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No. 8

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1955

TABLE A
(1st Revision)

CONTRACTING STATES OF ICAO

PASSENGER FATALITIES OCCURRING ON SCHEDULED INTERNATIONAL AND DOMESTIC OPERATIONS

YEAR 1955

Description	Country Total of Hours Flown	Number of Fatal Accidents /a/	Number of Passengers Killed a/	Country Total of Passenger Kilometres	Fatality Rate per 100 Million Pass.-Kms.	Millions of Passenger - Kilometres per Fatality
	(thousands)			(millions)		
Total Scheduled Operations						
Belgium	86	1	21	579		
Brasil	428‡	4	26	1 684‡		
Burma	16	1	6	61		
Colombia	145‡	1	5	484‡		
France	300‡	1	10	3 138‡		
India	126	1	6	515		
Israel b/	13‡	1	51	141‡		
Mexico	220*	1	23	1 366*		
Peru	23‡*	1	15	93‡		
United Kingdom	483	3	38	3 283		
United States c/	3 673	9	197	39 188		
Venezuela	98	1	9	325		
All other States	1 699	-	-	11 143		
Total	7 310	25	407	62 000	0.66	152
International Scheduled Operations						
Belgium	43	1	21	261		
Brasil	31‡	1	11	273‡		
Israel b/	12	1	51	138		
United Kingdom	339	2	29	2 765		
United States	583	1	2	7 248		
All other States	960	-	-	8 315		
Total	1 968	6	114	19 000	0.60	167
Domestic Scheduled Operations						
Brasil	397‡	3	15	1 412‡		
Burma	11	1	6	40		
Colombia	132*	1	5	338		
France	168‡*	1	10	1 503‡		
India	88	1	6	221		
Mexico	168*	1	23	911*		
Peru	23‡*	1	15	91‡*		
United Kingdom	144	1	9	519		
United States c/	3 090	8	195	31 940		
Venezuela	81	1	9	199		
All other States	1 040	-	-	5 826		
Total	5 342	19	293	43 000	0.68	147

NOTES:

Accident data have been recorded under the country in which the airline is registered and not in the country where the accident took place.

Under "Total Scheduled Operations" are listed all countries with scheduled airlines which had aircraft accidents resulting in passenger fatalities. These data have been segregated as to those fatalities occuring on a scheduled international flight and/or a scheduled domestic flight.

Source of data: ICAO Air Transport Reporting Forms and outside sources.

* Estimated data.
‡ Includes non-scheduled flights.

a/ Data excludes one accident for Yugoslavia (a non-member State) in which 6 passengers were killed.
b/ Data includes one accident with 51 fatalities in the forced landing of an Israeli aircraft brought down by anti-aircraft fire in Bulgaria.
c/ Data includes one accident with 39 fatalities in the crash of a United States aircraft caused by a bomb concealed on board.

CONTRACTING STATES OF ICAO
AIRCRAFT ACCIDENT SUMMARY FOR 1955
OF ALL OPERATORS ENGAGED IN PUBLIC AIR TRANSPORT

1955
TABLE B
(1st Revision)

Contracting States of ICAO	Number of Accidents		Passenger Injury			Crew Injury			Others Injured		By Operators With an Accident		Hours flown during year by all operators engaged in public air transport
	Total	Fatal	Fatal	Serious	Minor or None	Fatal	Serious	Minor or None	Fatal	Serious	Number of Landings	Hours Flown	
Afghanistan	nca	nca	nca	nca	nca	nca	nca	nca	nca	nca			
✓ Argentina	1	-	-	1	3	-	-	-	-	-	1 843	3 679	
✓ Australia	1	-	-	-	-	-	-	-	-	-	15 039	17 230	298 895
Austria	nca	nca	nca	nca	nca	nca	nca	nca	nca	nca			
✓ Belgium	1	1	21	-	-	8	-	-	-	-		103 360	
Bolivia	1	1	-	-	-	2	-	-	-	-			
Brazil	6	5	26	3	14	20	2	4	-	-			
✓ Burma	3	1	6	-	-	3	-	-	-	-	13 277	18 115	
Cambodia a/	nca	nca	nca	nca	nca	nca	nca	nca	nca	nca			
✓ Canada b/	1	-	-	-	-	-	-	-	-	-	169 045c/*	230 849c/	230 849
✓ Ceylon	-	-	-	-	-	-	-	-	-	-			
Chile	-	-	-	-	-	-	-	-	-	-			
China (Taiwan)	-	-	-	-	-	-	-	-	-	-			
Colombia	4	3	9	-	-	6	1	-	-	-			
Cuba	-	-	-	-	-	-	-	-	-	-			
Czechoslovakia	-	-	-	-	-	-	-	-	-	-			
Denmark	-	-	-	-	-	-	-	-	-	-			
Dominican Republic	-	-	-	-	-	-	-	-	-	-			
Ecuador	-	-	-	-	-	-	-	-	-	-			
Egypt	-	-	-	-	-	-	-	-	-	-			
El Salvador	nca	nca	nca	nca	nca	nca	nca	nca	nca	nca			
✓ Ethiopia	-	-	-	-	-	-	-	-	-	-			
✓ Finland	-	-	-	-	-	-	-	-	-	-			
✓ France d/	34	3	18	-	-	13	-	6	-	2		325 032	325 032
✓ Germany a/	2e/	2	6	-	-	1	-	-	-	-	1 500	1 819	
✓ Greece	-	-	-	-	-	-	-	-	-	-			
Guatemala	-	-	-	-	-	-	-	-	-	-			
Haiti	-	-	-	-	-	-	-	-	-	-			
Honduras	-	-	-	-	-	-	-	-	-	-			
Iceland	-	-	-	-	-	-	-	-	-	-			
✓ India	5	5	17	-	-	15	4	-	-	-		123 715	162 615
Indonesia	-	-	-	-	-	-	-	-	-	-			
Iran	1	-	-	-	9	-	-	4	-	-			
Iraq	3	-	-	-	-	-	-	-	-	-			
✓ Ireland	-	-	-	-	-	-	-	-	-	-			
✓ Israel	2	1	51	-	-	7	-	1	-	-	3 133	12 848	12 848
✓ Italy	-	-	-	-	-	-	-	-	-	-			
✓ Japan	-	-	-	-	-	-	-	-	-	-			39 568
Jordan	-	-	-	-	-	-	-	-	-	-			
Korea	-	-	-	-	-	-	-	-	-	-			
Laos	-	-	-	-	-	-	-	-	-	-			
✓ Lebanon	-	-	-	-	-	-	-	-	-	-			
Liberia	-	-	-	-	-	-	-	-	-	-			
Libya	nca	nca	nca	nca	nca	nca	nca	nca	nca	nca			
Luxembourg	nca	nca	nca	nca	nca	nca	nca	nca	nca	nca			
Mexico	3	2	42*	-	4	6*	-	3	-	-			
Morocco a/	-	-	-	-	-	-	-	-	-	-			
✓ Netherlands	-	-	-	-	-	-	-	-	-	-			
✓ New Zealand	9	-	-	-	-	-	-	-	-	-	110 674	55 252	
Nicaragua	2	1	-	-	-	1	-	-	-	-			
✓ Norway	3	1	-	-	-	1	-	-	-	-	9 461	8 192	53 705
✓ Pakistan	-	-	-	-	-	-	-	-	-	-			
Paraguay	nca	nca	nca	nca	nca	nca	nca	nca	nca	nca			
Peru	1	1	15	14	-	4	2	-	-	-			
✓ Philippines	2	1	-	1	-	1	-	-	-	-	4 475f/	38 524g/	38 524g/
Poland	-	-	-	-	-	-	-	-	-	-			
✓ Portugal	-	-	-	-	-	-	-	-	-	-			
✓ Spain	-	-	-	-	-	-	-	-	-	-			10 640
Sudan a/	-	-	-	-	-	-	-	-	-	-			
✓ Sweden	17	-	-	-	-	-	1	-	-	-	19 282h/	20 440	88 182
✓ Switzerland	-	-	-	-	-	-	-	-	-	-			
Syria	-	-	-	-	-	-	-	-	-	-			
✓ Thailand	2	-	-	-	4	-	-	2	-	-	8 434	13 170	13 170
Turkey	-	-	-	-	-	-	-	-	-	-			
✓ Un. of S. Africa	20	-	-	-	-	-	1	19	-	-			58 714
✓ United Kingdom i/	33	8	38	9	314	16	8	67	1	-	274 009	500 818	441 929
j/	(23)	(4)	(13)	(9)	(314)	(6)	(6)	(66)	(1)	(-)	(167 800)	(352 682)	(372 970)
✓ United States k/	95	19	224	41	1 339	40	7	257	7	1	2 636 077	4 498 643	4 099 605
Uruguay	1	-	-	-	-	-	-	-	-	-			
✓ Venezuela	5	4	15	-	-	7	-	2	1	-	78 550l/	58 336l/	118 476
Viet Nam	-	-	-	-	-	-	-	-	-	-			
Total for 70 States	257	59	488	69	1 687	151	26	365	9	3			
TYPE OF OPERATION													
Scheduled International	23	8	114	12	366	33	7	75	-	-			
Scheduled Domestic	106	24	293	54	1 056	63	7	175	6	3			
Non-Scheduled International	9	3	11	-	32	8	4	15	-	-			
Non-Scheduled Domestic	90	19	67	3	229	39	7	65	1	-			
Non-Revenue	29	5	3	-	4	8	1	35	2	-			
Total Operations	257	59	488	69	1 687	151	26	365	9	3			

NOTES: Source of Data: Air Transport Reporting Form G filed by countries indicated with a ✓.
All other country data collected from outside sources.

* Estimated
n.c.a. - No Civil Aviation.
a/ Country became a Contracting State in 1956.
b/ Data for scheduled operations only.
c/ Data for total operations of all scheduled operators.
d/ Excludes all domestic flights in Indo-China.
e/ Chartered aircraft.
f/ Landings at Manila International Airport only.
g/ Hours flown by private operators not available.
h/ Includes some helicopter landings.
i/ Data refer to airlines registered in the United Kingdom and its dependencies. Data somewhat incomplete for number of landings and hours flown.
j/ United Kingdom only. Data incomplete for number of landings and hours flown except in last column.
k/ Data refer to all public air transport i.e. scheduled U.S. and Alaska airlines as well as irregular air carriers.
Data incomplete for number of landings and hours flown.
l/ Data for LAV and RANSA only.

1955

TABLE C
(1st Revision)

CONTRACTING STATES OF ICAO
AIRCRAFT ACCIDENT SUMMARY FOR 1955
OF ALL OPERATORS ENGAGED IN PUBLIC AIR TRANSPORT
BY TYPE OF OPERATION

Type of Operation Contracting States of ICAO	Number of Accidents		Passenger Injury			Crew Injury			Others Injured		By Operators With an Accident	
	Total	Fatal	Fatal	Serious	Minor or None	Fatal	Serious	Minor or None	Fatal	Serious	Number of Landings	Hours Flown
SCHEDULED INTERNATIONAL OPERATIONS												
ø Belgium	1	1	21	-	-	8	-	-	-	-		43 404
Brasil	1	1	11	3	-	8	2	-	-	-		15 091
ø Israel	1	1	51	-	-	7	-	-	-	-	2 777	12 374
ø United Kingdom a/	15	4	29	8	214	8	5	42	-	-	96 624	304 671
b/	(12)	(2)	(13)	(8)	(214)	(3)	(5)	(42)	(-)	(-)	(86 112)	(263 681)
ø United States c/	5	1	2	1	152	2	-	33	-	-	145 789	521 682
Total for 5 States	23	8	114	12	366	33	7	75	-	-		
SCHEDULED DOMESTIC OPERATIONS												
ø Argentina	1	-	-	1	3	-	-	-	-	-	1 802	3 615
ø Australia	1	-	-	-	-	-	-	-	-	-		
Brasil	3	3	15	-	14	9	-	2	-	-		
ø Burma	3	1	6	-	-	3	-	-	-	-	10 162	11 442
ø Canada	1	-	-	-	-	-	-	-	-	-	143 329*	178 006
Colombia	1	1	5	-	-	3	-	-	-	-		56 792
ø France d/	19	1	10	-	-	2	-	4	-	2		299 611 e/
ø India	2	2	6	-	-	7	-	-	-	-		87 548
Iraq	1	-	-	-	-	-	-	-	-	-		
Mexico	1	1	23	-	-	3	-	-	-	-		
ø New Zealand	1	-	-	-	-	-	-	-	-	-	40 111	45 996
Nicaragua	1	-	-	-	-	-	-	-	-	-		
ø Norway	2	-	-	-	-	-	-	-	-	-	1 085	837
Peru	1	1	15	14	-	4	2	-	-	-		
ø Thailand	1	-	-	-	3	-	-	1	-	-	5 402	5 321
ø United Kingdom a/	6	2	9	-	56	4	1	11	1	-	135 723	146 632
b/	(3)	(1)	(-)	(-)	(56)	(-)	(-)	(11)	(1)	(-)	(64 054)	(68 419)
ø United States c/	60	11	195	39	980	26	4	155	4	1	2 469 041 f/	2 765 426 f/
ø Venezuela	1	1	9	-	-	2	-	2	1	-	35 554	28 672
Total for 18 States	106	24	293	54	1 056	63	7	175	6	3		
NON-SCHEDULED INTERNATIONAL OPERATIONS												
ø India	1	1	11	-	-	5	3	-	-	-		2 709
ø Thailand	1	-	-	-	1	-	-	1	-	-	128	347
ø United Kingdom a/	2	-	-	-	31	-	1	6	-	-	3 884	10 707
b/	(2)	(-)	(-)	(-)	(31)	(-)	(1)	(6)	(-)	(-)	(1 074)	(4 355)
ø United States c/	3	1	-	-	-	-	-	8	-	-	3 062 f/	40 894 f/
ø Venezuela	2	1	-	-	-	3	-	-	-	-	1 260	5 060
Total for 5 States	9	3	11	-	32	8	4	15	-	-		
NON-SCHEDULED DOMESTIC OPERATIONS												
Bolivia	1	1	-	-	-	2	-	-	-	-		
Brasil	1	1	-	-	-	3	-	-	-	-		
Colombia	2	1	4	-	-	1	1	-	-	-		
ø France g/	6	2	8	-	-	11	-	-	-	-		
ø Germany h/	1	1	3	-	-	1	-	-	-	-	810	735*
ø India	2	2	-	-	-	3	1	-	-	-		8 458
Iran	1	-	-	-	9	-	-	4	-	-		
Iraq	1	-	-	-	-	-	-	-	-	-		
Mexico	2	1	19*	-	4	3	-	3	-	-		
ø New Zealand	8	-	-	-	-	-	-	-	-	-	70 563	9 256
Nicaragua	1	1	-	-	-	1	-	-	-	-		
ø Norway	1	1	-	-	-	1	-	-	-	-	949	628
ø Philippines	2	1	-	1	-	1	-	-	-	-		1 589 i/
ø Sweden	16	-	-	-	-	-	1	-	-	-	15 395	18 171
ø Union of South Africa	20	-	-	-	-	-	1	19	-	-		16 839
ø United Kingdom a/	6	1	-	1	11	1	1	3	-	-	18 703	18 271
b/	(2)	(-)	(-)	(1)	(11)	(-)	(-)	(2)	(-)	(-)	(1 138)	(1 177)
ø United States c/ j/	16	4	27	1	205	9	2	36	1	-	18 185 f/	48 063 f/
Uruguay	1	-	-	-	-	-	-	-	-	-		
ø Venezuela	2	2	6	-	-	2	-	-	-	-		
Total for 19 States	90	19	67	3	229	39	7	65	1	-		
NON-REVENUE OPERATIONS												
Brasil	1	-	-	-	-	-	-	2	-	-		
Colombia	1	1	-	-	-	2	-	-	-	-		
ø France	9	-	-	-	-	-	-	2	-	-		15 038 k/
ø Germany h/	1	1	3	-	-	-	-	-	-	-	28	8
ø Israel	1	-	-	-	-	-	-	1	-	-	356	474
ø Sweden	1	-	-	-	-	-	-	-	-	-	145	103
ø United Kingdom a/	4	1	-	-	2	3	-	5	-	-	19 075	20 537
b/	(4)	(1)	(-)	(-)	(2)	(3)	(-)	(5)	(-)	(-)	(15 422)	(15 050)
ø United States c/ j/	11	2	-	-	2	3	1	25	2	-		91 770 f/
Total for 8 States	29	5	3	-	4	8	1	35	2	-		

NOTES: Source of Data: Air Transport Reporting Form G filed by countries indicated with a ø.
All other country data collected from outside sources.

* Estimated.

a/ Data refer to airlines registered in the United Kingdom and its dependencies. Data incomplete for number of landings and hours flown.
b/ United Kingdom data only. Data incomplete for number of landings and hours flown.
c/ Data for all scheduled U.S. and Alaska airlines.
d/ International scheduled operations are combined with domestic scheduled operations.
e/ Includes some non-scheduled and non-revenue data for airlines other than Air France.
f/ Data incomplete for number of landings and hours flown.
g/ Non-scheduled international operations are combined with non-scheduled domestic operations.
h/ Chartered aircraft.
i/ Hours flown by private operators not available.
j/ Data for all scheduled U.S. and Alaska airlines as well as irregular air carriers.
k/ Air France only.

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FOREWORD

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

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

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

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

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

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

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

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

Whenever possible, photos and diagrams have been obtained for illustration purposes in order to give a clearer over-all picture of the crash area, an idea of the probable flight paths of aircraft, the location of witnesses to the crash, and in general to make the reports more interesting to the reader.

Part II of this issue dealing with Aircraft Accident Statistics has been based on material derived from the Air Transport Reporting Forms G submitted by States and other sources. (For further review of material included refer to the Introduction, page 189). The tables for 1956 are presented in the same manner as those appearing in Digest No. 7 for the year 1955, and it is to be noted that revised tables for 1955 have been issued with this Digest.

Part III consists of Pilot Safety Exchange Bulletin 57-110 of Flight Safety Foundation Inc., an article on "Runaway Propellers" by Capt. T. J. Slaybaugh reprinted from "The MATS Flyer" of October 1957. This additional information ties in with the report on the ditching of a Pan American World Airways, Inc. Boeing 377 in the Pacific Ocean in October 1956, which is presented in this Digest.

Part IV is the most recent list of laws and regulations available relating to aircraft accident investigation, incorporating all amendments received by ICAO up to 29 November 1957.

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

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COMMENTS ON ACCIDENT SUMMARIES, CLASSIFICATION TABLES AND SUMMARY OF REPORTED ACCIDENT CAUSES - 1956

One hundred and sixty-six reports on aircraft accidents occurring during 1956 have been received by ICAO from nineteen Contracting States. The form of the original reports has ranged from a brief statement of the facts to a comprenhensive account of the investigation. Selection of thirty-four accident reports for inclusion, in summary form, in this Digest has been made on the following basis:

1) World-wide interest in the accident, due to either
    a) Major disaster aspect which had resulted in wide publicity, or
    b) Special nature of accident and possibility of remedial action
2) Suitability of the original report for preparation of a summary;
3) Interest as an example of good accident investigation practice.

Four reports carried over from 1955 have been inserted at the beginning of Part I. These do not appear on Tables A and B.

Summaries of certain known accidents in the category 1(a) would have been included in this Digest if the reports had been available in time for publication. Some of the reports received, of accidents in this category, proved to be unsuitable for summarizing. In order to present a more comprehensive picture, a list is included, at the end of Part I, of all the accidents falling in category 1(a) known to have occurred during 1956, in addition to those which have been summarized.

The classifications in Tables A and B closely follow the suggestions contained in the ICAO Manual of Aircraft Accident Investigation (Doc 6920-AN/855). While the tables serve a useful purpose in indicating the cause trends, the figures are not significant for statistical purposes and readers are warned not to place too much reliance on the trends indicated without comparison with other figures, such as those published by national administrations. The reason for this is that the classifications have been based on accident reports which have been founded on a variety of reporting and analyzing techniques. Also the accidents reported in 1956, and included in these classifications, do not include all accidents that occurred and that were investigated during the year; less than half of those investigated by States are included in published reports or sent to ICAO, and of these a selection, as described above, has been made. No effort has been made in this publication to classify according to the type of operations being conducted, for instance, whether scheduled, non-scheduled, airwork, or non-revenue operations such as testing, training or positioning. However, a notation on the type of operation being conducted, where known, is included in Table A.

The ICAO Manual of Accident Investigation has proved to be a valuable guide in securing the information required for accident prevention measures and in ensuring that the investigation and subsequent classification of accidents achieved some measure of uniformity. The Manual is being revised and it is hoped that the Third Edition will be available during 1958. The main structure of accident classification in Chapter 1 will be retained but some minor modification and rearrangement will be introduced.

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

A survey of the accident reports for 1956 suggests that the following features are worthy of attention:

Table A

(i) Of the 34 accidents classified, the largest percentages occurred during the following phases of operation:-

climb after take-off	17.7%	-same as the 1955 figure
en route	41.2%	-approximately 12% more than the 1955 percentage
final approach	17.7%	-same as the 1955 figure

(ii) the remaining 23.4% was made up as follows:-

take-off run	2.9%
initial climb	2.9%
landing procedure	2.9%
initial approach	2.9%
landing run	5.9%
missed landing	5.9%

Table B

(i) 59% of the accidents were due to pilot error - 30% of these occurred because the pilot misjudged his distance - 15% were due to the fact that he continued VFR into unfavourable weather

(ii) 20% were due to material failure - approximately half were because of propeller difficulties

(iii) the remaining percentages were -

error of crew member	3%
errors of other personnel	3%
weather	3%
miscellaneous	3%
undetermined	9%

TABLE 4:- ACCIDENT CLASSIFICATION - 1956 (based on phase of operation)

Phase of Operation	No.	Type of Accident	No.	Apparent Cause	No.	Description	No.	ICAO Ref.	* Type of Operation	Page
Take-off Run	1	Ground loop	1	Pilot error	1	Overcorrection of the portward course.	1	AR/455	NS	78
Initial Climb	1	Uncontrolled yaw	1	Pilot error	1	Operated No. 3 high pressure cock lever instead of No. 4 when simulating No. 4 engine failure on take-off.	1	AR/433	TR	34
Climb after Take-off	6	Stall	1	Material failure	1	Failure of No. 1 engine and subsequent loss of control through error of judgment.	1	AR/474	NS	41
		Emergency condition (immediate forced landing)	1	Error of crew member	1	Incorrect analysis of control difficulty which occurred on retraction of wing flaps due to flight engineer's failure to close the engine cowl flaps.	1	AR/446	S	72
		Other collisions	1	Weather	1	Encountered unpredictable thunderstorm cell.	1	AR/449	S	89
		Uncontrolled yaw	1	Pilot error	1	Uncoordinated emergency action.	1	AR/443	S	67
		Collision with building	1	Undetermined	1	The direct cause of the accident is unknown.	1	AR/482	S	159
		Collision with terrain	1	Material failure	1	Total loss of power in starboard engine due to failure of lubricating system.	1	AR/476	S	166
En Route	14	Emergency condition (immediate forced landing)	1	Material failure	1	Failure of starboard engine under icing conditions.	1	AR/454	NS	32
		Collision with terrain	4	Pilot error	4	Attempted flight in spite of bad weather reports and forecasts.	1	AR/451	NS	60
						Continued VFR flight into unfavourable weather.	1	AR/460	S	76
						Instrument flight at excessively low altitude.	1	AR/475	NS	156
						Violated flight rules.	1	AR/453	S	176
		Collision with other aircraft	2	Pilot error	2	Failure of both pilots to observe other aircraft.	2	AR/465 AR/462	S & NS S & S	126 95
		Miscellaneous	1	Miscellaneous	1	Passenger accidentally opened cabin door and fell out.	1	AR/457	S	86
		Emergency condition (precautionary landing)	3	Material failure	2	Inflight separation of No. 4 propeller as a result of excessive loads induced by a descent at too high an airspeed.	1	AR/461	S	113
						Mechanical failure precluded feathering No. 1 propeller - subsequent failure resulted in complete loss of power from No. 4 engine.	1	AR/469	S	133
				Pilot error	1	Inadequate navigational procedure.	1	AR/479	NS	117
		Fire in flight	1	Material failure	1	Undetermined - may have been occasioned by a number of causes - fuel or hydraulic leakage or electrical short circuit.	1	AR/447	S	152
		Dive into ground	1	Pilot error	1	Flew into darkness and adverse weather in which he could not maintain control.	1	AR/468	S	130
		Airframe failure in flight	1	Undetermined	1	Loss of control for reasons unknown, structural failure resulted.	1	AR/480	NS	173
Landing Procedure	1	Collision with terrain	1	Pilot error	1	Pilot-in-command failed to monitor co-pilot during direct approach procedure.	1	AR/431	S	56
Initial Approach	1	Undershoot	1	Undetermined	1	The cause of the accident could not be determined.	1	AR/484	S	183
Final Approach	6	Heavy landing	1	Pilot error	1	Improperly executed final approach resulted in a stall during steep turn at low altitude.	1	AR/437	S	36
		Undershoot	2	Material failure	1	Malfunctioning of propeller control switches.	1	AR/444	S	51
				Pilot error	1	Permitted aircraft to descend too low before power was applied to arrest its descent.	1	AR/467	S	82
		Collision with terrain	1	Pilot error	1	Continued approach following loss of visual reference.	1	AR/441	NS	61
		Sideslip into ground	1	Pilot error	1	Error of judgment resulted in execution of steep turn at low altitude.	1	AR/463	NS	116
		Other collisions	1	Pilot error	1	Relying on vision of airport lights to assess his height, the captain misjudged his distance.	1	AR/471	NS	138
Landing Run	2	Overshoot	1	Pilot error	1	Improper approach and subsequent landing too far down a snow-covered, slippery runway.	1	AR/436	S	27
		Nose up	1	Errors of other personnel	1	Inadequate maintenance of runway lights and incorrect reporting of their condition.	1	AR/442	S	64
Missed Landing	2	Sideslip into ground	1	Pilot error	1	Full retraction of wing flaps at low altitude without necessary corrective action.	1	AR/464	S	123
		Overshoot	1	Pilot error	1	Failed to reduce speed during latter portion of single-engine approach, overshot and attempted go-around too late.	1	AR/470	S	148

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

TABLE B:- ACCIDENT CLASSIFICATION - 1956 (based on accident causes)

Cause	No.	Description	No.
Personnel error			
Pilot	20	- misused brakes and/or flight controls on the ground	1
		- continued VFR flight into unfavourable weather	3
		- misjudged distance	6
		- misused powerplant or powerplant controls	2
		- exceeded operating limitation	1
		- failed to observe other aircraft	2
		- attempted flight beyond ability or experience	1
		- became lost	2
		- failed to maintain adequate flying speed	1
		- miscellaneous	1
Crew member	1	- misused powerplant or powerplant controls	1
Other personnel	1	- improperly operated aerodrome facilities and other ground aids	1
Material failure	7	- powerplant - propeller	3
		- powerplant - lubrication	2
		- powerplant - engine	1
		- equipment and accessories	1
Weather	1	- thunderstorm	1
Miscellaneous	1	- passenger opened main cabin door and fell out	1
Undetermined	3		3

PART I

No. 1

Trans World Airlines, Inc., Martin 404 aircraft crashed on Sandia Mountain, near Albuquerque, New Mexico, on 19 February 1955. Civil Aeronautics Board (USA) Amended Accident Investigation Report No. SA-303, File No. 1-0063. Revisions to the original report were released 26 August 1957.

(The following report is not included in the classification tables)

Circumstances

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

Investigation and Evidence

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

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

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

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

The pilot must have suddenly realized that he was practically at the precipitous wall of the mountain and acted quickly. We can

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* The Weiler Intersection is the intersection of the 026 radial from the Albuquerque Omni Range and the back course of the Albuquerque ILS localizer. It is 13 miles north of the center of the Albuquerque Airport. (See Figure 1.)

only conjecture as to whether this realization was spontaneous with the captain, or the first officer, or induced by a warning from the Hughes Terrain Warning Indicator of an obstruction ahead, below, or both. The realization of the mountain ahead may, of course, have been brought about by something other than the Terrain Warning Indicator, possibly a glimpse of terrain close below, or ahead, or both. Obviously, an evasive manoeuvre was started.

It is difficult to conceive of the crew attempting to cross a 10 682 foot ridge at 9 000 feet, especially when the aircraft was capable of climbing to an altitude which would more than clear the ridge. The Martin 404, grossing 40 027 pounds, should, at maximum continuous power, climb at 1 500 feet per minute up to 9 000 feet and slightly less than that thereafter. This rate of climb would have brought the aircraft several thousand feet above the ridge starting from Albuquerque, only 13 miles away. Even with much less power the ridge could have been easily topped. There appears to be no plausible explanation of why the aircraft was not climbed, presuming the pilots flew the direct route knowingly.

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

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

The pilot-in-command of the flight was well experienced over the route Albuquerque to Santa Fe. The first officer was flying it for the first time that month although he had been over it twice during the previous month. The weather was such that visibility along the airway was good for many miles ahead to the north. The base of the mountains was clearly visible from the airport although the crest was obscured. The flight took off from Runway 11, circled the airport to the right, and picked up a northeast heading directly toward Sandia Mountain instead of pursuing a course along the airway to the west and north of the mountain. It was contact during the turn around the airport and for approximately five minutes thereafter before entering the clouds obscuring the top of the mountain.

The possibility of malfunctioning of navigational instruments having caused or being contributory to this accident was considered at great length. In scrutinizing this possibility it is necessary to keep in mind a number of factors. One is the excellent visibility prevailing from the take-off to a point where a competent witness saw the aircraft enter an overcast near the area of the crash. Under these VFR conditions crews are required by the Civil Aeronautics Regulations to be visually alert. If this crew was, there is no understandable reason why the pilots would not know, by reference to the conspicuous terrain features, that they were not on the planned course. If we are to believe that undetermined malfunctioning of the aircraft's navigational equipment led the flight into the crash area we must presume a number of instrument failures - failures which would be more or less simultaneous, of similar magnitude, and in the same direction. Furthermore, this extreme unlikelihood would have to be accompanied by the crew not looking beyond the cockpit. And further, all these conditions would have had to prevail continuously from the very start of the flight up until it was within two or three miles of the crash site. This situation is thus based on improbabilities compounded to such an extent that the Board must reject it as being too tenuous to warrant serious consideration as a possible contributing factor of this accident.

It is difficult to understand why the flight took the heading it did from the airport to Sandia Mountain. However, there is no question that if the flight had followed the prescribed clearance to the Weiler Intersection the accident would not have occurred. As the Board has previously stated, the evidence is clear that if an instrument malfunction occurred during the VFR portion of the flight it should have become quite evident to the crew and by looking out they would have been sufficiently forewarned that the previously planned and approved course was not being followed.

Probable Cause

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

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ICAO Ref: AR/392

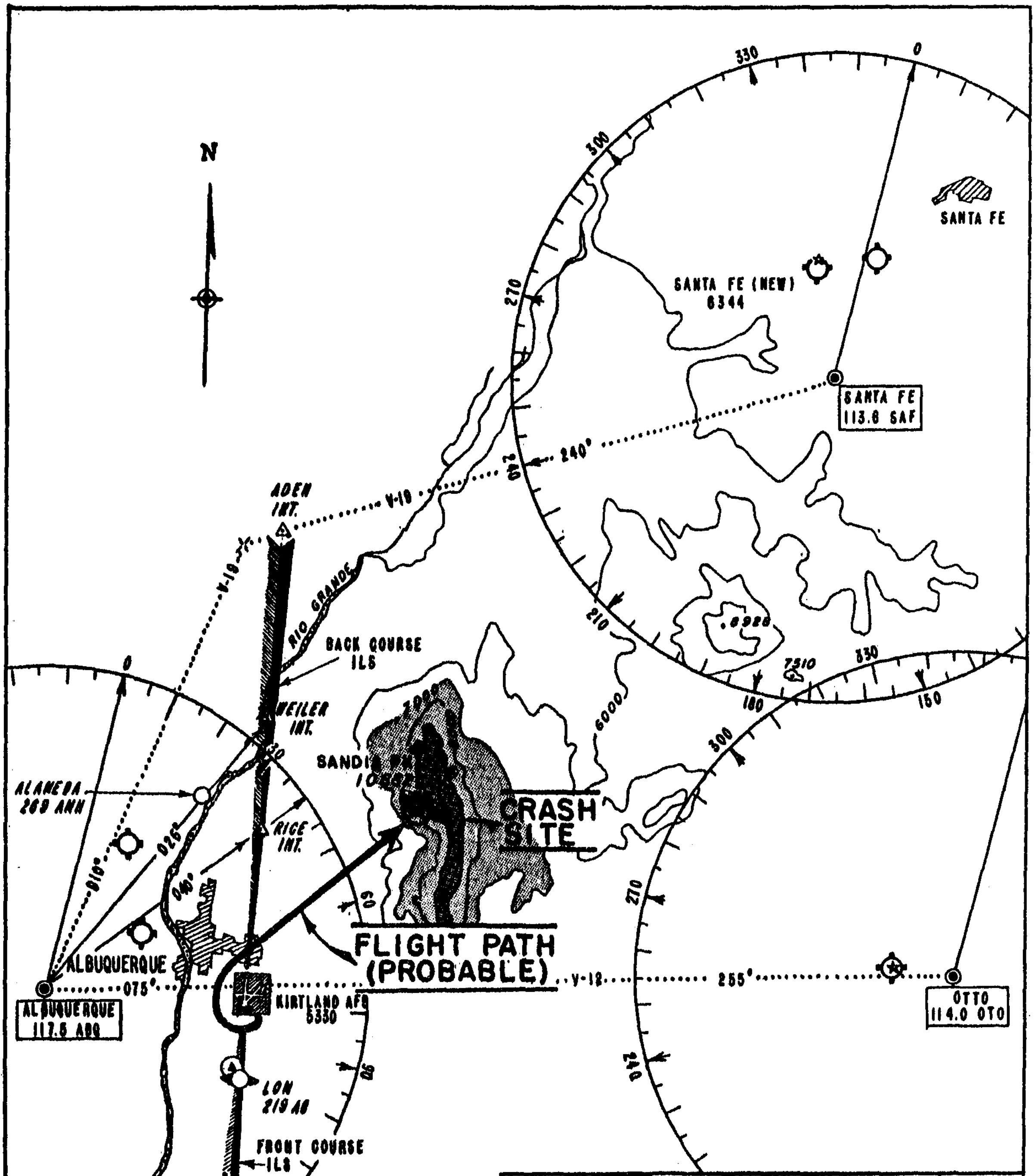

Figure 1

TWA, N40416, SANDIA MT.

Near Albuquerque, N.M.

FEBRUARY 19, 1955

No. 2

United Air Lines, Inc., Douglas C-54B-DC, struck Medicine Bow Peak, Wyoming, on 6 October 1955. Civil Aeronautics Board (USA) Accident Investigation Report SA-311, File No. 1-0130 released 22 March 1957.

(This report was received too late for inclusion in Digest No. 7 - 1955 reports).

Circumstances

The flight from New York, N.Y., to San Francisco, California, was routine up to Denver, Colorado, one of the intermediate stops. On board the aircraft on its departure from Denver at 0633 hours Mountain Standard Time were 63 passengers and 3 crew members. Prior to departure the captain was briefed on the en route weather and the flight was then dispatched to Salt Lake City, the next stop, via airways V-4, V-118, V-6 and V-32, to cruise at 10 000 feet and to fly in accordance with Visual Flight Rules. When the flight did not report at Rock Springs (the only obligatory reporting point) at 0811 hours, its estimated reporting time, efforts were made to establish contact with it. As these were unsuccessful an emergency was declared and a search begun. At 1140 hours the wreckage was sighted near Medicine Bow Peak, 33 miles west of Laramie, Wyoming. All occupants were killed and the aircraft was demolished.

Investigation and Evidence

The aircraft had struck the almost vertical rock cliff of the east slope of Medicine Bow Peak (elevation 12 005 feet). The crash had occured at an elevation of 11 570 feet. A base camp was established at 10 400 feet. Above the camp, travel was extremely difficult up a talus slope to the base of the cliff. From there it was necessary to scale the almost vertical cliff a distance of 600 feet to reach the point of impact. It was decided that working conditions were too dangerous for other than the experienced mountain climbers and, therefore, investigators, who had reached 11 275 feet, were not allowed to proceed further.

Sufficient portions of the aircraft were identified to indicate that the aircraft was intact at the time of impact. At the elevation of 11 275 feet several large sections of the aircraft were found including the empennage which had broken from the fuselage just in front of the vertical fin.

The fuselage forward of the empennage, including the cockpit, disintegrated at the time of impact. Only twisted and distorted portions of each were located. Examination of the control cables indicated tension type failures.

No evidence was found in the examination of the recovered parts of the aircraft or its components to indicate that fire or structural failure had occured prior to impact.

The four engines were badly damaged but no evidence was found to indicate they were not functioning in a normal manner prior to impact.

Examination of the propeller blades and propeller hubs indicated that all four propellers were rotating at the time of impact.

Three watches and an aircraft clock were found and examination showed that the average time of their stoppage was 0726.

The radio and navigational equipment on board the aircraft was damaged in a manner which did not permit reliable readings to be made. All ground navigational facilities that could have been involved were checked as soon as possible after the accident and were found to be operating within tolerances.

The weather was generally fair with some scattered clouds over the lower terrain of the planned route Denver to Salt Lake City. However, off the airway,broken to overcast cloud conditions, accompanied by light snow showers, were present over the high mountain peaks and ridges. The velocity of the wind in the immediate vicinity of Medicine Bow Peak can only be estimated; however, it is believed that because of added terrain effect it could have been increased to 50 to 60 knots. This would have resulted in downdrafts and turbulence being present near the lee slope and probably for a distance of 10 to 15 miles away from the mountain on that side.

Considerable thought and study were given to the possible existence of a mountain wave* condition in that area. Some of the factors associated with the formation of a mountain wave were present; however, a number of the factors considered vitally important were not present and it is doubtful if such a wave did exist at the time of the accident.

Witnesses in the general vicinity of Medicine Bow Peak could not positively identify the aircraft they saw as a United Air Lines C-54; however, they said the airplane was large and had four engines. All agreed that the airplane was silver in colour and was flying in a northwesterly direction toward the peak. Three witnesses at a logging camp located about 10 air miles southeast from the crash site and 21 miles west of the prescribed course said that the airplane did not appear to be turning but that its right wing was slightly down. They estimated its altitude to be about 10 000 feet. They said that the aircraft was flying immediately below the clouds and intermittently flew either into or behind clouds, momentarily obstructing their view of it. In the vicinity of the camp at the time were low rolling clouds and the visibility was somewhat hazy owing to dusting snow.

A review of all documents pertaining to the dispatch and release of the aircraft at Denver, together with the testimony of company personnel, indicates that other than the error in loading the rear baggage compartment the dispatch was made in accordance with United Air Lines' established procedure. Company officials testified that under VFR conditions any deviation from the prescribed route, either in altitude or direction, is the captain's responsibility but must be co-ordinated between the captain and dispatcher. The captain did not advise the dispatcher of any intended deviation from the flight plan.

The Company Flight Operations Manual re - Maximum Flight Levels - Unpressurized Cabins - states: "Flight will normally be conducted at levels not to exceed 12 000 feet above sea level . . ." Another company rule is: "In VFR conditions, flights will check and follow the radio navigational courses which define the airway . . ."

