations, and covering both certificated and large irregular airlines, achieved an all-time world record in the number of passengers and the number of passenger-miles flown.

TOTAL PASSENGER OPERATIONS BY U.S. CERTIFICATED AIR CARRIERS AND LARGE IRREGULAR AIR CARRIERS FOR 1953

Both U.S. certificated air carriers and U.S. large irregular air carriers flew an estimated 34.5 million passengers and 20.8 billion passenger-miles in all classes of passenger operations during the calendar year 1953.

A total of 250 passenger fatalities were recorded in both certificated and large irregular air carrier operations for 1953, while the overall total passenger fatality rate for both types of carriers was 1.2 fatalities per 100 million passenger miles flown.

U.S. CERTIFICATED AIR CARRIERS - 1953

Total passenger operations of the certificated air carriers for 1953 in all types of passenger service were estimated at 33.8 million passengers and 19.6 billion passenger-miles. The total passenger fatalities recorded for all certificated air carrier passenger services in 1953 were 109, while the passenger fatality rate for all certificated carriers in the same period was 0.6 per 100 million passenger-miles flown.

A breakdown of total passenger operations of U.S. certificated air carriers for 1953 follows:

1. Scheduled domestic passenger operations by the certificated air carriers in 1953 accounted for 30.7 million passengers and 15.4 billion passenger-miles. A total of 86 passenger fatalities occurred in this category of operation in 1953, and the passenger fatality rate was 0.6 per 100 million passenger-miles flown.

2. Non-scheduled (charters, etc.) domestic passenger operations of certificated air carriers for 1953 involved 107,000 passengers and 79 passenger miles. The passenger fatality rate in this category of operation in 1953 was zero.

3. Scheduled foreign/overseas passenger operations of certificated air carriers in 1953 involved 2.8 million passengers and 3.6 billion passenger-miles. A total of 2 passenger fatalities occurred in this type of operation in 1953, and the passenger fatality rate was 0.1 per 100 million passenger-miles flown.

4. Non-scheduled (charters, etc.) foreign/overseas passenger operations of certificated air carriers in 1953 accounted for 114,000 passenger and 163 million passenger-miles. The passenger fatality rate in this category of operations in 1953 was zero.

5. Military passenger operations of certificated air carriers for 1953 (including Civil Air Movements) accounted for 406 million passenger-miles flown. There were 21 passenger fatalities (one domestic accident) in this military passenger operation by the certificated air carriers in 1953, and the passenger fatality rate was 5.2 per 100 million passenger-miles flown. The Board stated that no passenger totals for military passenger services are available at this time and no breakdown of figures is available to separate domestic and foreign/overseas passenger-miles.

U.S. LARGE IRREGULAR AIR CARRIERS - 1953

Total passenger operations for all U.S. large irregular air carriers for 1953 in all types of passenger service reveal that an estimated 787,000 passengers were flown 1.3 billion passenger-miles.

The total passenger fatalities recorded for all large U.S. irregular air carrier services in 1953 were 141, while the passenger fatality rate for such carriers in 1953 was 11.1 per 100 million passenger-miles flown.

A breakdown of total passenger operations for all U.S. large irregular air carriers for 1953 follows:

1. Domestic common carriage and charter passenger services (non-military) of U.S. large irregular air carriers for 1953 flew 481,000 passengers and 675 million passenger-miles. A total of 5 passenger fatalities occurred in this category of operations in 1953, and the fatality rate was 0.7 per 100 million passenger-miles flown.

2. Foreign/Overseas operations of U.S. large irregular air carriers for 1953 accounted for 43,000 passengers and 151 million passenger-miles. A total of 50 passenger fatalities occurred (in a single accident) in this category of operation in 1953, and the passenger fatality rate was 33.1 fatalities per 100 million passenger-miles flown.

3. Domestic military passenger services (including CAM movements) operated by U.S. large irregular air carriers in 1953 flew 228,000 passengers and 319 million passenger-miles. A total of 56 passenger fatalities occurred in this category of operations in 1953, and the passenger fatality rate was 17.6 per 100 million passenger-miles flown.

4. Foreign/Overseas military passenger operations of U.S. large irregular air carriers in 1953 accounted for 35,000 passengers and 125 million passenger-miles flown. A total of 30 passenger fatalities occurred in this category of operations (all in one accident) in 1953 and the passenger fatality rate was 24.0 fatalities per 100 million passenger-mile flown.

(Extracted from Civil Aeronautics Board Report, prepared by the Analysis Division of the Board's Bureau of Safety Investigation. CAB 54-12, 18 February, 1954)

CIVIL AERONAUTICS BOARD

ESTIMATED PASSENGER SAFETY RATES FOR U.S. CERTIFICATED AND LARGE IRREGULAR AIR CARRIERS, INCLUDING MILITARY PASSENGER OPERATIONS, IN CALENDAR YEAR 1953

	Certificated Air Carriers				Irregular Air Carriers			
	Scheduled Services	Non-Scheduled Services	Military Services (Incl. CAM)	Total	Non-Military Services	Military Services (Incl. CAM)	Total	Grand Total
Passengers Carried								
Domestic	30,715,000	107,000	NA	30,822,000	481,000	228,000	709,000	31,531,000
Foreign/Overseas	2,831,000	114,000	NA	2,945,000	43,000	35,000	78,000	3,023,000
Total	33,546,000	221,000	NA	33,767,000	524,000	263,000	787,000	34,554,000
Passenger Miles Flown (000)								
Domestic	15,354,000	79,000	(*)	15,839,700	675,000	319,000	994,000	16,833,700
Foreign/Overseas	3,570,000	162,000	(*)	3,732,000	151,000	125,000	276,000	4,008,000
Total	18,924,000	241,000	406,700	19,571,700	826,000	444,000	1,270,000	20,841,700
Passenger Fatalities								
Domestic	86 a/	0	21 c/	107	5 d/	56 f/	61	168
Foreign/Overseas	2 b/	0	0	2	50 e/	30 g/	80	82
Total	88	0	21	109	55	86	141	250
Passenger Fatality Rate Per 100 Million Pass. Miles Flown								
Domestic	0.6	0	(*)	0.7	0.7	17.6	6.1	1.0
Foreign/Overseas	0.1	0	0	0.1	33.1	24.0	29.0	2.1
Total	0.5	0	5.2	0.6	6.7	19.4	11.1	1.2

NA - Not Available
(*) - Separation of Domestic and Foreign/Overseas passenger miles not available
a/ - Four fatal accidents
b/ - One fatal accident
c/ - One fatal accident
d/ - One fatal accident
e/ - One fatal accident
f/ - Two fatal accidents
g/ - One fatal accident

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SCHEDULED AIRLINE SAFETY RECORD

