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FOREWORD

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

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

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

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

The first Digest was issued in 1951 under the present title and with the new method of presentation. Since then, the usefulness of the series has continued to elicit favourable comment from the aeronautical world.

However, late in 1964, the Secretariat carried out a study of the problems associated with the publication of the Digest and considered various methods which, it was thought, would lead to a more rapid dissemination of accident reports forwarded to ICAO for release in summarized form in the Digest. This study also considered amending the presentation of the summaries with a view to producing them in a more standardized manner.

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*Provisional International Civil Aviation Organization.

Accordingly, the Secretariat prepared a uniform plan using fixed subject headings, in an agreed order and with standard paragraph numbering, to enable readers to extract pertinent information more readily, according to their particular interests. This plan was submitted to the Third Session of the Accident Investigation Division (Montreal, 19 January - 11 February 1965) for its consideration and development. The meeting accepted the concept of a uniform plan but modified the details. Summaries of accident inquiry reports are now being prepared in accordance with the final version of the uniform plan, as approved by the Council. This plan for the "Summary of Accident Report" appears in Appendix 3 of Annex 13 - Aircraft Accident Inquiry (Second Edition).

Digests are now published in separate volumes. Two of these volumes contain summaries prepared by the Secretariat from the inquiry reports received from States on accidents which occurred in a particular year and also normally contain one or more safety articles. The second volume contains, in addition, accident data such as classification tables, statistics and a list of laws and regulations of States pertaining to accident investigation. The other volume(s) contain(s) summaries of reports prepared by States in accordance with paragraphs 6.3 and 6.4 of Annex 13. These summaries are published as received as soon as a sufficient number justify the publication of a separate volume.

It is hoped that States will continue to co-operate to the fullest extent permitted by their national laws in submitting material for the Digests in accordance with the provisions of 6.3 and 6.4 of Annex 13. It is recognized that investigations take a diversity of forms under the variety of constitutional and juridical systems that exist throughout the Contracting States 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.

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

Follow-up action and other supplementary information or comments on an accident report by the State of Registry or State of Occurrence provide useful material for inclusion in the Digest.

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

COMMENTS ON ACCIDENT SUMMARIES AND CLASSIFICATION TABLES - 1964

Sixty-two accident reports are summarized in Volumes I, II, and III of Digest 16 because they satisfy one or more of the following criteria:

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

   a) major disaster aspect which resulted in wide publicity, or
   b) special nature of the accident and possibility of remedial action;

2) Suitability of the original report for preparation of a summary;

3) Interest as an example of good accident investigation practice.

These sixty-two summaries of accident reports concern accidents which occurred in 1964 (49 accidents), 1965 (2 accidents) and 1966 (11 accidents).

All these accidents have been classified according to the classification appearing in pages 16 to 20 of the ICAO Manual of Aircraft Accident Investigation - Doc 6920 - AN/855/3. However, only the 1964 accidents are included in the following classification tables. The 1965 and 1966 accidents will be included in the classification tables which will appear in Digests 17 and 18 respectively, although their classifications appear at the end of each summary.

Amongst the forty-nine 1964 accident summaries, 48 were prepared by the Secretariat (25 in Volume I and 23 in Volume III) and 1 by a State (Summary No. 1 of Volume II).

Not included in the following classification tables for 1964 are an incident involving a BOAC Comet 4 near Narobi Airport, Kenya, on 2 February 1964 (Volume I, Summary No. 4) and a test flight accident involving a BAC 111 on Salisbury Plain, England, on 20 August 1964 (Volume III, Summary No. 9).

The remaining forty-seven 1964 accidents which occurred during commercial air transport operations may be classified as follows:

Scheduled operations		34
International	12	
Domestic	22	
Non-scheduled operations		13
International	3	
Domestic	10	
Total		47*

The classifications in Tables A and B follow closely the suggestions contained in the ICAO Manual of Aircraft Accident Investigation. They have, however, been based on accident reports founded on a variety of reporting and analysing techniques. Only a portion of the total number of accidents investigated by States is either released for general publication or sent to ICAO. Due to the smallness of the total samples (47), no attempt has been made in this publication to prepare classification tables according to the type of operation being conducted, for instance, whether scheduled or non-scheduled; and no differentiation is made between accidents occurring on domestic and on international flights. However, a notation on the type of operation being conducted, where known, is included in Table A. While the tables may serve a useful purpose in indicating causal trends, the numbers are too small to be significant for statistical purposes and readers are warned not to place too much reliance on the trends so indicated without comparison with other sources, such as those published by other international organizations and national administrations.

Although considerable care has been taken in drawing up Table A to ensure that the classification conforms with the findings of the State as mentioned in the accident summary, the very brevity of the table might give a wrong impression in some instances. The reader is, therefore, always invited to refer to the summary in the Digest and, if necessary, to the report from which it was derived.

A survey of the 47 commercial air transport accident summaries for 1964 suggests that the following features are worthy of attention:

(i) 49% of these accidents occurred during the approach and landing phase, i.e. 5% more than in 1963. The main types of approach and landing accidents were: gear collapse (17%), undershoot (13%), loss of control (13%).

(ii) 32% of these accidents occurred during the en-route phase. The main types of en-route accidents were: collision with rising terrain (40%), forced landing (20%) and loss of control (20%).

(iii) 17% of these accidents occurred during the take-off phase. The main types of take-off accidents were: stall (25%) and loss of control (25%).

(iv) A single taxiing accident, a gear collapse, accounted for 2%.

TABLE A.- ACCIDENT CLASSIFICATION - 1964 (based on phase of operation)

Phase* of Operation	No.	Type of accident	No.	Description	Type** of Operation	Vol. I Summary No.	Vol. II Summary No.	Vol. III Summary No.
Taxiing (2%)	1	Gear collapsed	1	Port main landing gear leg forging failed as a result of a propagation of a previously repaired fatigue crack.	NS			8
Take-off (17%)	8	Ground loop	1	Pilot-in-command gave control of the aircraft to a person not authorized to fly it.	S	7		
		Overshoot	1	Following an aborted take-off and due to damage to the reverse thrust system of No. 2 engine, the aircraft overran the runway, then hit a steam roller and caught fire.	S			19
		Stall	2	During take-off, impact with a fuel drum on the runway caused partial destruction of the right elevator thus rendering the aircraft uncontrollable in flight.	NS			20
				Improper loading of the aircraft resulted in insufficient elevator effectiveness to reverse an unwanted pitching up motion.	S	5		
		Loss of control	2	Faulty distribution of the cargo on board the aircraft.	NS			13
				The degradation of aircraft stability characteristics in turbulence because of abnormal longitudinal trim component positions.	S	10		
		Collision - rising terrain	1	The pilot for undetermined reasons deviated from departure course into an area of rising terrain where downdraught activity and turbulence affected the climb capability of the aircraft sufficiently to prevent terrain clearance.	S			23
		Airframe - Air	1	Failure of the wing main spar occurred under flight loads as a result of weakness caused by fatigue cracks.	NS	22		
En route (32%)	15	Collision - rising terrain	6	Flew at low altitude over mountainous terrain in instrument meteorological conditions.	S	8		
				Continued VFR into unfavourable weather.	S	12		
				Attempted a visual landing approach in adverse weather conditions and hit high ground after having abandoned the approach and headed for another airport.	S	13		
				Flight was conducted in IMC conditions at an altitude unsafe for operations of that nature through the Huayna (Potosí) Pass.	NS			10
				Collision with an obstacle located 35 km to the right of the intended track for reasons unknown.	S			11
				Undetermined.	S			16
		Collision - objects - trees	1	The pilot continued to fly VFR into unfavourable weather with practically zero visibility due to heavy rain.	S			2
		Loss of control	3	Loss of control resulted from an intended abrupt turn to the left following an engine overspeed.	S			6
				Uncontrollable in-flight fire of undetermined origin in the fuselage which resulted in a loss of control of the aircraft.	S			7
				The shooting of the pilot-in-command and co-pilot during flight.	S			1

* Percentages are based on the total number of 1964 accidents classified - 47

** S - Scheduled NS - Non-scheduled

Continued on next page

TABLE A.- ACCIDENT CLASSIFICATION - 1964 (based on phase of operation) (Contd)

Phase* of Operation	No.	Type of accident	No.	Description	Type** of Operation	Vol. I Summary No.	Vol. II Summary No.	Vol. III Summary No.
En route (32%) (Contd)		Explosion in flight	1	Violent explosion of criminal origin which caused the tail unit to be torn off.	S			21
		Emergency conditions - precautionary landing	1	Impact with ground for unknown reasons during precautionary landing.	S	2		
		Forced landing	3	Engine failure due to fuel exhaustion.	NS	1		
				Failure to maintain safe single-engine speed and altitude following failure of the left-hand engine.	NS			22
				Rupture of the oil pipe which connects the engine to the oil cooler forced the pilot to shut down the left-hand engine.	NS	21		
Landing (49%)	23	Ground loop	1	The airstrip was unsuitable for the operation.	S			3
		Gear collapsed	4	The landing gear leg, weakened by fatigue, failed on first impact during a landing.	S	19		
				Left landing gear collapsed due to the fracture of the left-hand brace strut attaching fitting.	NS			12
				Starboard landing gear collapsed on landing due to fatigue fracture of the fixed head of the main retraction jack.	S	25		
				Both nose wheels came off due to a fatigue fracture in the nose wheel axle.	S	18		
		Gear retracted	1	The starboard landing gear retracted because the hydraulic change-over valve was in the "ground test" position.	S			14
		Heavy landing	2	Failed to counteract the effect of a down-draught and to react correctly to a bounce to a height of about 30 ft.	NS	9		
				The pilot lost visual reference during a landing in radiation fog. This resulted in a heavy landing during which the port gear collapsed.	NS			17
		Undershoot	3	The crew abandoned the established approach procedure and prematurely prepared to land.	S		1	
				Pilot selected full flap and reduced power too early in heavy rain and poor visibility.	S			15
				Failure of the pilot-in-command to plan and execute properly the final approach.	S			4
		Overshoot	3	Overlapping effects of excessive airspeed, inoperative propeller reversing and insufficient effect of foot brake.	S	11		
				The pilot carried out a landing without knowing his position relative to the length of the runway in a situation where the instrument approach had been missed.	S	17		
				The captain deviated from the glide slope during an ILS approach.	S	23		
		Collision - ground	1	The aircraft got below the prescribed altitude limits as a result of having deviated from the instrument flight rules.	NS	6		

* Percentages are based on the total number of 1964 accidents classified - 47

** S - Scheduled NS - Non-scheduled

Continued on next page

TABLE A.- ACCIDENT CLASSIFICATION - 1964 (based on phase of operation) (Contd)

Phase* of Operation	No.	Type of accident	No.	Description	Type** of Operation	Vol. I Summary No.	Vol. II Summary No.	Vol. III Summary No.
Landing (49%) (Contd)		Collision - water	1	The cause of the accident could not be determined.	S	24		
		Collision - runway lights	1	Loss of directional control during the landing roll because the aircraft ran into unexpected crosswind gusts on a runway where snow had considerably diminished tire adherence.	S	3		
		Collision - rising terrain	2	Failed to interrupt visual approach in the absence of minimum visibility conditions required for the type of manoeuvre involved.	S	20		
				Misinterpretation of the approach chart by the pilot-in-command which resulted in a premature descent below obstructing terrain.	S			18
		Stall	1	Tailplane icing.	S	16		
		Loss of control	3	Loss of control on final approach due to improper emergency procedure and misuse of engine controls.	S			5
				The pilot of HK-862 initiated evasive action which resulted in loss of control.	S	15		
				Failure of the crew to use available de-icing equipment and engine power to maintain positive control of the aircraft under conditions of rapid airframe ice accretion and vortex induced turbulence.	NS	14		

* Percentages are based on the total number of 1964 accidents classified - 47
** S - Scheduled NS - Non-scheduled

TABLE B.- ACCIDENT CLASSIFICATION - 1964 (based on accident causes)

Causal Factor	No.	Description	No.	Vol. I Summary No.	Digest 15 Vol. II Summary No.	Vol. III Summary No.
Pilot (49%)	23	Misuse, engine controls	1			5
		Misuse, flight controls	2	15		6
		Misjudged distance	3	17		4, 15
		Failure to compensate for wind	1	9		
		Improper IFR operation	6	6, 23	1	10, 18, 23
		Improper in-flight planning	1			22
		Continued VFR into unfavourable weather	5	8, 12, 13, 20		2
		Improper loading of aircraft	1	5		
		Excessive touchdown speed	1	11		
		Improper use of miscellaneous equipment	1	14		
		Other	1	7		
Other personnel (2%)		Improperly cleared	1			13
Powerplant (6%)	3	Lubrication system	1	21		
		Fuel system	1	1		
		Engine accessories	1			19
Airframe (4%)	2	Flight control system - elevator	1			20
		Wing	1	22		
Landing gear (11%)	5	Main gear	4	19, 25		8, 12
		Nose gear	1	18		
Weather (9%)	4	Icing conditions	1	16		
		Crosswind, snow	1	3		
		Turbulence	1	10		
		Fog	1			17
Airport terrain (2%)	1	Soft shoulder	1			3
Miscellaneous (6%)	3	Passenger shot crew	1			1
		Fire in flight	1			7
		Explosion of criminal origin	1			21
Undetermined (11%)	5	-	5	2, 24		11, 14, 16

* The percentages are based on the total number of 1964 accidents classified (47)

PART I

SUMMARIES OF AIRCRAFT ACCIDENT REPORTS AS PREPARED BY ICAO

No. 1

Pacific Air Lines, Inc., Fairchild F-27, N 2770R, accident near San Ramon, California, on 7 May 1964. Civil Aeronautics Board (U.S.A.) Aircraft Accident Report, File No. 1-0007, released 2 November 1964.

1. - Investigation

1.1 History of the flight

Flight 773 was a scheduled domestic flight from Reno, Nevada to San Francisco, California, via Stockton. The flight to Stockton was routine, and the aircraft landed there at 0628 hours PST. The flight was then cleared by the Oakland Air Route Traffic Control Centre to the San Francisco Airport to climb in VFR conditions to 6 000 ft and to maintain 6 000 ft. The clearance was acknowledged and departure was at 0638 hours. During its climb the flight reported leaving 2 000 ft and was instructed by Stockton tower to contact Oakland ARTCC on 124.2 Mc/s. After contacting Oakland Centre the flight was instructed to maintain 5 000 ft. Oakland ARTCC established radar contact with the aircraft 6 miles from Stockton, and at 0643 hours the flight reported reaching its assigned altitude of 5 000 ft. At 0645:10 hours, the Oakland ARTCC controller instructed the flight to turn left to a heading of 235° for a vector to the San Francisco final approach course. At 0646:49 hours, control of the flight was transferred to Oakland Approach Control. At 0647:53 hours, the flight established radio contact with Oakland Approach Control, who transmitted appropriate control instructions and the current altimeter setting and advised that the aircraft's transmission was garbled. At 0648:15 hours, a high-pitched message was heard and recorded on the Oakland Approach Control tape. The content of the message was not clear; however, on the basis of laboratory analysis, the most probable message was determined to be: "Skippers shot. We're ben shot. (I was) Try'in ta help."* No other transmissions were heard from the flight which disappeared shortly thereafter from the radar scope at a point about 18.5 NM from the Oakland radar antenna site. At 0720 hours, the Oakland ARTCC watch supervisor received information that the wreckage of the aircraft had been located on the up-slope of a 25.2° hill. The co-ordinates of the main crater were 37°45'34"N, 121°52'24"W and its elevation 640 ft. The time of the accident was approximately 0640 hours PST.

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* The Board sent the original tape to the Bell Telephone Laboratories for further analysis. On the basis of spectrogram comparisons provided by earlier recordings known to be the pilot-in-command and co-pilot, it was determined that the final message matched best the voice of the co-pilot. "I was" is shown in parenthesis to emphasize the uncertainty of these two words. The two utterances of "shot" and the one of "help" are probably the most reliable of the several words of the message.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	3	41	
Non-fatal			
None			

1.3 Damage to aircraft

The aircraft was destroyed by impact.

1.4 Other damage

No object other than the aircraft was damaged.

1.5 Crew information

The pilot-in-command, aged 52, held a valid airline transport pilot's certificate with type ratings in DC-3, Martin 202/404 and Fairchild F-27 aircraft. He originally qualified in the F-27 on 10 March 1959 and his last proficiency check in F-27 aircraft was on 8 September 1963. He had flown a total of 20 434 hours, of which 2 794 hours were in F-27 aircraft. His physical qualifications were current and without waivers.

The co-pilot, aged 31, held a valid commercial pilot's certificate with instrument rating. He originally qualified in the F-27 on 15 April 1959 and had his last proficiency check on 16 February 1964. He had a total of 6 641 hours flying experience, which included 988 hours in the F-27 aircraft. His physical qualifications were also current.

The third crew member aboard was a flight attendant.

1.6 Aircraft information

No mention was made in the report of the aircraft's certificate of airworthiness.

The aircraft had a total flight time of 10 252 hours computed to its last flight out of Stockton, California. Flight time accumulated since the last mid-period inspection on 3 May 1964 was 15 hours.

At Reno the aircraft was refuelled with about 264 gal of kerosene, bringing the total fuel aboard to approximately 754 gal. No refuelling took place at Stockton, where only the left engine was stopped.

Weight and balance were computed to be within limits.

1.7 Meteorological information

Weather conditions at the time of the accident were described as overcast sky with good visibility.

1.8 Aids to navigation

Not pertinent to the accident.

1.9 Communications

The flight was in contact with Oakland Approach Control until 0648:15 hours when the high-pitched message was transmitted by the aircraft. The aircraft's transmission was distorted.

1.10 Aerodrome and ground facilities

Not pertinent to the accident.

1.11 Flight recorders

The aircraft carried a flight recorder which was recovered intact from the wreckage although it sustained severe crushing damage.

A readout of the tape by the Civil Aeronautics Board indicated that the flight was normal from take-off at 0638 hours until about 10 minutes after departure from Stockton. The aircraft was then cruising at 5 000 ft indicated altitude on a magnetic heading of about 230° and at an airspeed of about 213 kt. The first erratic indications on the tape appeared to coincide with the high-pitched transmission by the co-pilot at 0648:15 hours. At this point the four traces for altitude, airspeed, heading and acceleration began to make sharp excursions. Within 22.5 seconds the altitude trace indicated a descent from 5 300 to 2 100 ft (a descent rate of approximately 9 000 ft/min), the airspeed trace an increase to 335 kt, the heading trace a change to approximately 265° and the vertical acceleration trace a decrease first to about minus 0.4 g and then an increase to plus 2.5 g. During the next 15 seconds the altitude trace indicated a climb to approximately 3 200 ft (a climb rate of 4 400 ft/min), the airspeed trace a decrease to approximately 265 kt, the heading trace a change to approximately 285° and the vertical acceleration continued to vary from plus 2.5 g to minus 0.4 g. From this point to the end of the recorded tracings, all traces were abnormal.

1.12 Wreckage

The aircraft struck the up-slope of a 25.2° hill at a relative angle of 90.2°. The wreckage was confined to the east slope of the 800 ft hill and strewn 1 050 ft up the slope along a 500 ft width from the main crater on approximately a 270° magnetic heading. The aircraft's heading at impact was 245° magnetic.

1.13 Fire

No details on the post-crash fire were contained in the report.

1.14 Survival aspects

None was mentioned in the report.

1.15 Tests and research

Portions of the seat frame tubing from the pilot-in-command's seat were recovered. Microscopic examination of this tubing at the Federal Bureau of Investigation (FBI) laboratory disclosed silvery metallic smears in an indentation in the tubing. Spectrographic analyses of these smears revealed the presence of lead and antimony. The FBI report concluded that the indentation in the tubing was produced by a bullet. All human remains were X-rayed for metal; no bullets or unusual types of fractures were found. Toxicological studies were essentially negative. Alcohol determination on the remains of the pilot-in-command was negative. Spectrographic examinations were made on specimens of human tissue recovered at the crash site from the vicinity where the remains identified as those of passenger Gonzales were found. In one specimen, the lead present in the sample was markedly elevated compared to the other metal components in the tissue, indicating that the object causing the wound was lead or predominantly lead. No spectrographic examinations could be made of the pilot-in-command and co-pilot because of the lack of identifiable human remains.

2. - Analysis and Conclusions

2.1 Analysis

Both engines were severely damaged by impact. Evidence showed that the right engine was developing power at impact while the left engine was not. However, there was no evidence to indicate that either powerplant had not been capable of normal operation. The asymmetric power condition is not deemed unusual when the conditions in the cockpit prior to impact are taken into consideration. A likely explanation would be accidental left engine control movement by at least one of the cockpit occupants immediately before impact, resulting in loss of power output and consequent propeller auto-feathering action in process at moment of impact.

The cockpit area was so completely destroyed by impact that only four small pieces of the instrument panel were retrieved.

There was no evidence of any failure or malfunction of the aircraft or any of its components prior to impact. There was no in-flight fire nor evidence of operational causal factors.

A search of the wreckage area disclosed the presence of a .357 Smith and Wesson Model 27 Magnum revolver S/N S210645, containing six empty cartridges which had been fired by the weapon. It had a broken frame, jammed cylinder, and missing pistol grips.

The gun, with ammunition and a cleaning kit, had been purchased by passenger Francisco Paula Gonzales on the evening of 6 May 1964. Mr. Gonzales had advised both friends and relatives that he would die on either Wednesday, the 6th of May, or Thursday, the 7th of May. He referred to his impending death on a daily basis throughout the week preceding the accident. On the evening of 6 May, passenger Gonzales departed San Francisco International Airport aboard a Pacific Air Lines flight for Reno, Nevada, with a return reservation for Flight 773 on the following morning. Shortly before boarding the flight to Reno, Gonzales displayed the gun to numerous friends at the airport and told one person he intended to shoot himself. Various persons saw Mr. Gonzales board the Pacific Air Lines flight at San Francisco International Airport on the evening of 6 May, carrying the small package which contained the gun and ammunition. On that same evening he had purchased two insurance policies at the San Francisco Airport in the total amount of $105,000. Another passenger aboard Gonzales' flight from San Francisco to Reno remembered that Gonzales was carrying a small package and was seated in the front seat behind the pilots' compartment. While at Reno, Nevada, Mr. Gonzales spent the night visiting various gambling establishments. Mr. Gonzales gambled that night and one casino employee asked how he was doing, to which Gonzales replied: "... it would not make any difference after tomorrow". Several persons recalled that Gonzales had a large bulge in his clothing and others reported that he was carrying a small package while in Reno. A janitor at a gambling club where passenger Gonzales was known to have spent a part of the evening discovered a cardboard carton for a Smith and Wesson .357 Magnum revolver and a gun cleaning kit in the wastepaper container. Both of these items were identified by the seller as part of passenger Gonzales' purchase on the preceding evening.

Interviews with relatives, associates, and acquaintances revealed that Gonzales was disturbed and depressed over marital and financial difficulties and that he cried continuously during the evening of 5 May 1964. A credit check showed Gonzales to have been deeply in debt and nearly half of his salary was committed for loan payments.

Thorough background investigations were conducted of the other occupants of the aircraft, including the crew. Those investigations revealed no undue health problems, unusual purchases or holdings of insurance, or indications of despondency by any other person aboard the aircraft from Reno to San Francisco.

2.2 Conclusions

Findings

The crew were properly certificated and qualified for the flight.

The aircraft was properly dispatched.

The aircraft and powerplants were maintained in accordance with existing Pacific Air Lines and Federal Aviation Agency approved directives and procedures. The aircraft and powerplants were in an airworthy condition prior to the occurrence of this accident.

No evidence of malfunction or failure of the aircraft, its engines or its equipment was found.

The flight recorder tape indicated normal flight until 0648 hours when a steep descent began. Fifteen seconds later, the co-pilot broadcast his last high-pitched transmission. That transmission and the flight recorder record of a momentary interruption in the dive 22 seconds after it began were the only indications of the flight crew's actions during the final minute of flight. This evidence does not furnish sufficient parameters to determine the specific time point at which both pilots became completely incapacitated, but indicated the improbability of pilot suicide.

The total evidence clearly indicated that the pilot-in-command and the co-pilot were shot by a passenger. As a result, the uncontrolled aircraft began the descent which ended in impact with the hill.

Cause or Probable cause(s)

The probable cause of this accident was the shooting of the pilot-in-command and co-pilot by a passenger during flight.

3. - Recommendations

None were contained in the report.

4. - Action taken

Prior to the accident (on 1 May 1964), the FAA adopted certain amendments to Parts 40, 41 and 42 of the Civil Air Regulations. These amendments which became effective on 6 August 1964 required that the door separating the passenger cabin from the crew compartment on all scheduled air carrier and commercial aircraft must be kept locked during flight. An exception to the rule will be during landing or take-off on certain aircraft such as the Fairchild F-27 where the door leads to an emergency passenger exit.

ICAO Ref: AR/846

No. 2

Philippine Air Lines, Inc., DHC-3 Otter, PI-C51, accident at Sibuco Point, Zamboanga del Norte, Philippines, on 20 May 1964. Report undated, released by the Civil Aeronautics Administration, Department of Public Works and Communications, Republic of the Philippines.

1. - Investigation

1.1 History of the flight

Flight F26/25 was a scheduled domestic flight originating at Zamboanga Airport at 0650 hours for Siocon, where it landed at 0730 hours. Due to unfavourable weather conditions, the pilot decided to return direct to Zamboanga instead of flying the following schedule: Siocon-Liloy-Dipolog-Liloy-Siocon-Zamboanga. At approximately 0810 hours the aircraft took off from Siocon. The take-off and climb were normal, and no operating difficulty was reported by the pilot. The aircraft crashed at Sibuco Point while flying in heavy rain on a heading of 205° towards Zamboanga. The co-ordinates of the accident site were 7°15'3"N, 122°01'E. The accident occurred at approximately 1000 hours.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	1	10	
Non-fatal			
None			

1.3 Damage to aircraft

The aircraft was destroyed by the impact and ensuing fire.

1.4 Other damage

No other damage was incurred.

1.5 Crew information

The pilot-in-command, aged 32, was the only crew member aboard. He held an airline transport pilot's licence with ratings on the DC-3 and DHC-3 and a valid radiotelephony licence. He had been checked out on the DC-3 and DHC-3 by CAA check pilots. He had flown a total of 4 163 hours, including 342 hours on the DHC-3 Otter. He had satisfactorily passed a route qualification check prior to his assignment as DHC-3 captain in that part of Mindanao. He qualified as DHC-3 captain on 22 January 1964. At the time of the accident, his medical certificate was current with no waivers.

1.6 Aircraft information

The aircraft had a certificate of airworthiness valid until 20 August 1964.

It had undergone all the periodic checks and progressive inspections laid out in the DHC-3 maintenance manual, and was properly released for the flight by a licensed airframe and engines mechanic. It had a total flying time of 7 197 hours, including 1 012 hours since the latest overhaul.

The aircraft carried a total pay load of 742 kg, which was less than the maximum permissible of 842 kg.

Prior to take-off at Zamboanga Airport, the aircraft was serviced with fuel for 7 hours.

The type of fuel being used was not stated in the report.

1.7 Meteorological information

The weather conditions prevailing in Western Mindanao were considered unfavourable for VFR flights. There was a heavy squall in the vicinity of the crash area at the time of the accident.

1.8 Aids to navigation

The aircraft was only rated for VFR flights, and there were no navigational aids aboard.

1.9 Communications

VHF and HF.

1.10 Aerodrome and ground facilities

Not pertinent to this accident.

1.11 Flight recorders

Not mentioned in the report.

1.12 Wreckage

No details on the side of the accident were mentioned in the report.

1.13 Fire

A fire followed impact.

1.14 Survival aspects

Two of the passengers were thrown out 10 ft from the final impact point. The pilot was found strapped in his seat.

1.15 Tests and research

No information was contained in the report.

2. - Analysis and Conclusions

2.1 Analysis

The aircraft hit a molave tree at 200 ft AMSL while in a left bank. The left wing was severed from the aircraft and the leading edge of the vertical stabilizer was severely damaged. The nose section then hit another tree before finally settling on the ground at an approximate 30-degree angle. The condition of the wreckage showed that the aircraft collided with the trees and terrain under power.

From the evidence gathered there was nothing to indicate that there was malfunctioning of the airframe and engine and/or components. Furthermore, no operating difficulty was reported by the pilot and the sound of the engine was reported as normal by witnesses.

There was heavy rain and strong winds in the area of the crash at the time of the accident. Visibility was limited to almost zero. This was most probably the reason that led the pilot to "hug" the coastline at low altitude, especially as the aircraft was not equipped with sufficient navigational instruments for an IFR flight. The pilot must, therefore, have resorted to visual flying, following the coastline, to reach his destination. With almost zero visibility, he lost track of the shoreline and the aircraft collided with trees and subsequently struck the terrain.

The PAL radio operator at Zamboanga received a blind garbled transmission from the pilot at approximately 0957 hours. Presumably the pilot must have attempted to report the bad weather he was in. The radio operator called up the aircraft immediately but received no answer. The accident might, therefore, have occurred shortly after the transmission was made.

2.2 Conclusions

Findings

The air carrier, the aircraft and the pilot were all properly certificated. There was nothing to indicate that the aircraft was not in an airworthy condition prior to the accident. It was properly loaded.

The flight was conducted at a relatively low and unsafe altitude over the jagged shoreline.

There was no known engine malfunctioning or operating difficulty reported by the pilot.

Due to heavy rain there was very limited visibility, almost zero, at the scene of the accident.

The aircraft collided with trees.

The aircraft was totally destroyed by impact and the fire which followed.

There were no survivors.

Cause or
Probable cause(s)

The pilot continued to fly VFR into unfavourable weather over the jagged shoreline with practically zero visibility due to heavy rain.

There was a heavy squall at the time and at the scene of the accident. Weather conditions in the Western Mindanao area during the day of the accident were generally unfavourable for VFR flights. When the pilot took off from Siocon the ceiling at the destination, Zamboanga, was below IFR minima.

3. - Recommendations

It was recommended that:

(a) PAL Otter aircraft should be equipped with an ADF and a more powerful HF; and

(b) PAL should exercise closer supervision over pilots based at Zamboanga.

4. - Action taken

Shortly after the accident, the CAA suspended the operations of the Otter pending compliance with the recommendations.

ICAO Ref: AR/841

No. 3

Curtiss Wright Super C-46, CF-PWE, accident at Hudson Hope Aerodrome, British Columbia, Canada, on 25 May 1964. Report undated, Serial No. 2264, released by the Department of Transport, Canada.

1. - Investigation

1.1 History of the flight

The aircraft was flying on a scheduled domestic flight from Vancouver International Airport to Hudson Hope Aerodrome. During the landing on runway 23 at Hudson Hope, the main wheels of the aircraft touched down 80 ft after the threshold and then skipped, touching down a second time about 500 ft further up the runway. This was followed by a second skip and touchdown by the left wheel 867 ft from the threshold with a wheel mark apparent to 930 ft. There was no evidence of contact by the right wheel in this area. The left wheel marks were again apparent at 975 ft and the marks continued until the aircraft came to rest. The right wheel made intermittent contact to 1 390 ft from the threshold and continuous contact from that point. The right wheel marks ran off the north side of the runway on to the soft shoulder 1 563 ft from the threshold, and the aircraft swung violently to the right and assumed a steep nose down angle before falling back to the three-point position. The aircraft came to rest 1 980 ft from the threshold facing 315° magnetic. The accident occurred at 0950 hours PST. The co-ordinates of the accident site were Lat. 56°02'N, Long. 121°59'W.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal			
Non-fatal			
None	4	39	

1.3 Damage to aircraft

The aircraft was substantially damaged.

1.4 Other damage

No object other than the aircraft was damaged.

1.5 Crew information

The pilot-in-command was occupying the right-hand pilot's seat at the time of the accident. He held an airline transport pilot's licence with a Class I instrument rating. He had accumulated a total of 12 000 hours flying experience, of which 2 000 hours were on C-46 aircraft, with 60 hours on that type in the 90 days prior to the accident. He had landed at this aerodrome many times and was familiar with it.

The co-pilot occupied the left-hand seat and was flying the aircraft at the time of the accident. He also held an airline transport pilot's licence with a Class I instrument rating. He had flown a total of 13 000 hours, of which 8:30 hours were on C-46 aircraft, with 5:30 hours on that type in the 90 days prior to the accident. The co-pilot had not landed at this aerodrome previously. His recent C-46 experience had been gained on hard-surfaced runways having a width of 200 ft.

1.6 Aircraft information

A certificate of airworthiness had been issued for the aircraft.

The gross weight of the aircraft and its centre of gravity were not mentioned in the report.

The type of fuel being used was not stated in the report.

1.7 Meteorological information

The weather was reported to be: sky clear, visibility unlimited, temperature about 50°F and the wind from the northwest at 8 mph.

1.8 Aids to navigation

Not pertinent to the accident.

1.9 Communications

Not mentioned in the report.

1.10 Aerodrome and ground facilities

Hudson Hope Aerodrome is unlicensed and is privately operated. It consists of a gravel-surfaced runway oriented on headings of 230° and 050° magnetic and is 4 200 ft long by 100 ft wide. Its elevation is 2 220 ft AMSL. The gravel surface of the runway is firm and hard-packed. The edges are not marked, and the shoulders at the time of the accident were soft mud, covered by about 2 inches of loose gravel. The presence of the loose gravel on the shoulders gave the impression that the runway was wider than its actual dimensions. This area had a spongy feeling to a person walking on it.

1.11 Flight recorders

Not mentioned in the report.

1.12 Wreckage

None.

1.13 Fire

There was no fire.

1.14 Survival aspects

None.

1.15 Tests and research

None.

2. - Analysis and Conclusions

2.1 Analysis

There was no evidence of any fault in the airframe, engines or controls prior to the accident.

The touchdown was slightly left of the runway centre line. At about 975 ft from the threshold the aircraft began a smooth curve to the right which continued to 1 563 ft, where the right wheel entered the soft shoulder. The marks then straightened out and ran almost parallel to the runway until the final swing to the right.

The runway width and soft shoulders provided little room for errors in landing.

2.2 Conclusions

Findings

The crew were satisfactorily certificated and had considerable experience. However, it was the first landing for the co-pilot at this airport.

The aircraft had a valid certificate of aircraft had a valid certificate of airworthiness.

There was no evidence of any fault in the airframe, engines or controls prior to the accident.

During the landing the right main wheel of the aircraft encountered the soft shoulder of the runway, following which the aircraft swung violently to the right and assumed a steep nose down angle before falling back to the three-point position.

Cause or
Probable cause(s)

The airstrip was unsuitable for the operation of this type of aircraft.

3. - Recommendations

None were contained in the report.

ICAO Ref: AR/866

No. 4

Northeast Airlines Inc., Douglas DC-6B, N 8221H, accident at La Guardia Airport, New York, U.S.A., on 5 June 1964. Civil Aeronautics Board (U.S.A.) Aircraft Accident Report, File No. 1-0005, released 25 January 1966.

1.- Investigation

1.1 History of the flight

Flight 715 was a scheduled domestic passenger flight from Lebanon, New Hampshire, to New York City via Boston, Massachusetts. The trip to Boston was routine. After crew change the aircraft departed Boston at 1133 hours Eastern Daylight Time for La Guardia Airport on an instrument flight rules clearance and proceeded normally to the New York area. The IFR flight plan was cancelled about 25 miles from La Guardia Airport. When over New Rochelle, New York, the flight contacted La Guardia Tower and was instructed to report over the field for landing on runway 31. When about 1½ miles west of the airport at an altitude of approximately 3 500 ft, the aircraft was turned on to the down wind leg. The La Guardia Tower then cleared the flight to land on runway 31. Wing flaps were lowered to the 25° position on the down wind leg and the aircraft was turned on to the base leg approximately two miles south of the airport at an altitude of approximately 2 000 ft. The propellers were then advanced to 2 300 rpm, the landing gear was extended and the flaps lowered to 30°.

At an altitude of approximately 1 000 ft the flaps were lowered to 40°. The pilot-in-command stated that he then noticed that the Visual Approach Slope Indicator (VASI) lights were on and that both sets of light bars were indicating white. When the aircraft was an estimated 1½ miles from the approach end of runway 31 at an altitude of approximately 600 ft, the up wind lights were observed to change progressively from pink to red with the down wind lights remaining consistently white. The pilot-in-command stated that at this point he decided to utilize the VASI lights to establish the final approach flight path. As the aircraft approached the runway threshold the pilot-in-command called for 50° of flaps. The co-pilot stated that he then placed the flap selector lever in the 50° detent. The flight engineer verified this and observed the flap indicator move downward and the hydraulic quantity and pressure indicators stabilize. The pilot-in-command then fully retarded engine power and simultaneously raised the nose of the aircraft to reduce the airspeed from 115 kt to the boundary speed of 100 kt. As the aircraft passed over the water-retaining dike located ahead of the runway threshold a "thump" was heard or felt by the crew. The aircraft continued ahead, initially touching down on its left main shock strut 1 164 ft from the runway threshold. The aft fuselage section contacted the runway 1 800 ft from the threshold. The aircraft slid down the runway, coming to rest just off the right edge at a distance of 3 400 ft from the threshold on a heading of approximately 325°. It was subsequently found that the entire right main landing gear assembly had separated from the aircraft on impact with the dike. The accident occurred at 1234 hours.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal			
Non-fatal			
None	4	39	

1.3 Damage to aircraft

The aircraft was substantially damaged.

1.4 Other damage

Minor damage was incurred by the water-retaining dike.

1.5 Crew information

The pilot-in-command, aged 43, had a total of 13 661 flying hours with the airline of which 3 390 hours were in DC-6B aircraft. He held an airline transport certificate with numerous ratings among which was the DC-6. His last proficiency check in the DC-6 was on 2 April 1964, and his last line check in the DC-6 was conducted on 6 December 1963.

The co-pilot, aged 38, had a total of 6 617 flying hours with the airline, of which 3 390 hours were in DC-6B aircraft. He held an airline transport certificate with ratings for the DC-3 and Vickers Viscount 745D. His last proficiency check in the DC-6 was on 8 June 1963.

The flight engineer, aged 31, had a total of 4 013 hours as flight engineer with the airline, of which 2 768 hours were in DC-6B aircraft. He held a flight engineer's certificate. His last proficiency check in the DC-6 was on 5 May 1964, and his last line check in the DC-6 was on 8 November 1963.

They had all satisfactorily passed a first class FAA flight physical examination and had a rest period of over 24 hours prior to the flight.

Also aboard was a stewardess who had satisfactorily completed company training on emergency procedures, including evacuation.

1.6 Aircraft information

At the time of the accident the aircraft had a total operational time of 31 383 hours. Maintenance had been current and in compliance with FAA requirements.

The gross weight and the centre of gravity of the aircraft at take-off from Boston were computed as being 78 444 lb and 21.0 per cent mean aerodynamic chord, both within prescribed limits. The aircraft's weight and c.g. were also within allowable limits at the time of the accident.

The type of fuel being used was not stated in the report.

1.7 Meteorological information

At 1238 hours, 4 minutes after the accident, the U.S. Weather Bureau at La Guardia Airport recorded a surface weather observation including: high thin scattered clouds, visibility more than 15 miles, temperature 65°F, dew point 35°F, wind 300° at 10 kt, altimeter setting 30.16 inches.

The accident occurred during daylight hours under sunny sky conditions.

1.8 Aids to navigation

Runway 31 at La Guardia was not equipped with an instrument landing system. However, it was served by a VASI installation which consisted of twelve light source units arranged in light bars with three units placed on each side of the runway at the 800 ft mark and three on each side of the runway at the 1 500 ft mark. (See Figure 4-1) These are the down wind and up wind bars respectively. The visual glide slope reference point is midway between the up wind and down wind bars.

Following the accident, Federal Aviation Agency (FAA) Systems Maintenance personnel ground checked the runway 31 VASI installation for proper operation and approach slope alignment. All light units, with the exception of the inboard unit on the right side down wind bar which was found at a setting of 2.5°, were within proper tolerances.* One unit out of tolerance does not affect the overall operation of the system.

Approximately six hours after the accident the FAA conducted a flight check on the VASI in which the light intensity, glide slope angle, angular coverage and obstruction clearances were inspected. The report of this check showed all of these items to be satisfactory with a computed glide slope angle of 2.90°.

The on glide path corridor or wedge was 42 ft thick directly above the dike on the approach end of runway 31, and the bottom of this wedge was 38 ft above the top of the dike.

1.9 Communications

All air/ground communications were normal.

1.10 Aerodrome and ground facilities

La Guardia Airport is bounded on three sides by water. Because the surface of the airport is located at a height nearly level with the water, a dike has been constructed around the shoreline to prevent flooding. This dike is approximately 250 ft from the threshold and stands approximately 6 ft above the runway surface. It has a steel retaining wall painted with red and white cross-hatching facing the water.

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* The VASI glide slope for runway 31 is attained by adjusting each light unit to a predetermined angular setting. Settings are 3.13° for the up wind units and 2.63° for the down wind units. These diverging angular settings produce a wedge-shaped band or light path. The centre line of the wedge is at a theoretically effective visual approach angle of 2.88°. From anywhere within this wedge-shaped band the down wind lights appear white and the up wind lights appear red.

Runway 31 is 5 965 ft long and 150 ft wide. However, the usable landing length was restricted to 5 813 ft due to construction work in progress on the far end of the field involving the use of pile-drivers and cranes. This information was contained in issued NOTAMS and was also included in tower transmissions to landing aircraft, including the subject aircraft.

1.11 Flight recorder

A flight recorder was not required nor was one installed in this aircraft.

1.12 Wreckage

See 1.1.

1.13 Fire

There was no fire.

1.14 Survival aspects

The aircraft did not burn, nor was there any major structural break-up on impact and during the ground slide. All the passengers left the aircraft via the main cabin door within an estimated two minutes. The evacuation was orderly and was supervised by the stewardess and the flight engineer. The emergency chute was attached and unfolded; however, because the aircraft was so close to the ground, it could not be utilized as an aid in the aircraft evacuation.

1.15 Tests and research

The wing flap control valve was functionally tested and found to be in satisfactory operating condition except for slightly excessive internal leakage with the sliding control valve in the neutral position. However, it should be noted that with system pressure being maintained, the flap follow-up linkage would compensate for this leakage by redirecting pressure to the actuator down line, thereby maintaining any pre-selected flap position.

The two-speed flap control valve was tested and found capable of proper operation.

Flap extension tests were conducted on the aircraft and it was found that maximum flap extension attained, with the flap selector lever in the full down or 50° position, was approximately 44° down.

The pilot and co-pilot airspeed indicators and altimeters were tested and found to be satisfactory in all respects.

2. - Analysis and Conclusions

2.1 Analysis

The pilot-in-command stated that the VASI approach path was intercepted on final approach at an altitude of approximately 600 ft, about 1½ miles from the threshold. He further stated that the remainder of the approach was made utilizing the VASI, and that on glide path colour indications were observed up to the time of impact with the dike.

Since the VASI system was operating satisfactorily at the time of the accident, as determined by the investigation, the pilot-in-command's testimony that he received the proper on glide path colour indication is not compatible, and cannot be reconciled with, the aircraft's striking the dike. Even if the aircraft was flown at the lower limits of the glide path, i.e. with the pilot's eye level at the bottom of the wedge-shaped band of the proper on glide path light array, there would still have been approximately 24 ft remaining between the top of the dike and the bottom of the main landing gear.

Therefore, the Board believed that the pilot-in-command did not properly utilize the VASI system during the final phase of the approach.

The aircraft's flight control system was inspected and found to be intact and capable of normal operation.

On the basis of the crew's testimony, in which the pilot-in-command stated that he called for full flaps shortly before the aircraft contacted the dike, as well as the flight engineer's confirmation of the 50° flap selection being accomplished, it was believed that the flaps were in the full down or near full down position at the time of impact with the dike. However, the flaps were found at the 20° extended position at the accident site with the cockpit flap selector lever in the full "up" position. This 20° flap position would have been attained, subsequent to impact, either through the inadvertent or accidental placement of the selector lever to the "up" position or through the interruption of system pressure when the hydraulic lines leading to the left and right main landing gear were ruptured, or a combination of the two.

Careful examination of the aircraft's hydraulic system failed to reveal any significant defect, such as appreciable leakage, which might have allowed an unwanted partial flap retraction. The only positive evidence of the degree of flap extension at impact was the left inboard flap actuator rod, which had a slight gradual bend with its centre seven inches from the rod eye fitting jam locking nut. This damage occurred when the aircraft contacted the runway exerting an upward force on the flaps, thereby creating a compressive load in the actuator rod greater than its column strength. Seven inches of inboard actuator rod extension corresponds to 20° of flap extension; therefore, the flaps would necessarily have been extended more than 20° when this damage occurred.

Therefore, it was believed that there was no change in the flap position prior to impact with the dike that would have caused an unexpected loss of altitude or that would have been in any way contributory to this accident.

It was not determined how the selector lever reached the "up" position. The only logical explanation would be the inadvertent or accidental placement of the lever to that position during the crew's hurried escape from the aircraft.

In view of the foregoing, the Board concluded that the aircraft was flown at too low an altitude during the final portion of the landing approach to allow reasonable clearance of the dike.

2.2 Conclusions

Findings

The crew were properly certificated.

The aircraft's weight and centre of gravity were within the allowable limits.

The meteorological conditions existing at the time of the accident did not contribute to the accident.

The VASI approach path was intercepted on final approach at an altitude of about 600 ft about 1½ miles from the threshold of runway 31.

The Board believed that the pilot-in-command did not properly utilize the VASI system during the final phase of the approach and the aircraft struck a dike.

The aircraft's two main landing gears separated from the aircraft on impact; however, the aircraft remained right-side-up.

Cause or
Probable cause(s)

The probable cause of this accident was the failure of the pilot-in-command to plan and execute the final approach properly.

3. - Recommendations

None were contained in the report.

ICAO Ref: AR/887

ACCIDENT TO DC-6B, N 8221H, OF NORTHEAST AIRLINES INC., AT LA GUARDIA AIRPORT, NEW YORK, U.S.A. 5 JUNE 1964

VISUAL APPROACH SLOPE INDICATOR (VASI) RUNWAY 31

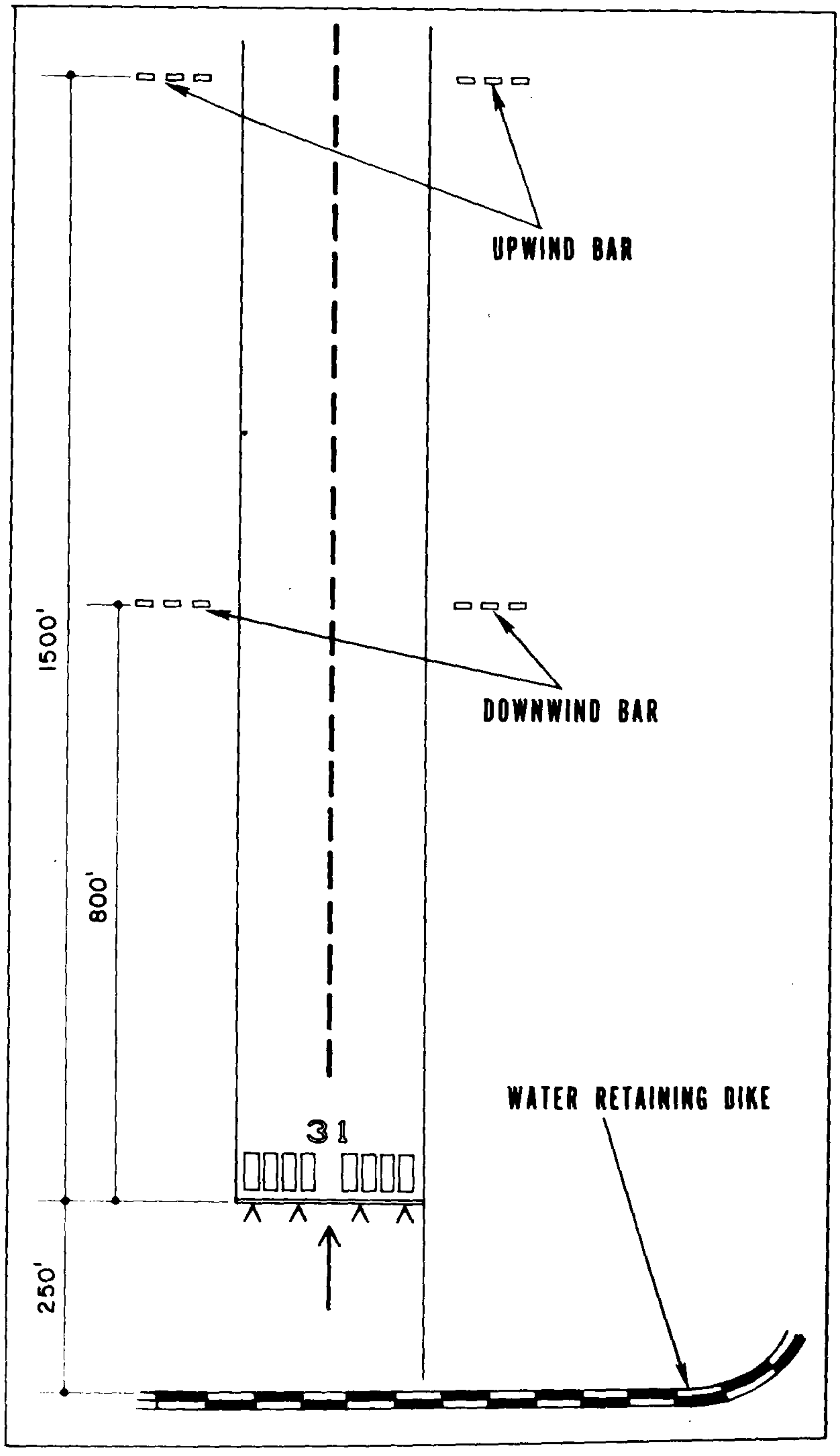

FIGURE 4-1

No. 5

Trans-Canada Air Lines, Vickers Viscount 757, CF-THT, accident at Toronto International Airport, Ontario, Canada, on 13 June 1964. Report undated, Serial No. 2287, released by the Department of Transport, Canada.

1. - Investigation

1.1 History of the flight

The aircraft departed Toronto at 1440 hours EST on a scheduled domestic flight Toronto-Montreal-Toronto. The flight from Toronto to Montreal was routine except for a radar malfunction and an intermittent synchronization problem with No. 2 engine which was not considered serious. The radar accessory was changed at Montreal and the aircraft departed Montreal at 1640 hours on an IFR clearance as Flight 3277. The en-route flight was normal except for the recurring synchronization problem with No. 2 engine. After reporting over the Peterborough intersection, successive descent clearances were given until the aircraft was at 4 000 ft. With the airport in sight, from a position about 8 NM east of Toronto Airport, the instrument flight was cancelled and a visual approach was made for a landing on runway 28.

About 2 miles east of the runway threshold on final approach at an altitude of about 700 ft above airport level, the No. 2 engine began to surge. The airspeed was 120 to 123 kt, and the aircraft was descending at about 600 ft/min with the undercarriage down and the flaps set at 32°. The No. 2 engine instruments showed wide fluctuations from normal rpm with a slight torque variation and fairly steady fuel flow. The pilot-in-command exercised the throttle in the prescribed manner, but this appeared to aggravate the surging. He stated that the fuel flow indicator was then fluctuating between 0 and 500 lb/hr.

The pilot-in-command decided to feather No. 2 engine but inadvertently shut down No. 1 engine by moving the HPC (high pressure cock) back through the closed position to the feather position. He immediately attempted to relight No. 1 engine and at the same time ordered the co-pilot to feather No. 2 propeller. The relight attempt was unsuccessful. The pilot-in-command then increased power on engines Nos. 3 and 4 and devoted his attention to maintaining control of the aircraft. He instructed the co-pilot to relight No. 1 engine.

The co-pilot made two attempts to relight No. 1 engine without success. During these attempts the stick shaker stall warning operated twice. By this time the aircraft was about 3 500 ft short of runway 28, 300 ft above ground and had deviated to the left of the runway heading. The aircraft was in about a 20-degree left bank attitude with full right aileron and rudder applied. When ground impact was imminent, the co-pilot closed Nos. 3 and 4 throttles and the pilot-in-command partially levelled the wings. The aircraft swung to the left, losing altitude, and struck upsloping ground heavily with the left main wheels while in a left wing low nose high attitude. It continued on a heading of 231° magnetic making intermittent contact with the ground for a distance of about 700 ft, during which it struck trees and two snow fences. About 900 ft from the first impact, the left wing began to separate and the aircraft started to curve to the left and continued across runway 14-32. The left wing complete with the left main wheels and Nos. 1 and 2 engines separated from the aircraft 240 ft west of runway 14-32. The remainder of the aircraft continued to the left and came to rest on a heading of 076° magnetic, 157 ft beyond the detached wing. The distance travelled from first impact to where the fuselage came to rest was about 1 790 ft. The accident occurred at 1809 hours. The accident site was Lat. 43°41'N, Long. 79°38'W.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal			
Non-fatal		1	
None	3	40	

1.3 Damage to aircraft

The aircraft was substantially damaged.

1.4 Other damage

None reported.

1.5 Crew information

The pilot-in-command occupied the left-hand seat and was flying the aircraft. He held an airline transport pilot's licence with a Class I instrument rating and had accumulated a total of 10 060 hours flying experience. His total experience on Viscount aircraft amounted to 117 hours, all of which had been flown in the 90 days prior to the accident.

The co-pilot also held an airline transport pilot's licence with a Class I instrument rating, and had accumulated a total of 2 657 hours flying experience. His total experience on Viscount aircraft was 46 hours, all of which had been flown in the 90 days prior to the accident.

Also aboard was one stewardess.

1.6 Aircraft information

A certificate of airworthiness had been issued for the aircraft.

No mention is made in the report as to the loading of the aircraft or the type or amount of fuel being carried.

1.7 Meteorological information

Weather was not considered to be a factor in the accident.

1.8 Aids to navigation

Not pertinent to the accident.

1.9 Communications

Not mentioned in the report.

1.10 Aerodrome and ground facilities

Not pertinent to the accident.

1.11 Flight recorders

Not mentioned in the report.

1.12 Wreckage

See paragraph 1.1.

1.13 Fire

Although fuel was escaping from the accident, there was no fire.

1.14 Survival aspects

No information was contained in the report.