In accordance with the Board's policy of keeping accident investigations open for consideration of new evidence, and since incapacitation of the crew was a possibility that could neither be supported nor negated by existing evidence, it was decided to return to the accident scene to continue the investigation. This could not be done for an appreciable time because of deep snow on the mountain.

On 27 August 1956 a second investigation was begun, on the mountain, which took three days and many aircraft parts which had previously been examined were re-examined. Numerous components of the cockpit, together with the fuselage nose section, were found at an elevation of 11 390 feet on a rocky ledge. This wreckage was badly damaged by impact and the ensuing fire. Beneath a portion of the wreckage the cockpit combustion heater was found. It was mashed flat and was bent 90 degrees near its middle. The igniter plug, with its lead torn away, remained in place. All fuel and air controls were missing. The heater was brought back to Washington, D. C., subsequent to the investigation and was delivered to the National Bureau of Standards for further examination. It was their determination that all failures were apparently caused by mechanical damage. It is possible that the mechanical damage referred to could have occurred at the time of impact.

The No. 3 propeller hub found on the talus slope was further examined. Its dome shell was broken off and the piston was broken. The distributor valve was mashed in the end of the propeller shaft. All but three of the barrel bolts were broken and the barrel halves had separated approximately one inch. The barrel bolts were removed and the barrel halves separated in order to examine the dome position. The stop rings were in place and had been in position for a blade range of 24 degrees low pitch and 93 degrees full feathering. The dome piston position indicated a blade angle of approximately 31 degrees.

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* Under certain atmospheric conditions, a strong windflow perpendicular to a mountain ridge will produce a wave-type structure on the lee side similar to the waves produced downstream from fast-flowing water over a submerged rock. These waves develop on a tremendous scale, often two or more times the height of the mountain barrier which produced them. Violent downdrafts, updrafts, and turbulence occur in the wave when it is well developed. When moisture content of the air involved is favourable, characteristic cloud patterns develop in the wave.

It is obvious from the established flight path that the aircraft deviated from the planned route a number of miles to the west of course. Although witnesses close to the scene of the accident were unable to positively identify the aircraft they saw, in the light of known facts it is reasonable to assume that the aircraft seen was the United C-54. Therefore, it can be concluded that considering the weather conditions and mountainous terrain the aircraft was flying at a dangerously low altitude at that time.

A UAL captain testified that it was normal procedure for UAL pilots, during a climb-out from Denver under VFR conditions, to fly several miles east of the airway. He said this was done to avoid incoming low-flying aircraft which usually begin their let-down near Fort Collins, Colorado. This fact was considered in computing probable flight data for the subject flight from which it was determined that the flight reached its cruising altitude of 10 000 feet approximately 25 miles north of Denver. From this point a heading of approximately 315 degrees magnetic would have been required to fly to Laramie. From this same location a magnetic heading of 300 degrees would have been necessary to fly directly toward Medicine Bow Peak.

An extension in both directions of the known flight path indicates that either a short-cut was being attempted when the accident occured or that the crew was incapacitated and the aircraft was flying without assistance.

In considering the first premise, it is difficult to understand how a pilot of this one's experience would deliberately attempt a short-cut, and even if he did why he would have flown at such a low altitude over hazardous terrain. It is true that the flight was an hour and 11 minutes late; however, the time saved by taking a shortcut would have been inconsequential. Prior to departing Denver the crew had full knowledge, through weather reports, that scud and turbulence were present in the mountainous areas and that snow squalls were expected to occur. Knowing this, and the fact that the weather along the planned route was good, makes a shortcut even more incomprehensible; also, the captain was fully aware of the hazards accompanying mountain flying. There is also the fact that the visibility was 40 miles that morning and it is evident that the clouds covering the mountains could have been seen from a considerable distance. To cross the mountains over Medicine Bow Peak safely, an altitude of approximately 14 000 feet would be necessary. Such an altitude and its attendant passenger discomfort in a non-pressurized aircraft would normally be avoided. Finally, to deviate from course in this manner the captain would have been breaking rigid company rules and his record indicated that he had never been known to do so.

Considering the navigation equipment on board the aircraft, the fact that all pertinent ground facilities were functioning in a normal manner, the pilot's knowledge of the terrain, and the good visibility prevailing that day, it does not seem possible that a navigational error of any magnitude could have been made.

The matter of crew incapacitation cannot be completely ruled out. The cockpit heater, when examined, did not indicate any burnouts prior to impact which could cause poisonous gases to enter the cockpit; however, the exhaust manifold was badly damaged and some of it was not recovered. Should this portion of the heater have been defective, dangerous gases could have entered the nosewheel well and could have been transported from there to the cockpit by means of the ground blower. However, the ground blower is normally turned off before the aircraft becomes airborne and is never turned on in the air unless there is a blockage of the nose ram airscoop. Although the incapacitation of persons in the cockpit in this manner appears unlikely it nevertheless cannot be completely discounted. Also, it is possible that the crew may have become incapacitated by some other means. One possible fact points strongly toward this not being true - when the aircraft was only four minutes from Medicine Bow Peak it was flying at an altitude of approximately 10 000 feet. Since the aircraft struck the mountain at an altitude of 11 570 feet it must have climbed about 1 500 feet in approximately four minutes, and it appears likely that some positive action on the part of the crew was necessary to accomplish the climb.

In consideration of the above facts, the Board is of the opinion that there is insufficient evidence to establish that the deviation from the planned route was due to incapacitation of the crew, errors in navigation, or malfunctioning of the aircraft or any of its components, but rather that the pilot deviated from the planned course for reasons unknown.

Probable Cause

The probable cause of this accident was the action of the pilot in deviating from the planned route for reasons unknown.

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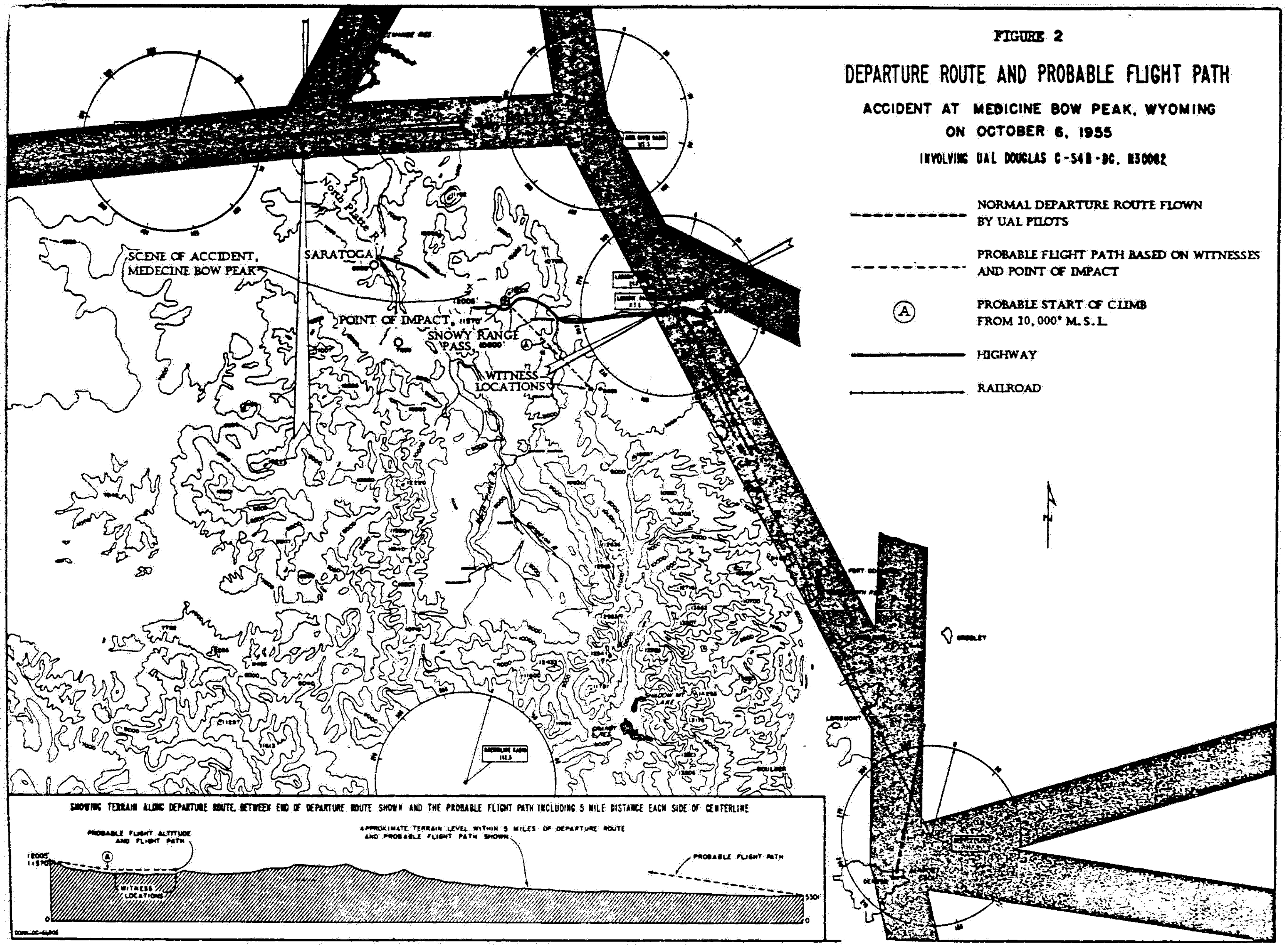

FIGURE 2

DEPARTURE ROUTE AND PROBABLE FLIGHT PATH

ACCIDENT AT MEDICINE BOW PEAK, WYOMING
ON OCTOBER 6, 1955
INVOLVING UAL DOUGLAS C-54B-DC, N30062

No. 3

Paraguayan National Airline, Norseman Norduuyn, ZP-CAX, crashed into a hill north of Río Tocomar, Salta Province, Argentine Republic, on 23 October 1955. Accident Investigation Report No. 538 released by Ministry of Aviation, Argentina.

(The following report was received too late for inclusion in Digest No. 7. However, it is here presented because of its medical aspects.)

Circumstances

The aircraft was on a delivery flight from Mexico City to Asunción, Paraguay, with intermediate stops at Antofagasta, Chile and Salta, Argentina. At 1245 hours local time the aircraft took off from Antofagasta for Salta. It was to be a VFR flight via Chosque, Chile and San Antonio de los Cobres, Salta Province. The aircraft was seen at 1400 hours flying in a straight line at very low altitude in the direction of San Antonio de los Cobres 40 kilometres east of Olapacato. One witness, believing that the aircraft intended to land, followed it in a jeep only to find its burned wreckage some 20 kilometres away. It had crashed into the side of a hill rising north of Río Tocomar, approximately 70 metres above the river bed. The height above sea level at this point is approximately 4 500 metres. One eye witness stated that the aircraft crashed in rectilinear horizontal flight into the northern slope of the hill and that the pilot had not taken any avoiding action. The pilot, the sole occupant, was killed, and the aircraft was destroyed by the crash and the fire which followed.

Investigation and Evidence

The crash occurred some forty kilometres to the left of the planned direct track, confirming the fact that the pilot was flying over the valleys of parallel mountain ranges which follow the railway line from west to east, to San Antonio de los Cobres, and that he was flying at low altitude, avoiding the mountain crests.

The first part of the aircraft to strike the ground was the undercarriage unit, followed by the impact of the lower portion of the engine and a violent somersault which caused the power unit to detach itself from the fuselage. The fuselage was projected seven metres from the main contact point and burst into flames. It is presumed that when the power unit and fuselage became separated, the seat attachment broke, with the result that the pilot was thrown a distance of 15 metres from the place of impact. The wreckage was strewn over an area of approximately 50 metres.

An inspection of the wreckage showed that the engine was operating at cruise power and that the propeller blades were set in the coarse pitch position, for normal flight. This was confirmed by the deformations of the propeller blades as they struck the ground.

The fire which followed the crash of the aircraft and the remaining fuel which was spilled on the ground show that there was an adequate amount of fuel on board and that the flight could not have been hindered by a fuel shortage.

The official weather report for the area at 1400 hours was as follows:

> "Overcast with low clouds; ceiling 1 100 m; visibility 23 km; wind ENE 8/10 km/h; atmospheric pressure at 1 000 m 906.4 mb; QFE 884.2 mb; temperature 12°C; R.H. 40%."

The area overflown is quite suitable for forced or precautionary landings. No major risks are involved, since the area consists of a very wide valley or glen, with a distance of 5 km between crests at its widest point and of 800 metres in narrower parts. At the site of the accident, the slope on which the aircraft crashed does not run from east to west. At this place the valley begins to narrow and runs exactly in a northwest to southeast direction. It should be borne in mind, however, that prior to the crash the pilot had flown along the valleys of the mountain range of the area. This leads to the assumption that the pilot, who did not have an oxygen mask on board the aircraft - an essential item for flights of this kind - endeavoured to maintain low altitude. In this respect the aeronautical medical authority sent to the scene to report, issued the following opinion:

> "... flights conducted at heights between 3 000 and 4 000 metres (high altitude flying) produce certain changes in the body of the pilot which are known collectively under the name of 'altitude sickness'. These changes are due to a lowering of the partial oxygen pressure which, at 4 000 metres, 97.02 mm of mercury, instead of 159.8 mm of mercury, which is the partial oxygen pressure on the ground. The altitude at which these phenomena begin to occur has been shown to be 4 000 metres, although there may be certain individual factors which will cause certain pilots to suffer from these changes at heights of less than 4 000 metres and others at greater heights. The first symptoms to appear are asthenia and loss of strength, sleepiness, violent headache, nausea, vomiting, tachycardia and praecordial pain. The mental condition is characterized by a state of exaggerated well-being which causes one to lose the sense of fear and understanding of the happenings about one. This condition becomes aggravated as the pilot remains at high altitude without any oxygen. After the initial state of well-being, a feeling of drowsiness and apathy follows which then becomes deep slumber which, in turn, is followed by coma and death. In such conditions, the pilot loses control of the aircraft and does not fully realize what is happening, and his reading of instruments becomes faulty. His visual acuity and power of accommodation are also altered. A hyperacute condition may occur; this usually does not appear at less than 8 000 metres, but may, in the case of certain individuals, present itself as low as 5 000 metres."

Setting aside the technical factors examined during the investigation and bearing in mind that the aircraft collided head-on against the hill while it was flying in an area where there were suitable stretches of land on which the pilot could have landed without any great risk - particularly in view of the experience which he is presumed to have had, judging by his licence - the Board decided in favour of the more plausible theory that the pilot suffered from the consequences of anoxia through flying an aircraft not provided with oxygen-breathing equipment essential for this kind of flight. The above conclusions are further borne out by the height of 60 to 70 metres at which the aircraft was flown, by the nature of the prevailing weather conditions at the place and time of the accident, and by the elevation of the area above sea level - approximately 4 500 metres.

Probable Cause

The accident was attributed to a loss of control over the aircraft due to a possible state of anoxia on the part of the pilot. A contributing factor was inadequate flight preparation, as no account was taken of the need for oxygen-breathing equipment for high altitude flying.

Recommendations

It appears necessary to recommend to pilots and to aircraft control and dispatching personnel that, for flights of this kind, aircraft should be provided with oxygen-breathing equipment in good working condition.

For its part, the aeronautical authority has decided to prescribe this as a mandatory requirement, and to issue specific directives aimed at prohibiting this type of flight if the requirement is not met.

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ICAO Ref.: AR/450

No. 4

Eastern Air Lines, Inc., Lockheed Constellation, L-749-A, crashed on final approach at Imeson Airport, Jacksonville, Florida on 21 December 1955. Civil Aeronautics Board (USA) Amended Accident Investigation Report SA-315, File No. 1-0169. Revisions to the original report were released 6 June 1957.

(The following report is not included in the classification tables)

Circumstances

The flight originated at Miami, Florida, its destination Boston, Massachussets with an intermediate stop at Jacksonville, Florida. It departed Miami International Airport at 0212 hours Eastern Standard Time on an Instrument Flight Rules flight plan with 12 passengers and 5 crew members aboard. At 0331 the flight reported over Sunbeam Intersection (16 miles SSE of Imeson Airport), was cleared for an ILS approach to Runway 5 and received the Jacksonville weather report - "Partial obscurement; visibility one-half mile; altimeter 30.18." This was followed immediately by another message - "Coming out with indefinite 300 obscurement now one-half with fog."* After acknowledging this information the flight reported leaving Sunbeam at 2 500 feet. Following a later query from the flight, approach control advised that there was no other known traffic in the area. Flight 642 reported over the outer marker inbound as requested and was cleared to land. Shortly thereafter the tower controller observed a large flash in the vicinity of the ILS middle marker. Further calls to the flight were not acknowledged and it was subsequently learned that the aircraft had crashed at 0343 hours approximately six-tenths of a mile southwest of the threshold of Runway 5. All 17 occupants were killed.

Investigation and Evidence

Investigation disclosed the main portion of the wreckage to be 212 feet northwest of the ILS middle marker and 3 486 feet southwest of the threshold of Runway 5. (See Figure 3).

First impact of the aircraft was with the top of a small pine tree approximately 200 feet below the ILS glide path, 260 feet to the left of the extended centerline of the runway, 4 000 feet from the threshold of Runway 5, and 420 feet southwest of the middle marker. This was followed by striking a 50-foot oak tree, the upper 20 feet of which were sheared off. The aircraft settled toward the ground, striking other large trees which disintegrated both wings and a portion of the empennage. Ground contact was on a heading of approximately 55 degrees magnetic. The distance from the first tree struck to the farthest piece of wreckage was 801 feet. Explosion and fire occurred immediately upon impact.

The cabin and cockpit areas were completely consumed in the ground fire with the exception of the lower fuselage skin and portions of the cabin flooring. The fuselage aft of the rear pressure bulkhead and the center rudder fin and portions of the stabilizer were intact, but with surface scorching indications. The tail cone was found in a relatively undamaged condition with the control booster mechanisms in proper position.

Outer portions of the left and right wings had been separated from the main structure during the passage through the trees and along the ground. The "speedpack" (a large detachable cargo compartment positioned on the underside of the fuselage) was torn from the bottom of the fuselage at ground impact. Wing flaps were determined to have been in the 60 percent extension position, and their positions were symmetrical at the time of impact.

Separation of the right main gear and part of the nose gear had occurred at ground contact. The left main gear was intact and in the extended and locked position; the cockpit landing gear lever was found in the "down" position. Measurement of the right main gear actuating cylinder piston rod revealed the same 15 inches as found on the down and locked left main gear actuating cylinder piston rod.

All boost control assemblies were found in the "boost on" position. A bench check revealed that all boost actuating cylinders had normal travel in both directions and showed no signs of abnormal internal leakage.

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* Eastern Air Lines' Constellation minima for ILS approaches at Jacksonville, day or night, are ceiling 200 feet, visibility one-half mile.

Relief valves and bypass controls operated normally. The filters showed a normal differential pressure between inlet and outlet. The elevator boost was installed in a similar aircraft, was flight tested and found to function in a normal manner.

On impact the four powerplants separated at their attach points and came to rest a few feet ahead of the main wreckage. Number 4 engine suffered extensive damage in the ground fire. Examination of the interiors of all four crankcases gave no indication of rotational or reciprocating interferences or operating irregularity of any kind. All oil pumps were free of metal particles and revealed no scoring. There was no evidence to indicate that the engines were not capable of developing power prior to impact.

All propeller blades were broken or bent, with bending generally rearward, and five of them were broken at the butt ends. The dome position and blade angles were found to be in settings that indicated normal operation of all engines.

The tearing free of all powerplants resulted in the pulling and breaking of control cables under tension. Several of the cable-controlled fuel shutoff valves were found in the closed position; the electrically controlled firewall fuel shutoff valves were all open.

From markings presented by ground object contacts of the airframe and propellers it was determined that just prior to impact the aircraft was in a slight turn to the right and banked approximately 11-1/2 degrees. The longitudinal attitude of the aircraft was approximately 4-3/4 degrees nose-up and the angle of descent during the last 200 feet of the flight path was about 2-1/2 degrees, with the rate of descent being 10 feet per second.

Several flight checks of ground navigational facilities soon after the accident showed operation of the systems to be normal. Simulated ILS approaches were made, with a Board investigator as observer, to determine the effect on cockpit instruments caused by vehicles parked on the highway below the glide path. The highway is about 100 feet east of the middle marker. On one approach, with a crane-equipped truck parked beneath the glide path, a flydown indication was noted prior to reaching the middle marker. It was necessary to descend 60 feet in order to center the needle. However, the glide path indication was found to be normal at the middle marker, where the accident occurred.

Several persons saw or heard the aircraft, with normal engine sound. A power surge was heard just before impact. One witness, who was near the middle marker, said he first saw the landing lights, lighted and pointing straight down, and that they partially extended before he lost sight of the aircraft. Other witnesses near the accident scene did not see the landing lights on. Subsequent investigation disclosed that the right landing light had been destroyed but the left light was found in the retracted position. There was no fire observed by any witness prior to impact. One witness saw the aircraft, at a very low altitude, make a slight turn to the right just before it contacted the trees and ground.

A witness who was driving a trailer-truck south along the highway adjacent to the airport said he saw what he believed to be two jet-propelled aircraft pass from right to left in front of him, flying at an altitude of 150-250 feet. He stated that at the same time he observed these aircraft he saw a bright flash, whereupon he immediately stopped his truck and walked down the highway. To his right he saw scattered parts of an aircraft burning. He also said that before reaching the airport he had passed through patches of ground fog, that at the airport there was an overcast condition, and that he again passed through patches of ground fog as he continued south.

The two airport tower controllers in radio contact with the flight stated they heard it pass over the south edge of the field, proceeding outbound. At this time the runway lights were on at their highest intensity. One of the two controllers on duty stated that he went downstairs to the radar room and, on the Airport Surveillance Radar scope, observed the flight just before it reached the outer marker outbound. He also said he saw the start and completion of a procedure turn and observed the aircraft start inbound, after which he gave the flight its three-, two-, and one-mile range positions. The tower recording of outgoing messages does not include the three-mile position message. The ASR equipment at Jacksonville does not show altitude above the ground. The controller stated that forward movement ceased soon after the image of the aircraft on the scope passed the one-mile position from the end of the runway. This radar observation coincides with the geographical position of the crash. During the entire time the controller was watching the scope, set to 10-mile range, he saw no other aircraft. Comprehensive investigation revealed no other traffic, either civil or military, in the area during the approach of the subject aircraft.

The night of December 20-21 weather stations from Miami to Savannah, Georgia, were reporting a small spread between temperature and dewpoint. The company terminal forecast for Jacksonville was ceiling and visibility unlimited; this was not amended until 0345 when it was changed to ceiling 300 feet, broken clouds; visibility three-fourths of a mile; fog. During the briefing the company forecaster advised the crew that patchy ground fog could be expected in the Jacksonville area.

It is evident that all components of the ILS system were operating normally at the time of the accident. This was also indicated by another flight which made an ILS approach and landing approximately 15 minutes before the accident. At that time the system was normal, as it was on two approaches made several hours after the accident. Monitoring records of the system gave no indication of any deviation from normal operation during the early morning of 21 December. All contacts with the flight by Jacksonville approach control were routine and the crew did not report any operating difficulties.

The testimony of witnesses who observed the landing lights of the aircraft come on during the approach and other witnesses who saw no landing lights, is not completely incompatible. Since the lights were found in the retracted position it is indicated that once lowered they might have been retracted to eliminate reflection as the aircraft descended into the layer of fog. The significance of the testimony concerning a power surge immediately before or at the time of initial contact with the trees cannot be fully established. The majority of the witnesses reported no surge of power, and it is possible that increase of power was apparent only as a result of the relative motion of the aircraft with respect to the witness and the rapidly changing conditions of reflection or shielding of sound at the low altitude at which the aircraft was being flown. The investigation of the wreckage clearly establishes that climb power which would be expected to be applied in a missed-approach procedure was not, in fact, being used at the time of impact with the ground. Furthermore, none of the other essential elements of a missed-approach procedure had been accomplished prior to the accident.

Every possible effort was made to account for jet-propelled aircraft being in the area when the accident occurred. All military services said they had no jet aircraft flying in that area at the time of the accident. Neither the tower personnel, witnesses on the airport, nor witnesses other than the truck driver near the accident scene saw any jet aircraft and such aircraft were not observed on the radar scope. In view of the truck driver's testimony, the Florida Air National Guard, under the direction of a CAB investigator, made several flights (using a jet aircraft) in an effort to simulate the conditions described by the truck driver. Each of these flights was plainly visible on the radar scope. It, therefore, is concluded that no such aircraft were in the vicinity.

From the testimony of other pilots flying in the vicinity a short time prior to the accident, there was a layer of cloud, which included smoke and fog, capping the airport with a general foggy condition existing a few miles to the southwest. All other areas appeared to be clear. It therefore appears likely that the flight was clear of clouds from the Sunbeam Intersection to the middle marker and outbound to the outer marker and that it probably did not encounter obscurement until in the vicinity of the middle marker inbound. Although this weather condition has been described as partial obscurement with horizontal visibility of one-half mile, it is apparent from the testimony of pilots that vertical visibility throughout the area was generally good. Some of the witnesses said the ground visibility at and near the accident was poor. There is no way of determining ceiling height or visibility distance at the accident site. However, the weather information reported to the crew was obtained at the control tower. The tower is located approximately one mile north-northeast of the accident scene. At the time of the accident a wind of six knots was blowing from the north-northwest, and it is believed that between the time of the last reporting and the accident the weather conditions at the observation point could have moved to the general area of the accident and therefore should have been essentially the same as that reported to the crew, "indefinite 300, sky obscured, visibility 1/2 mile and fog."

Assuming that weather conditions were similar at the crash point and the observation point, consideration should be given to the decrease of horizontal visibility with elevation. Horizontal visibility must have been near zero at 300 feet above the ground. Normally, slant visibility down the glide path should have gradually increased as the aircraft descended.

The radar scope at Jacksonville does not reflect altitude. However, since the radar operator testified that the aircraft was observed to fly beyond the outer marker, make a procedure turn, and return inbound, it is believed that this was accomplished at the normal altitude of 1 200 feet. The propeller slash marks at the scene indicated the speed of the aircraft at impact to be 140 knots. The company's instructions for this type aircraft show a recommended approach speed of 115 knots from the outer marker to the minimum authorized altitude.

Evidence indicates that the aircraft was flying in a normal manner just prior to impact and there is no known evidence to indicate any malfunctioning of the aircraft or any of its components. The flaps were extended to a position used for manoeuvring and this amount of flap extension is usually used in this type of approach until reaching the middle marker. Although the aircraft was 200 feet to the left of course this is a small deviation at that point in the approach and only a slight correction would have been required to again align with the runway. The fact that the aircraft was in a slight right turn and almost level horizontally at impact would suggest that the pilot was turning toward the localizer course, further indicating the aircraft was under control.

It is not unusual, with weather conditions such as existed this day, for pilots during an approach to an airport to find ceilings and visibilities that vary from those reported. If, on the morning of the accident, the captain found the visibility to be lower than one-half mile, it would then have been his responsibility to execute a missed-approach procedure.

Probable Cause

The Board determines that the probable cause of this accident was that during the final portion of an ILS approach the pilot, for reasons not determinable, either permitted or caused the aircraft to deviate to the left of course and descend below the glide path to an altitude too low to clear ground obstructions.

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ICAO Ref: : AR/438

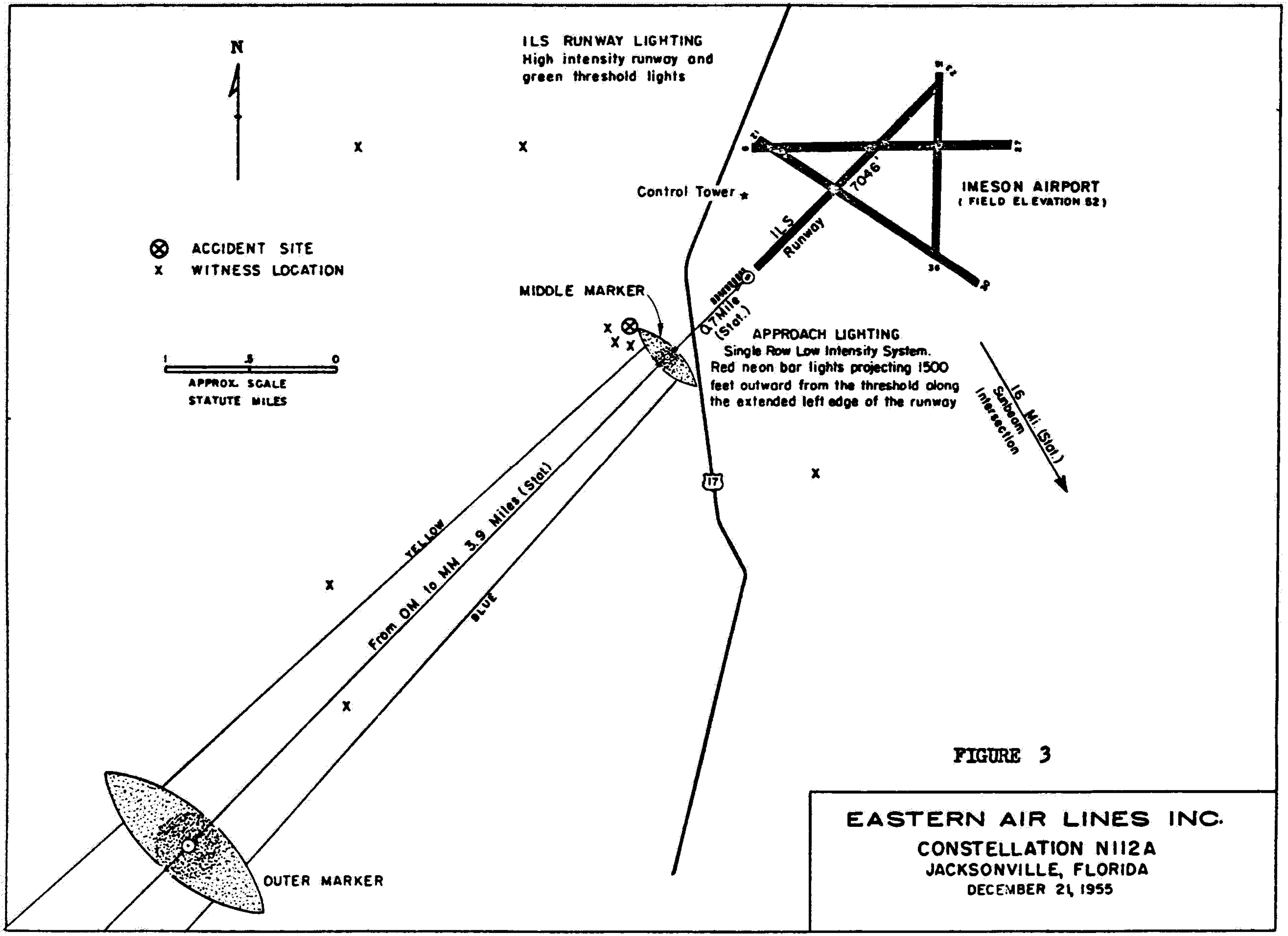

FIGURE 3

EASTERN AIR LINES INC.
CONSTELLATION N112A
JACKSONVILLE, FLORIDA
DECEMBER 21, 1955

No. 5

Eastern Air Lines, Inc., Martin 404, overshot the runway at Tri-State Airport, Huntington, West Virginia, on 15 January 1956. Civil Aeronautics Board (USA) Accident Investigation Report, File No. 1-0001, released 8 June 1956.

Circumstances

Flight 175 originated at Chicago, Illinois for Charlotte, North Carolina, via stops including Louisville, Kentucky and Huntington, West Virginia carrying 32 passengers and 3 crew members. The flight was uneventful until the Louisville-Huntington segment. The aircraft took off from Louisville at 1750 hours Eastern Standard Time on a VFR flight plan. En route the flight requested and received an IFR clearance, via V-4 airway to cruise at 5 000 feet and was given the latest Huntington weather. This indicated a 1 000 foot ceiling, visibility 1 mile, wind calm, light snow and "poor" braking action on the snow-covered runway. Charleston approach control* cleared the flight for an approach to Tri-State Airport. The aircraft crossed the end of Runway 30 at an estimated speed of 90 - 95 knots, at an altitude of 50 - 100 feet and passed over almost one half the length of the 4 600-foot runway before touchdown. The crew could not stop the aircraft within the confines of the airport and the aircraft nosed slowly over the brink of a slope approximately 100 feet beyond the end of the runway. There was no fire. No injuries resulted to either the crew or the passengers.

Investigation and Evidence

The aircraft reported to the company radio at Louisville at 1813 hours when over the Lexington VOR at 5 000 feet and was given an IFR clearance to Huntington. Over Bruin Intersection at 1833 hours it reported to Charleston approach control and was cleared via Wayne Intersection direct to the Huntington marker to maintain 5 000 feet and to report passing Wayne. Charleston approach control then transmitted to the flight the Tri-State weather conditions. At 1835 Huntington company radio advised the flight re poor braking conditions on the runway and also transmitted the 1830 weather conditions to the aircraft.

Charleston approach control then cleared the flight for an approach to the Huntington Airport to descend to and cruise at 4 000 feet.

The aircraft arrived over the Huntington H-facility**at 1842, and then, in accordance with prescribed procedure, flew outbound 17 degrees magnetic and made a procedure turn, descending to 700 feet above the ground before returning at 197 degrees magnetic over the H-facility. The aircraft then proceeded to and passed directly over the airport and its single runway at about a 90-degree angle. Both pilots stated that all airport runway lights were sharp and clear through snow precipitation. A check of the windshield wiper and leading edge of the wing showed no ice. After crossing the airport the captain made a left turn of about 270 degrees, concluding the turn at an estimated three fourths of a mile from the approach end of Runway 30. Final approach was continued with landing gear down and flaps fully extended. Just before touchdown the captain advised the co-pilot that he intended to use propeller reversing "because of snow on the runway and possible poor braking."

Upon touchdown the co-pilot raised the reverse thrust lockout flag, permitting propeller reversal before the aircraft's weight was on its landing gear, and the captain used reverse thrust beyond the normal reverse range into the emergency reverse range. The co-pilot observed the No. 1 propeller reversing light come on slightly before No. 2 came on. According to the captain, No. 2 propeller lagged momentarily. Forward visibility was completely cut off by surface snow blown forward and up by the reverse thrust. The captain noted a slight change in heading on the Flux Gate Compass and reduced r.p.m. in order to see where he was headed because of sharp drop-offs in the terrain near the runway edges, particularly to the left. When visibility was regained he realized that he was then going off the left edge of the runway. This was at a point about 1 400 feet beyond touchdown and about 1 100 feet short of the far end of the 4 600-foot runway. See Figure 4.

The captain then applied right rudder and right brake and increased the reverse thrust, taking more from No. 2 than from No. 1, bringing the aircraft to a course

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* Charleston approach control normally handles IFR air carrier traffic for Huntington.

** An H-facility is a non-directional radio transmitter used for homing and navigational fixes.

approximately paralleling the runway. Again blown snow blocked visibility and again the captain reduced power to regain it. He realized that he was again turning to his left, away from the runway, and quickly applied right rudder and right brake to change direction. This accomplished its purpose until the aircraft was parallel to and approaching the end of the runway. Again the captain applied maximum reverse and lost all forward visibility.

During this relatively short period the aircraft maintained a course generally parallel to and at the left of the runway until, when nearing the end, it was turning to its left. Both propellers remained in reverse thrust with varying amounts of power being used throughout the landing roll. Nose-wheel steering was not used to correct the swerves.

Just after the aircraft rolled over the brink of the slope the captain shut off all electrical power to lessen the possibility of fire. Total darkness resulted as the cabin emergency impact light did not come on.

The aircraft came to rest on a ledge about 186 feet beyond, and about 60 feet below the level of the runway. The rough terrain sloped downward about 28 degrees; the aircraft was nose-down even more to 40 degrees and tilted 15 degrees to the right.

The first point of touchdown was made by the left landing gear at a point 2 015 feet down the runway. All three landing gears were on the runway a measured distance of 2 130 feet from the approach end and slightly left of center laterally.* This runway has no gradient and is 4 600 feet long and 150 feet wide, with level sodded areas extending about 100 feet at both ends. The left or south side is bordered with a level sodded area about 125 feet wide; the other side has a similar area about 225 feet wide.

Both propellers and the nose sections of both engines were torn free before the aircraft stopped. The lower drag strut of the nose landing gear failed and the gear folded backwards damaging the adjacent lower portion of the fuselage. Damage to the fuselage, although of a major nature, was confined to the forward region generally below the aircraft's floor line. Emergency exits were not used but all were operational.

Examination of the landing gear latching mechanisms revealed that all three landing gears were extended and locked, and that the nose gear steering cylinder was intact and in normal operating condition. Examination of the brake system failed to reveal any indications of operating distress and all hydraulic lines were intact.

Both engines, both propellers, both propeller governors, and the two main landing gear wheels with their brakes were studied at the Miami base of Eastern Air Lines. This examination showed that:

a) Neither engine had had any evidence of failure or any pre-crash condition that would cause malfunctioning;

b) Both propellers had been operating within specified pitch limits and examination of their components indicated that they were in good condition prior to impact with the ground;

c) Bench tests of both propeller governors revealed no evidence of failures or any condition that might have caused malfunctioning;

d) Both brake assemblies were in good condition and should have been operating normally. All brake pucks were free in their housings and showed no excessive wear, nor did the brake housings show any evidence of excessive heat.

A careful examination showed that the rigging between the reverse throttle levers and the reversing throttle switches was such that final actuation of the reverse switches occurred when both throttles were moved aft 1-1/2 inches.

Examination of the rigging between the throttle levers in the cockpit and the throttle openings at both carburetors showed proper adjustment. With both throttles in the reverse idle position, both throttle arms were 1/4 inch from their stops; with both throttles in the full reverse position, both throttle arms were 1-1/2 inches from their stops. Impact had stretched the throttle cables to a degree where testing of their tensions could not be significant.

Logbook entries were carefully reviewed but

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* See Figure 4

nothing was found to show evidence of any operational difficulty or failure of the propeller reversing, hydraulic or braking systems or of the nose-wheel steering system.

The pilot stated that he was completely satisfied with the runway lighting and that runway lights were within his range of vision throughout the entire final approach.

Eastern Air Lines' landing minima for Martin 404's at Tri-State Airport are 700 feet ceiling and 1 mile visibility. Conditions prevailing at the last official observation (1830 hours) were reported to the incoming flight as 1 000 feet and 1 mile.

The captain and the co-pilot testified that their approach was substantially normal, that final was started at about three fourths of a mile from the approach end of the runway at an estimated altitude of 500 feet, and that they came over the end of the runway at an estimated 50 - 100 foot altitude. They also testified that their final turn into approach was terminated at the proper point so that little or no deviation from a straight path was necessary. However, this is contrary to the testimony of a number of ground witnesses who described an appreciable bank to the right immediately prior to touchdown. These witnesses were of the opinion that the approach was higher and/or faster than is customary with similar aircraft. The captain testified that he purposely came over the approach end of the subject runway a bit higher than at other airports because of the sharp drop in terrain at that end of the runway and the consequent possibility of turbulence at that point. There was some testimony that a burst or several bursts of power were used just before touchdown, but the captain insisted that he did not apply any power at that time or elsewhere during final approach.