Year	Fatalities per 100 million passenger-miles	Passenger-miles flown (Millions)
1938	5.2	614
1939	2.3	833
1940	2.8	1,262
1941	2.2	1,672
1942	3.2	1,742
1943	1.7	1,925
1944	2.6	2,534
1945	2.4	3,870
1946	1.6	7,199
1947	2.7	8,177
1948	1.3	8,208
1949	1.0	9,240
1950	1.3	10,702
1951	1.3	13,685
1952	0.9	16,173
1953	0.6	19,600

NONSKED SAFETY

Year	Fatalities per 100 million passenger-miles	Passenger-miles flown (Millions)
1948	19.7	458
1949	17.9	582
1950	3.8	770
1951	7.3	1,069
1952	2.1	1,252
1953	11.1	1,325

(Source: Civil Aeronautics Board)

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COMPARATIVE TRANSPORTATION SAFETY RECORD

Passenger Fatalities and Rate of Passenger Fatalities per 100 Million Passenger Miles

	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953*
Pass. Automobiles and Taxicabs			12,900	15,400	15,300	15,200	15,300	17,600	21,000	22,600	23,500
Rate	2.7	2.9	2.9	2.5	2.3	2.1	2.0	2.2	2.4	2.8	2.9
Buses			120	140	140	120	120	100	130	100	70
Rate	.22	.22	.17	.19	.21	.18	.20	.17	.22	.16	.13
Railroad Pass. Trains	262	249	145	115	75	52	29	184	150	14	50
Rate	.31	.26	.16	.18	.16	.13	.08	.58	.43	.04	.16
Domestic Scheduled Air Transport Planes	22	48	76	75	199	83	93	96	142	46	89
Rate	1.3	2.2	2.2	1.2	3.2	1.3	1.3	1.1	1.3	.35	.58
International Scheduled Air Transport Planes	10	17	17	40	20	20	0	48	31	94	2
Rate	3.9	5.3	3.7	3.6	1.1	1.0	-	2.1	1.2	3.1	.06

* 1953 figures from National Safety Council "Accident Facts", 1954 edition.

(Source: ATA Safety Digest No. 48)

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RECAPITULATION OF U.S. AIR CARRIER ACCIDENTS
(Calendar Year 1953)

(Extract from "Resume of U.S. Air Carrier Accidents for 1953" Civil Aeronautics Board, Bureau of Air Safety Investigation)

TYPE OF OPERATOR	Total Accidents	Fatal Accidents	Aircraft Damage			Crew Injury			Passenger Injury			Others Injured			Total	Fire		
			Destroyed	Substantial	Minor/None	Fatal	Serious	Minor/None	Fatal	Serious	Minor/None	Fatal	Serious	Minor	Aboard	In Air	After Impact	On Ground
Class of Operations																		
A. Scheduled Domestic																		
Scheduled Passenger	31	4	5	18	3	15	2	104	86	7	844	0	0	0	1058	2	3	0
Scheduled Other Revenue	1	0	0	1	0	0	0	2	0	0	0	0	0	2	2	0	0	0
Non-Revenue	1	1	1	0	0	1	1	1	0	0	0	0	0	0	3	0	1	0
Non-Scheduled Revenue	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Military Contract	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
All Cargo Carriers																		
Scheduled Revenue	4	1	1	3	0	2	0	7	0	1	2	0	0	0	12	0	1	0
Non-Revenue	1	1	1	0	0	4	0	0	3	0	0	0	0	0	7	0	1	0
Cruise Carrier																		
Military Contract:																		
Passenger	1	1	1	0	0	3	0	0	22	16	0	0	0	0	41	0	1	0
Other Revenue	1	1	1	0	0	2	0	0	0	0	0	0	0	0	2	0	1	0
Sub-Total	40	9	10	22	8	27	3	114	111	24	846	0	0	2	1125	2	8	0
B. Scheduled Foreign/Overseas		1/																
Scheduled Passenger	6	3	1	4	1	0	2	31	2	16	197	4	0	0	248	0	1	0
Scheduled Other Revenue	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Revenue	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Scheduled	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Military Contract	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
All Cargo Carriers																		
Scheduled Revenue	1	0	1	0	0	0	0	3	0	0	0	0	0	0	3	0	1	0
Sub-Total	7	3	2	4	1	0	2	34	2	16	197	4	0	0	251	0	2	0
C. Irregular Domestic		1/																
Passenger	5	2	1	2	2	2	1	13	5	18	127	1	0	0	166	0	0	0
Other Revenue	2	0	1	1	0	0	0	7	0	0	0	0	0	0	7	0	0	0
Non-Revenue	5	2	3	2	0	7	1	22	1	1	3	0	0	0	25	0	0	0
Military Contract:																		
Passenger	7	2	3	4	0	5	0	18	56	0	187	0	0	0	266	1	1	0
Other Revenue	1	0	0	1	0	0	0	2	0	0	2	0	0	0	4	0	0	0
Sub-Total	20	6	8	10	2	14	2	62	62	19	319	1	0	0	468	1	1	0
D. Irregular Foreign/Overseas																		
Passenger	1	1	1	0	0	8	0	0	50	0	0	0	0	0	58	0	0	0
Other Revenue	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Revenue	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Military Contract:																		
Passenger	1	1	1	0	0	5	0	0	30	0	0	0	0	0	35	0	1	0
Sub-Total	2	2	2	0	0	13	0	0	80	0	0	0	0	0	93	0	1	0
E. Contract Carriers 2/																		
Military Contract:																		
Domestic Passenger	1	0	0	1	0	0	0	4	0	0	39	0	0	0	43	0	0	0
Foreign/Overseas-Other Revenue	1	0	1	0	0	0	0	3	0	0	1	0	0	0	4	0	0	0
Sub-Total	2	0	1	1	0	0	0	7	0	0	40	0	0	0	47	0	0	0
F. Alaskan																		
Passenger 3/	15	1	2	13	0	1	0	18	1	0	41	0	0	0	61	0	0	0
Other Revenue	7	0	1	6	0	0	2	8	0	0	1	0	0	0	11	1	0	0
Non-Revenue	1	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0
Non-Scheduled	1	0	0	1	0	0	0	1	0	0	1	0	0	0	2	0	0	0
Military Contract:																		
Passenger	1	0	0	1	0	0	0	1	0	0	2	0	0	0	3	0	0	0
Sub-Total	25	1	3	22	0	1	2	29	1	0	45	0	0	0	78	1	0	0
G. Intra-State	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL - ALL CARRIERS																		
Passenger	58	11	10	37	11	26	5	166	144	41	1209	5	0	0	1591	2	4	0
Other Revenue	15	1	4	11	0	2	2	27	0	1	3	0	0	2	35	1	2	0
Non-Revenue	8	4	5	3	0	12	2	14	4	1	3	0	0	0	36	0	2	0
Non-Scheduled	1	0	0	1	0	0	0	1	0	0	1	0	0	0	2	0	0	0
Military Contract:																		
Passenger	11	4	5	6	0	13	0	23	108	16	228	0	0	0	388	1	3	0
Other Revenue	3	1	2	1	0	2	0	5	0	0	3	0	0	0	10	0	1	0
GRAND TOTAL	96	21	26	59	11	55	9	236	256	59	1447	5	0	2	2062	4	12	0

1/ Includes one propeller accident to person on ground.