1.15 Tests and research

Examination at the scene and subsequent exhaustive investigation of the Nos. 1 and 2 engines, their propellers and their associated systems, including test stand running of the engines, failed to reveal any fault, with the exception of the pitch control unit for the No. 2 propeller.

During dismantling of the No. 2 propeller pitch control unit, pieces of a rubber "O" ring were found in the unit. This material could have interfered with the high and low pitch ports. The unit had been installed on 13 October 1963, and had not been changed during the course of 870 hours flown since installation. A number of aircraft snags concerning engine surging or synchronization had been recorded during this time, any or all of which, including that which occurred on this flight, could have been the result of the interference noted above. The portion of "O" ring was foreign to any used in the system and its origin was unknown.

2. - Analysis and Conclusions

2.1 Analysis

There was no evidence of malfunction or failure in the aircraft, its engines or controls except for No. 2 engine. During the investigation the only fault found with this engine was the presence of foreign material in the pitch control unit. This fault could account for the surging observed by the pilot-in-command, but could not account for a complete loss of power.

The action of exercising the throttle when the surging was noted was the procedure recommended for a "partial flame out". The throttle is snapped shut, then opened rapidly to the three-quarter open position and then closed again. This gives the engine a slight thermal shock and would propagate the flame from the lit to the unlit engine burners. Under the circumstances, the use of this procedure was correct. Following this action, the high pressure cock was left in the open position and the throttle closed. The engine remained in this power situation until the high pressure cock was closed and the propeller feathered by the co-pilot.

Prior to the feathering of the No. 2 propeller, the pilot-in-command considered that the engine had stopped and the fuel flow was indicating zero. Unless there was a fault in the fuel system, zero fuel flow could not be indicated with the HPC in the open position and the propeller rotating, regardless of the throttle position.

Reasons for the failure to relight No. 1 engine were sought. When the pilot-in-command shut down the No. 1 engine in error, he did so by moving the HPC back through the closed position to the feather position; however, the feathering button was not pushed. Placing the HPC in the feather position would shut off the fuel supply to the engine and would initiate a coarsening of the propeller pitch. About 5 seconds is required to feather the propeller by use of the HPC alone. Feathering action is more rapid when the feather button is used, as it operates an electric feathering pump. Since the HPC was only momentarily in the feather position, the propeller could not have feathered although the engine would have flamed out.

The relight attempt by the pilot-in-command was made after the HPC had been reopened and with the throttle still set for 145 lb of torque. When he pulled the feathering button to apply ignition, a relight should have occurred.

The second and third attempts to relight No. 1 engine were made by the co-pilot. He carried out a portion of an "unfeathering - air relight" drill and in fact called out the items of the drill to the pilot-in-command on the final attempt. The procedure the co-pilot intended to carry out is as follows:

1. Close HPC (closed but not in the feathered position).
2. Check throttle closed.
3. Pull and hold the feathering button.
4. When rpm indication (approximately 1000 rpm) open HPC ... etc.

The co-pilot did not get beyond item No. 3: "Pull and hold the feathering button".

At this point in the drill, the co-pilot was waiting for an indication on the No. 1 engine rpm gauge. Since there was no apparent rpm indication, he did not reopen the HPC and thus fuel was not fed to the engine and the relight could not occur. Evidence shows that No. 1 propeller was windmilling and also that the rpm gauge was operable. Experiment established that a steady rpm indication of 7 200 could have been expected. Under the existing circumstances, the engine could not relight until the HPC was opened.

Technical examination of the engine revealed that it should have been capable of restarting. Lack of carbon on the igniter plugs established that they had been firing during the relight attempt.

It was determined from witnesses' statements and from a photograph of the aircraft taken about 12 seconds before impact, that the No. 2 propeller was feathered and that the No. 1 propeller was windmilling.

In the configuration which existed during the final approach, with the undercarriage down and the flaps set at 32°, the stalling speed would have been about 100 kt, the stall warning stick shaker speed 110 kt, and the minimum control speed* 125 kt. The stick shaker stall warning came on twice during the emergency indicating that the speed was around 110 kt, well below the minimum control speed.

Evidence from the engine manufacturer establishes that relight attempts should not have been adversely affected by the low airspeeds involved.

Following the pilot-in-command's attempt to restore power to No. 1 engine, power was increased on engines Nos. 3 and 4. Since the aircraft speed was by this time below the minimum control speed the aircraft entered a turn to the left.

2.2 Conclusions

Findings

(a) the approach was normal up to the time the surging occurred;

(b) the emergency situation was preceded by difficulty with the No. 2 engine, probably due to the presence of foreign material in the pitch control unit;

(c) the pilot-in-command inadvertently flamed out the No. 1 engine when he closed the high pressure cock;

(d) the No. 1 propeller was not feathered but was windmilling;

(e) the reason No. 1 engine failed to develop power during the pilot-in-command's first attempt to relight could not be determined;

(f) the aircraft speed was below the minimum control speed when the power was added to engines Nos. 3 and 4 and a turn to the left could not be prevented;

(g) the two attempts by the co-pilot to restore power to No. 1 engine were futile because the engine could not relight with the high pressure cock in the closed position;

(j) no reason was found why No. 2 engine could not have produced power before action was taken to shut it down.

Cause or Probable cause(s)

Loss of control on final approach due to improper emergency procedures and misuse of engine controls.

3. - Recommendations

None were contained in the report.

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* Minimum control speed in this report means the speed below which directional control cannot be maintained for the configuration of the aircraft, i.e. undercarriage down, flaps 32° extended, No. 2 propeller feathered, No. 1 propeller windmilling and power applied to engines Nos. 3 and 4.

ICAO Ref: AR/856

No. 6

Civil Air Transport Co. Ltd., C-46DM, B-908, accident at Triangle Village, Taichung, Taiwan, Republic of China, on 20 June 1964. Report dated 30 August 1964, released by the Civil Aeronautics Administration, Ministry of Communications, Republic of China.

1. - Investigation

1.1 History of the flight

The aircraft was on a scheduled domestic flight along the following route: Taipei-Taichung-Tainan-Makung-Kachsuing-Makung-Tainan-Taichung-Taipei. Between 1738 hours local time and 1740 hours, it crashed in a rice paddy at a place called San Chiao Village, north-northeast of Shui-Nan Airport, Taichung.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	5	52	
Non-fatal			
None			

1.3 Damage to aircraft

The aircraft was destroyed.

1.4 Other damage

None mentioned.

1.5 ,rew informat.on

The pilot-in-command, aged 39, held an airline transport pilot's licen..e with ratings for multi-engine land including C-46 and DC-4 aircraft and instruments. .e had flown a total of 12 453 hours, including 8 640 hours as pilot-in-command, 1 48] urs as co-pilot, 778 hours by night and 1 544 hours on instruments.

The co-pilot, aged 48, held a senior commercial pilot's licence wit atings for multi-engine land and se. including C-46, C-47, DC-4 and PBY-5A aircraft instruments. He had flow- : total of 14 911 hours.

1.6 Aircraft information

The aircraft had a certificate of airworthiness valid until 29 October 1964. It had logged a total of 19 488 hours. The aircraft's gross weight at the time of the accident was well within the maximum permissible limits. The position of the centre of gravity was not mentioned in the report.

1.7 Meteorological information

The weather at the time of the accident was good. Wind velocity was not high and visibility was good.

1.8 Aids to navigation

Not pertinent to the accident.

1.9 Communications

No difficulties were reported.

1.10 Aerodrome and ground facilities

Not pertinent to the accident.

1.11 Flight recorders

Not mentioned in the report.

1.12 Wreckage

The wreckage distribution was on a magnetic heading of 280°. Impact marks revealed that the aircraft struck the ground in a left wing low and a comparatively steep nose low attitude. The airplane structure was severely disintegrated. No indication of fatigue cracks was found.

1.13 Fire

No indication of in-flight fire was found.

Only a few pieces of the wreckage bore evidence of a relatively light and short fire after the accident. These were in the right outer wing forward of the aileron, the outer part of the left wing centre section, the left side of the vertical tail, one piece of wreckage comprising the outer section of the left elevator and the lavatory area of the passenger cabin.

1.14 Survival aspects

All of the 53 passenger seats and the two stewardess seats were accounted for. In general, the leg structures were buckled and broken due to loads acting to the left, downward and forward, and with the legs separated from the wedgit fittings. Most of the seat belts were unbuckled without any noticeable damage due to high impact loads, although several remained buckled and two were cut through the webbing after being mud splattered.

1.15 Tests and research

The right and left elevator trim cables were found to have failed at various distances from the cable drums. Sections of the cables were sent to the United States CAB in order to determine the type of failure. On 11 July 1964, the following report was received from the CAB:

> "Cable sections are standard twisted steel one-eighth inch aircraft cable seven strands, seven wires to a strand.
>
> Right elevator trim cable appears to be overload tension failure. No. evidence of significant damage or wire failure prior to failing overload. Left elevator trim cable: entire 8-inch length shows serious wear to extent that all exposed wires around most of periphery in each twist of outer strands are worn to about one half original diameter. In the last half inch preceding ravelled end there are 13 wire ends showing in a straight line along side. Centre strand failed in pure tension with no sign of previous damage or wear."

2. - Analysis and Conclusions

2.1 Analysis

At the time of the accident the flaps and the landing gear were fully retracted. No evidence of pre-crash malfunction or failure of the aircraft, its engines, controls and equipment was found. However, seven out of twenty witnesses who were near the site of the accident stated that they heard abnormal loud noises before the crash occurred. It was believed that this was due to the overspeeding of one engine. The impact marks at the site of the accident revealed that the aircraft made a sudden turn to the left. This was further confirmed by the testimony of six out of the twenty witnesses. Kung-Kuan Air Force Base was located about 5 miles west of the accident site and Shui-Nan Airport, from which the aircraft took off, was about 6 miles south-southwest of the accident site. It was therefore concluded that, when the engine started overspeeding, the pilot intentionally made a sudden turn to the left to land at one of these two airfields, but lost control of the aircraft during the turn and crashed.

2.2 Conclusions

Findings

The crew were satisfactorily certificated.

The aircraft had a valid certificate of airworthiness and was loaded within the permissible limits.

Weather was not a factor in the accident.

The left engine oversped. Since there were two airfields to the left of the flight pattern, the pilot effected a left turn which resulted in a steep descent and the aircraft crashed to the ground.

Cause or
Probable cause(s)

About 5 miles west of the accident site was Kung-Kuan Military Air Base. Six miles south-southwest was Shui-Nan Airport from where the aircraft took off. On the right side of the flight pattern was a chain of mountains. It was concluded that, when the pilot found that the left engine was overspeeding, he made an abrupt left turn to land at Kung-Kuan Military Air Base or return to Shui-Nan Airport. During the turn he lost control of the aircraft, which crashed to the ground.

3.- Recommendations

The power unit of the left propeller had not yet been recovered. In order to have the correct blade angle measurement of the power unit of the left propeller, it is recommended that the search for the power unit be continued.

During the examination of the wreckage some of the control cables of the aircraft were found to be severely worn out. This revealed some negligence on the part of the owner of the aircraft, Civil Air Transport, in the aircraft maintenance.

Civil Air Transport should pay more attention to proficiency checks and training of their pilots.

ICAO Ref: AR/912

No. 7

United Air Lines Inc., Vickers Viscount 745D, N 7405, accident near Parrottsville, Tennessee, U.S.A., on 9 July 1964. Civil Aeronautics Board (U.S.A.) Aircraft Accident Report, File No. 1-0033, released 9 June 1966.

1. - Investigation

1.1 History of the flight

Flight 823 was a scheduled domestic flight from Philadelphia, Pennsylvania, to Huntsville, Alabama, with intermediate stops at Washington, D.C., and Knoxville, Tennessee. Flight 823 departed Philadelphia at 1513 hours, arriving at Washington, D.C., at 1554 hours. No discrepancies were reported by the crew and no maintenance, other than servicing, was required or performed. It departed Washington, D.C. on an Instrument Flight Rules (IFR) flight plan at 1636 hours with an estimated arrival time of 1813 hours at Knoxville, Tennessee. The crew reported to the Atlanta Air Route Traffic Control Centre (ARTCC) over the Holston Mountain VOR at 1758:35 hours and estimated their arrival at Knoxville at 1821 hours.

Approximately one minute afterwards, the co-pilot requested a clearance to descend to the lowest available altitude. The flight was cleared to descend to and maintain 8 000 feet. At 1802:45 hours the flight cancelled its IFR clearance. The controller offered to pass control of the flight to Knoxville Approach Control when closer in and advised it could stay on the Centre frequency. At 1802:55 hours the crew responded to this transmission with "OK." This was the last known transmission from the aircraft.

The aircraft's radar target disappeared from the controller's scope at 1813:30 hours. At 1814 hours, after waiting four sweeps of the radar antenna, the Atlanta controller called the aircraft to advise that he had lost radar contact but he received no reply.

The aircraft was first observed by ground witnesses approximately 38 miles south-west of Holston Mountain VOR at an estimated altitude of 5 000 feet descending. There was no visible difficulty at that time. Numerous ground witnesses observed the aircraft flying at what they considered to be a very low altitude. Witnesses estimated the altitude of the aircraft to be from 200-500 feet above the ground along a line generally parallel to, but south of V16. The last 10 to 12 miles of the flight path were observed by a number of ground witnesses, several of whom stated they saw smoke of varying density apparently coming from the fuselage of the aircraft.

A witness who observed the aircraft from a position 11 miles north-east of the crash site was the first to report seeing anything unusual. She noted a violet red light burning on the fuselage, but could offer no precision regarding its location. While she could read the company name on the side of the aircraft, she did not see any smoke. The time was about 1810 hours and the aircraft was estimated to be at an altitude of 500 feet.

The first witness to report smoke from the aircraft was approximately five miles from the crash scene. He stated that "... smoke was coming out of the tail part ..." and "... there were brown spots like the paint was off of it about half-way back on the body..." Witnesses about one mile farther along the flight path did not observe anything unusual, except the low altitude, until the aircraft had passed them, at which time they observed smoke coming from the aircraft.

A number of witnesses about two miles from the crash site, near the flight path, did observe black smoke coming from the aircraft fuselage near the wings. A large black object, later identified as a passenger, was observed to fall away from the aircraft, followed by dense black smoke. The witnesses stated that the object did not strike the tail of the aircraft after coming out of the left side over the wing. Farther along the flight path a bright object, later identified as the left No. 9 emergency cabin window, fell from the aircraft. Heavy smoke was seen continuing to come from the aircraft.

While the majority of the witnesses did not report seeing any fire, some witnesses did report signs of fire in or on the aircraft.

Shortly after the passenger and the window fell from the plane the aircraft nosed up, the left wing went down, the aircraft nosed down and crashed into a rocky wooded hillside.

The crash occurred approximately 41 nautical miles east-northeast of the Knoxville VORTAC and about 2¼ nautical miles north-east of Parrottsville, Tennessee, at approximately 1815 hours. The accident occurred during daylight hours at an elevation of approximately 1 400 feet m.s.l.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	4	35*	
Non-fatal			
None			

1.3 Damage to aircraft

The aircraft was destroyed by impact and fire damage.

1.4 Other damage

Private property damage was confined to burned trees and ground cover.

* One of the passengers died of impact injuries after a free fall from the aircraft; his body was found about 1.6 nautical miles from the crash site.

1.5 Crew information

The pilot-in-command, aged 41, held an airline transport pilot certificate with type ratings for various aircraft including the Vickers Viscount. He had a total of 15 665 hours flying time, including 1 700 hours in the Viscount. His last Viscount proficiency training was completed on 30 June 1964, in the Viscount simulator. His last physical examination was completed on 4 April 1964, with no limitations. He had a 24-hour off-duty period prior to his first flight on 9 July 1964, and had been on duty 6:19 hours at the time of the accident.

The co-pilot, aged 37, held an airline transport pilot certificate with a Vickers Viscount rating. He had a total of 7 715 hours flying time, including 2 100 hours in Viscounts. He passed a co-pilot's proficiency check in the Viscount on 7 February 1964, and his last en-route check on 7 July 1964. His last physical examination was completed on 14 January 1964, with the limitation "Holder shall wear correcting glasses while exercising the privileges of his airman certificate". He had a 25-hour rest period before reporting for duty on 9 July 1964, and had been on duty 6:19 hours at the time of the accident.

There were also two stewardesses aboard the flight.

1.6 Aircraft information

The aircraft had flown a total of 23 804 hours and had undergone a numbered inspection (#2) 180 hours before the accident. It had received a pre-flight check six hours before the accident and an en-route pre-flight inspection just prior to take-off from Washington.

A review of the maintenance records revealed there were no known discrepancies when the aircraft left Washington. The records indicated that it had been maintained in accordance with existing airline and FAA approved directives with the exception of the deletion of a turbine blade inspection of No. 2 engine during the last block overhaul, and a similar deletion of an intercooler air inlet cleaning operation. The aircraft and powerplants were reported to be airworthy at the time of departure from Washington.

The take-off weight of the aircraft was 58 948 lb and the weight was estimated to be 51 468 lb at the time of the crash. Maximum allowable take-off weight for runway 33 at Washington was 60 600 lb. The centre of gravity (c.g.) limits for the flight were 9% Standard Mean Chord (SMC) forward and 26% SMC aft. The aircraft was within these limits at take-off and at the time of the crash.

The aircraft was loaded with 10 900 lb of Jet A (standard Kerosene turbine engine fuel) at take-off and was computed to have 6 327 lb of fuel aboard at the time of the crash.

1.7 Meteorological information

The crew was provided with the latest available weather sequence reports for their route before departure from Washington.

The ground witnesses reported that the weather in the accident area, and along the last segment of flight from Holston Mountain, was clear and calm, with a few high scattered clouds. The accident occurred in day VFR conditions about 1:40 hours before sunset.

Weather was not considered to be a factor in this accident.

1.8 Aids to navigation

There were no reported discrepancies of ground or airborne navigation equipment during the flight. The aircraft came under radar observation and control of the Atlanta Air Route Traffic Control Centre at 1735 hours. The flight was observed on radar to pass Holston Mountain VOR at 1757 hours. Both primary and secondary radar targets were observed until they disappeared at 1813:30 hours, some 15 minutes after passing Holston Mountain VOR. The centre's radar had been flight checked as usable down to 6 000 ft m.s.l. along Victor 16 from Holston Mountain VOR to the Ottway Intersection 39 miles south-west of the VOR. Radar beacon targets had been observed along this portion of Victor 16 down to an altitude of 4 000 ft m.s.l. The last altimeter setting given to the crew was 29.87 inches for Knoxville by Atlanta Centre.

The Knoxville VORTAC was operational during the period Flight 823 was flying between Holston Mountain and Knoxville.

1.9 Communications

Air to ground communications were normal until 1802:55 hours, when the last known transmission from the flight was received.

All subsequent attempts by the Atlanta controller to contact the flight were fruitless.

There was no evidence of an emergency or any unusual situation in any transmission by the crew.

1.10 Aerodrome and ground facilities

Not involved in this accident.

1.11 Flight recorder

The aircraft was equipped with a Lockheed Aircraft Service model 109C flight recorder, serial No. 578. The recorder was installed in the electrical compartment below the cabin floor at fuselage station (FS) 389. The recorder shell was crushed to one-half its original diameter and had separated due to shear loads. The contents were exposed to fire which destroyed the aluminium recording tape. No usable information was available. This is the first recorded instance of the destruction, by fire, of recording tape in a Lockheed recorder.

1.12 Wreckage

The aircraft struck on a 45-degree, heavily wooded slope at an elevation of approximately 1 400 ft m.s.l. The heading on impact was 135°, the nose was approximately 55° below the horizon, and the bank angle was about 45° left wing down. The wreckage, except the No. 9 emergency window and some small pieces from the cabin interior, was contained in an area 300 feet long and 200 feet wide.

A ½ to ¾ mile wide ground search was conducted for 5½ miles back along the flight path from the impact site. The No. 9 emergency window, scraps of cloth from the cabin interior, an emergency exit placard, and parts of a window seal were located 2 320 ft on a magnetic bearing of 035° from the primary wreckage site. The cabin material was scattered over an area which extended about 600 ft from the window. The free-fall victim was located 8 400 ft, on a magnetic bearing of 030°, from the primary wreckage site. A cigarette lighter with a clear plastic fuel reservoir 7/8 full was found near the body. No other material from the aircraft was found along the flight path.

The aircraft wreckage was fragmented and severe ground fires burned for several hours after the accident.

1.13 Fire

Both in-flight and post impact fire occurred in this accident. The extent of the post impact fire as well as the extensive break-up hampered the investigation with respect to origin and progress of the fire. However, a comprehensive mock-up did permit some determinations in these regards.

Ground witnesses established by observations of smoke that there was an in-flight fire. Burns and soot deposits on the free-fall victim and fire damage to bits of cabin material that fell away from the post impact fire area located in-flight fire in the passenger cabin of the aircraft.

There was no evidence of in-flight fire in the wings, powerplants, empennage or in the fuselage beneath the cabin floor rearward of the main spar (FS-414) and forward of FS 335.

A check of the cargo and stowed personal luggage revealed no hazardous materials aboard the aircraft.

The remaining portion of the fuselage beneath the cabin floor between FS 335 and and FS 414 is known as the electrical bay. Fire damage in this area was extensive, particularly on the left side. The majority of the components were destroyed or not recovered. Examination of the recovered electrical components did not reveal any evidence of a heat generating fault. One battery terminal did show an arc produced mark. No evidence of a hydraulic line leak was found. There was no consistent pattern of in-flight fire discernible in this area. Smoke patterns on the main spar cap as well as soot and discolouration patterns on seat track pieces that were installed between FS 335 and FS 414 were given detailed attention. Clean fracture and scrape marks next to sooted or discoloured areas and discolouration of seat track pieces on the underside, which is exposed in the electric bay, contrasted with clean upper surfaces which are in the passenger cabin but not exposed.

Fire damage and smoke patterns were found in the passenger cabin:

- On the left side from approximately FS 388 to FS 495, under the No. 4 window, there was heavy sooting of the shear cleats of the stringer, which were tightly compressed against the fuselage skin during break-up. Clean (unsooted) breaks were noted in the sooted areas under the window as well as clean areas where flush rivets had been pulled from the structure.

- On two large sections of the left forward bulkhead, FS 198, the vinyl material that covers the top half was missing but the backing material was not damaged while the bottom half was heavily matted with a deep soot pattern. Another piece of decorative wall material was heavily sooted and matted but the splintered edges of the plywood backing were comparatively clean. The front wall attachment bracket for the blanket rack was moderately sooted but was clean under the rotated reinforcement plate. Most of the fuselage former sections from FS 399 aft to FS 618 displayed distinct unsooted areas that were covered by blanket rack support brackets before break-up. A portion of a soundproof window was recovered coated on the inside with soot and a white deposit which was similar to the white smoke given off when the vinyl cover on the left forward bulkhead is burned. The plastic window material had flow marks on it which indicated that it had been heated to approximately 626°F, while in an upright position.

- On the exterior wall of the forward lavatory, right side at FS 232 and on other isolated areas throughout the cabin including the lower half of the No. 9 window, several public address system speakers, baggage racks and some passenger seats.

Evidence revealed that an in-flight fire existed in the passenger cabin. The only flammable liquid carried as a part of the aeroplane above the fuselage floor is hydraulic fluid in a reservoir located in a compartment between the carry-on luggage rack and the lavatory. The reservoir was damaged by impact and fire and was empty. The fire damage pattern in and about the reservoir compartment did not support hydraulic fluid as a contributing factor to the fire. Another source of flammable fluid known to have been aboard the aircraft was a one-gallon can containing a commercial paint modifier. This can was recovered in the wreckage area, crushed with no evidence of fire damage to either the can or its paper wrapping.

The fire-fighting equipment aboard the aircraft was examined to see if it had been used. Three of the four engine fire bottle discharge heads were recovered but none showed signs of having been discharged by electrical means. The forward cargo compartment CO_2 extinguisher had been fired electrically. No positive determination could be made as to whether the Janitrol heater compartment CO_2 extinguishers had been fired. One of the two cabin CO_2 fire extinguishers had been discharged and a cabin water extinguisher had been prepared for discharge; however, it had not been expended.

A flight crew walk-around oxygen bottle was recovered with the control valve open. The rubber diaphragm in the regulator had been discoloured by smoke. One passenger oxygen bottle was found with the shut-off valve "open." A portion of one of the three installed flight crew full-face smoke masks was recovered but there was no evidence of its having been in use.

The interior locking mechanisms for the No. 4 and No. 9 windows on the left side were found in the unlocked position, and the captain's direct vision (DV) window was found unlocked and partially open. The co-pilot's DV window track and frame with attached cockpit liner showed evidence of heating and sooting. Adjacent portions of the cockpit liner that had been covered before break-up were clean. The window position at impact could not be determined. There was no evidence of an in-flight fire originating in the cockpit portion of the fuselage.

The engines, underfloor cargo compartments, and the Janitrol heater are equipped with fire detection systems. The captain of the previous flight in this aircraft testified that he detected no problems with the fire warning systems when he tested them.

There is no smoke detection system other than crew sense of smell or observation of smoke in the aircraft.

In normal operation cabin air is drawn down under the cabin floor and circulated back into the cabin by the recirculating fan through ventilators in the cockpit and cabin. Any smoke generated under the cabin floor would be transferred to the cabin and cockpit within seconds where it would be seen or smelled by the crew and passengers.

1.14 Survival aspects

This accident was non-survivable and no studies were made of the structure from that standpoint.

1.15 Tests and research

The passenger who fell from the aircraft exited through an emergency window over the left wing. Witnesses who saw him fall said he did not strike the empennage but fell nearly straight down. An aerodynamic study as well as the body injury pattern confirmed the witness observations. He died of injuries received on impact with the ground. He had received burns on the hands, face and neck before death but had only a few carbon particles in his trachea and a carbon monoxide level of five per cent in his blood.* The upper portions of his clothes were impregnated with soot. There was no evidence of ground fire where the body was recovered.

The Armed Forces Institute of Pathology (AFIP) performed a number of tests of specimens from both crew members and passengers for the Board. Tests for carbon monoxide were not done on the flight crew due to a lack of suitable specimens. Passenger toxicological examination results were negative; no elevated carbon monoxide levels were found; no significant amount of alcohol was found; and tests for methylbromide yielded negative results. Histological examination of the seven recovered respiratory tract specimens revealed only a small number of carbon particles in each.

Laboratory tests were made by the Federal Bureau of Investigation to verify evidence of heat and smoke deposits, analyse various deposits on aircraft parts and on the free-fall victim's clothing, and evaluate possible evidence of sabotage. No residues were found to indicate that an explosion occurred aboard the aircraft. The reports did describe evidence of considerable heat or fire damage and sooting to various components within the cabin, cockpit, and under the cabin floor aft of the cargo pit and forward of the main spar.

Laboratory tests were also conducted by the British Aircraft Corporation on samples of aircraft structure, components, and the free-fall victim's clothing. They consisted of exposure to ultra-violet light, X-ray, infra-red and emission spectroscopy, microscopic and visual observation. Evidence of cabin fire on seats, windows, forward bulkhead trim, and the carry-on luggage rack was found. The side walls of the carry-on

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* Any concentration of less than 10 per cent carbon monoxide is considered negative.

luggage rack had been exposed to temperatures of the order of 122°F, and the plastic material from a soundproof window had been exposed to temperatures of 626°F. Duplication of heat damage to the free-fall victim's clothes was best obtained by burning and quenching a fire of lighter fluid in a sample of the material. The presence of black deposits on the bottom of seat track samples, taken from an area over the electrical bay, with none on the top of the samples, was noted. It was concluded, however, that the deposits had more the characteristics of lacquer than soot.

The National Bureau of Standards prepared a number of electron photomicrographs of carbon specimens taken from the free-fall window and passenger's clothing, and from various components of the aircraft found at the main wreckage site, primarily from under the cabin floor between FS 317 and FS 414. Tests to determine the effects of various temperatures on paint on pieces of seat track and underfloor runners taken from the aircraft wreckage were made. Aluminium paint samples exposed to heat of less than 400°F for two minutes showed no visible effects. Colour changes began after exposure for two minutes at 400°F and blistering began in two minutes at 450°F. At 900°F the paint darkened to dark brown or black. These results were used in conjunction with the electron photomicrographs to study various components of the aircraft for evidence of fire in flight. The examination of the Janitrol bottle firing strip was inconclusive and no determinations could be made regarding the conditions under which it fractured.

The photomicrographs of the carbon specimens were forwarded to a specialist in an effort to determine the identification of the material that produced the soot found on the wreckage and the free-fall victim's clothing. The carbon deposits taken from both the free-fall items and underfloor wreckage at the crash site were identified as being the produce of incomplete combustion of saturated aliphatic hydrocarbons. Examples of this type of fuel are kerosene, gasoline, paraffin, hydraulic fluid, lighter fluid, and naphtha. Of these examples, only kerosene, hydraulic fluid, and lighter fluid were known to be aboard the aircraft. The lighter fluid was not known to be aboard in sufficient quantity to produce the amount of fire experienced. Kerosene in the form of engine fuel and hydraulic fluid was aboard the aircraft in quantity.

Additional studies of the fire damage were made by a specialist from the Massachusetts Institute of Technology and tests to determine the effect of heat on aluminium surfaces were made under his direction. These tests included the exposure of numerous painted and unpainted specimens to open flames in one series and to oven heating in another series. In the open flame tests, kerosene, hydraulic fluid and turbine engine oil were used with both oxidizing and reducing atmospheres to produce soot deposits on the test specimens. It was found that soot was deposited only on those portions of specimens in the line of flame impingement. Scratches in areas of light sooting remained clean and bright, but became dark with progressively heavier deposits of soot. The soot build-up in scratches and cuts was also a function of flame impingement angle. In another series of tests, individual specimens were dipped in one of the above-mentioned fluids prior to insertion in the oven. They were retained in the oven for five minutes at temperatures ranging from 450°F to 1 000°F. Both oxidizing and reducing atmospheres were used. In these tests painted aluminium surfaces darkened progressively to 800°F; above this temperature the dark colouring disappeared and the surfaces became silver gray. Between 700° and 800° the fluid deposits burned, leaving black deposits on all surfaces. At lower temperatures scratches and edge cuts on specimens remained bright, independent of the surface discolouration caused by the fluids and other deposits on surface finishes on the specimens. From these tests and comparison with the underfloor wreckage of the aircraft it was concluded that there was no positive evidence of an underfloor fire prior to impact.

1.16 Additional information

Investigation of insurance purchased by passengers and crew members disclosed no suspect areas. Nothing unusual was noted regarding the passengers or baggage that went aboard the aircraft and there was no known hazardous cargo aboard the aircraft.

2. - Analysis and Conclusions

2.1 Analysis

There was no evidence of improper aircraft maintenance or that the aircraft was not airworthy at the time of its departure from Washington. All major components were accounted for at the accident scene and there was no evidence of pre-impact structural failure. The landing gear and flaps were retracted, the primary flight control trim settings were: aileron, one degree right wing down; elevator, one degree nose-down; and rudder, ¾ degree, nose right. There was no evidence of sabotage or of any malfunction or failure of the powerplants or the aircraft's systems prior to impact.

Having passed the Holston Mountain VOR, the crew began a normal en-route descent in VFR conditions that would have brought them into the Knoxville area at a reasonable altitude to manoeuvre for a landing. Their descent was probably normal, i.e., approximately 1 000 ft/min until they cancelled their IFR flight plan at 1802:45 hours. There was nothing in their transmissions to indicate any difficulty at that time. The aircraft should have been at approximately 11 000 feet and about 24 miles south-west of Holston Mountain when they cancelled their IFR flight plan.

At some time during the descent, the aircraft deviated to the south of V16 but was proceeding approximately parallel to the airway. The first witness believed to have seen the aircraft was 38 nautical miles south-west of Holston Mountain. He estimated the aircraft to be 4 000 ft (approximately 5 500-6 000 ft m.s.l.) above the terrain and to be normal at this time. Three miles farther along the flight path, at approximately 1810 hours, the aircraft was observed about 500 ft above the ground, and it continued to fly at very low altitudes and well to the left of the airway from this point on to the crash site. The average rate of descent from initiation to level-off at an estimated 500 ft above the ground was about 1 200 ft/min and the average ground speed was 174 kt from initiation of the descent to impact. This indicated that the airspeed was reduced from a cruising speed of 237 kt to some lower value and that the descent was continued to an altitude above the ground lower than that normally utilized in transport operation.

It was believed that the crew discovered a fire some time during the period between cancelling their IFR and before being observed in a descent about 4 000 ft above the ground.

Extensive fire damage was found in the electrical bay. However, this fact alone cannot be considered significant. This area in the Viscount, as in the majority of low wing aircraft, is in close proximity to and between the fuel tanks. Thus, in a break-up, this is a likely area to receive a substantial quantity of the spilled fuel and therefore to be heavily damaged by post impact fire. This fire damage pattern has been observed in many accidents where post impact fire occurred. The somewhat conflicting soot and discolouration patterns observed on certain isolated pieces from the electric bay area dictated further considerations with respect to in-flight fire. The only likely source of overtemperature in this compartment is a gross electrical fault to ground. The emergency procedure executed by the crew does not support a gross electrical system malfunction. An electrical source smoke or fire emergency is combated by turning the emergency power switch on and placing the battery master switch and generators off. Equipment that was operating at impact and DME operation to five miles before impact shows this particular emergency procedure had not been executed. Historically, under-the-floor fires that have persisted to a catastrophic stage have burned through the relatively light fuselage belly skin, have been observed by witnesses when present, and have left a path of partially burned debris on the ground. This did not happen in this case. Finally, to involve the hydraulic fluid in an electric bay fire would have required two essentially simultaneous failures, fluid leakage and an electrically induced overtemperature or sparking situation for ignition. Physical evidence failed to support either of these occurrences or that the origin of the fuselage fire was in the electrical bay.

Burns on the free-fall victim and fire-damaged passenger cabin material found remotely from the primary impact and ground fire area established conclusively that there was an in-flight fire in the passenger cabin. Evidence of use of the portable cabin CO_2 extinguisher and attempt to use the portable water extinguisher, together with the open valve of a flight crew walk-around oxygen bottle, suggested that the co-pilot went back to the cabin to fight the fire a few minutes before the crash. Opening the outflow valves, the left side cockpit window, and emergency exits was probably done in connexion with smoke evacuation efforts.

Spill valves to "spill" and discharge of CO_2 into the baggage compartment are procedural items to combat a cargo compartment fire, although the fact that these were accomplished was not compatible with the conclusion that an in-flight fire did not originate beneath the cabin floor. It was considered likely that as the situation aboard the aircraft became very grave, precise check-list items were supplemented by any action that offered even a remote possibility of being helpful.

The combustible material and source of ignition that started the fire were not determined.

A number of hypotheses were made to explain the loss of control evidenced by the final manoeuvre and the crash, including: distraction of the pilot; failure of the flight control rods due to fire damage; incapacitation of the pilot by heat and/or smoke; a shift of loading caused by the passengers moving to the aft end of the cabin; an overt act by some person aboard the aircraft; or any combination of these; however, there was no probative evidence as to the cause of the final manoeuvre.

2.2 Conclusions

Findings

The flight crew and stewardesses were properly qualified and certificated.

The weight and c.g. of the aircraft were within limits at take-off from Washington, and on the basis of known facts, computed to be within limits at the time of the crash.

Weather was not considered to be a factor in the cause of this accident.

There was no powerplant or airframe failure prior to the accident.

There were no known aircrew errors.

There was an in-flight fire in the passenger cabin.

Fire fighting and smoke evacuation procedures were carried out by the crew.

The free-fall victim was exposed to high heat and heavy soot before he left the aircraft through the No. 4 window. He did not strike the tail, but received fatal injuries due to impact with the trees and ground.

Sooting by in-flight fire was caused by incomplete combustion of an aliphatic hydrocarbon fuel.

The Board was unable to identify the source of fuel, the ignition point of the fire, or the cause of the final manoeuvre.

Cause or
Probable cause(s)

The probable cause of this accident was an uncontrollable in-flight fire of undetermined origin, in the fuselage, which resulted in a loss of control of the aircraft.

3. - Recommendations

On 17 July 1964 the Civil Aeronautics Board (CAB) asked the Federal Aviation Agency (FAA) what was the current status relative to specific recommendations, made in December 1963, for improving the accuracy and the survivability of flight recorders and in particular of the Lockheed 109-C flight data recorder.

Following a series of static and in-flight tests of the Pyrene Duo Head fire extinguishing system, installed on Viscount for the underfloor cargo compartment, the CAB recommended on 9 October 1964 that the FAA evaluate the design of the Pyrene Duo Head Model DCD-10 fire extinguisher and take such corrective action as necessary to increase its reliability and to prevent release of CO_2 into the cockpit. On 17 November 1964 the CAB further recommended that all operators of Viscount aircraft be requested to emphasize the need for pilots to don smoke masks before discharging the lower cargo bin CO_2 cylinder.

4. - Action taken

FAA Airworthiness directive 65-1-3 calling for certain modifications of Lockheed aircraft service company flight recorders Models 109-C and 109-D, to improve their survivability, was published on 28 December 1964.

Two FAA airworthiness directives to improve the survivability of Fairchild camera and instrument corporation flight recorder Model F-5424 and United data control flight recorder Model 542 were published respectively on 20 November and 5 December 1964 as a Notice of proposed rule making.

Technical Standard Order C 51, Aircraft flight recorder, was revised to incorporate increased crash strength standards.

A Notice of proposed rule making was expected to be released on or about 1 October 1964 requiring that flight recorders be located in aircraft as far aft as practicable, but not in a position where aft-mounted engines were likely to crush the recorder during impact.

As an interim precautionary measure, Vickers Armstrong notified all operators of Viscount aircraft equipped with Pyrene cockpit CO_2 system to normally discharge the extinguishing agent into the lower cargo bin and the FAA further requested them to re-emphasize to their pilots the possibility of CO_2 leaking into the cockpit and the need to don smoke masks before discharging the lower cargo bin CO_2 cylinder.

FAA Airworthiness Directive 65-21-6 calling for overhaul, inspection and test of certain types of Pyrene Fire Extinguishers on Viscount 744, 745D and 810, in accordance with revised requirements, was subsequently issued and became effective on 3 October 1965.

ICAO Ref: AR/914

No. 8

British Eagle International Airlines Ltd., Britannia 312, G-AOVF, accident at Karachi Airport, Pakistan, on 31 July 1964. Report undated, released by the Director General of Civil Aviation, Pakistan.

1. - Investigation

1.1 History of the flight

The aircraft was on an international flight from Singapore to London via Bombay and Istanbul. At Bombay, because of strong headwinds forecast on the next stage to Istanbul, it was decided to make a landing at Karachi for refuelling purposes, and the aircraft departed from Bombay at 1409 hours GMT, arriving at Karachi at 1614 hours GMT (2114 local time). The approach and landing on runway 28 right were normal. Deceleration in the landing roll was accomplished by the use of brake dwell (limited reverse) propeller settings, and without the use of wheel brakes; the aircraft then turned on to taxiway No. 4 towards the terminal area. Due to a misunderstanding between the tower R/T operator and the pilots, the aircraft subsequently turned into taxiway No. 1 and proceeded westwards intending to turn eventually into taxiway No. 2 towards the terminal area. During this taxiing period the pilot was instructed to hold position for other taxiing traffic but, because only the inboard engines and superfine propeller settings were being used, they were moving slowly and the other aircraft had cleared the taxiway before a halt became necessary. About 50 yd before the entry point of taxiway No. 2, the aircraft began to diverge gradually from the centre line of No. 1 taxiway and eventually started a gentle turn towards this entrance. During that turn the aircraft came to a stop without any action on the part of the pilots. Therefore, they believed that the left wheel had entered soft ground and applied power. The aircraft swung almost 90° to port and the port undercarriage leg collapsed. The engines were immediately switched off and precautionary fire action was applied to No. 2 engine. The accident occurred at 1614 hours GMT.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal			
Non-fatal			
None	8	111	

1.3 Damage to aircraft

The aircraft was substantially damaged.

1.4 Other damage

None reported.

1.5 Crew information

The pilot-in-command, aged 57 years, held an airline transport pilot's licence. He had flown a total of 19 300 hours, including a total of 2 673 hours on Britannias, of which 2 610 hours were as pilot-in-command. He had completed his route check on 30 June 1964.

The co-pilot, aged 29, also had a valid airline transport pilot's licence and had flown a total of 5 836 hours, including 1 936 hours as co-pilot on Britannias. He completed his last route check on 11 January 1964.

The flight engineer, aged 41, had flown a total of 3 218 hours, all on Britannias. His last route check was on 25 June 1964.

The navigator, aged 45, had flown a total of 4 861 hours, including 223 hours on this aircraft type.

Also aboard the flight were four stewardesses.

All eight crew members had recently completed training in emergency procedures on Britannias.

1.6 Aircraft information

The aircraft had a certificate of airworthiness valid until 30 December 1964. It also had a certificate of maintenance dated 24 June 1964 valid for 60 days or 560 flying hours. All mandatory modifications and inspections relevant to the undercarriage unit had been carried out. The port undercarriage leg of this aircraft had received a complete overhaul at 14 299 hours and 4 003 landings. It was installed on the aircraft on 14 January 1964. On 3 June 1964, during a 100-hour transit B check, an ultrasonic check of the forging was carried out. This check indicated that a crack existed in the blend radius between the left hand torque lug and the flat face of the forging barrel. This radius was reworked to a maximum depth of 0.020 in and final ultrasonic tests did not reveal any apparent defects. At the time of the accident it had flown 15 506 hours and had completed 4 408 landings.

The aircraft was properly loaded and trimmed within limits.

1.7 Meteorological information

The weather conditions were as follows:

ceiling: 3/8 at 1 500 ft
visibility: 5.4 NM
wind speed and direction: 250°/18 kt
temperature: 29°C
dew-point: 24°C
QNH: 999.7 mb

1.8 Aids to navigation

Not pertinent to the accident.

1.9 Communications

Radiocommunications were normal.

1.10 Aerodrome and ground facilities

The runway used for landing, 25R, and the taxiways concerned (No. 4, No. 1 and No. 2) were all adequately lighted, in good condition and dry.

1.11 Flight recorders

No information contained in the report.

1.12 Wreckage

The major portion of the aircraft was undamaged and in fully operative condition.

Principal aircraft damage was confined to nacelles, the rear of the port inner wing and the rear spar undercarriage fittings. There was further minor fuselage and wing tip damage.

1.13 Fire

There was no fire.

1.14 Survival aspects

The airport emergency services arrived promptly at the scene of the accident and provided assistance to the passengers and crew in leaving the aircraft.

1.15 Tests and research

No information contained in the report.

2. - Analysis and Conclusions

2.1 Analysis

Examination of the wreckage revealed that the port outboard undercarriage trunnion had broken at the attachments to the drag angles, and the trunnion had been wrenched rearwards from the spar, causing buckling of the spar web.

The top forging of the port leg, which combines the attachment to the aircraft, and the outer casing of the leg assembly had fractured into several pieces.

The inner leg was bent sharply to starboard at a point approximately six inches from its upper end, and the retraction jack was also bent.

Examination of the fractures suggested that these had progressed upwards from the lower portions of the forging and, at a point in the blend radius between the outer torque link lug and the main barrel of the casing, a nucleus was apparent (see Figures 8-1 and 8-2).

This is considered to have been the origin of the failure, and from this it is possible to establish a sequence of events. The first stage of the failure was the separation of that section of casing which carries the torque link lug and the attachment for the radius rod; this permitted misalignment of the bogie relative to the aircraft. It also produced an effective increase in the length of the radius rod, thus allowing the undercarriage leg to take up a rearward inclination under the influence of the aircraft weight, the geometry of the leg attachment to the aircraft, and the drag of the misaligned bogie.

The subsequent application of power had the result of turning of the aircraft about the misaligned bogie and displaced leg, and this explains the major separation of the casing and top forging and the final bending and collapse of the now unsupported inner leg.

Examination of the remaining components of the undercarriage assembly showed that the downlock was secure and the tires in good condition except for slight scuffing received when the bogie rolled over.

The starboard main undercarriage remained complete, but the bogie had cracked from the inner boss of the front axle upwards, outwards and rearwards towards the centre of the bogie beam. This has received further examination and is considered to have been the result of overstressing during the accident. The downlock was secure and the wheels and brakes were normal.

Almost all the witnesses confirmed that the landing made by the aircraft was normal and they did not feel any bump. The aircraft taxied normally. There was no evidence to establish that the pilot-in-command taxied faster than the normal safe limit. The turns made by the aircraft during taxiing prior to the final collapse of the port undercarriage were not very steep. It was, therefore, concluded that no undue stresses were imposed on bogie while landing and taxiing at Karachi.

According to records, the left landing gear had completed a total of 4 422 landings. The forging was a standard 100°C quenched DTD 683 aluminium alloy component. This forging had .02 inches of material removed from the torque link area at 4 301 landings as a result of the action initiated after the failure of the main leg forging on another Britannia previously. At the time of the repair the leg had completed a total of 4 301 landings. There were no reports of incidents on this unit in the period since repair.

From the shape of the fatigue crack it was presumed that the previous repair probably did not remove all the old crack, although it is accepted that no appreciable residual ultrasonic signal remained. It was also considered extremely improbable that such a crack could have been initiated and propagated to a failure condition from a sound surface in only 121 landings, since the previous defect took over 4 000 landings to develop. It was, therefore, concluded that the present crack probably propagated from a short length of shallow fatigue crack left over subsequent to repair which did not show up in ultrasonic inspection.

2.2 Conclusions

Findings

The crew were satisfactorily certificated.

The aircraft had a valid certificate of airworthiness.

The port main landing gear leg forging failed during taxiing. No undue stresses were imposed on bogie whilst landing or taxiing at Karachi. The initial failure was in the lower portion of the main forging casing, a crack originating at a nucleus adjacent to the attachment lug for the upper torque arm. The present crack probably propagated from a short length of shallow fatigue crack left over subsequent to repair which did not show up in ultrasonic inspection.

Cause or
Probable cause(s)

Port main landing gear leg forging failed as a result of a propagation of a previously repaired fatigue crack.

3. - Recommendations

It was recommended:

- that more frequent ultrasonic inspections be carried out to all legs, sound or reworked, to detect cracks before they propagate too far;
- that aircraft on which a repair had previously been carried out should have an additional special inspection after each ten landings;
- that while removing material to eliminate ultrasonic signals more material be removed than the minimum required for the purpose.

ICAO Ref: AR/854

ACCIDENT TO BRITANNIA 312, G-AOVF, OF BRITISH EAGLE INTERNATIONAL AIRLINES LTD., AT KARACHI, PAKISTAN. 31 JULY 1964

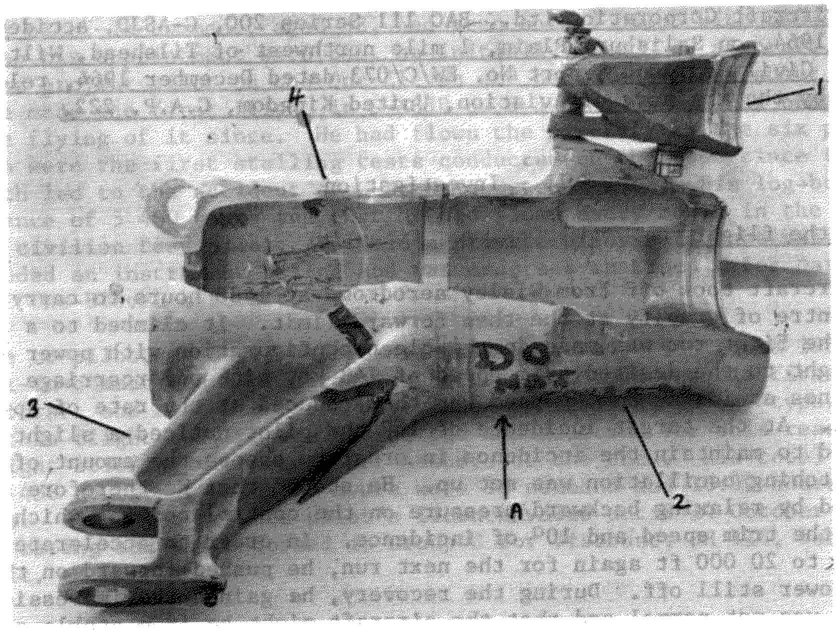

FIGURE 8-1

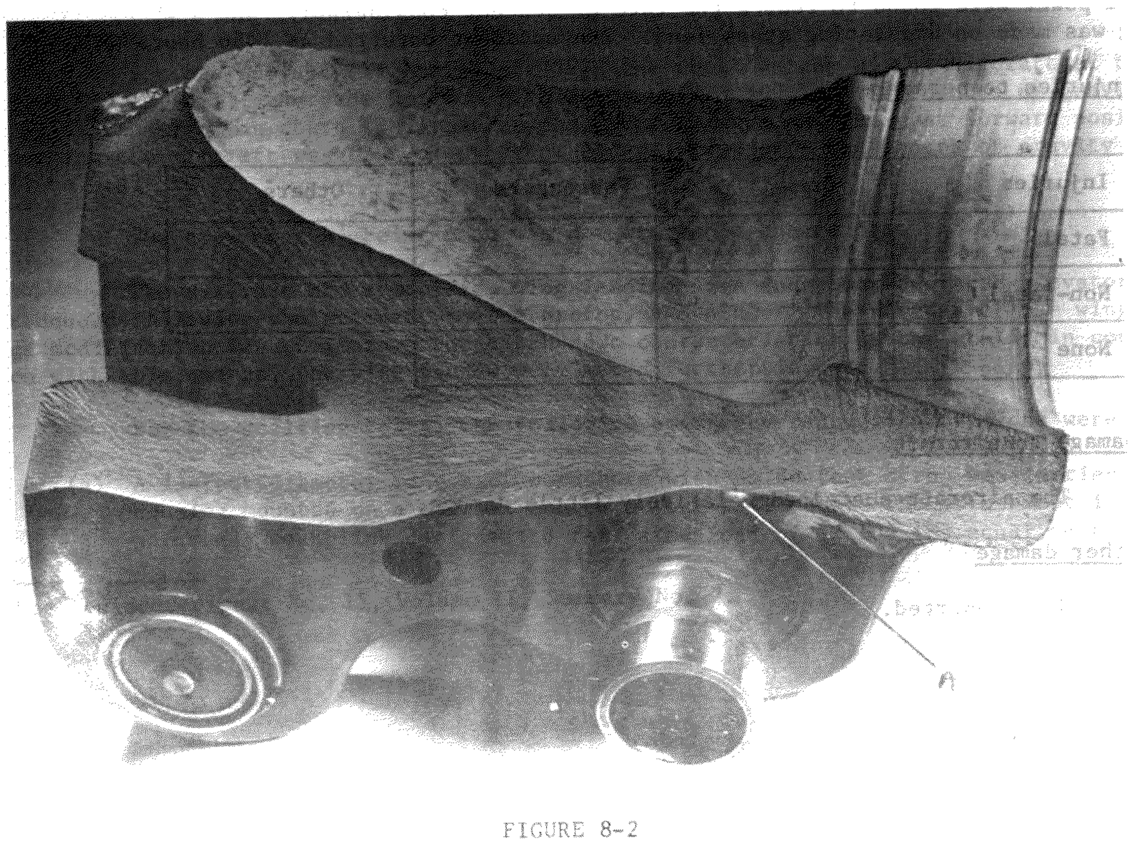

FIGURE 8-2

No. 9

British Aircraft Corporation Ltd., BAC 111 Series 200, G-ASJD, accident on 20 August 1964, on Salisbury Plain, 1 mile northwest of Tilshead, Wiltshire, England. Civil Accident Report No. EW/C/073 dated December 1964, released by the Ministry of Aviation, United Kingdom, C.A.P. 222.

1. - Investigation

1.1 History of the flight

The aircraft took off from Wisley aerodrome at 1438 hours to carry out stalling tests with the centre of gravity at the then forward limit. It climbed to a little over 20 000 ft, where the first run was made in the clean configuration with power off. The aircraft was brought to the desired trim speed of 143 kt, with undercarriage and flaps up and with the engines at idling rpm. Speed was then reduced at the rate of approximately .75 kt per second. At the target incidence of 18° the pilot noticed a slight pitch down and, when he tried to maintain the incidence in order to assess the amount of nose down pitch, a small pitching oscillation was set up. He stated that he therefore abandoned the test and recovered by relaxing backward pressure on the control column, which brought the aircraft back to the trim speed and 10° of incidence. In order to accelerate the aircraft prior to climbing to 20 000 ft again for the next run, he pushed forward on the control column with the power still off. During the recovery, he gained the impression that the elevator response was not normal and that the aircraft might be in a stable stall. The tail parachute was therefore streamed although the IAS had by then increased to 225 kt and incidence was 6°. With the parachute still streamed the application of upward and also forward thrust, which were tried on a number of occasions, served only to increase the pilot's conviction that a stable stalled condition existed. Late in the descent full flap and full power were found to reduce the rate of descent considerably, and a wheels-up landing was made on undulating grass land. The accident occurred at 1456 hours GMT.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal			
Non-fatal			
None	4		

1.3 Damage to aircraft

The aircraft sustained relatively little damage.

1.4 Other damage

None reported.

1.5 Crew information

Aboard the aircraft were a pilot-in-command, a co-pilot, a senior flight test observer and a flight test observer.

The pilot-in-command, aged 38, had been a test pilot with BAC since July 1963. When he took up his appointment with BAC, he initially flew VC 10 aircraft. In December 1963, he became project pilot on the One-Eleven and had since flown about 250 hours in that type. He made the first flight in G-ASJD on 6 July 1964 and had been engaged in almost all the flying of it since. He had flown the aircraft on the six previous stalling flights, which were the first stalling tests conducted on the type since the stable stall condition which led to the accident of G-ASHG in October 1963. His log-books show a total flying experience of 5 400 hours and that he had flown every month in the five-year period he had been a civilian test pilot. He held a private pilot's licence valid until 15 January 1966; it included an instrument rating and was endorsed in Group C for Dart Herald, VC 10, DH 114 and BAC One-Eleven aircraft.

The co-pilot, aged 41, had been a test pilot with BAC since 1954. He had flown with the pilot-in-command on many occasions before, but this was his first flight in this particular aircraft and also his first experience of stalling in the type. He had been detailed for this flight only on the day of the accident and for this reason was not present at the pre-flight briefing with the other members of the crew. His total flying experience amounted to 7 458 hours, of which 19 hours were in command and 16:30 hours were as co-pilot of One-Elevens. He held a private pilot's licence valid until 14 October 1964. It included an instrument rating and was endorsed in Group C for Viscount, DH 114, Vanguard and One-Eleven aircraft.