Reversal of the aircraft's propellers is accomplished by pulling back the main throttles to the idle position and then continuing rearward with the reversing throttle into the reversing range. For normal reversing the force required to pull the latter back is adjusted to eight pounds per throttle. An additional 15 pounds per throttle is required to bring them further back into the "emergency" reverse range. Thus the total force needed is 46 pounds.

The Martin 404 aircraft carries a placard in the cockpit relative to reversing propellers. It reads: "Exercise caution in using reverse thrust on runways covered with dust, snow, or other matter which would reduce visibility."

This same warning appears in Eastern Air Lines' Flight Manual for the Martin 404 which states further: "Caution should also be exercised when approaching the low speed range of the landing run so that the operator will be prepared for sudden control buffeting which might be injurious to the operator or structure unless the controls are monitored by the pilot or co-pilot during reverse thrust application. While the control forces are not excessive when operating in a normal power range for reverse thrust, the controls are subject to sudden and sharp reversals when approaching the slow speed range of the landing run."

All radio navigational and communication facilities, as well as the airport and runway lights, were found to have been operating normally.

The temperature on the morning of the accident had been down to 13 degrees and never rose above 32 degrees during the day. As thin obscuration of the sky existed, followed by an overcast, there was not much opportunity for the runway surface to have become warm enough to melt the snow even in the beginning of the fall. It, therefore, appears doubtful that ice existed below the snow cover unless it remained from a previous condition. However, in some cases very poor braking exists on a dry snow cover.

The weather reporting service at the Tri-State Airport at Huntington, West Virginia, is classed as a Supplemental Aviation Weather Reporting Station. This means that the observers have been obtained by the Weather Bureau from airline and/or airport personnel and that following a period of training in weather observations, they have been certificated as competent to make surface weather observations.

The captain attributed the first swerve to the left to a momentary lag in the No. 2 (right) engine. This would cause more, or quicker, reverse thrust on the left engine than on the right and consequently result in a tendency to yaw to the left. But it seems unlikely that any momentary lag in the No. 2 engine caused the initial swerve because the aircraft travelled a good 1 000 feet before swerving.

Subsequent swerves to the left, as the aircraft continued generally parallel to the runway, occurred as the captain attempted to use maximum reverse thrust to stop the aircraft on the airport. He was using different amounts of reversing to effect steering and stop the aircraft without any forward visibility except for two brief periods.

The given braking condition of "poor" did not carry with it a warning against landing; it was merely information for the captain to use as he saw fit.

The captain could not explain why he landed so far down the runway after a final approach such as he described. There was little or no wind, and if the aircraft had crossed the boundary at 50 feet altitude and at the conventional speed of 90 - 95 knots, then the touchdown should have been well within the first quarter of the runway.

If the approach was conducted as the captain testified, then there would have been no need for any final manoeuvre or manoeuvres just prior to touchdown as described by witnesses, although denied by the captain. It seems probable that there was some misalignment of the final approach to the right of the runway as a result of overturning during the close-in circling approach.

The fact that the captain advised the co-pilot to raise the reverse flag before touchdown indicates that he realized he was then critically far down the runway and wanted to be sure of instantaneous reversal on demand.

The Board concluded that the captain made his last turn into final somewhat higher, closer, or faster than he would have during better visibility.

It was found during the course of the investigation that additional training of the weather observers would be desirable. This does not appear to have been a factor in the accident; however, the Weather Bureau has started a program for improving the training of personnel and inspection of this class of stations.

Probable Cause

The probable cause of this accident was improper approach and subsequent landing too far down a snow-covered, slippery runway.

The following is an excerpt from Flight Safety Foundation Accident Prevention Bulletin 56-21 pertaining to this accident:-

"Moral . . .

When getting weather information from the tower at your landing airport, include the possibility of snow kicked up by the props. And remember that your landing run on a slippery runway is considerably longer than on a dry runway . . . and brakes won't be of much help. Also, no matter what your minima are, if you cannot see the horizon when you go from IFR to VFR and level out, the safety of your flight is jeopardized. As a safeguard, employ higher minima and better visibility during winter operations."

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ICAO Ref: AR/436

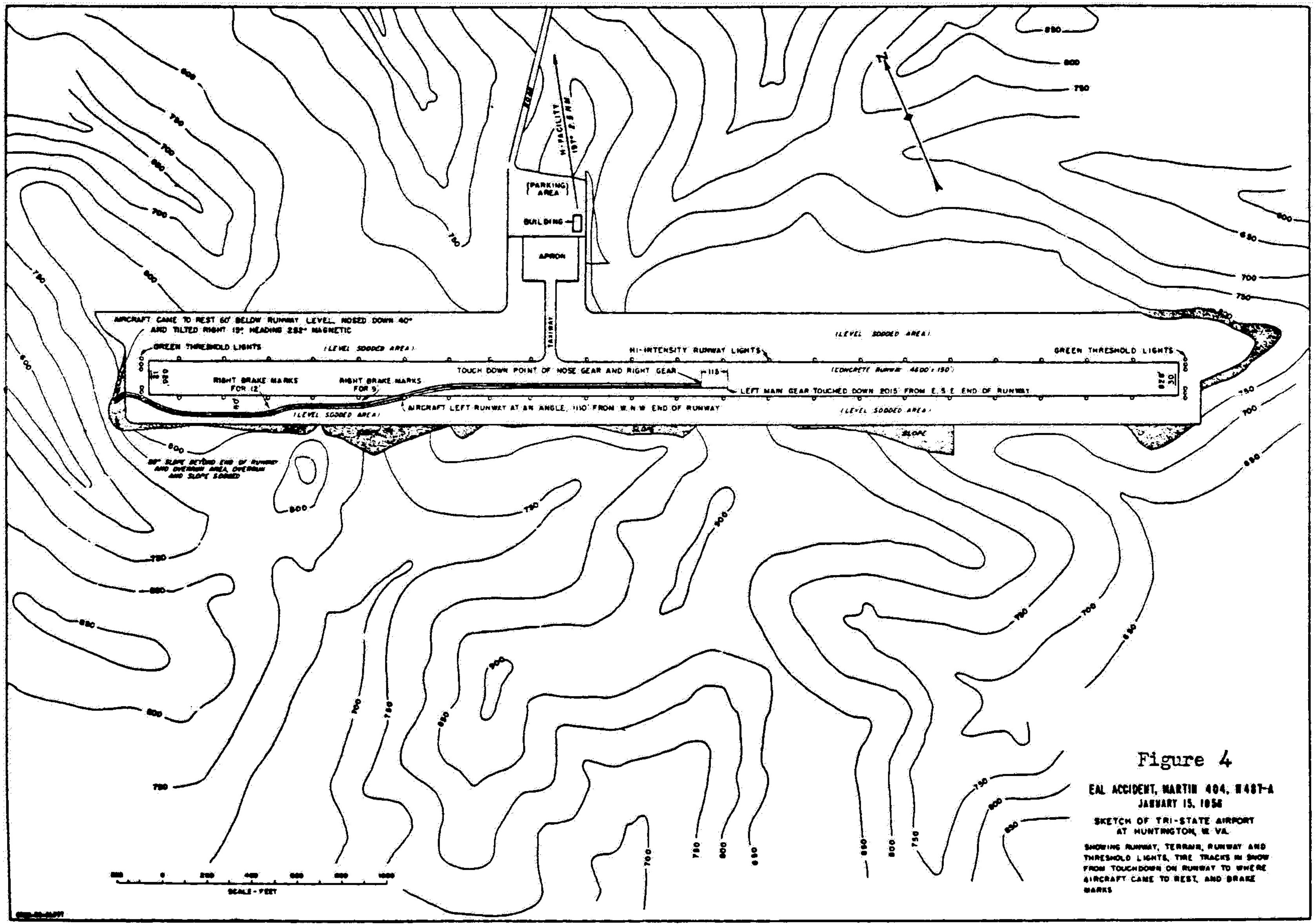

Figure 4

EAL ACCIDENT, MARTIN 404, N481-A
JANUARY 15, 1956

SKETCH OF TRI-STATE AIRPORT
AT HUNTINGTON, W. VA.

SHOWING RUNWAY, TERRAIN, RUNWAY AND THRESHOLD LIGHTS, TIRE TRACKS IN SNOW FROM TOUCHDOWN ON RUNWAY TO WHERE AIRCRAFT CAME TO REST, AND BRAKE MARKS

No. 6

Quebecair Limited, DC-3C, CF-GVZ, crashed while attempting a forced landing at Oreway, Labrador, on 17 January 1956. Report released by Department of Transport, Canada, Serial No. 56-1

Circumstances

At approximately 1436 hours Atlantic Standard Time on 16 January the aircraft took off on a non-scheduled flight from Mont Joli, Quebec, to Knob Lake via Seven Islands and arrived at Knob Lake at 2002 hours. At 2202 hours on 17 January the aircraft took off from Knob Lake on the return flight to Seven Islands via Oreway, Labrador, with a crew of three and fifteen passengers on board. The flight appears to have been normal until 2312 hours at which time, according to the navigation log, heavy to moderate rime ice was encountered and the aircraft was climbed to 10 000 feet. At 2335 hours a further note was made in the log that the oil pressure on the starboard engine had dropped to 40 pounds (per square inch) and that at 2336 hours the warning light came on and the starboard propeller was feathered. According to a statement obtained from one of the passengers and the declaration of the stewardess, the engine was subsequently re-started for about ten minutes and then stopped again. The aircraft gradually lost height on one engine and due to the hills ahead the captain decided to return to Oreway. At 0052 the aircraft crashed to the ground about 2 000 feet southeast of Oreway railway station, while a forced landing was being attempted. The captain, co-pilot and one passenger died in the accident and the stewardess died of injuries a few days later; two passengers were seriously injured and some of the remaining passengers received minor injuries.

Investigation and Evidence

A certificate of airworthiness, which was due to expire 5 March 1956, had been issued for the aircraft. Examination of both engines disclosed that one of the tubes near the periphery of the starboard engine oil cooler had a crack measuring about 1/4" by 1/20" through which an oil escape of about two gallons per minute was possible. It was considered that this crack might have been caused by a frozen water droplet in the tube. No other evidence of malfunctioning of the engine, airframe, or controls was discovered.

From calculations made by the Board, it would appear that the aircraft was overloaded when it took off from Knob Lake, the amount of the overload being of the order of 2.8% of the authorized gross weight.

The pilot was seen to examine weather reports in the radio station office at Knob Lake, but advantage was not taken of the opportunity to obtain a briefing at the meteorological office.

It was determined from an analysis of the weather situation, that a poorly defined stationary front extended from Belle Isle to Anticosti Island and Fredericton. The route between Knob Lake and Seven Islands lay in an east northeasterly flow of maritime arctic air, with an overrunning layer of maritime polar air above 10 000 feet over the southern section of the route. The general weather over the route was overcast, with light continuous snow. The cloud base was generally 2 - 3 000 feet above sea level, which would mean 1 - 2 000 feet above the ground over the higher sections. Vertical visibility in the snow was generally 1 500 - 2 500 feet at Knob Lake and Seven Islands, with horizontal visibility varying from 3/4 to 3 miles, being considerably lower in heavy snow showers. The forecasts issued at 1900 hours and 2001 hours on 16 and 17 January were not received at Knob Lake due to teletype trouble and the last forecast was, therefore, not available to the pilot of the aircraft.

The forecast issued on 16 January at 1800 hours for the Seven Islands Region indicated cloud base at 1 500 - 3 000 feet intermittent light snow and blowing snow, ceiling 1 000 - 1 500 feet arising to 2 000 feet at Seven Islands near the end of the period with visibility of 3 miles in snow and blowing snow. Light rime icing in cloud and occasional moderate to heavy mixed icing between 4 000 and 7 000 feet with a risk of clear icing in precipitation between the surface and 4 000 feet was forecast for the Seven Islands Region.

The Board concluded that the information that was available at Knob Lake did not indicate that Quebec was a suitable alternate for this flight, since the forecast indicated that icing conditions were possible and equally as critical at that point as at Seven Islands. In fact, on the basis of the information available at Knob Lake, it does not appear that a suitable alternate, within the range of the aircraft, existed at the time of departure.

Probable Cause

The aircraft was crash landed at night through inability to maintain height due to failure of the starboard engine under icing conditions when the aircraft was heavily loaded.

In addition to the facts cited by the Board it is concluded, from a review of its report, that the pilot committed an error in taking the aircraft off from Knob Lake at a weight calculated to be 729 lbs. in excess of the maximum permitted for that airfield.

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ICAO Ref: AR/454

No. 7

British European Airways Corporation, Vickers-Armstrongs Viscount, G-AMOM, crashed on take-off from Blackbushe Airport, England, on 20 January 1956. Civil Accident Report No. C.647, released by the Accidents Investigation Branch, Ministry of Transport and Civil Aviation (UK).

Circumstances

The aircraft took off from London Airport at 0755 hours Greenwich Mean Time on a training flight, which was part of a routine base check being carried out by a training captain on a line captain. Having completed the first part of the check the aircraft landed at Blackbushe. At approximately 0850 hours Greenwich Mean Time a take-off was commenced from this airport for another exercise. On reaching the take-off safety speed the training captain simulated a starboard outer engine failure. At this point the aircraft was just leaving the ground and as it did so the starboard inner propeller was seen to be stopping and the aircraft began turning to the right with an increasing amount of bank. It rose to about 30 feet and then descended and hit the ground at a point 250 yards from the runway in a steeply banked, nose-down attitude. It cartwheeled, slid along the ground backwards for 200 yards and came to rest just inside the northwest boundary of the aerodrome. The aircraft sustained major impact damage and fire broke out which almost completely destroyed it. The five occupants escaped with only slight injuries.

Investigation and Evidence

Following the landing at Blackbushe after completion of the first part of the check, No. 1 engine was again restarted and the aircraft was lined up on Runway 26. The training captain then told the line captain that he intended to simulate an engine failure during the take-off sequence which was to be purely visual. On take-off the training captain was in the right-hand pilot's seat and the line captain was at the controls in the left-hand seat. Upon reaching the V_2 speed of 106 knots when the aircraft was just becoming airborne, the training captain stated that he carried out manual feathering of No. 4 propeller by the three movements laid down on the BEA drill card namely by -

1) moving the high pressure cock lever to the feather position,

2) pulling back the throttle lever, and

3) pressing the feathering button.

He further stated that he then checked the gauges showing the r.p.m. and torquemeter pressure for No. 4 engine and that both showed zero, signifying to him that feathering was completed. Immediately after this it became apparent to him that the line captain was experiencing difficulty in maintaining directional control, as the aircraft was turning to starboard despite application of rudder and aileron controls. Because the rate of turn was increasing and the right wing was dropping the training captain took over control. As he did so the line captain selected the undercarriage up. He then noticed that the aircraft was not accelerating beyond 106 knots and believing that he could still gain control, he put the nose down slightly in an endeavour to increase the speed, but as a height of about only 30 feet had been reached the aircraft hit the ground.

Three eye witnesses stated that No. 3 propeller stopped rotating. One of these was another captain aboard the aircraft, who was looking out of the front starboard window at the propellers as he expected No. 4 propeller would be feathered during the take-off. Not only did he see No. 3 propeller feather, but he also noticed a sudden cessation of noise from the starboard side of the aircraft.

Inspection at the scene of the accident showed that initial impact with the ground was made by No. 3 propeller and the nosewheel tires followed by the starboard underside of the nose and the starboard wing tip. The outer half of the starboard mainplane broke off almost at once, closely followed by No. 3 propeller. The aircraft cartwheeled, slid along backwards on its belly and came to rest some 200 yards from the point of initial impact. No. 4 engine with its propeller attached broke off at the wing leading edge and was lying clear of the main wreckage. Fire had destroyed most of the aircraft but the nose section was intact and undamaged by fire.

Three of the blades of No. 3 propeller were in the feathering range, whilst three of the No. 4 propeller were in the fine pitch range. Damage to the blades indicated that No. 3 propeller was almost stationary on impact and that No. 4 was rotating.

Examination of the control cabin revealed that No. 3 H.P. cock lever was selected to the feathering position, to attain which the latch must be raised and the lever moved right back through the gate. The other three H.P. cock levers were forward of the gate. The throttles were all nearly fully open but these positions were considered to be unreliable owing to the effects of crash damage.

Nos. 3 and 4 engines and propellers were removed to London Airport for further examination. It was established that No. 3 propeller actuating piston was in the position to be expected if the H.P. cock lever had been moved to the feathering position and the feathering button had not been operated. It was also established that the No. 4 propeller piston was so positioned that the blades would have been in fine pitch and giving approximately 10 000 r.p.m. at the moment of impact. Electrical and mechanical feathering and unfeathering operations were carried out on No. 4 propeller in exactly the condition it was in when recovered, and it was found that the system functioned normally.

A consideration of the evidence in conjunction with the BEA drill for manual feathering made it apparent that the training captain had moved No. 3 H.P. cock lever (which was two inches longer than No. 4) to the feathering position instead of No. 4, and had then throttled back No. 4 engine and pressed No. 4 feathering button. These actions cut off the fuel from No. 3 engine and feathered its propeller and also reduced No. 4 engine to idling conditions. Pressing No. 4 feathering button had no effect on No. 4 propeller, however, as the H.P. cock lever was not in the feathering position. The aircraft was thus deprived of all power on its starboard side at the moment of becoming airborne and the situation was made worse by No. 4 propeller idling in fine pitch.

The training captain believed he had completed feathering of No. 4 engine and to confirm this glanced rapidly at the gauges showing r.p.m. and torquemeter pressure for No. 4 engine, both of which he read as zero. Because the engine was throttled right back the torquemeter pressure would have been zero but the small pointer of the two-pointer r.p.m. gauge would have been indicating 10 000. In his rapid glance at this gauge he must have misread it.

Movement of the throttle in the feathering drill on this occasion was not necessary as water-methanol injection was not being used. The movement was included in the feathering drill only to cut off water-methanol injection when that system was being used. Following this accident, BEA issued instructions that simulated engine failures on take-off during training flights would only be made when the use of water-methanol was unnecessary. The drill was altered accordingly to exclude movement of the throttle.

Probable cause

The accident was due to an error by the training captain who operated No. 3 high pressure cock lever instead of No. 4 when simulating a failure of No. 4 engine during take-off. This resulted in the loss of all power from both starboard engines at a critical point of the take-off.

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ICAO Ref: AR/433

No. 8

Eastern Air Lines, Inc., Martin 404, crashed during landing at the Owensboro Airport, Owensboro, Kentucky, on 17 February 1956. Civil Aeronautics Board (USA) Accident Investigation Report No. SA-316, File No. 1-0019, released 10 July 1956.

Circumstances

The flight was a scheduled operation between Evansville, Indiana, and Chicago, Illinois, with intermediate stops at Owensboro and Louisville, Kentucky. An IFR flight plan was filed at Evansville and an instrument clearance was given the crew before departure. Clearance was direct to Owensboro at 2 000 feet. The aircraft took off at 1441 hours Central Standard Time, the crew reported its position en route to Air Traffic Control according to its clearance and at 1447 called the company radio located at Owensboro Airport. The flight was given the latest weather and altimeter information and as there was no control tower at Owensboro the company representative there advised that surface wind favoured landing on Runway 5. A few minutes later it descended below the clouds north of the airport, flying on a southerly heading toward the field. It then levelled out and turned right onto a downwind leg for Runway 5. In the limited visibility, reported as one mile in rain and fog, the aircraft disappeared from view near the southwest boundary of the airport while still on its downwind leg. Shortly thereafter it reappeared, proceeding toward the landing runway, struck the ground suddenly, right wing down, rolled to an inverted position, and slid to a stop beside Runway 5. There were no reported serious injuries to the 3 crew members and 20 passengers.

Investigation and Evidence

Weather conditions reported at the time of the accident (1458 hours) were: precipitation ceiling 600 feet, sky obscured; visibility 1 mile; moderate thundershowers, fog; wind northeast 3; altimeter setting estimated 29. 66. At 1510, a few minutes after, conditions were reported as: precipitation ceiling 1 000 feet, sky obscured; visibility 2 miles; moderate thundershowers, fog; wind calm; altimeter setting estimated 29. 68; thunder overhead, movement unknown, lightning in clouds, cumulo-nimbus. The testimony of many witnesses, including the flight crew, indicated without controversy that the actual weather conditions were equal to or somewhat better than those reported.

The initial ground contact of the aircraft was made by the right dual wheels of the extended landing gear. Physical characteristics of the wheel tracks in the soft, rain-soaked ground showed the aircraft was not slipping or skidding and only a portion of its weight was on the ground. The wheel tracks began 125 feet to the right and 330 feet short of Runway 5. They were 31 feet long on a magnetic heading of approximately 30 degrees. For the next 16 feet there were no contact marks. Then for 20 feet there followed a series of irregular slash marks in the ground made by the right propeller. This irregularity indicated that the engine nose section and its propeller were torn off while the marks were being made. At a point opposite the last propeller mark, gouges showed the right wing struck with sufficient upward and rearward forces to break it off. The right wing center section was sheared practically flush with the side of the fuselage. Characteristics and the sequence of wheel tracks, the propeller cuts, and gouges made by the right wing showed that the aircraft, while still airborne, was rolling to the right along its longitudinal axis.

The fuselage then made ground contact with its right side and rolled toward an inverted position while sliding forward. When the aircraft became inverted the left wing contacted the ground, thus stopping the rolling action, but sliding continued for several hundred feet. The ground path swerved gradually to the right. As the fuselage moved forward it also turned on the vertical axis about 180 degrees and when it came to rest the nose of the aircraft was facing back along its path.

Investigation disclosed no evidence of structural failure or malfunction of the aircraft prior to impact and the flight crew stated none was experienced.

Results of the examination of the engines revealed no evidence of failures or condition which would cause malfunctioning. Both engines were determined to have been in good condition at the time of the accident and were capable of normal operation.

The propellers were also examined. There was no indication of malfunction of these units. The propeller governors indicated engine speeds at impact of 2 270 and 2 325 r. p. m. for the left and right engines, respectively. Assuming an airspeed between 95 and 110 knots, the average blade position found indicated that appreciable power, nearly maximum, was being produced by both engines at impact.

The Owensboro Airport is located 29 miles southeast of Evansville at a field elevation of 407 feet. Runway 5 is one of two runways and is 3 700 feet in length. Terrain surrounding the airport is gently rolling with the runway approaches unobstructed.

A commercial broadcast station located 1. 9 miles north of the airport on a bearing of 14 degrees, serves as the approved navigational facility for an Automatic Direction Finder instrument approach to the airport. Eastern's Martin 404 minima for this approach, the only type approved, are: Ceiling 500 feet, visibility 1 mile.

In accordance with a clearance, Evansville to Owensboro, direct, the instrument approach procedure required the flight to pass over the commercial broadcast facility and establish an outbound track of 14 degrees. The instrument approach then requires a procedure turn to an inbound track of 194 degrees. This, if maintained, again takes the flight over the commercial station to the airport. Descent in two intervals is required during the procedure to the minimum altitude, whereupon visual reference should be established with the ground normally just north of the airport. The aircraft is then positioned to land straight-in or circle to the runway of intended landing.

The captain and the co-pilot stated that the flight to Evansville was routine, as were preparations for the Owensboro segment of the flight. The co-pilot flew the aircraft to Owensboro, noting that there was a strong westerly wind at the cruising altitude of 2 000 feet.

According to the crew the instrument procedure was followed precisely and completely. During it, the aircraft was slowed to approach speed, take-off flaps were extended, and the landing gear was lowered. The propellers were adjusted to 2 300 r. p. m. and other pre-landing checks were completed. Visual contact was established approximately one mile north of the airport at about 550 feet above the ground.

The captain took control when the airport was sighted. When slightly northeast of the field he stated that he turned right to position the aircraft on its downwind leg. According to the crew the aircraft was then at an airspeed of approximately 120 knots, 400 - 450 feet above the ground. When approximately opposite the threshold of Runway 5 the captain began a left turn, using a normal 30-degree bank, and asked the co-pilot to apply approach flaps.

The crew members stated that when 45 - 60 degrees from the runway heading there was a slight vibration through the aircraft. This was followed by a gradual lowering of the left wing which steepened the bank. Both agreed that the wing went down gradually and was not caused by any control movement. The captain added power to 38 - 39 inches of manifold pressure and together with the pilot applied control to raise the wing. They stated that it responded normally.

The aircraft was then on final approach descending with its wings level. Then, the pilots said, the right wing dropped without warning but accompanied by a shudder and buffet minor in degree. Corrective control was applied to lift the wing and also to raise the nose. Believing the worst that could happen would be a hard landing off the runway, the captain said he did not attempt to abandon the approach.

Moderate rain was falling during the approach, and visibility and ceiling conditions were better than reported, with the runway visible throughout the entire circling approach. The captain added that he did not believe that the aircraft was stalled and stated that there were definite intervals between the left wing going down, the recovery, the straight-in approach, and the final dropping of the right wing. While still attempting to correct the wing-low position and raise the nose of the aircraft, ground contact occurred.

Most passengers agreed with the testimony of the crew until the aircraft was near Owensboro. None recalled the turning manoeuvres associated with the instrument approach procedure, as described by the crew, but several recalled when the flight became contact and the right turn onto the downwind leg. In this area several stated the flight was considerably lower, in their opinion, than 400 - 450 feet Some recalled the left turn, the slight shudder and the gradually increased bank, however, they placed the events considerably closer to the accident and at a lower altitude than did the crew.

A few ground witnesses saw the aircraft pass over the northeast boundary of the airport, turning right to establish the downwind leg. All agreed that at that time the engines sounded normal and that the position and altitude were comparable to other flights under similar conditions. No ground witnesses saw the aircraft from the time it disappeared on the downwind leg until a few seconds before it crashed. At this time three witnesses saw it proceeding toward the runway. Two stated the left wing was down, and the aircraft was low. These witnesses said the aircraft rolled to its right, from left bank to right, without stopping until the right wing hit the ground causing a spray of mud and water. One witness believed that there was an interval when the aircraft was level between the left-to-right rolling action.

The wind was nearly calm for a considerable period before and after the accident. Moderate rain was falling during the accident period and it did not vary in intensity. Several persons saw at least one lightning flash from a thunderstorm a short distance southwest of the airport. It appeared to the witnesses that the flash occurred close to the aircraft when the accident occurred. Neither the crew nor the passengers reported any lightning flashes, nor did any part of the aircraft indicate a lightning strike.

Weather conditions that existed in the Owensboro area at the time of the accident were dominated by a low pressure area centered in east Texas from which a trough extended northeastward through the subject area, then northward to the Great Lakes. Also factors in the conditions were two quasi-stationary fronts emanating from the low and extending northeastward through the area. The northernmost front passed through southeastern Oklahoma, northern Arkansas, central Indiana, and into northern Ohio. The other was parallel to it but well south of the Evansville-Owensboro sector. These factors produced showers and thunderstorms in the frontal zone with overcast conditions over the entire route. Moderate to severe turbulence was forecast in the thunderstorms, with ceilings and visibilities near minima at Owensboro.

Analysis of the available surface, upper air, and synoptic weather information indicated that at the time of the accident, moist, unstable, warm air was overrunning a stable cooler layer in the Evansville-Owensboro area. It appears the cooler layer extended from the surface to between 3 000 and 4 000 feet. The flight cruised at 2 000 feet remaining in this stable air which accounts for the smooth flight to Owensboro. Although thunderstorms existed they were above the stable air.

There was no evidence of an overriding wind below 500 feet. Lightning was observed southwest of the field in the direction of the approach area to Runway 5. Winds were from the southwest at altitudes controlling the movement of the thunderstorms; therefore, the thunderstorm southwest of the field should have shortly thereafter passed over the field. Official weather observations indicated that the lightning was in the clouds instead of cloud-to-ground. This indicates a thunderstorm cell in a dissipating stage rather than one with vigorous downdraft. If a downdraft and strong outflow existed at low altitudes, it would likely cause the surface wind to be at least fitful or gusty and the barograph tracing to have sharp changes, both of which were negative. It is, therefore, considered very doubtful that any strong or shifting winds affected the flight during the approach. Weather reports and observations indicated the ceiling and visibility conditions at Owensboro were above the minima for landing.

Evidence indicates that the flight was properly planned and flown in a normal manner to the vicinity of the Owensboro Airport. Visual reference to the ground was established about one mile north of the airport and this position was normal after completion of an instrument approach.

The evidence, except for statements of the crew, indicates that the position on the downwind leg from which the left turn was started to align the aircraft with Runway 5 did not allow sufficient distance for a normal turn to the runway and resulted in an abnormally steep bank. Further, it is apparent from nearly all passenger observations that the turning was continued to a low altitude. The Board was of the opinion that these factors indicated poor planning and execution of the approach by the captain. Undoubtedly his actions were influenced by the limited visibility; however, as the turn progressed the miscalculation should have become apparent to him with sufficient opportunity to have discontinued the approach.

Although both crew members stated the left wing of the aircraft went down when 45 - 60 degrees from the runway heading, it was the Board's opinion that this occurred much later during the approach and just before the accident. It is believed that the aircraft was turning left almost continuously until it began to roll from left to right. It appears that the rolling action resulted from a stalled condition of the aircraft caused by insufficient airspeed and increased back pressure as the captain attempted to raise the nose and left wing of the aircraft to avoid striking the ground. Nearly all witnesses said that the roll was continuous from left to right.

Evidence indicates that the situation became critical during the latter portion of the approach and that the captain was aware of it. That corrective action was attempted by power application is substantiated by passenger testimony and by physical evidence which showed that the engines were developing nearly full power at impact. Although the power application was too late to prevent the accident it undoubtedly decreased the force with which the aircraft struck the ground.

Probable Cause

The probable cause of this accident was an improperly executed final approach, resulting in a stall, during a steep left turn at an altitude too low to permit recovery.

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ICAO Ref: AR/437

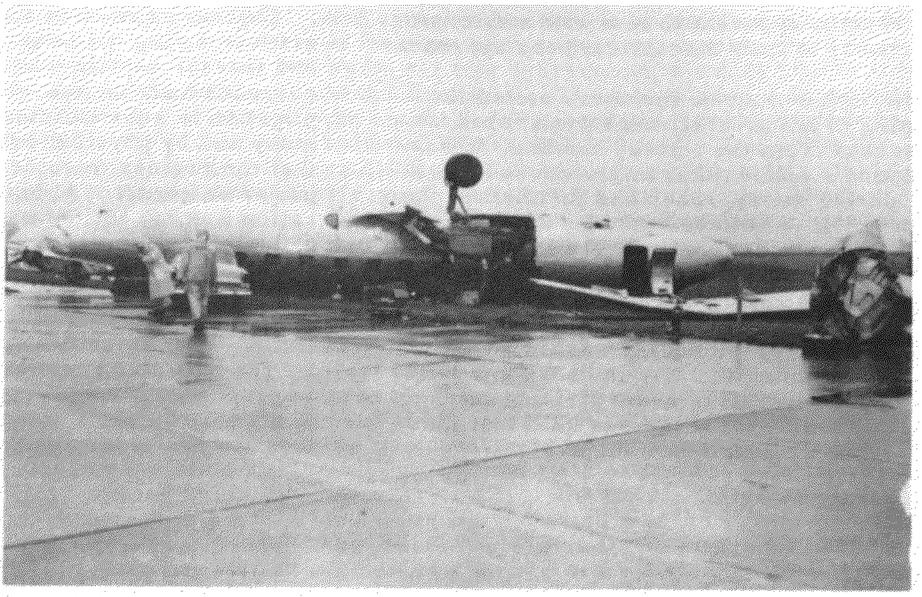

Figure 5 Aviation Crash Injury Research Photo

Eastern Air Lines crash at Owensboro, Kentucky. Left side of aircraft showing final resting attitude (inverted). Photo was made after the left wing was removed by salvage crew.

Figure 6 Aviation Crash Injury Research Photo

Right side of the aircraft - the right wing was torn completely free at the fuselage (1) during the latter part of the initial impact. Penetration of the fuselage at (2) by the inboard trailing edge of the wing forced one passenger seat free from its anchorages.

No. 9

Scottish Airlines (Prestwick) Limited, Avro York, G-ANSY, crashed at Zurrieq, Malta on 18 February 1956. Report of Court of Inquiry appointed by His Excellency the Governor of Malta.

Circumstances

On 18 February at 1221 hours Greenwich Mean Time the aircraft, which had arrived at Malta at 1046 hours on the same day, took off from Luqa Aerodrome, Malta on a flight to Stansted, England. The aircraft became airborne about two thirds of the way down the runway and the undercarriage was retracted. About this time black smoke was seen coming from the No. 1 engine. The aircraft instead of turning to starboard as instructed by the Ground Control appeared to drift to port. The port wing dipped steeply and at 1222-23 hours the aircraft nose-dived into the ground on the cliffs near Zurrieq and blew up on impact. The crew of 5 and 45 passengers were all killed.

Investigation and Evidence

Evidence confirms that the aircraft climbed in steps at a slow forward speed, flying in a tail-down, nose-up attitude and with a varying degree of smoke emanating from No. 1 engine. The climb continued in this manner until a maximum height of approximately 700 - 800 feet a.m.s.l. was achieved with a "crabbing" or "yawing" motion to port which was taking it towards higher ground. Meanwhile the smoke from No. 1 engine fluctuated in volume and colour until at maximum altitude it disappeared. Witnesses stated that at that time the engines of the aircraft had an unusual "booming" sound and the aircraft seemed to be in an unusual nose-up attitude. The aircraft reached its maximum height approximately half way in its flight, i.e. between Qrendi village and Zurrieq. Shortly after passing Qrendi village the aircraft began to turn to port towards the southeast where it passed over a ridge marked 400 feet a.m.s.l. At this point the aircraft was observed to be flying normally except that the engines seemed to have tremendous power and their vibration was felt by the driver of a car nearby. Shortly thereafter the aircraft was observed to falter in the air, its wings tilting both to port and starboard before finally dropping the port wing and turning over in a dive.

From the inspection of the wreckage it was determined that the aircraft was almost vertical at the time it struck the ground. The whole of the fuselage forward of the freight door aperture was destroyed by ground impact and all four engines had been torn from their mountings. On examination it was found that Nos. 2, 3 and 4 engines were functioning satisfactorily at the time of the accident. No. 1 engine had suffered an internal fire and all the induction flame trap elements had been severely burnt adjacent to the inlet valves of both cylinder blocks. The severe heat of the internal fire in the induction system had consumed the impeller. Moreover, the boost enrichment capsule was found to have two cracks.

The position of the piston in the remains of the flap hydraulic actuating jack indicated that the flaps were UP at the time of the ground impact and, as far as could be ascertained from the remains of the flap and flying control systems, no evidence of malfunctioning was found.

The propellers were also completely stripped and were all found to be in fine pitch setting.

The engine fuel master cocks for Nos. 1, 2 and 3 engines were found to be ON, but the master cock for No. 4 engine was not located.

The parties appearing at the Inquiry put before the Court all the circumstances which might have a bearing on or possibly disclose the cause or causes of the accident. The following causes were considered:

Sea gulls

No proof of damage from this source was forthcoming.

Sabotage

Having carefully considered all the facts the Court felt that, although there was undoubtedly opportunity for a sabotage device to have been planted in the aircraft at Nicosia by persons who, in view of the conditions prevailing at Cyprus, would presumably seek an opportunity, nevertheless the state of the evidence was certainly not such as to lead the Court to conclude that the cause, or one of the contributory causes of the disaster, was an explosive or incendiary bomb.

Excess of Weight

Examination of the Load Distribution and Trim Sheet appertaining to this flight and of the relevant evidence indicated that the aircraft was overloaded to the extent of 297 Kgs. The Court considered that this overload did not impair the take-off of the aircraft and was, therefore, of the opinion that the above-mentioned slight excess in weight should not in any way be considered as a contributory cause of the accident.

Engine failure

Evidence shows that there was a failure in No. 1 engine and it is considered that this was due to the failure of the boost enrichment capsule in the carburettor.

This capsule was found to have two cracks at the outside diameter or periphery of the second convolution from the top. These cracks were intergranular associated with corrosion and normal stresses, the stresses being those to which the convolutions were subjected under standard working conditions.

The failed capsule prevented the boost enrichment needle from moving to give the correct jet area during take-off power conditions, and resulted in weak mixture. This weak mixture gave rise to burning on the inlet side of flame traps, causing these to disintegrate but not to burn through completely. Particles of the burnt foils were trapped between the inlet valves and the seat inserts. This would intensify the burning, and, finally, the protective value of the flame traps would be overcome, and there would be a series of backfires or continuous burning through the supercharger. This burning would cause the supercharger rotor to disintegrate, and the engine would then cease to be a useful agent in the aircraft.

An investigation was undertaken by Rolls Royce Limited to ascertain whether normal ground and pre-flight checks would enable detection of a failed boost enrichment capsule, and this investigation was carried out on a York aircraft of the same type as G-ANSY. A simulated capsule failure was produced by blanking off the boost pressure supply to the carburettor chamber.

Under these conditions the engine was checked for R.P.M. response at standard boost up to +14 lbs./sq. in. Boost and single ignition checks were made at the same settings. The engine behaved in a standard manner and no evidence of irregular running could be detected.

Subsequently, Rolls Royce Limited carried out a further test on the same type of engine on a test bed with an assimilated failed capsule. The engine was subjected to +18 lbs. boost at 3 000 R.P.M. for half an hour and at the end of the test, after dismantling the engine, the flame traps and the supercharger were not damaged.

The Court was satisfied on the evidence that the failure of the boost enrichment capsule could not have been discovered by the normal exercise of vigilance reasonably expected from the Operators and their staff.

When the aircraft became airborne, it is conceivable that No. 1 engine was subjected to incipient pre-ignition due to partially burnt flame traps becoming incandescent together with the high charge temperature brought on by weak mixture at high boost pressure delaying the burning in the cylinders and leaving very hot gases, which would ignite the incoming charge when the inlet valve opened.

This would cause the incomplete combustion indicated by carbon particles of unburnt fuel accompanied by a proportion of burning oil, shown by smoke emanating from the exhaust stacks and would result in further burning of the flame trap matrix, particles being deposited on the inlet and exhaust valves and the seat inserts.

Continuous burning in the induction system would then occur, transmitting a heatwave to the supercharger rotor and the supercharger casing, and this would eventually cause the complete failure of the supercharger.

As G-ANSY became airborne the supercharger was subjected to extreme temperature, due to the fire in the induction system (shown by black smoke from the exhaust stacks) upsetting the internal combustion engine cycle. This would produce a considerable drop of power from the outset.

On a broad estimate the progressive loss of power available from No. 1 engine at the take-off stage probably corresponded to the spreading of the continuous burning taking place in the induction system, until the supercharger rotor was finally consumed by the internal fire. It is thought probable that the cessation of dense smoke coincided with the complete burning through of the supercharger rotor, causing a reduced airflow through the engine. It is estimated, with a reasonable degree of probability, that thirty seconds after the take-off the engine ceased to be a useful agent to the aircraft.

Thereafter, the propeller was windmilling. The gases were still burning in the induction system keeping the flame traps incandescent. Although the boost would then be reduced to more or less the zero reading, the pumping action of the pistons, consequent to windmilling, would maintain a reduced airflow through the engine and would eject particles of burnt flame trap elements or sparks through the exhaust stacks.