2/ No accidents recorded in Non-Military Operations.

3/ Includes two accidents involving Pilot-Owners.

PART II

SECTION 3

EXCERPTS RELATING TO AIRCRAFT ACCIDENTS FROM LLOYD'S CASUALTY REPORTS AND PRESS REPORTS

A Douglas DC-3, owners Devlet Hava Yollari Genel Mudurlugu, four crew, a hostess and 16 passengers, had one engine explode and burst into flames a few moments after taking off from Etimesgut Aerodrome, Ankara, for Van in the morning of 25 September 1953. The aircraft crashed into a river bed from a height of about 450 feet and was practically a total loss, the forepart being entirely burnt out. Five lives were lost and the hostess and 15 passengers escaped with only minor injuries.

(Lloyd's Agents)

A Douglas DC-3, owners Transportes Aéreos Mexicanos, S.A., pilot Rodolfo Sanders Briceno, while on a cargo flight from Campeche to Merida, Mexico, on 14 September 1953, struck the steel signal tower on arrival over the airport in dense fog and part of one wing was broken off. The aircraft kept on flying and crashed in woods near Chablekal, 16 kilometres north of Merida. The pilot died of his injuries.

(Lloyd's Agents)

A Panair Lockheed Constellation exploded in the air near Sao Paulo, 17 June 1953, killing the 10 passengers and seven crew on board. The plane was bound for Buenos Aires from London. The pilot reported engine trouble when nearing Sao Paulo and asked permission to make a special emergency landing. Witnesses state that the aircraft's wing hit a hill while trying to land and that the plane burst into flames.

(Reuter)

A Lockheed of Línea Aérea Nacional crashed and burst into flames about 570 miles north of Santiago killing its seven occupants on 15 June 1953. The plane, returning to Copiapo Airport owing to engine explosion, crashed while coming in to land at Copiapo Airport while on flight from Antofagasta to Santiago.

(Reuter)

Quick action by Capt. William O'Connor, a Capital Airlines pilot, averted a possible accident on 14 November 1953 on a Constellation plane carrying 61 persons, including the entire squad of the National Football League's Pittsburgh Steelers. Fifteen minutes after the four-engine plane left, the pungent odor of ether fumes began filling the ship. O'Connor turned the ship around and 15 minutes later landed at greater Pittsburg Airport. The aircraft was hurriedly evacuated but no one aboard was affected by the fumes which are highly inflammable. A Capital spokesman said the ether had spilled out of a can in a duffel bag in the baggage compartment, located in the belly of the plane. The bag was filled with first aid supplies used by the Steeler's trainer. The plane was ventilated for an hour before the flight was resumed to New York.

(Montreal Daily Star, 16 Nov. 1953)

A Philippine Air Lines' C-47 made an emergency landing in a rice paddy 16 miles northeast of Tuguegarao, North Luzon, on 15 October 1953 while on a regular passenger flight. Passengers and crew safe but aircraft wrecked.

A Dakota passenger aircraft of Air Atlas Line, Geneva for Casablanca, crashed on a beach after take-off at Tangier on 10 October 1953 when both engines failed. Three casualties in dangerous condition.

(Lloyd's Agents)

Douglas Dakota F-BEST was found 29 June 1953 burned on Phou Lassy Hill, about 30 miles northwest of Pakse, Haiphong. The crew of five and 29 passengers were killed.

(Lloyd's Agents)

One passenger died and six were seriously injured when an Orient Airways Dakota, carrying pilgrims to the Holy City of Mecca, crashed near Sharjah, 3 August 1953. Four of the crew and another passenger were also injured. According to latest reports received by the company's head office, the plane crashed one minute after leaving Sharjah airstrip. The plane was carrying 21 Pakistani pilgrims from Karachi to Jeddah, Saudi Arabia, on their way to Mecca. A special plane flew the injured to a Bahrein hospital but one man died.

(Reuter)

Twelve people on board a Comet owned by Union Aeromaritime, received only a shaking when it hit a wall at Dakar Airport 25 June 1953. The plane was badly damaged. The aircraft was bound for Marseilles and Paris. The airline sent another Comet from Paris to pick up the passengers and crew of six.

(British United Press)

A Douglas DC-3, owners Líneas Aéreas Costarricenses S.A., three crew and 12 passengers, crashed into mountainside in poor visibility at San Ramón de San Isidro del General, Costa Rica, on 15 June 1953, while on a flight from Palmar Sur to San Isidro del General. The aircraft is a total loss, nine lives were lost.

A Lockheed L-49, operated by Pan American World Airways, Inc., pilot, four crew and 23 passengers, was involved in an accident with Piper Pacer YS-92 and was substantially damaged on 26 July 1953 at San Salvador, El Salvador. Three occupants of the Piper were killed.

(Lloyd's Agents)

A Consolidated CV-340 Convair, operators United Airlines, Inc., three crew and 35 passengers (estimated) was substantially damaged at Cleveland, Ohio, on 26 July, while on a flight from Boston to Chicago. No lives were lost.

(Lloyd's Agents)

Two people were killed 22 October 1953 when a DeHavilland Dragon, owners, Trans-Australian Airlines, crashed 1,000 miles northwest of Brisbane; the dead are Mrs. Kathleen O'Leary 22, wife of a Dublin doctor, and Captain Martin Garrett, 26, the pilot of the aircraft, which is used on the "flying doctor" service operated in Queensland. Doctor O'Leary, the flying doctor on the plane, received head injuries. A mother and son, who were picked up from a lonely back station by the plane for medical treatment,escaped unhurt when the aircraft nosedived into the ground shortly after taking off from a cattle station.

(Exchange Telegraph Company)

A Dakota, owners Jamair Co., Ltd., pilot and two crew, landed too far down the runway and after crossing a road crashed through a brick wall, having failed to pull up within the aerodrome boundary, at Barrackpore, India, on July 8, 1953, while engaged on a non-scheduled freighter service. Substantial damage was sustained. The occupants escaped unhurt.

A Consolidated PBY-5A Catalina, owners Texas Petroleum Company, collided head on with the wing tip of a military F-47 trainer, owned by the Colombian Air Force, at some 5,000 feet in thick cloud over an area used by the air force base at Palanquero, Columbia, on 26 September 1953, while on a flight to Puerto Mino. Both aircraft are total losses. The pilot of the F-47 was able to bale out unhurt.