1.6 Aircraft information

The aircraft made its first flight on 6 July 1964 and had completed 38 test flights involving 47:35 hours flying. A certificate of safety for flight had been completed on the day of the accident. A 55-minute flight made in the morning was followed by a between-flight inspection.

For the subject flight (flight 39), the total weight of the aircraft at take-off was 69 890 lb, well under the maximum permissible of 73 500 lb. The centre of gravity was at 0.15 standard mean chord (SMC), aft of the SMC leading edge, the most forward position for which the aircraft was then cleared. The design range of the centre of gravity was 0.11 to 0.41 SMC.

The type of fuel being used was not stated in the report.

The aircraft had a modified wing leading edge and power-operated elevators, introduced following the accident to the prototype G-ASHG.* The purpose of the wing leading edge modification was to improve the pitch down characteristics in the stall; in conjunction with this change, the wing fences were moved further inboard.

For the stalling tests, the following emergency recovery provisions were made:

(a) A 13-foot diameter ring slot parachute with an 80-foot strop was carried in a housing mounted on a special gantry at the tail cone. The attachment incorporated a weak link designed to fail at a load of 32 100 lb, equal to the

* See Accident Digest No. 15, Volume II, Summary No. 7.

estimated steady parachute drag with no jet effect at 244 kt. The purpose of the parachute was to give a powerful nose down pitching moment if high angles of incidence were reached.

(b) A special modification to the engine reverse thrust cascades was incorporated. The upper cascades were partially blanked off and the lower cascades turned so that, by selecting reverse thrust, an upward thrust component of 44% of the gross thrust appropriate to the conditions could be obtained from each engine, thus giving a powerful nose down pitching moment to the aircraft.

The upper wing surfaces were tufted and four cine cameras were used to film the behaviour of the tufts during each stall.

Among special flight test instruments were two incidence indicators alongside each other in the lower left-hand corner of the first pilot's instrument panel, fed from separate vane sources and showing body incidence up to 45°, a pitch angle indicator covering the range 5° nose down to 20° nose-up, and elevator angle indicators showing port and starboard elevator positions.

1.7 Meteorological information

Observations of the weather in the area at the time of the accident by the meteorological office at Boscombe Down were:

wind:	060°/7 kt
visibility:	16 NM
weather:	nil
cloud:	3/8 cumulus at 3 000 ft; 4/8 stratocumulus at 4 000 ft; 7/8 cirrosstratus at 25 000 ft

The pilot stated that the cirrostratus cloud was about 23 000-24 000 ft; the horizon was not clearly defined at the test altitude when flying in a westerly direction, due to haze and the effect of the sun shining through the cirrostratus layer.

1.8 Aids to navigation

Not pertinent to this accident.

1.9 Communications

No difficulties were reported.

1.10 Aerodrome and ground facilities

Not pertinent to the accident.

1.11 Flight recorders

In addition to the flight recorders fitted for accident investigation purposes, the aircraft had its normal test flight automatic recording equipment so that a comprehensive record of the flight was available. There was also a voice recorder; unfortunately, the recording was garbled in many places due to the incomplete erasure of the record of a previous flight and added only a little to the information available from other sources. A time history of the more significant recorder data for the 250-second period before touchdown is given in Figure 9-1 and has been completed by reference to all the recorders. The record of pitch and elevator stick force for the period during which the normal test recorders were switched off was unreadable; the gap in the pitch record has been filled from calculation, but this could not be done in respect of elevator stick force.

1.12 Wreckage

During the ground slide the flaps and bottom of the fuselage received substantial damage; otherwise the damage was superficial and largely restricted to the underside of the wings.

1.13 Fire

There was no fire.

1.14 Survival aspects

No information was contained in the report.

1.15 Tests and research

No tests were mentioned in the report.

2. - Analysis and Conclusions

2.1 Analysis

The comprehensive record of the flight available from the automatic data recording equipment and the photographic record of the wing tufting behaviour showed that the aircraft made a complete recovery from the stall. There was nothing in the time history to suggest the risk of a stable stall developing and careful analysis of all the evidence confirmed that the aircraft behaved in a completely normal manner up to the streaming of the parachute. Subsequently, the only unusual features were those due to the parachute, and to the vertical thrust when this was applied. It was clear that the fore and aft oscillation and the whirling of the inboard tufting noticed by the second observer occurred during the period 225-235 seconds before touchdown, when the incidence was about 15° in the final stage of the stall recovery. His recollection that some of the tufting on the wing may have been whirling, either just before or just after the parachute was streamed, could not be checked against a film record of the tufting behaviour because filming ceased when the senior observer switched off the camera after the stall recovery. However, after the parachute was streamed, the aircraft came close to a stall on at least two occasions when a C_L was reached which was close to the expected C_L maximum for the prevailing flight condition; whirling of the tufting on these occasions may well account for his recollection.

Examination of the time history and the voice recording for the period covering the approach to the stall shows that, at the moment when the pilot said on the intercom that he was "leaving it at 18° incidence", the aircraft was at the third peak of incidence, an oscillation having arisen from the attempt to maintain the target incidence. Although pressure on the stick was then relaxed, the time history shows that for the next 12 seconds there was still a pull force ranging between 20 and 40 lb. During this period the following occurred:

(a) an up elevator angle of some 5^{o} was maintained;

(b) IAS increased to 143 kt;

(c) an initial nose down pitch to 7^{o} became 5^{o} nose-up;

(d) normal acceleration was approximately 1.2 g;

(e) incidence fell initially to 10^{o} then returned to around 15^{o}, and remained there for some 7 seconds during which there was partial disruption of the wing tufting; and

(f) altitude decreased at some 3 000 fpm.

At the end of the 12-second period, the elevator stick force was reversed over a period of 6 seconds to become a push of 70 lb, dropping to 50 lb 2 seconds later.

The pilot stated that he pushed forward when he wanted to accelerate the aircraft for the climb back to 20 000 ft. The effect of the push force was normal in that both incidence and pitch decreased, normal acceleration (g) decreased to below unity, the IAS increased steadily and, in the power-off dive that ensued, the rate of descent increased to about 6 000 fpm before the parachute was streamed. It was immediately after applying this push force that the pilot became concerned about the aircraft's behaviour - he was not satisfied that the pitch response was normal or correct, relating it to external reference rather than instruments. It seems possible, however, that the period previous to this, when incidence was held at 15^{o}, may have contributed to the pilot's doubts. He stated after the accident that he recovered from the stall by relaxing the pressure on the control column. This would be consistent with recovery having been initiated at about 240 seconds before touchdown, at the third peak of incidence and similar to his practice on previous flights of recovering from the stall by relaxing pressure on the control column rather than pushing forward. The pitch up and the continuation of the aircraft in a near-stalled condition after the apparent initiation of recovery some seconds previously might well have made the pilot receptive to the possibility of a stable stall.

The assistance of the Royal Air Force Institute of Aviation Medicine (I.A.M.) was sought on the question of why the pilot misinterpreted the behaviour of his aircraft in the way he did. After consideration of all relevant evidence and oral examination of the pilot, the I.A.M. concluded that the history of the incident closely resembled cases of loss of control resulting from various forms of disorientation, which are not infrequent, particularly those which commence with an illusion of some kind. There was, in this case, sufficient evidence to state that an illusion occurred at 228-225 seconds before touchdown and that it was sufficiently compulsive to act as a trigger to the subsequent action. When the pilot pushed forward on the control column, he transferred from his instruments to a visual reference. At the same time there was a recorded change of normal acceleration from 1.2 g to 0.7 g, i.e. a negative increment of 0.5 g which would have been exaggerated at the pilot's position due to its distance forward of the centre of gravity. The pilot stated that he was conscious of no visual reference to the aircraft nose, the ground or the wings, and it seemed probable that his actual visual reference would have been the lower cockpit coaming. Under these circumstances, he would have experienced an illusion of the same general kind as that experienced in an elevator but it would have been more akin to the oculogravic illusion, in which at the beginning there was an upward movement of the visual scene followed by a change in direction of the perceived vertical. This would have been much stronger than the elevator illusion, and the lower cockpit coaming frame would have appeared to tilt upwards, giving him the sensation that the pitch response was not normal or correct. Thereafter, the ensuing rise in airspeed of some 2.6 kt per second would have tended to maintain the illusion by giving a sensation of nose-up attitude which would have cancelled other indications of nose down attitude. The illusion which the I.A.M. concluded the pilot experienced would have been fostered by fatigue, of which the pilot might not have been aware, and by 'set'. The latter is a term used in experimental psychology meaning that if there are two possible responses to a given sensation or sensory stimulus, the person concerned would be more prone to choose the one which accords to that 'set'. It was known that:

(a) the pilot had had no real break from test flying since he took up his first civilian test pilot post some five years ago, and recently the intensity of his test flying had increased, although he himself was quite happy about this and felt no ill effects;

(b) while with Handley Page Ltd., he had needed to use an anti-spin parachute to recover from a spin which developed from a sudden uncontrollable pitch up during a test flight in a Victor bomber; and

(c) BAC had taken great care to prevent the occurrence of a further accident; the instructions given for the conduct of the stalling tests and the need for immediate use of the emergency devices, should these be required, amounted to a conditioning which could conceivably result in a reflex action if doubt arose in his mind.

The I.A.M. considered that a 'set' towards the occurrence of a stable stall was apparent from the evidence of the pilot's previous Victor experience, and the conditioning of his mind over a lengthy period to the possibility of entering a stable stall and the suddenness of its onset.

Although the effects of the tail parachute and of forward and upward thrust were consistent with what would be expected having regard to the IAS and incidence record and the stabilizing effect of the parachute, it seemed clear that the pilot had become convinced of the existence of a stable stall and the relatively small (to him) changes of pitch induced by the parachute and upward thrust were interpreted as the ineffectiveness of these devices in reducing the incidence. If the parachute had been jettisoned, the aircraft could have been flown away normally, but it appeared that the stress condition induced by the conviction that the aircraft had entered a stable stall from which it had not recovered ruled out any logical thought process.

During the investigation, consideration was given to the duties of the co-pilot and the extent to which he might have been expected to influence correction of the assumption the pilot had made. Although he was surprised when the pilot said the aircraft was in a stable stall, he nevertheless accepted his statement of the position and streamed the parachute when instructed to do so. Although the airspeed information might have given reason for stronger doubt on his part, the incidence gauges which were located on the left-hand side of the pilot's panel could not easily be read by him; nor was he in a position to question the pilot's interpretation of the response to the pressure he exerted on the control column. Responsibility for the conduct of the test lay entirely with the pilot, and the duties of the co-pilot were, in essence, to do what he was told; the co-pilot cannot therefore be criticised for lack of action, although some other pilots might not perhaps so readily have accepted the pilot's assessment of the situation.

2.2 Conclusions

Findings

The pilot and co-pilot were properly licensed and were experienced in experimental flight test work.

The aircraft was flying in accordance with the B Conditions of the Air Navigaidn Order, 1960; it had been certified as safe for the flight and was properly loaded.

No evidence of pre-crash malfunction or defect was found in the aircraft.

When the pilot pushed the control column forward after the stalling run the aircraft responded normally, resulting in a marked reduction of normal acceleration (g).

Although the aircraft's behaviour and instrument information indicated otherwise, the pilot believed the aircraft to be developing a stable stalled condition, and streamed the tail parachute.

The nose down pitch due to the tail parachute was small because the angle of incidence was low.

Had the tail parachute been jettisoned during the descent, the flight could have been continued normally.

Cause or Probable cause(s)

During a stalling test the pilot streamed the tail parachute under the erroneous impression that the aircraft was in a stable stall; an emergency landing was necessitated by the retention of the tail parachute.

3.- Recommendations

None were contained in the report.

Test
En route
Forced landing
Pilot - improper in-flight planning
Pilot was under the erroneous impression that the aircraft was in a stable stall

ICAO Ref: AR/864

ACCIDENT TO BAC 111, G-HSJD, OF BRITISH AIRCRAFT CORP. LTD., NEAR TILSHEAD, ENGLAND.
20 AUGUST 1964

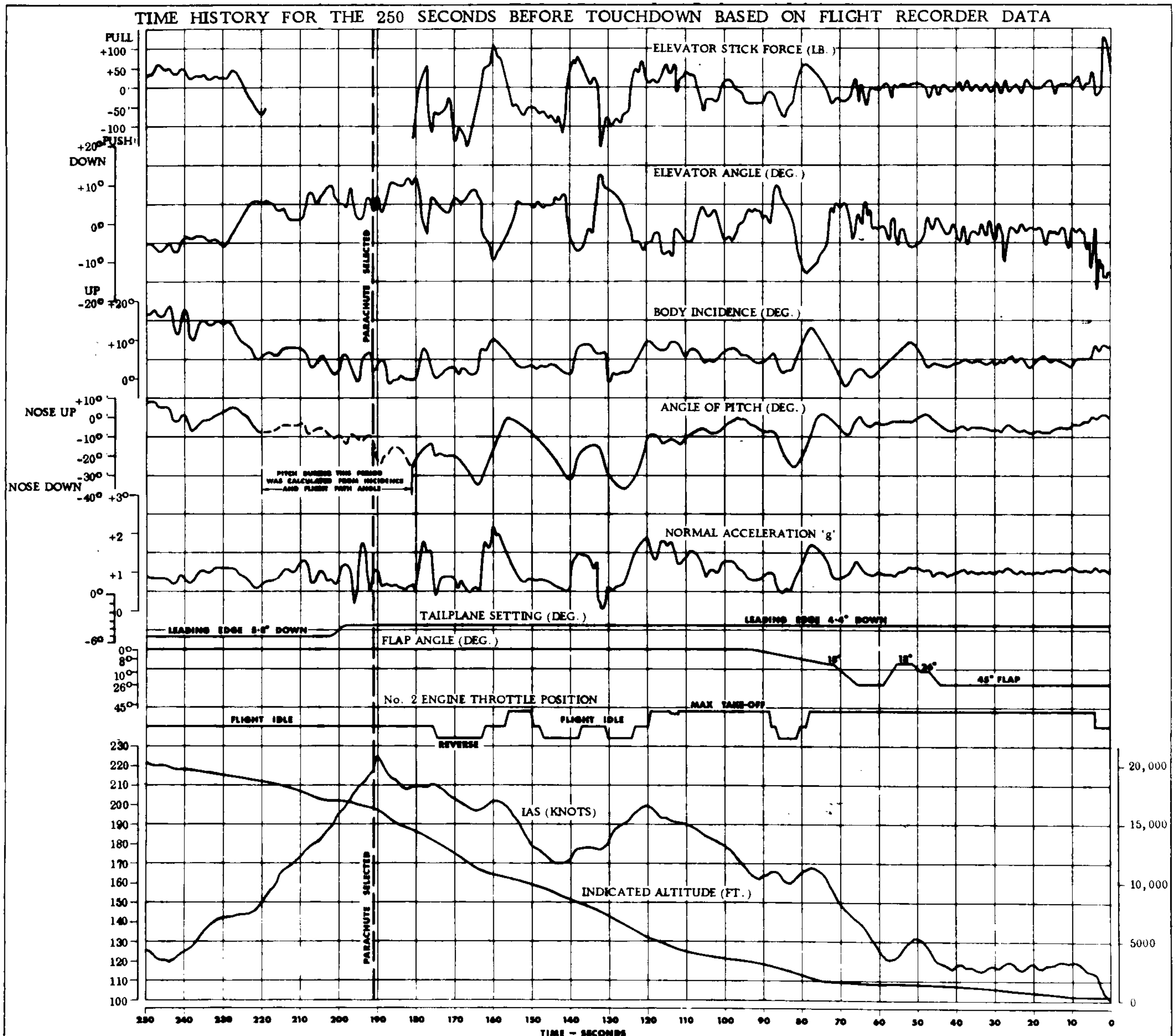

FIGURE 9-1

No. 10

Empress Servicios Aéreos Cochabamba, C-47, CP-680, accident on Huayna Hill, Potosí, Bolivia, on 22 August 1964. Report dated 27 January 1965, released by the Directorate General of Civil Aviation, Bolivia.

1.- Investigation

1.1 History of the flight

The aircraft took off from El Alto Airport, La Paz at 1212 hours* on a flight to Tipuani and return. It was a non-scheduled domestic flight. The flight had been planned for earlier in the day but was delayed because of bad weather over the Cordillera and over Tipuani. After take-off, the La Paz control tower received the last message from the aircraft, which reported that it would leave the control zone at 1222 hours. It was then authorized to change to en-route frequency. As the aircraft failed to reach Tipuani at the estimated time of landing, the appropriate emergency phases were declared. The wreckage of the aircraft was subsequently found on the following day on a peak on the north side of Huayna Hill.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	2	2	
Non-fatal			
None			

1.3 Damage to aircraft

The aircraft was completely destroyed.

1.4 Other damage

No other damage was incurred.

1.5 Crew information

The pilot-in-command, aged 36 years, was the holder of a commercial pilot's licence which was renewed on 27 July 1964. His flying experience was not stated in the report. His physical fitness certificate was valid until 17 May 1965.

* The report did not indicate whether the times are given in GMT or in local time.

The co-pilot, aged 29 years, was the holder of a private pilot's licence. His flying experience was not stated in the report. His physical fitness certificate was valid until 3 June 1965.

1.6 Aircraft information

A certificate of airworthiness, dated 27 July 1964, was issued for the aircraft. The most recent 100-hour maintenance of the airframe was carried out on 17 August 1964. The 50-hour maintenance to No. 1 engine was carried out on 2 August 1964 and to No. 2 engine on 8 August 1964.

The aircraft was loaded within prescribed limits.

The type of fuel being used was not stated in the report.

1.7 Meteorological information

The flight was dispatched with the following weather information from the airline's meteorological office at Tipuani:

> "1100 hours - wind calm, unlimited visibility, present weather overcast 2/8 stratus at 1 300 m, 3/8 stratocumulus at 1 500 m, 2/8 cumulus at 1 500 m, 1/8 altocumulus at 2 000 m. Runway OK, Caugally pass unflyable. Stratocumulus and stratus, Paniagua pass flyable."

The weather over the Cordillera did not permit VMC flight because of cloud and precipitation conditions, especially through the Huayna pass.

1.8 Aids to navigation

They were not mentioned in the report.

1.9 Communications

The aircraft's communication systems were functioning normally, and no communications failure was noted on the various radio frequencies.

1.10 Aerodrome and ground facilities

Not pertinent to the accident.

1.11 Flight recorders

They were not mentioned in the report.

1.12 Wreckage

The accident site was 35 km due north of La Paz.

The portion involving the nose and left side of the aircraft was totally destroyed and shattered into fragments which, along with the left engine, were embedded in the rock.

1.13 Fire

A fire burned only briefly because of the rain and snow which were falling.

1.14 Survival aspects

Not mentioned in the report.

1.15 Tests and research

No mention was made in the report of any tests or research.

2. - Analysis and Conclusions

2.1 Analysis

The Air Regulations required that aircraft, such as the C-47, with a critical operation ceiling, when on northbound flights from La Paz, cross the Cordillera in VMC through the railway pass, which is different from the Huayna Pass.

From the location and position of the wreckage, it was possible to establish that the aircraft was flying northwards at a heading comprised between 360° and 30° when it struck the summit of the Huayna Hill at an elevation of about 15 000 to 15 500 ft and with a speed of about 140 to 150 mph. The Commission believed that at the time of the accident the weather conditions in the area were not favourable and that the flight was being conducted in IMC at about 15 500 ft. The aircraft was, therefore, executing an unsafe instrument procedure in a narrow pass, two kilometres wide, and at an inadvisable height. Furthermore, it was established that at the time of the accident there was severe turbulence in the area. Therefore, the pilot probably experienced severe gusts which caused him to approach dangerously close to the hillside and he finally flew into it.

Also on the day of the accident, the weather reports mentioned a low pressure area in the northern Cordillera and this could have affected the altimeter reading in the aircraft.

2.2 Conclusions

Findings

The crew members were properly qualified.

The aircraft had a valid certificate of airworthiness. The maintenance services had been carried out in a perfunctory manner, and the airline had no fixed policy regarding maintenance service. The required maintenance manual was not produced for approval.

A VFR flight plan was prepared indicating a cruising altitude of 15 500 ft. This was contrary to the regulations in force, as the obstacle clearance limit was not observed; also, weather conditions dit not favour VFR operations. The airline was using meteorological information provided by its own radio station at Tipuani, whereas it could have provided the pilot with more up-to-date information using the reports from the official MET station under the supervision of the DGCA. Those reports indicated weather conditions around the established minima.

Cause or
Probable cause(s)

The flight was conducted in IMC conditions at an altitude unsafe for operations of that nature through the Huayna Pass.

3.- Recommendations

It was recommended that the airline:

(1) organize a better safety service for its operations;

(2) institute an adequate system for guaranteeing that flight regulations are observed;

(3) reorganize its inadequate maintenance service, laying down and implementing appropriate policy.

ICAO Ref: AR/901

No. 11

Viação Aérea São Paulo S.A., Viscount 701, PP-SRR, accident on Pico da Caledonia, 15 km southwest of Nova Friburgo, Rio de Janeiro State, Brazil, on 4 September 1964. Report released by the Department of Aviation of Brazil (SIPAER) on 15 December 1964.

1. - Investigation

1.1 History of the flight

The aircraft was flying a scheduled domestic flight from Recife to Rio de Janeiro with intermediate stops at Salvador and Vitoria. At 1553 hours GMT, the aircraft took off from Salvador for Rio de Janeiro, with clearance to fly at 4 200 m on Airway Green 1 and to make an intermediate stop at Vitoria. Over Caravelas the pilot requested permission to change altitude to 1 800 m without indicating his reason for doing so. Rio Area Control Centre modified the flight plan but as Radio Station Caravelas did not obtain contact with the aircraft, the latter maintained its altitude as far as Vitoria. At 1845 hours GMT the aircraft took off from Vitoria, climbing on instruments, and then informed Guarapari that it had reached the altitude of 1 800 m. At 1910 hours GMT, it reported over Campos above the clouds. At 1922 hours GMT, it reported over Macaé and estimated arrival at Rio Bonito at 1934 hours GMT. At 1933 hours GMT, the aircraft reported its position as Rio Bonito, 1 800 m in instrument meteorological conditions and was instructed by Rio ACC to maintain altitude, head for "Quebec" and pass to approach control. The real position at that time was reconstructed as being over the city of Nova Friburgo at a distance of 43 km from Rio Bonito (see Figure 11-1). Some 30 seconds later (at 1934 hours GMT) the aircraft, flying in IMC, crashed on the west slope of Pico da Caledonia at a point located 22°19'S - 42°33'W and at an elevation of approximately 1 950 m.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	5	34	
Non-fatal			
None			

1.3 Damage to aircraft

The aircraft was destroyed.

1.4 Other damage

There was no other damage.

1.5 Crew information

The pilot-in-command was a first-class reserve officer of the Brazilian Air Force and had considerable experience on the route. His instrument rating, certificate of medical fitness and equipment rating were all up to date. He had flown a total of 6 787 hours as pilot-in-command, including 284 hours night flying and 588 hours instrument flying. His total experience as pilot-in-command on Viscount 701 aircraft amounted to 428 hours.

The co-pilot had flown a total of 5 945 hours, including 1 494 hours instrument flying. His total experience as pilot-in-command amounted to 2 972 hours, including 433 hours on Viscount 701 aircraft. His instrument rating, certificate of medical fitness and co-pilot's rating for the aircraft were up to date. Most of his flying experience was on DC-3s, and therefore his experience on the particular route was relatively small since it was only flown by Viscount 701s.

Both pilots had considerable flying experience and were considered by their colleagues as attentive and disciplined pilots. Their recent flying activities and hours of work were perfectly normal, and fatigue was excluded as a possible factor in the accident.

1.6 Aircraft information

The aircraft had flown a total of 17 165 hours, including 1 494 hours since the last overhaul. No information on the aircraft's certificate of airworthiness was given in the report, but it appeared that the aircraft and its equipment had been properly maintained.

On arrival in Brazil, where radio direction-finding equipment is the basic navigational aid, the aircraft posed various problems for the pilots. The tropical climate and generally low strength of radio beacons affected adversely the efficiency of the equipment. The company's servicing, after various precautionary measures, resulted in the ADF equipment attaining satisfactory efficiency for the approach operation. Nevertheless, as far as navigation was concerned, the bearings remained deficient at a distance from the radio beacon. Another factor was the behaviour of the aircraft when traversing cold fronts at high altitudes. On a number of occasions, radar failure placed the pilots in a difficult situation. In order to overcome that deficiency, the pilots preferred to cruise at the lowest altitudes possible whenever there was a front to traverse although this tended to diminish the endurance.

These factors explained certain aspects of the accident, such as the change of altitude and the fact that the aircraft was not on the Macaé radio beacon.

The aircraft's weight and centre of gravity were within limits at take-off and there was no change by the time the impact occurred.

The type of fuel being used was not stated in the report.

1.7 Meteorological information

There was a cold front between Caravelas and Vitoria and a cloud cover of 8/8 in the area from Santa Cruz to Caravelas.

1.8 Aids to navigation

All NDBs between Vitoria "VT" and Quebec "Q" and also the Marica VOR "VTA" were operating normally. The radar at Rio was not in operation; however, even if it had been operating it could not have prevented the accident.

1.9 Communications

No communications difficulties were reported.

1.10 Aerodrome and ground facilities

Not pertinent to the accident.

1.11 Flight recorders

Not mentioned in the report.

1.12 Wreckage

The point of impact was on the west slope of Pico da Caledonia at an elevation of 1 950 m, i.e. 300 m below the summit. The aircraft collided at that point, flying horizontally at a magnetic heading of 257° and at an angle of 67° to the surface of the mountain.

The force of the impact caused the aircraft to disintegrate, scattering wreckage over an oval-shaped area, the horizontal axis of which formed an angle of 68° with the flight path of the aircraft. The shortest radius of that area measured 15 m, its longest radius (in the direction of the flight path) 200 m, and the median radius measured 75 m.

1.13 Fire

There was no fire.

1.14 Survival aspects

None given in the report.

1.15 Tests and research

None mentioned in the report.

2. - Analysis and Conclusions

2.1 Analysis

Due to the degree of destruction of the aircraft, little information could be gained from the examination of the wreckage. Only three instrument dials were found, and nothing was learned from their examination. It was estimated that the speed at the time of impact was about 495 km/h. No indication of in-flight failure or malfunction in the aircraft or its equipment was found.

All factors pertaining to the flight from Recife to Rio de Janeiro were reconstructed. The route segment Recife-Salvador was flown at 3 600 m and was uneventful. The route segment Salvador-Vitoria was flown at 4 200 m, despite the fact that over Caravelas the aircraft had requested permission to change altitude to 1 800 m. As the approval for the new altitude took 36 minutes to reach Caravelas, it had not been possible to reach the aircraft by VHF and it continued to fly at 4 200 m according to the position report over Praia. In Vitoria no deficiencies were reported by the pilots. The arrival at and the departure from Vitoria were made in IMC. The climb to en-route altitude was carried out according to climb procedure No. 2. The amount of cloud in the area as far as Rio left no doubt that the pilots had to fly in IMC. It was established that the aircraft's ADF equipment had not given rise to complaints since 19 August. A defect in the pressurization system was excluded in view of the fact that the aircraft was still flying at 4 200 m after it had requested permission to change altitude and that nothing was reported to the maintenance at Vitoria.

It was concluded that the request to change altitude over Caravelas was not made for technical reasons but was made in connexion with the presence of the cold front and the associated turbulence.

In view of the aircraft's characteristics, the Commission was unable to understand why the flight was continued towards Rio de Janeiro at 1 800 m. The altitude of 4 200 m was vacant, and there was no difficulty in obtaining permission for that altitude.

It was considered that the ADF functioned normally but that a good bearing from Macaé might not have been obtained.

When the aircraft passed over Campos it was on top of a cloud bank. However, the layer of cloud was of a type which must have made it possible for the pilots to see the river Paraíba and the city.

Bearing in mind the type of navigation instruments used by the Viscount 701, it would be difficult to assume that a malfunction of the instruments might have resulted in an erroneous heading.

A mean wind speed of 10 kt prevailed in the entire area and, consequently, this factor could not have caused the deviation which took place on the route segment Campos-Macaé.

Evidence suggested that the automatic pilot did not play any part in the accident.

According to the operating rules of the company, the pilot-in-command should have been flying the aircraft at the time of the accident.

The Pico da Caledonia and the adjacent mountains have erroneous spot elevation indications on the air navigation charts. The altimeters were found at a setting of 1 013 mb and indicated approximately 1 800 m. The aircraft had not yet started the descent.

The NDB of Rio Bonito frequently has no identification.

It is likely that the pilots sighted Nova Friburgo and gave their position as being over Rio Bonito. This could have happened in view of the fact that they had no indication from the radio direction-finder and that the estimated time over Rio Bonito was only one minute after the actual time at which they reported. In the expectation of being over Rio Bonito, it is possible that despite the topography the pilots mistook Nova Friburgo for Rio Bonito through the clouds.

2.2 Conclusions

Findings

Both pilots had considerable flying experience both in VMC and IMC.

The aircraft, its engines and equipment had been properly maintained.

No indication of malfunction or failure of the aircraft or its equipment was found.

From the reconstruction of the flight, it was concluded that the aircraft had deviated 35 km to the right of its normal route and as a result of this struck the mountain in a nearly horizontal attitude.

Nothing was found which indicated the reason for this deviation; however, it was believed that the pilots mistook Nova Friburgo for Rio Bonito through the clouds.

Cause or
Probable cause(s)

Collision with an obstacle located 35 km to the right of the intended track, for reasons unknown.

3. - Recommendations

The Directorate of Civil Aviation should study the possibility of requiring that radar be carried as essential equipment by all commercial aircraft with speeds of over 400 km/hr to facilitate flying through fronts and as an aid to navigation.

The Directorate of Civil Aviation and those in charge of airline operations should increase the use of VOR and ILS among air crews, not only in re-checks but also in normal operation.

The Directorate of Aviation Routes should study the possibility of augmenting the power of the Macaé and Rio Bonito non-directional radio beacons as well as the Route Service of the 3rd Area Zone to improve the assistance as far as transmission of the identification of the Rio Bonito NDB is concerned, and of equipping all towers, approach control offices, radar and area control centres with recording equipment.

The airline should examine the air navigation charts, completion of which is to be left to the pilots.

The airline should avoid, as far as is possible, that its turboprop aircraft request permission to change to lower altitudes unless an emergency exists, in which case information on the emergency shall be given in the message.

The airline should instruct the air crews to report all incidents in order that the latter may be fully analysed and the necessary information be obtained from them, and to adhere to the communication traffic rule which requires a minimum of 10 minutes when in direct contact with the area control centre, or 20 minutes when contact exists through other stations, as the time preceding a request for permission to change the flight plan.

For modifications of the flight plan, contact should be established whenever possible directly on VHF or HF with the area control centres, thus avoiding delay in messages.

The Directorate of Aviation Routes and the competent authorities should co-ordinate their efforts to correct the spot elevations of the Pico da Caledonia and nearby mountains and to verify the relief of other mountains in Brazil.

ICAO Ref: AR/861

ACCIDENT TO VISCOUNT 701, PP-SRR, OF VIAÇAO AEREA SAO PAULO, S.A., ON PICO DA CALEDONIA, BRAZIL.
4 SEPTEMBER 1964

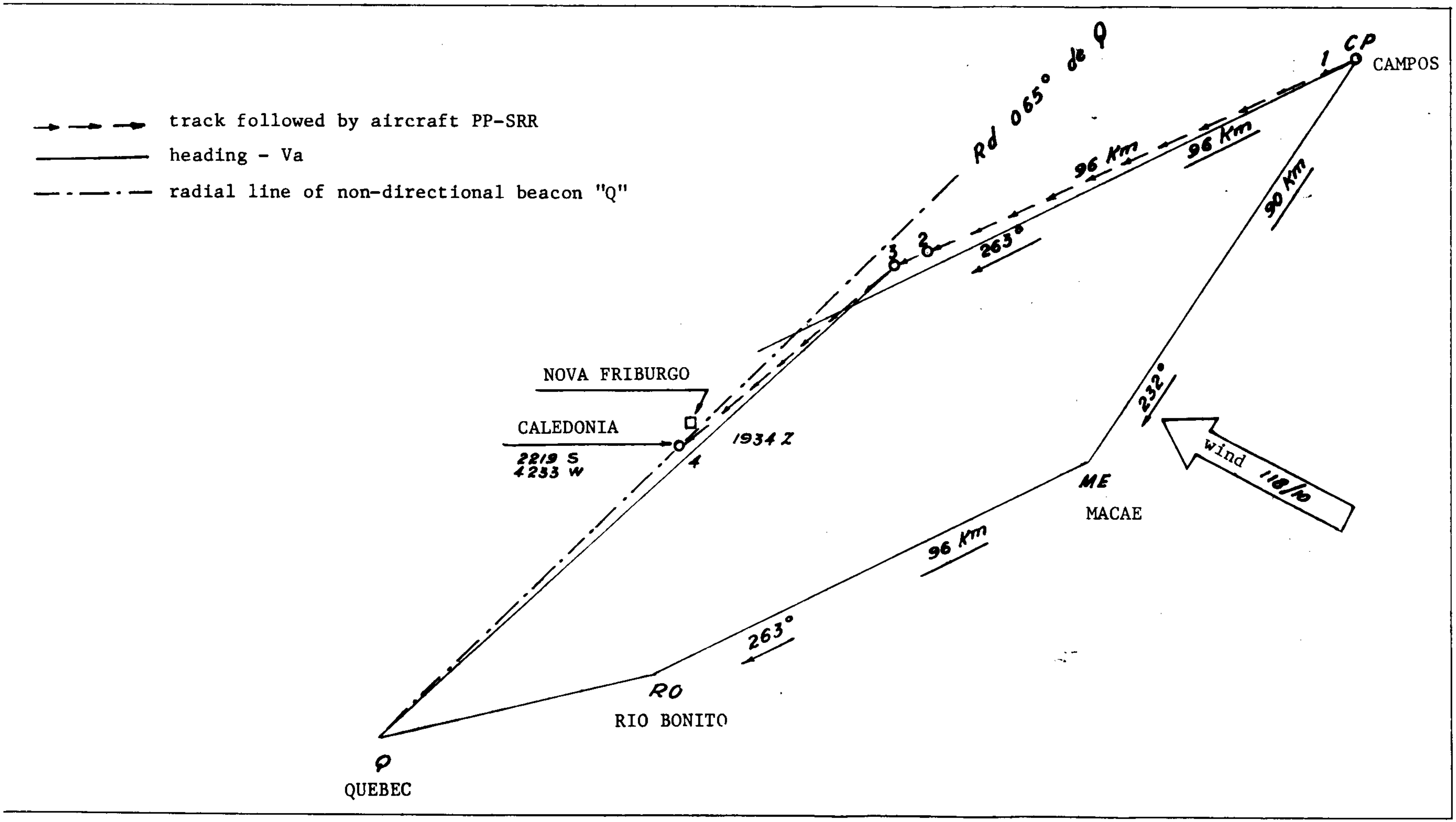

FIGURE 11-1

No. 12

Libyan Aviation Company Ltd., C-47, N 330, accident at Idris Airport, Libya, on 8 September 1964. Report dated 5 November 1964, released by the Department of Civil Aviation, Ministry of Communications, Libya.

1. - Investigation

1.1 History of the flight

The aircraft was on a non-scheduled domestic flight from E3-92 29°28'N - 18°26'E an oil camp desert landing strip) to Idris Airport, Tripoli, carrying 2 crew members and 12 passengers. The approach to land on runway 36 at Idris Airport was normal and the aircraft touched down at 1132 hours at the beginning of the runway. Shortly after touchdown, the left wing lowered and the aircraft started veering to the left. Power was applied to the left engine together with the right aileron but, with the decrease of roll-out speed, the left wing continued to lower. The pilot believed that there was a flat tire, so he retarded the left throttle and cut off all power. Then the left wing came into contact with the ground and the aircraft rolled off the runway, and came to a stop some 20 m from the runway edge and about 850 m from the runway threshold.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal			
Non-fatal			
None	2	12	

1.3 Damage to aircraft

The aircraft was substantially damaged.

1.4 Other damage

None mentioned in the report.

1.5 Crew information

The pilot-in-command held an airline transport pilot's certificate with various ratings, including one for the DC-3. He had flown a total of 11 287 hours including 6 366 hours on DC-3, of which 95 hours had been flown during the last 90 days.

The co-pilot held a commercial pilot's licence with no special rating for the DC-3. He had flown a total of 3 449 hours including 294 hours on DC-3, all of which were flown during the last 90 days.

1.6 Aircraft information

A certificate of airworthiness was issued for the aircraft on 26 April 1963. The aircraft had flown a total of 16 940 hours, including 91 hours since the latest inspection on 15 July 1964.

The weight and centre of gravity were not mentioned in the report.

The type of fuel being used was not stated in the report.

1.7 Meteorological information

Six minutes after the accident, the weather conditions were as follows:

wind: 010°/10 kt

visibility: 40 km

clouds: nil

QNH: 1 018 mb

1.8 Aids to navigation

No information was provided in the report.

1.9 Communications

Not pertinent to the accident.

1.10 Aerodrome and ground facilities

The runway in use was 36/18. It was 2 224 m long and 45 m wide.

1.11 Flight recorders

Not mentioned in the report.

1.12 Wreckage

At about 350 m from the runway threshold and slightly to the right of the centre line, half of the clamp attaching the brake hose at the rear of the brace strut and part of the main support of the oil cooler were found.

1.13 Fire

There was no fire.

1.14 Survival aspects

The passengers and crew evacuated the aircraft safely.

1.15 Tests and research

No information was contained in the report.

2. - Analysis and Conclusions

2.1 Analysis

The brace strut attaching fitting fractured. The fracture was located at the first bolt hole of the upper arm of this fitting. The lower arm of this fitting did not show any sign of damage. The portion of the upper arm fitting staying in the upper channel was still fixed correctly. The lower channel was not damaged and two portions of bolt were found in the second and fourth holes. The four holes of the lower arm of the fitting were free and clear.

2.2 Conclusions

Findings

The crew was properly licensed; however, the co-pilot had no rating for this type of aircraft.

The aircraft had a valid certificate of airworthiness. Its weight and centre of gravity were not mentioned in the report.

During the landing roll, the left landing gear collapsed due to the fracture of the left-hand brace strut attaching fitting.

Cause or
Probable cause(s)

The accident was attributed to the fracture of the left-hand brace strut attaching fitting. The reason for the fracture was not determined. It appeared that the fitting might have been previously cracked and that a progressive failure occurred.

3. - Recommendations

It was recommended that an inspection system be established to ensure that the brace strut fitting is tightly secured.

ICAO Ref: AR/842

No. 13

Aerovías Nacionales de Colombia, Douglas C-47, HK-319, accident at Mandinga Airport, Municipality of Condoto, Department of Chocó, Colombia, on 15 September 1964. Report dated 11 December 1964, released by the Air Safety Division, Administrative Department of Civil Aeronautics, Colombia.

1. - Investigation

1.1 History of the flight

The aircraft had arrived at Condoto from Medellín at 1648 hours GMT on a non-scheduled domestic cargo flight with two crew members aboard. The unloading of 2 565 kg of cargo then took place and 9 metal drums of graphite oil, each weighing 246 kg, were loaded on to the aircraft. Their total weight was 2 214 kg. These were distributed in the freight hold of the aircraft as directed by the dispatcher and secured with agave fibre cords of the type usually used by Avianca for lashing cargo. No refuelling was necessary. After signing the weight and balance sheet, which showed a total take-off weight of 11 045 kg (1 157 kg below the maximum authorized weight), the pilot-in-command went aboard with the co-pilot and started the engines. The aircraft took off from runway 27 at 1740 hours for Medellín and reported north of Condoto on visual climb and changed over to en-route frequency. Five minutes later, the pilot-in-command requested permission to return to the aerodrome as the aircraft was badly loaded. Permission was granted and the following landing instructions were given to him. "Approach left, runway 27, wind SW/8 kt, QNH 29.92". The aircraft was seen passing over the airport, making a left turn and coming to land on runway 27. Everything appeared normal during these manoeuvres. At 1750 hours, the aircraft reported on final approach. It was seen to touch down, bounce twice and then accelerate and climb sharply. Shortly thereafter it crashed on its left wing, facing roughly the direction of landing, and came to rest within the airfield 42.80 m from the south edge of runway 27, 725 m from the threshold and 480 m from the runway end. The accident occurred at approximately 1751 hours.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	2	-	-
Non-fatal	-	-	-
None	-	-	

1.3 Damage to aircraft

The aircraft was destroyed.

1.4 Other damage

None reported.

1.5 Crew information

Both crew members held valid licences and medical certificates. The pilot-in-command was wearing spectacles at the time of the accident as required. No other information was contained in the report received.

1.6 Aircraft information

No mention is made in the report of the certificate of airworthiness. However, the aircraft had been regularly maintained in conformity with aeronautical standards.

According to the weight and balance sheet prepared by the dispatcher at Condoto, the weight of the aircraft at take-off was within limits. The centre of gravity location is discussed in 2.1.

On take-off from Condoto, the aircraft was carrying 277 gallons of fuel. The type of fuel carried was not stated in the report.

1.7 Meteorological information

At the time of the accident, weather conditions at Condoto were good and suitable for the operation of aircraft. The accident occurred in daylight.

1.8 Aids to navigation

Not pertinent to this accident.

1.9 Communications

Communications between the aircraft and ground stations were normal.

1.10 Aerodrome and ground facilities

The runway at Condoto was 1 215 m in length, and there were no obstructions at the approaches. It had a smooth surface.

1.11 Flight recorders

Not mentioned in the report.

1.12 Wreckage

The wreckage of the left wing and of eight of the oil drums was found on the edge of a ditch, parallel to runway 27. In the ditch part of the left cockpit window, part of the pilot's headset and spectacles, the dial of one altimeter and the left propeller were found. The rest of the wreckage was submerged in the adjoining pond 3 metres deep in places.

1.13 Fire

Fire broke out following the accident.

1.14 Survival aspects

Both crew members were found still strapped in their seats, which had been torn out from the cockpit floor.

1.15 Tests and research

None were mentioned in the report.

2. - Analysis and Conclusions

2.1 Analysis

No evidence of malfunction or failure of the aircraft or its engines prior to the accident was found. According to the flight plan, 9 metal drums of graphite oil, each of them being 90 cm long, 63 cm in diameter and weighing 246 kg, were loaded at Condoto.

According to the weight and balance sheet filled by the dispatcher, the cargo was distributed as follows in the aircraft:

Compartment	Weight (kg)
B and C	214
D	700
E	600
F	200
G	500

This, added to the basic operating weight, plus fuel weight, gave a total aircraft weight of 11 045 kg, i.e. 1 157 kg less than the maximum permitted take-off weight of 12 202 kg.

The dispatcher's report after the accident stated that the actual loading was: 4 drums in compartment D, i.e. 984 kg; 2 drums in E, i.e. 492 kg; 1 drum in F, i.e. 246 kg and 2 drums in G, i.e. 492 kg. Assuming that these were the facts, the centre of gravity would have been at 27% of the MAC, very near to the C-47's aft limit of 28%.

Furthermore, when asked to say from memory, prior to writing his report, how he placed the drums, the dispatcher stated that, commencing at the cargo door and proceeding upwards, he put 3 drums first, then one, then 2 and then 3, because one had failed to go through the door of the forward compartment. If this was the case, there were 3 drums in compartment G, i.e. 738 kg instead of the 590 kg for which it is designed, and not only was compartment G heavily overweight but this would have created a tail heavy moment in the aircraft.

It was also found that three-eighths of an inch fibre cords, some new, some old, were used to secure the cargo and that these heavy drums were placed on the floor (two of them in compartment E, possibly lying down on their side), without cradles or any other attachment than those cords.

It was concluded that, the lashings of the cargo being inadequate, a light turn or pitch up before landing, or bounces during the landing, might have caused a displacement of the cargo to the rear. A missed approach procedure attempted in these conditions might have caused a further displacement of the cargo to the rear and the shifting of the centre of gravity, resulting in an excessive angle of attack and a loss of airspeed which the pilots were unable to control.

2.2 Conclusions

Findings

The crew held valid licences and medical certificates.

The aircraft's certificate of airworthiness was not mentioned in the report. The aircraft had been regularly maintained.

Weather conditions did not play a part in the accident.

The aircraft had been improperly loaded by the dispatcher, who did not have an appropriate licence, but was duly exempted of having one. The cords used to lash the cargo were unsuitable and permitted displacement of the cargo.

The pilot did not make a proper check of the cargo before signing the weight and balance manifest and commencing the flight.

Displacement of the cargo towards the rear caused an excessive shift of the centre of gravity and a dangerous nose-up attitude at the start of the missed approach procedure. A loss of airspeed resulted.

Cause or Probable cause(s)

The prime cause of the accident was error of other personnel inasmuch as the sequence of events leading up to the accident was initiated by faulty distribution of the cargo on board the aircraft.

3.- Recommendations

It was recommended:

(1) that when drums more than 60 cm high are carried on aircraft, they shall be laid flat on a non-slip surface and secured with chocks, cradles and other special devices;

(2) that steel cables shall be used to unite the staples in the floor of aircraft, to facilitate secure anchoring and distribution of the lashings and give them greater strength;

(3) that sisal or hemp cords not less than half an inch thick or similar netting shall be used to fasten cargo to the floor from above;

(4) that all persons dispatching aircraft shall have received special instruction and possess a dispatcher's or assistant dispatcher's licence;

(5) that aircrews pay more attention to, and make representations concerning damage, irregularities or other circumstances which may present a hazard in flight, whenever possible;

(6) that, wherever an aerodrome has a radio operator or traffic control officer, he and his equipment shall be placed in a control tower or other structure from which he has a clear view of the runways and surrounding area.

ICAO Ref: AR/899

No. 14

Turkish Airlines Incorporated, Viscount 794, TC-SEC, accident at Tel Aviv (Lod Airport), Israel, on 23 September 1964. Report undated, received from the Ministry of Communications, Turkey.

1. - Investigation

1.1 History of the flight

Flight TK-937/23 was a scheduled international flight from Tel Aviv to Ankara and Istanbul. It took off from runway 30 at 1109 hours GMT carrying four crew members. The number of passengers aboard was not stated in the report. At 1117 hours, No. 1 generator failure warning lamp came on, the reset button was depressed, the ammeter's pointer then moved to maximum and tripping was carried out. Five minutes later, the same set of circumstances occurred to No. 3 generator and changing the position of the overvolt switches did not help either. The steward was then told to switch off his electrical equipment; the automatic pilot, No. 2 VHF, No. 2 VOR and HF were also switched off. At 1135 hours the engines' noise increased and the crew, believing that all engines had stopped, switched the booster pumps ON. The inverter failure warning lamp then came on, the switch was moved to the "emergency" position and the pilot-in-command decided to return to Lod Airport. The inverter failure warning lamp continued to operate and some time later all radio equipment ceased to operate.

The aircraft was flown back to Lod Airport in VMC and passed over the control tower at an altitude of 1 200 ft. The pilot-in-command ordered the co-pilot to extend the landing gear; then, he realized that the landing gear would not operate because of the electrical failure and, therefore, requested the co-pilot to use the emergency procedure for extending it. The co-pilot was unable to remove the pin from the selector valve and tried to implement item No. 3 of the undercarriage emergency check list. The by-pass valve having been opened, the change-over valve was brought to the emergency position and pumping was started. During that time the aircraft was circling over runway 29 at an altitude of 400 to 500 ft.

When the co-pilot informed the pilot-in-command that the pump handle was stuck, he was told to check the mechanical locking indicators on the wings. He reported that both main gears mechanical locking indicators were protruding but not the nose wheel mechanical locking indicator. The pilot-in-command left the controls to the co-pilot and checked the procedures carried out. He found that the hydraulic manual pump was stuck and that all operations had been fulfilled in accordance with the check list on the hydraulic panel.

Considering that the nose wheel mechanical locking indicator might not be protruding because of a failure of the indicator itself, the pilot-in-command decided to find out whether the nose wheel was extended by landing on the two main wheels and lowering progressively the nose down to the normal level. Should this prove that the nose wheel was not completely extended, he would climb and fly until most of the fuel was burned. The two main wheels contacted the runway around 30 m after the runway threshold, then the pilot-in-command lowered the nose to the estimated angle at which the nose wheel should have touched the ground; finding out that the nose wheel was not lowered, he climbed. As the aircraft was climbing he noticed that the landing gears were extending, so he asked the steward to pump. This was done and the handle of the hydraulic pump got stuck again. It was assumed that the nose wheel w locked down and a second landing was initiated.

The aircraft headed for No. 3 runway and a green signal was fired from the ground when the aircraft was about 500 or 600 m away from the runway threshold. The aircraft landed on its main wheels approximately 20 m after the runway threshold, and around 1227 hours the nose wheel came into contact with the runway. After a landing roll of 1 400 to 1 500 m, the aircraft started to incline to the right. The pilot-in-command thought that the shock absorber had collapsed and feathered the engines. The aircraft went off the runway and stopped, approximately 15 to 20 m to the right of the runway, lying on its starboard wing.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal			
Non-fatal			
None	4	*	

1.3 Damage to aircraft

The aircraft was substantially damaged.

The starboard landing gear had collapsed and the aircraft was lying on its starboard wing. The leading edge and the underside of the starboard wing, as well as the aileron and flap, were damaged. The propellers and nacelles of Nos. 3 and 4 engines were also damaged.

1.4 Other damage

There was no other damage.

1.5 Crew information

The pilot-in-command, aged 38, held an airline transport pilot's licence. His last technical check was on 21 June 1964. He had flown a total of 4 219 hours, including 3 987 hours on Viscount aircraft. He had flown 218 hours during the last 90 days.

The co-pilot, aged 31, also held an airline transport pilot's licence valid until 1 April 1965. His last technical check was on 2 April 1964. He had flown a total of 1 878 hours, including 1 080 hours on Viscounts. He had flown 237 hours during the last 90 days.

The steward was 32 years old. No other information concerning him was contained in the report.

Also aboard was a stewardess, 22 years old.

* The number of passengers aboard was not stated in the report. The passenger capacity of the aircraft was 52 persons.

1.6 Aircraft information

The date of expiry of the airworthiness certificate was not contained in the report. The aircraft had flown a total of 9 311 hours and its last check was on 9 January 1964. The 150-hour maintenance check was carried out on 13 September 1964.

The aircraft's weight and centre of gravity were not mentioned in the report.

The type of fuel being used was not stated in the report.

1.7 Meteorological information

The forecast for Lod Airport between 0900 and 1600 hours was as follows:

wind: 280°/15 kt visibility: 20 km clouds: 4/8 cumulus and strato-cumulus at 3 000 ft

Forecasts were also provided for Nicosia, Ankara and Istanbul.

1.8 Aids to navigation

Not pertinent to the accident.

1.9 Communications

Communications were normal until the inverter failed at 1135 hours. Thereafter, the decay of the electric supply made communications impossible.

1.10 Aerodrome and ground facilities

Not pertinent to the accident.

1.11 Flight recorders

None mentioned in the report.

1.12 Wreckage

The aircraft stopped 20 m off runway 30 at Tel Aviv (Lod Airport).

1.13 Fire

There was no fire.

1.14 Survival aspects

No information was contained in the report.

1.15 Tests and research

The electrical system was tested after the accident with the engines running. The output voltages of the generators were 0 volt on No. 1 generator and 27 volts on Nos. 2, 3 and 4 generators. The warning lamps of Nos. 1 and 3 generators were operating, those of Nos. 2 and 4 were not.

The inverter warning lamp was also operating although the output voltage was normal.

The equalizer voltages of the generators were found to be 0 volt for Nos. 1 and 4 generators, 0.85 volt for No. 2 generator and 0.24 volt for No. 3 generator.

The hydraulic system was also tested both electrically and manually: nothing abnormal was found. However, it was noted that the landing gears being extended and locked when the change-over valve was moved from the "emergency" to the "ground test" position, the landing gears were freed from the locked position in the following order: starboard gear, port gear and nose gear.

2. - Analysis and Conclusions

2.1 Analysis

The generators went off line because their equalizer and output valves were not functioning properly. The batteries then became weak since they had to meet all the DC current requirements in the aircraft.

No. 1 generator went off line because its equalizer and output voltage did not have their proper values. When the adjustments of the equalizer and output voltages were corrected, No. 1 generator operated normally.

No. 2 generator had tripped automatically because the other generators were not on line and, consequently, No. 2 generator had to supply a load of over 200 amperes through the thermal circuit breaker. The generator failure warning lamp did not operate because the filament of the lamp was broken and, therefore, the pilot thought that the generator was operating. The ammeter and the circuit of No. 2 generator were in order. After the equalizer and the output voltages of No. 2 generator had been tested and adjusted, No. 2 generator and the circuit thereof operated normally.

No. 3 generator went off line automatically because its equalizer voltage was 0.25 volt and its output voltage was 22 volts. When it was reset, tripping was inevitable due to the fact that the batteries were too weak, and an excess current was being taken from No. 3 generator since it was the only generator on line. No. 3 generator and its circuit returned to normal after adjustment of its equalizer and output voltages.

Although the output voltage of No. 4 generator was 27 volts and its equalizer voltage was 0 volt, the generator failure warning lamp did not operate because its cable was broken at No. 3 contact of the contactor auxiliary relay and also because the differential relay of No. 4 generator was defective. After the generator differential relay had been changed and the connexion to the auxiliary contactor relay had been repaired, the circuit returned to normal following adjustment of the equalizer and output voltages. The ammeter of No. 4 generator was in order.

The inverter failure warning lamp operated because the inverter torque switch was defective. The inverter and its circuit operated normally after replacement of the inverter torque switch.

When the landing gear selector was put to the "down" position, the electric power was insufficient and could not operate the landing gear selector actuator.

When the emergency procedure was carried out, it was impossible to take out the pin which connected the landing gear selector actuator to the valve because it had been seated too tightly in its place.

When the co-pilot checked the mechanical locking indicators of the landing gears, he found both main gears locked but not the nose wheels. This was normal since the nose wheel would extend later than the main landing gears.