The developments of the failure of No. 1 engine, outlined in the foregoing paragraphs, go to show that the density of the smoke coincided and varied with the intensity of burning in the induction system. As the power of the engine diminished, the density of the smoke diminished, and, as the density diminished, the smoke must have appeared to onlookers at a distance to turn from a thick black colour to gray and vapourous. Moreover, the smoke was intermittent owing to the fact that particles of burnt flame traps were being deposited at intervals on the valves and seat inserts. This explains satisfactorily the apparent differences on the subject of smoke in the depositions of the witnesses of the flight.

A slight tendency to overspeed momentarily in No. 1 engine during take-off from Abu-Sueir was recorded in the technical log by the captain on the previous sector of the flight. His entry runs as follows:-

> "A slight tendency to overspeed momentarily in No. 1 engine during take-off. The engine surged up to 3150 R.P.M. but was immediately controllable by the pitch control lever and I recorded the defect on 18 February during the flight Abu-Sueir to Luqa. I had first noticed this slight surging tendency on the previous day during the take-off from Luqa."

This defect was recorded in the technical log as of the "deferred" category, which means that the aircraft was not thereby made unserviceable but the defect would be rectified on return to base at Stansted.

Judging by the subsequent events, the Court is inclined to think that the tendency to overspeed at take-off on the previous sectors, as reported by the captain, could have been the result of high induction temperature caused through weak mixture, and aggravated by partially burnt flame traps, momentarily upsetting the mixture strength and resulting in an engine revolution surge.

With regard to the 'B' Bank No. 6 cylinder rear exhaust valve causing the popping noise from No. 1 engine on the rundown check prior to the fatal flight, the evidence shows that when this defect was noticed the following action was taken by the Flight Engineer and the Station Engineer on duty: - the cowlings were removed as well as some of the exhaust stubs; the valve was examined through the exhaust port aperture and found to have stuck open; the propeller was turned by hand for the valve to be examined; it was scraped and a little thin oil was applied to it; the engine was then turned over and the valve freed itself; a check was carried out at 'O' boost; the R.P.M. which previously was 2200 now came back to 2350, and everything was normal after a complete run-up check.

It is considered unusual for carbon deposit in the area of the head of the valve and stem to restrict the function of the exhaust valve in the valve guide.

It is conceivable that the restriction that the Duty Station Engineer cleaned on the valve prior to take-off from Luqa Airfield could have been minute particles of flame trap elements, which caused the valve to stick in the open position. These particles would be consequent to the previous burning of the flame traps, particularly as the flame trap most affected by burning was located in 'B' Bank No. 6 cylinder area.

The pre-flight overspeeding and valve defect abovementioned would not, at the time, be related to the failure of a boost enrichment capsule and subsequent flame trap failure, unless the minute particles of flame trap elements were noticed. However, as these particles would be combined with carbon deposit, it would be most difficult to notice them.

The Court was therefore of the opinion that, in the circumstances, the rectification action taken with regard to the overspeeding and the valve was satisfactory.

The failure of No. 1 engine alone should not have caused the accident, because aircraft of the type York G-ANSY have a three engine performance. Normally, therefore, a pilot should be able to cope with that failure, particularly as, in his routine emergency check tests under the mandatory six monthly check system, he would be trained, as in point of fact the subject captain was trained, to take off when one engine fails.

Handling of Aircraft

As the aircraft took off with instructions from the Control Tower to turn right, it is clear that there was a partial failure of the critical (No. 1) engine, which failure became complete in a period estimated at thirty seconds. At the time of the take-off the speed of the aircraft would be between the minimum control speed of 108 knots and the safety speed of 125 knots. At this juncture the pilot should have felt a progressively heavy footload on the starboard rudder pedal and also a yaw to port. The pilot should have then:

a) obtained flying speed in the shortest space of time by depressing the nose of the aircraft and flying parallel to the runway or ground;

b) corrected the swing to port by means of the rudder and rudder trim tab control in order to keep the aircraft straight on course;

c) put the starboard wing slightly down in order to assist rudder control and offset the resulting asymmetric power as well as the natural wind drift, and

d) when No. 1 engine failed completely - after rapid consultation with his engine instruments, which would then be probably showing 2500 R.P.M. and a fluctuating boost, due to windmilling of the propeller, feathered the propeller in order to minimise the drag from its windmilling and ensure a better three-engine performance.

From the flight path of the aircraft, according to the evidence as assessed, this remedial action was not taken. In fact, the aircraft was not kept straight after take-off but was allowed to drift to port, the nose was not depressed to maintain flying speed, and the propeller was not feathered.

These omissions, in the opinion of the Court, ultimately led to the disaster. It appears that the pilot sacrificed speed for height. The evidence confirms that the aircraft climbed in steps with a nose-up attitude and with a slow speed, at the same time yawing to port, thus indicating lack of speed and consequent loss of directional control.

It is true that, by this method of a stepped climb, the aircraft eventually gained an estimated height of from 700 feet to 800 feet above mean sea level which, in that locality, would be 300 - 400 feet above ground level. As a matter of fact, from the evidence available it is certain that the aircraft cleared the high ridge in the Qrendi area at about 300 feet above ground level.

The height reached by the aircraft at this time was sufficient for manoeuvring, but here again the pilot failed to depress the nose of the aircraft in order to gain flying speed and directional control. Instead, he still kept the aircraft in a nose-up or level attitude getting thus dangerously close to the minimum control speed and to the stalling range. It is considered that, as, at this time, the aircraft was approaching the coast with reasonable ground clearance, if the pilot had depressed the nose of the aircraft, he would have been able to fly out to sea. By failing to depress the nose of the aircraft, and keeping it in a nose-up or level attitude, the pilot committed himself further to a turn to port and to an approach to higher ground.

As the turn progressed, it appears that the pilot retracted the flaps (found fully retracted when the wreckage was inspected) without depressing the nose of the aircraft. This action must have increased the stalling speed of the aircraft and brought it down under minimum control.

To add to the difficulties, stemming from this series of errors, the aircraft, at this stage of the flight, that is when it was flying almost parallel and near to the coast, would be affected to a greater degree by the turbulence which would be expected to be felt in that locality, due to the prevailing gusty conditions.

The Court has kept in mind the possibility that the captain may not have feathered the propeller because he was still hoping to get some power from No. 1 engine, but it is considered that, in any case, he should have felt the drag on the rudder and aileron controls, particularly as the drag was being progressively accentuated by the diminishing directional control and by the ever increasing approach to minimum control speed and stalling range. Moreover, the boost gauge should have indicated conclusively that no power was being derived from this engine. It should be added that even if it were to be assumed that the pilot, for some unaccountable reason, had been unable to feather the propeller, the aircraft would still have been capable of a three-engine performance with the associated conditions of a windmilling propeller and an all-up weight of 68 282 lbs.

The captain had been trained in his routine Emergency Check Tests to take off with an assimilated engine failure. This test, however, according to the evidence before the Court, was carried out, not at the all-up weight of 68 000 lbs., but at a lesser weight of from 55 000 - 57 000 lbs.

The Court appreciates that neither the captain nor any of his crew or of the passengers survived to give explanations but, after giving due weight to this circumstance, the Court is still of the opinion that there was an error of judgment on the part of the pilot, because, however much the Court applied its mind, making all allowances, to the possibility of some reason which might explain the faulty handling of the aircraft,. no such reason could be possibly found without sacrificing evidence and facts to sheer speculation and mere conjecture.

Probable Cause

The probable cause of the accident was the failure of No. 1 engine. However, failure alone did not cause the accident, which was caused by loss of speed and consequent loss of control through an error of judgment of the pilot.

Recommendations

Weight of Aircraft

Sub-section 3 of Section 43 of the Air Navigation (General) Regulations, 1954, authorises a method of computation of the weight of the crew and passengers in terms of a table of average weights in respect of an aircraft having a total seating capacity of twelve persons or more. It may be desirable to enact some limiting provision to the effect that, when the aggregate load of the aircraft comes to within a narrow specified margin of the maximum take-off weight, this fact alone would render inoperative the computation of the assumed weight, and, in any such case, the ac tual weight of each person should be ascertained by individual weighing.

Pilot training

It is suggested that at each six-monthly check of pilots it would be more advantageous, in similated cases of engine failure at take-off, that the weight of the aircraft should not be less than the maximum landing weight.

Torque meters

It is desirable that a further aid be given to the pilot to make sure that he is at all times aware of the power output on each engine. It is, therefore, recommended that Torque Meters or some equivalent device be fitted to aircraft not already provided therewith.

Replacement of boost enrichment capsules

The Court was informed by the Repair and Development Engineer of Rolls Royce Limited that the Company is now replacing all boost enrichment capsules by new ones whenever a Merlin 502 engine is returned for overhaul, irrespective of whether its overhaul life of 1050 hours has been reached or not. The Court understands that the Air Registration Board has approved this action.

Fire-fighting hoses

Bearing in mind that in the present instance the Royal Navy fire-fighting hoses could not be joined to those of the Royal Air Force because of a difference in diameter, it is recommended that suitable adapters be made available in order that the hoses can be joined as occasion requires.

Safety device for boost enrichment capsule

The balance effect of the boost enrichment capsule and the altitude capsule in the carburettor of a Merlin engine, through the medium of the two independent hinged connecting linkwork, controls the jet needle position in the jet orifice. The combined effect of both capsules is intended to provide suitable mixture correction for the engine at varying boost pressure and altitude conditions.

The starboard side capsule, controlling the altitude correcting jet needle in the event of a capsule failure, has a safety device which allows the jet to remain in the rich position at all altitudes above sea level. But the boost enrichment capsule, when punctured, will only allow the correct mixture to be maintained by the carburettor up to approximately +4 lbs. boost.

It is suggested that the boost enrichment jet needle be controlled by a spring balance device introduced into the linkwork mechanism, to allow the jet needle, when the capsule is punctured and expanded, to position itself in the jet orifice in a safe position, thus allowing a proportion of fuel to be delivered to the diffuser, and thereby creating a safety device also for the boost enrichment capsule in addition to the one already existing in respect of the altitude capsule.

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ICAO Ref: AR/474

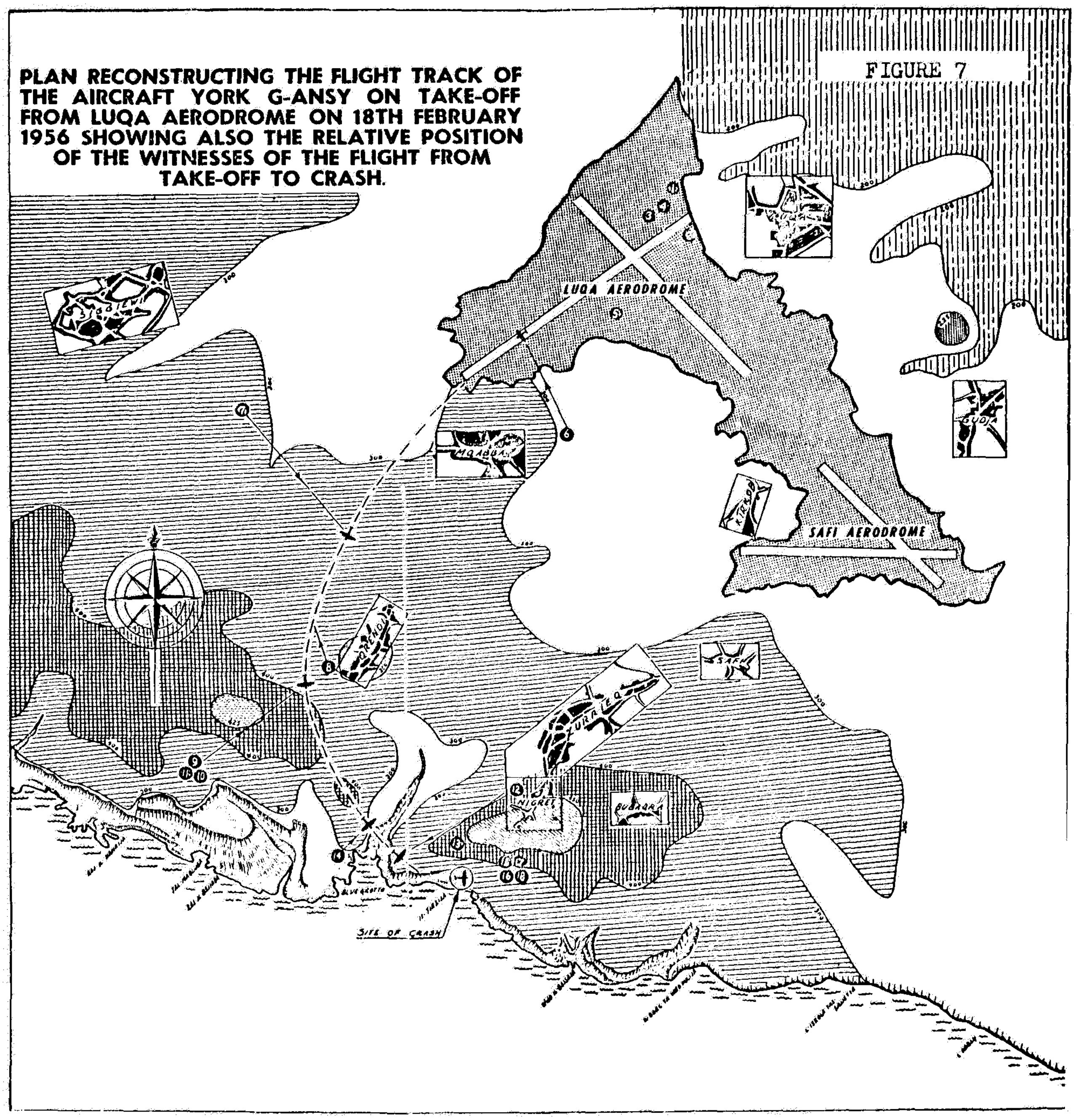

FIGURE 7

PLAN RECONSTRUCTING THE FLIGHT TRACK OF THE AIRCRAFT YORK G-ANSY ON TAKE-OFF FROM LUQA AERODROME ON 18TH FEBRUARY 1956 SHOWING ALSO THE RELATIVE POSITION OF THE WITNESSES OF THE FLIGHT FROM TAKE-OFF TO CRASH.

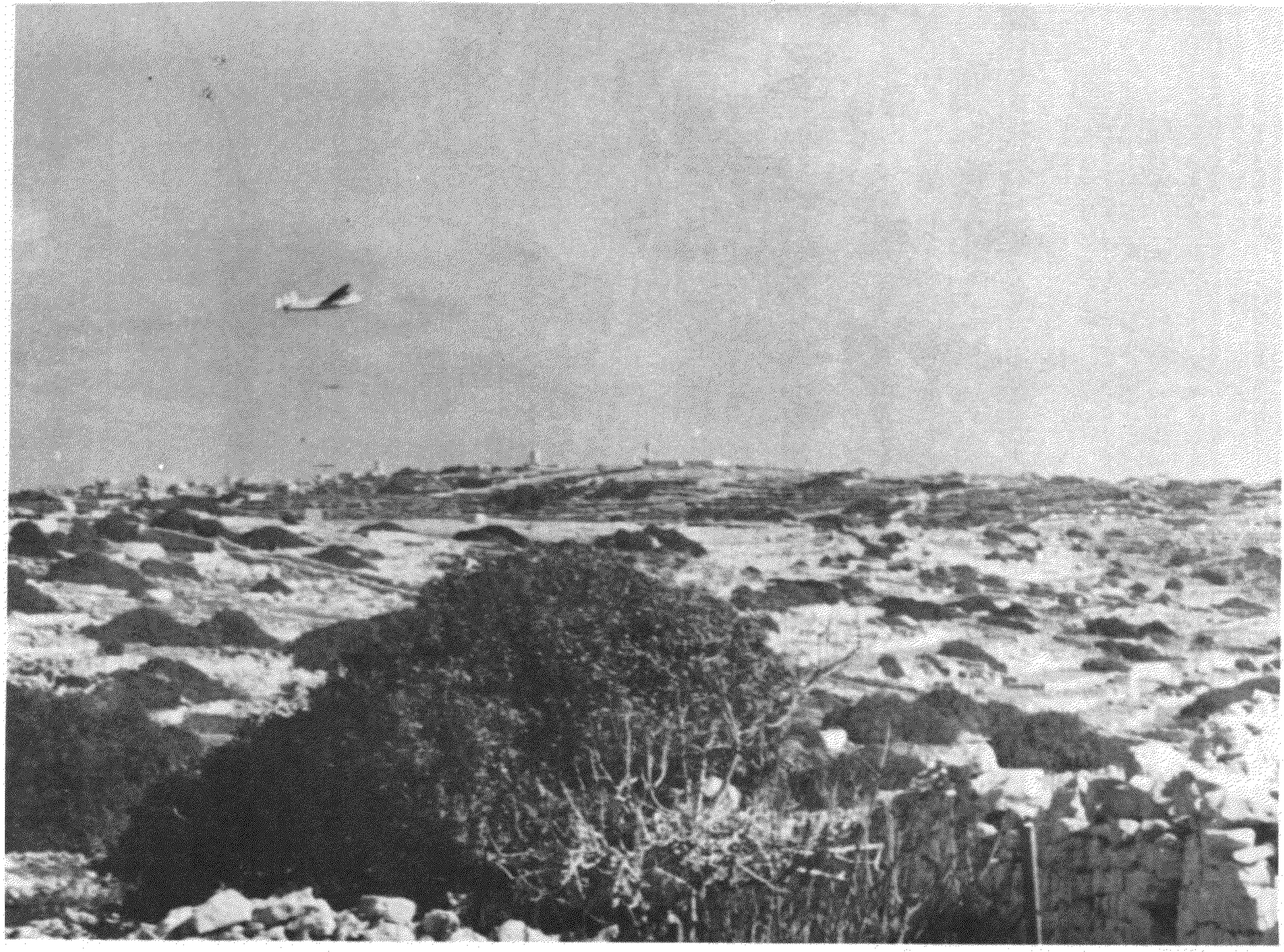

Figure 8

BEFORE - This photo was taken just a few moments before Avro-York, G-ANSY, crashed into the ground on the cliffs near Zurrieq, Malta, on 18 February 1956.

Figure 9

AFTER - The same Avro-York a few minutes later. It nose-dived into the ground and blew up on impact killing all 50 persons aboard.

Figure 10
General view of wreckage area of Avro-York, G-ANSY

No. 10

Capital Airlines, Inc., Vickers Viscount, crashed during the final portion of a landing approach at Midway Airport, Chicago, Illinois on 20 February 1956. Civil Aeronautics Board (USA) Accident Investigation Report SA-317, File No. 1-0020, released 8 October 1956

Circumstances

The flight originated at Willow Run Airport, Detroit, Michigan, and was a regularly scheduled one to Chicago. Following a weather briefing, a VFR flight plan was filed and the aircraft took off at 0700 hours Central Standard Time with a crew of 5 aboard and 37 passengers. The flight was cleared to land on Runway 31R at Chicago and was observed to make a right turn to final approach and appeared to descend in a normal manner until over the west side of Cicero Avenue (the eastern boundary of the airport) at an altitude of 25 to 50 feet above the ground. At this point the aircraft appeared to decelerate and descend rapidly and struck the ground at approximately 0811 hours in a nose-up attitude several hundred feet short of the threshold of the runway. As the aircraft proceeded down the runway the landing gear retracted and the aircraft slid on its belly until it came to rest to the left of the runway, 1 626 feet beyond the point of initial impact. Only minor injuries to a few of the passengers and crew resulted.

Investigation and Evidence

The Chicago weather at 0720 hours was - sky clear; visibility 6 miles; smoke; wind north-northwest 7 knots.

The aircraft touched down on the east taxiway 414 feet short of the threshold of the runway. It was determined from the pattern of marks that in proceeding down the runway the aircraft gradually swerved and crossed the left boundary of the runway approximately 1 200 feet beyond the initial contact point.

The aircraft sustained major structural damage at the time of landing and during the subsequent slide. The main landing gear oleo struts were completely bottomed on impact. The left wing lower spar cap failed in the area rearward of the No. 2 nacelle and the upper spar cap failed adjacent to the fuselage attachment. Considerable buckling and tearing of the upper left wing skin and main spar web were found in the general area of the fuselage and the No. 2 nacelle.

The fuselage broke open in the vicinity of the main spar attach frame. This rupture started at the upper fuselage centreline just to the rear of the Automatic Direction Finder antenna cut-out and extended downward and rearward on both sides to the wing fillet.

The wing flaps were in the 40-degree down position at the time of impact. The torque tube, which extends outboard from the gearbox on either side, was damaged and failed during the ground slide. Failure of the torque tubes permitted the flaps to pivot freely. No evidence was found to indicate that the wing flaps and their associated systems had not functioned properly prior to ground impact. Flaps may be positioned either 0, 20, 32, 40 or 47 degrees. Owing to an interconnection between the throttles and the flap lever, the flaps will return automatically from the 47-degree to the 40-degree position if one (or more) of the throttles is advanced more than one-third.

Two of the six frangible crash switches and one of the two inertia crash switches actuated on impact. This permitted the crash circuit to release CO_2 into the cargo compartments and methyl bromide to be discharged into all engine nacelles. The intercommunication system between the cockpit and the main cabin was disconnected at impact by the operation of the inertia switches.

There was no evidence to indicate any in-flight failure or malfunctioning of the airframe or flight controls.

All engines had suffered substantial damage. All nose cases, except that of No. 2 engine, were broken. The propellers and reduction gears of Nos. 1 and 3 engines were totally separated from their respective engines. The first stage compressor outer casing of No. 1 engine was fractured at the bottom extending along the inboard side. All blades of the high pressure turbine, portions of the intermediate nozzle guide vanes, and the low pressure turbine wheel buckets of this engine were burned in varying amounts. No indication of overheating was evident in any of the other engines.

When over the east boundary of the airport (according to the statement of the first officer) the captain reduced all power and simultaneously called for 47 degrees of flaps. As the first officer moved the flap control to 47 degrees he felt the aircraft decelerate and settle. Glancing at the instrument panel he saw that three of the four 17-degree pitch lights were lighted. The 17-degree pitch lights are actuated by a blade switch on each of the four propellers when the blades are at 17 degrees or below and warns the pilots that the blades are below the 21-degree pitch position which is normally the minimum in-flight blade angle. The filament of one of the light bulbs was found to be broken when tested during the investigation. The first officer said: "I knew that that was an abnormal situation, and the only way I could think to get out of it was to apply power ... " consequently, he pushed the throttles forward quickly and when they were three-quarters fully forward the aircraft struck the ground; he immediately closed all throttles. The captain said that during the flight he did not see any of the propeller warning lights come on, and that he did not know that the first officer advanced the throttles during the latter part of the approach.

The captain stated that over the east edge of the airport ramp, and at an altitude of about 25 feet, he checked the airspeed and it was then 105 knots. Immediately following, when the flareout was started, the aircraft did not respond as expected, but continued to sink rapidly and struck the ground. He said that during the attempted flare-out the aircraft responded to the controls; however, the descent was so rapid that the touchdown occurred almost where the attempted flare-out began.

All witnesses to the approach of the aircraft, including some with Viscount piloting experience, said that the approach appeared to be normal. They expected the aircraft, because of the glide angle and speed, etc., to land farther down the runway, and were surprised when it settled so rapidly. None of the witnesses could reconcile the rapid deceleration and drop of the aircraft with its normal attitude and apparent speed at the time.

In addition to the four 17-degree pitch warning lights, a warning light is provided in the cockpit that is illuminated when the four 21-degree pitch lock solenoids are energized. The 21-degree pitch lock functions as an in-flight low pitch stop. The design of the propeller provides that this stop be withdrawn when the pitch lock solenoid, which is incorporated in the propeller control unit, is energized and the blade angle required to maintain the selected rpm. is less than 21 degrees. Three factors which determine the blade angle are selected rpm., power output of the engine, and airspeed. Energization of the pitch lock solenoids normally is accomplished by switches which are closed by the telescoping action of the landing gear upon landing and when the throttle-actuated switches which are closed by retarding the throttles below the take-off position. An emergency switch is provided in the cockpit to deactivate the pitch lock solenoid circuit should it be energized in flight for any reason, as would be indicated by the pitch lock solenoid warning light. Subsequent to the accident, the wiring of this circuit and the warning light were checked and found to be capable of normal operation.

The first officer said that prior to taking off at Detroit, all propeller-lock warning lights were set to daylight brightness by rotating the light covers to their widest aperture. He also testified that because of the location of the propeller system lights on the left side of the cockpit some difficulty is experienced during daylight hours in readily determining if the 21-degree pitch lock solenoid light is on, and especially so under certain cockpit lighting conditions.

The captain testified that during the "Before Take-off Check" at Detroit all propeller warning lights functioned in a normal manner.

At the request of the Board, the manufacturer conducted flight tests to determine Viscount flight characteristics in the event power was suddenly applied during an approach when the propellers were being governed below the 21-degree pitch stop. As a part of the tests, a landing was made with all propeller stops withdrawn. Throttles were closed during the approach, the aircraft was held off the runway to the lowest speed possible, and touchdown was made at approximately 90 knots. The elevator control force was considered to be high, but not abnormal, for this type of landing. The propellers were observed to reach the ground fine pitch stop just before the aircraft touched down. It was obvious to ground observers, because of the increasing nose-up attitude, that the aircraft was held off the ground as long as possible; otherwise, the landing appeared normal.

Another test was made under similar conditions. At an airspeed of 100 knots, and about 8 feet above the ground, all throttles were quickly opened about half-throttle distance. When this was done, there appeared to be a complete loss of lift and the aircraft sank rapidly to the runway. The aircraft's attitude did not change, and no changes were noticed in elevator forces. Ground observers said the aircraft dropped about 8 feet onto the runway.

Analysis

The captain stated that early in the landing approach the landing gear selector lever was placed in the down position, and the three green lights, indicating the gear was down and locked, were observed. Shortly after initial ground contact, the nose gear and the two main gears retracted. Examination of the landing gear components disclosed that the down lock pins were not sheared, the hydraulic selector valve and its electrical actuator were found in the gear-retracted position, and the cockpit selector lever was found in the gear-up position. These facts, and other evidence definitely indicate that the system was actuated hydraulically by movement of the cockpit selector lever. It is considered likely that the landing gear selector lever was moved unknowingly by a crew member following impact. It is also believed that the gear retraction minimized the possible serious consequences of the fuselage break.

Considerable thought was given to the possibility that the aircraft stalled. The captain testified the speed of the aircraft was approximately 105 knots at the time of the drop. This is well above the stalling speed of the aircraft which, under existing conditions, would have been approximately 81 knots. The captain also said that the stall warning device did not operate. This device is designated to warn the pilot when the speed of the aircraft is 5 to 15 knots above stalling speed. It is thought that the slight nose-up attitude at the time of touchdown was not of sufficient magnitude to have caused the aircraft to stall. It is concluded, therefore, tha the aircraft did not stall.

Several of the witnesses testified that th fuselage failure occurred in flight, just before the ground impact. Sections of the fuselage skin and stringer material from one side of the fracture were removed and sent to the Bureau of Standards for testing and evaluation The Bureau's report clearly shows no evidence of fatigue or defective material. The fractures were all of the ductile, overload type; therefore, it is virtually impossible that these failures occurred in flight. This is also true because, in the absence of a fatigue failure, excessive loads would have to have been applied to produce the failure. An evaluation of the fuselage loading for the time involved indicates that the aft fuselage would be very lightly loaded during the approach condition. Since no violent manoeuvring was involved, it is inconceivable that excessive loads, sufficiently high enough to fracture the fuselage, could have been imposed in flight. Further, the reported and observed flight path is not consistent with an in-flight fuselage failure. Had the fuselage failed in flight, the down-balancing tail load would have been relieved and the aircraft would have violently pitched nose downward. The developed facts indicate that this did not happen. In summary, the fuselage failure did not occur while the aircraft was airborne; the failure undoubtedly occurred as a result of the hard landing. The wing spar failures and the condition of the main landing gear are further evidence of the severity of the landing.

The circuit of the 21-degree pitch lock solenoid contains four microswitches, two connected in parallel on the positive side and two connected in parallel on the negative side. This necessitates that one switch on each side of the circuit be electrically conductive before the solenoid is energized, thus completing one of the steps toward withdrawal of the 21-degree pitch stops. This circuit is designed expressly as a safety measure in that malfunctioning of two switches is required to establish an unwanted circuit. However, this double failure feature of the circuit was compromised in that a failure of one switch could go undetected for an indeterminable period of time.

Examination of these microswitches showed three were capable of having malfunctioned by either freezing or sticking. In the light of the first officer's statement that he saw the 17-degree pitch warning lights on before touchdown, it is concluded that at least two of these switches malfunctioned in flight.

The switch mounted on the right main landing gear was found to contain water in the switch housing, including the contact cavity, and showed evidence of corrosion. The switch operated freely; however, a considerable amount of corrosion products in granular form were loose inside the switch housing. Significant with respect to the water found in this switch housing is that the aircraft was exposed to a 19-degree F. temperature for approximately one and one-half hours at Detroit, Michigan, prior to take-off for Chicago, Illinois. This condition was simulated in laboratory tests and in about 45 minutes the moisture in the switch was frozen so that the contacts would not open.

Initial checks of the landing gear mounted switches revealed the contacts of all to be open, except the switch on the left main gear. This switch was found to be stuck in the closed position. This sticking of the contacts could be duplicated readily. Laboratory examination revealed a deposit of silver oxide on the contact surfaces. After this deposit was removed, sticking no longer occurred. It was found during laboratory tests that silver oxide deposits could be formed on the contact surfaces when the contacts were bridged by water while an electrical potential existed across the contacts.

The third switch found to be unsatisfactory was the one mounted on the aft side of the nose gear. However, its condition, though unsatisfactory, is not believed to be pertinent to this accident.

Power control of the Viscount aircraft consists of four throttles which simultaneously schedule rpm. and fuel flow for each of the four engines. The propeller response to the signal for higher rpm. is more rapid than the engine response to increase power to maintain this rpm. This is a normal turbine propeller characteristic and the lag of the Rolls Royce Dart engine is considered to be acceptable. A number of variables, such as airspeed and rate and extent of throttle movement would affect the duration of this lag. In this instance, it is believed the lag was approximately 2.5 seconds. During a major portion of this period, the propeller blades would be at four degrees attempting to maintain the higher called for r.p.m. through windmilling action with resultant greatly increased drag.

Under the above circumstances, two deleterious effects on aircraft performance are produced. These two effects are the increased propeller drag and the loss of wing lift due to the reduced local air velocity over the wing in the area aft of the propellers. In this instance, the loss of lift effect was more significant since the effect was immediate, whereas the drag effect requires a longer time interval to be fully effective. Since the subject aircraft was only 25 to 50 feet above the ground when the drop occurred, and the time interval from the beginning of the difficulty to ground impact was so short, it is thought that loss of lift was mainly responsible. Subsequent flight tests, conducted by the manufacturer, confirmed this belief. These tests also showed that under similar conditions, if the throttles were advanced slowly, drag detrimental to flight and deterioration of lift does not develop.

In conclusion, it is apparent that at least two of the microswitches malfunctioned when the aircraft became airborne at Detroit and continued to do so throughout the flight. The failure of these switches permitted the energizing of the 21-degree pitch lock solenoid, making it possible for the stops to be withdrawn during the approach. The crew did not observe the 21-degree pitch lock solenoid warning light and consequently the emergency switch which was provided to prevent the propellers going into the ground fine pitch range while in flight was not actuated. As the aircraft neared the ground at Chicago, the first officer did see the 17-degree pitch lights come on. No instructions having been provided the crew of the consequences, he quickly advanced the throttles, causing the propellers to immediately seek the lowest possible blade angle. The ensuing loss of lift dropped the aircraft to the ground.

Probable Cause

The probable cause of this accident was a malfunctioning of the propeller control switches which culminated in an abrupt loss of lift.

As a result of the investigation of this accident, immediate corrective action was taken:

1. A dual, 21-degree pitch lock solenoid warning light was installed on all company Viscount aircraft. This second light is a safety factor in the event of a broken or burned-out bulb.
2. A 300-hour periodic check of all microswitches* was implemented. This requires their removal and installation of newly overhauled microswitches.
3. A hole was drilled in each microswitch case to allow excess moisture to drain from the switch.
4. Prior to installing any new switch received from the manufacturer, an inspection of the switch will be made.

Following the public hearing of this accident, the company decided to take this additional immediate corrective action:

1. A test circuit was installed in all Capital Airlines Viscount aircraft consisting of a dual light and single pole double throw switch which provides a means to check, while in flight, the positive and negative sides of the 21-degree pitch solenoid circuits to determine if the microswitches are malfunctioning. This test circuit will also indicate an inadvertent positive or negative feed which might have been introduced directly to the wiring of the circuit.
2. The 21-degree pitch lock warning lights were duplicated on the fire control panel in front of the copilot.
3. Hermetically sealed landing gear actuated microswitches were ordered and are to be installed upon delivery.

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* Note: - To prevent any misconception that may arise from use of the word "microswitch" in this report, it should be noted that the small switches referred to as "microswitches" were manufactured by Dowty Equipment Ltd., Cheltenham, England, and have no connection with "MICRO SWITCH", the trade name of a manufacturer in the United States.

ICAO Ref: AR/444

No. 11

Compagnie de Transports Aériens Intercontinentaux, Douglas DC-6B, crashed near Cairo, Egypt, on 20 February 1956. Report released by the Ministry of Communications, Civil Aviation Department, Egypt.

Circumstances

The aircraft was on a scheduled flight from Saigon to Paris, France and had left Karachi for Cairo on 19 February at 1715 hours Greenwich Mean Time with 9 crew and 55 passengers aboard. The flight was routine until 0230 hours (20 February) when the aircraft reported to Cairo Air Traffic Control that it had passed Suez (60 miles east of Cairo) at 0224 at a flight level of 8 500 feet, flying VFR and was descending. At 0240 it reported the Cairo aerodrome in sight and being 15 miles out, was granted an authorization for a VFR approach and at the same time was given the QFE and QNH, 29.42 and 29.73 respectively. Contact was established with Cairo approach and the aircraft requested and received landing instructions on 118.5 megacycles and was asked to call down wind. This message was acknowledged and was the last heard from the flight. Several attempts to contact the aircraft on all available frequencies were made but were unsuccessful. At 0450 hours the wreckage was sighted 18 miles southeast of the aerodrome. Only 6 crew members and 6 passengers survived.

Investigation and Evidence

The investigation disclosed that the captain-in-command, a company DC-6B captain and check pilot, with extensive piloting experience, occupied the right-hand seat during the flight leg between Karachi and Cairo, and the co-pilot, the left-hand seat. The latter was being checked on this flight as a DC-6B trainee-captain by the captain-in-command. Since they had left Saigon where the flight originated both had completed 21-1/2 hours of flying at the time of the accident. A crew change was to be effected at Cairo.

The aircraft struck the ground in a nose down attitude with the landing gear fully extended and locked and the flaps set at 20°. The general direction of the wreckage distribution following impact was about 240° magnetic.

The aircraft was totally destroyed by fire after impact. The probable cause of the fire was the rupturing of the starboard wing following the severe shocks sustained by the landing gear, engines and propellers and transmitted to the wing structure with the result that the petrol content of the latter was sprayed on some broken live electric connections, which initiated the fire that spread quickly over the starboard wing and the fuselage portion aft of the cockpit.

All aircraft fire extinguisher bottles recovered after the accident were found discharged but had little effect on the fire intensity.

Due to the hilly nature of the terrain and the softness of the sand dunes, no vehicles were able to reach the crash site.

All aircraft aids were certified serviceable by the radio officer up to the time of the accident and little radio interference was encountered after Suez.

Investigation did not reveal any structural failure prior to impact and no malfunctioning of the engines was reported to justify their dismantling at the shops.

The captain stated that the flight was uneventful up to Suez and that between Suez and Cairo the aircraft had drifted to the south for some reason. Clearance had been granted for a visual let-down. When he realized that the aircraft was over a dangerous area it was too late to take any corrective action. It seemed to him that there was a very important wind component from the north when all forecasts indicated a southerly component. The radio compass indications were unreliable due to the night effects and to stormy weather. The aircraft ILS indications were unsatisfactory and the glide path was unserviceable and the co-pilot misinterpreted the indications and turned the aircraft towards the left following a false ILS axis. He also testified that a direct approach procedure was adopted and a minimum altitude of

2 000 feet was maintained to intercept the localizer. He said that his estimated time of arrival was 0237 hours and that he saw the aerodrome lights to his right and realized that the aircraft had drifted to the south but not appreciably as it turned out to be later on. He also stated that he gave the co-pilot the order to carry out an ILS procedure when the latter started descending. To the question how he allowed an ILS procedure with a direct approach, he answered that the aircraft was supposed to reach the outer marker locator at an altitude of 2 000 feet. He also testified that it is difficult to recognize the aerodrome by night because it is not isolated and one has to wait a long time before recognizing it.

The co-pilot stated that the aircraft's position relative to Suez was fixed visually and at the time was about 3 nautical miles to the south of Suez, flying at 8 500 feet. He testified that Cairo ATC authorized the aircraft to descend from that altitude according to the visual flight rules. The aircraft heading at that moment was 280 degrees magnetic and that heading was maintained to intercept the ILS localizer. He stated that the pilot-in-command estimated to reach the outer marker at 0237 hours. Cairo approach cleared the aircraft to descend VFR for runway 230 and transmitted the QNH and QFE and he adjusted his altimeter setting to the QFE. He stated that the pilot-in-command and himself thought that they were going to overshoot so they decided to put the aircraft into the landing configuration at 4 500 feet altitude. The ILS localizer needle was to the right, so he assumed a new heading of 300° to intercept as quickly as possible the axis of the ILS. When the needle moved slowly towards the centre of the instrument dial, he assumed the heading of 230° corresponding to the ILS axis. One radio compass was on the range and the other on the outer compass locator, but both of them, he stated, were giving rather incorrect indications and the needles were pointing near the zero position. Now the aircraft's altitude was 2 000 feet, corresponding to the altitude at the beginning of the ILS procedure. As the glide path was unserviceable, he maintained the altitude of 2 000 feet with an engine boost of 31" Hg, waiting to reach the outer marker. A few moments later the accident occurred. When asked whether he was able to determine his distance from the aerodrome and his altitude when the indication of the ILS localizer was central, he said that he was at that time too busy watching his instruments and that his altitude was 4 000 feet.

The procedure agreed upon for the approach consisted of a direct approach to the outer marker. The first visual contact with the aerodrome was at an altitude of 4 500 feet. Both the pilot-in-command and the co-pilot thought they were going to overshoot so they lowered the undercarriage and the flaps to increase the rate of descent while maintaining the same speed. It is conceivable that they based their estimate of the distance from the aerodrome on the assumption made by the captain-in-command that they would arrive over the latter at 0237 and that the aircraft's altitude was regulated accordingly down to 2 000 feet.