(Lloyd's Agents)

More than 20 people were killed in a plane crash on 19 October 1953 while on their way to a meeting between President Eisenhower and President Adolfo Ruiz Cortinez, of Mexico. There were apparently no survivors. Passengers included leading Mexican journalists and entertainers. The plane, a C-47, left Monterrey at 1 p.m., GMT, for Falcon Dam which was being opened by the presidents. The plane was completely wrecked on the side of a deep ravine, and was sighted 16 miles northeast of Monterrey. The plane, a Dakota, belonged to Pemex, Mexico's Petroleum Corporation. It was one of a fleet of 22 planes which had carried reporters and Government officials to the ceremonies marking the inauguration of the dam.

(Reuter)

The wreckage of an air liner CP-600 lost between Camiri and Sucre was sighted from the air 5 November 1953, on top of a mountain range 37 miles from Sucre. The aircraft was burned out and the 28 persons on board killed. The scene of the crash was on top of the Rodeo Pampa mountain range south of the town of Tarabuco.

(Reuter)

The steward of a Sabena Convair was killed on 10 December 1953 when the door of the aircraft flew open a few minutes after the aircraft had left Paris for Brussels. The steward, who made unavailing attempts with the radio operator and co-pilot to reclose the door, was sucked out by the wind when the door was torn from its hinges as the aircraft banked to turn back to Le Bourget. The aircraft succeeded in landing on one engine, the other having been seriously damaged by impact with the door.

("The Times" Correspondent)

One passenger was killed and six passengers and 3 crew were injured when a Sabena Convair crash landed a mile from Kloten Airport, Zurich on 19 December 1953. The aircraft, on flight from Brussels to Zurich, was badly damaged.

(British United Press)

An airliner of the Turkish State Airlines, on the regular Istanbul-Bandirma-Canakkale route, struck a hill near Lapseki and burst into flames, on 5 January 1954. There were five passengers and five members of the crew on board, of whom two members of the crew and two of the passengers were killed. The others were seriously injured.

("The Times" Correspondent)

A Pan American World Airways DC-6B struck the ground 150 yards short of the main runway at Shannon Airport on 15 February 1954. It ploughed into soft ground, damaging a wing and the undercarriage. External radio equipment was swept away. None of the 46 people on board was injured.

(Evening Standard)

A plane crashed near Praha, Czechoslovakia, 14 January 1954. It is reported from Vienna that 15 persons were killed; 11 passengers and four crew members. The plane was on the service Praha-Moravska-Ostrava.

(Ouest France)

A Boeing Stratocruiser, owners British Overseas Airways Corporation, London for New York, pilot and crew of ten, with 42 passengers, made a heavy landing at Keflavik Aerodrome, Iceland, on 28 February, stated to be owing to propellers reversing during bounce. Aircraft sustained extensive damage. No lives lost.

(Lloyd's Agents)

A Vickers' Viking, operated by Eagle Aviation Ltd., belly-landed at Torslanda Airport, Gothenburg, 24 February 1954 and had propellers damaged. There were no casualties.

(Lloyd's Agents)

An Indian Airlines Corporation's Dakota crashed about 10 miles from Delhi on 25 February 1954, while on a test flight. All three crew were killed.

(Lloyd's Agents)

A BOAC Constellation, en route Sydney to London 13 March 1953, undershot runway at Kallang airport, Singapore, and hit a low wall, causing the plane to overturn. The aircraft burst into flames. All 31 passengers and two of the crew of nine were killed. Weather at the time was clear with a wind of 18 to 20 knots down the runway.

(Lloyd's Agents)

36 people were killed 8 April 1954 when a trans-Canada airlines North Star and a Royal Canadian Air Force training plane collided over Moose Jaw and plunged to earth in flames. Eye witnesses said that the trainer, a Harvard, struck the right wing of the four engined

airliner. There were no survivors. Eye witnesses said that the collision tore off the right wing of the North Star and it plunged to earth, exploding into a tremendous ball of flame on the way down. Pieces flew in all directions. A petrol tank flew off and crashed into a house, setting it on fire. Two other homes burst into flames. The North Star took off from Winnipeg early today after being delayed on a flight from Montreal to Vancouver. The Royal Canadian Air Force plane came from the North Atlantic Treaty Organization training station outside Moose Jaw. One of the houses which caught fire was burned to the ground, another was reported badly damaged. Trans-Canada Airlines state that 35 persons were on board the North Star, 31 passengers and four crew. The Royal Canadian Air Force state that one man was in the Harvard.

(Reuter)

A Douglas DC-4, owners Pan American World Airways, Inc., pilot, two crew and six passengers, sustained substantial damage at Nandi Airport, Fiji, on 7 March while on Search and Rescue flight. No lives were lost.

(Lloyd's Agents)

A twin engined Lockheed newspaper-carrying aircraft owned by A. B. Airtaco, Stockholm, force-landed in a forest at Aghult, near Eksjo, 3 May 1954. The aircraft caught fire and is a total loss but the pilot was saved. The accident was caused by failure of the starboard engine owing to a drop in oil pressure. The pilot was endeavouring to make Kalmar Airfield for an emergency landing when an engine cut out.

(Lloyd's Agents)

A Darbhanga Aviation's Dakota crashed two miles south of Dum Dum Aerodrome on 30 April 1954, shortly after taking off from the airport, killing the crew of three and one passenger. The plane was carrying eight passengers and a cargo consisting of textiles, stationery and tinned provisions.

(Lloyd's Agents)

A Douglas DC-3, owners Transportes Aereos de Jalisco, S.A., crashed at Guadalajara, Mexico, on 28 April 1954. The port engine was destroyed by fire and the port wing, landing gear and tail were badly damaged.

(Lloyd's Agents)

An Avro Anson, carrying a pilot, co-pilot and four passengers crashed on San Gabriel mountain at 8 a.m. on 24 April, ten minutes after taking off in bad visibility from Copainala. The occupants are believed to have been killed.

(Lloyd's Agents)

A DH-104 Dove crashed while landing in heavy downpour after windscreen wipers failed at Kamembe airport, Belgian Congo, on 1 May, while on a flight from Goma to Bukavu, Belgian Congo. The aircraft was heavily damaged. 2 members of the crew and three passengers were injured.

(Lloyd Anversois)

A twin engined charter plane with 5 passengers on board, is missing and believed to have come down today between the islands of Hawaii and Oahu, in the Hawaiian group. The plane belonged to Cockett Airlines and had been on a special flight to Honolulu.

(British United Press)

A Douglas DC-4 VH-TAB, owners Trans-Australian Airlines, was damaged by a severe hailstorm on 27 February 1954 while in flight between Sydney and Brisbane. The fuselage nose section was damaged beyond repair and sundry other damage was sustained.

(Lloyd's Agents)

Three children were killed but the remainder of the 26 passengers and crew of two escaped when a New Zealand National Airways Corporation Douglas airliner crashed just before reaching Paraparaumu, 22 May 1954, and burst into flames. The aircraft was on a flight from Christ-church to Auckland when the engines failed. The pilot steered for a gap in the trees as the plane came in low. The engines were functioning again by then but the aircraft just failed to clear a ridge before the airport. It struck a house, uprooted a pine tree, crashed through more trees and landed in a clearing. The pilot and co-pilot were thrown clear, suffering minor injuries. Residents dragged passengers clear. All escaped with burns and minor injuries except three children aged between one year and five sitting in the forward part of the plane.