The second landing was started when the three mechanical locking indicators indicated that the landing gears were extended and locked.

At the end of the landing the starboard landing gear collapsed. The hydraulic emergency change-over valve was found on "ground test". The Board believed that it had been moved for unknown reason from the "emergency" position to the "ground test" position during the landing. Consequently, the back pressure, created in spite of the fact that the by-pass cock was fully open, forced the actuator pistons of the landing gear to the "up" position and moved the piston.

Since the shuttle valves, which separate the emergency and normal pressure lines, closed the normal pressure line before the emergency line, the hydraulic fluid completed its return through the emergency change-over valve and freed the landing gear from the locked position.

2.2 Conclusions

Findings

The crew were properly licensed.

The aircraft's certificate of airworthiness was not mentioned in the report nor were its weight and centre of gravity.

Shortly after taking off from Lod Airport, deficiencies were noted in the aircraft's electrical system and it was decided to return to Lod Airport.

The generators of the aircraft failed because of improper adjustments, a broken connexion and a defective relay. Also, improper indication of the inverter failure lamps was caused by a defective inverter torque switch.

Due to the failure of the electrical system, emergency procedure had to be used for extending the landing gears and some difficulties were experienced in doing so. During the landing, the starboard landing gear collapsed because the hydraulic change-over valve had been moved from the "emergency" position to the "ground test" position.

Cause or Probable cause(s)

None specifically mentioned in the report.

3. - Recommendations

With regard to the electrical failures

I. During flight

(a) The generator failure warning lamps and the ammeters thereof should be checked frequently.

(b) In case of failure of one generator, recommendations in sub-paragraph (a) above should be implemented more often, as well as the principles set forth in the check-list.

(c) In case too much supply is taken from the generators due to the failure of the batteries, the battery master switch should be moved to the "off" position and the flight should be carried on with the generators only to the nearest airport.

(d) The batteries should be checked under load.

II. During the ground tests

(a) When the generators and the circuits thereof are being checked, Chapter 75, Section 2 of the Viscount maintenance manual should be strictly observed.

With regard to the hydraulic failure

(1) In hydraulic emergency cases, the pilot in charge of the hydraulic cupboard should immediately contact the pilot-in-command through the interphone. The matter should be entered in the emergency check list.

(2) A special device should be fitted to the hydraulic cupboard door in order that it would not close by itself once it is opened.

(3) The hydraulic emergency instructions should be put on the hydraulic cupboard door.

(4) Automatic illumination of the hydraulic panel should be provided when the hydraulic cupboard door is opened.

(5) A special device should be made in order that the hydraulic emergency valve will not move from the emergency position when not required.

(6) Some means must be found to take the hydraulic selector actuator pin out easily.

(7) A hydraulic pressure gauge must be fitted to the outlet of the hydraulic manual pump before the change-over valve in a way to be seen from the hydraulic cupboard.

(8) The landing gear mechanical indicators should be painted with some fluorescent paint in order that they can be seen even at night.

ICAO Ref: AR/876

No. 15

Caledonian Airways (Prestwick) Ltd., DC-7C, G-ASID, accident at Yesilkoy/Istanbul Airport, Turkey, on 28 September 1964. Report undated, released by the Turkish Ministry of Communications. Published by the Ministry of Aviation, United Kingdom, C.A.P. 237.

1. - Investigation

1.1 History of the flight

Flight 355 was a scheduled international flight from London to Singapore with a refuelling stop planned at Yesilkoy/Istanbul Airport. It took off from Gatwick on 27 September at 2215 hours GMT on an IFR flight plan. The last part of the flight was conducted at 17 000 ft. After passing the Tekirdag NDB/VOR station severe turbulence was encountered, the speed was reduced from 180 kt to 160 kt, and the ETA was changed.

While approaching the Istanbul radio range, the aircraft was cleared to descend to 4 000 ft. After commencing the descent and upon encountering severe turbulence with heavy rain, the pilot considered diverting the flight to Ankara/Esenboga, the alternate aerodrome on the flight plan, but he decided to land at Istanbul upon hearing a British Eagle aircraft report to the tower that the base of cloud was 1 000 ft. The aircraft was cleared to approach runway 24 and the pilot extended the landing gear, selected 40-degree flap and left the range station outbound at 4 000 ft.

After completing the instrument pattern, the aircraft continued descending inbound to the range to 1 500 ft. Turbulence became moderate, but heavy rain continued. While the co-pilot was trying to locate the runway lights through the direct vision panel, the pilot-in-command was busy flying on instruments. The windscreen wipers were ineffective in clearing the heavy rain off the windows. After passing the range station, the aircraft flew approximately 75 to 80 seconds, descending to 500 ft at a heading of 240°. At that moment, the co-pilot saw the runway lights to the right and ahead and reported this to the pilot-in-command; however, the pilot-in-command did not see the lights and called out overshoot procedure - full power, flaps up to 20° and gear up. The tower asked the pilot-in-command his intentions and whether he would try a VFR landing or not.

Upon request of the pilot-in-command, the aircraft was cleared to the range for a second descent. When the aircraft crossed the range station outbound at 2 000 ft for the second descent, VHF communication was lost because of a power failure in the tower transmitter and did not come back until the procedure turn. The descent, after the procedure turn, developed normally and the range station was passed at 1 500 ft; the gear was extended and the flaps set to 40°. The aircraft continued descending at a rate of 500 to 700 ft/min. During the descent, lightning and heavy turbulence were experienced.

At the last stage of the descent to 500 ft, heading 248°, the co-pilot saw the runway lights and reported to the tower that the aircraft was on final; at the same time the pilot-in-command saw the runway lights, made a slight right correction to line up the aircraft and ordered full flap and a power reduction to 20" boost. His order was carried out by the flight engineer.

Upon feeling the aircraft sinking quickly, when the clearway, short of the runway, was seen, the pilot-in-command ordered more power. A power increase could not be obtained because at that moment the left main gear struck the ground in line with the runway and 72 m short of the threshold. The right central wing hit the upper bar of the ILS screen followed by the two port engines hitting the ground. The aircraft, without changing direction, made a second touchdown with the right main gear and nose wheel after bouncing 14 m from the first impact point. At this time the blades from the left propellers were broken and thrown off. The left main gear was broken off and the nose wheel collapsed. First the port engines and later the left wing disintegrated. The fuselage skidded along a heading of 235°, 260 m down the runway, slightly to the left and came to rest. Fire started and developed on the broken left wing and in the damaged right fuel tanks. The accident occurred at 0450 hours.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal			
Non-fatal		1	
None	8	88	

1.3 Damage to aircraft

The aircraft was destroyed by impact and fire.

1.4 Other damage

The ILS screen was demolished.

1.5 Crew information

The pilot-in-command, aged 39, held an airline transport pilot's licence with an instrument rating and a rating for DC-7C aircraft. He had flown a total of 9 530 hours, including 227 hours flown during the last 90 days.

The co-pilot, aged 46, held a commercial pilot's licence with an instrument rating for DC-7C aircraft. He had flown 1 811 hours, including 311 hours during the last 90 days.

The flight engineer, aged 37, held a flight engineer's licence and a DC-7C rating. He had flown a total of 6 896 hours, including 245 hours during the last 90 days. All flight crew members had valid medical certificates.

Information concerning the other five crew members aboard was not included in the report.

1.6 Aircraft information

The aircraft had a certificate of airworthiness valid until 6 January 1965, and a certificate of maintenance valid until 1 November 1964.

It had flown a total of 20 668 hours, including 1 901 hours since its last overhaul. The inspection of the log-book showed that the periodic checks and maintenance had been performed properly in accordance with the approved maintenance schedule.

The aircraft's weight at the time of the accident was 46 117 kg approximately and its centre of gravity was within limits.

The type of fuel being used was not stated in the report.

1.7 Meteorological information

At the time of the accident the weather was as follows:

clouds:	4/8 fractostratus 600 ft, 6/8 stratocumulus 2 500 ft, 3/8 cumulonimbus 3 000 ft, 8/8 altostratus 8 000 ft
visibility:	2 km
wind speed:	210/10 kt
temperature:	16°C
weather:	thunderstorm and heavy rain

This weather observation was reported to the pilot.

1.8 Aids to navigation

Tekirdag NDB/VOR and Istanbul RNG were used. Inspection of the relevant log-books indicated that these facilities had been flight-checked, pertinent NOTAM had been issued within sufficient time and the aids were operating normally.

Aids aboard the aircraft were as follows: ADF equipment, ILS/VOR equipment, marker receiver, airborne search radar, radar altimeter and Loran. The navigational aids of the aircraft were in good condition and were operating normally before the accident.

1.9 Communications

The communications equipment in the aircraft was operating normally and route and approach communication was conducted properly.

Before the second approach to Yesilkoy/Istanbul Airport was commenced, the tower VHF transmitter was unserviceable for 3 to 4 minutes due to an electrical power failure. Communication between the aircraft and the tower was restored when the emergency generators were connected and remained normal until the time of the accident.

1.10 Aerodrome and ground facilities

The concrete runway 24 was 7 546 ft long and 197 ft wide. The clearway from the threshold extends 68 m with a 2.30% slope without obstruction. The remaining part has a rather steeper slope.

1.11 Flight recorders

Not mentioned in the report.

1.12 Wreckage

From the point of first impact the aircraft started to disintegrate within an area approximately 60 by 300 m. The starboard engines and wing remained attached to the fuselage.

1.13 Fire

The port wing became detached and caught fire on the first impact and came to rest on the runway 170 m further on. The fuselage skidded along the runway with the starboard wing and engines still attached. The fire developed mostly on the starboard central wing. The fire was started when fuel spilled on the hot engine exhaust pipes after the first impact when both inboard fuel tanks were torn open.

Airport fire-fighting personnel and equipment

Personnel

1 chief
3 chiefs of team
35 firemen
15 drivers

Equipment

2 Ford rescue trucks (300 lb dry chemical)
2 Thames tankers (4 000 litres water)
2 Cordox rescue and fire-fighting trucks
(600 gallons water and 42 gallons foam)
1 GMC tanker (2 000 litres water)
2 ambulances

All these vehicles were equipped with two-way radio and were used for fire-fighting and rescue operations.

Number of personnel on duty at the time of the accident

1 team chief
1 assistant to the team chief
2 fire-fighting sergeants
1 fire-fighting corporal
6 fire-fighting soldiers
9 fire-fighting drivers

1.14 Survival aspects

Immediately after the evacuation order was given by the pilot-in-command, the front crew door and a rear cabin emergency exit were opened and evacuation commenced. During this period the fire-fighting service of the airport arrived and, while getting the fire under control, helped the passengers to evacuate the burning aircraft.

1.15 Tests and research

The investigation team was of the opinion that laboratory tests or any other special examination of any part were not necessary.

2. - Analysis and Conclusions

2.1 Analysis

The examination of the wreckage showed that there was no malfunctioning or failure of the airframe, engines, propellers, wings and accessories prior to the accident. At the time of the accident the engines were developing power.

The aircraft hit the ground with its left main landing gear at a point 72 m before the threshold and 2.5 m below the runway surface level. The mark from the left main gear was 7.5 m long and fairly deep. The mark from the right main gear started 4 m after the commencement of the mark from the left gear and continued for 12 m.

There were four propeller slashes starting 1.5 m after the end of the left main gear marks, paralleling each other and 60 cm apart, and 3.5 m to the left of these slashes were four other propeller slashes (55 cm between the first two and 70 cm between the last two slashes).

A trace from the nose wheel started 30 m before the threshold. This was followed, 4 m further on, by the start of another trace from the right main landing gear. These traces, parallel to the centre line of the runway, continued to the threshold and became deeper.

There was also a deep cut from a propeller blade on the ILS detector box which was perpendicular to the landing gear trace. The ILS detector box is located 1.5 m after the start of the right main landing gear trace, and its height is 60 cm.

On the runway a metal trace from the nose wheel rim was seen, without interruption, from the threshold to the point where the aircraft came to rest. No other trace appeared on the runway or on the terrain.

2.2 Conclusions

Findings

The crew was properly licensed and authorized to carry out the flight.

The aircraft had a valid certificate of airworthiness. Its maintenance and inspection had been properly performed.

The weight and centre of gravity of the aircraft were within the specified limits.

No mechanical malfunctioning or abnormality of any kind had been reported during the flight up to the time of the accident.

All ground equipment and navigational aids were operating normally.

The air-ground communications recorded showed that they had been conducted normally in accordance with the regulations. Upon hearing the report of the cloud base of 1 000 ft from the British Eagle aircraft, the pilot-in-command decided to make an attempt to land.

After the first approach the aircraft overshot. Due to heavy rain, the runway lights could not be seen by the pilot-in-command and the aircraft was to the left of the runway centre line.

On the second approach, the aircraft was slightly to the left. The pilot-in-command made a correction and decided to land.

Due to the heavy rain the visibility was poor. Possibly, the pilot-in-command could not control his height; it is also possible that distortion caused by water on the windscreen gave him a feeling of being too high and he called for full flap and 20" boost. Immediately before the impact, the pilot-in-command ordered full power to prevent undershooting.

The aircraft struck the ground in a slight left bank attitude, 72 m before the runway with the left main gear.

Cause or
Probable cause(s)

The probable causes of this accident are:

(a) During the last approach, the pilot was too early in selecting full flap and reducing the power.

(b) Due to heavy rain and poor visibility, the height could not be controlled precisely.

(c) The order for full power was given too late; this created the undershoot condition.

Contributory factors

Probably the rain formed a layer of water on the windshield which refracted the light and caused the threshold to be seen nearer than it was; additionally, the rain was so heavy that the wipers, which were operating normally, could not satisfactorily wipe the windshield for clear vision.

3. - Recommendations

None were contained in the report.

ICAO Ref: AR/867

No. 16

Union des Transports Aériens, Douglas DC-6, F-BHMS, accident at "El Goterón", Trevelez (Granada), Spain, on 2 October 1964. Report dated 16 February 1965, released by the Sub-Secretariat for Civil Aviation, Spain.

1. - Investigation

1.1 History of the flight

The aircraft was flying a scheduled international passenger flight from Paris to Marseilles, Palma de Mallorca and Port-Etienne. The trip to Palma was uneventful and, following receipt of the latest meteorological information available, the aircraft took off from runway 27 for Port-Etienne at 0314 hours GMT. According to its flight plan the aircraft was to check with the following while en route: area control centres at Barcelona, Seville, Casablanca and Dakar and the control tower at Port-Etienne. At 0339 hours, it advised Palma control tower that it was over Ibiza. It reported to Barcelona FIR that it had crossed the FIR boundary at 0401 hours at flight level 100. At 0353 hours, it reported to Seville FIR that it was estimating the FIR boundary at 0401 at flight level 100 and Los Alcazares at 0415 hours. At 0420 hours, it reported having passed Los Alcazares in clear skies at 0415 hours, estimating abeam Malaga at 0500 hours, overhead Tanger at 0524, and Port-Etienne at 1020 hours. This was the last communication from the flight. Seville FIR tried subsequently, without success, to contact the aircraft. The aircraft hit a mountain at 0445 hours.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	7	73	
Non-fatal			
None			

1.3 Damage to aircraft

The aircraft was completely destroyed.

1.4 Other damage

No objects other than the aircraft were damaged.

1.5 Crew information

The pilot-in-command held an airline transport pilot's licence and a navigator's licence. He had flown a total of 10 964 hours.

No information was contained in the report concerning the other crew members on the subject flight.

1.6 Aircraft information

The aircraft had a certificate of airworthiness. It had flown a total of 29 620 hours, including 16 119 hours since its last overhaul.

The times on its four engines were as follows:

	(Hours)			
Total time flown:	24 892	11 698	18 330	19 116
Since last overhaul:	871	922	1 493	695

1.7 Meteorological information

The following are the weather conditions which existed at Granada around the time of the accident:

wind: calm
horizontal visibility: 10 to 15 km, light haze, clear skies
QNH: 1 025.2 mb
QFE: 1 017.9 mb

1.8 Aids to navigation

Navigation aids aboard the aircraft and along its route are not mentioned in the report.

1.9 Communications

Communications were normal until 0420 hours. No further message was received from the aircraft after that time.

1.10 Aerodrome and ground facilities

Not pertinent to the accident.

1.11 Flight recorders

The flight recorder was recovered and sent to Paris by the French Board of Inquiry. No further information was forthcoming.*

1.12 Wreckage

The debris were scattered over a wide area of the mountain. The aircraft, its engines and propellers were completely destroyed.

* Secretariat Note: Subsequent enquiries indicate that no information could be obtained.

1.13 Fire

No mention of fire was made in the report.

1.14 Survival aspects

No information was contained in the report.

1.15 Tests and research

No information was contained in the report.

2. - Analysis and Conclusions

2.1 Analysis

No instruments or assemblies were found on which a technical investigation could be based. Possible causes of the accident could, therefore, not be determined.

It is believed that after Los Alcazares (0415 hours), the aircraft headed for Tanger, deviating slightly from the planned route which was 25 km away from the scene of the accident and at altitudes which were within the established safety margin.

The difference between the Los Alcazares - Tanger route and the Los Alcazares - site of the accident route, exceeds 5°. Since the automatic pilot error is plus or minus 1°, the remaining 4° may have been caused by wind or some other undiscovered error.

2.2 Conclusions

Findings

The pilot-in-command held an airline transport pilot's licence and had considerable flying experience.

The aircraft had a certificate of airworthiness.

At the time of last contact with the aircraft it was flying in clear skies.

The aircraft deviated from the flight plan but flew at altitudes within the established safety margin, then struck a mountain. The reason for the deviation from the planned route could not be determined.

Cause or Probable cause(s)

The cause of the accident was not determined.

3. - Recommendations

None were contained in the report.

ICAO Ref: AR/862

No. 17

British Midland Airways Ltd., Dakota C-47, G-AGJV, accident at Derby (Burnaston) Airport, England, on 14 October 1964. Civil Accident Report No. EW/C/078, dated October 1965, released by the Ministry of Aviation, United Kingdom, C.A.P. 247.

1. - Investigation

1.1 History of the flight

The aircraft was on a non-scheduled international flight from Hamburg, Germany, to Derby, England. It took off from Hamburg at 1759 hours GMT carrying 2 crew members and 36 passengers. The estimated time of arrival at Derby was 2059 hours. The aircraft was cleared for a visual approach to runway 10 during which visibility deteriorated. The pilot-in-command lost sight of the threshold sodium lights and took overshoot action from a height of 400 to 600 ft. The pilot-in-command then informed the controller that he would make an approach tu runway 28 and requested that yellow Very lights be fired from the threshold. However, the aircraft made the approach before the ground staff was in position and this resulted in a second overshoot, the pilot-in-command estimating that he was too high to carry out a landing. The aircraft was then positioned for a longer visual approach to runway 28, but this again resulted in overshoot procedure from about 600 ft. The aircraft was again positioned for another long visual approach to runway 28. The controller advised the aircraft that the visibility was deteriorating and there were fog patches on the aerodrome.

This last approach was commenced from approximately 4 miles at a height of about 1 000 ft and was monitored in the aircraft with the Decca Navigator and the Derby NDB. When about 1.5 miles from the threshold at a height of 700-800 ft, the pilot-in-command requested Very lights because the runway lights were not visible. Three quarters of a mile from the threshold at 500-600 ft, the pilot-in-command saw Very lights and the initial third to one half of the runway lighting. He was informed by the controller that the first gooseneck flares of the runway were being obscured by fog. A turn to the right was made to align the aircraft with the runway and, with its landing lights on, it crossed the threshold in the landing configuration at a speed of about 85 kt. The pilot-in-command said that at this time about three quarters of the runway lighting was visible. Immediately after the initial touchdown the aircraft ballooned, entering radiation fog at the same time. The pilot-in-command lost visual reference and the aircraft struck the ground heavily, causing the port undercarriage leg to collapse. The aircraft then ran into a fence and a ditch on the south-west boundary of the aerodrome. The accident happened at 2121 hours GMT.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal			
Non-fatal			
None	2	36	

1.3 Damage to aircraft

The aircraft was substantially damaged.

1.4 Other damage

The aircraft ran into a fence.

1.5 Crew information

The pilot-in-command, aged 39, held a valid airline transport pilot's licence endorsed in Group 1 for Dakota C-47 aircraft. His total flying experience at the time of the accident was 8 695 hours, of which 3 700 hours were as pilot-in-command of Dakota C-47 aircraft. He had flown 291 hours in the 90 days preceding the accident.

The co-pilot, aged 29, held a valid commercial pilot's licence endorsed in Group 2 for Dakota C-47 aircraft and a current instrument rating. At the time of the accident his total flying experience amounted to 803 hours, including 545 hours as co-pilot of Dakota C-47 aircraft. He had flown 271 hours in the 90 days preceding the accident.

1.6 Aircraft information

The aircraft had a valid certificate of airworthiness. It had been maintained to an approved maintenance schedule and had a current certificate of maintenance. The aircraft had flown a total of 26 656 hours, including 63 hours since the last Check 2 inspection.

The load sheet showed 35 passengers were on board and that the aircraft was at its maximum permissible take-off weight. In fact, 36 passengers were carried and, consequently, it appears that the maximum total weight authorized for take-off was exceeded. The landing weight and centre of gravity were within the permitted limits.

Before departure from Hamburg, the fuel tanks contained 340 gallons of fuel. The type of fuel being used was not stated in the report.

1.7 Meteorological information

Before departure from Hamburg, the pilot-in-command and the co-pilot received weather briefing at the meteorological office. No landing forecast was available for Derby but the forecast for the alternate, Birmingham, gave visibility not less than 2 km in smoke haze. Weather information for Derby was obtained in flight at 2010 hours and again at approximately 2045 hours; both reports indicated:

surface wind: calm
visibility: 2 km, no cloud

The Derby area forecast issued by Birmingham meteorological office at 1420 hours for the period 1500 to 2100 hours did not indicate fog between these times, but it included an outlook until 1200 hours the following day that fog could be expected around dawn. An amendment issued at 2000 hours for the area 5 NM radius of Birmingham stated that fog patches were likely where the sky was clear and that visibility would fall to 500 m in patches by 2300 hours. This amendment was passed by telephone at 2005 hours to the Derby air traffic controller, who was also informed that fog patches might affect Derby Aerodrome if the sky cleared.

Derby Aerodrome had no meteorological office, and the meteorological facilities in use were the subject of criticism in a Meteorological Office inspector's report following a visit to the aerodrome on 17 March 1964. This report commented on the inadequacy of the meteorological observational work carried out at the aerodrome and there was no evidence that any improvement had resulted by the time of the accident. There was no system at the airport for measuring runway visual range.

According to testimony of the ground staff, who were sent to the threshold of runway 28, when they arrived, the lights of the control tower were hardly visible and the visibility along the runway was estimated to be 200 to 300 yd. At the time of the last approach, visibility had deteriorated further and the lights of the control tower were not visible anymore. The visibility was estimated to be between 30 and 100 yd.

1.8 Aids to navigation

There was an NDB at Derby.

1.9 Communications

No difficulties were mentioned in the report.

1.10 Aerodrome and ground facilities

At the time of the accident, the aerodrome was operated by British Midland Airways Ltd. It had three grass runway strips; the longest 10/28 (1 094 m) was in use on the night of the accident. The runway lighting consisted of two parallel rows of 12 gooseneck flares 150 ft apart, the interval between the flares in each row being 300 ft. A red boundary light was positioned at each end of the runway. Two sodium lights were located at the threshold of runway 10 but there were none for runway 28; there was no approach lighting serving either runway, and it had been the practice to fire Very lights from the runway threshold in conditions of poor visibility. Angle of approach indicators were not in position on the night of the accident and the aerodrome identification beacon was not in use; these two facilities, which had been unserviceable for some time, were among the necessary requirements when the aerodrome licence was issued but their unserviceability was not considered to have had any direct bearing on the accident.

The control tower was 15 ft high and situated on the north side of the aerodrome, adjacent to the edge of the airport buildings. When viewed from the control tower, runway 28 runs from left to right and its threshold was about 380 yd away. The nearest point of the runway was about 140 yd from the control tower. There were no visibility lights of known candle power for use in estimating night visibility; the lights of Willington power station, 1.2 miles south-east of the control tower were used for this purpose.

Two air traffic controllers were employed at the airport by British Midland Airways Ltd. The controller on watch at the time of the accident had commenced duty at 0630 hours; he did not possess a meteorological observer's certificate. There was no R/T recording equipment and no R/T log had been kept by the duty controller. The company ATC instructions stated that a log must be kept but added that, since safety of aircraft is of primary importance, control must not suffer as a result of log keeping.

1.11 Flight recorders

Not mentioned in the report.

1.12 Wreckage

Inspection at the scene the following morning showed the aircraft had been brought to a stop on the south-west boundary of the aerodrome. It had carried forward a wire mesh fence and stopped when the starboard wheel ran into a ditch. The port undercarriage was retracted and the wheel was resting on the bank of the ditch, thus maintaining the aircraft in a level attitude. The port propeller blades were bent backwards by striking the ground; one blade of the starboard propeller was buried in the bank. Examination of the aircraft after removal showed that the port undercarriage had collapsed due to the failure of the rear brace attachment lug. This failure had allowed the undercarriage to collapse into the wheel bay in a forward direction.

1.13 Fire

There was no fire.

1.14 Survival aspects

No information was contained in the report.

1.15 Tests and research

No information was contained in the report.

2. - Analysis and Conclusions

2.1 Analysis

The relevant company weather minima for Derby Airport were:

Runway	Aid	Critical Height	Runway Visual Range
10	NDB	600 ft	1 000 yd
10	Decca	600 ft	1 000 yd
28	Decca	650 ft	1 250 yd
Dakota Circling Minima		650 ft	2 000 yd

The following information was also extracted from the Company's operations manual:

"Under IMC where RVR is passed whilst in the holding pattern or preparatory to landing using an instrument approach, the holding pattern must not be vacated or an approach to land commenced whenever that RVR is below the Company Minima as published in this operations manual."

"At airfields where an RVR is not available, then the meteorological visibility as passed will be substituted for the RVR limits as published in this manual."

The actual weather for Derby passed to the aircraft before the initial approach indicated conditions which were above the Company's weather minima. During the first approach, the pilot-in-command lost sight of the threshold lights and the existence of shallow ground fog was noticed in the aircraft's landing light beams by the controller.

During the third approach, the pilot-in-command was informed that visibility was decreasing and, during the final approach, he was again informed of this and that there were fog patches on the aerodrome although their location was not given; the fact that they were affecting the runway in use was,however, implicit in the information that the ground staff at the runway threshold probably could not see the controller's Aldis lamp signals because of the fog patches. Although the conditions associated with radiation fog at night are very deceptive, this matter has been the subject of many warnings and much publicity and is a phenomenon well known to pilots. The information about the deterioration of visibility and the existence of fog patches given to him by the controller and his experience during the abandoned approaches to land should have alerted the pilot-in-command to the possibility that runway visibility conditions might be deceptive and cause difficulty; this should in turn have led him to consider diversion.

It is apparent from the evidence that radiation fog developed over the aerodrome, and that the horizontal visibility from the control tower by reference to Willington Power Station lights bore no relationship to that on the runway. The advantage of measuring visibility in the form of RVR on the runway when minimal conditions apply,particularly if the possibility of radiation fog developing exists, is obvious, and standardization of such a practice would help to avoid accidents like this. Attention is drawn to the report on a similar accident which occurred at Blackpool on 25 January 1963 (C.A.P. 196)*, in which a recommendation was made on the measurement of RVR in conditions of low visibility at aerodromes where public transport operations take place.

The lights displayed at Derby on the night of the accident did not meet the requirements of paragraph 124 of C.A.P. 168 - The Licensing of Aerodromes. Although the deficiency in respect of visual approach guidance is not considered to have been a direct contributory factor in the accident, it reflects adversely on the operator, since British Midland Airways Ltd. was also responsible for the operation of the aerodrome and thus had a measure of direct control over the facilities provided for its aircraft operations.

2.2 Conclusions

Findings

The pilots were properly licensed.

The aircraft was maintained in accordance with an approved maintenance schedule.

The maximum total weight authorized for take-off was exceeded, but this had no bearing on the accident.

The aircraft encountered radiation fog during landing causing the pilot to lose visual reference.

Overstressing of the rear brace attachment lug during a heavy landing on the port wheel caused the port undercarriage to collapse.

The lack of adequate visual approach guidance increased the pilot's difficulties but had no direct bearing on the cause of the accident.

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* See ICAO Circular 78-AN/66, Volume I, Aircraft Accident Digest No. 15, Summary No. 2

Runway visual range, if it had been available, would probably have indicated that conditions were below minima.

The difficulties encountered by the pilot during the abandoned approaches, and the information given to him on the existence of fog patches, should have indicated to him that it would be prudent to divert.

Cause or
Probable cause(s)

The aircraft struck the ground heavily, causing the port undercarriage to collapse, after the pilot lost visual reference during a landing in radiation fog.

3. - Recommendations

None was contained in the report.

ICAO Ref: AR/885

No. 18

Bonanza Air Lines Inc., Fairchild F-27A, N 745L, accident at Las Vegas, Nevada, USA on 15 November 1964. Civil Aeronautics Board (USA) Aircraft Accident Report, File No. 1-0066 released 19 November 1965.

1. - Investigation

1.1 History of the flight

Flight 114 was a scheduled domestic flight between Phoenix, Arizona, and Las Vegas, Nevada, with intermediate stops at Prescott and Kingman, Arizona. The flight departed Phoenix at 1920 hours Pacific Standard Time with an Instrument Flight Rules (IFR) clearance from Phoenix to Las Vegas via Victor Airway 105, at 10 000 ft. The flight did not attempt to land at Kingman and Prescott because of below minima weather and airport conditions. While en route to Las Vegas the flight requested and was cleared to climb to and cruise at 14 000 ft. At 2010 hours Los Angeles ARTCC issued a descent clearance to 10 000 ft. The flight acknowledged the clearance and reported leaving 14 000 ft.

One minute later ARTCC instructed the flight to turn left to a heading of 260°, to expect a VOR/DME-3 approach and to contact Las Vegas Approach Control on 121.1 Mc/s. This was acknowledged by the flight.

At 2012:48 hours Las Vegas Approach Control reported radar contact with the flight five miles west of Willow Beach Intersection, and passed the current Las Vegas altimeter setting.

At 2013:17 hours Las Vegas Approach Control broadcasted the following message: "All aircraft on approach control frequency copy, the zero four one two special weather observation, indefinite ceiling six hundred, sky obscured visibility five, light snow, over." Within seconds this special weather report was amended to "visibility south one mile."

At 2014:05 hours the flight was turned to a heading of 245° and at 2015:13 hours it was cleared to descend to and maintain 9 000 ft. It reported level at 9 000 ft at 2017:23 hours.

Shortly thereafter the flight was advised that the visibility had lowered to two miles in light snow and at 2018:26 hours that the visibility was now one mile in light snow.

Approximately two minutes later the flight was cleared to descend to and maintain 7 000 ft altitude.

At 2019:57 hours the flight was advised that the visibility had dropped to ½ mile and instructed to turn to 290° shortly thereafter.

At 2020:53 hours Las Vegas Approach Control broadcasted the latest weather observation: indefinite ceiling five hundred, sky obscured, visibility ½ light snow. Shortly thereafter the flight was instructed to turn right to a heading of three six zero, informed that its radar position was 18 miles south of the VORTAC and was cleared for a VOR/DME-3 approach to cross the 15 mile fix at or above seven thousand feet. The flight acknowledged these instructions as it had all previous communications from Las Vegas Tower.

At 2022:53 hours Approach Control advised the flight that another F-27 ahead of it had missed its approach.

At 2024:20 hours the flight requested the latest wind conditions. This information was not given to the flight. At 2024:55 hours a transmission "Flight one fourteen" ended abruptly as did the sound of the transmitter carrier wave. This was the last communication from the flight. Radar contact was lost at 2025:05 hours following an advisory from approach control that the flight was passing the 10 mile fix.

It was subsequently found that the aircraft had crashed 9.7 nautical miles from the Las Vegas VORTAC on the 196° radial. The wreckage, confined to an area approximately 1 200 ft long and 300 ft wide, was found on the southern slope of a 3 602 ft rise at elevations from 3 575 ft up to the crest. Some portions of the wreckage sprayed over the crest and came to rest on the northern slope at an elevation of 3 570 ft.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	3	26	
Non-fatal			
None			

1.3 Damage to aircraft

The aircraft was destroyed on impact.

1.4 Other damage

There was no damage to other property.

1.5 Crew information

The pilot-in-command, aged 41, held an airline transport pilot certificate with aeroplane single and multi-engine land, instrument and F-27 ratings. He also held a valid flight instructor's certificate. In each of the six-month proficiency checks from 1961 to the last check on 8 August 1964, he was graded average to above average. He had passed a line check on 22-25 December 1963, and was scheduled for a recurrent check before 30 November 1964. Company records indicated that he had recurrent training on 8 April

1964, 4 June 1964, 3 September 1964, and 4 November 1964. The airline Operations Training Manual provided, among other things, that each type rated pilot will have a minimum of three hours' practice and necessary instructions in the synthetic trainer at each six-month check period. VOR approaches were conducted in the course of practice in the synthetic trainer but the trainer was not equipped for DME training. On 8 July 1964, during a six-month flight proficiency check, a VOR/DME-1 approach to Las Vegas was accomplished satisfactorily by the pilot-in-command. This was the only check were a VOR/DME approach was listed.

His last physical examination for a first-class medical certificate was completed on 28 September 1964. There were no limitations. He had flown a total of 11 072:49 hours, including 4 057:23 hours in F-27 aircraft. In the past 90 days he had flown 239:45 hours of which 9 hours were instrument time. In the past 30 days he had flown 63:41 hours of which 3:15 hours were instrument time. On the day of the accident he had accumulated 4 hours and 38 minutes flight time and 8 hours duty time.

The co-pilot, aged 26, held a commercial pilot certificate with aeroplane single and multi-engine land and instrument ratings. He also held a flight instructor's certificate. Company records relating to transition and instrument checks, pilot evaluation reports, and co-pilot surveys consistently rated him as above average in flying ability. Grades on VOR procedures were listed as average. A 6-month check given him on 15 June 1964, which included a DME check, listed his performance as "average." His last physical examination for a first-class medical certificate was administered on 22 August 1964. There were no waivers. He had accumulated a total of 3249:41 hours of flying time, of which 811:41 hours were in F-27 aircraft. His total flight time for 15 November 1964 was 4 hours and 38 minutes while his on-duty time was 8 hours 1 minute at the time of the accident.

Operations personnel who witnessed the departure of the flight from Phoenix indicated that the pilot-in-command was occupying the left seat and the co-pilot the right seat as the aircraft departed.

There was also a stewardess aboard the aircraft.

1.6 Aircraft information

Maintenance records revealed that the aircraft was properly inspected and maintained in accordance with existing FAA specifications and airline procedures. It had been released as airworthy on the day of the accident. There was no maintenance required on the aircraft prior to the flight and no discrepancies were reported during the flight.

The gross weight at take-off, 35 909 lb, was well under the authorized maximum of 39 400 lb, and the centre of gravity (c.g.) was within allowable limits.

The aircraft was being operated on MIL-J-5624F kerosene fuel.

1.7 Meteorological information

The U.S. Weather Bureau forecast indicated low clouds, snow and light icing conditions in the Las Vegas area for the period during which the flight would be on approach. Pilot reports from aircraft in the area near the time of the accident reflected instrument conditions below 13 000 ft, light to moderate icing, light to moderate turbulence and snow. Weather observations made at Las Vegas near the time of the accident reflected low ceilings, visibility ½ mile in moderate snow. Weather information provided to the flight crew at Phoenix included the prognosis of the regional forecast, but the pertinent area forecast and SIGMET advisories were omitted. However, Las Vegas Approach Control informed the flight of each significant change in terminal weather conditions.

The accident occurred at night during a snow storm.

1.8 Aids to navigation

Primary navigation on an instrument approach to Las Vegas was effected by the use of the Las Vegas VORTAC, with DME providing distance from the station. Surveillance radar advisories on azimuth and distance served as a double check on the primary system. The DME monitor panel at Las Vegas was located in the Flight Service Station (FSS) approximately one mile from the operating position of the Las Vegas approach controller. Because of this and the lack of repeater alarm in the tower, the Las Vegas tower controller could only assume that the primary navigational device was functioning, unless advised otherwise by the the FSS or aircraft using the system. At 2029 hours another flight reported that it had lost the Las Vegas DME, and at 2035 hours a second one reported that it was not receiving distance information. These reports were relayed to the FSS. After a check was made, the system was declared to be malfunctioning at 2035 hours, i.e. 10 minutes after the time of the accident. A period of time of unknown duration elapsed before the tower had knowledge that the primary navigational device had malfunctioned.

1.9 Communications

At 2024:20 Flight 114 transmitted the following message: "And one fourteen request the latest wind." This request was made at the same time that the Las Vegas approach controller and the local controller were co-ordinating with each other by interphone. Consequently there was no response to the request at that time.

At 2024:55 Flight 114 transmitted the following message: "(unintelligible) flight one fourteen is." The transmission then ended abruptly.

The Las Vegas approach controller at 2025:05 advised Flight 114 as follows: "Bonanza fourteen passing the one zero mile fix remain on frequency." There was no acknowledgement. Radar contact was lost following the issuance of this advisory.

1.10 Aerodrome and ground facilities

Elevation of McCarran airport is 2 171 ft.

1.11 Flight recorder

A Fairchild flight recorder was installed in the aircraft. The static ports for the flight recorder, altitude and airspeed instruments were located on the same panel. The recorder tape was recovered intact. Readout indicated compatibility with the clearances and instructions to the 15 mile DME fix. At approximately the 15 mile DME fix, the flight commenced a descent from approximately 7 000 ft AMSL which continued with no indication of level-off except for a few seconds at 3 700 ft AMSL. After this momentary level-off, the aircraft continued its descent until it crashed at approximately 3 575 ft AMSL. (See figure 18-1).

1.12 Wreckage

The initial impact occurred on a rocky ledge at an elevation of 3 575 ft. Both main gears were in the extended position and were torn from the aircraft. The fuselage bottom anti-collision light assembly struck a ledge at an elevation of 3 578 ft and was followed immediately by impact of the lower fuselage and propellers. The first propeller impact marks found at an elevation of 3 580 ft indicated that the aircraft was in a near level attitude on a magnetic heading of 20°.

1.13 Fire

There was no major fire on impact nor was there any evidence of fire in flight.

1.14 Survival aspects

The wreckage of the aircraft was not located until dawn on the morning of 16 November 1964. Structural deformation and disintegration throughout the occupiable areas of the fuselage precluded the survival of any occupant. Anatomical examination revealed that a majority of passengers had sustained skull fractures. During and following the principal impact all 20 double passenger seats were torn from their respective attachments and thrown free of the wreckage. Attachment failures occurred equally from leg shearing at the weld points on the seat frames, seat legs to floor attach fitting failures, and floor attach fittings pulling through the honeycomb type cabin flooring.

1.15 Tests and research

No special tests or research were required.

1.16 VOR/DME approach chart

In accomplishing a DME-3 approach to Las Vegas the crew would have referred to a Jeppesen approach chart (see figure 18-2) which was used by the airline. The upper portion of the chart - the plan view - listed a series of fixes at 15, 10, 6 and 3 miles and the minimum altitudes between these fixes. The minimum altitude limitations were portrayed as 6 000 ft between the 15 and 10 mile DME fix, 4 300 ft between the 10 and 6 mile fix, and 3 100 ft between the 6 and 3 mile fix.

A profile view displayed on the lower half of the chart depicted the last 3 miles of the approach as a level altitude of 3 100 ft into the 3 mile fix then a descent to 2 800 ft to the 2 mile fix, and finally a descent to authorized minimum altitude at the airport. The 3 100 ft depicted on the profile view of the chart was indicated by numbers which were approximately twice the size of the numbers shown on the plan view.

2. - Analysis and Conclusions

2.1 Analysis

After passing the 15 mile DME fix the aircraft commenced a normal descent which continued until it struck high terrain at an altitude of approximately 3 600 ft AMSL. From a detailed examination of the wreckage, it was determined that the aircraft's powerplant, controls, and systems were operating normally prior to initial impact. No evidence of incapacitation of the crew was found.

Because of the forecast for icing conditions, the possibility of ice accumulation on the static port panels and consequential erroneous altitude and airspeed information was considered. Since the flight recorder static port was located on the same panel as the altitude and airspeed ports, ice accumulation on one and not the other would be highly improbable. Therefore, as there was no evidence of ice accumulation reflected in the readout of the flight recorder tape, it was believed that ice was not a factor. This was substantially confirmed by the readout of the flight recorder tape which showed a high degree of compatibility with the configuration and flight regime of the flight during its approach up to the point of impact. Additionally, another flight immediately ahead did not experience any icing.

The possibility that the flight received erroneous DME indications was also considered. A correlation of the flight recorder data and the communication tapes showed that the flight had just passed the 15 mile DME fix when it reported leaving 7 000 ft. This would indicate the reception of current DME information at the time. Supporting this conclusion, the mileage indicators of the DME module were recovered from the wreckage and were found seized at 9.60 and 9.65 NM, from impact damage; this corresponded to the distance from the crash site to the Las Vegas VORTAC, which was measured as being approximately 9.7 NM. Furthermore, other aircraft using the navigational facilities at that time did not report any discrepancies prior to the time of the accident. This supported the fact that the DME was operating at the time.

Based on the available evidence, there appeared to be two possibilities for explaining why the flight went below the minimum safe altitude. One would be that the descent of Flight 114 below 6 000 ft was unintentional. This would suppose that:

(1) The crew was aware of the 6 000 ft minimum altitude between the 15 and 10 mile fixes and intended to level off upon reaching it;

(2) Their attention was diverted from altitude consideration for a period of two minutes or more after initiating the descent; and

(3) Neither pilot paid any attention to the altimeters.

Since a rate of descent of 1 500 fpm was common in the airline operation of the F-27, it was unlikely that both pilots would have ignored altimeter indications for a period of two minutes when it would have been their intention to level off in approximately 30 seconds after starting the descent. There was no evidence of any distraction, and the contact with approach control at 2024:20 hours appeared completely routine. The flight recorder showed rather precise prior compliance with altitude requirements throughout the flight. The records of both pilots with respect to Company checks, FAA en-route inspections, and previous employment records argued against the probability that both pilots would have ignored the descent for so long a period at this stage of the approach if their intention had been to level off at 6 000 ft.

Therefore, the Board did not accept the conclusion that the descent of the flight to 3 600 ft was unintentional.

Evidences indicated that the descent below the 6 000 ft level at some 3 miles and two minutes prior to reaching the 10 mile fix was intentional. This was substantiated by the very uniform, continuous and normal descent shown by the flight recorder and the crew's apparent lack of concern for anything but the wind conditions that they could expect on landing, at a time when they were already nearly 2 000 ft below the prescribed minimum altitude for their position. It was highly unlikely that both pilots would have descended some 2 400 ft below the minimum altitude in mountainous terrain if they had been aware of the altitude limitations imposed. On the contrary, if they were unaware of the 6 000 ft minimum to the 10 mile fix and the subsequent altitude limitation of 4 300 ft until passing the 6 mile fix, a descent to some lower altitude, which they believed to be safe, could be expected. Such a descent was indicated by the flight recorder down to about 3 750 ft, at which time a level-off was shown for a period of approximately 8 to 12 seconds before the descent was again continued. Based upon previous altitude indicators, the altitude indication in the cockpit would have been 150 feet higher than shown by the recorder; i.e., the altimeter would have read 3 900 ft. This would be consistent with an intended descent to some predetermined altitude less than 4 000 ft, and a break in the rate of descent in anticipation of reaching the preselected altitude. This could have been brought about by a misinterpretation of the instrument approach chart. In considering this possibility, the following interrelated and contributory factors were examined:

(1) The VOR/DME-3 procedure which became effective on 3 October 1964 was relatively new. Weather conditions at Las Vegas between the effective date of this procedure and the date of the accident were such that instrument approaches had not been necessary. Accordingly, the night of the accident was the first occasion for the crew to use this new instrument approach procedure.

(2) The airline's link trainer was not set up to give DME practice and the only training on DME approaches was received during proficiency checks. The records of the crew for the three years preceding the accident revealed the execution of several VOR, ADF and ILS approach procedures. However, the check in July 1964 was the only one during which a DME approach was executed. This was due to the fact that the airline barely met the deadline of 31 December 1963 for the installation of DME equipment in turbo-prop aircraft.

(3) The profile section of approach chart displayed no information for the segment of the approach between the 15 mile fix and the 6 mile fix, and a solid horizontal line between the 6 mile fix and the 3 mile fix, with an altitude of 3 100 ft. Further, the solid line was defined in the Chart Legend as "Flight Path," which implied that a descent to 3 100 ft was proper once the fix to which the flight has been cleared is reached.

With the exception of the DME approaches at Las Vegas, all approach charts used by the airline for all terminals it was regularly serving showed critical descent information in the profile section of the chart. Pilots conducting a DME approach at Las Vegas were therefore required to use a chart which, while similar in appearance, displayed critical descent information in a manner entirely different from all the other charts used for all other approaches (including those for conventional VOR approaches at Las Vegas).

(4) Prior to the transfer of control from Las Vegas Centre to Las Vegas Approach Control, the flight had been advised to expect a VOR/DME-2 approach. However, at about 2012 hours, the flight was advised to expect a VOR/DME-3 approach. The crew had approximately 9 minutes to study the VOR/DME-3 approach chart prior to starting the actual approach. During this 9 minutes the flight was given 7 instructions relating to changes in heading or altitude, and was in contact with the tower on 16 occasions for this and other information relating to its approach, its airspeed on final, and the rapidly deteriorating weather conditions. During this same period the crew would also have been accomplishing the pre-landing check.

The flight recorder readout showed that from the time the flight was turned over to Las Vegas Approach Control at about 2012 hours until 2018 hours the aircraft was encountering light turbulence. Since the aircraft was not equipped with an autopilot, it would have been necessary for one crew member to devote practically his entire attention to flying the aircraft. In view of this, it was concluded that there was little uninterrupted time in which the pilot-in-command could familiarize himself with the approach procedure details.

2.2 Conclusions

Findings

The flight was properly dispatched.

The crew was properly certificated and no evidence was found of incapacitation.

The aircraft's powerplants, airframe controls, and systems were operating normally prior to impact.

No icing problem was encountered and all navigational instruments, both ground and air, were operating normally.

The descent below prescribed minimum altitude was intentional. The crew were not cognizant of the limiting altitudes specified for a DME-3 approach and were therefore not aware of a premature descent.

The VOR/DME approach charts for Las Vegas portray the descent information in a manner different from all other approach charts used by Bonanza Air Lines, which could have led to misinterpretation if the charts were consulted superficially.

Cause or Probable cause(s)

The probable cause of this accident was the misinterpretation of the approach chart by the pilot-in-command which resulted in a premature descent below obstructing terrain.

3. - Recommendations

On 25 November 1964, the Civil Aeronautics Board by letter to the Federal Aviation Agency recommended "That the depiction of altitude restriction on the plan view of the approach plates be included on the extended profile of such plates in order to more clearly identify critical height above the terrain."

The Federal Aviation Agency replied on 16 December 1964, and its letter pointed out that the profile and the plan view sections of the approach plate are to be read together and that a pilot should not execute an approach by an independent reference to either view.

The letter also indicated that the FAA had a standing committee on charting and an invitation was extended to the Civil Aeronautics Board to have a representative sit with this committee. The Civil Aeronautics Board accepted the invitation and was represented at several meetings of the Subcommittee on Instrument Approach Charts of the FAA Flight Information Advisory Committee. A unanimous recommendation of the subcommittee was to extend the approach track in the profile to at least ten miles. The work of the Committee is continuing.

ICAO Ref: AR/879

ACCIDENT TO FAIRCHILD F-27A, N 745L, OF BONANZA AIRLINES, INC., AT LAS VEGAS, U.S.A.
15 NOVEMBER 1964

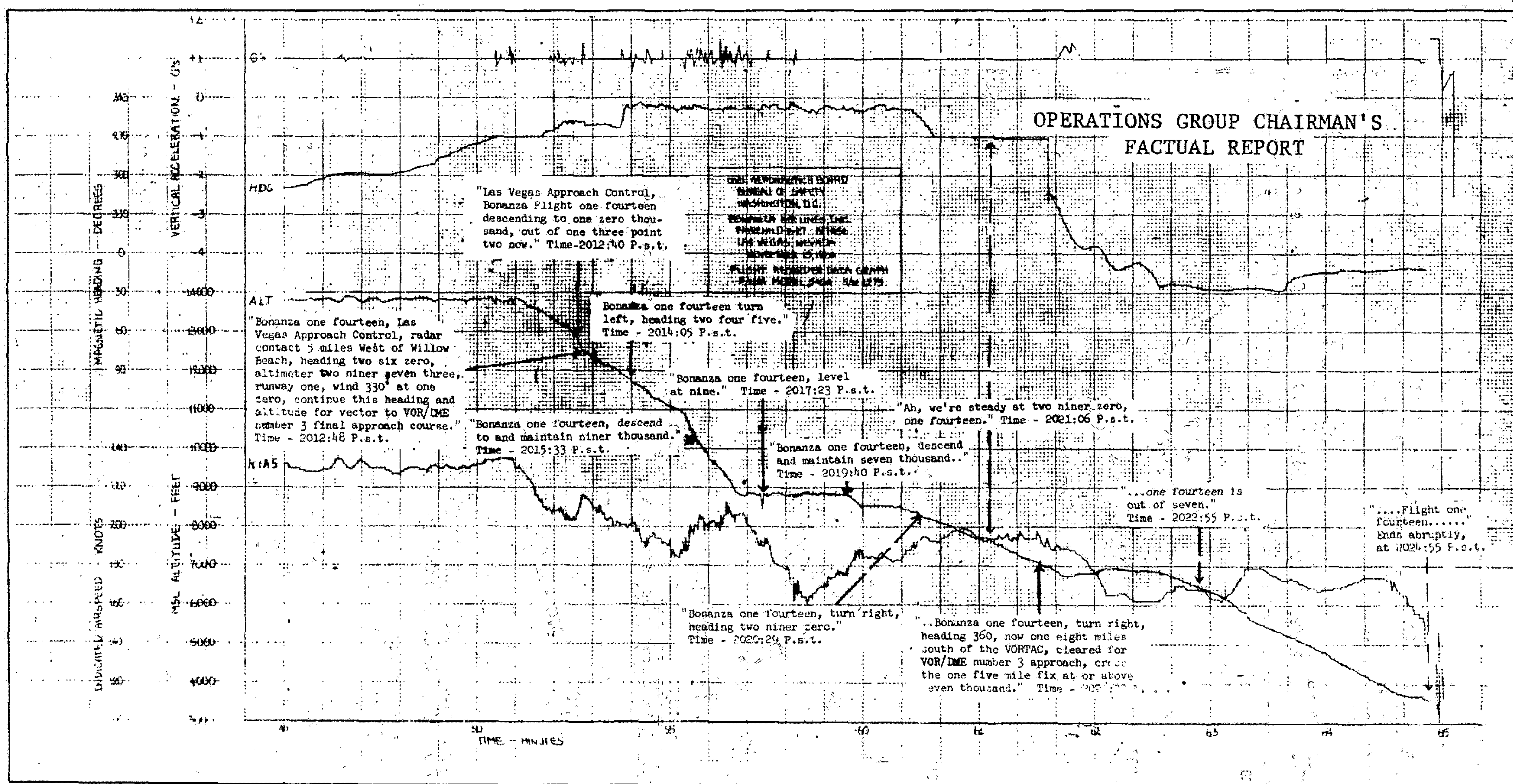

FIGURE 18-1

ACCIDENT TO FAIRCHILD F-27A, N 745L, OF BONANZA AIRLINES, INC., AT LAS VEGAS, U.S.A. 15 NOVEMBER 1964

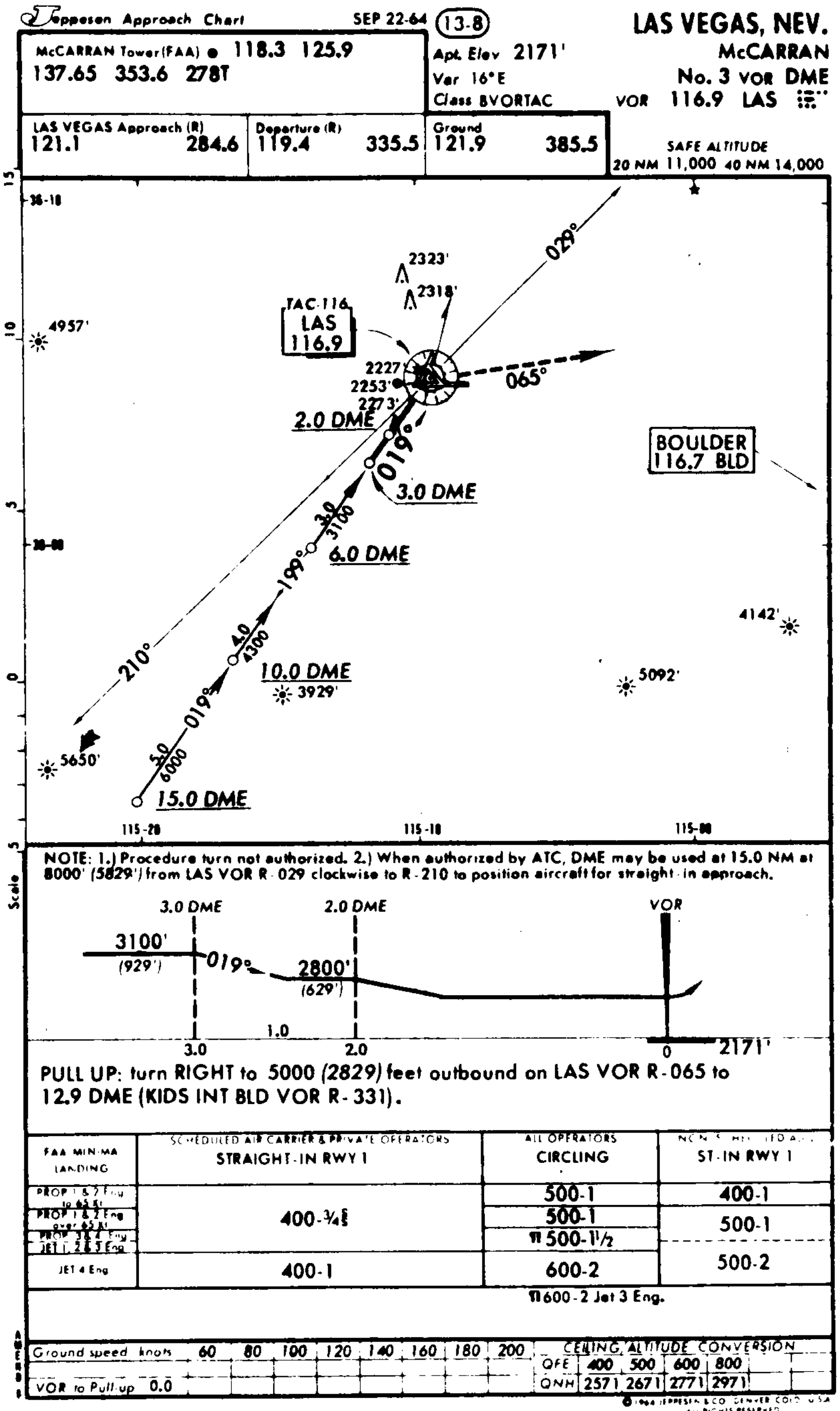

FIGURE 18-2

No. 19

Trans World Airlines Inc., Boeing 707-331, N 769TW, accident at Leonardo da Vinci Airport, Fiumicino, Rome, Italy, on 23 November 1964. Report dated January 1966. released by the Ministry of Transport and Civil Aviation, Rome, Italy.