If the average rate of descent was 500 ft/min. as stated by the pilot and co-pilot, it would take approximately 8 minutes to reach the altitude of 4 500 feet from a level flight of 8 500 feet so it was probably 0232 when the aircraft reached the altitude of 4 500 feet and had only according to the captain-in-command's assumption 5 more minutes to reach the aerodrome. Actually, if the aircraft had reached the aerodrome, it would have exceeded its estimated time of arrival by 9 minutes. At that moment, according to the statements of the captain and co-pilot, the pointer of the localizer was fully deflected to the right, this indication was taken by the co-pilot that the aircraft was to the left of the axis of the localizer, so he took the heading of 300° to intercept as quickly as possible the ILS axis. The pointer returned slowly to the centre. Taking into consideration the aircraft's position, that indication could not correspond to a normal functioning of the instrument, but the co-pilot who was on the controls considered the instrument indication as intercepting the localizer and took the heading of 230° corresponding with the QFU of the runway.

That was contrary to safe navigation because during the above manoeuvres the aircraft was all the time descending until it reached an altitude of 2 000 feet, which is 1 500 feet below the minimum safe flight altitude for the sector (3 500 feet); and as the approach was carried out from the beginning according to the visual flight rules, all flying below the safe altitude should have been done exclusively by visual means and the instruments should have been used just as an aid to fix the aircraft's position in relation to the aerodrome.

Moreover, the captain testified that at the end of the left turn, he became aware of the red flag showing on the ILS dial, which emphasized to him the fact that the co-pilot's interpretation of the instrument indication was erroneous and it should have been his duty to order the co-pilot to stop descending at once, but apparently he was too slow to take any corrective action before the aircraft hit the ground.

The ILS approach procedure for Cairo International Aerodrome requires aircraft to make an initial approach over the ILS outer marker maintaining 2 000 feet until over the outer marker outbound. The aircraft will then proceed outbound for at least 2 minutes descending to 1 700 feet and maintain this altitude until below the glide path. A procedure turn will then be made to the north of the localizer course maintaining 1 700 feet. This altitude will be maintained until intercepting the glide path inbound and then descent will be made on the glide path.

In the event of a missed or baulked approach, aircraft should immediately climb to 2 000 feet outbound on the back course of the localizer and return to the outer marker at 2 000 feet or as directed by Cairo Approach Control; but although the initial intention of the flight for the landing consisted of a direct approach to the marker, this intention was abandoned in favour of a hasty decision to try and intercept the localizer axis as quickly as possible.

The co-pilot testified that the aircraft hit the ground tangentially and in a straight and level attitude. This is in contradiction with the facts gathered at the scene of the accident that the first point of impact was with the nosewheel and that the aircraft ran for about 6 metres on the nosewheel. On the other hand, if the aircraft was flying straight and level before the accident and no sudden failure had occurred it could not possibly clear a hill 250 metres before and 40 feet higher than the first point of impact.

The approximate rate of descent was determined from the following co-ordinates:

aircraft speed at time of impact	125 knots
distance flown after clearing hill	250 metres or 0.15 miles
height of hill	40 feet
rate of descent	550 ft/min.

which corresponds approximately with the rate of descent mentioned by the pilot-in-command in his statements and is a normal rate for approach with the flaps extended 20°.

Although the pilot and co-pilot testified that before the accident the aircraft was maintaining an altitude of 2 000 feet for a direct approach to the outer marker, the aircraft hit the ground at an altitude of 1 360 feet approximately. This discrepancy between the above two figures was thought at the beginning to be due to a faulty QFE setting. Both altimeters were recovered from the wreckage and examined. One of the altimeters showed on the sub-scale a setting of 29.42, corresponding to a correct QFE as transmitted from the tower. This was the co-pilot's altimeter. The other altimeter setting, set to the QNH as testified, could not be determined due to the excessive damage caused by the fire on the scale. On the other hand, the remote possibility of the static system becoming suddenly blocked in such a way as to affect both precision altimeters was explored. If this happened the obstruction should form an air tight plug to be of any real effect, and the instrument casings should also be air tight. In that case the altimeters would indicate the higher altitude at a lower level (precisely the altitude at which the static lines became blocked). But this would have affected at the same time the airspeed indicators and the other instruments fed from the same static sources; but the airspeed indicator seemed to function normally up to the time of the accident and there were no complaints as to unserviceability.

The fact that both pilot and co-pilot do not recall any altitude below 2 000 feet might be due to the fact that during a short period before the accident they were too busy looking outside the aircraft to identify the runway lights.

It is also noteworthy to mention that the co-pilot was using Cairo Aerodrome ILS for the first time and, therefore, was not sufficiently acquainted with it and in such a case was in need of a severe monitoring on the part of the pilot-in-command.

The weather forecast indicated mainly westerly winds with moderate strength having a very slight south component. The actual weather at the time of the accident agreed with the forecast but the winds were lighter and some medium clouds covering half the sky at 1 200 - 3 000 metres developed over Cairo Aerodrome.

Probable Cause

The accident was due to the failure of the pilot-in-command to monitor the co-pilot during a direct approach procedure and the reliance of the latter on his instruments exclusively to fix his position relative to the runway at an altitude below the minimum safe altitude.

The factor of crew member fatigue cannot be ruled out.

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ICAO Ref: AR/431

No. 12

Pakistan International Airlines, Dakota aircraft, AP-ACZ, crashed on Lash Golath Mountain, near Jalkot on 25 February 1956. Report released by Department of Civil Aviation, Government of Pakistan.

Circumstances

The aircraft took off at 0820 hours West Pakistan Standard Time from Chaklala aerodrome on a charter flight to Gilgit. After landing at 1014 hours at Gilgit, the captain advised the passengers and ground staff that he would not carry passengers on the return flight due to the very bad weather conditions en route. At 1400, AP-ACZ departed Gilgit on the return flight and at 1410 was in wireless telegraphy communication with Gilgit aerodrome. At 1421, Chaklala passed on to the aircraft the latest MET observation and the transmission was acknowledged. Nothing further was heard from the aircraft until 1454 when the following S. O. S. was picked up by the ground stations and two other aircraft:-

> "S. O. S. , AP-ACZ, INDUS mouth position trapped in bad weather, Indus mouth"

Chaklala aerodrome acknowledged the S. O. S. but failed to contact the aircraft. The flight crashed on the peak of Lash Golath Mountain at a height of approximately 14 000 to 15 000 feet. All three crew members, the sole occupants, were killed.

Investigation and Evidence

No technical investigation was carried out.

While AP-ACZ was at Gilgit the following message was transmitted from Chaklala to Gilgit:-

> "From Captain AP-AAG, weather deteriorating very badly between points A and B. Precipitating. Visibility 1 to 1-1/2 miles."

This message was passed on to the first officer of AP-ACZ. Subsequently, telephone messages were exchanged between the control tower at Gilgit and the captain of AP-ACZ. According to the air traffic control officer, only bad weather reports were passed on to the captain.

Documentary evidence shows that bad weather messages and forecasts between points B and A (i. e. the region of mountains flanking gorge of the River Indus) were repeatedly passed on to the captain of AP-ACZ, by the meteorological office at Chaklala, the captain of aircraft AP-AAG and the air traffic control officer at Gilgit Tower.

It appears that the aircraft, on its return flight, maintained an altitude of 10 000 feet to 11,000 feet until it entered the area of the gorge flanked by high mountainous terrain rising up to 16 720 feet. According to villagers in this area, visibility was very poor and there was rain followed by sleet and a thunderstorm. The aircraft was hemmed in between three mountain peaks, each rising to well over 16 000 feet in the form of an equilateral triangle.

According to eye witnesses, the aircraft completed two circuits near Jalkot village but whilst carrying out the third circuit there was an explosion and they realized that the aircraft had crashed.

The villagers were unable to reach the scene of the accident immediately due to bad weather, but two days later some of them managed to climb up to the wreckage, which had been swept down the mountain slope by an avalanche. On the arrival of a ground party from Rawalpindi, it was found that most of the wreckage had been taken away by local tribesmen.

Probable Cause

The accident was attributed to pilot error while he was attempting a flight beyond his ability or experience.

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No. 13

West Coast Airlines, Inc., Douglas DC-3, crashed near Pullman-Moscow Airport, Pullman, Washington, on 26 February 1956

Civil Aeronautics Board (USA) Accident Investigation Report

File No. 1-0009, released 12 September 1956.

Circumstances

The flight departed Idaho Falls, Idaho at 1430 hours Pacific Standard Time for Spokane, Washington, with numerous intermediate stops including Lewiston, Idaho, Pullman, Pasco and Walla Walla, Washington. The aircraft carried a crew of 3 and 12 passengers. At Lewiston the captain checked the weather with the company's station agent at Pullman and the flight departed Lewiston at 1916 hours. When in the vicinity of Pullman, at 1929, an Automatic Direction Finder instrument approach was made, using the company's 'H' facility, and visual contact was made at 3 500 feet m.s.l. The aircraft flew over the airport then made a right turn, followed by a left turn, planned to align the aircraft with the runway. During this manoeuvre a small snow squall was encountered and momentarily the captain lost visual contact. The aircraft then struck the side of a hill and crashed at 1940 hours in a snow-covered field injuring the co-pilot and two of the passengers slightly.

Investigation and Evidence

The aircraft made its first contact with the ground at a point 1-1/4 miles northeast of the airport while moving on a course of 230 degrees. (The runway is aligned on a 229-degree heading.) The altitude of the point of contact is 2 660 feet m.s.l., 109 feet higher than the runway. The flight had failed by 50 feet to clear a round-topped hill which lies between the point of contact and the airport. First impact, which occurred while the aircraft was in a nose-high attitude, caused both main wheels to fail rearward driving each drag strut upward through the wing; the second ground contact was made 100 feet beyond the first, and the aircraft then skidded 650 feet.

Examination of both engines and both propellers indicated that they were capable of normal operation prior to impact. Examination of the airframe disclosed no defect that could have existed prior to impact.

The airport at Pullman has a single landing strip, 100 feet wide and 4 931 feet long, aligned 229 degrees and 49 degrees magnetic. Hills, reaching 100 to 250 feet above the landing strip, lie in all directions within one mile.

The company-owned 'H' facility is located near the centre of the landing strip. West Coast Airlines uses two ADF approach procedures:

1) requires reference to a commercial broadcasting station that operates on week days only and was not available on Sunday, 26 February;

2) specifies, "Initial approach from the south at 5 100 feet. Outbound track is 225 degrees from the 'H'. Procedure turn is to the south, minimum altitude 4 000 feet. Maximum distance 25 miles. Minimum altitude over the 'H' on final approach is 3 500 feet. If visual contact is not established over the 'H' on final, or landing is not accomplished the following "Missed Approach" procedure is established. Turn left and climb to 5 500 feet on a 225-degree track from the 'H' within 10 miles of the station."

At the time the flight departed Boise, the stop before Lewiston, en-route weather was being reported as generally overcast, with light rain at Walla Walla, light snow at Spokane and Pullman, and precipitation generally over the mountains. Ceilings were being reported ranging from 1 200 to 5 000 feet and a visibility 10 miles or better, except three-quarters of a mile at Pullman. The area forecast available at Boise indicated the following expected conditions en route - broken to overcast, ceilings 4 500 or better but occasionally lowering in snow showers to ceiling 800, sky obscured, visibility 1 to 3 miles. Snow showers were expected to be frequent over all mountains. The terminal forecast for the Spokane area after 2 000 hours was gusty southwest wind and occasional ceiling 600, sky obscured, visibility one mile, light snow and fog. The Lewiston terminal forecast was ceiling 3 000 overcast, occasional light rain showers, wind south-southwest 12. No terminal forecasts are issued for Pullman.

At 1855, prior to departure from Lewiston the flight had called Pullman and requested the local weather. The reply was as follows: "Special No. 15 1850 Pacific time precipitation ceiling 1 000 feet* obscuration; visibility 2 miles;** light snow; temperature 30; dewpoint 30; wind southwest 8." This was the last weather requested or received by the flight.

The ADF approach was completed in a routine manner and visual contact was established over the southwest end of the runway with the obstruction lights in sight. The captain then flew over the runway for its entire length and noted his heading as 50 degrees while descending to 3 100 feet and advanced power to 25"-26" to maintain that altitude.

On reaching the eastern end of the runway the captain started a restricted - visibility procedure turn. This manoeuvre is used to assist the pilot in reversing his course and to provide a means of staying fairly close to the runway on which he plans to land and be certain that on completion of the procedure he will be aligned with the runway and at the right position to complete his final approach and landing by visual means. He made a standard rate right turn to a heading of 95 degrees and held it for 40 seconds. Thereafter he executed a standard rate left turn to the runway heading of 230 degrees. This series of manoeuvres performed at 3 100 feet and 110 knots throughout was calculated to end with the aircraft aligned with the runway on the proper heading. During much of the final turn few, if any, lights on the ground were within the angles of vision from the cockpit. At the approximate instant of completing the procedure turn the flight encountered a snow squall, which reduced visibility to zero for an estimated 10 seconds.

The captain testified that during this interval on instruments he reached for his throttles to abandon the approach but changed his mind when the airport lighting again became visible and completion of the landing appeared to be a routine matter. He saw that he had reached a point from which the airport lights were on a bearing about 10 degrees farther south than he had planned. He testified that he then altered his heading an estimated 10 degrees to the south to bear upon the lights at the threshold and continued his approach, starting his descent along a path a little to the north and at a small angle from the projected centreline of the runway. At that time he reduced his manifold pressure to about 19 inches, and his speed to 90 or 95 knots. A moment later his only landmark, the lights on the airport, disappeared. Believing the loss of visual reference to be only another snow squall he attempted to initiate a missed approach by climbing through the squall. He told his co-pilot to raise the gear (flaps had not been extended) and to shut off carburettor heat. The captain then opened the throttles, pulled back on the elevator controls and started reducing propeller pitch. The aircraft had been put into a climbing attitude at about 90 knots but had not started to climb when, at 2 660 feet m.s.l., it struck the snow-covered hillside which was in its path to the runway threshold. At impact the gear was still locked down.

The flight was entirely routine until it reached the Pullman-Moscow Airport, completed the instrument approach, and the circling approach had advanced to the very end of the planned 225-degree turn into final. During this turn the crew were compelled to fly by reference to instruments. The weather as recorded, reported to the crew and observed by them was above authorized minima except for about 10 seconds while the aircraft was passing through a snow squall. During that interval the captain decided to abandon the approach but when he emerged from the squall and re-established visual contact he reversed his decision.

Although he was slightly north of his alignment upon starting the final leg, he considered the correction for this to be no additional hazard as the runway lights were then in sight. The approach was continued following a pattern that was normal except for the small deviation toward the north. When the lights ahead

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* WCA's night approach limits at Pullman-Moscow were 900 feet ceiling and 2 miles visibility. After this accident they were changed to 1 000 feet and 3 miles with descent prohibited unless all runway lights could be seen.

** The weather observer on duty testified that the actual observation of visibility at night is limited to the farthest lighted target; to the east this is 3/4 mile.

disappeared again the captain thought a second snow squall was in his path straight ahead, and as the condition seemed to be worse than reported and to be below minima, he tried to abandon the approach. But the restriction to visibility ahead was not merely airborne snow; it was in fact, a snow-covered hill, or more likely a snow-covered hill shrouded in falling or wind-driven snow. At this point the aircraft had actually descended too low to clear the terrain. The captain also testified that when he pulled the aircraft up it did not stall but he did feel it descend as if in a downdraft.

In his attempt to pull out for a go-around the captain had changed the attitude of the aircraft to tail-down, thus getting much of the effect of a flare-out and probably reducing the force of impact a great deal.

Probable Cause

The probable cause of this accident was the continuation of a landing approach following loss of visual reference to the airport, and the delayed attempt to execute a missed approach procedure.

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ICAO Ref.: AR/441

No. 14

Northeast Airlines, Inc., Convair 240 landed in deep snow at the Municipal Airport, Portland, Maine, on 29 March 1956. Civil Aeronautics Board (USA) Accident Investigation Report, File No. 1-0048, released 14 September 1956.

Circumstances

Flight 124 was a scheduled flight between La Guardia Field, New York and Bangor, Maine. Intermediate stops included Boston, Massachusetts and Portland, Maine. Departure from Boston for Portland was at 2120 hours Eastern Standard Time. The flight was conducted in instrument weather conditions in accordance with an Instrument Flight Rules flight plan and was routine to the vicinity of Portland. At 2147 the aircraft was cleared by Air Route Traffic Control to descend from 3 000 feet, its cruising altitude, to 2 000 feet and thereafter to make an instrument approach to Portland Airport. Shortly thereafter the tower personnel saw the aircraft over the airport and below the overcast circling left to land on Runway 20. It disappeared momentarily in the limited visibility, reported as 1-1/2 miles in light snow, while flying on the downwind leg. It was then seen with landing lights on, aligned with the runway and descending normally on final approach. Seconds later it touched down, rolled a few hundred feet, went up on its nose and stopped abruptly. Of the 3 crew members and 32 passengers aboard, only 5 of the passengers received minor injuries.

Investigation and Evidence

The aircraft landed parallel to and to the left of Runway 20 and continued about 450 feet before it stopped. The touchdown position was approximately midway laterally between the left* row of white runway lights which border the left side of the runway and a parallel row of white lights marking the left boundary of the field. The area was covered by packed snow 18 to 24 inches in depth. Lateral distance between the left row of runway lights and the boundary lights is about 168 feet. The runway is 150 feet wide with its two rows of runway lights 160 feet apart.

As the aircraft moved forward parallel to the runway, rearward forces fractured the nose gear drag link and permitted the nose gear to fold back. The main landing gears remained extended and locked, therefore, the aircraft came to a stop resting on the nose section and main landing gear.

Examination of the aircraft structure, equipment, controls, engines and propellers as well as confirming statements of the pilots revealed there was no malfunctioning or failure of the aircraft prior to impact. Performance of the powerplants and aircraft equipment was also normal in all respects before the accident.

Examination of the runway lights revealed that ten of the lights along the right edge of Runway 20 were inoperative for mechanical reasons, broken, or covered by snow. Eight of the ten were consecutive, beginning at the approach end and extending down the runway in the landing direction. One was partially obscured by snow and considered dull as compared to normal brilliance. The broken lights were the result of being struck by snowplows during several snow-removal operations and appeared to have been broken for a considerable period. The distance covered along the runway by the broken, inoperative, or obscured lights was about one-half of the runway total length of 4 260 feet.

At the time of the accident the three rows of lights (the row of boundary lights and the two parallel rows of runway lights) were white in colour with the boundary lights somewhat brighter than the ones for the runway. The latter were set for maximum intensity. The runway fixtures were flush mounted, and the fixtures for the boundary units extended 24 inches above the ground, or a few inches above the snow cover.

The approach end of Runway 20 is marked normally by three green threshold lights. Inspection of these disclosed they

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* Left and right are used as viewed from the cockpit while approaching Runway 20.

varied in brilliance and that the green glass cover of one was broken. The left light, as viewed from the approach area, was bright, the middle one was dull, and the cover for the right light was broken.

At the time, the policy of the City of Portland in connection with inspection of the airport lighting was to contact the control tower personnel daily for any lighting irregularities reported to them during the previous night. If required, action was taken by the City to make corrections before the next night. The policy also required a complete inspection of the lighting system once each month by an electrician employed by the City to detect any unreported faults. During the snow season it was the policy not to replace each broken light as it was reported or discovered unless complaints by pilots showed too many lights were broken. In this season repairs were deferred until spring.

Tower personnel, on the day of the accident, reported no irregularities had been brought to their attention and so indicated in the daily report to the City. These personnel stated that they were unaware of the broken lights and that existing snowbanks precluded them from seeing the area where the broken lights were located.

The electrician's report of 13 February indicated all lights were repaired. His report of 12 March did not indicate any broken lights. Records showed that eight snow-removal operations had taken place during March and the last one preceding the accident was on 25 March. No current "Notices to Airmen" had been issued relative to the Portland Municipal Airport except that runway 10-28 was closed during the winter months.

Northeast Airlines company procedures require that the company ground personnel at Portland submit a periodic field condition report to the Boston operations office. This is required three times daily. The condition of the airport lighting is included as follows:

> "Remarks as to lighting conditions. Will specify if boundary contact or runway lights are operating, and if any are out when expected to be replaced and if smoke pots will be used to replace any inoperative lights, etc."

A message in compliance with the above instruction was sent 29 March, the day of the accident, at 0518 hours. The message stated - "Lites Normal". The same message was sent in the noon field report. The station manager responsible for the message indicated that his understanding was to reflect the lighting condition as outlined in the policy of the City of Portland for the snow season. The snow season policy was the basis on which "Lites Normal" was reported.

According to the pilots, during the final approach to Runway 15, the instrument runway, visual reference was established at approximately 1 000 feet above the ground. This permitted a circling approach for landing on Runway 20. Clearance was obtained for this approach and the captain chose this runway because of its length, grade, and the existing winds. The captain stated that while turning onto the final approach he was able to pick out the runway lights and instructed the first officer to complete the landing checklist. During the final approach the captain stated that he noted landmarks below which were familiar to the final approach path; landing flaps were extended and landing lights turned on. He recalled that what he assumed to be the runway, during the approach, was white and without wheel tracks; because of light to moderate falling snow this seemed to be normal. At touchdown, the pilots said that the aircraft decelerated very rapidly, nosing down as the nose gear collapsed and stopped after a short slide. Both pilots were completely amazed when they learned that the landing had been to the left of Runway 20.

As previously described, numerous runway lights were obscured or inoperative along the right side of the runway. As the final approach was made the pilots saw a row of field boundary lights and the left row of runway lights. This, undoubtedly, appeared to the pilots as the left and right rows of runway lights and created an illusory runway to the left of and parallel to Runway 20. Considering the nearly equal distance between the boundary lights and the left row of runway lights as compared to the distance between the left and right rows of runway lights, their same colour and comparable spacing, the appearance of an actual runway is even more apparent. These factors considered together with the existing weather conditions make the captain's off-runway landing understandable.

With moderate falling snow to restrict flight visibility and the normal tendency to concentrate on the landing area of the runway (the first one-third) during the final approach, it is not difficult to understand why the pilots did not see the operating lights of the right row located along the far one-half of the runway. Further, these lights, when normally viewed during the final approach, would probably have been near the limit of forward flight visibility.

According to company procedures, a field condition report was required which included a section on the field lighting. In accordance with the reporting requirements, the field lighting was stated as "Lites Normal" on the day of the accident. This being a report to the operations branch of the airline and principally for pilot information, the Board does not understand the report or the reason for indicating that the lights were normal. It is believed that the detailed field condition report procedure was definite and clear but complied with inadequately.

It is further believed that the policy of the City of Portland was not adequate for the maintenance of its airport lighting. Although it is recognized that the maintaining of field lighting in northern areas is difficult because of the many snows and resulting snow-plowing operations, it is believed that the maintenance of lighting should be geared to this situation. The responsibility for adequate lighting and the detection of irregularities rests properly with the airport management.

It is believed that sufficient inspections should be made by airport and company employees to ensure an accurate knowledge of the condition of the lighting facilities and that the condition be reported so that users of the airport be on notice of the conditions.

Weather conditions reported at the airport at the time of the accident were: scattered clouds 400 feet; precipitation ceiling 900 feet; sky obscured; visibility 1-1/2 miles; light snow; temperature 32; dewpoint 31; wind south-southwest 8; altimeter setting 29.99.

Probable Cause

The probable cause of this accident was inadequate maintenance of runway lights and incorrect reporting of their condition resulting in an illusionary position of the runway under conditions of low visibility.

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ICAO Ref: AR/442

No. 15

Trans-World Airlines, Inc., Martin 404, crashed following take-off from Greater Pittsburgh Airport, Pittsburgh, Pennsylvania on 1 April 1956. Civil Aeronautics Board (USA) Accident Investigation Report SA-318, File No. 1-0070, released 14 September 1956.

Circumstances

The crew were briefed at Pittsburgh on the en-route weather and received the sequence and forecast reports. Although the en-route weather was generally good the flight, a regularly scheduled one between Pittsburgh, Pennsylvania and Newark, New Jersey, was dispatched at 1919 hours Eastern Standard Time on an Instrument Flight Rules flight plan via airways as is customary. The aircraft completed a seemingly normal take-off and initial climb, which was followed immediately by a left turning descent, a crash and fire just beyond the southwest boundary of the airport. Both pilots survived. However, the hostess and 21 of the 33 passengers were killed.

Investigation and Evidence

During the flight the first officer was in the left seat being line-checked for captaincy by a company-qualified line check captain.

After becoming airborne, a sharp yaw was experienced at the time of the first power reduction by the first officer. Almost simultaneously he saw the left engine No. 1 zone fire warning light flash on and off and then stay on. He did not hear a fire warning bell. The captain, on the right, who was performing the duties of the first officer, stated that at the time he had operated the gear up handle and was toggling the rpm to the proper engine speed following the first power reduction. The captain, at the time of feeling the aircraft yaw left, did not see the zone 1 fire warning light nor hear an alarm. However, he did observe a rapid drop in the left brake mean effective pressure gauge, which went to zero, and reached under the right arm of the first officer, then on the throttles, to retard the left engine mixture control to idle cutoff which action is Item No. 2 on the emergency checklist under the heading "Power Plant Fire-Failure." The first officer stated that he then removed his right hand from the throttles and reached for the manual feathering button, whereupon the captain informed him that the automatic feathering device would cause the propeller to feather. The first officer then, without actuating the feathering button, placed his right hand on the control column and reached forward with his left hand for the zone 2 firewall shutoff lever. The aircraft continued to yaw to the left and stayed sharply banked to the left despite attempted strong corrective control. At about that time the left wing struck the ground and the crash resulted. The time interval from the start of the difficulty to the crash was only approximately 10 seconds.

Items 1 through 4 of TWA's Martin 404 emergency checklist under "Power Plant Fire-Failure" (meaning fire or failure) are as follows:

1. Throttle . . . . CLOSED
2. Mixture . . . . OFF
3. Prop. . . . . FEATHER
4. Live Eng. . . . . METO POWER

The Martin 404's automatic feathering system is actuated by a substantial drop in the BMEP sustained over a period of at least two-tenths of a second. The principal reason for the use of autofeathering is to provide a nearly instantaneous feathering upon significant power loss during or immediately following take-off. It is an extremely important safety device to prevent quickly the insurmountably heavy drag associated with a windmilling propeller during take-off. It is ordinarily deactivated except during take-off.

The autofeathering toggle switch on the overhead panel when placed in the "on" position supplies electrical current to the arming switches in the throttle quadrant. The movement of the throttle forward from closed position beyond these switches arms the system for autofeathering. Movement of the throttle aft of the switches unarms the system (at about 42" manifold pressure). The switches are located at a point in the throttle travel approximately one inch rearward of where the throttles normally would be after the first power reduction.

An attempt to reconstruct the flight from the testimony of witnesses leads to the belief that the aircraft banked to a near 45-degree position prior to ground contact and that recovery from the bank and turn was under way at impact.

Subsequent flight tests were conducted on a Martin 404. At 6 000 feet m.s.l., operating at METO power and 125 knots IAS, the left throttle was retarded abruptly to a zero thrust position and the aircraft yawed sharply about 30 degrees to the left. The aircraft was allowed to bank to the left about 45 degrees. Speed dropped abruptly to 105 knots, at which time nearly full right rudder and right aileron were applied. When power was returned to normal a full recovery was made. The test was not exactly representative of the flight involved because of different gross loads. However, the simulation was close enough to indicate that the subject aircraft underwent substantially the same motions.

Testimony indicated that the Martin 404 aircraft with a gross load similar to that of the aircraft involved, with landing gear extended, with take-off flaps, and with a windmilling propeller, has a negative rate of climb.

Weather conditions had no bearing on the accident.

First impact with the ground was with the tip of the left wing while the aircraft was steeply banked to its left. A study of wreckage and ground marks indicates that this bank was approximately 35 degrees. The general direction of impact was about 180 degrees or about 50 degrees to the left of the direction of take-off from Runway 23. As the aircraft cartwheeled up a small incline, the left wing disintegrated and the wreckage came to rest with the right wing elevated. This resulted in fuel from the ruptured fuel tanks of the right wing flowing down and under the shattered fuselage, feeding a fierce gasoline fire and quickly trapping many occupants. Investigation revealed no evidence of fire prior to impact.

Examination of the airframe disclosed no indication of a mechanical failure prior to impact with the ground. All three landing gears were found down despite the fact that the captain stated they were started up at the proper time after breaking ground. The right propeller blades were found in take-off pitch position. The left propeller blades were found against the low pitch stops which would cause maximum drag (while windmilling).

Tests of the engines, propellers, and their components did not disclose any indications of mechanical failure or malfunction that would have resulted in a power loss. Very comprehensive tests were conducted and some discrepancies were noted, such as a broken inner intake valve spring and a ruptured carburettor derichment valve diaphragm. A power loss could not be duplicated by several types of tests made duplicating the latter condition.

The exhaust system was inspected for indications of any burned section or openings and the only discrepancy noted was the left lower "Y" section exhaust connector clamp which was fractured and gaping open adjacent to the welded area of its securing belt bosses. The manufacturer had installed a Fenwall overheat pickup unit in close proximity to each of the connector outlet "Y" clamps. The unit involved had a coating of soot in the interior of the scoop and on the pickup unit. It was subsequently tested and found to be operating properly.

Subsequent laboratory tests have confirmed that there was an appreciable interval of time in which the fractured surfaces of the clamp had been exposed to combustion exhaust gases resulting in a scale deposit similar to other exposed surfaces. (These fractured surfaces were not exposed to ground fire.) There was slight evidence of fatigue failure even though the positive indications of such are not as pronounced after exposure to high temperatures.

At the time the clamp was inspected, approximately 127 hours prior to the accident (at the time of the second prior 100-hour inspection), a record of a cracked clamp was observed and written up by inspection; there is no record of its condition at the last 100-hour inspection, 27 hours before the accident.

These clamps are partially hidden by exhaust stack covers which remain in place when the accessory cowling is removed, with the result that the clamps are not open to thorough examination except at their scheduled 100-hour inspections when the stack covers as well as the accessory cowling are removed.

The type or design of the welded bolt securing boss area is conducive to stress concentrations as evidenced by the laboratory analysis of this particular clamp. This was the only clamp broken even though the exhaust collector ring on the other engine was much more damaged by impact.

It is not possible to determine just when the subject exhaust connector clamp failed. It is possible that this clamp, whether it was the old cracked one or a replacement, could have failed during the flight from Newark on the day of the accident and have shifted so that during the take-off at Pittsburgh the collector ring mating connections separated just enough for escaping exhaust to impinge on the Fenwal unit scoop, deposit the observed soot, and signal a fire warning. It has happened on other occasions at this particular location. Presumably, the clamp was replaced at the time of the second prior 100-hour inspection and the replacement was found satisfactory at the time of the last 100-hour inspection. The subject clamp has been a troublesome and costly maintenance item and the carrier has changed designs several times. Currently the carrier is conducting service tests on a new type in its continuing efforts to find a satisfactory clamp. As a result of this accident, the Board recommended more frequent inspections of the exhaust system and the carrier has agreed to do so.

As mentioned, the first officer saw the fire warning light flicker. He either reduced the left throttle in compliance with the first item on the Martin 404 cockpit checklist under the heading "Power Plant Fire-Failure" or he diverted his attention from throttle movement to the fire warning light and inadvertently pulled the throttle sufficiently rearward to unarm the autofeathering. Because he testified that he did not recall moving the throttle rearward it seems more than likely that he did so intuitively when his attention was diverted by the fire warning light.

The captain on the right did not see the zone 1 fire warning light and only noted the BMEP gauge indicate power loss (which in all probability was the result of the first officer's retarding the left throttle). The captain pulled the mixture to idle cutoff. The throttle having been retarded, did not allow automatic feathering, only windmilling, thus setting up excessive drag and yaw to the left.

Since the captain attempted to obtain autofeathering by pulling back the mixture lever, it is apparent that he neither knew the left throttle had been retarded to a point where autofeathering was inoperative nor did he expect this action by the first officer, despite such action being called for in the company's emergency checklist for "Power Plant Fire-Failure".

It is believed that the yaw to the left was first experienced when the left throttle was pulled aft and this yaw was violently aggravated by the windmilling of the left propeller brought about with the captain's movement of the left mixture control to the idle cutoff position.

In reference to the landing gear handle being found up, the captain may have raised the landing gear handle out of neutral position but not sufficiently upward to open the hydraulic valve for gear-up operation. The gear-up action probably was interrupted by the captain directing his attention to the drop in BMEP and the yaw. This would account for the landing gear being found in the down position at the time of impact. There appears to be no explanation of why the captain did not see the fire warning light.

Testimony of TWA's chief pilot for the Atlantic Region was that under similar circumstances he would not, as his first act, have pulled the left throttle back to the point where it disarmed the autofeathering feature. He felt that the wisest procedure under these critical circumstances would have been temporarily to ignore the fire warning (particularly as it was a zone 1 warning) until enough altitude and speed were obtained to ensure single-engined flight. This opinion was shared by the captain. However, an emergency checklist had been provided to apply in the event of either a zone 1 fire or loss of power. The first officer started execution of this checklist but as he was reaching to feather the propeller manually, the captain interrupted his action, believing that autofeathering would take place. It is logically concluded that had the first officer continued as prescribed, the left propeller would have feathered. The complexity of modern aircraft and coordinated efforts required by multiple crews in an emergency dictate that all procedures must be carried out in strict conformity to prescribed checklists.

The Board must conclude that each pilot reacted to the emergency as he understood the emergency but, as the two pilots had not full common knowledge of what was happening nor precisely what the other was doing, the resulting joint and uncoordinated actions resulted in a windmilling propeller making the aircraft unflyable under the circumstances.

To minimize the possibility of any recurrence of this nature the carrier, after the accident, modified its emergency procedures for power plant fire or failure. These revised procedures specify that the crew member who first observes the difficulty shall call out the emergency so that the captain can initiate immediate coordinated action by the crew. After it has been determined which engine has the fire or failure, the propeller is to be manually feathered before the throttle is closed or the mixture is cut. If the emergency occurs during take-off and autofeathering has not taken place by the time proper determination of the malfunctioning engine has been made, the propeller is to be feathered manually by pushing the feathering button.

Probable Cause

The Board determined that the probable cause of this accident was uncoordinated emergency action in the very short time available to the crew, which produced an aircraft configuration with insurmountable drag.

Fire Aspects - Excerpt from NFPA Aviation Bulletin No. 190 dated July 1957

Ironically, this accident sequence started with the operation of a fire warning light in the cockpit (indicating a fire in the left engine) immediately after the aircraft became airborne. Subsequent investigation proved no pre-impact fire but after the aircraft yawed to the left and the left wing struck the ground, a severe crash fire resulted.

The in-flight fire warning was the result of failure of an exhaust connector clamp which allowed heat exhaust gases to impinge on an overheat detector. The aircraft was estimated to have been at an altitude of approximately 100 feet and had just taken off from a municipal airport. From the time the initial fire warning light flashed on until the crash was only approximately 10 seconds.

The accident site was about 1 690 feet from the end of the runway but because of the nature of the terrain, airport based fire fighting equipment, which was immediately dispatched, took 20 minutes to reach the scene, traversing circuitous country lanes. One fire truck, belonging to the County Department of Aviation, attempted to reach the scene by crossing the Air Field (the shortest route) but bogged down in the muddy terrain. Air Force crash trucks based at the Airport did reach the scene as indicated above, but by that time fire had nearly consumed the wreckage. (No detailed fire fighting report could be secured from the Air Base Fighter Group stationed at the Airport. The CAB report merely indicates that the remaining fire was quickly smothered once the fire equipment reached the scene.)

The 12 passengers who survived extricated themselves from the jumbled wreckage through and ahead of the fire as best they could; some helped others while a few found themselves thrown out through tears and rents in the shattered fuselage. The intensity of the fire must have had a decided influence on the deaths which resulted.

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ICAO Ref: AR/443

Figure 11 Wide World Photo

TWA, Martin 404, which crashed following take-off from Greater Pittsburgh Airport, Pennsylvania on 1 April 1956. While the crash site was only 1 690 feet from the end of the runway, circuitous country lanes had to be used by fire equipment to reach the burning plane because of terrain conditions.

No. 16

Northwest Airlines, Inc., Boeing 377 ditched in Puget Sound, near Seattle, Washington, on 2 April 1956. Civil Aeronautics Board (USA) Accident Investigation Report SA-319, File No. 1-0051, released 14 November 1956.

Circumstances

The flight (No. 2) was scheduled daily between Seattle, Washington and New York, N. Y. with stops at Portland, Oregon and Chicago, Illinois. Departure from Seattle-Tacoma Airport was at 0806 hours Pacific Standard Time on an IFR flight plan to Portland, Oregon via Victor Airway 23 to cruise at 6 000 feet. On board the aircraft were 6 crew members and 32 passengers. Following take-off the aircraft climbed to 1 000 to 2 000 feet. Power was reduced and the wing flaps which had been set at the normal 25-degree take-off position were retracted at an airspeed of 145 knots. Immediately the crew became aware of severe buffeting and a strong tendency of the aircraft to roll to the left. Because the buffeting began almost immediately after the flaps were retracted, the captain believed that it was due to a split-flap condition (i.e. the wing flaps on one side of the aircraft being retracted while the flaps on the other side remained partially or fully down). Power was reduced in an attempt to alleviate the buffeting but this was not effective and maximum power was again restored. The Seattle tower cleared the aircraft for return, but the captain decided not to turn the aircraft because of control difficulty and advised that he would proceed to McChord Air Force Base at Tacoma. The trouble became worse, the aircraft continued to lose altitude and was ditched at approximately 0810 hours Pacific Standard Time, 4.7 nautical miles southwest of Seattle-Tacoma Airport - only 4 minutes after take-off. All occupants evacuated the aircraft, however, 4 of the passengers and one crew member drowned, and 2 passengers received minor injuries. The aircraft sank 15 minutes after ditching. All survivors were rescued within 30 - 35 minutes of the ditching.

Investigation and Evidence

The Seattle-Tacoma Airport 0730 weather was: measured ceiling 1 200 feet; visibility 10 miles; altimeter setting 30.12; wind east-northeast 7 knots.

Inspection of the wreckage revealed that the No. 1 engine had been torn off, that the wing flaps of both wings were fully retracted, and that the cowl flaps of the three remaining engines were fully open.

The cowl flaps were open approximately eight inches as measured between the No. 7 cowl flap shingle and the accessory cowling. Full cowl flap opening is eight inches, plus or minus one-fourth inch. Cowl flap actuators of all four engines were one-eighth inch from contacting the full-open limit switches. The cowl flap jack screws were extended approximately 6-1/2 inches; full-open jack screw extension is approximately seven inches. Functional bench testing of the cowl flap actuators, relays, and indicators revealed normal operation.

Search for the missing No. 1 engine continued for more than a week without success. A metallurgical examination of the No. 1 engine mount revealed no evidence of fatigue failure. Marks on the shank of a bolt in an upper outboard member indicated a load in an upward inboard direction. This is unlike previous failures in flight. The three crew members testified that normal power from all four engines was available at all times until contact with the water.

The No. 1 engine top accessory cowling section was not found. This part is believed to have been forced off by hydraulic action during the ditching. Confirmation of this belief is indicated by the buckling rearward of the No. 1 firewall and also by the lack of wing surface damage in the No. 1 nacelle area. No crew member or passenger recalled observing any parts leaving the aircraft prior to impact.

Examination of the aircraft disclosed no failure or irregularities in any of the aircraft controls, control indicators, or limit switches prior to the ditching. The aircraft was ditched under full control.