(Exchange Telegraph Company)

A Dakota EP-AAK was extensively damaged while landing at Shiraz, Persia, 17 May 1954.

(Lloyd's Agents)

A Douglas DC-3 Dakota, operated by Jamair Company, Ltd., crashed while landing at Saugaon Airport, West Bengal, on 15 May while on a flight from Calcutta.

(Lloyd's Agents)

A Vickers Viscount, owners Compagnie Nationale Air France, had a port outer engine fail while taking off from Kloten Airport, Switzerland on 4 July 1954. The aircraft overran the runway, struck a boundary marking light and nosed over in soft mud, where the defective engine caught fire. The fire was quickly extinguished. Damage was sustained to the undercarriage and the propellers were bent. The passengers escaped injury.

(Lloyd's Agents)

A Skymaster of the Sabena Line, flying from Belgium with 49 passengers and a crew of six was struck by lightning over Lichfield, on its way to Manchester Airport on 5 July 1954. The nose was crumpled and a square foot of metal covering was stripped from the port side of the tailplane.

(Daily Telegraph and Morning Post)

A Vickers Viking of Airwork, Ltd., with a pilot, four crew and 32 passengers, on a flight from Blackbushe to Nice, reported to have returned owing to engine trouble and crashed and caught fire on landing at Blackbushe on 15 August 1954. The aircraft burnt out, but no lives lost.

(Lloyd's Agents)

A Paris Airport control tower official has been dismissed after a British and a French Airliner narrowly escaped a serious collision in dense fog on 11 August 1954. A British European Airways Elizabethan about to land at Le Bourget, and a DC-4 Skymaster of Air France, which had just taken off from Orly, brushed wing tips as they circled 8,000 feet over Paris. A tear was found in the Elizabethan's port wing. The DC-4 flew on to Dusseldorf undamaged.

(Reuter)

Two men were killed on 8 August 1954 in the crash of an Alaska Airlines DC-3 cargo plane in the wild Kuskokwim Mountains, 250 miles northwest of Anchorage, Alaska.

(New York Maritime Association)

A Douglas aircraft, owners Linea Aerea Nacional, pilot, co-pilot and 26 passengers, was caught by a strong wind, ran on to uneven ground, caught fire and was destroyed, while landing on an airfield about five miles from Porvenir, Tierra del Fuego, Chile, on 29 May 1954. The crew and passengers escaped unhurt.

(Lloyd's Agents)

At Gage, Oklahoma, 15 June 1954, a DC-4 passenger plane, forced down by a burning engine, burst into flames and was completely destroyed just after all 78 people on board had scrambled to safety. The plane with 75 passengers and 3 crew was flying from New York to Los Angeles.

(Reuter)

Transportes Aereos Nacional, Ltda., has reported that one of their C-47 air liners crashed and burst into flames in the Serra do Cipo Mountains, 31 May 1954. The plane was on a routine flight from Governador Valadares to Belo Horizonte. The plane crashed about 50 miles from Belo Horizonte. There were 15 passengers and four crew on board. There were no survivors.

(Reuter)

On 4 June 1954 a Curtiss Commando, owners Soc. Anon. Empresa de Viacao Aerea Rio Grandense, carrying cargo from Sao Paulo to Porto Alegre, crashed on take-off at Congonhas. The pilot and crew were all killed. The accident was caused by failure to remove the elevator securing device before take-off.

(Lloyd's Agents)

Trans-World Airlines plane Star of Madiera, with a blazing engine, made a safe emergency landing at Washington on 20 July 1954. The 33 passengers and 5 crew escaped and the fire was put out in two minutes. The plane was on a flight from Washington, D.C., to Los Angeles by way of Dayton, Ohio, and Chicago. The starboard inboard engine of the plane burst into flames almost immediately after taking off.

(New York Maritime Association)

The wreckage of the transport plane which crashed and burst into flames on 23 April 1954 with 25 people on board, was found in Central Argentina today. The twin-engined DC-3 was on a routine flight from Mendoza to Cordoba. It was diverted from its route by a storm and crashed on Vilgo Ridge, in the province of La Rioja. A communique issued by the Aerolineas Argentinas stated the plane was carrying a crew of four and 21 passengers. There were no survivors.

(Reuter)

A pilot and two other members of the crew died 30 April 1954, in a Darbhanga Aviation passenger plane which crashed and burst into flames within minutes of taking-off from Dum Dum Airport, Calcutta. One of the plane's passengers also died in the crash and the other seven were injured, four of them seriously. The plane, bound for Balurghat, dived into a fruit garden two miles from Dum Dum after fire had broken out in the port engine.

(Reuter)

The crew and 20 passengers of a Convair escaped with slight injuries when their aircraft was in collision with a United States Navy Twin Beech one mile from Port Columbus Airport tower on the night of 27 June 1954, as both aircraft were about to land. The two airmen in the naval plane were killed. The Convair's landing gear was damaged in the collision and the plane skidded over 1,000 feet on landing.

(Exchange Telegraph Company)

An Air France Trans-Atlantic Airliner on its way to New York from Paris, crashed near Preston, Connecticut, on 8 August 1954. The aircraft, which was unable to land at Idlewild because of bad weather was diverted to Hartford aerodrome but ran out of fuel before it could reach its destination. The aircraft which made an emergency landing on a farm, mowed down a row of trees before hitting a garage where it demolished a car. The aircraft burst into flames. All 37 passengers on board evacuated the aircraft quickly and without panic and no one was seriously injured; however, 2 crew members and 10 passengers were injured slightly.

(Reuter)

Koninklyke Luchtvaart Maa Ischappij N.V. (KLM) Douglas DC-6B, en route New York to Amsterdam, crashed into the sea approximately 17 miles off the Dutch coast on 23 August 1954. The wreck was located in about 50 feet of water and salvage operation begun. All twenty-one people on board were killed.

(Reuter and British United Press)

An Air France Constellation slewed off the runway at Shannon Airport as it landed 25 August 1954, but its 58 passengers and nine crew members escaped injury. Inbound from Europe, the aircraft had come down on the runway safely when the nose wheel skidded to the left. The aircraft straddled a 10 feet deep drainage ditch, battering its nose and pushing the tricycle landing gear into the fuselage.

(New York Maritime Association)

A Braniff Airways' DC-3 caught in a blinding rainstorm crashed on a farm south of Mason City, Iowa, 22 August 1954, and 11 of the 19 persons on board were killed. The aircraft was demolished but did not burn. Witnesses said it bounced 500 feet, scattering debris, after first hitting the earth. The aircraft apparently struck a power line while buffeted by wind, hail and rain. It was only a few minutes away from Mason City Airport. It was bound to Minneapolis from Memphis.