1. - Investigation

1.1 History of the flight

Flight 800 was a scheduled international flight from Rome, Italy to Athens, Greece. It departed the parking area at 1300 hours GMT with the co-pilot at the controls and the take-off run on runway 25 started at 1307 hours. The aircraft had reached a speed above 80 kt when the pilot-in-command noticed that the No. 4 engine pressure ratio gauge was reading 1 (zero thrust) and, immediately thereafter, the amber light indicating thrust reversal of No. 2 engine came on. Since the speed was still below V_1 for the weights and runway conditions, he decided to abort take-off and took over the controls to carry out the required manoeuvre. The tower was advised of this decision when the aircraft had reached a point 800 to 900 m after the threshold. The aircraft started to decelerate but at a much slower rate than expected, and at the same time veered strongly to the right with the result that the right landing gear was grazing the runway edge. Reverse thrust on the two right engines was reduced in an attempt to bring the aircraft back to the centre line. The aircraft continued travelling beyond the declared runway limit and struck with No. 4 engine a pavement roller which was being used for maintenance work on taxiway 16/34 in an authorized area. After travelling a further 260 m, the aircraft came to a stop with fire on board. After a series of explosions, it was engulfed in flames and completely destroyed. The accident occurred at 1309 hours GMT.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	5	44	
Non-fatal	5	15	
None	1	3	

1.3 Damage to aircraft

The aircraft was completely destroyed.

1.4 Other damage

There was no other damage.

1.5 Crew information

The pilot-in-command, aged 44, held a pilot's licence for commercial single and multi-engined land and sea planes and ratings for several types of aircraft including the Boeing 707. He had been a pilot-in-command of jet aircraft since May 1960. His last emergency procedure practice was on 16 October 1964 and his last in-flight check was on 14 October 1964. He had flown a total of 17 408 hours including 2 617 hours on the Boeing 707, of which 132 hours were flown within the last 90 days. He had not been involved in any previous accidents.

The co-pilot, aged 46 years, held a pilot's licence for commercial multi-engined land planes. His last emergency procedure practice was on 13 March 1964 and his last in-flight check was on 11 March 1964. He also had several ratings including one for the Boeing 707. He had flown a total of 17 419 hours including 1 269 hours on the Boeing 707, of which 108 hours were flown within the last 90 days. He had not been involved in any previous accidents.

The second officer, aged 41 years, also held a licence for commercial multi-engined aircraft with various ratings including the Boeing 707. He had flown a total of 9 928 hours including 1 920 hours on the Boeing 707, of which 43 hours were flown within the last 90 days.

The engineer, aged 47 years, held a flight engineer's licence for multi-engined aircraft including jets, and a rating for the Boeing 707. He had flown a total of 14 231 hours, including 1 308 hours on the Boeing 707.

All flight crew members had their last medical examination in the last six months and were medically fit with no restrictions.

The cabin crew consisted of a steward and 5 hostesses; nearly all of them had their last emergency procedures training and practice in 1963.

One extra crew member was on board.

1.6 Aircraft information

The aircraft had a valid certificate of airworthiness. All periodic checks and overhauls had been effected at the prescribed periods.

On 20 July 1964, the Kollsman EPR transducer No. 2166 was taken off from another aircraft because of a sudden falling of the reading to 1 (zero thrust). It was overhauled, checked and installed on No. 4 engine of the subject aircraft on 7 August 1964. No malfunction was reported.

The weight and centre of gravity were within permissible limits.

The aircraft carried a total of 61 500 lb of JP 4 fuel.

1.7 Meteorological information

Just after the accident a special weather report was issued at Fiumicino. The weather conditions had no bearing on this accident. The surface wind was calm (230°/3 kt), and the average visibility was good (14 km) although slightly hazy.

1.8 Aids to navigation

Not relevant to the accident.

1.9 Communications

In accordance with current procedures, the aircraft had maintained continuous radiotelephony contact with the Fiumicino tower during taxiing and for take-off clearance. All communications were conducted in the English language and in the prescribed phraseology both by the flight crew and by the tower controllers. The VHF equipment of the aircraft operated normally up to the time of the accident.

1.10 Aerodrome and ground facilities

Runway 16/34 was usable over its entire length but taxiway 16/34 was not usable because of construction work (see Figure 19-1).

The length of runway 25 from which the aircraft took off was reduced from 2 220 to 2 000 m because the threshold of runway 07 had been displaced to ensure normal traffic on the runway during resurfacing in the work area.

Class I NOTAM No. 1699 was issued on 21 September 1964, giving notice of the reduction in length of runway 25 for a period of 60 days as from 23 September 1964; a subsequent NOTAM No. 2138, issued on 20 November 1964, advised that this period had been extended a further 15 days.

At the time of the accident, a power roller was located on taxiway 16/34, 301 m beyond the declared limit of runway 25 and 46 m north of the centre line of runway 25. It was moving northward and its height above the ground was 2.65 m, which was below the 1/50 gradient of the take-off climb surface specified in the ICAO Standards in Annex 14. Another piece of construction equipment, smaller in height (2.36 m), was also on taxiway 16/34, moving northward, at approximately the same distance beyond the declared limit of runway 25. This piece of equipment was also below the take-off surface.

The surface of the runway was dry.

1.11 Flight recorders

The aircraft was equipped with a Lockheed flight recorder. The recorder was sent to the Civil Aeronautics Board in Washington for graphic and numerical transcription of the data recorded. The Boeing Company also issued a document concerning the study of transcribed data from this flight recorder.

1.12 Wreckage

The aircraft came to a stop at the intersection of runways 7/25 and 16/34, near the extension of the north edge of runway 7/25, on a heading of 250° and with the engines in line with the centre line of runway 16/34.

The main part, consisting of the fuselage, wings, tail assembly, engine nacelles, landing gear etc., was lying at the 2 250 m point (extension of runway 25).

Upon coming to a stop, the aircraft was resting on its landing gear and was still practically intact, except for the left nose wheel which had come off approximately 50 m before the stopping point, and No. 4 engine and nacelle, which were damaged by impact with the roller.

Immediately after the stop, fire and subsequent explosions destroyed and burnt the centre part of the fuselage and the wings. Following the explosion of No. 3 fuel tank and of the centre tank, several fragments of these tanks were projected into the surrounding area, and the wings and fuselage subsided on the runway pavement after collapse of the landing gear; the forward part of the fuselage dropped and rotated to the left, the centre part of the fuselage, i.e. the passenger cabin, was completely destroyed. The aft section of the fuselage, with the tail assembly structure, was considerably fire damged, particularly on the right side, but remained upright.

1.13 Fire

When the aircraft hit the power roller, fuel leaked from the vent scoop of the right wing tip and the ruptured fuel feed pipes to No. 4 engine. These leaks started the fire and a series of explosions followed. The fire then engulfed the aircraft and destroyed it.

A considerable amount of fire-fighting equipment was sent to the scene of the accident, viz:

> 3 water foam vehicles, 2 water tank trucks, 3 fire trucks, 1 dry chemical truck, 1 trailer truck, 1 rescue vehicle, 1 truck, 7 complete protective suits, 16 asbestos sheets and 6 rescue ropes.

Also, the following equipment was dispatched from Rome and vicinity:

> 8 vehicles, 1 travelling crane, 1 fire-ladder vehicle, 1 jeep, 1 radio car and 1 truck.

Fifty-three airport firemen and forty-nine firemen from Rome and vicinity took part in fighting the fire.

The airport fire-fighting squad was alerted by the tower within seconds after the aircraft came to a stop and reached the scene of the accident approximately 3:45 minutes later. The rest of the fire equipment arrived 1 minute later. Within three minutes, the fire was brought under control; after 20 minutes, the fire was practically extinguished.

For the next three hours, firemen continued to douse the aircraft with water spray in order to cool the wreckage.

The rapid intervention of the fire-fighting services permitted removal of the survivors that were in the fire area, and prevented the flames from spreading to other unexploded tanks, from which 14 400 litres of fuel were subsequently removed.

1.14 Survival aspects

The explosion of some of the fuel tanks, the most violent occurring about 20 seconds after the aircraft came to rest, and the very rapid propagation of the violent fire resulted in practically instant death to the passengers who remained in the aircraft or on the ground near it.

On the basis of statements by survivors and by other witnesses on the ground, it was established that the passengers made use of all regular and emergency exists on the left side of the aircraft, and of the cockpit exit and the forward and aft service doors on the right side as follows:

left side		right side	
crew cockpit exit	2	crew cockpit exit	1
forward exit	13	forward exit	4
emergency exit to the wing	9	emergency exit on to the wing	-
aft door exit	11	aft door exit	4

Some passengers used the escape ropes, but it did not appear that the chutes were used. The left forward door chute was destroyed by the explosion while it was being placed in position. The left aft door chute was removed from its container but could not be placed in position because of the smoke and fire.

1.15 Tests and research

Investigations, tests and analyses of the engines, parts of the landing gear and other components of the airframe and systems were conducted at Fiumicino Airport, at the Laboratories of the Military Aviation in Rome, of Alitalia at Fiumicino, of Alfa Romeo at Naples and at the FAA, TWA and Boeing Centres in the U.S.A.

It was determined that all four engines were operating until the time they were shut off by the pilot-in-command. However, evidence revealed that the following discrepancies existed in the thrust reversing system of No. 2 engine before the explosions:

- detachment of the compressed air hose of the pneumatic system for No. 2 engine reverser, through loosening of the B nut connexion to the shuttle valve.

- incorrect calibration of the microswitch in No. 2 reverse thrust gauge circuit, with travel four times less than the prescribed value.

The rules for baulked take-off on the Boeing 707/331 are based on the assumption that the pilot's reaction time (elapsing between awareness of malfunction and completion of prescribed manoeuvres) has a total value of 3.44 seconds, divided into 2 seconds of reaction time and 1.44 seconds for completion of the manoeuvre by means of the controls. This supposes that the take-off is initiated and aborted by the pilot-in-command, whereas in the present case take-off was initiated by the co-pilot but aborted by the pilot-in-command.

Since a time lapse of 3.44 seconds was considered insufficient in such circumstances, a number of tests were conducted on one of the Boeing 707/331 simulators installed at the TWA training centre at Kansas City, U.S.A., with the participation of a qualified member of the Board of Inquiry.

The results led to the conclusion that, while the reaction time in the specification is adequate in the case of take-off initiated and aborted by the pilot-in-command, it is insufficient when operations are initiated by the co-pilot and aborted by the pilot-in-command.

It was found that the average time, counted from the appearance of the amber reverse thrust warning light, for intervention by the pilot-in-command and completion of the manoeuvre (excluding application of reverse thrust) was about 5 seconds.

In the speed range from 80 to 124 kt, the flight recorder shows an average acceleration value of approximately 5 kt per second, so the speed increase in the 5 seconds preceding the peak of 131 kt had amounted to about 25 kt (not counting delayed engine response).

The speed at the time of the decision to abort can therefore reasonably be construed as about 106 kt (131 - 25).

The point at which tower personnel observed the aircraft at the moment when the decision to abort was communicated, when compared with the speed-distance chart drawn from flight recorder data, approximately confirms the order of magnitude of the speed as computed by the Board.

2. - Analysis and Conclusions

2.1 Analysis

The take-off was started by the co-pilot while the pilot-in-command used his left hand on the nose steering at the lower speeds. During the first phase of the take-off run, the pilot-in-command handled the EPR (engine pressure ratio) fine trim controls. On reaching 80 kt, the co-pilot took over the nose steering control from the pilot-in-command as prescribed in the airline's B-707 operations manual.

A few seconds after passing 80 kt, the pilot-in-command observed that the EPR reading (for No. 4 engine) was almost on the figure 1 (zero thrust).

The pilot-in-command's direct reading of No. 4 instruments, the lack of any feeling of decrease in acceleration or of yawing moment, the acceleration recording, and the technical examination of No. 4 engine all lead to the conclusion that the engine was operating normally.

Technical examination of the retrieved parts of No. 4 EPR system failed to establish the cause of malfunction.

While the pilot-in-command was checking No. 4 instruments, the amber warning light for No. 2 reverse thrust went on (these lights are designed to appear when the reverse thrust clamshell doors leave the "stowed position").

The transcribed flight recorder data showed steady acceleration and constant heading even after the warning light went on, and it was concluded that, whatever the cause of the lighting (wrong setting of microswitch, probable slight movement of clamshell doors due to pressure loss in the system etc.), the take-off thrust of No. 2 engine was largely unimpaired.

The pilot-in-command, after a quick check of the positions of the controls and faced with indications of malfunction of two engines, decided to abort take-off, a decision which was in accordance with operational procedures and was professionally correct.

The pilot-in-command later stated that he could not tell the indicated airspeed at which he took that decision because he was busy checking the engine instruments at the time. He considered, however, that this speed was between the 80 kt mentioned above and 124 kt corresponding to computed V_1; he suggested an estimated value of about 100 kt. As indicated in paragraph 1.15 above, the speed reached by the aircraft when the decision to abort the take-off was taken was computed to have been in the order of 106 kt.

The sequence of actions for discontinuing take-off was reconstructed on the basis of the pilot-in-command's statements and other testimony. Power reduction, brake application, raising of spoilers and application of reverse thrust were completed in accordance with the operations manual procedures and were adequate for aborting take-off at a speed well below V_1.

The time-distance speed charts transcribed from the recorder showed that the time taken to decelerate from 131 to 123 kt was about 9 seconds, which is considerably more than the specified time for the same deceleration. This could be explained by adding the times required to complete abort procedures, which were initially conducted without haste, to reverse the thrust (about 2.5 seconds) and to expect the increased reverse rpm of the engines with the resulting braking effect.

However, when that effect should have been felt, the deceleration did not increase and the aircraft started to yaw to the right.

The probable causes of this could have been of an aerodynamic or mechanical nature, since weather and ground conditions were excluded (3 kt wind at ground level and dry runway).

The rudder could not have spontaneously assumed an abnormal position. This was confirmed by the fact that the pilot-in-command did not mention any anomaly and that the post-crash tests revealed that the rudder hydraulic control was operating. Furthermore, if it had occurred, it would not explain the lack of deceleration after the application of reverse thrust.

Involuntary differential use of the brakes or malfunction of the brake system on the right landing gear were rejected. The well-marked tracks on the ground indicated pronounced and continuous application of left brakes whereas there were but few traces of braking on the right, thus giving proof of action to correct the yaw to the right.

Furthermore, technical examination of the parts retrieved showed that the rotating brake discs were entire, with no trace of seizing.

The persistence of the yawing effect and the simultaneous and persistently slow deceleration, led to the assumption of an asymmetry in the reversed thrusts.

The pilot-in-command declared that the reversing manoeuvre was normal and differences in the setting of the reverse controls would have only produced a slight asymmetry of thrust, resulting in a slight yaw with a deceleration almost normal.

Only an asymmetry due to malfunction of the actuating system of the clamshell doors of one of the two left engines producing forward thrust can explain both the amplitude of the yaw and the lack of deceleration.

The reverse thrust system is so designed as to exclude the possibility of an increase in rpm beyond a certain limit if the reverse controls have not been set beyond a safety position called interlock position, and full reverse occurs only if the clamshell doors are almost completely closed, so as to guarantee that the thrust will in any case be reversed; however, three cases have been recorded of technical difficulties in passing the interlock position, with resulting forward thrust.

The technical examination of the left engines revealed that the B nut that should have joined the shuttle valve to the ducts of the cylinders actuating the clamshell doors of No. 2 engine had completely separated, thus causing a total loss of pneumatic pressure in the system. As a result, No. 2 engine was developing forward thrust. In computing that thrust, the following facts were taken into account:

- the pilot-in-command reported exceptional steering difficulty due to the strong and persistent drift to the right;

- difficulties were also noted by the navigator and the flight dispatcher;

- the tracks on the runway indicated an intense asymmetrical braking action applied almost solely to the left landing gear, as well as violent corrective action applied to the nose wheels;

- the tracks of the latter showed that their vertical axis was almost constantly oriented to the left in relation to the direction of motion;

- the resulting persistent stresses caused structural failures sufficient to cause break-off of the left nose wheel, which was found about 50 m behind the point where the aircraft came to a stop;

- application of reverse thrust together with the pronounced use of the brakes (even though asymmetrical and therefore partial) should have stopped the aircraft within the declared runway limit;

- the 550 m travelled by the aircraft beyond the declared runway limit is consistent with a considerable forward force counteracted only by a partial braking action;

- the pilot-in-command stated that he had correctly switched the controls beyond the interlock position and applied full reverse thrust.

The series of computations made both in Italy and in the United States by different methods failed to establish exactly the amount of forward thrust, owing to the many variables involved. However, on the basis of the above factors, and in view of the pilot-in-command's long flying experience, it seems likely that the forward thrust developed by No. 2 engine was probably close to maximum. This would explain the exceptional efforts required of the pilot-in-command in taking corrective actions which, however, were not sufficient to avoid impact of No. 4 engine with the power roller located 301 m after the displaced end of runway 25.

At impact, the fuel feed pipes to No. 4 engine were ruptured near the high pressure pumping and fuel flow regulating system, and the electric generator of No. 4 engine was torn off. The booster pump being in operation, the fuel escaped at a rate which was estimated to be of about 30 gal/min and ignited. The generator selector switch on the engineer's panel being set on position 4, as prescribed in the operations manual, the power was cut off from the emergency bar supplying energy to the fire warning system, when No. 4 generator separated. As a result, the fire warning system became inoperative and precluded immediate indication of fire to the crew. When the crew became aware of the fire and took remedial action, the fire had already developed beyond control. The manner in which the fire propagated was traced through evidence and it was concluded that the first explosion occurred in No. 3 fuel tank, the second explosion, which was the most violent, in the central fuel tank (No. 2 tank) and the third explosion in No. 1 reserve tank.

2.2 Conclusions

Findings

On the basis of the foregoing it was concluded that:

- the crew held the required licences;
- the aircraft had been declared airworthy;
- flight planning was complete and in accordance with regulations;
- the pilot-in-command acted in accordance with the prescriptions in the operations manual;
- on the Boeing 707/331, the information supplied by the reverse thrust system warning light regarding the position of the clamshell doors is inadequate; in the subject case, it was out of setting;
- the take-off data in present manuals apply and are valid only in the case of manoeuvres conducted by the pilot-in-command in person;
- in the manual, aborted take-off is not considered an emergency manoeuvre;
- acceleration of the aircraft was normal;
- the decision to abort take-off was taken before reaching V_1;
- the thrust reversing system on No. 2 engine was impaired, and that engine therefore continued to supply forward and asymmetrical thrust during the deceleration phase;
- it is certain that the pilot-in-command moved all four levers beyond the interlock position;
- deceleration was slower than expected and irregular;
- the aircraft was submitted to pronounced and continuous yawing moment;
- the aircraft travelled beyond the declared runway limit, thereafter hitting with No. 4 engine a power roller operating in a work area authorized in accordance with ICAO Standards;
- fuel spilled from the vent scoop in the right wing, admitting fire into the system;
- the fire warning device failed to operate;

- the explosions, which occurred very shortly after the aircraft stopped, were followed by a fire of vast proportions;

- the biggest explosion occurred in the centre fuel tank;

- the emergency exits to the wings of the Boeing 707/331 were difficult to open and use because of the seats;

- there were difficulties in using the escape chutes;

- rescue units from two different stations reached the scene approximately 3 to 5 minutes after the aircraft stopped.

Cause or
Probable cause(s)

Damage to the reverse thrust system of No. 2 engine, not discernible by means of cockpit instruments, and consisting in the disconnection of a duct with resulting lack of pressure in the pneumatic clamshell door actuating mechanism.

This malfunction allowed the development of considerable forward thrust by No. 2 engine even though the four levers were in the "reverse" position.

Rupture of fuel feed tube to No. 4 engine by impact with a power roller, and resulting ignition of spilled fuel.

Failure of surge tank drainage because of a blocked valve, forcing the fuel out through the vent scoop and permitting access of fire to the wing.

Presence of fuel-air vapour, formed in the tanks in explosive proportions, which caused the explosions when ignited.

3. - Recommendations

Operational recommendations

It was recommended that:

- airworthiness and operational standards be developed for take-offs performed by the co-pilot;

- aborted take-off procedures be included in the emergency procedures for practical purposes;

Technical recommendations

- a system be installed to indicate the successive positions of the reverse thrust clamshell doors;

- checking for tightness of all connexions in the pneumatic thrust reversing system be prescribed;

- consideration be given to a modification whereby the fire warning system would be fed in parallel by all sources of electric energy available on board;

- studies be conducted regarding systems designed to eliminate the danger of explosion in fuel systems and the entry of fire through ventilation outlets;
- the efficiency of the drainage system of the fuel surge tanks be improved;
- the emergency exits to the wings be made more readily accessible; and that a more rapid and less difficult method of use of escape chutes be developed.

ICAO Ref: AR/893

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Comments by the United States of America (State of Registry)

The National Transportation Safety Board, as the agency of primary interest in this accident at Leonardo da Vinci Airport, Fiumicino, Rome, Italy on 23 November 1964 has reviewed the Italian report and wishes to make known that it neither approves nor disapproves the report.

The United States wishes to observe that since the No. 2 reverse interlock system was found intact during the investigation, the worst possible effect from the operation of the PS4 line in the No. 2 reverse system would not negate the design safety features of the interlock system. These features, together with the clamshell door design, limit the thrust developed to safe values in the event of any single failure/malfunction in the reverse system.

ACCIDENT TO B-707-331, N 769TW, OF TRANS WORLD AIRLINES INC., AT ROME, ITALY. 23 NOVEMBER 1964

LANDING CHART - ROME (FIUMICINO)

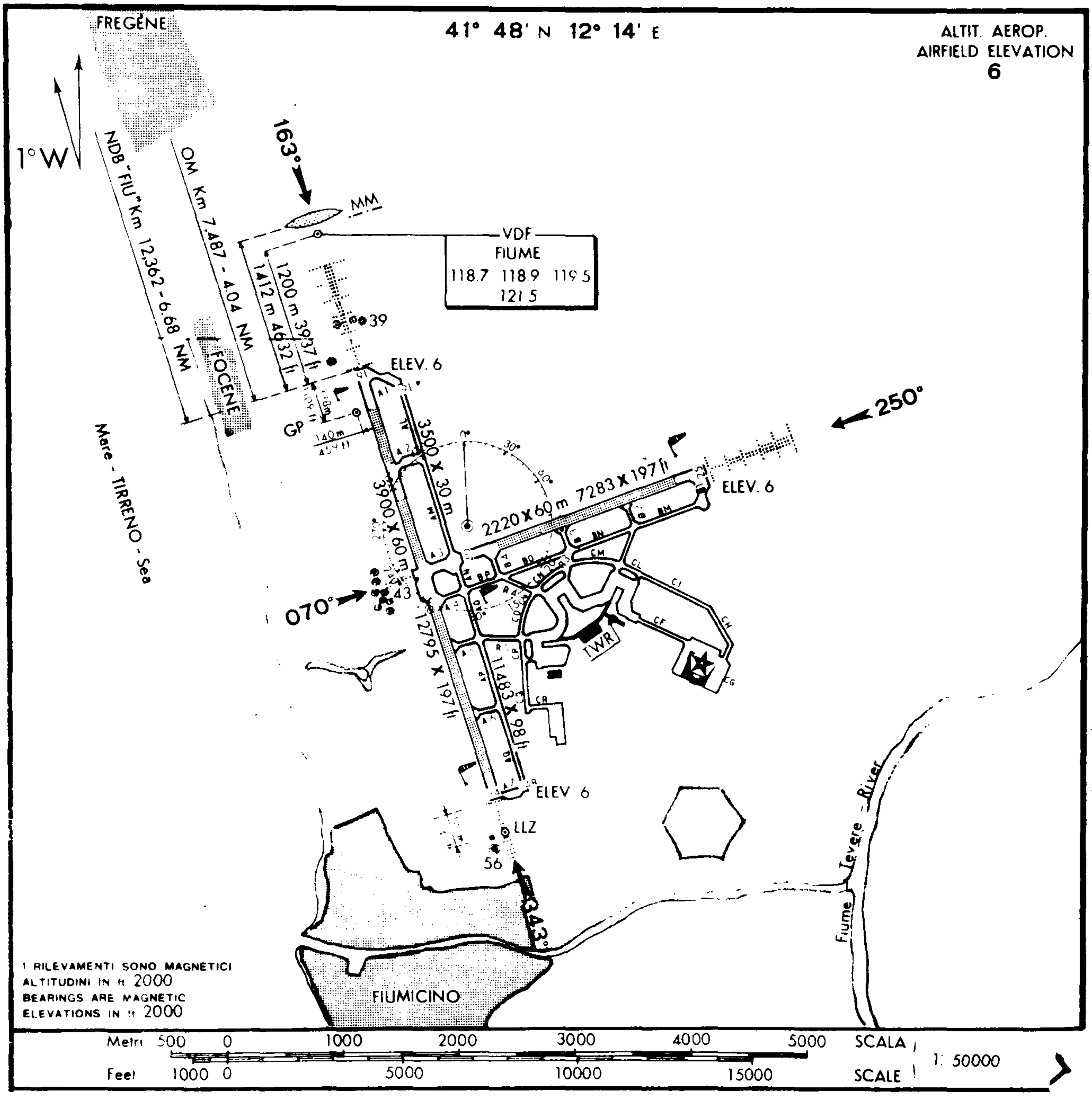

FIGURE 19-1

No. 20

B.I.A.S., DC-4, OO-DEP, accident at Stanleyville Airport, Democratic Republic of the Congo, on 29 November 1964. Report dated 23 December 1964, by the Aeronautics Administration, Ministry of Communications, Democratic Republic of the Congo.

1. - Investigation

1.1 History of the flight

The aircraft was chartered by Air Congo and was carrying out a non-scheduled domestic flight Kamina-Stanleyville-Kamina. Eleven passengers embarked at Stanleyville and the aircraft started its take-off run at 1920 hours local time. After approximately 900 m the pilot suddenly saw, in the darkness, an empty fuel drum on the runway. In an attempt to avoid it, he veered left by braking violently on the left wheels. In spite of this manoeuvre, the nose wheel hit the drum. The forward part of the aircraft was lifted off the ground, aided perhaps by the pilot's manoeuvre in attempting take-off. By that time, the aircraft had attained a speed at which take-off would have been possible under normal conditions. Unfortunately, following the shock the drum bounced, fell back on the runway, bounced again and the aircraft in a nose high attitude caught the drum with the right stabilizer. Part of the stabilizer was torn away and fell on to the runway while the drum was tossed on to the edge of the clearway. The aircraft continued further, now deflected to the right by the unbalanced right stabilizer, which was probably completely distorted. The crew immediately retracted the landing gear. After being airborne about 500 m, the aircraft, out of vertical control, dived into the clearway at an angle of about 30°, bounced up, fell back 50 m farther, skidded on its belly and finally came to a stop after a swing of 90° to the right. During that swing, the passengers in the rear of the cabin were thrown out of the aircraft through the torn-off cargo door and through the open cabin door. Fire broke out immediately after the aircraft came to a stop. The accident occurred on the north clearway of runway 28, about 150 m from the runway end.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	3	3	
Non-fatal		8	
None			

1.3 Damage to aircraft

The aircraft was completely destroyed.

1.4 Other damage

There was no other damage.

1.5 Crew information

The pilot-in-command, aged 37, held an airline transport pilot's licence with ratings for the DC-4 and DC-6 aircraft as well as instrument and night flying ratings. He had flown a total of about 14 000 hours, including 167 hours during the last 90 days. His last medical examination was on 21 May 1964.

The co-pilot, aged 31, also held a valid airline transport pilot's licence with ratings for DC-4 and C-54 type aircraft as well as instrument and night flying ratings. He had flown a total of 319 hours during the last 90 days.

No information regarding the flight engineer was given in the report.

1.6 Aircraft information

The aircraft had a valid certificate of airworthiness. By 29 November 1964, it had flown a total of 48 113 hours. It had undergone a 2 000-hour type III overhaul at 47 561 hours, and the last periodic 150-hour check had been made on 20 November 1964 at 48 024 hours. Daily and pre-flight inspections had been carried out regularly by qualified personnel. The latest flight records gave no information of irregularities that might have affected flight performance.

On take-off, the aircraft's total weight was 25 068 kg which was less than the maximum allowable weight of 33 500 kg.

Based on the 6 hours' endurance declared by the pilot, the aircraft carried approximately 6 000 litres of fuel. The type of fuel being used was not stated in the report. No load sheet was issued prior to the subject flight.

1.7 Meteorological information

Because of the disorganization of aerodrome services on the day of the accident, the meteorological observation centre was not operating. According to witnesses, the visibility was good at the time of the accident, the sky was clear and the wind from the west was light. The barometric pressure at aerodrome level was 1 018 mb.

1.8 Aids to navigation

The aircraft was equipped with the standard instruments prescribed for its category in operating condition.

1.9 Communications

No communications difficulties were mentioned in the report.

1.10 Aerodrome and ground facilities

The lighting of the runway and the taxiways was very deficient; only a few lights remained, the others were replaced by kerosene lamps.

1.11 Flight recorders

Not mentioned in the report.

1.12 Wreckage

Part of the right stabilizer was found on the take-off runway about 1 200 m from its end. The distance between the point from which the take-off run probably started and the first aircraft impact marks on the ground was approximately 1 410 m. The distance between these impact marks and the point where the aircraft finally came to rest was 200 m.

1.13 Fire

The aircraft was completely destroyed by post-impact fire.

The aircraft was equipped with a warning device and fire extinguishing system on each engine as well as in the two baggage holds. There were also hand extinguishers in the cockpit and in the passenger cabin. This equipment could not be used, however, because of the extent of damage to the aircraft as soon as it first hit the ground.

1.14 Survival aspects

Nine of the passengers seated in the rear of the cabin were thrown out of the aircraft through the torn-off cargo door and through the open cabin door and were injured to various degrees. One of them died from burns in hospital.

1.15 Tests and research

No information was contained in the report.

2. - Analysis and Conclusions

2.1 Analysis

The engines were so badly damaged by the post-crash fire that it was impossible to determine their condition or performance at the time of the accident. However, examination of the propeller revealed that the engines were at full power on first impact (blade tips bent forward) and that power was reduced, either consciously or involuntarily, before the second impact (backward twist of the blades right down to their base). It was, therefore, concluded that the four engines were in perfect operating condition at the time of the accident.

It was also concluded that, after a vain attempt to remain airborne following a take-off performed at critical speed, the crew, intentionally or unconsciously, reduced the engine power after the first impact with the ground in an attempt to lessen the damage.

Examination of the airframe wreckage revealed that the flaps were in the take-off position (15°) and that the flight control cables were not broken at the time of the accident.

A large portion of the right stabilizer was found on the runway. It was greatly distorted and its leading edge bore an imprint of a cylinder object. This imprint had been caused by a fuel drum which was found on the edge of the clearway.

This fuel drum was one of the many drums which had been previously obstructing the runway and which were removed to the edges of the runway when the aerodrome was recaptured by the regular army. This drum was probably blown on to the runway by another aircraft which took off shortly before. For operational reasons, the aircraft were taking off with no lights whatsoever and were guided only by the few runway lights still operating.

2.2 Conclusions

Findings

The crew were properly licensed for the aircraft type. The pilot-in-command had considerable flying experience on this type of aircraft and was fully qualified for the flight.

The aircraft had a valid certificate of airworthiness.

Aircraft maintenance had been performed by qualified personnel in accordance with current manuals and with the standard prescribed by the manufacturer.

The weight of the aircraft at take-off was well under the maximum permissible take-off weight and the centre of gravity was within limits.

The meteorological conditions were favourable.

The condition and operation of the aircraft instruments were not determined because they were totally destroyed by fire.

The radio equipment was operative.

The aircraft was provided with fire prevention equipment, which was of no use because it was destroyed before fire broke out.

No information could be drawn from the engines themselves. However, the condition of the propellers showed that the engines were operating normally and at full power on first impact with the ground.

Examination of the airframe revealed that the accident can be ascribed to loss of control through partial destruction of the right stabilizer and probable distortion of the elevator. These were caused by collision during take-off with an empty fuel drum on the runway.

Cause or
Probable cause(s)

The accident was brought about by impact with a fuel drum which caused partial destruction of the right elevator, thus rendering the aircraft uncontrollable in flight.

3. - Recommendations

None were contained in the report.

ICAO Ref: AR/889

No. 21

Abaroa Airlines, Douglas C-47, CP-639, accident at Paso Huayna Potosi, Bolivia, on 8 December 1964. Report undated, released by the Directorate General of Civil Aviation, Ministry of Public Works and Communications, Bolivia.

1. - Investigation

1.1 History of the flight

The aircraft was on a scheduled domestic flight from Caranavi Airport to La Paz via Tipuani. It arrived at Tipuani at 0913 hours Bolivian time, carrying a crew of three, a supernumerary crew member and a passenger for La Paz. At Tipuani, eleven adult passengers and a baby boarded the aircraft. Departure from Tipuani was at 0934:36 hours and the estimated time of arrival at La Paz was 1010 hours. The last communication with Tipuani control was made at 1002 hours when it requested permission to change to the frequency of the La Paz aerodrome control zone. When the aircraft did not enter the control zone within the normal five-minute time, an emergency was declared at 1022 hours, and at 1048 hours it was learnt from the Milluni broadcasting station that the aircraft had been seen exploding in the air and falling to earth near the cemetery of that mining area. At 1121 hours the disaster was confirmed by another aircraft, CP-621, which was flying over the area. The site of the accident was 16°21'00"S, 68°10'00"W, at an elevation of 14 000 to 14 500 ft.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	4	13	
Non-fatal			
None			

1.3 Damage to aircraft

The aircraft was totally destroyed.

1.4 Other damage

There was no other damage.

1.5 Crew information

The pilot-in-command, aged 40, held an airline transport pilot's licence with a multi-engine rating. He had flown a total of 5 161 hours as pilot-in-command of C-47, YC-125, B-17 and PV-2 aircraft, in addition to 941 hours on single-engined aircraft and 1 367 hours on Beechcraft AT-7 (twin-engined aircraft) as Air Force pilot.

During the 30 days preceding the accident, he had flown 69 hours. He passed his last medical examination on 25 July 1964 and had a valid medical certificate.

The co-pilot, aged 25, held a national licence validated on an Argentine private pilot's licence. He had flown a total of 720 hours, including 625 hours as co-pilot on C-47 and C-46 aircraft. He had flown 63 hours during the preceding 30 days. He passed his last medical examination on 5 July 1964 and had a valid medical certificate.

The flight engineer had 17 years of continuous experience in aviation.

The supernumerary crew member was a general of the Air Force and manager of the airline. He was 49 years old and held an airline transport pilot's licence rated for twin-engined aircraft.

1.6 Aircraft information

The aircraft's certificate of airworthiness was valid until 4 January 1965.

The aircraft had flown a total of 17 007 hours, including 1393 hours since last overhaul. The aircraft had been properly maintained.

At the time of take-off from Tipuani, the aircraft's gross weight was 9 721 kg. The load and trim sheet for this flight was not signed by the co-pilot.

The aircraft carried 180 gallons of fuel weighing 490 kg. The type of fuel was not mentioned in the report.

1.7 Meteorological information

The weather conditions all along the route were favourable for flying in VMC.

1.8 Aids to navigation

Not pertinent to the accident.

1.9 Communications

Communications between the aircraft and ground stations were normal.

1.10 Aerodrome and ground facilities

Not pertinent to the accident.

1.11 Flight recorders

Not mentioned in the report.

1.12 Wreckage

The wreckage of the aircraft was scattered along an area 1 070 m long at a true heading of 210° (see Figure 21-1) and was distributed as follows:

Area 1: Close to the Milluni cemetery small paint flakes (½" x ¼") were found scattered over an area of 200-m radius. They were identified as belonging to the tail unit and tail cone.

Area 2: Approximately 50 m further on, at the top of the first rise in the ground, hundreds of small fragments of aluminium and paint flakes (¾" x ½") were found. They were all identified as belonging to the rudder.

Area 3: Another 50 m further on, hundreds of metal fragments ranging from bits half an inch in diameter to parts 2 to 3.5 ft long were scattered over an area of 150-m radius. They were all identified as belonging to the rear part of the fuselage and to the tail unit.

Area 4: About 400 m further on, the horizontal and vertical tailplanes, the flight deck escape hatch and the rear cargo door were found in an area of 50-m radius.

Area 5: An area approximately 300 m long, where no wreckage was found.

Area 6: An area of approximately 300 sq. m in which the main wreckage of the aircraft was located, including the wings and ailerons, the engines and propellers, pieces of the fuselage and the central wing section, and the landing gear.

Area 7: At the top of the last rise in the ground, the upper part of the fuselage and the heating duct of the passenger cabin were found. The tail skid was located further down, 5 m from the road to La Paz.

1.13 Fire

Fire broke out after impact. Since the traces left by most of the fire had not caused any significant fusing of metal parts, it was believed that the remaining fuel, estimated at 130 gallons, exploded when the aircraft hit the ground.

1.14 Survival aspects

There were no survivors.

1.15 Tests and research

Numerous fragments of aluminium plating, showing the distortion resulting from explosion, were collected in order to ascertain, as far as possible, what type of explosive could have led to the disintegration of the starboard side of the fuselage.

Tests carried out in the Bolivian Police laboratories revealed the presence of sodium nitrate and residues of other explosion-producing substances.

2. - Analysis and Conclusions

2.1 Analysis

From the distribution pattern of the wreckage, it was determined that the tail unit was torn from the aircraft at an estimated height of 1 500 ft above the ground. The stabilizers and elevators, the fin, the rudder and the rear door of the hold were all found in one piece and no evidence of in-flight damage was found on them. Examination of the main part of the wreckage, which was located 300 m farther than the tail unit wreckage, revealed that the wings, together with their ailerons and tabs, and the flaps were intact prior to the impact of the aircraft with the ground in a nearly vertical attitude. Also the distance between the 2-ft deep craters in which the engines and their propellers were found indicated that they were still in position at the time of impact.

During the examination of the wreckage, it was found that the entire port side of the fuselage was perfectly identifiable, but that a large portion of the starboard side between station 623 and station 294, as well as part of the passengers' and freight compartment floor, had completely disintegrated.

Evidence showed that the disintegration started at a point behind the passenger cabin, in an area adjacent to the toilet, and that it was due to an explosion.

Seven days after the accident, the police found a 2-inch piece of burnt out dynamite fuse amongst the main wreckage, another piece approximately 4-inch long and not burnt in the area of great dispersion and also fragments of solidified cement.

Nothing could justify the presence of this material, which forms part of an explosive device, in the accident area.

2.2 Conclusions

Findings

The crew were adequately certificated for their duties.

The certificate of airworthiness was valid and up to date. The maintenance procedures prescribed for the aircraft had been carried out. The aircraft was properly dispatched.

The weather conditions were good.

No trace of structural or component failure of the aircraft was found that might have caused the accident.

It was proved beyond any doubt that the tail unit of the aircraft, consisting of stabilizer, elevators, fin, rudder and rear freight door had been torn off the aircraft while it was still flying normally on descent to the aerodrome of destination.

Examination of all the collected pieces revealed that this was due to sudden disintegration caused by an explosion.

The disappeance of a large portion of the starboard side of the fuselage, the breaking up of the metal parts indicated that the cause was an explosion within the aircraft.

Parts of explosives were found such as dynamite fuses and pieces of solidified cement.

Cause or Probable cause(s)

A violent explosion of criminal origin inside and at the rear of the aircraft during flight, which caused the tail unit to be torn off.

3. - Recommendations

The report of the technical investigation proves that the accident was of criminal origin. It is recommended that this report be transmitted to the police authorities to ascertain whether the author or authors of the act were actually on board the aircraft.

ICAO Ref: AR/900

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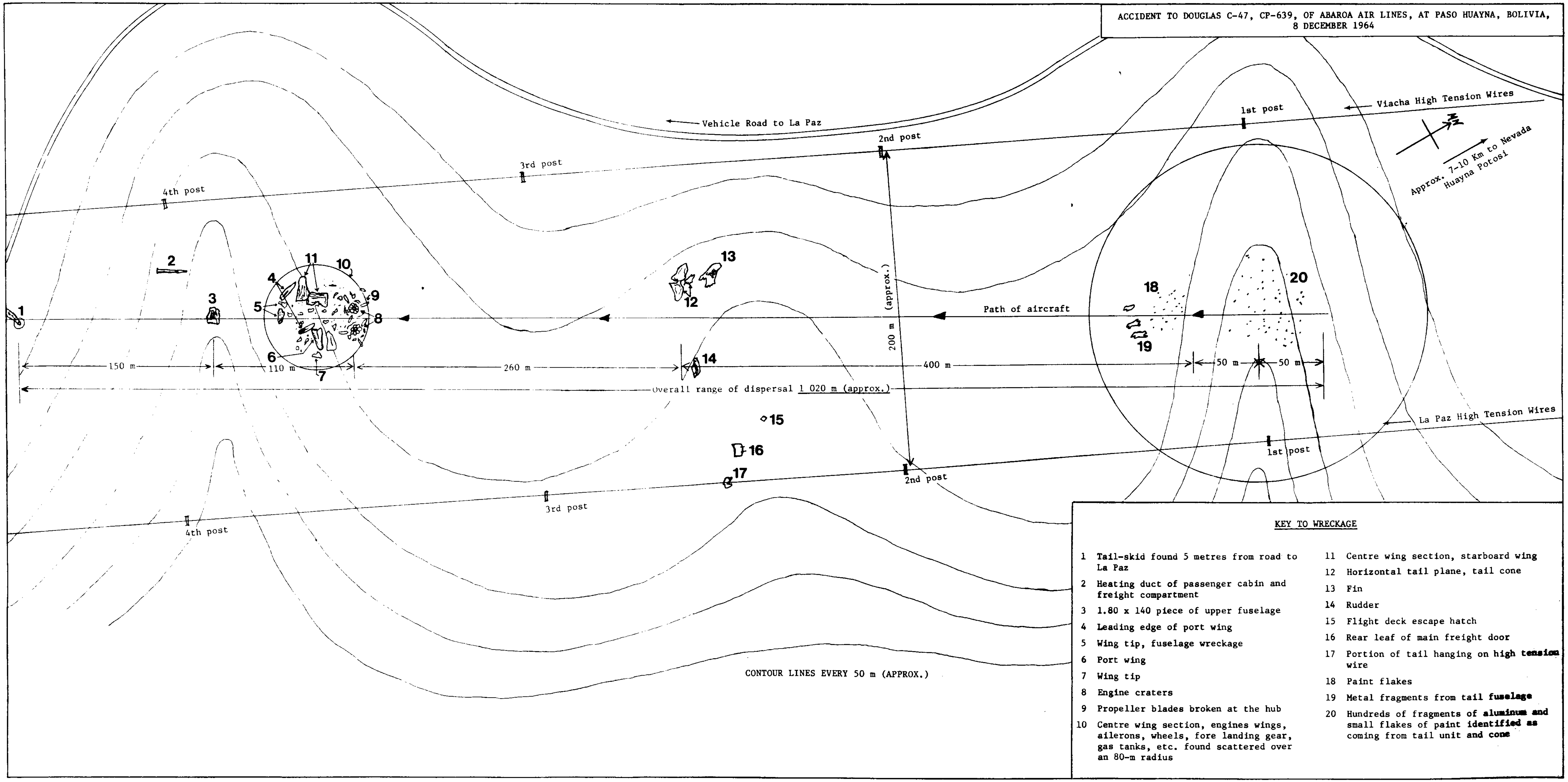
ACCIDENT TO DOUGLAS C-47, CP-639, OF ABAROA AIR LINES, AT PASO HUAYNA, BOLIVIA, 8 DECEMBER 1964



KEY TO WRECKAGE

1 Tail-skid found 5 metres from road to La Paz
2 Heating duct of passenger cabin and freight compartment
3 1.80 x 140 piece of upper fuselage
4 Leading edge of port wing
5 Wing tip, fuselage wreckage
6 Port wing
7 Wing tip
8 Engine craters
9 Propeller blades broken at the hub
10 Centre wing section, engines wings, ailerons, wheels, fore landing gear, gas tanks, etc. found scattered over an 80-m radius
11 Centre wing section, starboard wing
12 Horizontal tail plane, tail cone
13 Fin
14 Rudder
15 Flight deck escape hatch
16 Rear leaf of main freight door
17 Portion of tail hanging on high tension wire
18 Paint flakes
19 Metal fragments from tail fuselage
20 Hundreds of fragments of aluminum and small flakes of paint identified as coming from tail unit and cone

FIGURE 21-1

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No. 22

Fleming Air System Transport (FAST), Douglas DC-3, PI-C569, accident at Barrio Camansi Norte, Numancia, Aklan, Philippines, on 21 December 1964. Report dated 10 May 1965, released by the Aircraft Accident Investigation Board, Civil Aeronautics Administration, Department of Public Works and Communications, Republic of the Philippines.

1. - Investigation

1.1 History of the flight

The aircraft was on a non-scheduled flight from Kalibo to Manila. It took off from runway 05 at 1740 hours Philippine local time and the co-pilot testified that the take-off was normal and all engine instruments were indicating within normal operating range throughout the take-off and during the initial climb. He further testified that approximately 20 minutes after take-off, severe vibration and misses, decreasing oil pressure and increasing oil temperature of the left-hand engine, were noted as the airplane was climbing to 2 200 ft. The left-hand engine was shut down, its propeller feathered, and shortly after the pilot-in-command reversed course and descended with the intention of landing at either Kalibo or Roxas Airports. Neither airport was rated for night operations. The flight proceeded to Kalibo. Precipitation was encountered on the way and the visibility was so poor that the crew failed to make visual contact with Kalibo Airport. At 1823 hours, a climb to 2 000 ft was attempted to clear the terrain on the way to Bacolod Airport, the nearest airport available for night operations. However, with METO power on the remaining engine, the aircraft not only failed to climb but also failed to maintain altitude with the airspeed decreasing to 80 mph. Several attempts to climb were made but were discontinued due to pre-stall warning. At 1835 hours with 500 ft altitude, the pilot-in-command decided to ditch and warned the passengers accordingly. At 1839 hours, the ditching was attempted but the airplane collided with coconut trees located approximately 500 ft from the Barrio Camansi Norte shoreline and crashed on the muddy bed of an abandoned fishpond on a heading of 300°, approximately 160 ft from the point of initial collision. The accident occurred around 1840 hours.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	1		
Non-fatal	2	16	
None		20	

1.3 Damage to aircraft

The aircraft was substantially damaged.

1.4 Other damage

There was no other damage.

1.5 Crew information

The pilot-in-command, aged 37, held a currently valid senior commercial pilot's licence with a rating for DC-3 airplanes and an instrument rating. He had a total flying time of approximately 6 000 hours, of which approximately 2 000 hours were on the DC-3. His medical certificate was current but required that he wear correcting lenses while executing the privileges of his licence. He was not wearing them at the time of the accident.

The co-pilot, aged 32, held a currently valid commercial pilot's licence with ratings on L-4, L-5 and DC-3 aircraft. He had a total flying time of approximately 1 000 hours. In November 1964 after undergoing 5 days company transition for the DC-3 airplane, he was hired as a DC-3 first officer. His medical certificate was current without limitations.

On the day of the accident, both the pilot-in-command and the co-pilot had flown 7:45 hours on that same aircraft before departing Kalibo.

The third crew member aboard was a flight attendant.

1.6 Aircraft information

The aircraft had a currently valid certificate of airworthiness.

The aircraft log-book showed frequent malfunctioning of the left engine since it was installed on the aircraft and frequent discrepancies on the right engine during the last month.

On the day prior to that of the accident, significant discrepancies were logged by the first crew which flew the aircraft. These included 100 rpm drops on one magneto, on both engines, and required immediate corrective action. Maintenance work was performed after the flight; however, on the following flight carried out by another crew, some significant discrepancies on the left engine were again logged. No corrective action was taken; however, a company aircraft and engine mechanic released the aircraft for flight.

On the day of the accident and presumably during the flight prior to the ill-fated one, the pilot-in-command logged again discrepancies on the left engine (including a 300 rpm drop on the right magneto) and on the landing lights. However, no corrective action was taken. No maintenance or refuelling was carried out at Kalibo.

It was also found during the investigation that the maintenance records were badly kept. The total time of the left engine since last overhaul appeared on the log-book as 122:36 hours when it should have read 717:23 hours, and that of the right engine as 676:05 hours instead of 1 076:45 hours.

The pay load of the airplane was 4 672.2 lb, well below the allowable 5 737 lb. The maximum gross weight and the centre of gravity at take-off were determined to be within the allowable limits.

The fuel and oil on board were 275 and 47 gallons respectively. The type of fuel being used was not stated in the report.

1.7 Meteorological information

The accident occurred in darkness, and precipitation and poor visibility prevailed over Kalibo at that time.

1.8 Aids to navigation

Not pertinent to the accident.

1.9 Communications

There were no communications difficulties. When the emergency occurred, the co-pilot made a blind transmission on 118.1 Mc/s, declaring the emergency. At that time, the aircraft was flying at an altitude of approximately 1 100 ft over New Washington (7 miles east of Kalibo). This transmission was first received around 1817 hours by another aircraft, which then started to relay all radiocommunications between the aircraft and Romblon radio station. The last transmission from the aircraft was received at 1839 hours when it announced that it was trying to ditch.

1.10 Aerodrome and ground facilities

No information was contained in the report.

1.11 Flight recorders

Not mentioned in the report.

1.12 Wreckage

The accident occurred about 8 miles northwest of Kalibo Airport.

1.13 Fire

There was no fire.

1.14 Survival aspects

The pilot-in-command was thrown out of the aircraft 40 ft forward, when the left side of the nose section hit a coconut tree.

The passengers evacuated the aircraft through the opening created by a break at the periphery of the fuselage, forward of the main door. All the emergency exits were found closed. The left-hand exits were found safe-tied.

1.15 Tests and research

The left engine was subsequently stripped and subjected to technical examination. All the front row pistons were stuck frozen in their respective cylinders and distorted apparently by high temperature. The front master rod and all the front connecting rods were broken and the fractured ends were further deformed by repeated pounding.

All the rear row pistons, cylinders and connecting rods were found normal.

The right engine was likewise strip-examined and was found normal.

2. - Analysis and Conclusions

2.1 Analysis

According to the IFR flight plan, the aircraft should have climbed after take-off so as to reach 6 000 ft over Romblon, which is 25 minutes flight time from Kalibo. According to the DC-3's performance curves, the aircraft should have been capable, with the load carried, of reaching 6 000 ft altitude 20 minutes after take-off. Furthermore, it should have been able to maintain or climb to 3 000 ft altitude on one engine. The failure of the airplaine to reach 6 000 ft altitude 20 minutes after take-off suggested that both engines were not delivering their rated power. This was also substantiated by the fact that the aircraft could not maintain its altitude with the left propeller feathered, despite application of METO power on the right engine. The apparent failure of the right engine to deliver the desired power limited the courses of action available to the flight crew. The continuous loss of altitude left no other choice for the crew but to make an emergency landing. However, strip examination of the right engine did not reveal any deficiency and the Board could not factually determine why it was impossible to maintain altitude after the failure of the left engine.

2.2 Conclusions

Findings

The crew were properly certificated for the flight.

The aircraft had a valid certificate of airworthiness. Malfunctioning of both engines were reported on several occasions. Also some discrepancies in the maintenance records of the aircraft were found during the investigation. The gross weight and centre of gravity were within limits.

Precipitation and poor visibility prevailed over Kalibo at the time of the accident.

Strip examination of the left engine revealed that all front row pistons had seized in flight and that the front master rod and all front connecting rods were broken. Strip examination of the right engine did not reveal any discrepancies and no reasons were found to explain why the aircraft was unable to maintain its altitude with the left engine feathered and the right engine on METO power.

Cause or Probable cause(s)

The Board determined that the probable cause of the accident was failure to maintain safe single-engine speed and altitude following failure of the left engine.

The precipitation and poor visibility prevailing at the time of the accident over Kalibo and its vicinity and the failure on the part of the maintenance personnel to take action to correct discrepancies logged in the aircraft log-book, individually or collectively contributed to the cause of the accident.

3. - Recommendations

After the investigation, the Board recommended a review of the maintenance practices of FAST. The Director, upon the recommendation of the Aviation Safety Regulations Division, directed FAST to stop top-overhauling its engines after it was factually determined that their facilities were inadequate.

ICAO Ref: AR/905

No. 23

The Flying Tiger Line Inc., L-1049H, N 6915C, accident at San Francisco International Airport, San Francisco, California, U.S.A., on 24 December 1964. Civil Aeronautics Board (U.S.A.) Aircraft Accident Report, File No. 1-0064, released 8 June 1966

1. - Investigation

1.1 History of the flight

Flight 282 was a scheduled domestic cargo flight from San Francisco International Airport, California, to John F. Kennedy International Airport, New York. It was originally scheduled to depart at 2100 hours, Pacific Standard Time, on 23 December, but the flight was delayed because of the non-availability of a flight engineer. An engineer obtained from Los Angeles arrived in San Francisco at 2315 hours and the flight departed at 0028 hours on 24 December.