Boeing 377 aircraft operated by Northwest Airlines are equipped with a wing flap unbalance detection system which gives a signal in the cockpit of five degrees' flap differential between the left and right flaps. The wing flap position indicator in the cockpit is operated from the right wing flap. According to the crew, the normal and emergency wing flap drive systems and the wing flap unbalance detection system were checked before take-off and all functioned normally. Also, the crew stated that when the flaps were retracted from the 25-degree take-off position the wing flap indicator showed full-up or retracted position. There is also a propeller unbalance system that was checked before take-off and all crew members testified there was no signal of propeller unbalance during the flight.

It is the flight engineer's responsibility to close the full-open engine cowl flaps prior to take-off. The flight engineer stated he was not certain the cowl flaps had been closed at that time. Flight crew members testified that a visual check of cowl flap position was not made prior to the ditching or after the buffeting commenced.

During the hearing the flight engineer was asked if he remembered actuating the cowl flap switches during the before-take-off check. His answer was, "I can't actually, honestly tell you that I really did or did not." The cockpit cowl flap controls on the B-377's and L-1049's move in opposite directions for the closing of cowl flaps and at the hearing the flight engineer testified that it was possible he had moved these controls in the wrong direction prior to take-off, thus leaving the flaps in their already open position. (The flight engineer testified that most of his flight time had been on L-1049's and DC-6's the preceding year.)

Following the accident a special check flight was made in another Northwest Airlines B-377 with the crew of Flight 2 operating the aircraft and the Superintendent of Flying Western Region, Northwest Airlines, acting as observer. In addition to the check flight, simulation of the conditions experienced on Flight 2 was also conducted. Four take-offs were made with the engine cowl flaps in various positions. Control was normal until the wing flaps were retracted. The final take-off was with fully open cowl flaps on all four engines. There was no distinguishable effect on control, or buffeting, until the wing flaps were retracted. As the flaps retracted, buffeting and control difficulty commenced and reached a degree that, in the opinion of the crew, was very similar to that experienced by them during the flight of 2 April.

In addition, test flights made by the Boeing Aircraft Company in a similar aircraft, using open engine cowl flap positions on take-off, produced the same results when wing flaps were retracted. In all of these flights, buffeting ceased and aircraft control became normal when the engine cowl flaps were moved to the normal flight position.

Following the take-off Flight 2 was observed by the Seattle-Tacoma Airport tower controllers directly and on the Airport Surveillance Radar scope. The visual controllers testified there was no change in heading of the aircraft from runway 20 until it disappeared below the tree line. Other ground witnesses observed the descent and ditching and, with one exception, stated that they did not observe any part separate from the aircraft prior to water contact. The witness, who stated that he saw a part come from the aircraft while it was in the air, was stationed approximately four statute miles to the east of the line of flight. He was subsequently accompanied by Board investigators to his point of observation and through an actual flight path re-enactment it was determined that the subject aircraft could not have been seen from that location. The witness described the part as being similar to the size of a door and coming from the area of the lower forward baggage compartment. Examination of the wreckage accounted for all such parts as having been in place when the ditching occurred. A wide search of the ground was made and no parts were found. In addition, a door check was made before take-off and the crew stated no door warning light came on during the flight.

All of the flight crew members had several years and many hours of experience in B-377 aircraft. They stated that buffeting from excessively positioned cowl flaps had never been experienced by any of them either in check or regular flights. However, their testimony indicated that all three crew members were familiar with the pages of the flight operations manual covering the subject of buffeting. The manual notes open cowl flaps as a cause of buffeting in cruise configuration and prescribes the extension of wing flaps as a corrective measure.

There have been other previous instances where other operators of B-377 aircraft have experienced flight difficulties because of cowl flaps being inadvertently opened. Details of these instances were disseminated (in 1952) by request of the CAB to all operators of B-377's through the medium of CAA alert bulletins, notices from the manufacturer, and the Air Transport Association.

At the Board's request, the airframe manufacturer prepared a study of the effect of full-open cowl flaps on the performance and controllability of the B-377 aircraft. This study indicates that the use of full-open cowl flaps during take-off, with the normal 25 degrees of wing flaps, does not result in abnormal take-off characteristics.

Further, the study indicates that when wing flaps are retracted and cowl flaps are fully open, no noticeable buffeting is experienced until the wing flaps are within about 10 degrees of the fully retracted position. Vibration and buffeting then build up rapidly and become severe as wing flaps reach full-up. This vibration is more regular than buffeting in a full stall but is not as violent. With the increase in turbulence over the wings associated with the buffeting, lateral stability is reduced and tends to give the impression that the airplane is being balanced on a pedestal. Lateral trim requirements will more than likely be abnormal but not excessive. Performance capabilities of the airplane in the cruise configuration with all cowl flaps wide open and operating all engines at maximum continuous power may be likened to that with one engine inoperative and the cowl flaps in the normal setting. In this regard, positive rates of climb in excess of 600 feet minimum would be possible, and turns in either direction could be made without undue difficulty.

The data further indicate that buffeting with flaps up, although considered severe, is not of immediate concern as a cause of structural damage. The most pronounced effect on control or stability is in a lateral direction and a moderate amount of aileron control for trim may be required, probably to the right, even though all cowl flaps may be open the same amount.

All evidence indicates that the cowl flaps on all four engines were approximately full-open during the entire period of the subject flight. Test flight results proved conclusively that in the above aircraft configuration buffeting occurs when the wing flaps are retracted. It is believed that the cowl flaps remained in the full-open position during and after the before-take-off check for the following reasons: The NWA operations manuals direct that the flight engineer, after hearing the take-off clearance in his own headset, shall then make his own challenge and response to the item; "Cowl flaps - SET FOR TAKE-OFF." To accomplish this requires that he actuate the four cowl flap switches forward, either individually or by the gang-bar, and then monitor the movement of each cowl flap on its respective indicator in front of him on the engineer's pedestal and above the cowl flap switches. This monitoring ensures that the flap openings shall be the recommended amount, temperaturewise, and in no event more than three inches.

The Board can offer no explanation for the flight engineer's failure to set the cowl flaps properly in the take-off position. During the investigation and public hearing the adequacy of Northwest's flight engineer training program was thoroughly explored. The training program was complete and complied with the applicable Civil Air Regulations in every respect. Furthermore, it was developed that the flight engineer had successfully completed the basic program and the subsequent periodic checks. In addition his total flying time and time in the equipment involved is impressive, and is, the Board believes, further evidence of his general competency. Airline flight personnel are trained to be deliberate and to follow prescribed check procedures. Had the flight engineer acted in accordance with his training and previously demonstrated capabilities, his original omission would not have been made, or, if made, would have been detected before the captain had committed the aircraft to a ditching.

The CAA approved manual recommends that in a water landing 25 degrees of wing flaps should be used to decrease airspeed and rate of descent. The fact that the wing flaps were not extended in the subject landing supports the captain's statement that, in his mind, a split flap condition existed. However, if his analysis of the difficulty had gone further, his knowledge of the B-377 would have made him aware that with the wing flap cockpit indicator showing full retraction and his thought of a failure of the flap unbalance system allowing an unsignaled extension of the left wing flap, the tendency of the aircraft would have been to roll to the right and not to the left as in the actual occurrence. Regardless of the incorrect analysis of the difficulty, a visual check of the wing flaps would have eliminated this factor and pointed to a check of other possible causes.

The majority of causes of buffeting listed in the NWA flight manual could have been checked by actual observation or cockpit indication. Nos. 1 and 4 nacelles could have been observed from the cockpit. Had this been done the open cowl flap condition would certainly have been detected.

Although the evidence shows that the captain and the first officer could have leaned forward and looked out their respective side windows and have seen the cowl flap settings, this did not occur to them, since the flight engineer's challenge and response was, in itself, the customary assurance that the cowl flaps were set properly for take-off. In addition, the captain was faced with a series of adverse conditions, such as low ceiling and unfavourable terrain, and it was his belief and decision that ditching was the safest action since he was convinced that any attempt to continue flight would result in complete loss of control of the aircraft.

The Board realizes that all of these events were occurring within an extremely short period of time and that the apparent urgency of the situation required a rapid decision by the captain. The captain did act promptly as the situation demanded but his incorrect analysis of the control difficulty led to an unfortunate decision. The pressures of the situation and the limited time available to the captain to arrive at a decision no doubt had an important bearing on the action he initiated. However, the Board believes that flight manual information on the conditions created by excessive cowl flap openings was sufficiently stressed to allow the captain, and indeed the entire crew, to evaluate the difficulty properly within the time available.

The subject flight being domestic, the carrying of flotation gear is not required by Civil Air Regulations. Although the use of seat cushions for buoyancy is not listed in the manual, the crew members were aware that they could be so used and their prompt action ensured that no passenger or crew member was in the water without means of flotation after the aircraft sank.

Probable Cause

The probable cause of this accident was the incorrect analysis of control difficulty which occurred on retraction of the wing flaps as a result of the flight engineer's failure to close the engine cowl flaps - the analysis having been made under conditions of great urgency and within an extremely short period of time available for decision.

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ICAO Ref: AR/446

No. 17

Cordova Airlines, Aero Commander, crashed on a mountain slope near Skilak Lake, Alaska, on 9 April 1956. Civil Aeronautics Board (USA) Accident Investigation Report, File No. 1-0038, released 7 March 1957.

Circumstances

The flight departed Anchorage, Alaska, at 0905 hours Alaska Standard Time for Seward, Alaska. The pilot filed a VFR flight plan estimating time en route to Seward as 45 minutes. Witnesses saw the aircraft flying southeast toward Seward, heard it circle Russian Lake and saw it pass them again flying west-northwest at 0951. At 1255 the flight was still unreported and search and rescue procedures were initiated. On 10 April at approximately 1400 hours the wreckage was sighted on the south slope of an unnamed mountain east of Skilak Lake at an elevation of about 3 000 feet mean sea level near latitude 60° 24' N, longitude 150° 03' W. The pilot and five male passengers were killed and the aircraft was demolished. The accident occured at approximately 0954 hours, 3 minutes after the aircraft was last seen 5.7 miles southeast of the crash point.

Investigation and Evidence

A CAB investigator surveyed the terrain and the wreckage from a helicopter on 12 and 18 April. While on a heading of approximately 274 degrees magnetic the aircraft had struck the southern slope of the mountain and had come to rest approximately 200 yards to the west of and about 30 yards below the point of first impact. Detailed inspection was delayed by weather and ground conditions.

On 14 July the investigator was able to reach the scene of the accident by helicopter, landing about 100 yards above the main wreckage.

The ground at the scene and in the adjacent area was covered by large, jagged fragments of loose rock. The conditions of this surface showed that one or more large rock slides had occured subsequent to the accident.

Impact marks made by the mountain slope upon the aircraft were on the lower side of the fuselage at a point approximately even with the pilot's cockpit. The cockpit and passenger compartment of the fuselage were shredded to a point 6 - 8 feet forward of the vertical fin attachment. Seats, instruments and controls were demolished.

Both power plants were torn from the main wreckage and only one was located. Neither propeller was found. The centre section remained attached to the fuselage but its structure had collapsed.

The fuel cells remained unruptured but practically all of the fuel had drained away through broken fuel lines.

The empennage with the rear portion of the fuselage was separated from the main wreckage and was thrown to the left. It was severely damaged throughout all components.

Such detailed examination of the wreckage as was possible at the site disclosed no indication of inflight failure, malfunction of the aircraft or any of its components, or of fire.

The point at which the wreckage was found is just within the northern limit of airway Red 103. The centerline of this airway is marked by the southeast leg of Kenai radio range, which is oriented at 267 degrees magnetic, toward the station. At this point the centerline of Red 103 passes over the northern nose of a mountain to the south. That nose is about 4 000 feet high at that point, and it rises to 5 000 feet within the airway. Also at that point, the actual pass, with its low ground at 500 to 1 000 feet, lies about midway between the centerline of Red 103 and the scene of the accident.

The route includes two mountain passes, the one described between Skilak Lake and Upper Russian Lake, and also one called Resurrection Pass, between Upper Russian Lake and Seward. The floor of both these passes is generally as low as 500 feet with small knolls reaching 1 000 feet. High ground on both sides of both of these passes reaches 3 500 to 4 500 feet. The lodge from where the aircraft was last seen is at 690 feet. The Russian River and the pass to Skilak Lake lie along the same direction (northwest) from the lodge for 3.29 miles, then the river bends to run approximately north along the eastern base of an unnamed

4 113-foot mountain. South of this mountain the low ground (1 000 feet or less) continues west to Skilak Lake.

The centre of gravity was within authorized limits, but the gross weight at the time of take-off was approximately 5 892. 6 pounds, 392. 6 pounds over the authorized gross weight which is 5 500 pounds. Maximum take-off weight of 5 700 pounds had been authorized by the company's chief pilot, who advised the Board's investigator that this was done on the basis of figures contained in the CAA approved flight manual pertaining to Aero Commander model 520 aircraft.

The chief pilot was not familiar with CAA aircraft specification 6A1, which authorizes take-off gross weight of 5 700 pounds for certain Aero Commander model 520 aircraft, but does not apply to the subject aircraft which is excluded by note 3 of the specification.

Cordova's superintendent of maintenance, and the chief inspector, participated in preparation of the current CAA Form 337 for the aircraft, which specified a maximum gross weight of 5 500 pounds, and they were familiar with specification 6A1. The aircraft was certificated for operation with five persons aboard - pilot and four passengers. On this flight it carried six - pilot and five passengers.

Cordova Airlines' operating certificate required that the operation of light aircraft over the routes involved be done under daylight VFR conditions only, and that the dispatch of these aircraft be at the discretion of the pilot-in-command. It was determined that the chief dispatcher did work with the pilot in the planning of the subject flight. The 0700 and 0900 weather forecasts were available to both the chief dispatcher and the pilot prior to the flight's departure. Since this weather information clearly indicated that the flight could only have been flown under extremely marginal conditions, the Board is of the opinion that the pilot, having available weather data which indicated that the flight could not be completed throughout its entirety under VFR conditions, should have cancelled the flight before take-off or turned back immediately upon encountering IFR conditions.

An analysis of the weather indicates that along the route Anchorage to Kenai and to Skilak Lake during the time of the flight scattered clouds existed as low as 700 feet with broken to overcast layers beginning at 2 500 feet above the surface to 25 000 feet. Intermittent light rain was occurring, occasionally mixed with light snow. Winds at 1 500 feet were southeasterly about 20 knots, becoming more southerly and increasing in speed at higher altitudes. Between Skilak Lake and Russian Lake the clouds obscured the mountains with ceiling and visibility at or near zero. Strong southeasterly winds were funneling through this pass, resulting in moderate to at times severe turbulence; this turbulence would undoubtedly have been in the nature of strong gusts in the area where the accident occured.

The evidence indicates further that the pilot was unable to proceed under VFR conditions in the vicinity of Upper Russian Lake because of low ceiling and visibility. It is, therefore, believed that he decided to discontinue the flight to Seward and return to Anchorage. It is further thought that during the return trip he was unable to maintain visual reference to the ground and elected to climb, hoping to clear terrain in the area. The fact that the pilot held an instrument rating and the aircraft was equipped with the necessary instruments for flight under IFR conditions, together with the fact that the accident occured at an elevation well above that at which VFR flight could be flown lends credence to this belief.

Subsequent to this accident, the company revised its personnel structure by the addition of a vice president in charge of all operations, who coordinates the Operations Department with all other departments within the company. In addition, it was made possible for the company to obtain weather reports, by radio, from the lodge on Upper Russian Lake.

Probable Cause

The probable cause of this accident was the pilot's action in continuing flight during instrument weather conditions on a planned VFR flight through a mountain pass, and striking a mountainside while attempting to climb out.

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ICAO Ref: AR/460

No. 18

Scottish Airlines (Prestwick) Ltd., York aircraft, G-AMUL, swung on take-off run and lost a wheel at Stansted Airport, Essex, England, on 30 April 1956. C.A.P. 139 released by Ministry of Transport and Civil Aviation (U.K.)

Circumstances

The flight was to be via Malta to Habbaniyah, Iraq, and was being made on charter by the Air Ministry to carry R.A.F. personnel and their families. On board were 5 crew members, 45 passengers and four babies. The take-off run was begun at approximately 0930 hours Greenwich Mean Time. After travelling some 300 yards along the temporary runway, the aircraft developed a swing to starboard with a consequential skidding movement of the tires so severe that within a further distance of less than 100 yards it left the runway on the starboard side still under the influence of the swing, skidding and travelling at about 45 knots. On reaching a "French" drain some 25 feet from the runway the undercarriage collapsed, the starboard wheel fell clear and the aircraft settled on its belly and on the port wheel. The aircraft finally came to rest pointing back almost in the direction from which it had begun its run. One aircraftsman and a 4-year old girl were killed and 4 other passengers were seriously injured.

Investigation and Evidence

Due to the belly of the fuselage, as it settled, being forced to starboard, it met the starboard inner propeller which cut the control lines to the fuel cocks with the result that it was impossible to prevent the escape of some 700 gallons of petrol - a large quantity of which poured into the passenger cabin and onto those who were pinned by the entry of the port wheel. The Airport Fire Brigade was at the scene within a few seconds and laid a blanket of foam over all so that the risk of fire was averted.

Due to reconstruction of the main runway taking place, all aircraft use a temporary runway parallel to the main runway and some 650 feet to the northwest of it. The temporary runway is 5 700 feet long and is composed of the former taxiway of that length with the addition of a strip (called a shoulder) on either side to provide the extra width required for a runway.

The former taxiway was 90 feet wide with a good macadam surface and capable of sustaining the weight of any aircraft. To this has been added on each side a strip or shoulder 25 feet wide constructed of a layer of "Class C Fill" (a kind of compacted gravel) with in places some broken concrete in addition, the whole being covered with two inches of close macadam to form the same surface as that of the former taxiway. Although not so strong as the taxiway, the shoulders are of sufficient strength to support occasional use by aircraft. The width of the runway formed by the old taxiway and the two shoulders is thus 140 feet, being the same as that of the main runway before reconstruction. In practice, however, this overall width is to some extent reduced by American type electric lights standing some 19 inches high fixed to the runway by spikes at intervals along either side and connected together by rubber tubing. These lights are fixed at a distance of 10 feet in from the outer edge of each shoulder so that the width of the runway between the lights is only 120 feet. A broken white line marks the centre of the runway throughout its length and there is also a continuous white line painted on either side at the junction of the old taxiway and the shoulders.

This runway is undoubtedly narrow for an aircraft of the size of a York, which has a wing span of 102 feet and a wheel base of just under 24 feet. A pilot taking off a York from this runway would naturally seek to avoid letting his wheels go on to a shoulder, although, if he did, it would support the weight as it supported that of G-AMUL on the morning in question, whilst if he hit any of the lamps it would be most unlikely to cause the aircraft the slightest damage. Although admittedly narrow for an aircraft of this size, there is no doubt that this temporary runway is serviceable. The captain of G-AMUL had himself taken off York aircraft from this runway without difficulty on at least 10 to 12 previous occasions and stated in the course of his evidence, when asked whether he was at all troubled on this occasion by the width of the runway, that he was "not conscious of any undue narrowness".

On the south side of the temporary runway and 25 feet out from the outer edge of the shoulder is a "French" drain laid parallel to the runway throughout its length. Evidence showed that after the aircraft had left the runway (still swinging to starboard and with its wheels skidding to port) it met the obstacle formed by this drain and the undercarriage collapsed. This drain, which has its counterpart on the north side of the runway, was constructed at the same time as the shoulders. It consists of a trench 3 feet 6 inches deep along the bottom of which a porous cement pipe has been laid on a concrete bed. The trench above the pipe has then been filled with what are termed "rejects". These stones and pieces of concrete are, in fact, those which would not pass through screens used to select the Class C fill and pieces of concrete employed to form the base of the shoulders. Any attempt to ram or roll this filling might result in breaking the pipe and in consequence it was necessary either to leave the filling some inches "proud" to allow for settlement or to top up from time to time as settlement occurred. The filling was left "proud" and now that a year has elapsed since the work was done it is in many places at least 6 inches "proud" whilst the stones at the top are large and in some cases could be described as small boulders.

The drain follows a line formed at the point where the grass sloping down from the outer edge of the shoulder makes a dip with the slightly rising ground further to the south. It is accordingly sited at a point where drainage is obviously necessary both for the ground south of the runway and in order to take away surface water from the runway itself and water which might otherwise accumulate below the shoulder.

Ideally, perhaps, a runway should have on either side an expanse of grass large enough to ensure that an aircraft leaving the runway in any foreseeable circumstances will be able to run its course unimpeded by any obstacle. In practice this is obviously impossible. This drain was of a type which appears unobjectionable and in accordance with standard practice. It was properly sited and necessary and the investigator does not think that the fact that some criticism may be made of the manner of filling made any real difference in this particular case. This aircraft left the runway in most unusual circumstances and it is considered that the blame for what occurred cannot be put upon the drain. If this incident had occurred in wet weather and there had been no drain so that the ground would have been water-logged a similar result would have occurred whilst if on this occasion it had swung to port instead of to starboard there were many obstacles with which it might have collided as well as taxiways and hard standings which would have had a similar effect.

The aircraft was properly and efficiently maintained and entirely fit to carry passengers on the flight contemplated. It had been properly loaded and trimmed, the brakes had been carefully tested and tests carried out after the accident served to prove that no engine failure or failure of controls occurred.

The legs of the undercarriage were fractured at their top points of attachment. Calculations and inspection of the fractures made at the Royal Aircraft Establishment at Farnborough after the accident show that the stresses imposed on the undercarriage when it met the drain were increased to the order of some three or four times those which it was already undergoing and to an extent which no undercarriage is designed to support whilst the fractures disclosed no sign of fatigue but, on the contrary, tensile strength very much above the specified minimum.

A York aircraft, in common with many aircraft, has a tendency when rolling to pull to port. This tendency is, of course, well known to all experienced pilots and is not difficult to correct. The aircraft while on the ground can be controlled in three ways; firstly, by the use of the throttles, secondly, by the brakes which can be applied either to the port or starboard wheel or both and thirdly, by the rudder which is operated with the feet.

There are four throttles (one for each engine) consisting of four levers projecting downwards from the throttle box which is fixed rather above the first pilot's head and to his right front. It is, of course, to the left but otherwise in a similar relationship to the position of the second pilot. The method of operating the throttles is for the pilot to grasp all four in his hand inserting his fingers between the levers so that he can push these forward to open the throttles or pull back to close them, whilst by an inclination of his hand to one side or the other as he opens the throttles he can advance the port throttles ahead of the starboard or vice versa. In taking-off there is normally no question of closing the throttles and the pilot is occupied in pushing them forward until he attains the desired speed - correcting his course by advancing one pair of throttles beyond the other as may be necessary. Thus, to correct the York's tendency to roll portwards it is generally necessary to advance the port throttles slightly in front of the starboard. The pilot, once he has got the aircraft rolling straight and at the desired speed, requires his right hand to join his left with which he has been holding the control column and accordingly the practice is for the second pilot to keep his left hand close behind the right hand of the pilot and ready to take over the throttles when the pilot relinquishes them.

The handles operating the brakes are fitted on either side of each control column, there being one provided for the pilot and another for the first officer. The brakes can be operated equally or differentially and are extremely powerful.

The effect of the rudder is negligible until there is sufficient speed or power to provide a stream of air over it. As the aircraft makes its run and the speed increases so the effectiveness of the rudder will gradually increase.

The captain's evidence was that he lined up the aircraft on the threshold of the runway straddling the white line but pointing 5° to the left of it. After carrying out the usual pre-take-off checks, he received permission to take-off and the aircraft moved forward.

What happened thereafter is described by the captain as follows:

> "It (the aircraft) moved slightly to the left. I corrected the take-off run. The aircraft seemed to come straight. Then I felt a violent swing to the right. I did not like it. I pulled everything (meaning the throttle levers) off and continued on. The aircraft seemed to roll fairly well. After I had got my hands off the throttles I was preparing to use control of the brakes to pull the aircraft up. The aircraft seemed to roll off. The next thing we were off in a 180° turn. Then of course we sat down."

The captain was insistent that he had not at any time used his brakes but thought that he might have used his rudder instinctively. When he closed the throttles he did so because he had decided to abandon the take-off run in view of the swing which had developed. Asked what could have been the cause of the violent swing to starboard he said: - "I cannot think of one myself. The only possible thing I could think of was that I must have somehow over-corrected." He added that he was "not conscious of having over-corrected" and that at the time he closed the throttles, which was before the aircraft crossed the centre line, he thought his speed was "fast enough to cause trouble but not too fast to get out of it."

The first officer's account is that as the aircraft left the threshold he had his head down watching the instruments. He said - "I was aware we were moving to the left of the centre line - it definitely was not a swing in any way but a slight movement to the left of the centre line. The boost pressures were at this time +16 lbs. each approximately. I put my left hand up by the captain's right hand. I anticipated taking over from him and had my hand I think on the throttles and I felt him using differential throttle and still juggling with them and I looked up to see why. I saw that we were on the left-hand side of the runway - I would not know how much but towards the left. The captain pulled the throttles back and put his right hand on the control column. Almost immediately I pulled back No. 1 throttle - the port outer - because it was not fully closed." He went on to described the increasing severity of the swing and the outcome and stated that the port outer throttle was "not as much as half open" when he himself closed it but more than would have been the case if it had merely bounced back a little on being closed. He was not conscious after putting up his left hand that the captain made any violent or abnormal movement of the throttles.

The investigator states that, in the light of the evidence, he cannot think that this swing can have developed without some grave error on the part of the captain. The violent swing at so early a stage of the aircraft's run could only result from a correction of the portward course due either to a sudden and excessive differential use of the throttles or to a momentary application of brake to the starboard wheel or to both these factors. The captain was not conscious that he did either of these things. The investigator has no doubt that the captain over-corrected violently and excessively when he used the throttles to bring the aircraft straight and that this caused the beginning of the swing. In the light of the starboard wheel mark * and despite the captain's belief to the contrary, the investigator is inclined to think that he must at the same time have also applied the starboard brake. The latter supposition is necessarily speculative but nothing else in the investigator's opinion accounts for the sudden development of so severe a swing that even before he crossed the centre line he decided to close all throttles and to abandon the take-off. The fact that in closing the throttles he left the port outer open would, since it had been at 16+ boost, serve to accentuate the swing, but the effect of this error was quickly corrected by the first officer.

It is difficult, without experiencing the violence of the swing as the captain did, to attempt to judge whether his decision to close the throttles and to abandon the take-off was the right decision. Equally, it is not easy to criticize what he did or failed to do after he had closed the throttles. In the latter stages of the swing use of the rudder would hardly have influenced his course whilst experienced pilots who gave evidence expressed the opinion that it was better at this stage not to use the brakes.

In these circumstances the investigator is not prepared to condemn the captain's decision to close the throttles or his subsequent failure to control the course of the aircraft. The error was committed earlier when he started to correct his portward course.

Probable Cause

An over-correction of the portward course of the aircraft possibly accompanied by some application of the starboard brake caused the aircraft to swing to starboard off the runway and to encounter the "French" drain with the resulting failure of the undercarriage. The over-correction by the pilot, whether or not accompanied by some application of the starboard brake, should be termed a grave error of judgment and skill rather than a wrongful act or default.

Recommendation

Whilst the investigator did not think that the manner in which the "French" drain was filled had any significant effect in the circumstances of the accident, it must be recognized that if the top of the trench is left over "proud" to the extent that it was left in this case and if the stones at the top are of the size employed here, danger could still arise if an aircraft had left the runway in more normal circumstances. There can be no justification for a filling which involves risk to an aircraft if it runs off the runway for a distance as short as 25 feet. It is recommended that, in the case of this particular drain, steps should be taken to reduce the extent to which it is over "proud" to at most two inches and to substitute for the top layer of stones at present in position, smaller stones less likely to cause damage. It is suggested that since this method of filling is apparently employed at other airfields, all necessary steps should be taken to check the top layer in these cases also.

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* It was cbserved from the track of his tires that the initial tire mark was that of the starboard wheel and that at this point the width of the track was over 24 feet and accordingly somewhat wider than the normal track width of 23 feet 9 inches. Although the wheels are so set that they can float to a tolerance of some inches, the start of the track and the fact that the starboard wheel track was the first to appear are in the investigator's opinion important factors.

ICAO Ref:: AR/455

No. 19

Trans World Airlines, Inc., Martin 404, was damaged on landing at Greater Pittsburgh Airport, Pittsburgh, Pennsylvania, on 7 June 1956. Civil Aeronautics Board (USA) Accident Investigation Report, File No. 1-0055, released 23 July 1957.

Circumstances

Flight 509 was regularly scheduled between La Guardia Airport, New York and Houston, Texas, with several scheduled stops including Pittsburgh. The aircraft departed La Guardia on schedule at 1120 hours eastern daylight time carrying 3 crew, 28 adult passengers and 2 infants. The flight operated uneventfully in VFR weather over the entire route New York to Pittsburgh. On arrival there, the crew requested and received clearance to make a simulated ILS approach to runway 28, the instrument runway. During the last portion of the final approach the aircraft lost altitude rapidly. This high rate of descent continued until the main landing gear of the aircraft struck two centreline approach lights and then contacted the ground just short of and below the approach end of the overrun extension of the runway. The aircraft slid down the runway, without appreciable yaw, on its undamaged nose wheel and the rear portion of the bottom of the fuselage, for a distance of approximately 3 500 feet. Two passengers received minor injuries during evacuation via emergency exits.

Investigation and Evidence

The first officer was in the left seat being checked for upgrading to captaincy by a company qualified check pilot and this was the first flight they had made together. The first officer had made other simulated ILS approaches at Pittsburgh but from the right seat. His total left seat time in Martins was about nine hours acquired during transitional training at Kansas City. It is company policy not to give first officers left seat time except during this transitional checking for captaincies.

Runway 28, the one used, is approximately 7 500 feet long with a 600-foot paved overrun area on its approach end. This end of the runway is 1 137 feet above sea level; the far end of the runway is 1 168 feet above sea level. A horizontal row of high intensity approach lights leads to the approach end of the overrun area.

At 1321, two minutes after the accident, the weather conditions were as follows: scattered clouds at 5 000 feet; visibility 7 miles; wind calm; temperature 78 degrees; altimeter 30.00.

Investigation at the scene disclosed that the right main gear wheels struck the last two high intensity centreline approach light towers located 800 feet and 700 feet from the threshold of the runway. These lights, as well as others beyond them, are substantially at the same elevation as the runway and its overrun area. A fresh cut, three-quarters of an inch wide and one-half inch deep, in the outboard rim of a right main landing wheel was made when that wheel struck the tower 800 feet from the threshold. Guard rails on the other tower were broken and bent in the direction of flight and one of its right-hand lights was broken off. Tire marks were found on both light tower railings and a six-inch section of inner tube was found on the ground below the light tower 700 feet short of the runway threshold and 100 feet from the beginning of the overrun area.

Both main landing gears struck the embankment about 50 inches short of the overrun area, and approximately 22 inches below its level. Marks at the start of the pavement indicate that the nose wheel made first contact at that point. Both main gears were displaced rearward as their drag struts failed, with the left gear separating at the strut cylinder and coming to rest on the runway forward of the threshold. Blades of the left and right propellers were bent rearward and their tips were ground down.

The entire landing gear support structure and the shear shelf of the left nacelle were bent and torn loose and the strut cylinder was swung rearward.

After the accident the wing flaps were found up, the flap handle was in its "up" detent, and the flap position indicator in the cockpit read "up". The trailing edges of the flaps were not damaged by contact with the runway. However, the rear portion of the right inboard flap was deformed downward at its trailing edge by a pair of concavities closely mating with the contour of the outer curvature of the pair of right tires.

Following the accident, an intensive investigation was made of the flaps and their operating mechanisms and associated components. No irregularity of any significance was found during this examination.

While the aircraft was in the TWA hangar on jacks, the right gear was moved rearward in an effort to match the fractures, abrasions, and deformities of the gear with the bottom skin of the wing and flap. This was accomplished. Both hinge joints of the right landing gear were intact; however, the support bracket of the right side of this gear was fractured. The Y section of the main landing gear was displaced upward and rearward, leaving its imprint in the bottom of the wing skin aft of the wheel nacelle. The T door unit that is normally attached and remains with the gear while it is in the full down position was found crushed and displaced. It had broken free from the lower attach point on the gear strut cylinder. This lower attach fitting is approximately 33 inches below the hinge point of the gear strut. When the gear was placed in position, this fitting on the cylinder matched a puncture in the lower skin of the trailing edge of the wing. The trailing edge of the wing had been deformed and displaced to some extent. The landing gear scissor was extended full length. The upper end of the piston portion of the landing gear strut had bottomed against and fractured the retaining unit at the lower extremity of the main strut cylinder. A grease fitting located on the hinge position of the scissor matched a puncture in the lower skin of the flap. This puncture was elongated by the flap moving upward. Damage to the underside of the wing and to the flap mated with the landing gear when the flaps were extended about 12-1/2 degrees.

Certain hydraulic system components were removed from the aircraft and bench checked. Among these was the wing flap load relief valve, a spring-loaded hydraulic relief valve that relieves hydraulic pressure in the flap extension mechanism when the flaps are subjected to high airloads. This unit prevents full flap extension and/or allows partial flap retraction before excessive airloads are developed, thus preventing damage to the mechanism or the wing structure. All components tested were found to operate in a normal fashion with no significant variations from accepted performance tolerances being noted.

There were no indications of any failure or malfunctioning of any sort prior to initial impact with the ground.

Crew testimony was as follows:

Upon approaching the localizer course, the captain lowered the flaps to take-off position and verified that position by the flap indicator. Approach control advised the flight of its position, and told it to continue the approach and to contact the tower. When established on the localizer course the landing gear was lowered, also by the captain and checked down and locked, with three green lights showing. The propellers were set at the customary 2 300 rpm, and the remainder of the checklist was completed.

The tower was contacted about one minute east of the River radio beacon (about 5. 6 miles east of runway 28), and the flight was cleared to continue its approach to runway 28, with the tower advising that traffic was a jet aircraft making a low approach to the runway and about three miles out. Upon approaching the glide path the flaps were extended by the captain to the approach position and this position was verified by the flap indicator. According to the crew, the ILS approach was normal. The left transparent sun visor was in the down position to lessen outside visibility as is customary during simulated ILS approaches. The right sun visor was up. The captain testified that at approximately 1 400 feet m.s.l., about 250 feet above the level of the runway, he raised the left sun visor with his left hand and extended the flaps to landing position, the latter at the request of the first officer.

Shortly thereafter, the aircraft lost altitude more rapidly. This was apparent to both pilots by sensation and ground reference. Airspeed at that time was noted to be about 110 knots (about 5 knots more than normal because the long runway permitted a longer landing roll). The captain started to advise the first officer of the settling, but the latter was already taking corrective action by applying power. The aircraft sink appeared to be arrested momentarily, but it then resumed despite the application of power. The amount of power applied was nearly full throttle - almost to the stops. Although the aircraft was low, and getting lower, it appeared to both pilots that they would reach the runway without difficulty.

As power was applied, the nose of the aircraft came up more and more. The first officer, along with applying power, was also bringing back the control wheel. This nose-up attitude was such that the runway threshold was lost to view from the cockpit, although the far portion of the runway could still be seen. A tower controller who observed the settling estimated that it started about one-fourth mile short of the approach end of the runway and about 50 feet above the row of approach lights.

The sinking continued until contact with the approach lights, 200 and 100 feet from the end of the overrun. It was the impression of both pilots that they had first contacted the runway proper. The captain testified that he believed that he started the flaps up upon sensing the runway contact, but did not recollect specifically raising them at any time.

The only other traffic in the vicinity at the approximate time was an Air Force jet fighter, also making a simulated ILS approach. When Flight 509 reported to the tower as passing the outer marker inbound, it was told that the jet aircraft was about 3 miles ahead. Neither pilot saw it. When the jet aircraft discontinued its approach, TWA 509 was cleared to land. Observation of the path of the jet by the tower controller leads to his estimate that it passed over the approach end of runway 28, where TWA 509 first made ground contact, at an altitude of from 200 to 300 feet, and that it did so between one and two minutes before TWA 509 reached that location. Both pilots stated that there was no significant turbulence either from the jet aircraft or from any eddying of air just beyond the approach end of the runway where the terrain falls away rather sharply.

The rapid settling should not have been caused by natural turbulence because a jet that landed seven minutes previously experienced none of any importance. Also, the lack of wind - reported as calm - coupled with a rather normal noonday temperature of 78 degrees militate against it. The rapid settling seems most certainly not to have been caused by the jet making the low pass over runway 28 just ahead of Flight 509 because neither of the pilots of Flight 509 reported trouble from that source. Considering this primarily, and recalling there was some 3 miles separation between the flight and the jet, the Board believes that insufficient jet wash or natural turbulence existed to cause the sink.

The first officer stated that the airspeed was 110 knots and that engine manifold pressure was 20 inches when he called for "landing" flaps. Bench testing of the wing flap load relief valve disclosed that its cracking pressure was 870 p.s.i. A valve so adjusted would prevent full flap extension at speeds above 98 knots, with engine power as reported. At 20 inches of manifold pressure, and at an airspeed of 110 knots, the flaps would not extend fully, but due to load relief valve action they would cease their downward movement and become stabilized at an intermediate position of approximately 36 degrees. An increase in engine power at this time would cause further flap retraction; however, flight tests have shown that such retraction is accompanied by a slight increase in airspeed and little or no settling of the aircraft is experienced.

Because it is believed that neither jet wash nor natural turbulence were factors and because no defect was found in the aircraft or its components, the reason for the low altitude appears to be operational. However, the physical evidence available to us concerning the flight path of the aircraft cannot be reconciled with the testimony of the flight crew concerning airspeed, flap management, and time of power application. If the airspeed of the aircraft was as testified, 110 knots, and sufficient power was applied at the proper time and the flaps were not retracted, there is no known reason why the aircraft's descent could not have been arrested in time to avoid undershooting the runway and striking the lights. In the light of the testimony of the pilots, along with the physical evidence available, the Board is left with no other conclusion than that the landing approach was so poorly executed by the copilot as to have made it obligatory for the captain to have taken, or caused to be taken, earlier corrective action.

In reconstructing this accident it is necessary to premise certain happenings upon possibilities rather than known actualities. A reconstruction so constituted would be as follows:

At or shortly before the time when the captain raised the copilot's sun visor and then lowered the flaps, the copilot increased his rate of descent. This is understandable inasmuch as he had only then changed from instrument to visual reference. At that time, seeing ahead of him a 600-foot overrun area short of the runway and indistinguishable from it in colour, it may safely be presumed that he increased his rate of descent so that his touchdown would be at the proper place on the runway, but in relation to the approach end of the overrun area rather than in relation to the approach end of the runway proper. Then, when it became apparent that this resulted in the aircraft sinking too rapidly, the corrective application of power was made too late to arrest the descent before the lights were struck. These lights, as previously stated, are substantially at the same altitude as the runway and its overrun area. As has been pointed out, the attitude of the aircraft at that time was such that only the far end of the runway could be seen, the approach end being blocked off by the intervening nose of the aircraft.

The above hypothesis seems to be strengthened by an incident which occurred at the identical place some time after the accident. In the latter case, the main wheels also struck just below the level of, and just short of, the approach end of the overrun area.