(Reuter)

The Government of Switzerland, on 24 September 1954, accused the pilot and co-pilot of a crashed airline of homicide through negligence. The Swissair plane plunged into the English Channel 19 June. Three passengers were killed. The Government move came with the announcement of the findings of an official probe set up to investigate the crash. The report said the plane crashed because it ran out of gasoline. "No fuelling was carried out before the aircraft left Geneva", the report said. After the accident, Swissair dismissed the pilot, Capt. Jacob Glattenagg, 35, and the co-pilot, Walter Flachsmann, 25.

The report of the investigation indicated that the second pilot "failed to watch or control the operation of refuelling the plane which was his duty". "As for the plane's captain, he did not check or else did not sufficiently check the gasoline gauge during the flight. After the forced landing in the sea, the crew took no measures whatsoever to save the passengers unable to look after themselves. Given the grave consequences of the accident, the offences can be enumerated as homicide through negligence and abandonment".

It added that the Federal Council had decided to hand over the matter of following up the investigation to the Geneva cantonal authorities.

(Reuter)

Three men forced the pilot of a Burmese airline at pistol point to land his plane on a beach near Bassein, Burma, 25 June 1954, and stole 3,000,000 hyats (about $630,000) intended for government treasuries. Neither passengers nor crew were hurt and the plane was able to take off from the beach and continue its scheduled flight.

(Reuter)

A passenger awoke from a snooze to find himself dangling as far outside a DC-6 as his loosened safety belt, which had caught at his knees, would allow. Fellow passengers grabbed a leg and an arm and pulled him back.

The DC-6 carrying 66 passengers and a crew of four was bound for New York and was at 12,000 feet when the escape hatch cover beside the passenger blew off.

The passenger had dozed off after loosening his safety belt with the intention of unbuckling it when the warning light went off. However, by that time the passenger was asleep and the safety strap still buckled. The hatch cover damaged the aircraft's tail assembly

(Montreal Star, 4 October 1954)

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PART III

List of Laws and Regulations of the Contracting States containing provisions relating to "Aircraft Accident Investigation"

(Replacing lists in Digests No. 2, 3 and 4)

ARGENTINA

1952	Oct. 9	Resolución Núm. 100 (SAC) - Normas para la investigación de accidentes de aviación civil y directivas generales para la investigación.
1954	julio 15	Ley Núm. 14.307 - Código Aeronáutico de la Nación: Título XVIII. - Disposiciones varias (Art. 208).

AUSTRALIA

1947	Aug. 6	The Air Navigation Regulations, S.R. No. 112/1947, as amended up to 26 March, 1954: Part XVI. - Accident Inquiry (Reg. 270-274).

BOLIVIA

1949	junio 18	Procedimiento para el informe de accidentes (Boletín Oficial Núm. 2 - Sec. OP-100).
1950	marzo	Reglas Generales de Operaciones (Provisional): Accidentes de Aeronaves (02.46-02.52).

BRAZIL

1951	July 24	Portaria No. 280 - Recommendations relating to aircraft accident investigations.

BURMA

1934		The Union of Burma Aircraft Act, 1934 (XXII of 1934): Section 7. - Power of the President of the Union to make rules for investigation of accidents.
1937		The Union of Burma Aircraft Rules, 1937, as amended up to 16 June 1952: Part X. - Investigation of Accidents.
1949	August	Notice to Airmen No. 5/1949 - Aircraft Accident and Incident investigations.

CANADA

1951	May 24	The Air Regulations, P.C. 2575: Part VIII. - Section 3 - Accidents and Boards of Inquiry.

CEYLON

1950	March 29	Air Navigation Act, No. 15/50: Part I. - Section 12 - Power to provide for investigation into accidents.

CHINA

1947	Oct. 16	Regulations relating to civil aircraft accidents.

COLOMBIA

1948	marzo	Manual de Reglamentos ejecutados por el Decreto Núm. 969 de 14/3/47 y el Decreto Núm. 2669 de 6/8/47: Part IV - 40.13.0: Accidentes.

COSTA RICA

1949	Oct. 18	Ley de Aviación Civil: Parte I. - Título Primero - Cap. 2 - Sec. 8: Accidentes (Art. 45-47).

CZECHOSLOVAKIA

1947		Decree of Ministry of Interior on accident investigation, No. 1600/47.

DENMARK

1920	Sept. 11	Air Navigation Regulations: Para. 22. - Notifications in case of certain aircraft accidents.

EGYPT

1941	May 5	Decree: Air Navigation Regulations - Article 10.
1951		Notice to Airmen No. 5A/1951 - Instructions to be followed in the event of "Flight Accidents".

EL SALVADOR

1950		Ley de Aeronáutica: Cap. V. - Accidentes y Emergencias (Art. 73-89).

FRANCE

1937	avril 21	Décret relatif à la déclaration des accidents d'aviation.
1953	jan. 3	Instruction ministérielle relative à la coordination de l'Information judiciaire et de l'enquête technique et administrative en cas d'accident survenu à un aéronef français ou étranger sur le territoire de la Métropole et les territoires d'outre-mer.
	déc. 11	Instruction du Secrétariat d'Etat aux Travaux Publics et à l'Aviation Civile n° 200 IGAC/SA, concernant les dispositions à prendre en cas d'irrégularité d'incident ou d'accident d'aviation.

GUATEMALA

1948	Oct. 28	Decreto Núm. 563 - Ley de Aviación Civil: Capítulo X. - De los siniestros aeronáuticos (Art. 116-121).

HONDURAS

1950	marzo 14	Decreto Núm. 121 - Ley de Aeronáutica: Cap. IV - Sec. Cuarta - Accidentes y Emergencias (Art. 70-88).

INDIA

1934	Aug. 19	The Indian Aircraft Act, 1934 (corrected up to 1 November 1950): Section 7. - Powers of Central Government to make rules for investigation of accidents.
1937	March 23	The Indian Aircraft Rules, 1937 (as corrected up to 21 October 1953): Part X. - Investigation of Accidents (Art. 68-77).

IRAQ

1939	Aug. 6	Air Navigation Law No. 41: Article 5 (h).

IRELAND

1928		The Air Navigation (Investigation of Accidents) Regulations, S.R. and O. No. 21, as amended by Air Navigation (Amendment) Regulations, S.R. and O. No. 288, 3 August 1943.
1936		Air Navigation and Transport Act, No. 40: Part VII - Section 60 - Investigation of Accidents. This Act has been amended by Amendment Acts No. 10, 1942; No. 23, 1946 and No. 4, 1950.

ITALY

1925	Jan. 11	Decree Law No. 356 - Rules for Air Navigation: Chapter VII.
1942	April 21	Navigation Code - Second Part - Air Navigation: Investigation of Accidents (Art. 826-833).