At 0015 hours, while taxiing to runway 28L, the flight advised Ground Control that because of a heavy load, they would like to proceed out past the GAP Radio Beacon to the Golden Gate Intersection, and thence via Victor 150 to Sacramento instead of direct to Sacramento as originally filed. The request was co-ordinated with Oakland Air Route Traffic Control Centre and approval obtained. The crew was then advised that for take-off on runway 28L there would be a "heavy" left cross-wind from 210 degrees at 18 to 25 knots, which they acknowledged.

After having switched to clearance delivery frequency, the flight was cleared to Kennedy Airport via Victor one fifty Sacramento, Victor six north, and requested to climb out on the San Francisco two eight seven radial for a vector to Golden Gate Intersection to intercept Victor one fifty. This was acknowledged. The Clearance Delivery Controller then stated: "You can disregard the vector, climb outbound San Francisco 287-degree radial to Golden Gate Intersection, then Victor 150, and, depending on your altitude, they probably will give you a vector to intercept (Victor) 150 before you get to Golden Gate.* This was also acknowledged.

The Local Controller, who was also Tower Supervisor, noted the time of 0030 on his clock as the aircraft became airborne and passed the tower. An eyewitness observed the landing lights retracting as the aircraft crossed the end of the runway. However, several witnesses along the flight path, including some located at points just prior to the crash, saw both landing lights on. Landing lights of the L-1049H may be retracted flush with the lower wing surface and remain on until switched off.

After take-off, witnesses stated the aircraft made a slight turn to the right, then a steeper turn to the left, and then was observed returning to a wings-level attitude as it entered the clouds.

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* Radar vectoring could not be provided an aircraft departing runway 28 via the Golden Gate Standard Instrument Departure until the aircraft reached an altitude of 1 500 ft. This was because standard obstruction clearance from the terrain, both vertical and lateral, could not be achieved in so far as criteria, as existing on 24 December 1964, were concerned Lateral clearance from obstructing terrain is so critical that there is no space available in which to vector an aircraft safely below 1 500 ft. (See Figure 23-1).

At 0030:22, the flight was advised to contact Departure Control and did so immediately. The Departure Controller advised the flight at 0300:57 that he had radar contact with it and requested it to report leaving thousand-foot altitudes.

At 0031:05, the crew asked how they were tracking toward the GAP. The Departure Controller switched his radar scope from the 30 to the 10-mile setting and requested the flight's altitude. The crew replied they were at 900 ft.

At 0031:20, the Departure Controller advised that they were left of the San Francisco 287° radial. As he received no acknowledgement he repeated his message. The Departure Controller stated that within seconds after the second transmission, the target stopped, bloomed, and disappeared from the radar scope. Repeated attempts to communicate with the flight after its disappearance from the scope were unsuccessful. At this time, 0032:30, the controller placed a time hack on the communications tape. Ground impact was computed to have occurred at approximately 0031:30. Main impact occurred 860 ft above sea level on Sweeney's Ridge, at approximately 4.3 miles on the 257° radial of the SFO TVOR. The co-ordinates of the impact area were 122°28'00" west longitude, 37°38'28" north latitude. (See Figure 23-2)

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	3		
Non-fatal			
None			

1.3 Damage to aircraft

The aircraft struck the east slope of a hill and disintegrated. Portions of the aircraft were partially or completely consumed in the intense ground fire which developed.

1.4 Other damage

The aircraft crashed on a Coast Guard Reservation. Impact damaged numerous antenna structures and fire consumed portions of the hillside foliage.

1.5 Crew information

The pilot-in-command, aged 49, held a valid airline transport pilot certificate with type ratings in C-46, DC-4, L-1049H, and CL-44 aircraft. He had a total of 14 911 flying hours, of which 3 942 hours were in L-1049H aircraft. He held a current first class medical certificate with the limitations: "Holder shall possess correcting glasses for near vision while exercising the privileges of this airman certificate." No eyeglass frames, lenses, or broken lenses were found at the accident site. A slip-in eyeglass case was found at the site, labelled with an east coast optometrist's name and address. It contained no traces of broken glass. The pilot-in-command was the only east coast crew member.

The pilot-in-command had risen some time before 1000 hours on 23 December, and had been on duty since 2030 of that date. He had not flown in the previous 24-hour period. He was based in Newark, New Jersey, and his last departure as a crew member from the San Francisco International Airport was on 14 December 1963, as a co-pilot.

The co-pilot, aged 33, held a valid airline transport pilot certificate with type rating in DC-3, and a flight instructor's rating. He had a total of 3 636 flying hours, of which 1 277 hours were in L-1049H aircraft. He held a current first-class medical certificate with no limitations. He had been on duty for 4.3 hours during the previous 24-hour period, of which 1.8 were flying hours.

The flight engineer, aged 37, held an airframe and powerplant certificate and a flight engineer's certificate. He had a total of 4 113 flying hours, of which 3 811 hours were in L-1049H aircraft. He held a current first class medical certificate with no limitations. He had 17 hours of rest during the previous 24-hour period and had been on duty for 7 hours but had not flown except for the deadhead flight from Los Angeles.

Blood specimens from each crew member were subjected to toxicological examination. Results were negative for the co-pilot and engineer and only a small amount of blood ethanol was indicated in the pilot-in-command's specimen. Since alcohol production may be associated with post-mortem changes, the concentration did not of itself constitute evidence of alcohol ingestion. There was no evidence to indicate the possible consumption of alcohol by the pilot-in-command prior to the flight.

Examination of the pilot-in-command's heart indicated extensive arteriosclerosis of the coronary arteries with considerable narrowing of the lumina of the vessels. However, there was no thrombus or plague haemorrhage found that would have acutely compromised the circulation within the arteries. There was also no anatomical evidence that the pilot-in-command had experienced an episode of anginal pain in the few seconds preceding the crash.

Review of the medical records of all the crew members failed to disclose any indications of significant pre-existing disease.

1.6 Aircraft information

When the aircraft taxied from the ramp, it weighed 142 073 lb, within 27 lb of the allowable take-off gross weight. The c.g. limits for maximum gross weight of this aircraft are 23 to 32% of MAC; it had a c.g. of 29.3%. The station agent certified on the flight clearance that the aircraft was loaded within limits.

The type of fuel being used was not stated in the report.

1.7 Meteorological information

Surface weather charts for the evening of 23 December and the early morning hours of 24 December indicated that San Francisco was under the influence of a cold frontal system moving onshore. At the time of the accident rain, low cloudiness, and considerable fog were shown along virtually the entire Pacific coast. The San Francisco terminal forecast issued at 2045 on 23 December, valid for a 12-hour period beginning at 2100, was in part as follows:

> 2100-0400: 700 ft scattered clouds, ceiling 1 800 ft overcast, visibility 6 miles in light rain, occasionally ceiling 600 ft broken clouds, 1 800 ft overcast, visibility 6 miles in light rain.

The 0028 San Francisco International Airport surface weather observation in part showed the following:

> Scattered clouds at 400 ft, measured 1 100 ft overcast, visibility 6 miles in light rain and fog, temperature 59°F, dew point 57°F, wind from 240 degrees at 22 kt, gusts to 28 kt.

The Flying Tiger Flight Operations Agents on duty prior to the departure of the flight indicated that the flight crew was provided with the 400-150 mb significant weather prognostic chart, the winds from the 500 mb prognostic chart, as well as terminal weather information.

There were five departures from San Francisco International Airport within approximately one half hour after the flight departed. Most of the pilots-in-command of these flights testified that the winds were strong and gusty on take-off; that there were low clouds and intermittent rain; and that the turbulence was light to moderate until reaching at least 1 000 ft altitude.

The meteorologist stationed at the San Francisco International Airport at the time of the accident testified that there would have been moderate to severe turbulence in the area of Sweeney's Ridge with moderate downdraughts as one approached the ridge.

1.8 Aids to navigation

All radar and NAVAID equipment operated within prescribed tolerances when checked following the accident. The pilot-in-command certified on the flight clearance that he considered conditions were satisfactory for flight in accordance with his analysis and current airline and Civil Air Regulations.

1.9 Communications

All communications between ATC and the flight were recorded. Communications were normal until 0031:20 hours, when the crew did not acknowledge the message of the Departure Controller advising them that they were left of the 287° radial. No further communication was received from the aircraft.

1.10 Aerodrome and ground facilities

There were no unusual aerodrome or ground facility activities or conditions at San Francisco International Airport during the departure of the flight. The runway and taxiways were wet from the light rain and fog conditions which existed at the time of take-off.

1.11 Flight recorders

No flight recorder was required or installed aboard this aircraft.

1.12 Wreckage

Initial impact was by the left wing tip at an elevation of 840 ft. The fuselage struck the hill at 860 ft, on a magnetic heading of 225 degrees, and spilled over the top of the hill and down the west side of the slope. The wreckage was scattered in an area approximately 300 ft wide and 600 ft long. Sweeney's Ridge runs from north-west to south-east, and the top is 925 ft at the accident site.

1.13 Fire

The fire that followed impact was extinguished by local fire-fighting apparatus.

1.14 Survival aspects

This was a non-survivable accident.

1.15 Tests and research

Following the accident, flights were conducted to correlate ground witnesses and traffic controller information. These flights pinpointed the probable speed and flight path of the flight, and established that the initial left turn immediately after take-off was in excess of 25 degrees of bank. Validation of times and rates of climb were also established by the flight tests.

Performance figures of the manufacturer indicated that this aircraft's rate of climb should have been in excess of 800 ft/min from lift-off. The chief pilot of the airline at San Francisco stated that in his experience similarly loaded L-1049H aircraft will normally climb between 400-500 ft/min on departures from runway 28 at SFO. While no minimum rate of climb per mile was established for runway 28 departures at the time of the accident, the FAA has since specified that 250 ft/mile is the minimum acceptable. (See Figure 23-3)

Tests were made to determine what effect, if any, an aircraft taxiing in the vicinity of the TVOR antenna on the airport would have on the 287° radial reception in flight. These tests revealed no appreciable effect on radial reception.

A review of previous L-1049 aircraft accidents indicated that a number of these involved navigation errors of some type on aircraft of the L-1049H series purchased by the airline.

After the accident a radio transfer switch assembly* containing loose wire-clipping contamination was removed from a sister aircraft (N6917C), as a result of extensive trouble-shooting for a VOR course deviation bar discrepancy. Examination of this switch and another one removed from another aircraft (N6919C) revealed short pieces of wire, varying from 1/16 to 1/4 inch in length, within the wafer switch mechanisms. Several wire-to-switch terminals had untrimmed wire strands extending up to 1/2 inch beyond the terminal lug. A review of the last available log sheet of N6915C, the accident aircraft, revealed that the VOR system had write-ups similar to N6917C. The log of N6915C indicated that the corrective action was removal of the VOR receiver which checked out normally during the subsequent bench check.

During the FTL campaign to examine all relay switches in the fleet, two switches were found to be contaminated and four were found to have a source of contamination present. Electrical shorts caused by relay switch contamination have been known to cause navigation bearing angle errors of as much as 60 degrees.

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*Lockheed Part No. 319122. A multiple gang-type circular switch that switches navigation signals and allows the captain to view on his instrument information from the co-pilot's VOR system. There are three of these switches on each Lockheed 1049 aircraft. The type of switch here referred to is the deviation indicator transfer switch.

2.- Analysis and Conclusions

2.1 Analysis

An examination of the evidence indicated that there was no malfunction or failure of the structure, powerplants, and system components prior to initial impact. The landing gear was fully retracted and the flaps in a 25° setting at impact.

The medical records of all flight crew members failed to disclose any significant pre-existing diseases which would have disqualified any of the crew members from performing their duties for this flight.

An analysis of available meteorological information indicated that, at the time of the accident, Sweeney's Ridge would have been obscured by clouds and light rain. Winds would have been from the west-south-west at 30 to 35 kt, with occasional gusts to 45 kt. This would have created moderate to severe turbulence and a marked downdraught condition in the lee of Sweeney's Ridge. Turbulence would have been encountered throughout the flight path, increasing in intensity as the flight approached the ridge.

The ATC clearance and routing provided was in accordance with the crew's request and all ground electronic navigational aids were operating satisfactorily. The GAP homer and the Outer Marker compass locator frequencies were selected on the aircraft's ADF receivers and the loop bearing of the No. 2 ADF system validates electrical power at impact. Even assuming a malfunction of the aircraft's VOR course deviation needle, adequate guidance to a safe altitude was possible from the localizer course, the outer compass locator of the instrument landing system or the GAP low frequency homer. Also, three separate sources of heading information were available.

The term "radar contact" is used when radar identification of an aircraft is established. Critical obstruction clearance criteria for the Runway 28 departure at San Francisco, and limitations of the facility radar equipment, precluded radar vectoring service until the aircraft reached 1 500 ft. If the foregoing limitations were unknown to the crew, they may have believed the aircraft was under continuous radar surveillance from the time departure control reported radar contact. The crew may have disregarded their instruments believing their flight was monitored by the radar controller and, because of the turbulent weather conditions encountered, they may have concentrated their efforts on maintaining control of the aircraft. In those circumstances, the crew may have failed to detect errors in the instrument presentation to the extent that there were in fact erroneous indications portrayed.

A contaminated switch could cause intermittent large errors in navigational information displayed on the pilot's instrument. A review of log discrepancies on a number of L-1049 aircraft presently owned and flown by the airline revealed navigation errors in the VOR system that may have been caused by contamination of the radio relay switch, even though the VOR navigation selections had been properly made.

The flight made a left turn of approximately 55 degrees shortly after take-off. The reconstructed flight path indicated that this heading was maintained until impact. Since the relay switches in N6915C were destroyed by fire, it was impossible to determine whether contamination existed. However, the radio transmission before impact indicated the co-pilot's concern about the position of the aircraft. The turn after take-off and the subsequent concern of the co-pilot could be attributed to a malfunctioning VOR since it is the prime navigation aid. The straight track flown after the turn indicated that the pilot was using at least some of the aircraft's navigation instruments for guidance.

Immediately after take-off, the aircraft would have drifted to the right because of strong south-west winds. Moderate to severe turbulence would have been encountered and should have continued while the aircraft was in the lee of Sweeney's Ridge. Drift corrections would have been made to the left and high power settings were required to maintain a positive rate of climb. The aircraft was near maximum gross weight. It was considered that because of this, the crew would have been more concerned with flight and engine instruments than with navigational instruments and that, accordingly, the initial period of the flight was spent flying the aircraft, maintaining proper attitude, and a positive rate of climb. It was considered possible that the crew became aware that they were left of course and requested information on their position from the departure controller. At this point, 0031:05, they were considerably left of the course and 25 seconds from impact.

Under conditions of instrument flight, during a departure, if the crew were concerned with incorrect navigational readings combined with turbulence and marginal climb performances, the cumulative demands upon the pilot would have been very great.

Since no reason was apparent why the left turn would not have been displayed on the instrument panel, the Board concluded that the crew apparently failed to refer to the total instrument portrayal in the cockpit.

The investigation of this accident revealed that the lateral and horizontal terrain clearance for a runway 28 departure at San Francisco could be marginal for an aircraft operating in this environment. With respect to the radar procedures utilized, radar vectoring is not provided during this instrument departure until the aircraft reaches 1 500 ft. This is because standard vertical and lateral obstruction clearance from the adjacent terrain cannot be achieved in so far as present criteria are concerned. The lateral clearance from obstructing terrain is so critical that there is no available space in which to vector an aircraft safely until it has reached an altitude of 1 500 ft.

As far as can be determined the flight was initially climbing at approximately 250 ft per mile minimum rate of climb and would have undoubtedly made a safe climb-out had it remained on the appropriate standard instrument departure route. However, after the aircraft left the prescribed departure route, it entered an area of rising terrain where downdraught activity and moderate to severe turbulence affected the climb capability of the aircraft sufficiently to prevent terrain clearance. The deviation to the left was not detected in time to avert impact with the hill.

2.2 Conclusions

Findings

The crew of the flight was properly certificated and there was no evidence of pre-impact incapacitation.

The aircraft was loaded to within the c.g. limits and was under the maximum gross take-off weight limitation.

Take-off was normal and the landing gear and landing lights were retracted after the aircraft became airborne. The landing lights were not turned off after retraction.

The aircraft made a slight right turn, then a left turn exceeding 25° of bank, rolled out and proceeded in an approximately straight line until it impacted Sweeney's Ridge.

The engines were functioning properly and were operating at a high rate of power at impact.

There were navigation instruments in the cockpit that were giving accurate heading and cross-check information at the time of the accident.

Cause or
Probable cause(s)

The pilot, for undetermined reasons, deviated from departure course into an area of rising terrain where downdraught activity and turbulence affected the climb capability of the aircraft sufficiently to prevent terrain clearance.

3. - Recommendations

The Civil Aeronautics Board (CAB) submitted the following recommendations to the Federal Aviation Agency (FAA).

3.1 On 22 April 1965 it recommended that all operators of Lockheed L 1049 aircraft equipped with radio transfer switch assembly (Lockheed part No. 319122) initiate a campaign to determine whether contamination of the switch assembly existed and take such steps as necessary to eliminate further contamination.

3.2 On 23 July 1965 it suggested to review the use of the term "radar contact" which could create a false impression of safety in the minds of the pilots, and to display prominently on aeronautical charts for departure limitations imposed by local features to radar vectoring.

3.3 On 24 September 1965 it recommended that the San Francisco departure controller be provided with an additional radar display, to be operated on a suggested 6 mile range setting.

4. - Action taken

4.1 On 14 May 1965 the FAA issued an Airworthiness Directive applicable to all L 1049 C, E, G and H series aircraft equipped with Lockheed radio transfer switch assembly (P/N 319122), requiring disassembly and checking of each switch assembly for wire clipping within 300 hours time in service.

4.2 New standard instrument departure (SID) procedures for San Francisco were issued and became effective on 22 July 1965. A note, to the effect that a minimum climb rate of 250 ft per mile up to 2,000 ft was required on certain SIDs, was included on the appropriate chart.

4.3 On 3 August 1965 the FAA advised the CAB that some of the terms in current use such as: "radar contact", "radar flight following", "radar hand-off", "radar service", radar surveillance", "radar target", "radar traffic information", "radar vector" and "radial" had been redefined and that their definition would be included in the Airman's Information Manual.

4.4 On 28 September 1965 approval was granted to the Western Region to proceed with the development of a common terminal radar control facility located at Oakland for the San Francisco/Oakland area.

ICAO Ref: AR/907

ACCIDENT TO L-1049H, N 69150C
OF THE FLYING TIGER LINE INC.,
AT SAN FRANCISCO, U.S.A.
24 DECEMBER 1964

SAN FRANCISCO INTERNATIONAL SID's
STANDARD INSTRUMENT DEPARTURES

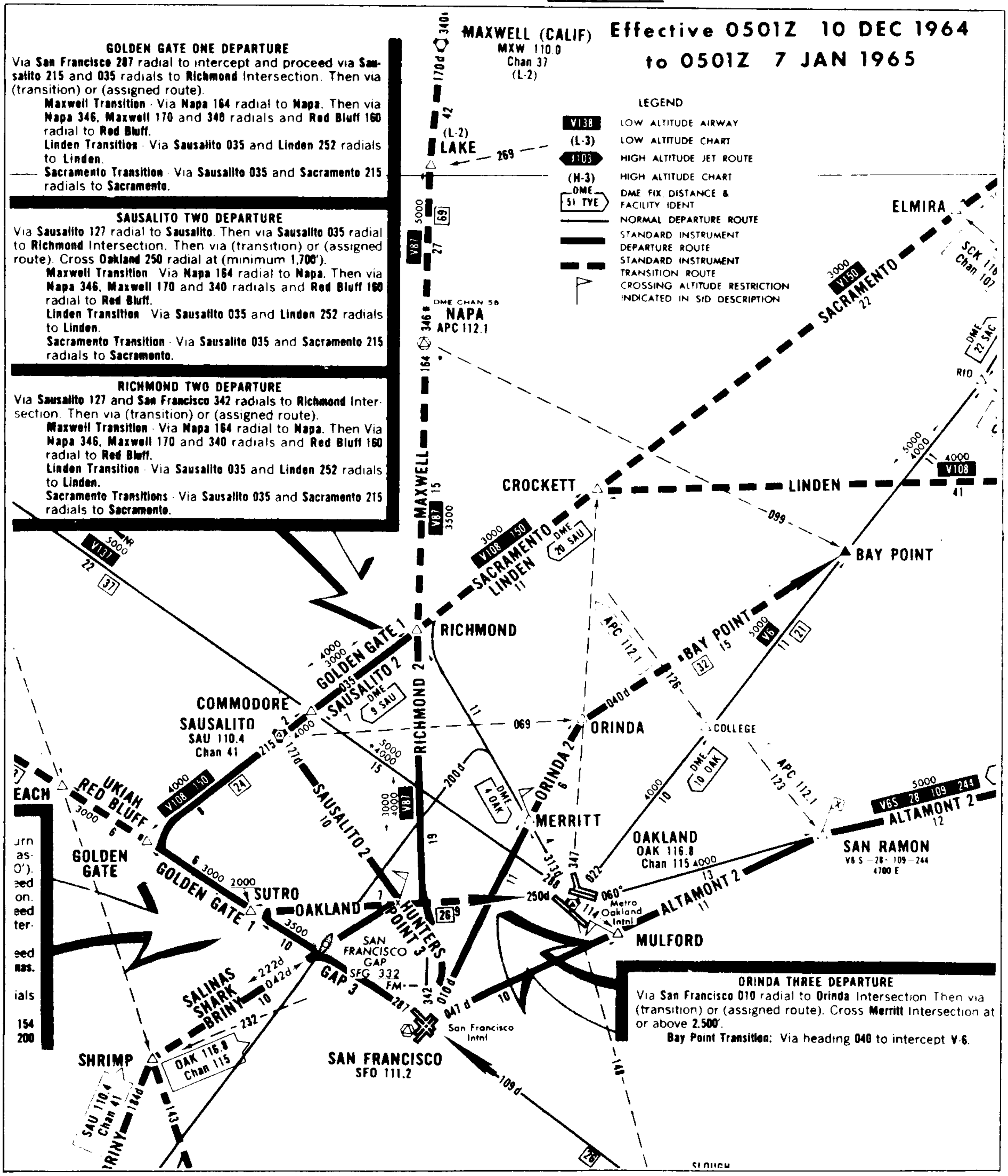

FIGURE 23-1

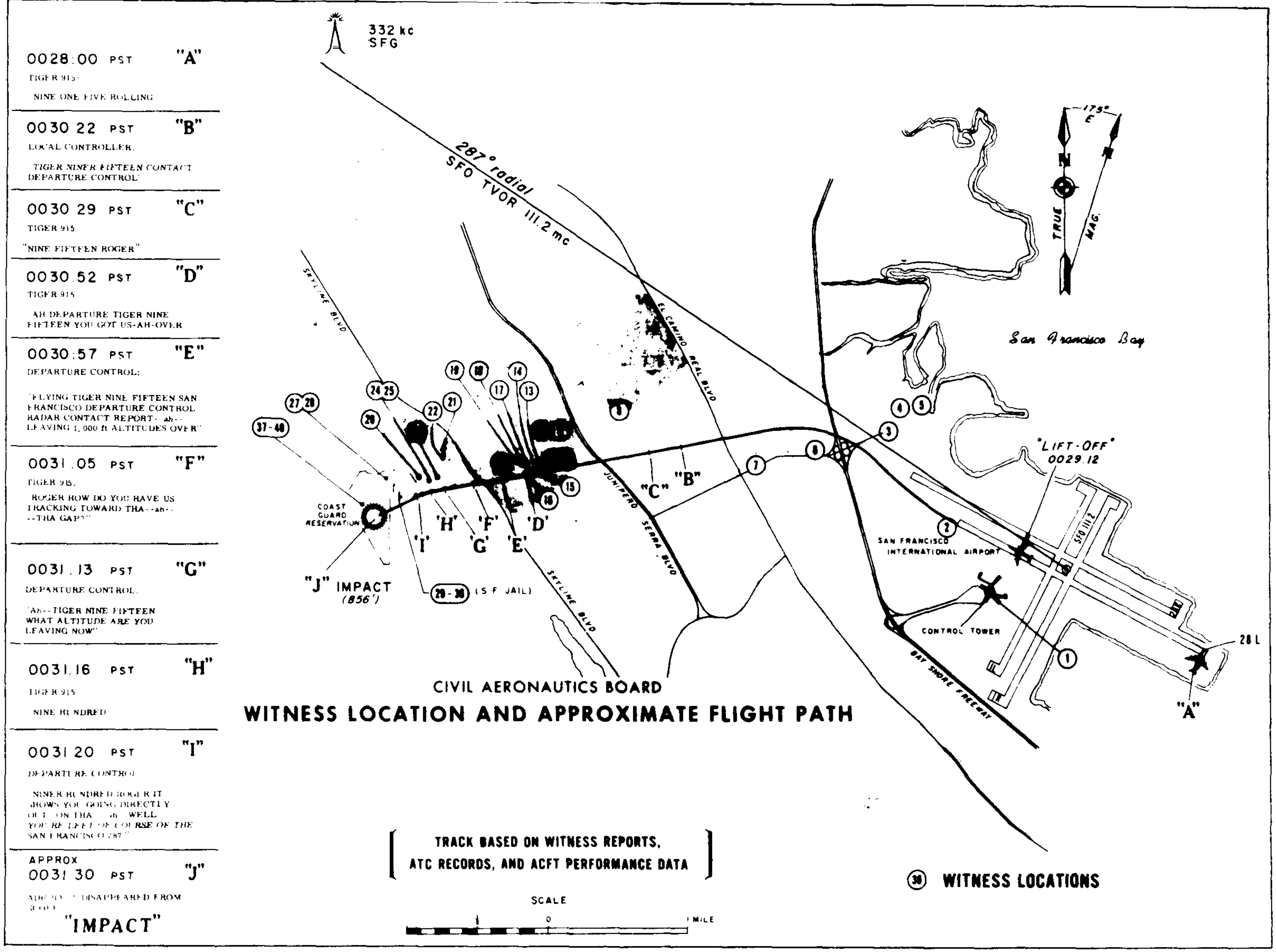
0028:00 PST "A"
TIGER 915:
NINE ONE FIVE ROLLING
0030 22 PST "B"
LOCAL CONTROLLER.
TIGER NINER FIFTEEN CONTACT DEPARTURE CONTROL'
0030 29 PST "C"
TIGER 915
"NINE FIFTEEN ROGER"
0030 52 PST "D"
TIGER 915
AH DEPARTURE TIGER NINE FIFTEEN YOU GOT US-AH-OVER
0030:57 PST "E"
DEPARTURE CONTROL:
'FLYING TIGER NINE FIFTEEN SAN FRANCISCO DEPARTURE CONTROL RADAR CONTACT REPORT- ah-- LEAVING 1,000 ft ALTITUDES OVER"
0031.05 PST "F"
TIGER 915.
ROGER HOW DO YOU HAVE US TRACKING TOWARD THA--ah-- --THA GAP?"
0031.13 PST "G"
DEPARTURE CONTROL.
'Ah--TIGER NINE FIFTEEN WHAT ALTITUDE ARE YOU LEAVING NOW"
0031.16 PST "H"
TIGER 915
NINE HUNDRED
0031 20 PST "I"
DEPARTURE CONTROL
APPROX
0031 30 PST "J"
"IMPACT"
332 kc
SFG
287° radial
SFO TVOR 111.2 mc
SKYLINE BLVD
EL CAMINO REAL BLVD
JUNIPERO SERRA BLVD
BAY SHORE FREEWAY
San Francisco Bay
175°
TRUE
MAG.
"LIFT-OFF"
0029.12
SAN FRANCISCO INTERNATIONAL AIRPORT
CONTROL TOWER
28 L
"A"
"B"
"C"
'D'
'E'
'F'
'G'
'H'
'I'
COAST GUARD RESERVATION
"J" IMPACT
(856')
29-36 (S.F. JAIL)
37-40
CIVIL AERONAUTICS BOARD
WITNESS LOCATION AND APPROXIMATE FLIGHT PATH
TRACK BASED ON WITNESS REPORTS, ATC RECORDS, AND ACFT PERFORMANCE DATA
WITNESS LOCATIONS
SCALE
0
1 MILE

FIGURE 23-2

ACCIDENT TO L-1049H, N 69150C
OF THE FLYING TIGER LINE INC.,
AT SAN FRANCISCO, U.S.A.
24 DECEMBER 1964

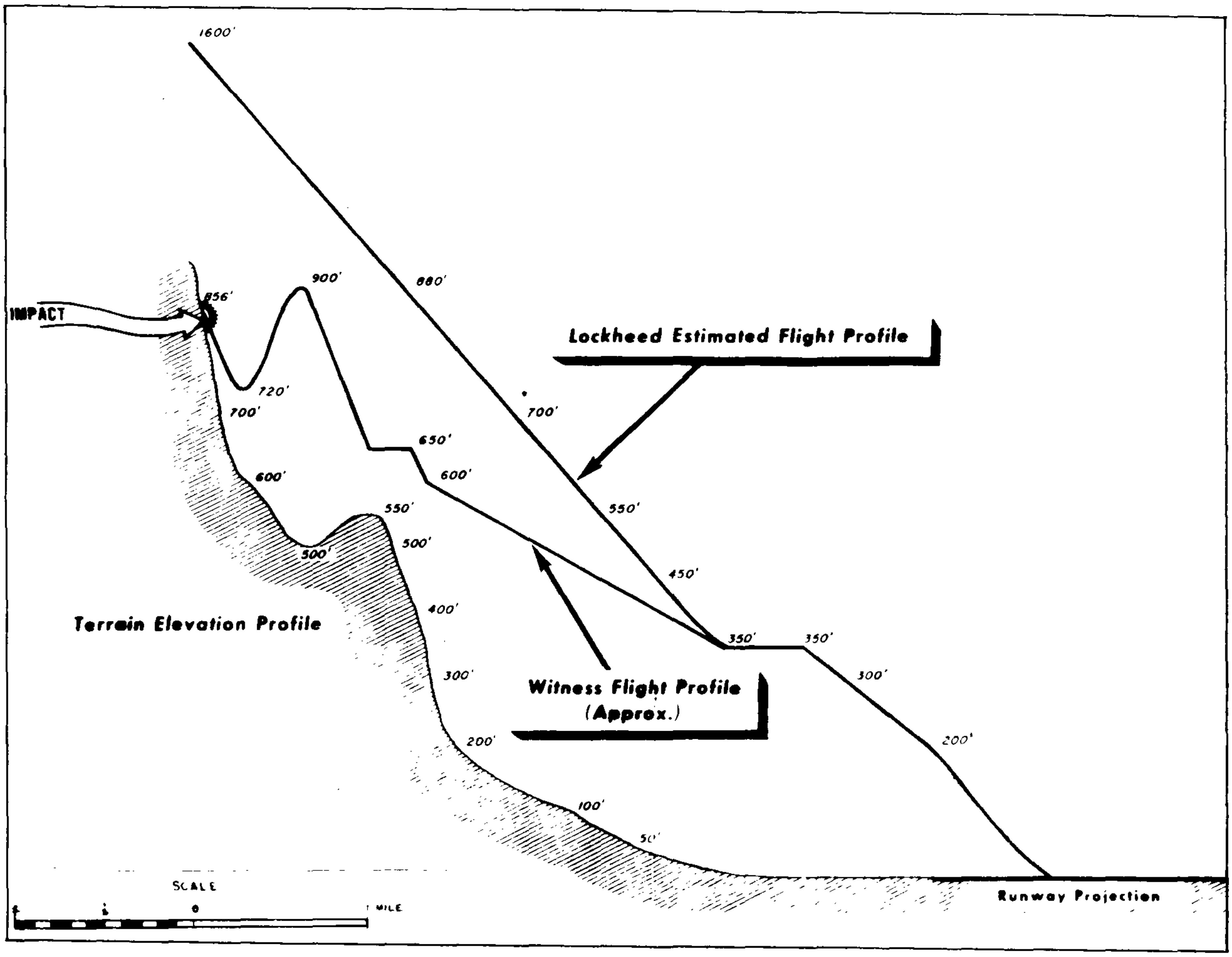

FIGURE 23-3

PART II

AIR SAFETY ARTICLES

FLIGHT OVER MOUNTAINS

Reprinted from Aeronautical Information Circular - United Kingdom (7/1968 - 15th January), published by the Board of Trade, Civil Aviation Department.

Since the issue in 1964 of an Information Circular entitled "Detection and Avoidance of Mountain Wave Systems - Safety Heights over High Ground", further research has been carried out which has added to the knowledge of the effects of high ground on airflow. The need for such research has been stressed by the fatal accident to the Boeing 707 which broke up in the air near Mount Fuji, Japan, on 5th March, 1966. The Report on this accident published by HMSO as C.A.P. 286, stated that it was not unreasonable to assume that on the day of the accident powerful mountain waves existed in the lee of Mount Fuji, and concluded that the probable cause of the accident was that the aircraft suddenly encountered abnormally severe turbulence which imposed a gust load considerably in excess of the design limit.

2. The aim of this Circular is, therefore, to remind pilots of the basic theory of airflow over mountains and to include additional information that has become available, to describe the effect of the airflow on aircraft in flight and to offer advice on avoiding or minimising the various hazards that may be encountered. The Circular is divided into three parts:

Part 1 - Meteorology - contributed by the Meteorological Office;

Part 2 - Flying Aspects - based on information provided by the Meteorological Office with advice from the Royal Aircraft Establishment; and

Part 3 - Advice to Pilots - based on the experience of pilots of the Royal Aircraft Establishment and the Air Registration Board participating in mountain wave and severe storms research flights in the United States.

Part 1 - METEOROLOGY

1. General Description

1.1 The flow of an airstream over mountainous terrain is disturbed in a manner broadly analogous to the disturbance of a river flowing over a rocky bed; the ripples and scattered breakers on the river surface corresponding roughly to the mountain waves and turbulence often found above mountainous terrain. In general, the higher the mountains or the faster the airflow, the greater is the resulting disturbance.

1.2 In stable air conditions, the disturbance of a transverse airflow by a mountain range can create an organised flow pattern comprising waves and/or large scale eddies in which strong vertical currents and turbulence sometimes occur. These effects are often manifest to a considerable height above the level of the high ground, and there is some evidence that strong wave conditions are very favourable for the propagation of disturbances well into the stratosphere, occasionally to altitudes of 80 000 ft. Wave disturbances occurring over mountains are referred to as mountain waves; when these disturbances are propagated for some distance over relatively flat ground to the lee of the mountain they are termed lee-waves.

1.3 In unstable air, vertical air currents are liable to be more intense over mountains than over level terrain, especially in strong airstreams transverse to the general direction of the mountain ridges. In these conditions the distribution of vertical currents is irregular.

1.4 The meteorological conditions favourable for the formation of mountain and lee-waves are:

(a) A wind blowing within about 30° of a direction at right angles to a substantial ridge. A ridge with a gentle up-wind slope and steep down-wind escarpment is the most efficient generator of lee-waves.

(b) A wind speed at crest level of more than about 20 kt and speed increasing with height, but with little change in direction. It should be noted that strong wave conditions are often associated with jet streams.

(c) A marked stable layer (approaching isothermal, or an inversion) somewhere between crest level and a few thousand feet above. This stable layer must be bounded by less stable air above and below.

1.5 The resulting wave systems may extend well into the stratosphere for many miles down-wind of the initiating high ground and will often persist for a number of hours. Satellite photographs have shown wave clouds as much as 500 miles down-wind of the Andes, but 50-100 miles is a more usual value in most areas.

1.6 The average wavelength of lee-waves is about 5 miles but may be anything up to 30 miles; in general, the stronger the wind, the longer the wavelength.

1.7 The wave amplitude is a more complex factor, but tends to be greatest if the dominant wavelength of the mountain wave is roughly "matched" to the shape of the topography (i.e. a form of resonance) and also tends to increase with the "amplitude" of the terrain.

1.8 The speed of the vertical currents within the wave system depends upon the wavelength, wave amplitude and wind speed. Even over the British Isles vertical currents up to 35 ft/sec have been recorded, but values greatly in excess of this may occur near large mountains.

1.9 In extensive mountainous areas the lee-wave system generated by one ridge is disturbed by further ridges down-wind. Furthermore, the characteristics of any given airstream are always slowly changing with time, and occasions when a small change in airstream characteristics gives rise to a large change in mountain wave characteristics can be envisaged, but not forecast. Such a change may generate a transient but severe disturbance resulting in violent turbulence (e.g., due to wave "breaking").

2. Visual Detection of Mountain Waves

2.1 The varieties of special clouds which owe their appearance to the nature of wave flow are a valuable indicator to the pilot of the existence of wave formation. Provided there is sufficient moisture available, the ascent of air will lead to condensation and formation of characteristic clouds. These clouds form in the crest of standing waves and therefore remain more or less stationary in relation to the surface relief.

2.2 They occur at all heights from the surface to cirrus level and are described briefly in the following paragraphs read in conjunction with the diagram (after Kuettner) on page 159 which shows the characteristic distribution of clouds and turbulence to the lee of the Sierra Nevada. This is an area in which mountain wave phenomena are exceptionally marked, but the diagram has a fairly general application.

(a) Lenticular clouds provide the most unmistakable evidence of the existence of the existence of mountain waves. They form within stable layers in the crests of standing waves while air streams through them, the clouds regenerating at their up-wind edges and dissipating down-wind. They have characteristically smooth lens shaped outlines and may appear at several levels, sometimes resulting in an appearance reminiscent of a stack of inverted saucers. Lenticular clouds usually appear up to a few thousand feet above the mountain crests, but are also seen at any level up to the tropopause and even above. (Mother-of-pearl clouds, seen on rare occasions over mountains, are undoubtedly a form of wave cloud at an altitude of 80 000 ft or so). Airflow through these clouds is usually smooth unless the edges of the cloud take on a ragged appearance which is an indication of turbulence.

(b) Rotor or roll-clouds appear at first glance as harmless bands of ragged cumulus or stratocumulus parallel to and down-wind of the ridge. On closer inspection, these clouds seem to be rotating about a horizontal axis and are produced by local breakdown of the flow into violent turbulence. They often occur in the crests of strong waves, but underneath the stable layers associated with the waves. The strongest rotor normally forms in the first wave down-wind of the ridge, and is therefore usually near or somewhat above the level of the ridge crest, but may occasionally be much deeper (rotor clouds have been reported to extend to 30 000 ft over the Sierra Nevada). There are usually not more than one or two rotor clouds in the lee of a given ridge.

(c) Cap clouds form on the ridge crest or mountain summit and strong surface winds which are commonly found sweeping down the lee slope may sometimes extend the cap cloud down the slope producing a "cloud fall" or "föhn wall".

2.3 Although cloud often provides the most useful visible evidence of disturbances to the airflow, the characteristic cloud types may sometimes be obscured by other cloud systems, particularly, frontal cloud. On the other hand, the air may be too dry to form any clouds at all, even in strong wave conditions.

3. Turbulence

3.1 Although flights through stable mountain waves are often remarkably smooth, turbulence is likely to be encountered at any level and may on occasions be as violent as that encountered in severe thunderstorms.

(a) Rotor turbulence

The worst turbulence encountered over mountainous terrain is usually found in standing rotors. Within these rotors vertical velocities of up to ± 100 ft/sec may occur and can cause structural damage or may even break up an aeroplane.

(b) Low Level turbulence (within a few thousand feet of the mountain summit)

A strong wind flowing over irregular terrain will produce general low level turbulence which increases in depth and intensity with increasing wind speed and terrain irregularity. Strong winds confined to the lower troposphere generally produce the most turbulent low level conditions, sometimes accompanied by "rotor streaming" comprised of violent low level rotors which are generated intermittently near the lee slopes and move down-wind for a distance before decaying. These low level rotors are distinct from the stationary rotor zones in wave crests at higher levels.

(c) High Level turbulence

Most public transport aircraft now fly at or near jet stream levels and evidence is accumulating that turbulence in jet streams is frequently greatly increased in intensity and extent over mountainous areas, particularly in the vicinity of stable layers in the upper troposphere, e.g., the tropopause. Although the worst turbulence may occur just underneath stable layers, it may also occur within stable layers if the wind shear is strong enough. Strong vertical wind shears are often concentrated in one or more stable layers a few thousand feet below a jet stream core and in the base of the stratosphere above. Note here that although the cold side of a jet stream is known to be prone to turbulence, mountain wave conditions may be most pronounced on the warm side.

(d) Stratospheric turbulence

Recent evidence from research flying undertaken by the Royal Aircraft Establishment over the Rocky Mountains in America shows that strong waves, sometimes with associated severe turbulence, may occur well into the stratosphere on days favourable for strong wave formation in the troposphere, and can cause serious difficulties to an aircraft flying near its ceiling.

(e) Turbulence due to changing conditions

Changes in wave amplitude and wavelength, due to changing airstream characteristics and interference between adjacent wave trains, may be expected to produce severe turbulence on occasion at any altitude. These disturbances will probably be transient and not necessarily stationary. Virtually nothing is known about them, either by observation or in theory and they cannot be forecast, apart from a general indication that they are most likely to occur anywhere over and to the lee of mountainous terrain in mountain wave conditions, particularly when marked changes in the upper air pattern are occurring.

4. Icing

4.1 Adiabatic cooling caused by the forced ascent of air over mountainous regions in wave systems generally results in a lowering of the freezing level and an increase of liquid water concentration, particularly in wavecrests. Thus airframe icing is likely to be more severe than at the same altitude over lower ground when extensive cloud is present. This hazard is at a maximum a few thousand feet above the freezing level, but in general is unlikely to be serious at altitudes much above 20 000 ft.

Note. Further information on meteorological aspects is contained in WMO Technical Note No. 34 "The Airflow over Mountains", which is obtainable from the World Meteorological Organization in Geneva.

Part 2 - FLYING ASPECTS

1. The effects of mountain waves on aircraft in flight depend on the magnitude of the disturbance to the airflow, the performance of the aircraft, its altitude and the aircraft's speed and direction in relation to the wave system. A broad distinction may be made between low level hazards (below about 20 000 ft) and high level hazards (above 20 000 ft).

2. Low Altitude Flight

2.1 The main hazards arise from severe turbulence in the rotor zone, from down-draughts and from icing. The presence of roll clouds in the rotor zone may warn pilots of the region of most severe turbulence, but characteristic cloud formations are not always present or, if they are present, may lose definition in other clouds. Similarly, the up-draughts and down-draughts are, in general, not visible. If an aircraft remains for any length of time in a down-draught (e.g. by flying parallel to the mountains in the descending portion of the wave), serious loss of height may occur.

2.2 During up-wind flight the aircraft's height variations are normally out of phase with the waves; the aircraft is, therefore, liable to be at its lowest height when over the highest ground. The pilot may also find himself being driven down into a roll cloud over which ample height clearance previously appeared to be available.

2.3 Down-wind flight may be safer. Height variations are usually in phase with the waves, but it must be appreciated that the relative speed of an accidental entry into the rotor zone will be greater than in up-wind flight, because the rotor zone is stationary with regard to the ground. Thus, the structural loads which may be imposed on the airframe when gusts are encountered are likely to be greater and there will probably be less warning of possible handling difficulties.

3. High Altitude Flight

3.1 The primary danger at high altitude is that of a sudden encounter with localized disturbances (i.e. turbulence, sudden large wind and temperature changes) at high penetration speeds, and this is particularly relevant at cruising levels above 30 000 ft where the buffet-free margin between the limiting Mach number and the stall is restricted. In this respect flight down-wind is likely to be more critical than flight up-wind, especially when the wind is strong. As in the case of low altitude flight the waves are stationary relative to the ground, and the higher relative speed on accidentally encountering a standing wave while flying down-wind is likely to place greater loads on the airframe. There will often be no advance warning of the presence of wave activity from preliminary oscillation or turbulence. Although down-draughts are present, they are unlikely to be hazardous and icing and rotor zone turbulence are unlikely.

4. General

4.1 While flying through strong mountain waves large fluctuations in wind velocity may be encountered, with associated turbulence, and an aircraft entering a wave system with its auto-pilot, including height and airspeed locks, fully engaged may begin to oscillate in the pitching plane as it attempts to maintain the selected height and airspeed. This oscillation can become unstable and, if unchecked, may put an aircraft into a dangerous attitude as a result of excessive tailplane deflection. If the aircraft is being flown manually and the pilot chases height or airspeed, a similar result may occur. In either case, there is the risk of an upset developing with catastrophic results. This emphasises the importance of the well established technique of flying "attitude" in these conditions.

Part 3 - ADVICE TO PILOTS

1. Areas of turbulence associated with mountain and lee-waves cannot be forecast with accuracy, but Meteorological Offices can help pilots to assess the probability of occurrence of mountain and lee-waves, and assess the height of layers of marked stability. When planning a flight over mountainous terrain, take care to ensure that the possibility of mountain wave conditions is considered at the meteorological briefing, particularly if frontal conditions are present in the area and a jet stream is expected at altitude. Pay careful attention to any warnings which may be given in SIGMET broadcasts by the Air Traffic Control network during the course of the flight.

2. If wave development is forecast or known to be present:

(a) do not attempt to penetrate or approach rotor clouds or likely rotor zones adjacent to mountain ranges;

(b) an in-flight clearance of at least 5 000 ft is necessary above mountains which are up to 5 000 ft in height above the surrounding terrain; for higher mountains the clearance should be at least equal to their height above the terrain; this should enable the worst of the lower altitude hazards to be avoided;

(c) choose cruising altitudes well away from the base of layers of marked stability in the atmosphere where severe turbulence is most likely to occur (present information suggests that while there may be more than one stable layer, a margin of 5 000 ft on either side of the tropopause is advisable);

(d) be prepared for the occurrence of icing if cloud formations are present.

3. When flying in an area in which mountain wave conditions are suspected, always be prepared for turbulence, even in clear air, and take precautions accordingly. These precautions should include:

(a) setting up the recommended speed for flight in turbulence;

(b) re-trimming the aircraft and noting the trim position so that any changes that may occur (due to auto trim action when using the auto-pilot) can be quickly detected;

(c) ensuring that crew and passengers are securely strapped in and that there are no loose articles;

(d) following the recommendations on the use of auto-pilot, height and airspeed locks and stability aids (yaw dampers etc.) as appropriate.

4. If entry into turbulent mountain wave conditions is unavoidable, or unexpected, the following procedures are advisable subject to any recommended operating techniques for the particular aircraft type:

(a) make certain that the passenger seat belt sign is on and that the crew are properly strapped in;

(b) attempt to maintain a constant pitch attitude, avoiding excessive control applications; adjust speed slowly and progressively to that recommended for rough air penetration (if this has not already been done), monitoring the auto-pilot very closely if engaged;

(c) if the auto-pilot is used, ensure that the height, speed and Mach locks are disengaged;

(d) ignore the minor transient speed and height fluctuations induced by gusts and maintain a good instrument scan; correct any steady speed variations at the expense of altitude if necessary;

(e) do not attempt to chase the gust-induced lateral rocking but aim to keep the aircraft laterally level to within reasonable limits;

(f) try to make all control inputs smoothly and gently.

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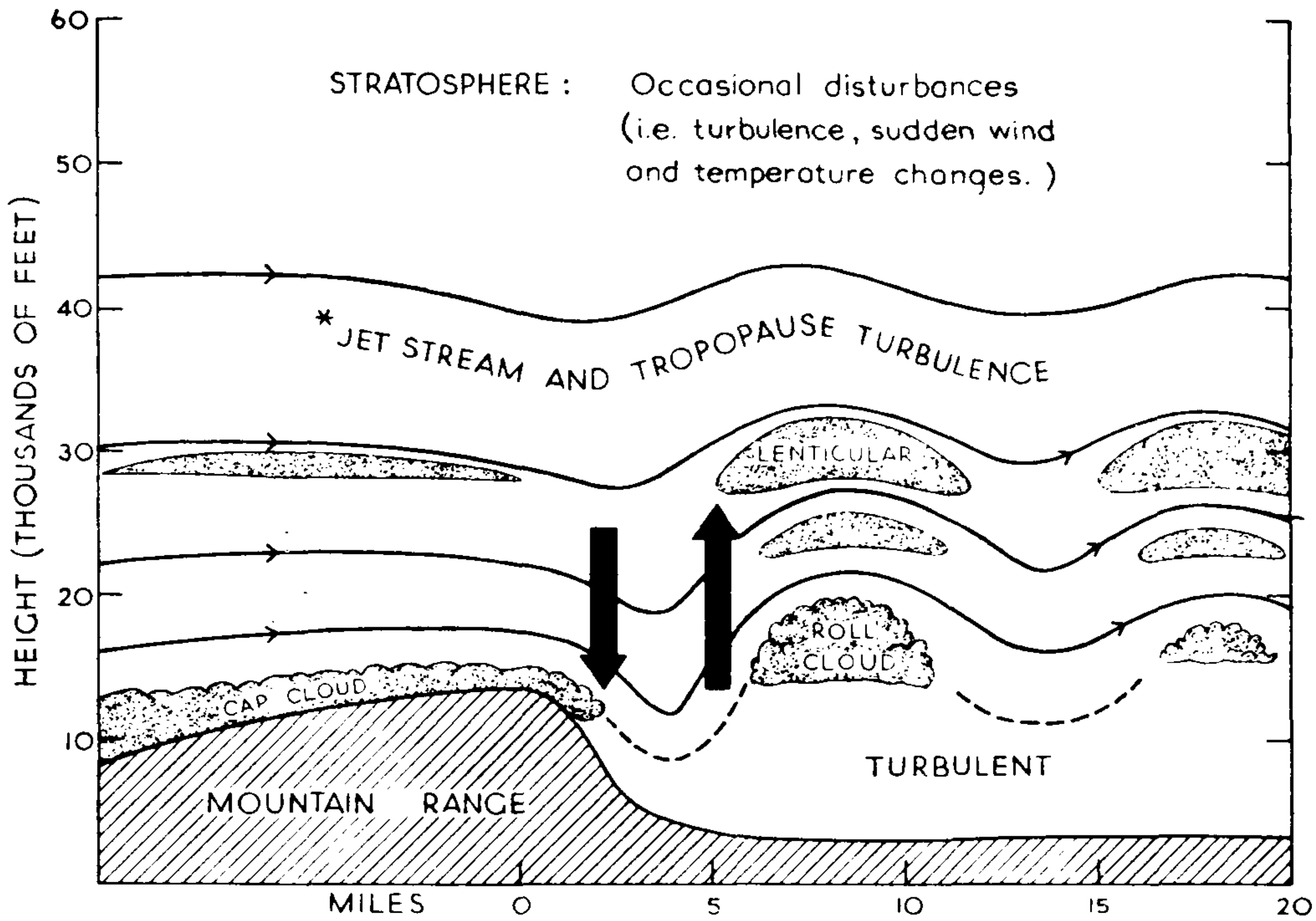

* The tropopause and level of maximum wind are usually located somewhere within this layer

MODEL OF A WELL-DEVELOPED MOUNTAIN WAVE SHOWING TYPICAL FEATURES

THE POTENTIAL ROLE OF FLIGHT RECORDERS IN AIRCRAFT ACCIDENT INVESTIGATION

The following paper, prepared by B.R. Allen, Director, Bureau of Safety, and J.S. Leak, Chief, Technical Services Section, Engineering Division, of the Civil Aeronautics Board,* Washington, D.C., was presented at the CASI/AIAA/CGASC Aviation Safety Meeting, held in Toronto on 1 November 1966, and appeared in the Canadian Aeronautics and Space Journal dated June 1967.

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SUMMARY

The history, present state and developments of flight recorders are discussed. Sample cases, with explanations, are presented to show the capability of the presently installed recorders to furnish data from which energy analyses, flight tracks and profiles can be made. Also discussed are the advantages to be gained in accident investigation and prevention from added parameters such as attitude and angular rates about the three axes, powerplant condition and selected systems indications. Evaluation is now being made by several airlines on the feasibility of "maintenance recorders" which monitor several powerplant and systems parameters for subsequent analyses concerning the progression of aircraft components toward needed maintenance or replacement. The prospects and advantages of combining flight recorders and maintenance recorders into one data recording system, adaptable to EDP, are discussed along with the application of the collected data to accident investitation, e.g. analyzing recorded component trends, matching powerplant and systems parameters with aircraft attitudes and motions, and assisting the investigator in his efforts to concentrate on those aspects of the investigation most likely to yield causal information.

INTRODUCTION

Admittedly, the flight recorder, which has been in operation for several years, is no panacea. It was never intended nor will it ever be an all-seeing, all-knowing automation of the type a science-fiction writer might conjure up. The flight recorder, however, has proven its value as an accident investigation tool, and it is showing its potential as an aid to accident prevention. Additionally, flight recording in the rapidly advancing state of the art may became one of the greatest single boons to air management since the log book.

Because of the flight recorder's ever increasing importance in aviation, it is imperative that everyone associated with accident investigation and prevention should become familiar with this instrument, not necessarily with its mechanical and electronic features, but with its role in the investigative process, what it can and cannot do and, above all, its potential. Toward this end, this report presents a brief history of the flight recorder, how it is presently read out and to what uses the data can be put. It also discusses the nee

* On April 1, 1967, the safety functions of the Civil Aeronautics Board were transferred to the newly created National Transportation Safety Board, Department of Transportation.

for additional parameters and what they should be, other needed improvements, and how the increasing use of recorder data can enhance accident investigation and prevention.

HISTORY

The first Civil Air Regulation on flight recorders, Amendment 100, took effect in April 1941 and required on air carrier aircraft a device that would record altitude and radio transmitter operation (on and off). The compliance date was subsequently extended three times and finally in June 1944, the Civil Aeronautics Board rescinded the requirements primarily because of maintenance difficulties and lack of replacement parts for the recorders due to the war effort.

A similar regulation was adopted in September 1947, requiring recorders in aircraft of 10 000 lb or more to record altitude and vertical acceleration. Again, on July 1, 1948, the CAB rescinded the requirement as there were no instruments readily available of proven reliability or adequate for the intended purpose.

During the next nine years CAA and CAB studied possible requirements, met with industry representatives, and proposed amendments defining the flight recorder program.

In 1948 the French Air Safety Commission became interested in flight recorders, leading to the installation of recorders in ten aircraft belonging to Air France and TAI. The experiment aroused so much interest that TAI decided to equip all its aircraft voluntarily at its own expense.