Since this last incident and as a result thereof, the subject overrun area has been conspicuously marked to distinguish it from the runway proper.

Probable Cause

The probable cause of this accident was that during the final approach the captain permitted the first officer to descend too low before power was applied to arrest the aircraft's descent.

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ICAO Ref: AR/467

No. 20

Piedmont Airlines, DC-3C, lost a passenger near Shelby, North Carolina on 13 June 1956. Civil Aeronautics Board (USA) Accident Investigation Report released 21 February 1957. File No. 1-0093.

Circumstances

Flight 5 originated at Fayetteville, North Carolina, for Louisville, Kentucky, with stops at Charlotte and Asheville, North Carolina, and Tri-Cities, Tennessee. On board were 3 crew members and 24 passengers. Seated in next to the rearmost pair of seats on the left side were a man and his wife, who had been transferred to this flight after arriving at the airport (Charlotte) too late to claim their reservation on another carrier's flight that departed Charlotte at approximately 1715 hours. Flight 5 departed Charlotte at 1744 hours eastern standard time. The aircraft reached 6 500 feet m.s.l. cruising altitude at approximately 1806. About one minute later while the purser was on the flight deck obtaining information for a passenger, the aircraft suddenly yawed to the left as the cockpit door-warning light came on. The first officer and purser immediately went to the rear of the cabin where they found the main cabin door fully open. A passenger check revealed that the male passenger previously mentioned was missing. The captain circled to establish the location and then proceeded to Asheville where a routine landing was made.

Investigation and Evidence

Investigation disclosed the main cabin door of the aircraft to be a Metropolitan Air Stair, model A, serial number 2363, located on the left side of the aircraft. Attached to its inner side are five steps, which are an integral part of the door and provide a means of entering and leaving the aircraft when the door is down. The air stair door is hinged at the bottom and opens out and down when the door latch is released.

The door latch mechanism is actuated by a five-inch lever handle pivoted at its lower end and recessed in the center of the step riser between the second and third step from the top of the door when viewed from the closed position. The handle is approximately waist-high when the door is closed. Latching of the door is accomplished by rotating the lever handle approximately 90 degrees counterclockwise through an arc of approximately 6-1/2 inches. This extends three tapered latch pins 1-3/4 inches into the doorframe in the fuselage. Inspection windows are installed in the fuselage so that engagement of the latch pins can be checked. The lever handle is held in the locked or unlocked position by a detent-type friction plate, which is also a part of the latching mechanism. There are three warning lights installed - one near the outside of the door, another at the purser's station in the cabin, and a third on the pilot's instrument panel. When the door is closed and latched all warning lights go off. When the lever handle is moved clockwise or toward the open position approximately one-half inch, the three warning lights come on. The handle movement continues more than two inches before the latch pins start to move slowly from their closed position. When the pins are retracted sufficiently for the door to open, the lever handle has traveled 70 or 75 degrees of the full 90-degree movement. This 90-degree movement is 45 degrees on either side of vertical.

A test of the subject door, after the accident, revealed normal functioning of the latch pins, all warning lights, and the latching mechanism. A check of the door-warning lights was made for correct door closure prior to take-off from Charlotte.

In the main cabin door installation of the aircraft there was no means of preventing the door from fully opening if the latches were inadvertently actuated. Investigation revealed that the door can be opened accidentally. Many operators of DC-3 aircraft equipped with air stair doors have a safety device installed, such as a quickly removable chain preventing full door opening, or a means of retarding movement of the unsafeguarded door latch handle.

Since this accident, Piedmont Airlines has installed on its entire fleet a means of safeguarding against accidental opening of the door. As a result of its investigation of this accident, the Civil Aeronautics Board recommended to the Administrator of Civil Aeronautics that an Airworthiness Directive be issued requiring correction of this unsafe condition.

The seat belt sign had been on for the entire 22 minutes of the flight because of anticipated turbulence. However, the turbulence did not develop. In fact, both passengers and crew stated that the flight was smooth. Therefore, it is highly improbable that the passenger was thrown against the door by turbulence.

In view of the investigation which found the door latching mechanism normal in its operation, it must be concluded that the passenger opened the door by operating the unlatching handle.

It is probable that the passenger while standing in the area by the main door accidentally grasped the door handle and moved it to the open position. This accidental act is substantiated by the statement of a passenger who observed the subject passenger's efforts to retain his grasp of the doorframe from outside the aircraft. A lack of normal acuteness on the part of the passenger is suggested by evidence of his drinking before arrival at the airport.

Probable Cause

The probable cause of this accident was a passenger's accidental opening of the main cabin door in flight.

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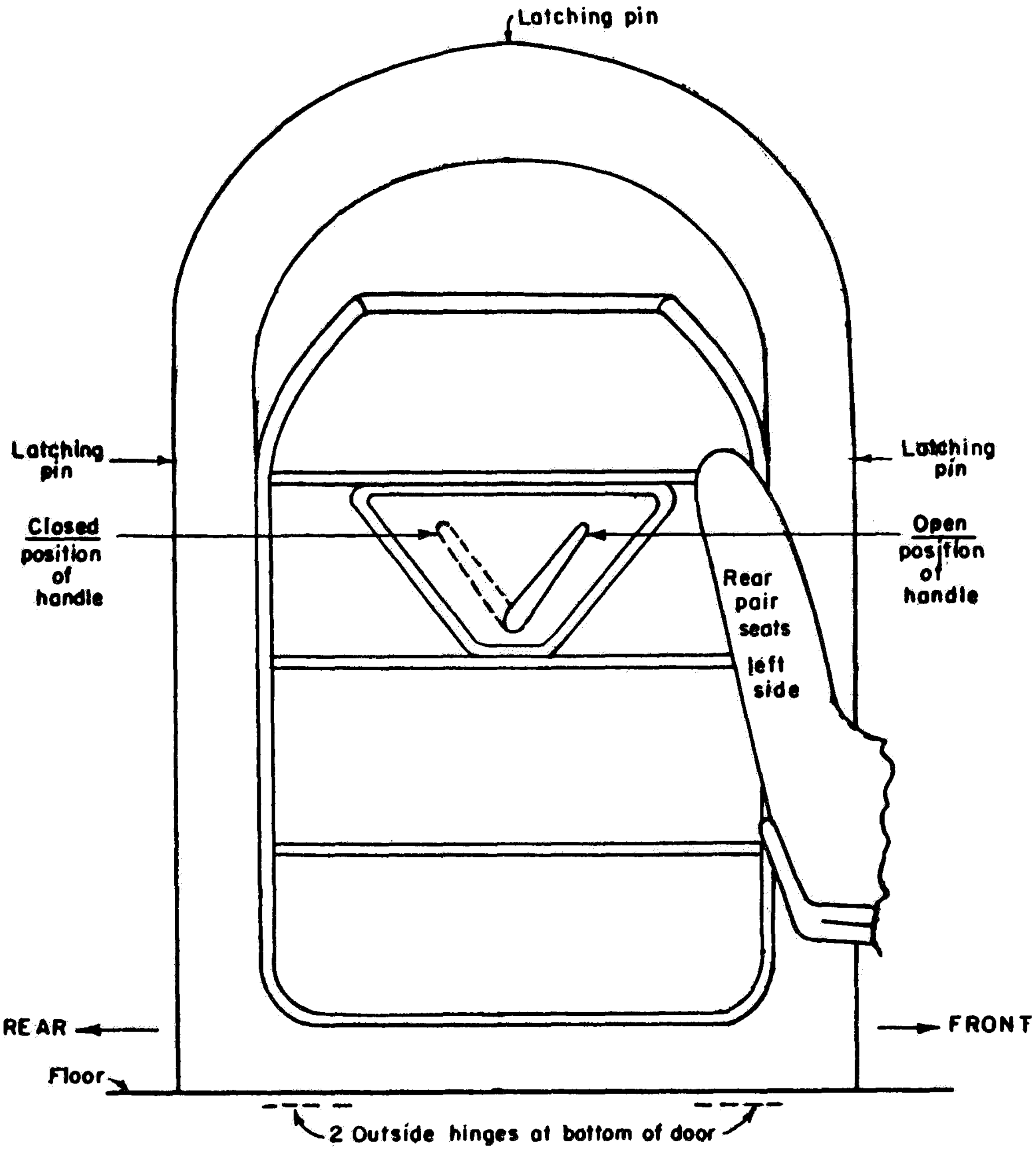
ICAO Ref: AR/457

Figure 12

PIEDMONT AIRLINES DC-3C, N45V
NEAR SHELBY, NORTH CAROLINA, JUNE 13, 1956



INTERIOR VIEW FACING CLOSED DOOR

NOT DRAWN TO SCALE

No. 21

British Overseas Airways Corporation, Canadair C. 4 (Argonaut) , G-ALHE, crashed at Kano Airport, Nigeria, on 24 June 1956. Report by Ministry of Communications and Aviation, Federation of Nigeria. (Also released as C. A. P. 141 by Ministry of Transport and Civil Aviation - U. K.)

Circumstances

The aircraft was operating on a B. O. A. C. scheduled service Lagos - Kano - Tripoli - London. It took off normally at 1721-1/2 hours Greenwich Mean Time from Runway 25 at Kano Airport for Tripoli in moderate rain and climbed to 250 feet. The aircraft then began to lose height rapidly and although the pilot-in-command ordered full power, the descent could not be checked. Notwithstanding the increased power he was unable to prevent it striking a tree and the aircraft crashed about 1-1/2 miles from the end of the runway. Of the 7 crew and 38 passengers aboard, 3 crew members and 29 passengers were killed.

Investigation and Evidence

The aircraft arrived at Kano from Lagos at 1640 hours and refuelling commenced at once. The pilot-in-command discussed with the incoming pilot-in-command the aircraft serviceability and was informed that the automatic propeller synchronisation control was inoperative but full manual control was available. After being told that previous attempts at rectification had been unsuccessful, he decided to proceed without delaying the aircraft.

Earlier the pilot-in-command had seen the meteorological forecast and had noted that it mentioned scattered thunderstorms in the vicinity of Kano. He could see that there was a large thunderstorm centred some distance away to the east-northeast of the Airport, but did not hear any thunder. At the time the sky over the Airport was clear, and it was also clear to the north (on the aircraft's intended track), but to the west he could see one or two cumulus type clouds in the distance.

After his discussion with the incoming pilot-in-command, he noticed that the edge of the overhang from the storm to the east-northeast was over the Airport and the storm itself had moved round to the northeast. This movement had also revealed the tops of more thunderstorms further east. The pilot-in-command, therefore, decided to consult the meteorological forecaster to ascertain whether there was any line squall reported near the airport and to inquire how fast and in what direction the thunderstorm to the northeast was moving. The duty forecaster informed him that there was a line of thunderstorms about 400 miles to the east but that the thunderstorms in the Kano area were purely local and had no association with any line squall. The pilot-in-command was advised that the thunderstorm to the northeast, being a local storm, would probably move very little but if it did it would move slowly from east to west.

After leaving the forecaster, the pilot-in-command met the navigating officer and told him that they would probably have to go a little way off track to the west after taking-off, to avoid the main belt of rain from the thunderstorm whicl he estimated would pass about 8-10 miles north of the airport. He mentioned that they had adequate fuel for the flight as they had over 100 gallons more than flight plan requirements. He then informed both the navigating officer and the duty operations officer that he wanted to take off as quickly as possible.

The engines were started at about 1715 hours and the aircraft received taxy clearance from the tower at 1716 hours; permission to taxy to runway 25; QNH 1012 mbs. and surface wind 300° 15 knots. Both pilots set the QNH of 1012 mbs. on their respective altimeters.

During the time the engines were being started, rain began to fall and during the taxy out it became quite heavy though the visibility remained fairly good. The pilot-in-command; looked particularly for any sign of wind gusting and roll type cloud, which are usually associated with the line squall type of storm, but there were no such indications, though the centre of the black area was now very near to the northeast.

In order to save time, most of the pre-take-off checks were carried out and engines run up during the taxy out. Windscreen wipers were operating. When the aircraft stopped at the threshold of runway 25, the pilot-in-command did not check the visibility with the tower, as he could see clearly to the end of the runway and estimated the visibility as 2 miles. It was now completely overcast and raining heavily and no clear patches could be seen.

At time of take-off, the reported weather conditions on runway 25 were as follows:- cloud 3/8 base 2 500 ft; wind 270° 20 knots; visibility 1 500 yds, moderate rain.

The take-off was perfectly normal and the aircraft became airborne after a run of approximately 2 000 yards.

During the take-off, the visibility decreased owing to the heavy rain on the windscreen which caused the pilot-in-command to fly on his instruments after the aircraft became airborne. At no time before taking-off or during the take-off did the pilot-in-command have any misgivings about the conditions or consider abandoning the take-off. He had previously taken-off on several occasions in weather conditions that had appeared to be of a similar nature.

Note. - All heights in this report are actual heights above the official Reference Point of the airport, which is the highest point on runway 25 (1 575 feet a.m.s.l.). Both pilots in their evidence gave QNH heights and the heights given in the report are the difference between their altimeter readings and 1 575 feet.

After taking-off the undercarriage was retracted, and when the aircraft passed over the end of the runway at about 100 feet its airspeed was 125 knots. Shortly afterwards, the pilot-in-command called for the first power reduction to 2 850 rpm and 54" manifold pressure. As the aircraft passed over the end of the runway the pilot-in-command noticed a slight updraught. Before reducing power he had assessed flight conditions and found them quite reasonable with a maximum airspeed fluctuation of 5 knots and felt no tendency for either wing to drop.

A normal climb was made to above 240 feet when the pilot-in-command called for 'Flaps up'. At this time the airspeed was fluctuating 125-130 knots with a rate of climb of 300 feet/min.

The rain was still heavy and there appeared to be more ahead but the pilot-in-command could see a gap to the west-northwest. At this stage (when about 250 feet) the aircraft was seen to disappear into heavy rain.

No sink was noticed by the pilots when the flaps were retracted although the speed dropped and remained steady at 123 knots. The pilot-in-command checked the altitude after the flap retraction and noted it was 260-270 feet; the aircraft was quite level and steady. This situation remained the same for what seemed a few seconds - long enough for the pilot-in-command to think that the airspeed should be building up — when he was horrified to see the indicated airspeed dropping steadily and quickly. He immediately called for full power and eased the aircraft's nose down slightly but by that time the airspeed was down to 103 knots.

Note. - The stalling speed of the aircraft at that time has been calculated as 97 knots indicated airspeed with power on, and 104 knots with power off.

The co-pilot, who had just checked that the engine instrument readings were normal, immediately opened the throttles fully with the rpm still set at 2 850. He did not have time to increase rpm to 3 000 because the master rpm lever was not serviceable.

The application of full throttle did not increase the airspeed, which remained steady at about 103 knots, and there were no unusual reactions to the handling characteristics of the aircraft when increased power was applied.

During the sudden emergency, the pilot-in-command did not find it necessary to adjust the trim of the aircraft, and does not recall experiencing any turbulence or sinking of the aircraft. His sole concern was the low airspeed and neither he nor the co-pilot had time to note what loss of height, or rate of descent, was being indicated by the instruments. The aircraft lost height very rapidly and by the time the co-pilot had fully opened the throttles, and taken note of the rising manifold pressures, he looked out quickly and saw that the aircraft was nearly down to tree-top height in an almost level attitude. After he was satisfied that the aircraft was not losing any more airspeed, the pilot-in-command looked out and saw that it was flying level about 15-20 feet above the ground with a tree directly in its path 100-200 yards ahead and was amazed that the aircraft had lost height so rapidly. He started to bank the aircraft to the right, being careful that his right wing did not touch the ground, and attempted to climb. The aircraft began to respond to the controls but the pilot-in-command was unable to prevent it striking the tree.

Inspection at the scene of the accident showed that the first point of impact was with a

35-foot tree about 2 500 yards from the end of runway 25 and approximately 100 yards north of the extended line of the runway. The aircraft had struck the tree about 17 feet from the ground with the left wing and the underside of the nose section. The left wing fuel tanks became ruptured and caused fire to break out immediately; the left outer wing after becoming detached came to rest 160 yards from the tree. A second tree about 300 yards from the first was then struck by the left wing root, the left side of the rear fuselage, and the leading edge of the right tail plane. This impact caused the rear fuselage and tail unit to break away and the aircraft to yaw to the left, and third and fourth impacts with trees followed almost immediately. These last two impacts caused the break-away of the remaining portion of the left inner wing; the rear passenger cabin to fail under side loading, and the aircraft to disintegrate as it swung around to the left. Wreckage was scattered forward over a distance of 140 yards and the right wing broke into three sections. The main wreckage sustained extensive fire damage and the forward fuselage and cockpit were burned out.

The main undercarriage and nose wheel were found in the fully retracted and locked-up position. Examination of the flap operating mechanism which was severely damaged showed that the flaps were almost certainly in the retracted position. The flying control system was severely damaged but no evidence of pre-crash failure was revealed.

All instruments had suffered incineration and, therefore, provided little useful evidence but the left side cockpit altimeter was found set to 1012 mbs.

Detailed examination of the four engines revealed no mechanical defect. The domes of the four propellers were removed and the position of their rotating cam pistons checked. The angles of the blades of N^os. 1,2 and 4 were found to be in the fine pitch range and N^o. 3 had moved into the feathering range due to crash damage. The engine reduction gear casings in each case had been torn out and were still attached to the propellers; from this evidence and from the damage suffered by the blades of each propeller, it was apparent that all were under a high degree of power on impact.

The Kano weather conditions from 1600 - 1800 hours on 24 June were as follows:-

> "At 1600 Greenwich Mean Time there were two thunderstorms in the vicinity of Kano, one about ten miles to the northeast of the airport and the other about six miles to the southwest. Both were moving slowly towards the southwest and by 1700 GMT the former lay a mile or two to the northeast with an associated cloud overhang extending over the airport itself. Moderate rain from this overhang started to fall at the Terminal Building at 1714 GMT and ended at 1722 GMT. The main centre of the thunderstorm passed a little to the north of the airport but a new cell appears to have developed in the overhang which gave heavy rain and squalls over the western half of the airport at about 1720 GMT and moved westwards. A probable synoptic map of the wind and rain at and near the airport, based upon official observations at the Terminal Building and Temporary Tower and upon lay evidence elsewhere, is given as Figure 13. The evidence of witnesses in the area south and west of the end of the runway establishes beyond reasonable doubt that a strong easterly squall with associated heavy rain was experienced there, though instrumental evidence is lacking. A probable vertical cross section through the runway-line of the wind is given as Figure 14."

> "The strong wind and heavy rain from the new cell appear to have reached the ground as the aircraft was taking-off. The surface wind from this cell would fan out from the centre, but the easterly winds in the western sector would be considerably stronger than the westerly winds in the eastern sector because of the momentum brought down from the easterly air current prevailing above about ten thousand feet. This is the normal experience in squalls in this region at this season of the year."

> "Initially, the aircraft would experience a moderately enhanced head wind, which is suggested by the evidence of the captain ('up-draft') and a passenger ('air pocket'). This would rapidly change to a strong tail wind, with possibly an element of downdraft, though it is improbable that any significant downdraft was experienced near the surface."

> "There would probably have been a pressure rise of the order of 2-3 millibars within the cell which would have caused the altimeter of the aircraft to indicate a height 50-100 feet lower than the true height; that is, the aircraft would have

> actually been 50-100 feet higher than was registered on its altimeter."
>
> "The relatively sudden change of wind from a moderate head wind to a strong tail wind experienced in the cell would cause a corresponding decrease in the airspeed of the aircraft."

The Board gave close consideration to the question as to whether the pilot-in-command was justified in commencing the flight in the weather conditions that obtained at the time of take-off. That he had taken care to ascertain the nature of the approaching storm is clear from the questions that he posed to the meteorological forecaster.. He was mainly concerned as to whether the thunderstorm approaching from the northeast was associated with a line squall and how fast and in what direction it was moving. The forecaster rightly assured him that the thunderstorm had no association with any line squall and that it was a slow moving local thunderstorm. The moderate rain that fell at the time of take-off did not cause the pilot any concern, as the conditions were considerably above B. O. A. C.'s minima, and as he had taken-off in as bad conditions on several previous occasions he did not at any time consider the need to abandon the take-off. Neither he nor the forecaster could have been aware that a thunderstorm "cell" was forming close to the west of the airport along the take-off path from runway 25, since the associated vertical cloud development was obscured by lower cloud. Kano Airport was equipped with storm warning radar capable of identifying storms some distance away but incapable of detecting the formation of a thunderstorm cell at close range.

The Board was not aware of any official notification to pilots prohibiting them from or advising them against taking-off in, or in the vicinity of, thunderstorms.

The Board, therefore, was of the opinion that the pilot-in-command was justified in taking-off in the prevailing conditions.

The effect of the weather conditions on the aircraft's performance when it was at a height of approximately 250 feet after taking-off has been closely investigated. It is clear from the meteorological analysis that a thunderstorm cell was developing in the area into which the aircraft was climbing. In the early stages of the climb the aircraft encountered an increased westerly wind component as it passed over the end of the runway. But when it reached approximately 250 feet it became affected by a sudden reversal of wind direction of considerable magnitude accompanied by heavy rain and possibly a down-draught. The effect of these conditions was to cause the aircraft to lose speed relative to the surrounding air, i. e., airspeed, and to lose height rapidly. The situation was aggravated by the fact that the speed of the aircraft had become very close to its stalling speed. Throughout this period, all engines were operating at a high degree of power but had no noticeable effect in preventing rapid loss of height. The approximate path of the aircraft in elevation has been plotted from the take-off point to a point about 150 yards short of the first point of impact, and shows that the descent occurred in a very short period of time - probably within the range 5-15 seconds. It has not been possible to estimate the exact height and point at which the aircraft became affected by the cell conditions and, therefore, the rate of descent is largely a matter for conjecture. The rapid descent was in no way caused by the attitude of the aircraft which remained almost level throughout.

The question as to whether the accident might have been averted had full power been applied, i. e., 3 000 rpm instead of 2 850 rpm, has been carefully considered. If the master control lever of the automatic synchronising unit had been operative, the co-pilot would have been able to apply maximum power with 3 000 rpm in less time than if he had tried to obtain 3 000 rpm by "MANUAL" means, i. e., using the toggle switches for individual rpm control. However, in the event, as an emergency action, he applied full throttle without increasing the rpm and although this action has been timed to take about 3 seconds, he has stated that after applying full throttle and taking note that the manifold pressures were rising, he looked out and saw that the aircraft was nearly down to tree-top height. It seems reasonable to assume, therefore, that had he attempted to obtain 3 000 rpm by manual operation of the toggle switches the accident might have occurred before he could have obtained full power. The Board, having considered all the factors involved, considers that even if the master control lever had been operative, it is a matter of doubt whether the extra power available would have had any marked effect on the aircraft's ability to climb.

Probable Cause

The accident was the result of loss of height and airspeed caused by the aircraft encountering, at approximately 250 feet after take-off, an unpredictable thunderstorm cell which gave rise to a sudden reversal of wind direction, heavy rain, and possible downdraught conditions.

Recommendations

It is recommended that:-

(i) the International Civil Aviation Organization (ICAO) should be asked to consider setting up a technical committee to investigate the danger to aircraft taking-off or landing when in close proximity to thunderstorms, and to frame recommendations to member States for the safer operation of aircraft in such conditions and,

(ii) as an interim measure, all pilots should be warned of the danger of taking-off or landing when thunderstorms are in the vicinity.

The following remarks have been received (25 January 1957) from the United Kingdom Member on the Air Navigation Commission of ICAO concerning recommendation (i):-

> "The United Kingdom has given most serious consideration to this recommendation and concluded that there is not sufficient justification for asking ICAO to consider setting up a technical committee. It is the United Kingdom view that there is already a great deal of information available on the nature of the risks and the real problem is to apply the known lessons. Therefore, instead, United Kingdom action will be as follows:-
>
> a) to revise the United Kingdom Information Circular N°·131/1954 dealing with the effect of thunderstorms on aircraft operations in order to make special mention of the take-off and landing risks shown up at Kano.
>
> b) to prepare and issue a new Information Circular on the effects of cross-winds, gusts and wind-shear on take-off and landing. This will incorporate a description of the wind-shear effect demonstrated at Kano.
>
> c) to inform ICAO of these actions with the purpose of enabling ICAO to take any further steps that might seem appropriate but without making a United Kingdom request for compliance with the Board's original recommendation.
>
> The agreement of the Nigerian Government to this proposal has been obtained. Action is in hand now on items (a) and (b) above."

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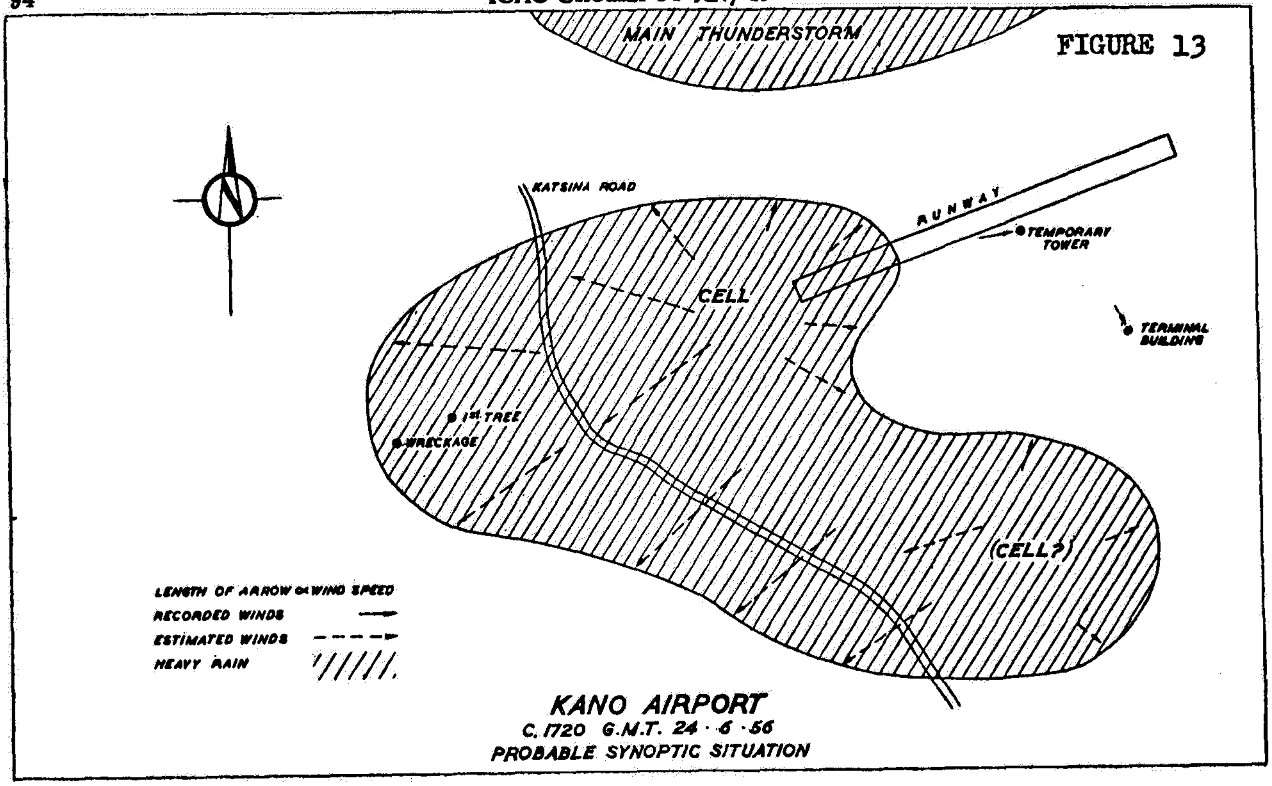
ICAO Ref: AR/449

FIGURE 13



KANO AIRPORT

C. 1720 G.M.T. 24 · 6 · 56

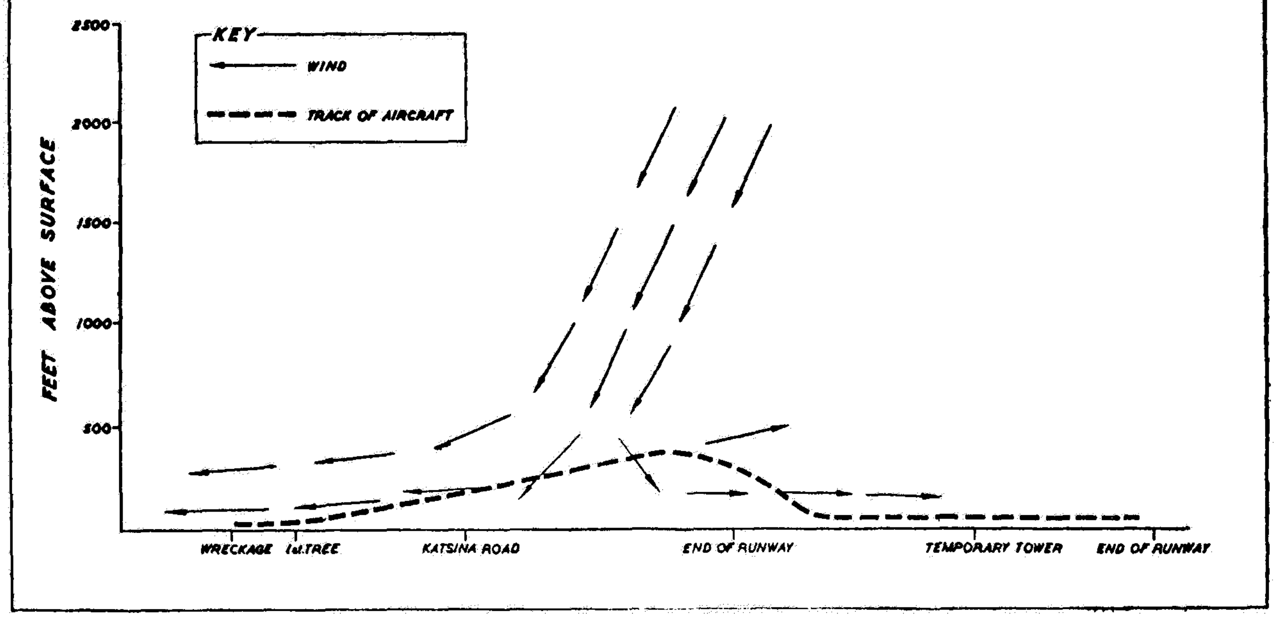
PROBABLE SYNOPTIC SITUATION

FIGURE 14

KANO AIRPORT

C 1720 G.M.T. 24-6-56

PROBABLE WIND VERTICAL SECTION



No. 22

Trans World Airlines, Inc., Lockheed 1049A, N 6902C and United Air Lines, Inc., Douglas DC-7, N 6324C collided over the Grand Canyon, Arizona on 30 June 1956. Civil Aeronautics Board (USA) Accident Investigation Report, SA-320, File No. 1-0090, released 17 April 1957.

Circumstances

TWA Flight 2 took off from Los Angeles International Airport on an instrument flight rules flight plan at 0901 hours Pacific standard time for Kansas City, Missouri, via Green Airway 5, Amber Airway 2, Daggett direct Trinidad, direct Dodge City, Victor Airway 10 Kansas City. Cruising altitude was to be 19 000 feet. On board were 70 persons. The aircraft reported "on top" (2 400 feet) and then switched to Los Angeles Air Route Traffic Control Centre* frequency 118.9 mcs., for its en-route clearance. This clearance specified the routing as filed in the flight plan, however, the controller specified that the flight climb to 19 000 feet in visual flight rules conditions. The flight then requested a routing change to Daggett via Victor Airway 210, which was approved. At 0921 the aircraft reported approaching Daggett and requested a change in flight plan altitude from 19 000 to 21 000 feet. Los Angeles Centre advised that they could not approve the request because of traffic (United Air Lines - 718). Flight 2 then requested a clearance of 1 000 feet on top. Ascertaining from the radio operator that the flight was then at least 1 000 on top, Los Angeles Centre cleared the flight. At 0959 TWA 2 reported that it had passed Lake Mohave at 0955, was 1 000 on top at 21 000 feet and estimated that it would reach the 321-degree radial of the Winslow omni-range station (Painted Desert) at 1031. This was the last radio communication with the flight.

United Air Lines Flight 718 was regularly scheduled from Los Angeles, California to Chicago, Illinois. It took off from Los Angeles International Airport at 0904 hours on an IFR flight plan to Chicago via Green Airway 5 Palm Springs intersection, direct Needles, direct Painted Desert, direct Durango, direct Pueblo, direct St. Joseph, Victor Airway 116 Joliet, Victor Airway 84 Chicago Midway Airport. Cruising altitude was to be 21 000 feet. Fifty-eight persons were aboard. Flight 718 made position reports to Aeronautical Radio, Inc., which serves under contract as United company radio, and reported passing over Riverside and later over Palm Springs intersection. At approximately 0958 United 718 made a position report to the CAA communications station located at Needles and stated that the flight was over Needles at 21 000 feet and estimated the Painted Desert at 1031. At 1031 an unidentified radio transmission was heard at Salt Lake City and San Francisco. The message could not be understood but later when the recorded transmission was played back it was interpreted as: "Salt Lake, United 718... ah... we're going in."

The two aircraft collided at approximately 1031 hours in visual flight rule weather conditions at 21 000 feet over the Grand Canyon and fell into the Canyon near the confluence of the Colorado and Little Colorado Rivers. There were no survivors among the 128 persons aboard the flights and both aircraft were destroyed.

Investigation and Evidence

The L-1049 Constellation crashed in a draw on the northeast slope of Temple Butte, which is on the west bank of the Colorado River within the Grand Canyon. The main wreckage site was at an elevation of 3 400 feet. The wreckage was found strewn across the draw along a southwesterly heading, with portions of the nose section on the south bank of the draw and sections of the cabin fuselage on the north bank. A relatively short wreckage distribution path showed that the aircraft contacted the ground at a steep angle. The distribution and condition of parts indicated that the Constellation was inverted at initial impact. Severe disintegration of the L-1049 had occurred during ground impact, followed by an intense ground fire. With the exception of the empennage, portions of the aft fuselage, and light pieces of aft cabin interior, all of the aircraft was at the main wreckage area. Several parts of the DC-7 left outer wing structure were also found at the L-1049 wreckage area.

The main wreckage area of the DC-7 was located 1.2 statute miles northeast of the

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* referred to as Los Angeles Centre

L-1049 area. The DC-7 struck the south face of Chuar Butte opposite the Little Colorado River. Impact was about 10 feet below the top of this ridge at an elevation of 4 050 feet. Initial impact was on a northeast heading with the aircraft nosed down and its right wing below a level attitude.

Impact forces caused severe disintegration of the DC-7 with major components falling into an inaccessible deep chimney and upon sheer ledges below the impact site. An intense ground fire followed impact. Except for a large portion of its left wing, the DC-7 major components were accounted for by identification of parts and pieces found at or reasonably near the main wreckage area.

During the difficult and hazardous structural investigation every effort was made to determine whether or not an in-flight collision had occurred and, if so, the manner in which the aircraft collided. Results disclosed several areas of damage which conclusively established that such collision did occur.

One of the significant areas involved in the in-flight contact was the left outer wing panel of the DC-7. The largest single piece of left wing outer panel was found between Temple and Chuar Buttes about one-third mile west of the TWA wreckage site. This piece consisted of the outer portion of the panel from the tip inboard to approximately station 627. To this station the upper and lower wing skin and the leading edge were generally intact. Portions of lower skin were in place for another six feet inboard. Collision evidence in the form of dents, scratches, tears and bends were found on much of the lower surface of this entire structure. Part of this damage consisted of an upward and inboard deformation in the wing tip cap between the position light and aileron cove. Black rubber smears and red paint smudges were evident at several locations in the deformation. Examination showed the smears on the DC-7 were from the L-1049 de-icer boot; also, the paint smudges were from the L-1049.

A fragment of DC-7 wing tip assembly was found separately. This 11-inch piece was part of the aileron cove from the extreme wing tip area. Fragments of top and bottom wing skin were still attached to this piece. Just aft of the tear the tip radius was deformed inboard, rearward, and upward with heavy deposits of L-1049 red paint in the crumpled area. Further, the tip lower surface inboard to the tip attach point was deformed upward and marked by scratches running inboard and aft. Also, in this general area on the lower wing surface, smears and scratches ran diagonally aft and inboard about 23 degrees in relation to the wing centre spar line.

Two pieces of the DC-7 left aileron were found severely buckled inboard and upward and both bore heavy deposits of black rubber smears on their lower surfaces.

Between stations 627 and 603 the wing leading edge of the DC-7 was deformed rearward and outboard. Rearward and inboard scratches on the lower leading edge were continuous through areas of deep buckling, indicating they were made before the leading edge struck the object causing buckling. Aft of the leading edge on the lower wing surface there were more scratches running aft and inboard at an angle of approximately 25 degrees relative to the centre spar.

At the L-1049 wreckage area a section of lower wing skin from the DC-7 was found. This section was from the left wing where the aircraft registration is painted. Scrape marks corresponded directionally to those previously described. Imbedded in a tear on this part was a piece of Constellation headlining used in the aft cabin ceiling. Brown smudges, running in the same general direction as the scratches, were determined by chemical analysis to be material used to seal Constellation fuselage seams and stringers in the pressure cabin area.

A second area of damage significant to the investigatory objectives and closely allied with the DC-7 wing damage was the Constellation empennage. This major component had struck the ground inverted but came to rest in an upright position about 550 yards north of the concentration of L-1049 wreckage. It was generally intact except for the left and right fins and rudders. Respectively, these were found about 30 and 10 yards removed. The distance of the empennage from the rest of the L-1049, together with the evidence of severe damage where it was separated from the aft fuselage, showed this major component had separated in flight after collision impact. Heavier pieces of the L-1049 aft fuselage structure and aft interior equipment were found west of the main TWA wreckage site. Light interior materials from the aft fuselage were found on Cape Solitude 1-1/2 miles east, indicating that they were torn or spilled out at a sufficient altitude to drift this distance.

Two pieces from the Constellation empennage were recovered away from the main empennage at sufficient distance to indicate separation prior to ground impact. These, consisting of sections of the left upper fin leading edge and bearing portions of red and white stripes of the Constellation colour scheme, showed collision evidence. One piece was concaved on its leading edge, in the area of the red stripe, by an object moving right to left. The concave area fitted precisely with the damage on the DC-7 left wing tip. The red paint found on the wing tip came from this red stripe, and the black marks resulted from contact with the fin leading edge de-icer boot. The second piece, which fitted below the concaved piece, was crumpled to the left by the same force that damaged the concaved piece.

The L-1049 aft fuselage was a third area of collision damage. Most significant was a piece of fuselage skin about 1-1/2 x 4 feet in size. Identification showed it came from the upper right side of the Constellation fuselage just forward of the tail. Its outer surface was painted white. This metal piece was bent inward about 90 degrees so that its inner surfaces were folded toward each other. There were red, blue, and black marks in various directions on the white outer surface paint in the area aft of the bend. In addition to these marks there were gray deposits in a random pattern creating a stippled effect over the entire surface. Together with these there were also long grayish smears progressing in the same direction as the stippling. Pile-up of the individual marks within the deposits was heavier on the upper edge. This evidence indicated that the gray deposits were made by an object moving up and along the circumferential frames of the Constellation fuselage.