JAPAN

1952		Civil Aeronautics Law No. 231: Chap. 9 - Article 132. - Investigation of Accidents.

LEBANON

1949	Jan. 11	Aviation Law: Chap. III. - Sub-Chapter 2 - Landing of Aircraft (Art. 39).

MEXICO

1949	Dic. 27	Ley de Aviación (Libro IV de la Ley de Vías Generales de Comunicación): Cap. XIV. - De los accidentes y de la búsqueda y salvamento (Art. 358-361).
1950	Oct. 18	Reglamento para Búsqueda y Salvamento e Investigación de Accidentes Aéreos (en vigor a partir del 1 de enero de 1951).

NETHERLANDS

1936	Sept. 10	Law: Investigation of Accidents to civil aircraft, amended by Law of 31 December, 1937, (concerns inter alia the greater part of the provisions of Annex 13).
	Sept. 22	Royal Decree: Application of paras 8 and 9 of Article 1 and of para. 5 of Article 32 of the Law dated 10 September 1936.
	Sept. 22	Royal Decree: Application of para. 2 of Article 6 of the Law of 10 September 1936.

NEW ZEALAND

1948	Aug. 26	The Civil Aviation Act, 1948: Art. 8. - Power to provide for investigation of accidents.
1953	Nov. 11	The Air Navigation Regulations, Serial No. 152/53, (made in accordance with ICAO Annex 13).

NORWAY

1923	Dec. 7	Civil Aeronautics Act, as amended up to 17 July, 1953: Chapter XI. (Paragraph 46).
		Royal Resolution - Regulations on aviation enacted by the Department of Defence, 15 October 1932, in accordance with the Civil Aeronautics Act of 7 December 1923 and the Royal Resolution of 22 April 1932, as amended up to 1950: VIII. - Aircraft Accidents.

PAKISTAN

1934	Aug. 19	The Aircraft Act, 1934, No. XXII (corrected up to 26 October 1950): Para. 7. - Power of Central Government to make rules for investigation of accidents.
1937	March 23	The Aircraft Rules, 1937 (corrected up to 14 April 1953): Part X. - Investigation of Accidents.

PHILIPPINES

1946	May 9	Civil Aviation Regulations: Chap. XVI. - Aircraft Accident Regulations.
1952	June 20	The Civil Aeronautics Act of the Philippines, No. 776: Chap. V. - Section 32 - Power and Duties of the Administrator: (11) Investigation of Accidents.

PORTUGAL

1931	Oct. 25	Decree No. 20.062 - Air Navigation Regulations: Chapter VIII.

SPAIN

1948	March 12	Decree relating to investigation of civil aircraft accidents.

SWEDEN

1928	April 20	Royal Proclamation No. 85 regarding Application of the Decree of 26 May 1922 (No. 383) on Air Navigation (amended up to 1953 - Code of Law 42:1953): Para. 28. - Notification of aircraft accidents.

SWITZERLAND

1948	déc. 21	Loi fédérale sur la navigation aérienne (entrée en vigueur le 15 juin 1950): Articles 22-26.
1950	juin 5	Règlement d'exécution de la loi sur la navigation aérienne: XIV. - Accidents d'aéronefs (Arts. 129-137).

UNION OF SOUTH AFRICA

1923	May 21	Aviation Act No. 16:- Art. 10. - Investigation of Accidents.

UNION OF SOUTH AFRICA (Cont'd)

1949 Dec. 30 The Air Navigation Regulations, No. 2762, 1950, as amended by Schedules of Amendments Nos. 1023/50; (No. 2) 1275/50 (No. 3) 2608/50; Notice No. 2500 of 28 September 1951: Chap. 29. - Investigation of Accidents (Reg. 29.1 - 29.7).

UNITED KINGDOM

1949 Nov. 24 The Civil Aviation Act, 1949 (12 and 13 Geo. 6. Ch. 67): Part II - Section 10 - Investigation of Accidents.

1951 Sept. 5 The Civil Aviation (Investigation of Accidents) Regulations, S.I. No. 1653. Came into operation on 1 October, 1951.

1954 June 24 The Air Navigation Order, S.I. No. 829: Part VI. - Article 70 - Application of accident regulations to aircraft belonging to or employed in the service of Her Majesty.

UNITED KINGDOM COLONIES

1949 Oct. 28 Article 69 of the Colonial Air Navigation Orders, 1949 to 1953, and Section 10 of the Civil Aviation Act, 1949, apply [the latter by virtue of the Colonial Civil Aviation (Application of Act) Order, 1952, (as amended)] to the undermentioned Colonies:

Aden (Colony Protectorate)
Bahamas
Barbados
Basutoland
Bechuanaland Protectorate
Bermuda
British Guiana
British Honduras
British Solomon Islands Protectorate
Cyprus
Falkland Islands and Dependencies
Fiji
Gambia (Colony and Protectorate)
Gibraltar
Gilbert and Ellice Islands Colony
Gold Coast - (a) Colony
(b) Ashanti
(c) Northern Territories
(d) Togoland under United Kingdom trusteeship
Hong Kong
Jamaica (including Turks and Caicos Islands and the Cayman Islands)
Kenya (Colony and Protectorate)
Leeward Islands - Antigua
Montserrat
St. Christopher and Nevis
Virgin Islands
Malta
Mauritius
Nigeria - (a) Colony
(b) Protectorate
(c) Cameroons under United Kingdom trusteeship
North Borneo
St. Helena and Ascension
Sarawak

UNITED KINGDOM COLONIES (Cont'd)

Seychelles
Sierra Leone (Colony and Protectorate)
Singapore
Somaliland Protectorate
Swaziland
Tanganyika
Trinidad and Tobago
Uganda Protectorate
Windward Islands - Dominica
Grenada
St. Lucia
St. Vincent
Zanzibar Protectorate.

BAHAMAS

1952 Aug. 1 Air Navigation (Investigation of Accidents) Regulations.

BARBADOS

1952 April 29 Air Navigation (Investigation of Accidents) Regulations.

BERMUDA

1948 Dec. 18 Air Navigation (Investigation of Accidents) Regulations.

BRITISH GUIANA

1952 Aug. 18 Air Navigation (Investigation of Accidents) Regulations, No. 19/1952.

BRITISH HONDURAS

1939 May 17 Air Navigation (Accidents) Regulations (S.R.O. No. 41/1939).

CYPRUS

1952 Nov. 17 Civil Aviation (Investigation of Accidents) (G.N. 517/1952).

FIJI

1952 May 1 Civil Aviation (Investigation of Accidents) (L.N. 90/52).

GAMBIA

1937 May 1 and Nov. 15 Air Navigation (Investigation of Accidents) Regulations, No. 8 and No. 17 of 1937.

GIBRALTAR

1952 Jan. 3 Air Navigation (Investigation of Accidents) Regulations, 1952.

GOLD COAST

1937 Feb. 17 Aircraft (Accident) Regulations, No. 5/1937.

HONG KONG

1951 Air Navigation (Investigation of Accidents) Regulations (G.N. A 228/51).

UNITED KINGDOM COLONIES (Cont'd)