Finally, in August 1957, CAB adopted amendments to CAR Parts 40, 41, 42 and 43. Required was the installation of flight recorders after July 1958 in all aircraft over 12 500 lb and being operated in air carrier service at altitudes above 25 000 ft. The functions to be recorded were airspeed, altitude, direction and vertical acceleration against a base of time. At about the same time the French issued similar requirements.

In September 1959 the regulations were amended to establish a 60-day record retention period and to clarify the time period of recorder operation, i.e. continuously from beginning of takeoff roll to completion of landing roll.

Many of the early major accidents of the newly introduced jet transports occurred during training operations. Much valuable investigative data were lost, or had to be sifted out by long and tedious work, because the flight recorders were not turned on. The CAB and FAA recognized that the training accident often stems from intentionally introduced problems or emergencies (dutch roll practice, flight near V_{MC}, takeoffs and landings with engines inoperative etc.) and, therefore, provides an excellent base for implementing corrective measures. Consequently, the regulations were again amended to require operation of the flight recorder on all flights. Additionally, the regulations were extended to include all turbine-powered transport category airplanes operated by US air carriers.

During the past few years several governments have either issued or have made moves toward issuing flight recorder requirements and some carriers have installed or are planning installation of recorders voluntarily. The military services have become increasingly interested in recorders for accident investigation purposes, have installed them on some aircraft, e.g. C-133 and C-141, and are planning for future planes, e.g. C-5A.

The latest action to be taken in the United States toward improvement of the flight recorder program was the recent change recommended by CAB in the Federal Aviation Regulations to relocate the recorder in the rear portion of the aircraft. It is yet too early for the CAB to offer any statistics on how much this will improve the overall flight recorder readability; however, the results of a French study may be a good indicator. In examining the post accident conditions of 51 serious accidents, including 39 total destruction cases, 3 mid-air collisions, 3 in water ranging from 5 fathoms to deep seas, 28 with fire following impact, an aft mounted recorder either was or could have been recovered in 98% of the accidents. Superimposed here is the fact that the recorder in this study uses a photographic process and is protected from impact and fire only by its aft location. The US recorders, tested to 100 g and 1100°C for 30 min., should give at least comparable recoverability in the aft position.

CURRENT ACCIDENT INVESTIGATION ROLE

As of September 30, 1965, the Civil Aeronautics Board had investigated over 181 accidents involving aircraft with flight recorders installed. Vital information was obtained from flight recorders in 125 cases, although in 6 of these the quality and quantity of data were seriously reduced because of impact damage to the recording medium. In ten other accidents during this period recorder information was not available as follows:

Recording medium fragmented; pertinent pieces not recovered - 3 cases.
Aluminum foil medium consumed by prolonged exposure to fire - 3 cases.
Medium supply expended prior to the accident - 2 cases.
Medium not advancing - 1 case.
Recorder not turned on - 1 case.

The other 46 of the 181 accidents were of a nature such that readout was considered unnecessary (e.g. landing gear collapse during taxi, fire during engine starting, injuries to ground crew). Flight recorders have also been read out in a large percentage of the incidents investigated by the CAB, primarily those involved in turbulence.

Beyond the flight recorder's primary purpose as an investigation tool toward determination of probable cause, it has provided data for many studies conducted by NASA, FAA, airlines, manufacturers, and other groups in such areas as turbulence, airplane handling qualities and pilot techniques.

Cited below are examples of how the flight recorder has been used in accident investigation.

CASE 1

A DC-8 landed with an existing hydraulic malfunction. Early during the rollout the aircraft veered off the runway, struck obstacles and burned. Examination of the readout showed a fluctuating altitude trace shortly after touchdown. This fluctuation was traced to disturbed airflow at the static ports as the result of unsymmetrical reverse thrust. Further, the airspeed and heading traces, combined with tire track information, formed the basis for an analysis which proved that the yawing rate was not possible with application of full rudder, full nose steering and full braking on one side; it required positive thrust on one side of the aircraft and reverse thrust on the other.

CASE 2

The pilot of a Boeing 707 attempted to abort a takeoff near V_1. The aircraft travelled the full length of the runway, struck an obstacle and burned. The airspeed and heading traces were used as bases for an energy analysis, which showed when the power was reduced, when and to what degree the retarding devices (speed brake, wheel brakes, reverse thrust) were used.

CASE 3

A Viscount on a go-around pitched over sharply from less than 200 ft, crashing nose down just beyond the far end of the runway. Upon examination of the recorder readout plot, there was a suspicion that the aircraft may have struck a bluff or other obstacles under the approach, thus damaging the control system. Figure 1 shows the profile of the flight, made by converting indicated airspeed to true airspeed and ground speed, then integrated to find the geographic points under the altitude trace. The profile shows that, while the aircraft was close to the bluff, it did not strike it or other obstructions. The profile also revealed excessive airspeed for landing near and over the runway, followed by rapid deceleration, probably flap actuation, but too far down the runway for a landing. While this investigation was underway the flight recorder readout of an approach incident involving empennage rime ice led to wind tunnel tests and other analytical work. It was finally concluded that the accident resulted from empennage ice. On the basis of these developments through the flight recorder, the CAB reopened the investigation and changed the probable cause of a Viscount accident in 1958 before the installations of flight recorders.

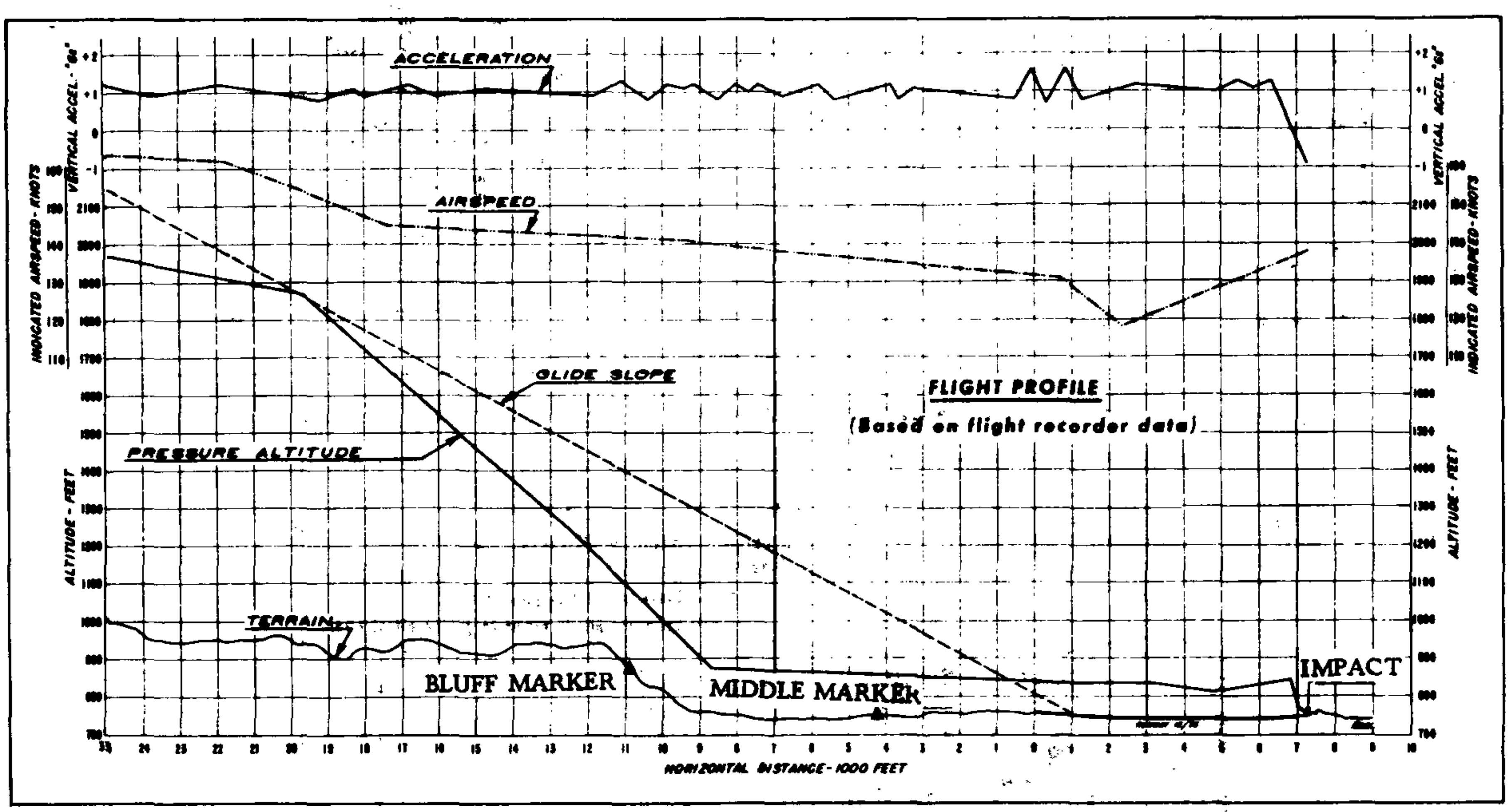

FIGURE 1.- Flight profile

CASE 4

A Boeing 727 struck the ground short of the runway on a long, straight-in, visual approach. Figure 2 shows the profile obtained by integrating the readout and plotting the result against a terrain profile. Also depicted is the high rate of descent as the aircraft approached the airport. This information, obtained from the flight recorder, helped materially to define the flight conditions surrounding this accident and to arrive at the probable cause: failure of the captain to take timely action to arrest an excessive descent rate during the landing approach. Figure 3 shows only the final stage of this approach and, therefore, better detail of the descent path with relation to the glide slope and the runway.

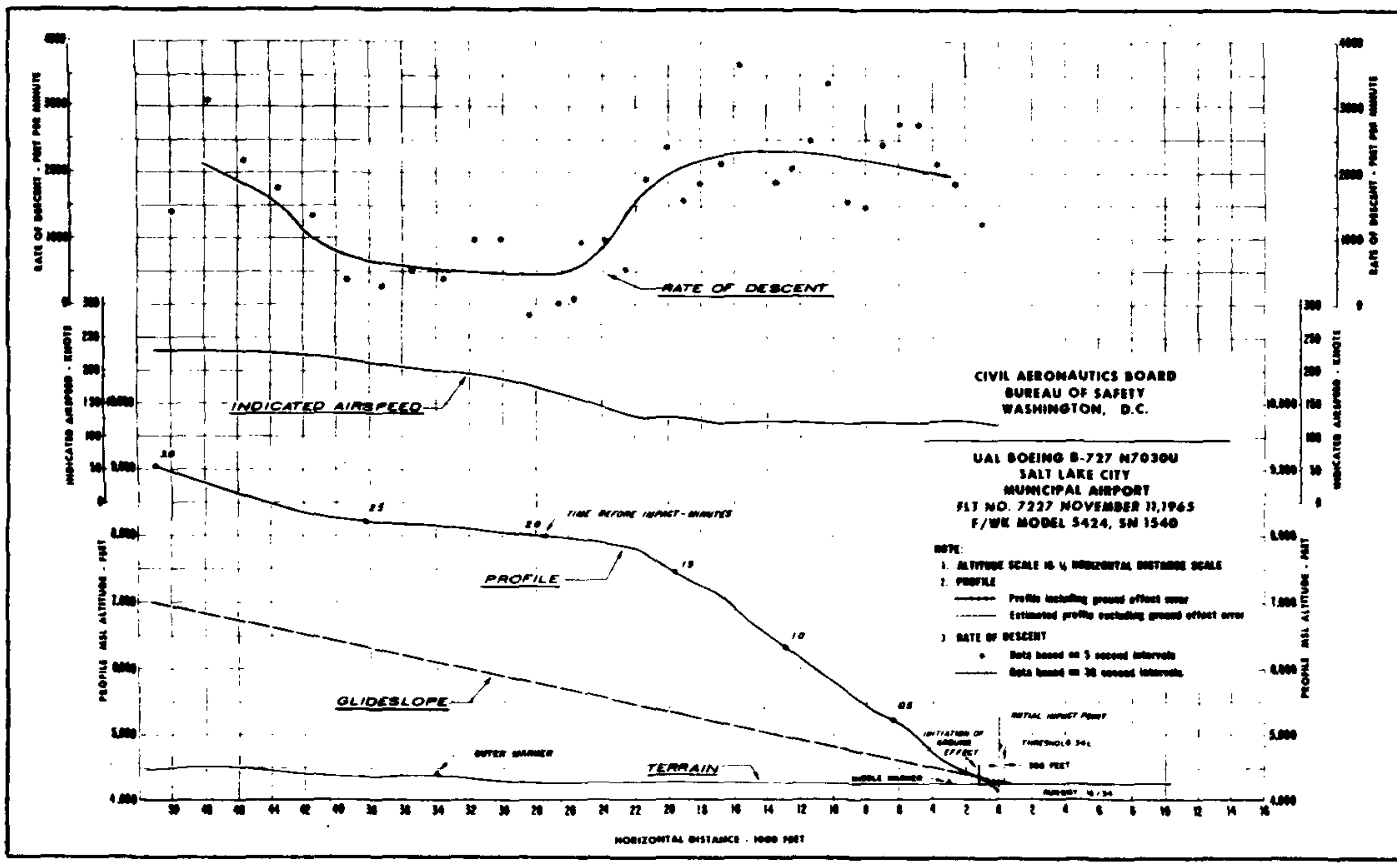

FIGURE 2.- Flight profile (based on flight recorder data)

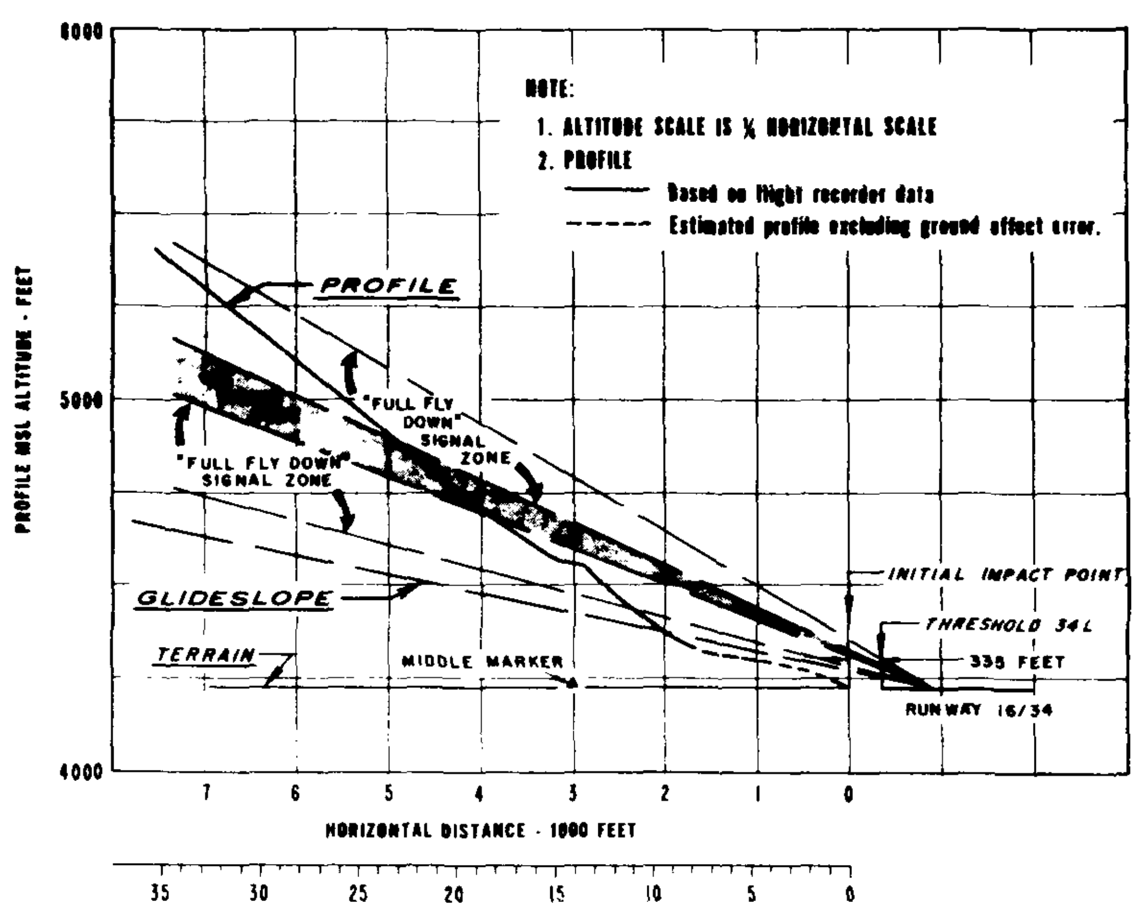

FIGURE 3

CASE 5

Another 727 crashed short of the airport while making a circling, visual approach in deteriorating weather. The flight recorder in this case gave the usual airspeed, altitude, heading and normal acceleration, thus giving valuable information on rates of descent, turning rates etc. Additionally, as shown in Figure 4, it was used to recreate the airplane's track durirg its final moments. The first calculations were done on a no-wind basis, producing the broken line shown in Figure 4. Later, after the low altitude wind velocity and direction had been well firmed up, the wind was applied to produce the hash line. By merging this information with data gathered by the Witness Group and the ATC Group, the superimposed tracks from the several sources appear as shown in Figure 5.

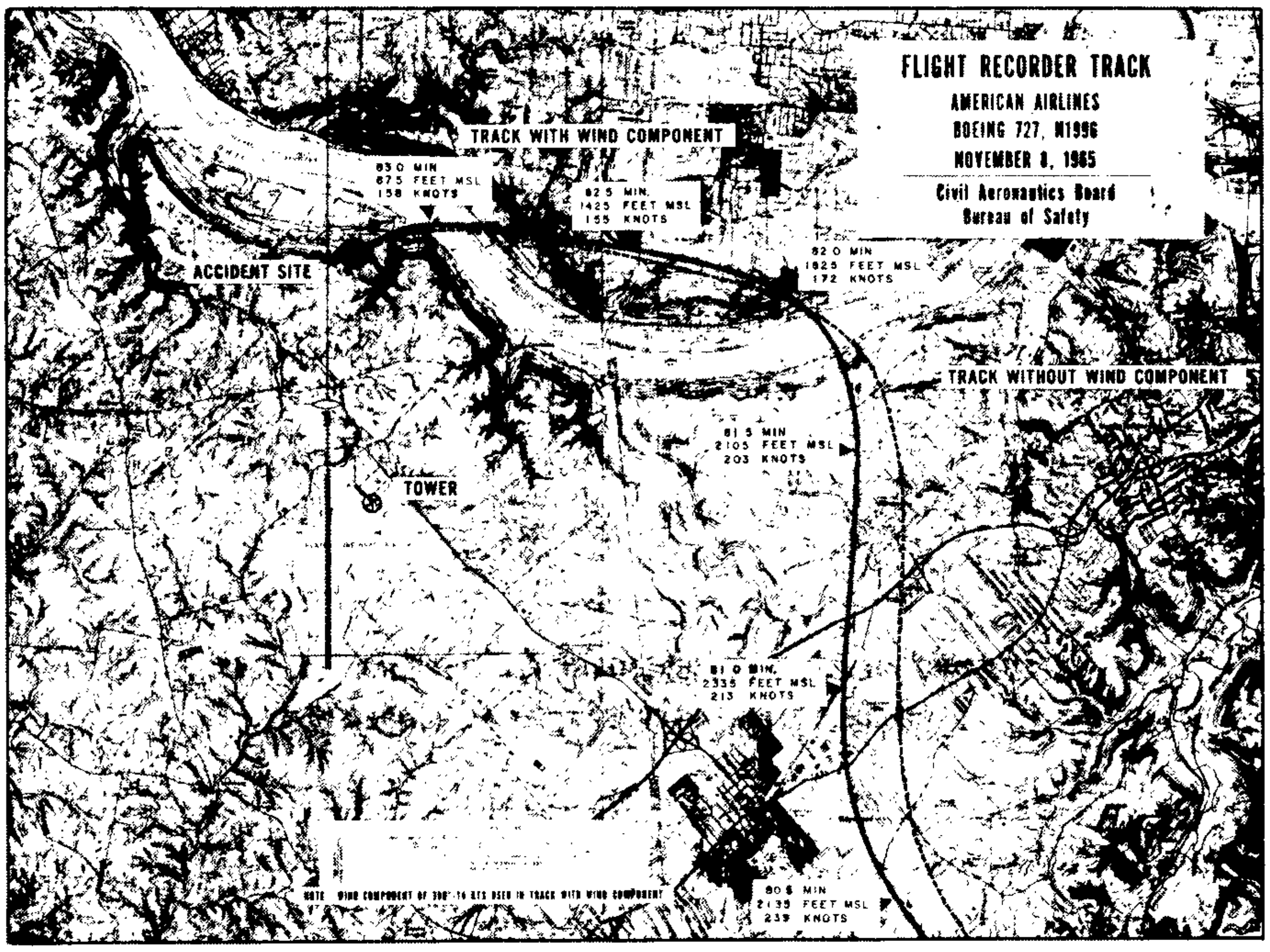

FIGURE 4.- Flight recorder track

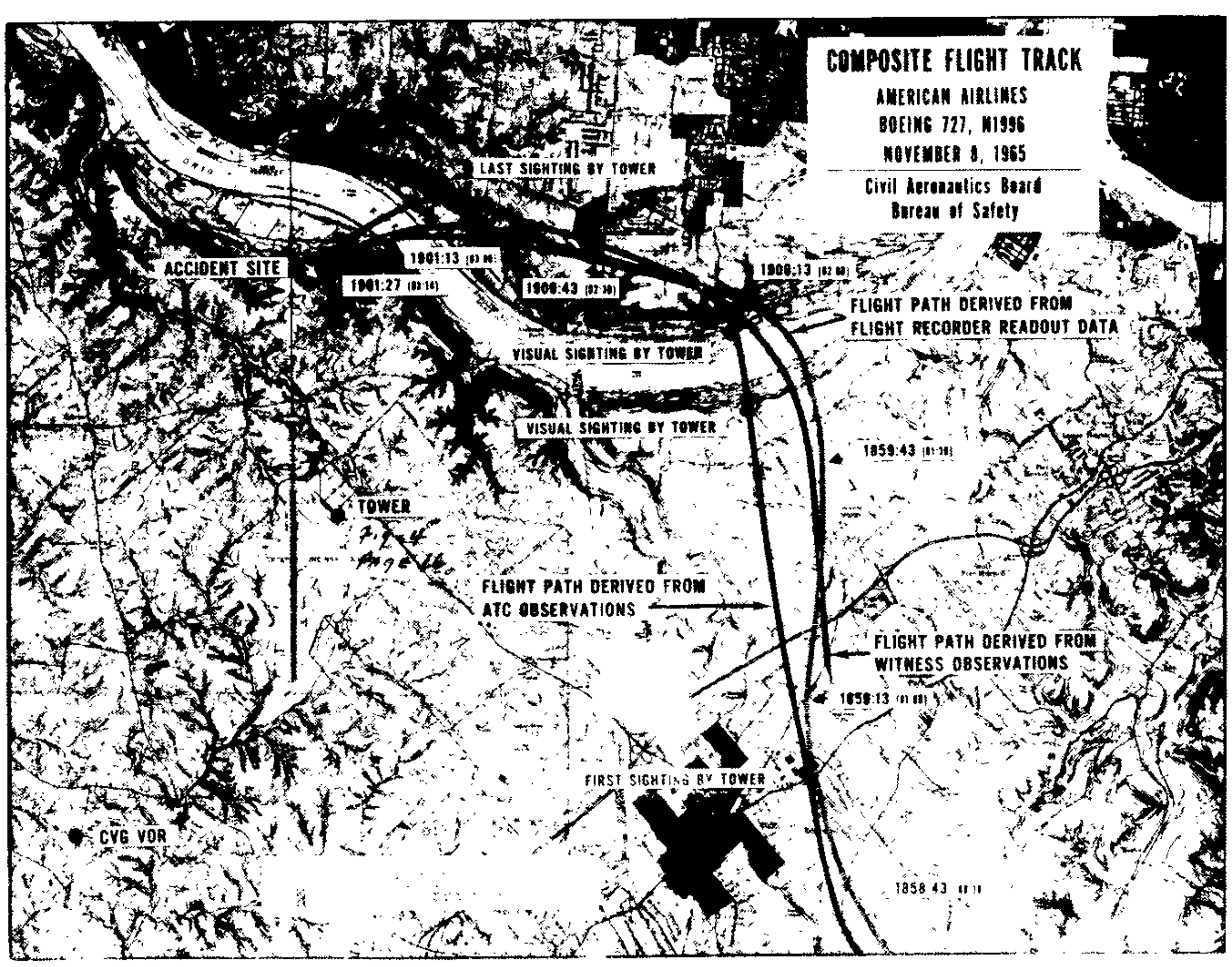

FIGURE 5.- Composite flight track

CASE 6

A Boeing 720 crashed after reaching about 18 000 ft during climb through a turbulent area. Before reaching the ground all four engines had separated as had the outer wing sections, the forward fuselage and the empennage. Figure 6 depicts the readout. One of the first areas of interest in this figure was the normal acceleration trace. It became evident from this trace that turbulence, per se, was not a likely candidate for probable cause. It can be seen that the early portion of the flight was conducted through far worse conditions than the latter. The Boeing Company, in a cooperative effort with the CAB, undertook several studies based on the flight recorder data. The early analog and digital studies were most helpful in demonstrating that the aircraft was intact during the initial steep climb, the pitchover and during most of the ensuing dive. The angle of attack, pitch attitude, elevator angle and stick force time histories (Figure 7) resulting from the digital computer study, coupled with the derived flight path (Figure 8), provided an excellent graphic display of the final maneuver and a clearer understanding of the problems confronting the crew. Perhaps the most significant finding was that the maneuver required (a) full nose-down trim, (b) full nose-down elevator for about eight seconds followed by (c) full up elevator about nine seconds later. This one finding was perhaps the most convincing of all in indicating an essentially intact aircraft down to a lower altitude. Still air was assumed for the study, an assumption which might first appear ridiculous; however, the excellent parametric comparison shown in Figure 8 certainly indicates that the motions must have been produced principally by elevator and stabilizer controls rather than vertical gust inputs. For gusts to have been the major generating forces for the initial negative g portion of the maneuver, their velocities would have had to be inconceivably greater than the most severe measured during the National Severe Storms Project, and would have had to persist in one direction for nearly ten seconds.

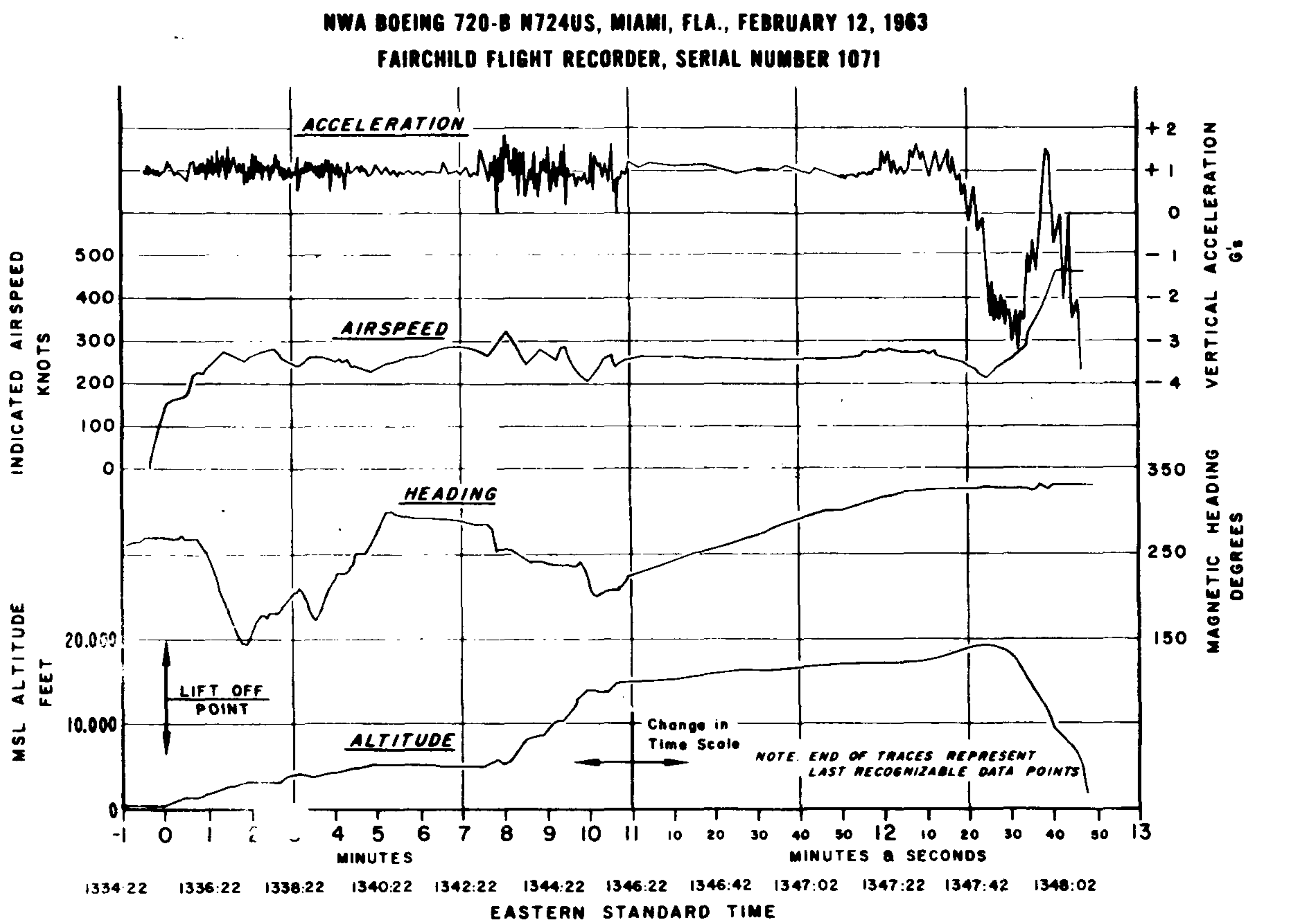

FIGURE 6.- Flight recorder data

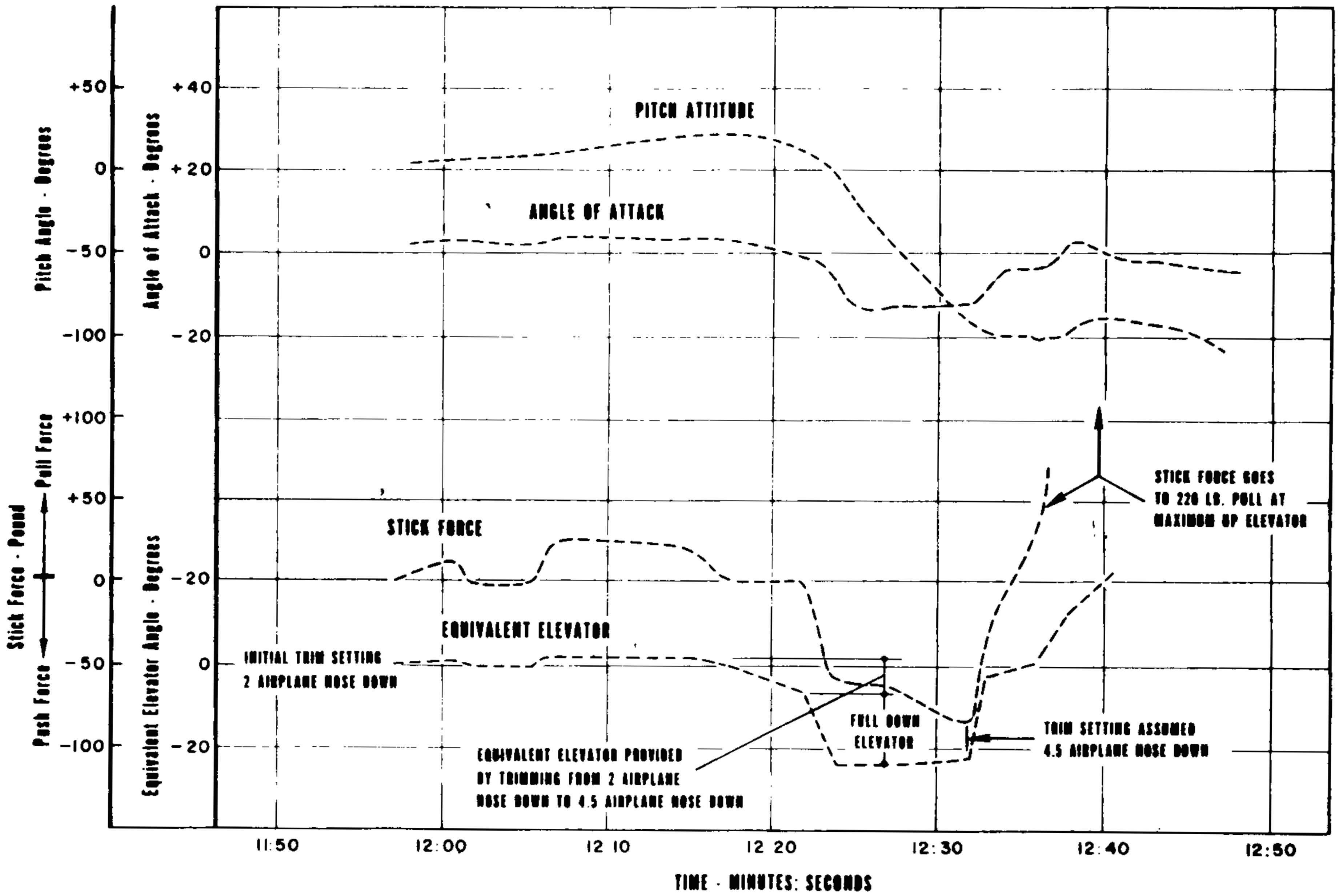

FIGURE 7.- Data from flight path analysis

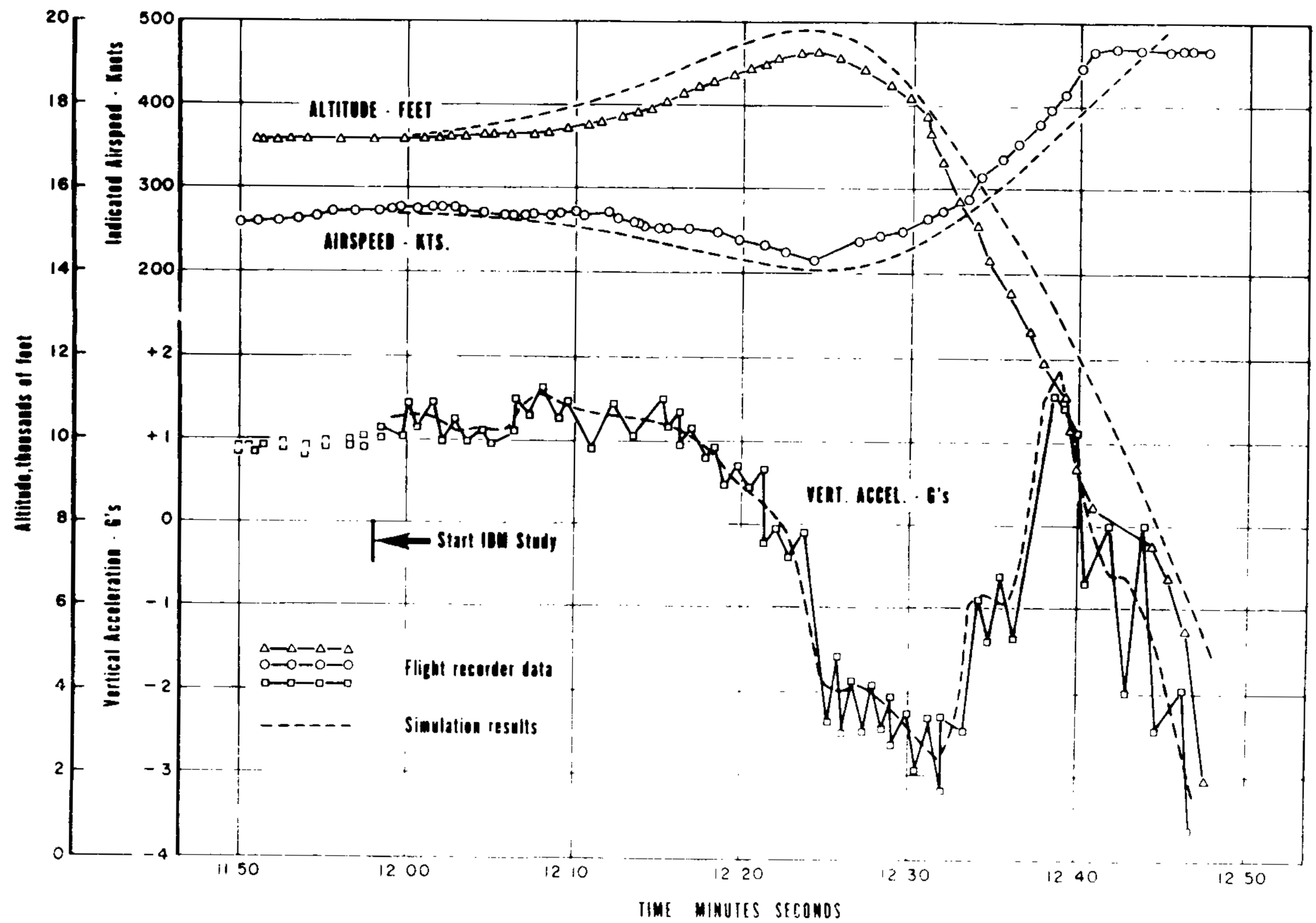

FIGURE 8.- Comparison of traces from flight recorder and flight path analysis

FUTURE OF THE FLIGHT RECORDER

For several years now accident investigators have recognized that wreckage examination is becoming less and less fruitful. In the days when the DC-3 represented the ultimate in travel comfort and speed, an inflight breakup was considered the most tedious and time consuming to investigate. Now, the investigator finds that the investigation of the inflight breakup, while far more tedious than previously, may be one of his easier investigations. This has been brought on, of course, by tremendous increases in the two energy generators, speed and mass. Additionally, the failure patterns of the newer aluminum and steel alloys do not lend themselves to quick and easy field examination.

While the art of wreckage examination is not yet dead, its prognosis is not very promising. The best medicine which can be administered is the flight recorder - not the recorder of today, but a unit which will record many parameters, be ejectable, and locatable in a wide variety of circumstances.

Many technical papers from a variety of government, airline, manufacturer and academic sources have been prepared over the past several years concerning the necessity or desirability of additional parameters. How many data sources depends on how expansively or expensively the writer is thinking. The equipment and techniques are available for recordin an almost infinite array of data to the ridiculous ultimate, that the payload of an aircraft could be measured in numbers of data channels rather than tons of cargo or number of passengers. Among this vast array of possible parameters there is one group which, for subsonic aircraft, has almost universal approval. This group consists of:

(1) Power indication parameters, such as torque, EPR, gas temperatures and rpm
(2) Angle of attack
(3) Pitch attitude and/or rate
(4) Roll attitude and/or rate
(5) Yaw attitude and/or rate
(6) Longitudinal trim position
(7) Control column and/or elevator position
(8) Control wheel and/or aileron position
(9) Pedal and/or rudder position
(10) Ambient air temperature
(11) Wing flap position

These, for a four-engine aircraft and depending on number of engine parameters selected and depending on the use of "and" or "or", could range from 16 to 36 additional data sources. While these additions would represent a 400% to 900% increase in data sources over those now required, they appear extremely modest when compared with the proposed recorder for the Lockheed C-5A. In addition to the parameters now recorded and those listed above, the C-5A recorder is being programmed for:

(1) Thrust reverser position
(2) Fuel flow
(3) Power lever angle
(4) Cabin pressure
(5) Master Fire Warning
(6) Autopilot ON-OFF (3 axes)
(7) Hydraulic pressure
(8) Takeoff cg
(9) Speed brake position
(10) Engine turbine vibration

(11) Engine compressor vibration
(12) Gross weight
(13) "Q" system
(14) Cabin and cargo smoke detection
(15) Yaw damper ON-OFF
(16) Electrical generator output
(17) Engine fire warning
(18) Engine fire bottle

All in all, the C-5A recorder is being planned for at least 41 parameters encompassing at least 98 data points. The recording unit, which also will contain voice channels, is to be ejectable by impact, fire, immersion, or by selection. It is to be floatable and will contain a radio beacon.

To increase the data channels by more than three or four on the presently used foil-type recorder would require either extremely wide foils or the use of several separate foils. This is not practical operationally, nor is it practical in the investigator's view. What is needed in addition to "information" is "timely information". Recording additional data mechanically would serve to increase the current problems of the flight recorder specialist, e.g. shift of the medium, bent or broken styli, and improper casette installation, and thus lengthen readout and data reduction time. During this period the investigator has been slogging through the wreckage, searching for answers he may not find.

The obvious reason for the recording of additional parameters lies in electronic recording, specifically wire or tape. It not only lends itself to compactness but also to rapid processing, using the standard digital computer from the initial readout, through calibration correction (if any) to the plotting of the data by an X-Y plotter. What now takes days with five channels could be reduced to a few hours with many channels.

The investigation of a major accident of a large aircraft now runs for several months and, where wind tunnel tests, flights tests and computer studies are required, can and does run as long as two years. Several times second accidents have occurred before the first could be solved. If one applies to these second accidents in the past the word 'regrettable', he must, in terms of the 300- to 1000-passenger aircraft of the near future, apply the word 'intolerable'.

Perhaps the best way to assess the potential of the expanded flight recorder is to examine some past investigations in the context of having available a flight recorder record for fast readout. In some of the cases reviewed there was a flight recorder and, in these cases, the potential of increased data sources is examined.

CASE A

In September 1959, an Electra experienced a wing separation. The field investigation of this accident lasted for months. Experts from all parts of the industry, several aircraft manufacturers, National Bureau of Standards, NASA, FAA and CAB viewed the remains. There was unanimous agreement: the wing failed in positive overload. A flight recorder would clearly have shown that the g necessary for overload failure was not present. It would also have shown there was no dive preceding the failure, a factor over which there was much argument and many manhours expended. Recorded engine parameters would have indicated power irregularities in the No. 1 engine prior to the wing failure, and angle of attack and attitude indications would probably have reflected analyzable abnormalities. These time-consuming investigative operations could, no doubt, have been eliminated:

(1) A second ground search involving 400 army personnel.
(2) Searching ARTC and military records for other aircraft which might have created a near miss condition.
(3) Long and expensive trajectory studies.
(4) Fuel analyses.

The real tragedy of this case lies in the fact that it took a second accident five months later to provide enough additional information to solve the two accidents.

CASE B

On February 12, 1963, a Boeing 720-B crashed after reaching 18 000 ft during a climb through turbulence (Case 6, above). In this case a flight recorder trace was available and assisted immeasurably in the investigation, as previously discussed. The additional parameters of angle of attack and attitude, however, could have reduced by many weeks the work which went into obtaining the curves shown in Figures 7 and 8. Primary control and stabilizer trim position records would have given a true picture of how the aircraft was placed in its extreme attitude, positions concerning which crew members testified during the investigations of subsequent upset situations. The investigation could also have been shortened as follows:

(1) Powerplant investigation could have been held to a minimum if the recorder had shown power information from all four engines until separation occurred.
(2) The extent of airframe mock-up could have been reduced materially.
(3) Many systems investigations could have been reduced in extent or eliminated.

Had this investigation been able to proceed more rapidly, many of the corrective actions, both in aircraft modification and in the operational and flying technique education and improvement, could have occurred early enough to have prevented several turbulence upsets, some of which became fatal accidents.

CASE C

Preceding most of the so-called turbulence upset accidents in the US, there was an accident of a large swept-wing jet in Europe during climb after takeoff. No recorder was installed. A recorder, particularly one with expanded data sources, could have given data which was absolutely unobtainable by the investigators. Had they had flight recorder information, there is a strong possibility that even Case B, above, and all the others like it could have been averted.

CASE D

A Viscount shed its wings and empennage in turbulence in 1959. Among the investigators of that accident there is no doubt that a flight recorder would have answered many questions early in the investigation. Furthermore, an expanded-parameter recorder, together with the weather and ATC packages, would have been all that was necessary to have solved the accident.

There are many more. Any investigator can review his cases and recognize in each what a recorder could have done for him and for the industry. Equipped with a good readout of the several proposed parameters, the investigating team can conclude its work months earlier. More important, positive answers to many questions are available immediately, leading to at least interim corrective measures far earlier than they occur now in many cases.

FLIGHT RECORDER AND ACCIDENT PREVENTION

In the past there has been much discussion over the role the present recorder could play in accident prevention if only someone would or could devote time to read out the recorders routinely. The operators argue that they do not have the manpower, and they are right. There is probably no organization which could devote, on a routine basis, the man hours necessary to read, even on a sampling basis, these numbers of tapes. However, magnetic recording, adaptable to computer equipment already in use, can eliminate this problem and make analyses relatively easy. In addition to revealing unwanted characteristics in airplane equipment (such as increased fuel consumption or decay in available power), the flight recorder could be used as a supplement to the check ride. It could show whether the crews are adhering to the flight manual and to established procedures. In very recent history one fatal accident of a jet transport on approach might have been prevented if the means had been available to detect the pilot's persistence in departing from standard, normal operation. History has recorded many such cases where the flight recorder, used as a supplement to check rides, could have prevented accidents.

Several of the airlines and the military are now experimenting with the so-called 'maintenance recorder', with which 20 or more channels of information are collected. The primary purpose of the maintenance recorder is, as its name implies, to enhance maintenance. It will reduce equipment down-time, reduce cost of repair work, and allow more efficient management of maintenance activities. This device is, however, by its very nature an accident prevention device. Certainly it is both cheaper and safer to remove an engine because of tell-tale warnings than to have it remove itself in flight and, in the process, break primary structure and kindle a fire.

Because the maintenance recorder, per se, and the electronic flight recorder differ in essence only in some of the recorded parameters, it logically follows that they could be merged into one. This does not mean one wire or one tape, nor does it necessarily mean one black box but, rather, one integrated recording system. Regulatory requirements concerning numbers of parameters, recording and retention times, protection etc., are beyond the scope of this paper, but the required parameters, whatever they might be, could be triggered to one tape or wire casette and the remaining data to another. Or by general agreement all the data, required and non-required, could be protected from impact and fire, and eventually ejectable.

CONCLUSION

The flight recorder, despite the problems it has presented and despite the numerous times it has been destroyed, has proved its worth as an investigation tool. If it has done nothing more, it has increased the investigator's confidence level, the value of which cannot be overemphasized. But it has done more, as reported in this paper. It can and must do even more. The expanded flight recorder, ejectable, locatable, and containing voice channels, could further enhance safety in many ways.

(1) It could eliminate or materially reduce the costly and time consuming diving and dredging operations of water accidents. At the least it would allow the investigation to progress while these activities go on.

(2) It could, in deep water accidents, provide data which now are lost forever.

(3) It could furnish early data on which to base immediate interim corrective action.

(4) It could, conceivably, in some accidents provide all the information necessary to the probable cause.

(5) It could be the first giant step toward telemetering data to a ground based recorder and computer for complete monitoring of an SST flight from takeoff to landing.

INADVERTENT FUEL TRANSFER IN FLIGHT
(all types of aircraft need to be considered)

(Air Registration Board, United Kingdom -
Notice No. 78, Issue 1, dated 1 July 1968)

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1.- INTRODUCTION

Problems of inadvertent fuel transfer in flight have been reported on the particular aircraft types listed in paragraphs 2 and 3 below. However, operators of all types of aircraft are asked to consider their own aircraft fuel systems to determine whether similar problems could occur and if so to guard against them by suitable training and practices in regard to both maintenance and flight operations.

2.- CANADAIR C4 (ARGONAUT), DOUGLAS DC4/C54 AND CARVAIR AIRCRAFT

2.1 A fatal accident to a Canadair C4 is attributed to a loss of power in both engines on the starboard side. The loss of power is attributed to inadvertent fuel transfer leading to fuel starvation of one or both engines. Other cases of significant inadvertent fuel transfer have since come to light.

2.2 Some of the types listed, and also other aircraft, use main/auxiliary tank selector fuel cocks and inter engine/cross ship crossfeed cocks made by the Parker Appliance Co. It is a feature of these cocks that when correctly positioned the ports not required are closed by carbon pads. However, at intermediate positions (about 10° or more from the correct selection) the carbon pads do not completely cover any of the ports and the cocks are then partially open; in these positions not only is the next selection partially made but also all ports are connected together through the clearances in the cock.

2.3 This feature has led, through slight misrigging of the cock controls or slight mis-selection of the cockpit lever, to inadvertent transfer of large quantities of fuel in flight. This transfer should be shown by the fuel gauges and confirmed by the amount of fuel uplifted into each tank at the next refuelling. However, if the problem is not appreciated the transfer can pass unnoticed and the gauge readings can be attributed to gauge inaccuracy which then builds a climate in which fuel transfer is likely to be masked by a reputation for gauge inaccuracy. This is a situation which may have led to the Canadair C4 accident.

2.4 Operators must ensure precise rigging of fuel cock control systems and maintenance of the correct feel of detent positions and ensure that their pilots are aware of the need and reasons for correct positioning of the cock lever and prudent use of the fuel gauges.

2.5 Operators should further assess the ease of correctly positioning the cock levers when seated in the flight position and wearing safety harness. If any difficulty can exist (as is the case with the Canadair C4) in ensuring that the levers are in the extreme or detent positions, crews should be warned of the fact and suitable practices developed to ensure correct selection of cock lever positions.

3.- BOEING 707 AIRCRAFT

3.1 Several cases of unintended transfer of very considerable quantities of fuel have been reported. These have occurred during flight with the manifold valves open when fuel use was intended to have been determined by booster pump selection.

3.2 Correct fuel use in these circumstances depends on correct non-return valve operation. In the event of a non-return valve malfunction causing it to remain open fuel can flow at a very high rate into the affected tank. In the cases reported no mechanical faults to which the malfunction could be attributed were found and non-return valve malfunction has been attributed to ice. The incidents were safely contained by the transfer being recognised from the fuel gauges and by the appropriate use of booster pumps and manifold valves.

3.3 Operators must ensure that their crews are aware of the possibility of such fuel transfer and that, in the event of it occurring, their practices would detect it before a dangerous situation could arise.

PART III

AIRCRAFT ACCIDENT STATISTICS 1964

INTRODUCTION

GENERAL COMMENTS

1. This section of the Aircraft Accident Digest No. 16 contains a detailed analysis of the statistics for the year 1964, as well as selected data for the years 1925 to 1967 inclusive. Figures for the years subsequent to 1951 were obtained largely from the ICAO Air Transport Reporting Forms G - Aircraft Accidents (see pages 183 and 184) filed by Contracting States. In order to arrive at as complete a picture as possible of accidents in which public aircraft were involved, other sources had to be used for those countries which have not yet filed the required reporting Form.

2. The statistics shown are the best available to date but are subject to adjustment when additional Forms G are filed.

DESCRIPTION OF TABLES AND CHART

3. CHART Passenger fatality rate and traffic on scheduled air services 1945 - 1967.

TABLE A-1 Accidents with passenger fatalities on scheduled air services 1925 - 1967.

TABLE A-2 Number of fatal accidents, passenger fatalities and survivors of turbo-jet, propeller-driven (turbine and piston) aircraft - scheduled air services 1960 - 1967.

4. Three tables are given for the year 1964. The accident data have been recorded under the country in which the airline which suffered an accident is registered, not under the country where the accident took place. These three tables give the following information:

TABLE B Passenger fatalities occurring on scheduled international and domestic operations.

TABLE C Aircraft accident summary of all operators engaged in public air transport by type of operation.

TABLE D Aircraft accident summary of all operators engaged in public air transport by country.

AIRLINE SAFETY RECORD

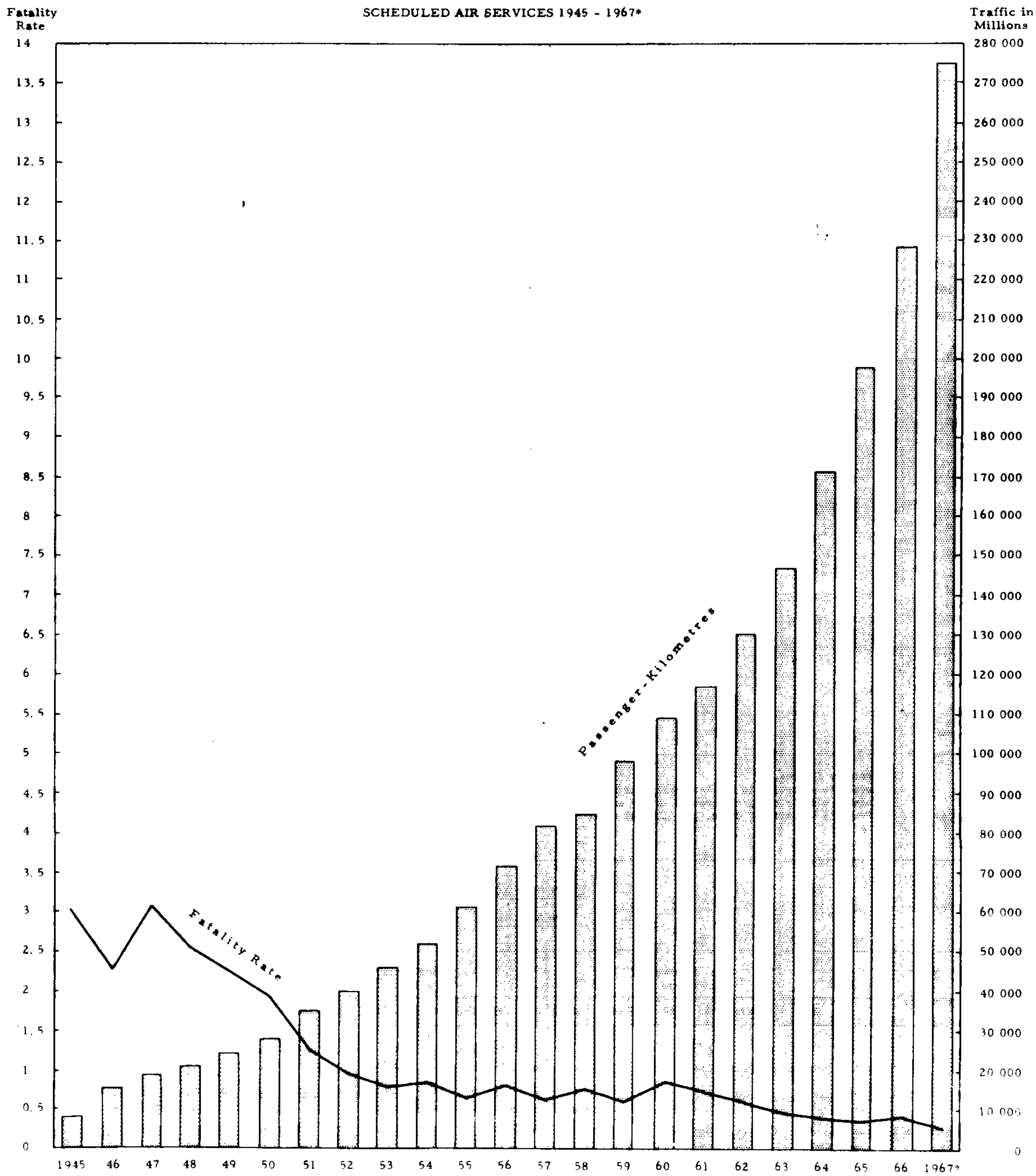
5. The long-period downward trend in the passenger fatality rate for the scheduled air services of the world (international and domestic), which had shown signs of flattening out, or even rising slightly, between 1955 and 1960, has been falling about 15 per cent per year since then and seems likely to continue to fall, although probably not at so high a rate. In the past five years (see Table A-1) this steady decrease in the passenger fatality

rate has been sufficient to offset the expansion of scheduled operations, so that the number of passenger fatalities has not increased (apart from the exceptional year 1966) although the number of fatal accidents has remained about constant and the average number of passengers per aircraft has increased (from 43 in 1963 to 52 in 1967). The statistics for 1966 indicate an increase in the fatality rate per 100 million passenger-kilometres to 0.40 from 0.39 in 1964 and 0.35 in 1965. This increase can only be regarded as a temporary phenomenon due to the chance occurrence of a number of serious accidents, during the first quarter of the year, to relatively large aircraft with unusually high load factors. Such occurrences may be expected to take place from time to time according to the rules of statistical probability. To reinforce the concept of temporary phenomenon, the preliminary statistics for the following year, 1967, indicate that the year was an exceptionally good year for passenger safety on the scheduled air services of the world. As can be seen from the graph on the following page, the fatality rate for 1967 was about as much below the long-period trend curve as that for 1966 was above it. Since the trends of the various accident rates themselves slope downwards, the comparison between 1967 and 1966 shows very substantial improvements. The number of passenger fatalities on the scheduled air services decreased from 926 in 1966 to 674 in 1967. The volume of passenger traffic increased 20 per cent, so that the passenger fatality rate per 100 million passenger-kilometres fell 37 per cent from 0.40 to 0.25.

6. Table A-2 shows how scheduled air services accidents were distributed between turbo-jet, turbo-propeller and piston-engined aircraft since 1960. It is a fact that the new aircraft introduced since 1960 have had a relatively low incidence of the kind of catastrophic accident where all passengers are killed. This is probably due chiefly to the greater reliability of the jet engine. Engine failure does not normally cause a serious accident, but when it does (the engine having caught fire or other serious complications being present), the accident is usually extremely serious. Thus an improvement in engine reliability attacks a particularly serious group of accidents and greatly helps to reduce passenger fatality rates. The number of fatal accidents on turbo-jet aircraft at 12 for 1967, was the higher of the period, but as indicated above, their accidents include a smaller proportion of catastrophic accidents than in the case of propeller-engined aircraft and their fatality rate per 100 million passenger-kilometres is considerably lower; in 1967 perhaps as much as 75 per cent lower. Turbo-prop aircraft came in 1967 somewhere between the turbo-jets and the piston-engined aircraft for passenger safety. The better safety of the turbo-jets is, of course, partly associated with the fact that they operate predominantly long stage lengths on routes with well-developed ground facilities and at heights above such potential hazards as mountains and weather, while the piston-engined aircraft are now operating predominantly on short stages in the less developed parts of the world where ground facilities are not as good and, of course, at lower altitudes. It remains true, however, that under identical conditions, a passenger flying a given number of kilometres per year on jet aircraft is a considerably better insurance risk than a passenger flying the same distance on piston-engined aircraft.

PASSENGER FATALITY RATE AND TRAFFIC

SCHEDULED AIR SERVICES 1945 - 1967*



NOTES: Fatality Rate equals number of passengers killed per 100 million passenger-kilometres flown.

* Preliminary

TABLE A-1

ACCIDENTS WITH PASSENGER FATALITIES

ON SCHEDULED AIR SERVICES

1925 - 1967 a/

YEARS	Accidents in which Passengers were killed: Number of Aircraft Involved	Accidents in which Passengers were killed: Number of Passengers Killed	Passenger-Kilometres Flown (millions)	Fatality Rate per 100 million Pass-Km.	Millions of Pass-Km. per Fatality	Aircraft Hours Flown (millions)	Fatal Accidents per 100 000 Aircraft Hours
YEARLY AVERAGE							
1925 - 1929	...	36	130	28	4	...	...
1930 - 1934	...	80	445	18	6	...	...
1935 - 1939	...	133	1 475	9	11	...	...
1940 - 1944	...	114	3 795	3	33	...	...
YEAR							
1945	...	247	8 000	3.09	32	2.5	...
1946	...	376	16 000	2.35	43	3.8	...
1947	...	590	19 000	3.11	32	4.2	...
1948	...	543	21 000	2.59	39	4.6	...
1949	...	556	24 000	2.32	43	4.8	...
1950	27	551	28 000	1.97	51	5.0	0.54
1951	20	443	35 000	1.27	79	5.7	0.35
1952	21	386	40 000	0.97	104	6.1	0.34
1953	28	356	46 000	0.77	129	6.5	0.43
1954	28	443	52 000	0.85	116	6.7	0.42
1955	26	407	61 000	0.67	150	7.3	0.36
1956	27b/	552	71 000	0.78	129	8.0	0.34
1957	31	507	82 000	0.62	162	8.7	0.36
1958	30	609	85 000	0.72	138	8.8	0.34
1959	28	613	98 000	0.63	160	9.0	0.31
1960	33b/	873	109 000	0.80	129	8.6	0.38
1961	25	805	117 000	0.69	145	8.0	0.31
1962	28	765	130 000	0.59	170	7.7	0.36
1963	31	715	147 000	0.49	205	7.9	0.39
1964	24	659	171 000	0.39	260	8.2	0.29
1965	24	684	198 000	0.35	289	8.7	0.28
1966	29b/	926	229 000	0.40	247	9.3	0.31
1967*	29	674	275 000	0.25	408	10.5	0.28

NOTES: * Preliminary figures.
a/ Revised data according to the best available sources.
b/ Includes a mid-air collision counted as one accident.

Exclusions: The People's Republic of China, the USSR and other States which were not members of ICAO as at 31 December 1967.

TABLE A-2

1960 - 1967

TYPE OF AIRCRAFT	Fatal Passenger Accidents 1960	1961	1962	1963	1964	1965	1966	1967*	Passengers Killed 1960	1961	1962	1963	1964	1965	1966	1967*	Passengers Surviving 1960	1961	1962	1963	1964	1965	1966	1967*
Turbo-Jet	3a/	6	7	5	3	5	7	12	113	257	424	347	136	250	452	358	16	105	79	88	180	51	80	276
Propeller-driven (turbine)	7	6	7	5	6	2	5b/	9	264	192	100	47	252	35	143b/	152	15	13	23	1	205	0	1	97
Propeller-driven (piston)	24a/	13	14	21c/	15	17	18d/ e/	8	496	356	241	321c/	271	399	331e/	164	191	51	81	179	117	53	51	106
Total	34	25	28	31	24	24	30	29	873	805	765	715	659	684	926	673	222	169	183	268	[illegible]	[illegible]	132	479

NOTES: * Preliminary figures.
a/ Includes one mid-air collision between a turbo-jet and a propeller-driven (piston) aircraft (counted as two accidents in the total).
b/ Includes 1 helicopter with 20 passenger fatalities.
c/ Includes 1 helicopter with 3 passenger fatalities
d/ Includes one mid-air collision between two piston-engined aircraft (counted as two accidents in the total).
e/ Includes 1 helicopter with [illegible] passenger fatalities.

Exclusions: The People's Republic of China, the USSR and other States which were not members of ICAO at 31 December 1967.

CONTRACTING STATES OF ICAO PASSENGER FATALITIES OCCURRING ON SCHEDULED INTERNATIONAL AND DOMESTIC OPERATIONS FOR 1964

1964

TABLE B

Description	Country Total of Hours Flown	Accidents in which Passengers were killed: Number of Aircraft Involved	Accidents in which Passengers were killed: Number of Passengers Killed	Country Total of Passenger-Kilometres	Fatality Rate per 100 Million Pass-Kms.	Millions of Passenger-Kilometres per Fatality
	(thousands)			(millions)		
Total Scheduled Operations						
Argentina	98	1	27	1 044		
Bolivia	13	2	3	50		
Brazil	252	1	34	2 594		
China	11	1	52	153		
Colombia	170	2	36	1 319		
France	225	1	73	6 697		
Italy	139	1	40	3 589		
Japan	163	1	17	3 997		
Lebanon	31	1	42	485		
Philippines	77	2	31	606		
Sweden	73	1	29	1 420		
United Kingdom	513	1	75	10 867		
United States	3 775	11	200	94 134		
All other States	2 660	-	-	43 469		
Total	8 200	26	659	170 424	0.39	259
International Scheduled Operations						
France	175	1	73	6 053		
Lebanon	31	1	42	485		
United Kingdom	368	1	75	9 272		
United States	358	3	94	14 435		
All other States	1 383	-	-	37 295		
Total	2 315	6	284	67 540	0.42	238
Domestic Scheduled Operations						
Argentina	75	1	27	546		
Bolivia	11	2	3	34		
Brazil	224	1	34	1 661		
China	5	1	52	35		
Colombia	155	2	36	970		
Italy	48	1	40	513		
Japan	132	1	17	2 492		
Philippines	72	2	31	433		
Sweden	34	1	29	302		
United States	3 417	8	106	79 699		
All other States	1 712	-	-	16 199		
Total	5 885	20	375	102 884	0.36	274

NOTES:

Accident data have been recorded under the country in which the airline is registered and not under the country where the accident took place.

Under "Total Scheduled Operations" are listed all countries with scheduled airlines which had aircraft accidents resulting in passenger fatalities. These data have been segregated as to those fatalities occurring on a scheduled international flight and/or a scheduled domestic flight.

Source of data: ICAO Air Transport Reporting Forms and outside sources.

1964

TABLE C

CONTRACTING STATES OF ICAO
AIRCRAFT ACCIDENT SUMMARY FOR 1964
OF ALL OPERATORS ENGAGED IN PUBLIC AIR TRANSPORT
BY TYPE OF OPERATION

Type of Operation Contracting States of ICAO at 31 December	Number of Accidents		Passenger Injury			Crew Injury			Others Injured		By Operators With an Accident	
	Total	Fatal	Fatal	Serious	Minor or None	Fatal	Serious	Minor or None	Fatal	Serious	Number of Landings	Hours Flown
SCHEDULED INTERNATIONAL OPERATIONS												
ø Argentina	1	-	-	-	7	-	-	9	-	-	11 848	19 041
ø Australia	1	-	-	-	73	-	-	10	-	-	-	50 381
ø Colombia	1	1	-	-	-	2	-	-	-	-	2 196	9 797
ø Czechoslovakia	2	-	-	-	106	-	-	20	-	-	2 304	17 287
France	1	1	73	-	-	7	-	-	-	-		
ø Lebanon	1	1	42	-	-	7	-	-	-	-	204	439
ø United Kingdom	6	1	75	-	342	8	-	36	-	-	128 572	286 860
ø United States	8	3	94	88	339	12	13	28	1	-	133 202	290 132
Total for 8 States	21	7	284	88	867	36	13	103	1	-		
SCHEDULED DOMESTIC OPERATIONS												
ø Argentina	2	1	27	1	-	3	-	-	-	-	44 072	57 229
ø Australia	1	-	-	-	59	-	-	6	-	-		76 482
ø Bolivia	4	2	3	-	24	1	2	-	-	-	9 147	9 299
Brazil	1	1	34	-	-	5	-	-	-	-		
ø Canada	2	-	-	1	40	-	-	3	-	-	118 077	137 889
ø Chile	1	0	-	-	4	-	-	2	-	-		
ø China	1	1	52	-	-	5	-	-	-	-	4 306	2 757
ø Colombia	4	2	36	2	15	6	-	-	-	-		23 700
ø Italy	1	1	40	-	-	5	-	-	-	-	34 549	39 909
ø Ivory Coast	1	-	-	-	3	-	-	2	-	-	314	617
Japan	1	1	17	20	-	3	2	-	-	-		
ø Kenya	1	1	-	-	21	1	-	2	-	-	19 817	19 833
ø Malagasy Rep.	1	-	-	-	6	-	-	2	-	-	15 732	12 737
ø Philippines	3	2	31	1	50	4	-	3	-	-	49 160	85 352
ø Sweden	1	1	29	2	8	2	-	2	-	-	26 895	18 928
ø United Arab Rep.	3	1	-	-	64	1	-	11	-	-		
ø United Kingdom	2	-	-	-	100	-	-	11	-	-	58 859	58 647
ø United States	49	8	106	6	1 452	21	8	177	-	-	2 520 552	2 545 564
Total for 18 States	79	22	375	33	1 846	57	12	221	0	-		
NON-SCHEDULED INTERNATIONAL OPERATIONS												
ø Kenya	1	-	-	-	3	-	-	1	-	-	1 170	1 720
ø Sweden	1	-	-	-	-	-	-	-	-	-	6 790	26 783
ø United Kingdom	3	-	-	-	236	-	-	19	-	-	10 511	43 347
Total for 3 States	5	-	-	-	239	-	-	20	-	-		
NON-SCHEDULED DOMESTIC OPERATIONS												
ø Australia	1	-	-	-	-	-	-	1	-	-		16 024
ø Bolivia	14	2	14	-	-	6	-	-	1	-	8 665	8 186
Brazil	1	1	-	-	-	3	-	-	-	-		
ø Canada	39	7	6	2	38	4	6	29	1	1	287 527	221 484
ø Germany	1	-	-	-	-	-	-	3	-	-		
ø Jamaica	1	-	-	-	-	-	-	1	-	-	4 332	1 990
Japan	1	1	1	2	6	1	-	-	-	-		
ø Kenya	2	-	-	-	4	-	-	2	-	-	4 803	12 070
ø New Zealand	2	1	-	-	-	1	-	2	-	-	7 433	2 642
Panama	1	1	1	-	-	1	-	-	-	-		
ø Philippines	2	2	1	1	29	2	2	-	-	-	3 810	6 597
ø Sweden	8	-	-	-	-	-	-	8	-	-	23 251	13 763
ø South Africa	2	2	3	-	-	1	-	1	1	-	3 982	6 297
ø Turkey	1	1	-	-	-	3	-	-	-	-	545	865
ø United States	13	2	2	-	4	3	1	23	-	-	27 400	152 545
United States	3	3	90	-	28	6	1	1	-	-		
ø Viet-Nam	1	-	-	-	5	-	-	1	-	-	1 463	3 043
Total for 16 States	94	24	126	14	137	33	11	73	3	1		
NON-REVENUE OPERATIONS												
Brazil	1	1	-	-	-	3	-	-	-	-		
ø Bolivia	3	1	2	-	-	2	-	-	-	-	754	359
ø Germany	7	2	-	1	6	4	-	6	-	-	23 992	7 700
ø New Zealand	1	-	-	-	-	-	-	1	-	-	119	113
ø United Arab Rep.	3	-	-	-	-	-	-	4	-	-		
ø United Kingdom	1	-	-	-	-	-	-	4	-	-	..	..
ø United States	6	-	2	-	1	-	-	13	-	-	N.R.	47 312
Total for 7 States	22	4	4	1	7	9	-	28	-	-		
TOTAL OPERATIONS	221	57	789	136	3 096	135	36	445	4	1		

Source of Data: Air Transport Reporting Form C filed by countries indicated with a ø. All other country data collected from outside sources.

1964

TABLE D

CONTRACTING STATES OF ICAO

AIRCRAFT ACCIDENT SUMMARY FOR 1964

OF ALL OPERATORS ENGAGED IN PUBLIC AIR TRANSPORT

Contracting States of ICAO at 31 December	Number of Accidents		Passenger Injury			Crew Injury			Others Injured		By Operators With an Accident		During Year by all Operators Engaged in Public Air Transport	
	Total	Fatal	Fatal	Serious	Minor or None	Fatal	Serious	Minor or None	Fatal	Serious	Number of Landings	Hours Flown	Hours Flown	Aircraft Landings
Ø Afghanistan	-	-	-	-	-	-	-	-	-	-				
Ø Algeria	-	-	-	-	-	-	-	-	-	-				
Ø Argentina	3	1	27	1	7	3	-	9	-	-	55 920	76 270	98 000	68 295
Ø Australia	3	-	-	-	132	-	-	17	-	-	-	142 887	332 819	-
Ø Austria	-	-	-	-	-	-	-	-	-	-			20 741	14 764
Ø Belgium	-	-	-	-	-	-	-	-	-	-			88 819	48 533
Belgium	1	1	8	9	23	2	-	1	-	-				
Ø Bolivia	21	5	19	-	24	9	2	-	1	-	18 566	17 844	23 586	26 190
Brazil	3	3	34	-	-	11	1	-	-	-				
Ø Burma	-	-	-	-	-	-	-	-	-	-			19 936	
Ø Cambodia	-	-	-	-	-	-	-	-	-	-				
Ø Cameroon	-	-	-	-	-	-	-	-	-	-			2 496	3 224
Ø Canada	41	7	6	3	78	4	6	32	1	1	405 604	359 373		
Central African Rep.	-													
Ø Ceylon	-	-	-	-	-	-	-	-	-	-			4 953	3 450
Chad	-													
Ø Chile	1	-	-	-	4	-	-	2	-	-				
Ø China (Rep. of)	1	1	52	-	-	5	-	-	-	-	4 306	2 757	9 655	8 282
Ø Colombia	5	3	36	2	15	8	-	-	-	-				
Congo (Brazzaville)	-													
Congo (Leopoldville)	-													
Costa Rica	-													
Cuba	-													
Ø Cyprus	-	-	-	-	-	-	-	-	-	-			1 759	1 624
Ø Czechoslovakia	2	-	-	-	106	-	-	20	-	-	2 304	17 287	41 978	13 317
Dahomey	-													
Denmark	-													
Dominican Rep.	-													
Ø Ecuador	-	-	-	-	-	-	-	-	-	-			1 279	3 125
El Salvador	-													
Ethiopia	-													
Ø Finland	-	-	-	-	-	-	-	-	-	-			44 763	39 605
France	1	1	73	-	-	7	-	-	-	-				
Gabon	-													
Ø Germany (Fed. Rep. of)	8	2	-	1	6	4	-	9	-	-	23 992	7 700	194 780	214 903
Ø Ghana	-	-	-	-	-	-	-	-	-	-				
Ø Greece	-	-	-	-	-	-	-	-	-	-			31 317	21 484
Guatemala	-													
Guinea	-													
Haiti	-													
Honduras	-													
Iceland	-													
India	-													
Indonesia	-													
Iran	-													
Iraq	-													
Ø Ireland	-	-	-	-	-	-	-	-	-	-			47 102	35 817
Ø Israel	-	-	-	-	-	-	-	-	-	-			19 906	5 493
Ø Italy	1	1	40	-	-	5	-	-	-	-	34 549	39 909	18 447	100 952
Ø Ivory Coast	1	-	-	-	3	-	-	3	-	-	314	617	30 677	6 521

CONTRACTING STATES OF ICAO

AIRCRAFT ACCIDENT SUMMARY FOR 1964

OF ALL OPERATORS ENGAGED IN PUBLIC AIR TRANSPORT

1964

TABLE D
(Contd)

ø Jamaica	1	-	-	-	-	-	-	1	-	-	4 332	1 990	3 329	7 914
Japan	2	2	18	22	6	4	2	-	-	-				
ø Jordan	-	-	-	-	-	-	-	-	-	-				
ø Kenya *	4	1	-	-	28	1	-	5	-	-	25 790	33 623	55 362	43 349
Korea (Rep. of)	-													
Kuwait	-													
Laos	-													
ø Lebanon	1	1	42	-	-	7	-	-	-	-	204	439		
Liberia	-													
Libya	-													
Luxembourg	-													
ø Malagasy Republic	1	-	-	-	6	-	-	2	-	-	15 732	12 737	13 482	15 955
Malawi	-													
Malaysia (Fed. of)	-													
Mali	-													
Mauritania	-													
Mexico	-													
ø Morocco	-	-	-	-	-	-	-	-	-	-				
Nepal	-													
ø Netherlands	-	-	-	-	-	-	-	-	-	-			126 683	62 176
ø New Zealand	3	1	-	-	-	1	-	3	-	-	7 552	2 755	69 973	37 141
Nicaragua	-													
Niger	-													
Nigeria	-													
Norway	-													
ø Pakistan	-	-	-	-	-	-	-	-	-	-			51 287	40 103
Panama	1	1	1	-	-	1	-	-	-	-				
Paraguay	-													
ø Peru	-	-	-	-	-	-	-	-	-	-				
ø Philippines	5	4	32	2	79	6	2	3	-	-	52 970	91 949		
ø Poland	-	-	-	-	-	-	-	-	-	-			22 500	14 905
ø Portugal	-	-	-	-	-	-	-	-	-	-			38 668	27 008
Rwanda	-													
Saudi Arabia	-													
Senegal	-													
ø Sierra Leone	-	-	-	-	-	-	-	-	-	-			1 144	2 955
Somalia	-													
ø South Africa	2	2	3	-	-	1	-	1	1	-	70 540	60 288		
ø Spain	-	-	-	-	-	-	-	-	-	-				
Sudan	-													
ø Sweden	10	1	29	2	8	2	-	10	-	-	56 936	59 474	166 100	197 000
ø Switzerland	-	-	-	-	-	-	-	-	-	-			79 913	62 336
Syrian Arab Rep.	-													
Tanzania (Un. Rep. of)	-													
Thailand	-													
Trinidad and Tobago	-													
Tunisia	-													
ø Turkey	1	1	-	-	-	3	-	-	-	-	545	865	23 245	19 860
ø United Arab Rep.	6	1	-	-	64	1	-	15	-	-			39 554	19 662
ø United Kingdom	12	1	75	-	678	8	-	70	-	-	197 942	388 854	634 751	398 910
ø United States	76	13	204	94	1 796	36	22	241	1	-	2 681 154	3 035 553	4 091 067	4 041 578
United States	3	3	90	-	28	6	1	1	-	-				
Upper Volta	-													
Uruguay	-													
Venezuela	-													
ø Viet-Nam (Rep. of)	1	-	-	-	5	-	-	1	-	-	1 463	3 043	21 860	14 273
Yemen	-													
Yugoslavia	-													
ø Zambia	-	-	-	-	-	-	-	-	-	-				
Total 109 States	221	57	789	136	3 096	135	36	455	4	1 -				

Source of Data: Air Transport Reporting Form G filed by countries indicated with a ø. All other country data collected from outside sources.

INTERNATIONAL CIVIL AVIATION ORGANIZATION

FORM G

AIR TRANSPORT REPORTING FORM

AIRCRAFT ACCIDENTS

Year ended: Country:

Name of Operator	Type of Operation	Number of Landings	Aircraft Hours	Number of Accidents		Number of Persons Aboard		Number of Persons Injured					
								Passengers Injured		Crew Members Injured		Others Injured	
				Total	Fatal	Passengers	Crew	Fatal	Serious	Fatal	Serious	Fatal	Serious
a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*	*k*	*l*	*m*	*n*
	Scheduled international Scheduled domestic Non-scheduled international Non-scheduled domestic Non-revenue												
	Scheduled international Scheduled domestic Non-scheduled international Non-scheduled domestic Non-revenue												
	Scheduled international Scheduled domestic Non-scheduled international Non-scheduled domestic Non-revenue												

Total hours flown and number of landings during the year by all operators engaged in public air transport:	Aircraft hours Landings	**Remarks:**

1965 Edition — 12/65, E/P1/1500

The attention of ICAO should be drawn to any unavoidable deviation from the instructions.

FORM G

INSTRUCTIONS

Form to be filed by **each State** in respect of operators registered in the country to perform public air transport, which have had aircraft accidents (regardless of where the accident takes place or the nationality of the aircraft involved). The Form should also include accidents to aircraft on the country's register when, at the time of the accident, the aircraft was under control of a foreign public air transport operator (which should be identified).

This form is to be filed **ANNUALLY**, not later than **2 months** after the end of the year to which it refers.

DATA TO BE REPORTED

Data in columns *a* to *n* for an **individual operator** is to be reported only if its aircraft (whether owned or not owned) is involved in an accident (regardless of where the accident takes place).

Data should be reported in columns *c* and *d* relating to the total activities of the operator during the year, subdivided into the types of operation indicated.

Data should be reported in columns *e* to *n* opposite the type of operation in which the aircraft was engaged at the time of the accident.

NOTES:

A collision between two or more aircraft should be reported separately for each operator involved, and additional details should be provided under "Remarks".

Accidents resulting in only minor injuries or damages should not be reported.

Each State is to report the "hours flown" and "landings made" in the lower left hand corner of the Form, whether or not an accident has been reported.

EXPLANATION OF TERMS

Aircraft accident means an occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, in which:

a) any person suffers death or serious injury as a result of being in or upon the aircraft or by direct contact with the aircraft or anything attached thereto, or

b) the aircraft receives substantial damage (Annex 13).

Scheduled and **non-scheduled operations** relate to operations for which remuneration is received. The terms apply to the stages of an operation, but not necessarily to the operator; thus, an airline whose operations are predominantly scheduled may, from time to time, operate non-scheduled flights.

Non-revenue relates to operations such as positioning flights, test flights, training flights, etc.

International and **domestic** are classifications according to the rules given below for the classification of flight stages, a "flight stage" being the operation of an aircraft from take-off to landing:

International:

A "flight stage" with one or both terminals in the territory of a State other than the one in which the airline is registered.

Domestic:

A "flight stage" with both terminals in the territory of the State in which the airline is registered.

COLUMNS

Number of landings (Column *c* and lower left):

If the number of landings cannot be ascertained without difficulty, an estimate may be given and a note inserted under "Remarks" indicating that the figure is an estimate.

Aircraft hours (Column *d* and lower left):

Report to nearest number of whole hours. Indicate under "Remarks" basis used — such as "block-to-block", "wheels off-wheels on", etc.

Passengers injured (Columns *i, j*):

Include the total number of passengers involved, both revenue and non-revenue.

Crew members injured (Columns *k, l*):

Include hostesses, stewards and supernumerary crew in addition to flight crew.

Others injured (Columns *m, n*):

Include all persons injured other than those aboard the aircraft.

PART IV

List of Laws and Regulations of Countries containing provisions relating to "Aircraft Accident Investigation"

(Replacing list in Digest No. 15)

ARGENTINA

1952	oct.	9	Resolución Núm. 100 (S.A.C.) - Normas para la investigación de accidentes de aviación civil y directivas generales para la investigación. Ampliada el 8 de enero de 1954.
1954	enero	12	Decreto Núm. 299 - Creación de la Junta de Investigaciones de Accidentes de Aviación y competencia de la Subsecretaría de Aviación Civil y Comando en Jefe de la Fuerza Aérea Argentina en la Investigación de Accidentes Civiles y Militares respectivamente.
1957	feb.	19	Normas para investigación de accidentes de aeronaves de propiedad particular.
1967	mayo	17	Ley Núm. 17.285 - Código Aeronáutico: Título IX. - Investigación de Accidentes de Aviación.

AUSTRALIA

1947	Aug.	6	The Air Navigation Regulations, S.R. No. 112/1947, as amended: Part XVI. - Accident Inquiry, (Regs. 270-297).

AUSTRIA

1957	Dec.	2	The Federal Air Law: Part VIII. - D) Investigation of civil aircraft accidents.
1958	March	29	Ordinance No. 68 relating to aircraft accident investigation. *Amended by Ordinance No. 216 of 27 July 1965.

BOLIVIA

1964	agosto	28	Decreto Supremo Nº 06877 - Reglamentación Técnica y Administrativa de la Ley de creación de la DGAC de 25 de octubre de 1947: (Art. 1 t).

BRAZIL

1948	April	15	Accident Inquiry Service Regulations (Decreto Nº 24.749).
1951	July	24	Portaria 280 - Recommendations relating to aircraft accident investigation.
1955	Feb.	28	Aviso Núm. 6 - Establishment of time for the accident inquiry service regulations.

* The text does not exist in the files of ICAO.

BULGARIA

1963			Law on Civil Aviation (Official Gazette No. 1 - 4 January 1963): VI. - Section 44.

BURMA

1934			The Union of Burma Aircraft Act, (XXII of 1934): Section 7. - Power of the President of the Union of Burma to make rules for investigation of accidents.
1937			The Union of Burma Aircraft Rules, as amended: Part X. - Investigation of Accidents.
1949			Regulations relating to Aircraft Accident and Incident Investigations, (Notice to Airmen No. 5/1949).

BURUNDI

1966	avril	13	Arrêté-loi n° 001/19 sur la loi relative à la navigation aérienne: Article 11. - Enquêtes.

CANADA

1960	Dec.	29	The Air Regulations, Order in Council P.C. 1960-1775 (SOR/61-10), as amended: Part I. Sec. 101. (6), (7), (7a) - Interpretation. Section 102. - Application. Part VIII. Div. III. - Aircraft Accident Investigation, (Order in Council P.C. 1967-413 - SOR/67-111).
1964	Oct.	7	Air Navigation Order, Series VIII, No. 1 - Aircraft Accidents and Missing Aircraft (SOR/64-433).

CEYLON

1950	March	29	Air Navigation Act, No. 15/1950, as amended: Part I, Section 12. - Power to provide for investigation into accidents.
1955	May	4	Civil Air Navigation Regulations: Chapter XVI. - Accident Inquiry.

CHAD

1963	avril	11	Décret N° 78/PR/TP portant Code de l'Aviation Civile: Livre Ier - Titre IV. - Des Accidents.

CHILE

*1951			Manual sobre Investigación de Accidentes de Aviación (Publicación de la Dirección de Aeronáutica MT 4-9).

CHINA (TAIWAN)

1953	Oct.	21	Civil Air Regulations No. 102 - Accident Reporting and Investigation.

* The text does not exist in the files of ICAO.

COLOMBIA

1960	julio	18	Decreto Supremo Nº 1721 por medio del cual se crea y organiza el Departamento Administrativo de Aeronáutica Civil y se fijan sus funciones: II. Art. 5 c), IV. Art. 10b), XII. Art. 38d), XIII. Art. 40 b), XXII. Art. 61.
1964			Manual de Reglamentos Aeronáuticos: Parte VIII. - Seguridad Aérea - 82. Investigación de Accidentes.

COSTA RICA

1949	oct.	18	Ley General de Aviación Civil Nº 762: Parte I. - Título I. - Cap. 2 Sección VIII. - Accidentes.
*1957	nov.	27	Decreto Ejecutivo Nº 47 - Regulaciones aéreas: Part VI. Accidentes. (La Gaceta, 12.12.57)

CUBA

1964	sept.	18	Ley Nº 1160 por la que se crea el "Instituto de Aeronáutica Civil de Cuba": Art. 2. d). (Gaceta Oficial Nº 30 - 22.9.64, p. 585)

CZECHOSLOVAKIA

1947			Decree of Ministry of Interior on accident investigation, No. 1600/47.
1957	Sept.	24	Civil Aviation Act: Para. 45. - Investigation of Aircraft Accidents.
*1961			Regulations on Administrative Investigation of Aircraft Accident Causes. (CAIC No. 12/1961)

DAHOMEY

1963	déc.	27	Ordonnance nº 26/GRPD/MTP portant Code de l'Aviation Civile et Commerciale: Livre 1er - Titre IV. - Des Accidents.

DENMARK

1960	June	10	The Civil Aviation Act. Came into force on L January 1962: Chapter XI. - Investigation of Accidents (Paras. 134-144).

EAST AFRICA

1964			The East African Civil Aviation Act, No. 22/1964. Amended by Amendment Act No. 12 of 31 December 1965: Part IV. - 12 (q).
1965	Jan.	14	The Civil Aviation (Investigation of Accidents) Regulations, L.N. 49/1965. Amended up to 14 October 1965.

* The text does not exist in the files of ICAO.

ECUADOR

1954	julio	8	Acuerdo Ministerial N° 7 - Reglamento de Aeronáutica Civil del Ecuador: Título II. Parte 8. - Investigaciones y encuestas de accidentes de aviación.

EL SALVADOR

1955	dic.	22	Decreto N° 2011 - Ley de Aeronáutica Civil: Cap. XV. - De la Investigación de Accidentes Aéreos (Art. 173-187).

ETHIOPIA

1961	March	1	Investigation of Accident Regulations.
1962	Aug.	27	The Civil Aviation Decree No. 48/1962: 2. (b) (xiv) - Power of the Civil Aviation Administration to provide for investigation of accidents.

FRANCE

1937	avril	21	Décret relatif à la déclaration des accidents d'aviation.
1953	janv.	3	Instruction interministérielle relative à la coordination de l'information judiciaire et de l'enquête technique et administrative en cas d'accident survenu à un aéronef français ou étranger sur le territoire de la Métropole et les territoires d'Outre-mer.
1957	juin	3	Instruction du Secrétaire d'Etat aux Travaux Publics, aux Transports et au Tourisme n° 300 IGAC/SA, concernant les dispositions à prendre en cas d'irrégularité, d'incident ou d'accident d'aviation.
*1961	nov.	2	Arrêté relatif aux commissions d'enquête sur les accidents d'aviation.
1962	juin	20	Arrêté portant organisation et attributions du bureau "Enquêtes - Accidents" à l'inspection générale de l'aviation civile.

GERMAN DEMOCRATIC REPUBLIC

1963	July	31	Civil Aviation Law: IX. Flight Operation - Para. 44 - Investigation of Incidents.

GERMANY, FEDERAL REPUBLIC OF

1959	Jan.	10	The Aeronautics Act, as amended up to 5 April 1965: Article 32 6).
1960	Aug.	16	General Administrative rules with respect to the technical inquiry in case of accidents occurring during the operation of aircraft.

* The text does not exist in the files of ICAO.

GHANA

1958			Civil Aviation Act: Part II. - Paragraph 8 - Investigation of Accidents.

GREECE

*1968	May	11	Royal Decree No. 324 on aircraft accident investigation.

GUATEMALA

1948	oct.	28	Decreto Nº 563 - Ley de Aviación Civil: Capítulo X. - De los siniestros aeronáuticos (Art. 116-121).

HONDURAS

1957	sept.	3	Decreto Nº 146 - Ley de Aeronáutica Civil: Título I. - Cap. II. - Dirección General de Aeronáutica Civil - (Art. 6 XIII); Cap. XIV. - Investigación de Accidentes Aéreos.

ICELAND

1964	May	9	Aviation Act: Chapter 11. - Flight Accidents - Articles 141-147 - Investigation of Flight Accidents.

INDIA

1934	Aug.	19	The Indian Aircraft Act, 1934: Section 7. - Power of Central Government to make rules for investigation of accidents.
1937	March	23	The Indian Aircraft Rules, 1937, as amended: Part X. - Investigation of Accidents.

IRAQ

1939	Aug.	6	The Air Navigation Law No. 41: Article 5 (h).

IRELAND

1936			The Air Navigation and Transport Acts 1936 to 1965*: Part VII. - Section 60 - Investigation of Accidents.
1957	Feb.	9	The Air Navigation (Investigation of Accidents) Regulations, S.I. No. 19/1957.

* The text does not exist in the files of ICAO.

ITALY

1925	Jan.	11	Decree Law No. 356 - Rules for Air Navigation, as amended: Chapter VII.
1942	April	21	The Navigation Code, approved by Royal Decree No. 327 of 30 March 1942: Second Part - Air Navigation - Investigation of Accidents (Arts. 826-833).

IVORY COAST

1963	déc.	26	Loi nº 63-528 relative à l'aviation civile et commerciale: Livre Premier - Titre IV. - Des Accidents.

JAMAICA

1953			The Air Navigation (Investigation of Accidents) Regulations, No. 37/1953.
1966			The Civil Aviation Act, No. 19/1966: Part II. 5. - Investigation of Accidents.

JAPAN

1952	July	15	Civil Aeronautics Law No. 231, as amended: Chapter 9 - Art. 132.- Investigation of Accidents.

JORDAN

1953			Law No. 55 on Civil Aviation: Investigation of Accidents (Article 106).

KOREA

1961	March	7	Aviation Law No. 591:- Chapter IX. - Investigation of Accidents (Article 114).

LEBANON

1949	Jan.	11	Aviation Law: Chapter III. - Sub-chapter 2 - Landing of Aircraft (Article 39).

LIBERIA

1962			Civil Aviation Regulations, effective July 1, 1963: Part VIII. - Aircraft Accident Investigation.

LIBYA

1965	March	1	Royal Decree on the Law Organization Civil Aviation Affairs, Part VII. - Aviation Accidents.

* The text does not exist in the files of ICAO.

MALAWI

1965	July	30	Air Navigation Regulations (Government Notice No. 198/1965): Part 16. - Accidents.

MALAYSIA, FEDERATION OF

*1953	Nov.	1	Air Navigation (Investigation of Accidents) Regulations (L.N. 584/53).

MALI

1962	janv.	15	Loi no 62-12 AN-RM relative à l'aviation civile et commerciale: Ière Partie - Titre VI. - Des enquêtes sur les accidents d'aviation.
*	-		Instruction relative à la conduite des enquêtes concernant les accidents d'aviation survenus sur le territoire malien.

MALTA

1956			Civil Aviation (Investigation of Accidents) Regulations.

MAURITANIA

1962	juil.	3	Loi no 62-137 portant Code de l'Aviation civile: Article 9. - Enquêtes.
1962			Décret portant réglementation de la navigation aérienne: Première Partie - Titre VI. - Des enquêtes sur les accidents d'aviation.

MEXICO

1949	dic.	27	Ley de Aviación Civil (Libro IV de la Ley de Vías Generales de Comunicación): Cap. XIV. - De los Accidentes y de la Búsqueda y Salvamento (Art. 358-361).
1950	oct.	18	Reglamento para Búsqueda y Salvamento e Investigación de Accidentes Aéreos (en vigor a partir del 1º de enero de 1951).

MOROCCO

1962	juil.	10	Décret nº 2-61-161 (7 safar 1382) portant réglementation de l'aéronautique civile: Ière Partie - Titre VI. - Des enquêtes sur les accidents d'aviation (Arts. 106-114).
*1962	sept.	14	Arrêté du Ministre des Travaux Publics nº 533-62 relatif à la conduite des enquêtes concernant les accidents d'aviation sur le territoire marocain. Modifié par l'arrêté nº 602-66 du 7 septembre 1966.

* The text does not exist in the files of ICAO.

NEPAL

1959	April	22	Act No. 22 to control and regulate civil aviation: Section 5. - Power of His Majesty's Government to issue rules pertaining to investigation of accidents.

NETHERLANDS, KINGDOM OF THE

1936			Act regulating the Investigation of Accidents to Civil Aircraft (St. B. 1936, 522).

NEW ZEALAND

1953	Nov.	11	The Civil Aviation (Investigation of Accidents) Regulations, Serial No. 152/1953.
1964	Nov.	17	Civil Aviation Act No. 68/1964: Part III. - Investigation of Accidents.

NICARAGUA

1956	mayo	18	Decreto. Nº 176 - Código de Aviación Civil: Título II. - Cap. V. De la Investigación de Accidentes Aéreos.

NIGER

1962	juil.	17	Loi nº 62-13 portant Code de l'Aviation civile: Livre Ier - Titre IV. - Des Accidents (Arts. 63-65).

NORWAY

1960	Dec.	16	The Civil Aviation Act. Came into force on 1 January 1962: Chapter XI. C. - Investigation of Accidents (Paras. 164-168).
1961	Feb.	8	Royal Decree establishing a permanent aircraft accident investigation commission.(1)

PAKISTAN

1960	July	19	Civil Aviation Ordinance (No. XXXII of 1960), corrected up to 31st March 1966: Section 7 - Power to make rules for investigation of accidents.
1937	March	23	The Aircraft Rules (corrected up to 31st March 1966): Part X. - Investigation of Accidents (Rules 68-77A).

PANAMA

1963	agosto	3	Decreto-Ley Nº 19 por el cual se reglamenta la Aviación Nacional: Título II. - Cap. VII. De la Investigación de Accidentes Aéreos.

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(1) The substance of ICAO Annex 13 is used in principle at aircraft accident inquiries in Norway. The Annex is partially implemented as regulations through that Decree.

PARAGUAY

1954	enero	15	Resolución Nº 54 por la que se establece la definición "Accidentes de Aviación" y las normas a ser cumplidas en tales casos.
1957	sept.	30	Ley Nº 469 - Código Aeronáutico: Título XVI. - Accidentes Aeronáuticos.

PERSIAN GULF TERRITORIES

BAHRAIN

1958	March	2	The Bahrain Aircraft Accident Regulation, Notice No. 2/1958.

QATAR

1957	Aug.	17	The Qatar Aircraft Accident Regulations.

TRUCIAL STATES

1958	March	2	Aircraft Accident Regulations, Notice No. 1/1958.

PERU

1965	oct.	28	Ley Nº 15720 de Aeronáutica Civil: Título X. - Accidentes Cap. I. Investigación.
1965	dic.	28	Decreto Supremo Nº 16 - Reglamento de la Ley de Aeronáutica Civil del Perú: Accidentes (Artículos 124-132).

PHILIPPINES

1946	May	9	The Civil Aviation Regulations: Chapter XVI. - Aircraft Accident Investigation.
1952	June	20	The Civil Aeronautics Act, No. 776: Chapter V. - Section 32 - Power and Duties of the Administrator: (11) Investigation of Accidents.

POLAND

1962	May	31	Civil Aviation Act: Part V. - Chapter Two - Articles 50.2 and 55.

PORTUGAL

1930	Oct.	25	Decree No. 20.062 - Air Navigation Regulations: Chapter VIII.

ROMANIA

1953	Dec.	5	Decree No. 516 - The Air Code of the Romanian People's Republic. Amended by Decrees No. 204 of 11 May 1956 (B.O. No. 15) and No. 212 of 20 June 1959 (B.O. No. 17): Chapter VI. - Search and Rescue of Civil Aircraft in Distress - Handling of flight accidents and incidents.

ENEGAL

1963	Feb.	5	Law No. 63-19 - Code of Civil Aviation: Book IV. - Flight Personnel - Title I. - General Provisions - Chapter II. Discipline (Articles 143-146).

IERRA LEONE

*1953	Dec.	10	Civil Aviation (Investigation of Accidents) Regulations (P.N. 114/53).

OUTH AFRICA

1962	June	21	The Aviation Act, No. 74: Section 12. - Investigation of Accidents.
1963	Nov.	15	Air Navigation Regulations, G.N. No. R.1779, as amended up to 5 May 1967: Chapter 29. - Investigation of Accidents.

PAIN

1948	marzo	12	Decreto del Ministerio del Aire sobre investigación de accidentes y auxilio de aeronaves.
1960	julio	21	Ley Nº 48 sobre Navegación Aérea: Cap. XVI. - De los accidentes, de la asistencia y salvamento y de los hallazgos.

UDAN

1960			The Air Act, No. 49/1960: Chapter V. - Accidents and Insurance.

WEDEN

1957	June	6	The Swedish Air Act, No. 297/1957. Came into force on 1 January 1962: Chapter 11 - Paras. 7-13 - Investigation of Accidents.

WITZERLAND

1948	déc.	12	Loi fédérale sur la navigation aérienne (entrée en vigueur le 15 juin 1950): Articles 23-26.
1959	oct.	2	Loi fédérale concernant les enquêtes sur les accidents d'aéronefs, modifiant la loi fédérale sur la navigation aérienne de 1948.
1960	avril	1	Ordonnance sur les enquêtes en cas d'accidents d'aéronefs.

The text does not exist in the files of ICAO.

THAILAND

1954	Sept.	1	The Air Navigation Act, (B.E. 2497): Chapter 7. - Accidents (Sections 63 and 64).
1955	June	5	Civil Air Regulations No. 3 - Aircraft Accident Inquiry.

TRINIDAD AND TOBAGO

1954	Nov.	23	Air Navigation (Investigation of Accidents) Regulations (G.N. 205/54).

UNITED ARAB REPUBLIC

1941	May	5	Decree - Air Navigation Regulations: Article 10.

UNITED KINGDOM

1949	Nov.	24	The Civil Aviation Act (12 and 13 Geo. VI, Ch. 67): Part II. - Section 10 - Investigation of Accidents.
1951	Sept.	5	The Civil Aviation (Investigation of Accidents) Regulations, S.I. No. 1653. Came into operation on 1 October 1951.
1959	Aug.	6	The Air Navigation (Investigation of combined military and civil air accidents) Regulations, S.I. 1959, No. 1388. Amended by S.I. 1960, No. 1526; S.I. 1966, No. 785; The Defence (Transfer of Functions) (No. 2) Order, S.I. No. 489, 26 March 1964.

UNITED KINGDOM DEPENDENT TERRITORIES

Article 76 of the Colonial Air Navigation Order, 1961, 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 Dependent Territories:

Bahamas
Bermuda
British Honduras
British Solomon Islands Protectorate
Central and Southern Line Islands - Malden
Starbuck
Vostock
Caroline
Flint

Falkland Islands and Dependencies
Fiji
Gibraltar
Gilbert and Ellice Islands Colony
Hong Kong

UNITED KINGDOM DEPENDENT
TERRITORIES (Contd)

Leeward Islands - Antigua
Montserrat
St. Christopher and Nevis
Virgin Islands
St. Helena and Ascension
Seychelles
Southern Rhodesia
Swaziland
Tonga Islands
Windward Islands - Dominica
Grenada
St. Lucia
St. Vincent

BAHAMAS

*1952	Aug.	1	Air Navigation (Investigation of Accidents) Regulations.

BERMUDA

*1948	Dec.	18	Air Navigation (Investigation of Accidents) Regulations.

BRITISH HONDURAS

*1953	Dec.	19	Air Navigation (Investigation of Accidents) Regulations, (S.I. 1/54).

FIJI

*1952	May	1	Civil Aviation (Investigation of Accidents) Regulations, (L.N. 90/1952).

GIBRALTAR

1952	Jan.	3	Air Navigation (Investigation of Accidents) Regulations.

HONG KONG

*1951			Air Navigation (Investigation of Accidents) Regulations.

LEEWARD ISLANDS

*1952	July	31	Civil Aviation (Investigation of Accidents) Regulations, (S.R.O. 18/52).

* The text does not exist in the files of ICAO.

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).

SOUTHERN RHODESIA

1954	March	26	Aviation Act No. 10/1954: Section 4(s), (t), Section 13 - Enquiries.
1954	June	18	Air Navigation Regulations (F.G. No. 246/1954): Part 18. - Accidents.

UNITED STATES

Federal Statutes

1958			The Federal Aviation Act of 1958, as amended, (Public Law 85-726, 85th Congress, 2nd Session; 72 Stat. 731; 49 U.S. Code): Title II. - General Powers and Duties of the Civil Aeronautics Board - 204(a) General Powers; Title III. - Organization of Agency and Powers and Duties of Administrator - Sec. 313(c) Power to Conduct Hearings and Investigations; Title VII. - Aircraft Accident Investigation; Title IX. - Penalties - Sec. 902 (o) - Interference with aircraft accident investigation.
			The Federal Aviation Act of 1958, Annotated: Title VII.
1966	Oct.	15	Department of Transportation Act (Public Law 89-670, 89th Congress, 2nd Session, 80 Stat. 941): Sec. 5 - National Transportation Safety Board; Sec. 6 - Transfers to Department: (c) Federal Aviation Agency, (d) Civil Aeronautics Board.

U.S. Code of Federal Regulations

Title 14 - Aeronautics and Space

(Chapter II. - Civil Aeronautics Board Regulations)

1955			Part 399 - Statements of General Policy (as issued, effective May 25, 1955, F.R. 4117; amended and codified, effective January 29, 1964, 29 F.R. 1454): Subpart F - Policies relating to aircraft accident investigations: 399.70 - Investigation of accidents involving foreign aircraft.

* The text does not exist in the files of ICAO.

NITED STATES (Contd)

(Chapter III. - National Transportation Safety Board)

1967			Part 400 - Statement of Organization and Functions of the Board and Delegations of Authority, (as adopted, effective July 4, 1967, 32 F.R. 12839).
			Part 430 - Rules pertaining to Aircraft Accidents, Incidents, Overdue Aircraft and Safety Investigations, (as reissued by Regulation No. SIR-4, effective April 1, 1963, 28 F.R. 583; amended and reissued by Regulation No. SIR-7, effective May 18, 1966, 31 F.R. 6585; part 320 transferred to Chapter III - NTSB in Title 14 and redesignated and amended as Part 430, effective December 1, 1967, 32 F.R. 16491).
			Part 431 - Rules of Practice in Aircraft Accident Investigation Hearings, (as issued September 15, 1950, 15 F.R. 6440; revised effective February 15, 1957, 22 F.R. 1026; Part revised by Reg. PR-35, effective March 21, 1959, 24 F.R. 2224; Part 303 transferred to Chapter III - NTSB in Title 14 and redesignated and amended as Part 431, effective December 1, 1967, 32 F.R. 16491).
			Part 435 - Disclosure of Aircraft Accident Investigation Information (as issued September 15, 1950, 15 F.R. 6441; reissued effective April 1, 1963, 28 F.R. 582; revised effective January 3, 1966, 30 F.R. 14920; Part 311 transferred to Chapter III - NTSB in Title 14 and redesignated and amended as Part 435, effective December 1, 1967, 32 F.R. 16491).

U.S. Code of Federal Regulations
Title 22 - Foreign Relations

1952			Part 102 - Civil Aviation - Subchapter K - Economic, Commercial and Civil Aviation Functions: U.S. Aircraft Accidents Abroad; Foreign Aircraft Accidents Involving U.S. Persons or Property. (As issued in Department Regulations 108.164, effective October 1, 1952, 17 F.R. 8207; Part 102 as republished, effective December 23, 1957, 22 F.R. 10871).

RUGUAY

1955	feb.	2	Decreto N° 23.826 - Reglamento para la investigación de Accidentes de Aviación de carácter Civil.

ENEZUELA

1955	abril	1	Ley de Aviación Civil: Cap. X. - De los accidentes y de la búsqueda y rescate.

WESTERN SAMOA

1963	Aug.	1	Civil Aviation Act, No. 6/1953: Part VIII. - Accident Inquiry.

YUGOSLAVIA

1965	March	15	Air Navigation Law (published in the Official Gazette of the Federal People's Republic of Yugoslavia, No. 12/65): IV. Accidents, Search and Rescue.

ZAMBIA

1954	March	26	Aviation Act No. 10/1954: Section 4(a), (t); Section 13 - Enquiries.
1954	June	18	Air Navigation Regulations (F.G.N. No. 246/1954): Part 18. - 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 derive their status from the International Standards, Recommended Practices and PANS from which they are compiled. They are prepared primarily for the use of personnel engaged in operations in the field, as a service to those Contracting States who do not find it practicable, for various reasons, to prepare them for their own use.

TECHNICAL MANUALS provide guidance and information in amplification of the International Standards, Recommended Practices and PANS, the implementation of which they are designed to facilitate.

AIR NAVIGATION PLANS detail requirements for facilities and services for international air navigation in the respective ICAO Air Navigation Regions. They are prepared on the authority of the Secretary General on the basis of recommendations of regional air navigation meetings and of the Council action thereon. The plans are amended periodically to reflect changes in requirements and in the status of implementation of the recommended facilities and services.

ICAO CIRCULARS make available specialized information of interest to Contracting States. This includes studies on technical subjects as well as texts of Provisional Acceptable Means of Compliance.

EXTRACT FROM THE CATALOGUE
ICAO SALABLE PUBLICATIONS

ANNEX

	U.S.$
Annex 13 - Aircraft accident inquiry. 2nd edition, March 1966. 16 pp.	$0.50

MANUAL

Manual of aircraft accident investigation. (Doc 6920-AN/855/3). 3rd edition, 1959. 257 pp.	$4.00

ICAO CIRCULARS

18-AN/15 - Aircraft Accident Digest No. 1. June 1951. 116 pp.	$2.00
24-AN/21 - Aircraft Accident Digest No. 2. 1952. 170 pp.	$0.85
31-AN/26 - Aircraft Accident Digest No. 3. 1952. 190 pp.	$1.00
38-AN/33 - Aircraft Accident Digest No. 4. 1954. 186 pp.	$3.00
39-AN/34 - Aircraft Accident Digest No. 5. 1955. 186 pp.	$2.00
47-AN/42 - Aircraft Accident Digest No. 6. 1956. 237 pp.	$2.50
50-AN/45 - Aircraft Accident Digest No. 7. 1957. 245 pp.	$2.50
54-AN/49 - Aircraft Accident Digest No. 8. 1958. 212 pp.	$2.25
56-AN/51 - Aircraft Accident Digest No. 9. 1959. 290 pp.	$3.00
59-AN/54 - Aircraft Accident Digest No. 10. 1961. 286 pp.	$3.00
62-AN/57 - Aircraft Accident Digest No. 11. 1961. 266 pp.	$4.25
64-AN/58 - Aircraft Accident Digest No. 12. 1963. 376 pp.	$5.75
69-AN/61 - Aircraft Accident Digest No. 13. 1964. 359 pp.	$5.50
71-AN/63 - Aircraft Accident Digest No. 14.	
Volume I. 1965. 115 pp.	$2.00
Volume II. 1966. 202 pp.	$3.25
78-AN/66 - Aircraft Accident Digest No. 15.	
Volume I. 1966. 156 pp.	$2.50
Volume II. 1967. 256 pp.	$4.00
82-AN/69 - Aircraft Accident Digest No. 16.	
Volume I. 1968. 171 pp.	$2.75
Volume II. 1968. 107 pp.	$1.75
Volume III. 1968. 205 pp.	$3.25

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