JAMAICA

1953 March 24 Air Navigation (Investigation of Accidents) Regulations (G.N. 37/1953).

KENYA

1928 June 22 Air Navigation (Accident) Regulations.

LEEWARD ISLANDS

1952 July 31 Civil Aviation (Investigation of Accidents) Regulations (S.R.O. 18/1952).

MALAYA (FEDERATION OF)

1953 Nov. 1 Air Navigation (Investigation of Accidents) Regulations (L.N. 584/53).

MALTA

1952 Sept. 2 Civil Aviation (Investigation of Accidents) Regulations.

MAURITIUS

1952 Sept. 4 Civil Aviation (Investigation of Accidents) Regulations (G.N. 200/52).

NIGERIA

1953 April 28 Civil Aviation (Investigation of Accidents) Regulations (No. 15/1953).

NORTH BORNEO AND LABUAN

1950 Jan. 6 Air Navigation (Investigation of Accidents) Regulations (S. 8/1950).

ST. LUCIA

1948 Nov. 27 Air Navigation (Investigation of Accidents) Regulations (S.R.O. No. 40/48).

ST. VINCENT

1953 Jan. 8 Air Navigation (Investigation of Accidents) Regulations (S.R.O. No. 6/53).

SARAWAK

1949 Air Navigation (Investigation of Accidents) Regulations (G.N.S. 62/49).

SIERRA LEONE

1953 Dec. 30 Civil Aviation (Investigation of Accidents) Regulations (P.N. 114/53).

SINGAPORE

1953 Oct. 1 Civil Aviation (Investigation of Accidents) Regulations (G.N. 301/1953).

SOMALILAND

1951 Nov. 7 Civil Aviation (Investigation of Accidents) Regulations (G.N. 48/1951).

UNITED KINGDOM COLONIES (Cont'd)

TANGANYIKA

1933	June 30	Air Navigation (Investigation of Accidents) Regulations (G.N. 91/33).

TRINIDAD

1940	Oct. 26	Air Navigation (Investigation of Accidents) Regulations 1940, as amended by A.N. (Investigation of Accidents) Regulations of 16 August 1948, G.N. No. 139.

UGANDA

1929	Sept. 1	Air Navigation (Accidents) - (as published in 1939).

ZANZIBAR

1937	Sept. 4	Air Navigation (Investigation of Accidents) Regulations (G.N. 41/1937).

FEDERATION OF RHODESIA AND NYASALAND

SOUTHERN RHODESIA

1952	Jan. 25	Air Navigation Regulations, 1952, as amended up to 4 December 1953: Part 18.- Investigation of Accidents.

UNITED STATES OF AMERICA

1938		Civil Aeronautics Act - Title VII (Air Safety).
1949	May 1	Civil Air Regulations - Part 62 - Notification and reporting of aircraft accidents and overdue aircraft.
1950	Sept. 15	Economic Regulations - Part 303 - Rules of practice in aircraft accident investigation information.
	Sept. 15	Economic Regulations - Part 311 - Disclosure of aircraft accident investigation information.
1951	May 14	Civil Aeronautics Board - Organizational Regulations - Description of Functions: Course and method by which functions are channeled - Scope and contents of documents - Hearings concerning accidents involving aircraft.
1952		Title 22 - Foreign Relations - Part 134 - Civil Aviation; Aircraft Accidents (issued in Department Regulations 108.164, effective October 1, 1952, 17 F.R. 8207).
1954		Public Notice PN 7 - Administrator of Civil Aeronautics: Delegation of certain accident investigation functions, (as issued, effective January 1, 1954, 19 F.R. 2133).

YUGOSLAVIA

1949	June 1	Decree relating to air navigation: IV.- Article 28 - Investigation of Accidents.

- END -

ICAO TECHNICAL PUBLICATIONS

The following summary gives the status, and also describes in general terms the contents of the various series of technical publications issued by the International Civil Aviation Organization. It does not include specialized publications that do not fall specifically within one of the series, such as the ICAO Aeronautical Chart Catalogue *or the* Meteorological Tables for International Air Navigation.

INTERNATIONAL STANDARDS AND RECOMMENDED PRACTICES are adopted by the Council in accordance with Articles 54, 37 and 90 of the Convention on International Civil Aviation and are designated, for convenience, as Annexes to the Convention. The uniform application by Contracting States of the specifications comprised in the International Standards is recognized as necessary for the safety or regularity of international air navigation while the uniform application of the specifications in the Recommended Practices is regarded as desirable in the interest of safety, regularity or efficiency of international air navigation. Knowledge of any differences between the national regulations or practices of a State and those established by an International Standard is essential to the safety or regularity of international air navigation. In the event of non-compliance with an International Standard, a State has, in fact, an obligation, under Article 38 of the Convention, to notify the Council of any differences. Knowledge of differences from Recommended Practices may also be important for the safety of air navigation and, although the Convention does not impose any obligation with regard thereto, the Council has invited Contracting States to notify such differences in addition to those relating to International Standards.

PROCEDURES FOR AIR NAVIGATION SERVICES (PANS) are approved by the Council for world-wide application. They comprise, for the most part, operating procedures regarded as not yet having attained a sufficient degree of maturity for adoption as International Standards and Recommended Practices, as well as material of a more permanent character which is considered too detailed for incorporation in an Annex, or is susceptible to frequent amendment, for which the processes of the Convention would be too cumbersome. As in the case of Recommended Practices, the Council has invited Contracting States to notify any differences between their national practices and the PANS when the knowledge of such differences is important for the safety of air navigation.

REGIONAL SUPPLEMENTARY PROCEDURES (SUPPS) have a status similar to that of PANS in that they are approved by the Council, but only for application in the respective regions. They are prepared in consolidated form, since certain of the procedures apply to overlapping regions or are common to two or more regions.

The following publications are prepared by authority of the Secretary General in accordance with the principles and policies approved by the Council.

ICAO FIELD MANUALS have no status in themselves but derive their status from the International Standards, Recommended Practices and PANS from which they are compiled. They are prepared primarily for the use of personnel engaged in operations in the field, as a service to those Contracting States who do not find it practicable, for various reasons, to prepare them for their own use.

TECHNICAL MANUALS provide guidance and information in amplification of the International Standards, Recommended Practices and PANS, the implementation of which they are designed to facilitate.

AIR NAVIGATION PLAN documents detail requirements for facilities and services for international air navigation in the respective ICAO Air Navigation Regions. They are prepared on the authority of the Secretary General on the basis of recommendations of regional air navigation meetings and of the Council action thereon. The plans are amended periodically to reflect changes in requirements and in the status of implementation of the recommended facilities and services.

ICAO CIRCULARS make available specialized information of interest to Contracting States.

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September 1951. 16 pp. $0.15

MANUAL

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2nd edition (Doc 6920-AN/855). October 1951. 130 pp. $0.75

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Aircraft Accident Digest No. 2, 1952. 170 pp. $0.85

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