The final area of important damage was also in the aft fuselage of the L-1049. It was a series of three propeller cuts in the lower and bottom fuselage in the vicinity of the rear baggage compartment. The cuts were generally upward and inboard and of varying lengths. They were essentially parallel about 35 inches apart with the middle cut about 52 degrees relative to the longitudinal axis of the aircraft. Red and blue paint marks at the edge of one cut in the baggage bin area coincided with the paint scheme on the DC-7 propeller.

Two additional propeller cuts were located in the L-1049 forward fuselage. One cut was approximately in line with the L-1049 No. 3 propeller arc and the other was about four feet forward. This damage was not consistent with the other collision damage and the cuts were probably made by the propeller of the Constellation during ground breakup.

Both flights were planned as high-altitude operations (above 14 500 feet west of the 100-degree Meridian) which under current regulations and operating specifications permitted them to be planned and flown off airways over direct courses to take advantage of the most favourable weather and wind factors as well as the shortest distance between origin and destination of the long-range non-stop flights. Before flight, however, a definite flight plan is required over the direct route with numerous reporting points indicated to clearly define the proposed route to be flown. To this end numerous company high-altitude routes have been established. From these the most favourable is selected for an individual operation commensurate with existing conditions.

United Airlines' operational policy permitted a high altitude flight to be conducted on an IFR or VFR flight plan but the company did not permit its flights to be flown in instrument weather conditions, regardless of the flight plan, during that portion of the flight off airways. In this regard Trans World Airlines' policy, at the time of the accident, permitted off airways flights in instrument weather conditions but only on an IFR flight plan with an assigned altitude. When operating 1 000 on top the company required adherence to visual flight rules.

As previously stated, approaching Daggett the TWA flight asked for a change in its flight altitude from 19 000 feet to 21 000 feet on its IFR clearance, and if unable, 1 000 on top. The TWA radio operator who received this request from the flight called Los Angeles ARTC and at 0921 advised, "TWA 2 is coming up on Daggett requesting 21 000 feet." The Los Angeles controller then contacted the Salt Lake ARTC controller and said, "TWA 2 is requesting two one thousand, how does it look? I see he is Daggett direct Trinidad, I see you have United 718 crossing his altitude - in his way at two one thousand." According to the recording of this conversation the Salt Lake controller replied, "Yes, their courses cross and they are right together." The Los Angeles controller then called the TWA radio operator and said, "Advisory, TWA 2, unable approve two one thousand." At this time the radio operator interrupted and said, "Just a minute. I think he wants a thousand on top, yes a thousand on top until he can get it." After determining from the flight, through the TWA radio operator, that it was then 1 000 on top the Los Angeles controller issued the following amended clearance, "ATC clears TWA 2, maintain at least 1 000 on top. Advise TWA 2 his traffic is United 718, direct Durango, estimating Needles at 0957." The TWA ground radio operator stated that this clearance was given TWA 2 and it was repeated back to him verbatim by the flight. The operator said that in this transmission he included the information concerning United 718, adding that it was at 21 000 feet which he concluded from the overall situation although the altitude was not part of the information from the controller. The TWA operator testified that he recognized the voice of the captain of the TWA 2 flight and that the captain acknowledged the information on the United flight as "traffic received."

The two controllers participating in this action were called to testify at the Board's public hearing. In response to questions they stated that because TWA 2 would soon pass from the Los Angeles ARTC area of responsibility to the Salt Lake area it was necessary to coordinate the TWA request for altitude change. Both stated that at this time the flights were IFR traffic operating in controlled airspace and ARTC was required to separate them from each other as well as from any other aircraft on IFR clearances. The controller who gave the clearance said he offered the United Information to TWA merely as an explanation for the denial of 21 000 and not as a traffic advisory.

The Director of the CAA Office of Air Traffic Control explained that when TWA requested 21 000 feet the flight had not reached Daggett nor had the United flight reached Needles. They were not traffic for each other at that time but in projecting their tracks eastward both would cross Red Airway 15 with ill-defined horizontal separation. On this airway ARTC was required to separate the flights; thus TWA was denied 21 000. The witness added that this separation was an ARTC responsibility for instrument flights only in the controlled airspace and that Red Airway 15 was the last such area for the flights to traverse until they were well beyond the accident scene. He said that ARTC maintains only progress information with respect to IFR flights flying through uncontrolled airspace and that this information is used for the purpose of providing a safely spaced flow of instrument traffic into the next controlled airspace to be entered. He stated that air traffic control does not provide any control service or function in uncontrolled airspace. The witness explained that flights are not bound by clearance or flight plan, whether VFR or IFR, while operating in uncontrolled airspace and that instrument traffic must only leave and re-enter a control area according to traffic control clearance. The controllers' manual of control procedures stated that, "Clearances authorize flight within control zones and control areas only; no responsibility for separation of aircraft outside these areas is accepted."

When TWA amended its flight plan from an assigned 19 000 feet to 1 000 feet on top, no information concerning this was given to United 718. The Director of Air Traffic Control stated that none was required though the flights were in controlled airspace at the time. The clearance to TWA 2 was to maintain 1 000 feet on top while it was in a control area. The witness said the flight was not restricted to any specific altitude in control areas except that it be at least 1 000 feet above the general cloud layer. When outside controlled airspace and under certain conditions of limited visibility flight should be conducted at an altitude conforming to the "Quadrantal Rule*." The witness stated that the controller therefore did not know what altitude the captain of TWA 2 would select as a cruising altitude or if he might later change the altitude from time to time. The witness stated that with respect to separation the TWA flight at this time was a VFR flight and that the basic VFR minima applied for it to maintain flight in VFR conditions. **

Civil Air Regulations do not provide a definition for 1 000 on-top operation either within or outside controlled airspace; however, with respect to on-top operations in control areas the Flight Information Manual states: "'At least 1 000 feet on top' may be filed in an IFR flight plan, or assigned by ATC in an IFR clearance, in lieu of a cruising altitude. Even though this type of operation places the responsibility for avoidance of collision with other aircraft on the pilot, the flight is an IFR operation and must obtain an amended clearance for a specific altitude before proceeding into IFR weather conditions." It further states, "Air Traffic clearances which specify 'at least 1 000 feet above all clouds' in lieu of a cruising altitude permits flight to be conducted at any altitude at or above the minimum en-route altitude which is 1 000 feet or more above the cloud layer..."

The present concept for separation of aircraft and avoidance of collision in VFR weather conditions, regardless of flight plan or clearance, depends on the flight crews' ability to visually provide separation between aircraft. Civil Air Regulations expressly place this responsibility on the pilots*** and the concept is commonly referred to as the "see and be seen" principle. Rules for avoidance and right-of-way are set out in the

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* Civil Air Regulations. Part 60.32 (b) 1, 2, 3, and 4.

** Civil Air Regulations. Part 60.30 (b) (1)

***Civil Air Regulations. Part 60.12 (c)

Regulations also*. With respect to an IFR flight operating in VFR weather conditions the Flight Information Manual states, "During the time an IFR flight is operating in VFR weather conditions, it is the direct responsibility of the pilot to avoid other aircraft, since VFR flights may be operating in the same area without knowledge of ATC." In consonance with these provisions the vast percentage of flying today is separated by the "see and be seen" philosophy with little or no external traffic control assistance.

During the public hearing the Salt Lake controller and the CAA Director of Air Traffic Control were questioned as to whether or not traffic advisory information should have been issued the flights when the controller had received position reports from both flights and knew both were flying at the same altitude, estimating the Painted Desert line of position at the same time on converging courses. The controller stated that when the reports were received by him he had no knowledge of the track that either flight would make to the line of position because both were in the uncontrolled area and a specific track was not required. He said the Painted Desert line of position is nearly 175 miles long with no definite position within this distance. The estimates from the flights, therefore, did not mean that they would converge there but merely that both would pass the line eastbound at that time. He testified that he was not required to give advisory information to flights which were in uncontrolled airspace and it was only a discretionary duty in the controlled area. He also said this advisory service would not be possible as a day-to-day practice without control of flights and more definite position information, as well as additional facilities and personnel.

The CAA Director of ATC testified that it was not the policy or concept of ATC to provide traffic information outside of controlled airspace and that normally such information would be of little value. Many aircraft unknown to ATC may be operating in this area; further, ATC has no authority over those aircraft that are known. The witness testified that with respect to these two particular flights, the controller certainly knew about them; however, he explained that advisory information must be viewed in its overall application in day-to-day operations. He stated that advisory service for traffic in uncontrolled areas would be tantamount to positive control of all traffic which would require personnel, facilities, and equipment not presently available. He added that this was known to be correct, having several years ago attempted to provide this service on a test and evaluation basis. He added that the workload of an advisory service was found to be nearly equal to that required for a control service. He concluded that the present complement of persons assigned to perform the controller's functions in the uncontrolled areas could not be considered sufficient to offer either an advisory service or perform a control service.

According to the United estimate the flight would reach the Painted Desert at 1031, or 33 minutes after passing Needles. Investigation showed the accident occured at 1031, approximately 17 miles or nearly 3 1/2 minutes' flying time from the position of expected progress. Compared to another United flight which climbed over the same course to cruise at 21 000 feet approximately one hour earlier, Flight 718 should have reached the Painted Desert in its estimated elapsed time.

The TWA 2 estimates were in accord with accepted performance of the Constellation and the flight expected to reach the Painted Desert at 1031, or 36 minutes after passing Lake Mohave. This flight also was approximately 3 1/2 minutes' flying time from its estimated position when the collision occurred.

The winds aloft were carefully reviewed to determine whether or not they could have been a factor in the delays, however, it was learned that they were light in consideration of altitude and varied little from the winds forecast.

The severe damage sustained by the United aircraft leaves little question but that the aircraft crashed soon after the collision and therefore the last transmission from its crew (1030:53) came very close to the collision time (1031).

The recorded transmission was examined under laboratory conditions to determine what the exact message was, whether or not anything was said which was inaudible under normal listening conditions, and whether or not the tragedy was reflected during all or just part of the message. The latter objective would assist in determining whether or not the DC-7 crew sighted the L-1049 during the transmission and if the accident occurred during it. The analysis was based on a correlation of the spoken words with a spectrographic analysis,

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* See CAR Part 60.14 (a) through (c) and CAR Part 60.15

a technique used in "Visible Speech." Tests involving binaural listening and speech stretching were also made.

The results showed the principal speaker said, "Salt Lake, area (or ah), seven eighteen... we are going in."* During the time represented by the dots a second speaker yelled two known words which were, "up...up." This speaker also yelled words which preceded "up." These were indefinite but fitted energy patterns of "look", "pull", or "come". The tests showed clearly that the principal speaker throughout was speaking between 100 and 200 cycles above the normal male voice pitch spectrograms. The background or second speaker's pitch was even higher, being well above that of a female voice; however, it was fairly certain that it was a male speaker. According to the laboratory study both general voice patterns, particularly as to pitch, showed the speakers were under great emotional stress, indicating that they were already in serious trouble.

An exhaustive search for eyewitnesses to the in-flight collision was conducted. During this search no witnesses were found who saw the collision although at least one person apparently saw smoke from the crashes and dismissed it as a brush fire in the Canyon. On 10 July two witnesses were made known to the Board and were called to appear at the public hearing. They stated that while driving west on Route 66 between Winona and Flagstaff they saw two aircraft collide. Their descriptions fitted the subject aircraft and especially the Constellation. Both stated that when collision occurred there was no evidence such as fire, smoke, or falling pieces and that following impact the aircraft seemed to continue on without falling but locked together.

Investigation showed that the collision occurred a short distance west of and above the wreckage locations, approximately 70 miles from the witnesses. Calculations and visual capability indicated that at this distance it would be impossible to see the aircraft. Relative positions with respect to each other if visible, would be extremely deceptive. The Board does not question the sincerity of these witnesses but believes they must have seen two other aircraft; several are known to have been operating in this general area. At a considerable distance and at certain angles of observation two widely separated aircraft could well present the illusion of a collision.

A third witness reported having seen a puff of smoke in the sky over the Grand Canyon area. This witness was near Winslow, about 80 miles from the accident site, and was also proceeding in a private automobile west on Route 66. The puff of smoke seemed very high and from it two objects appeared to fall on a trajectory path and disappeared into lower clouds. This observation may have been the collision but because little detail could be seen it adds little to the investigatory objectives other than those already clearly established by more positive evidence.

To establish conclusively the importance of the information offered by these witnesses, Board investigators were stationed about 14 miles east of Flagstaff, the approximate position of the nearest witnesses as indicated by their testimony. On separate days United and Trans World flights flew the proposed routes of Flights 2 and 718, making position reports to the investigators according to a prearranged detailed plan. These were received by a CAA communications truck located with the investigators. Weather conditions on one day were better than those on the day of the accident and on the second day they were equal to or better than the accident day. Results of this work showed that the aircraft could not be seen though their exact positions were known, as were the angles on which to sight to the positions. Many reports and sightings were undertaken. Once a reflective flash was seen and binoculars were trained on it. With this assistance to the observers' normal vision the aircraft could be seen but it could not be identified as to type or make.

The Board was about to publish its report on this accident when, on 1 February 1957, it was advised of another alleged eyewitness to the collision. All of the testimony of this witness was carefully evaluated; however, it was concluded that it had no probative value. Under the circumstances, the Board could not accept the witness' testimony.

The possibility that both aircraft could have been south of their courses, using the 3-1/2 minutes of unaccounted for time in this manner, is remote. A radius of action computation shows the time to be insufficient to bring the aircraft, especially TWA Flight 2, to a position much closer that 45 miles to the observers' point and thereafter flown to the known collision position.

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* Differences between initial listening and laboratory results relative to message context are recognized.

The initial impact occurred with the DC-7 moving from right to left relative to the L-1049 and with the L-1049 moving to the right and aft relative to the DC-7. From analysis of physical damage in consideration of locations of the damaged components of the aircraft, it appears that first contact involved the centre fin leading edge of the L-1049 and the left aileron tip of the DC-7. Instantly thereafter the lower surface of the DC-7 left wing struck the upper aft fuselage of the Constellation with disintegrating force. Without question this force caused complete destruction of the aft fuselage and destroyed the structural integrity of the left wing outer panel. As this occurred and the aircraft continued to pass laterally, the left fin leading edge of the Constellation and the left wing tip of the DC-7 made contact, tearing off pieces of both components. During this same time the DC-7 No. 1 propeller inflicted a series of cuts in the area of the aft baggage compartment of the L-1049. This entire sequence occurred in less than one-half second and in such a manner that an interlocking of the aircraft was virtually impossible.

From the extent of damage and the locations of various components on the ground, the collision ripped open the fuselage of the Constellation from just forward of its tail to near the main cabin door. The collision also caused the empennage of the Constellation to separate almost immediately. This aircraft then pitched down and fell on a short forward trajectory to the ground. Consideration of these factors leads the Board to conclude that the collision occurred in space over a position just west of the TWA crash site.

The United aircraft appears to have sustained lesser but equally critical damage affecting flight. Most of its left outer wing separated during the collision and it appears likely that the horizontal stabilizer of the DC-7 was struck by pieces torn off the Constellation. It is also reasonable that damage to the left wing restricted aileron control. It is believed that the DC-7 fell less steeply, probably on a turning path, to the ground.

For damage to have resulted as described earlier and for other areas to have escaped in-flight contact, the aircraft had to be oriented in a certain manner relative to each other when the collision occurred. Additionally, and independent of the matching of damage, a study was also made relative to the propeller cuts. Both studies gave nearly identical results relative to the angle between the aircraft at the instant of impact. This angle was found to be approximately 25 degrees relative to the longitudinal axes.

From the layout work matching the in-flight contact areas, it was determined that the DC-7 left wing was above the L-1049 relative wing plane or the DC-7 was rolled approximately 20 degrees right wing down relative to the L-1049. The study also indicated the aircraft were oriented such that the vertical distance between empennages of the aircraft was less than the vertical distance between their nose sections. The difference as an angle was between 5 and 10 degrees. It is important to recognize that the aircraft attitudes described are relative or with respect to each other and do not necessarily reflect their orientation with respect to the ground.

From all that could be examined there was no evidence of malfunction or failure of the aircraft and from all the evidence surrounding the accident the Board believes there was none.

Analysis of all the available weather information, including pilot reports, indicates that the forecast conditions for the flights were reasonably accurate. It shows that the two flights departed Los Angeles and climbed through an overcast approximately 700 feet thick to clear conditions on top. The overcast was local in nature and confined to the Los Angeles coastal area. Thereafter, the flights, except for some scattered clouds, were in clear weather as they climbed eastbound over their respective tracks.

Clear weather appears to have prevailed east of Las Vegas along the Colorado River to near Havasu Creek but becoming overcast with a few breaks beginning a short distance east of Havasu Creek. Along the proposed routes of TWA 2 and UAL 718, scattered clouds commenced shortly east of the California-Arizona border. Eastward therefrom clouds increased to broken, then overcast with some breaks in the Grand Canyon area to somewhat east of the accident site. Tops of this main weather coverage were approximately 15 000 feet with several lower layers, the lowest being about 2 000 feet above the ground.

Northwest of Grand Canyon Village, or over the western portion of the main Grand Canyon, the first of several scattered build-ups appears to have existed. It appears to have been isolated with others northeast of it.

The build-ups were apparently formed in the lower clouds and protruded through and above them to approximately 25 000 feet. An airline captain described the westernmost build-up as large but of an indeterminable width and length. He believed it was almost over Grand Canyon Village. Pilots below the overcast saw no evidence of it there but at least two noted a rain area northwest of this position. It is entirely likely that the rain area was from the build-up noted by the captain from above. Pilots flying below the overcast also stated that they saw breaks in the overcast but that they were few and scattered. They observed that the overcast condition covered most if not all of the Grand Canyon.

From the evidence available the Board is of the opinion that the weather conditions at 21 000 feet would not have precluded flight in VFR conditions in this accident area but that deviations may have been required to circumvent the build-ups while the subject flights traversed the area.

According to company procedures United flights were not permitted to fly in instrument weather conditions while operating off airways. Similarly, TWA procedures precluded instrument flight under the flight clearance on which its Flight 2 was proceeding at the time of the accident. Each company, under the conditions during which this accident occurred, therefore required its flight to adhere to visual flight rules. Further, it is unlikely that the captain of the TWA flight would proceed into instrument weather conditions, having previously been informed that the United flight was in the general area at 21 000 feet. The Board is, therefore, of the firm opinion, based on the weather conditions, company procedures, and good pilot practice, that both flights were operating according to rules prescribed for VFR conditions when the collision occurred.

The last position report from each flight indicated, at the time the report was given, that each was at 21 000 feet. Although there was no requirement for either to remain at that altitude in the uncontrolled area, with respect to Air Traffic Control, each company did require that it be notified of an altitude change. Because there was no notice and no known reason for the flights to alter altitude, it is considered reasonable to believe that the collision occurred at 21 000 feet.

Considering each flight's estimate to the Painted Desert, together with aircraft performance, it appears that both flights should have reached the line of position about 17 miles, or 3-1/2 minutes' flying time, farther east when the accident occurred. Although there are several possibilities, no definite conclusion has been reached as to the cause of the 3-1/2-minute delay of these aircraft. One possibility is that it could have been caused by manoeuvring to provide a more scenic view for the passengers, although the evidence is not sufficient to establish this fact. Another possibility is that a less favourable wind was encountered during the subject segments than was used for estimates which slowed the progress of the flights. A third possibility is that one or more build-ups in the Grand Canyon area may have required deviations and, if so, could account for the time element involved.

At approximately 1013 the Salt Lake controller was in possession of the last position report made by each of the subject flights. He was then aware that when the reports were made both aircraft were operating at 21 000 feet, were on converging courses, and were estimating the Painted Desert at the same time. He advised neither flight of this situation. In considering whether or not this should have been done, the traffic control concept, the controller's express duties, and the requirements involved to provide this information to flights must be considered.

Air Traffic Control undertakes to separate air traffic when it is operating in accordance with an IFR clearance and while it is within the confines of controlled airspace. If instrument weather conditions exist and the above requirements are met, all air traffic would be separated. However, when visual flight conditions exist instrument traffic is separated only from other like traffic and not from aircraft being flown under visual flight rules, much of the latter being unknown to Air Traffic Control. For this reason flights in visual conditions are required to provide their own separation regardless of flight plan or clearance.

Outside the controlled airspace the air traffic control concept has not embraced the responsibility for separation of air traffic regardless of flight plan, clearance or weather conditions. In this area no control is exercised by Air Traffic Control, its principal function being to monitor the progress of flights through an uncontrolled area so that an orderly flow of instrument traffic may be accomplished into the adjacent control area. Control is not presently available in the uncontrolled airspace because sufficient facilities and means for such control do not exist.

At the present time traffic advisory information to flights is offered when and where control of air traffic is being exercised. Then, such advisory is discretionary with the controller and is not a mandatory procedure of control. Accurate and worthwhile traffic information requires that the controller be informed of the aircraft involved and have precise and timely information on the position of flights relative to their altitude and lateral and forward position along a defined track. This information must thereafter be posted and correlated with like information on other flights to determine whether or not a conflicting situation exists. In the uncontrolled airspace flights are permitted greater flexibility to take advantage of wind and weather factors. Further, in this area the navigational aids enabling a flight to report its position with the precision necessary to enable accurate advisory information are insufficient. The aforementioned factors affecting the value of traffic advisory information are evident with respect to TWA 2 and United 718. Both flights were somewhat north of their proposed tracks, both were approximately 17 miles west of where they had estimated they would be at that time, and their actual tracks intersected a considerable distance before the proposed tracks converged. Such deviations are not unusual in off-airways operation.

Although knowledge of the projected flight paths of the subject flights could have prompted the Salt Lake controller to offer both flights traffic advisory information on a voluntary basis, giving the best information available to him at the time, the Board is of the opinion that the existing control concept, Air Traffic Control policies and procedures, and the express duties of a controller did not require him to do so.

This accident, as nearly all other midair collisions, apparently occurred in visual flight weather conditions and there is no reason to believe the aircraft were not being operated in accordance with cloud separation criteria of visual flight rules. Under these conditions and according to these rules the vast portion of flying today is being conducted. Accordingly, the present means for avoiding collision rests with the pilot to see and avoid other aircraft.

Extensive study of most collision accidents has shown that there was an opportunity, of varying degree, for the pilot or pilots to see the conflicting aircraft in sufficient time for them to take evasive manoeuvres to avoid the accident. In many of these accidents where there was survival, however, testimony of the pilots was that they were maintaining a carefull lookout but despite it they did not see the other aircraft in time to avoid it or that they did not see it at all.

Collision studies, including controlled flight tests, have pointed out that seeing other aircraft in flight is difficult. The degree of such difficulty is variable with numerous tangible and intangible factors affecting it. The first tangible factor is the angular limits of cockpit vision, or the vision afforded by cockpit structure and design only.

The second tangible factor is visual range or the distance that an object can be seen. Many conditions and circumstances enter into this factor and are variable. Some of these are colour of the object, its background, and the contrast between them. Others are mass of the object, its angular size and shape, and the atmospheric condition of visibility. The latter may also include altitude effect and cloud obstruction.

A third group of factors is physiological or human and many of these are intangible, depending on the individual's physical condition, degree of fatigue, and training. The human eye will best see an object when it is within the sensitive or focal field of vision, which is two to three degrees. An object may be seen through the peripheral portion of vision or the area of several degrees outside of the focal field. The number of degrees is dependent upon motion and/or the aforementioned factors providing sufficient stimuli. It may be noted that aircraft converging on constant, unvarying collision courses provide no relative motion when viewed from the aircraft. Searching for aircraft within the visual limits of cockpit visibility required scanning through those limits. This requires time, the amount being allied to the physiological factors and the adaquacy depending on all considerations, including closure speed.

Allied to the element of opportunity it is important to recognize that the operation of a modern aircraft requires regular and frequent attention of the pilot or pilots to duties within the cockpit. Attention to instrumentation, both operational and navigational, is required during all phases of flight, as well as computations and records pertaining to the progress and anticipated progress of the flight.

Many combinations of adverse factors, conditions, and circumstances can result in a limited opportunity to see another aircraft. On the other hand the opportunity to see another aircraft may be good. Here the factors act to a good and reasonable opportunity for the vigilant pilot and in this regard the Board expects pilots to maintain the highest degree of vigilance.

It is recognized that the basic means for traffic separation in VFR conditions is presently the "see and be seen" philosophy. This concept has existed as a matter of necessity, with its known limitations, and will continue until there are sufficient technological advances to provide additional assistance to the pilot for collision avoidance. The progress of aviation is moving rapidly toward higher altitudes and greater speeds, with traffic in increasing density. Fully aware of this and its effect, the Board is lending its support to industry, other governmental agencies, and interested persons to find and develop methods, means, and devices which will assist the concept of visual separation.

Knowing full well that insufficient evidence would preclude determining with positive results the existing opportunities for the subject crews to see the conflicting aircraft, the Board nevertheless conducted an exhaustive analysis. This was done to present all information possible from the available evidence. The analysis was successful in this objective and disclosed much which the Board believes will assist its principal goal of greater safety in aviation.

Since the attitudes of the aircraft relative to the ground and their probable flight paths prior to collision are so closely interrelated, they can be treated together. A determination of these is imperative relative to the opportunity for the pilots to have seen the conflicting aircraft.

As indicated, correlation of the physical damage relates one aircraft with respect to the other and not with respect to the ground. Obviously, the physical orientation is valid only at the instant of impact. Because of this, and in the absence of eyewitnesses, it is not known whether one or both aircraft were rolled, pitched, or yawed relative to the ground. Without a known orientation of at least one of the aircraft with respect to the ground, an analysis cannot determine a single flight path of the aircraft prior to the collision, nor is it possible to establish the flight paths by other known factors in this accident. It is therefore necessary to evaluate the objective on the basis of several flight path combinations, knowing that only one existed. Generally, however, the possibilities may be narrowed into two broad categories with variations. The possibilities may also be limited by the known orientation of the aircraft to each other at the instant of impact, which precludes certain other relative attitudes between the aircraft.

The first category assumes that there was no evasive action prior to collision and that one or both aircraft were turning within the limits afforded by the known collision orientation. This category accepts as reasonable that both aircraft were being flown commensurate with their performance for the en-route phase of flight. Analytical studies recognized the variations to this category but found that three limit considerations seem to cover the infinite number with respect to the pilots' visual opportunities. Two of these are that either aircraft was turning while the other flew straight and level to collision; the third is that both were turning prior to the accident.

The second category of possibility is based on the assumption that there was an evasive action initiated by one or both flights but that it came too late to avoid the accident. Again, it is reasonable to believe the evasive action was limited to the known orientation and that the aircraft were being flown according to the normal performance for the en-route phase of flight. The evasive action was also limited to aileron-elevator type manoeuvres. Although rudder displacement was studied and evaluated, the aileron-elevator action appeared to be more consistent with the preponderance of all evidence; however, this was not entirely conclusive. Even accepting this limit there are variations, but these can be narrowed by a limit consideration. This is possible because manoeuvre characteristics of both aircraft showed that an evasive action without sufficient time to avoid the collision would not appreciably alter the flight path of either aircraft from flight paths which presumed there was no evasive action. It must be noted, however, that relative attitudes of the aircraft would be changed. Accordingly, the studies under the second category relating to the visual opportunities of the crews are not appreciably altered from the situation where both aircraft were approaching one another in straight and level flight at the angle between the longitudinal axes shown to have existed at the initial impact, 25 degrees.

It is known that several cloud buildups existed in the immediate area of the collision and their heights extended well above the cruising altitudes of both flights. Although it is unknown, it is entirely possible that the aircraft may have been flown so that one was on each side of a buildup shortly before collision. The effect of this would, of course, preclude the crews from seeing the other aircraft during the time the cloud or clouds were between them. Clouds would also require course deviation in certain situations. They would also seriously limit the time for pilots to see the conflicting aircraft, the amount depending on the size and shape of the clouds, the lateral distance maintained by the flights from them, and the distance of the clouds from the collision point. Thus, a cloud positioned close to the collision point would limit the time opportunity as would one which was narrow or elongated. The intervening cloud factor appears to be a possibility and therefore was a necessary consideration in the visual opportunity study. To this end several representative cloud sizes and shapes were selected and introduced in the analytical study. The study also included the consideration which presumed that clouds would not have been a factor. The study accepted as the limit of visual range a distance of five to six statute miles and assumed that the aircraft passed the cloud formation at a horizontal distance of 2 000 feet and that they were at the same altitude.

The results of this analysis were then applied to the individual crew members from their respective cockpit positions. This was accomplished in the form of windshield displays, thereby incorporating the several situations with the angular limits of cockpit vision. (See Figures 16 and 17).

From the display it is apparent that the L-1049 was within the angular limits of the DC-7 window area from the captain's seat during all the flight path situations. In the situation of no intervening clouds, motion would be involved in three of the four situations. Windshield formers would block the captain's view for varying portions of the time opportunity. The time opportunity with no clouds was 50 to 120 seconds according to the situation being considered. The worst cloud situation could reduce the time opportunity to as low as 12 seconds.

With respect to the DC-7 first officer's position, the L-1049 was within the angular limits of the DC-7 window area during two of the limit considerations and during the early part of the other two. In the "no cloud" factor situations the L-1049 would have been near maximum visual range in two conditions, without relative motion in one, and with relative motion in another. Time opportunity without intervening clouds and with both aircraft straight and level was 120 seconds. For the other three considerations, including the intervening cloud condition, the opportunity varied from 12 seconds to 50 seconds.

In only one of the conditions does it appear that the L-1049 captain could have seen the DC-7 from his seat; in this the time opportunity was for a period of up to 40 seconds with no intervening clouds. In the other three conditions, according to the study, his opportunity was precluded by the limits of cockpit structure or because the DC-7 was beyond visual range.

The study indicates that without the intervening cloud condition the DC-7 was within visual range and within the angular limits of cockpit vision from the L-1049 co-pilot's seat during three of the four flight path situations. Then the time opportunity varied from 50 to 120 seconds, according to the situation. Two of the displays reveal relative motion. Again, in the worst cloud situation his time opportunity was as low as 12 seconds.

Analysis of the various possible flight path variations relative to cockpit angular limits of vision has shown that one or both pilots of one aircraft could have been precluded from seeing the conflicting aircraft during critical periods. The study must also recognize the possible effect if one crew member was occupied with cockpit duties and he alone had the visual opportunity during this time.

The Board has shown the existence of cumulus-type clouds in the accident area. It has shown that these clouds may not have been an intervening factor between the flight paths of the aircraft. Here the time opportunities for the pilots to effect visual separation were good. In this situation, despite the possible flight path variations, and in consideration of the aforementioned factors controlling visual ability of the pilots, the Board is of the opinion that the range of opportunities was adequate. If this situation existed, the Board believes the pilots should have seen and avoided the other's aircraft.

On the other hand, evidence has shown that during other of the possibilities the pilot's opportunity to effect visual separation could have been seriously impaired. Analysis has shown how clouds, if positioned between the flights at a critical time, could have reduced the time opportunity for collision avoidance to less than the minimum of 15 or more seconds necessary for scanning, pilot reaction, and aeroplane response.

The Board has carefully studied and arduously evaluated all the available evidence surrounding this accident. It has learned all that existing methods of investigation and evaluation enabled it to do. This was done without the assistance of survivors or eye-witnesses whose testimony is considered imperative to a complete knowledge and to single conclusions in the collision-type accident. Because of the lack of this vital information and when all factors, including intervening clouds, cockpit visual limitations, cockpit duties, the several flight path variations, the time opportunities, and the physiological limits to human vision are considered, the Board concludes there is not enough evidence to determine whether or not there was sufficient opportunity for the pilots to avoid the collision.

Probable Cause

The probable cause of this mid-air collision was that the pilots did not see each other in time to avoid the collision. It is not possible to determine why the pilots did not see each other, but the evidence suggests that it resulted from any one or a combination of the following factors:

(1) Intervening clouds reducing time for visual separation;

(2) visual limitations due to cockpit visibility, and;

(3) preoccupation with normal cockpit duties;

(4) preoccupation with matters unrelated to cockpit duties such as attempting to provide the passengers with a more scenic view of the Grand Canyon area;

(5) physiological limits to human vision reducing the time opportunity to see and avoid the other aircraft, or;

(6) insufficiency of en-route air traffic advisory information due to inadequacy of facilities and lack of personnel in air traffic control.

ICAO Ref: AR/462

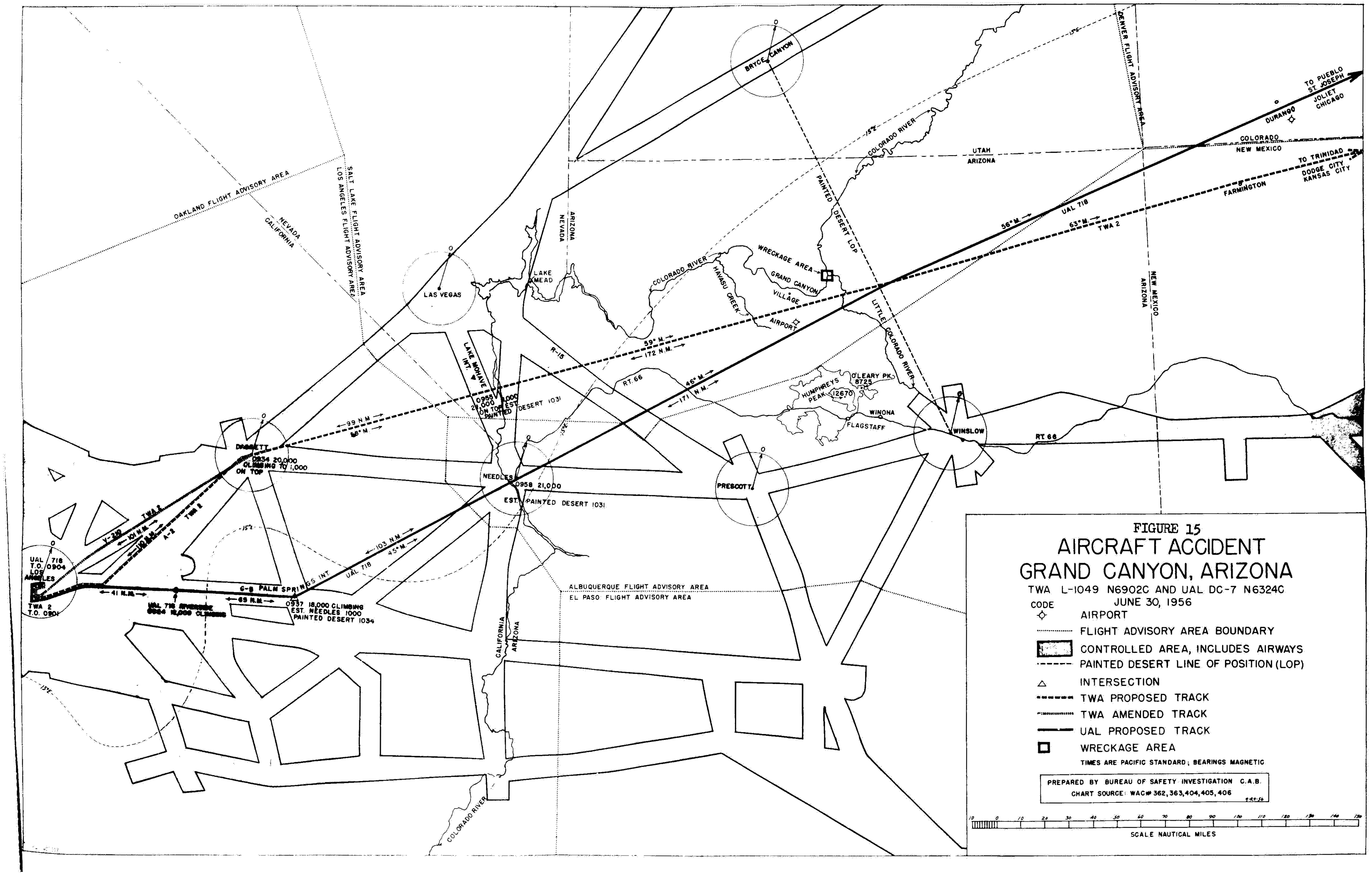

FIGURE 15
AIRCRAFT ACCIDENT
GRAND CANYON, ARIZONA
TWA L-1049 N6902C AND UAL DC-7 N6324C
JUNE 30, 1956

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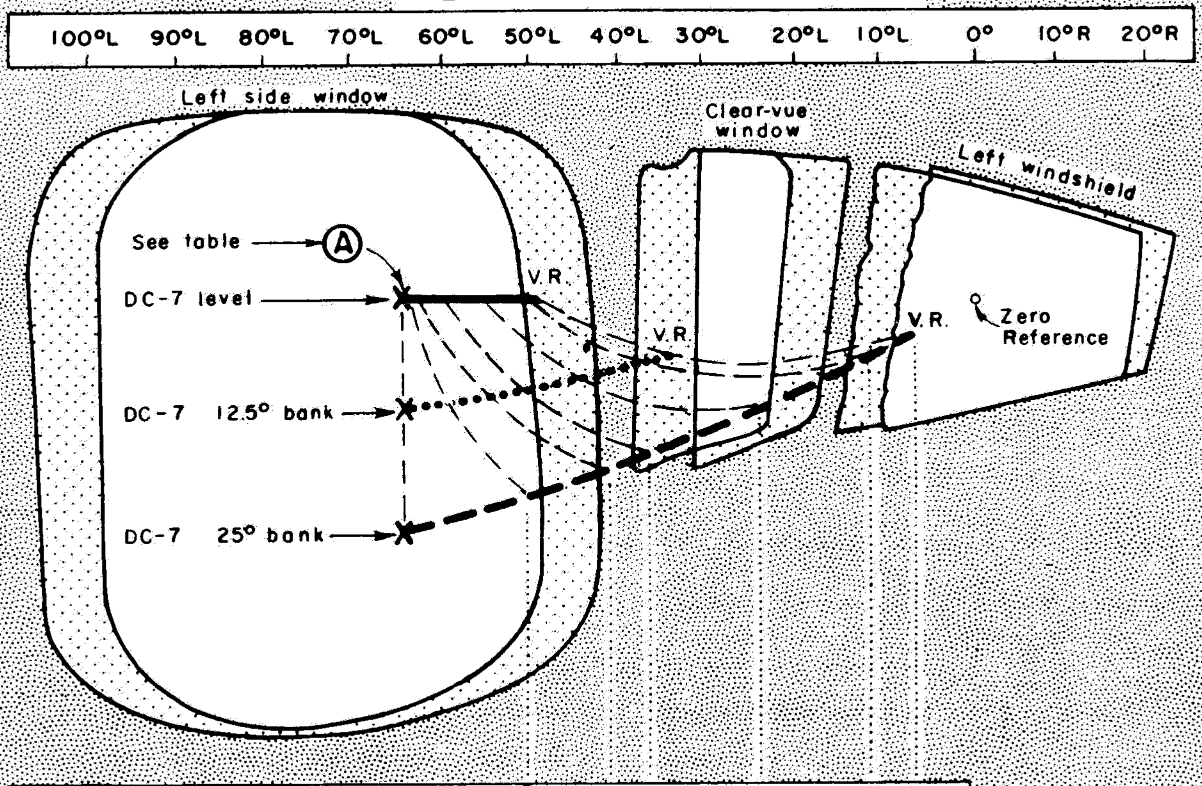
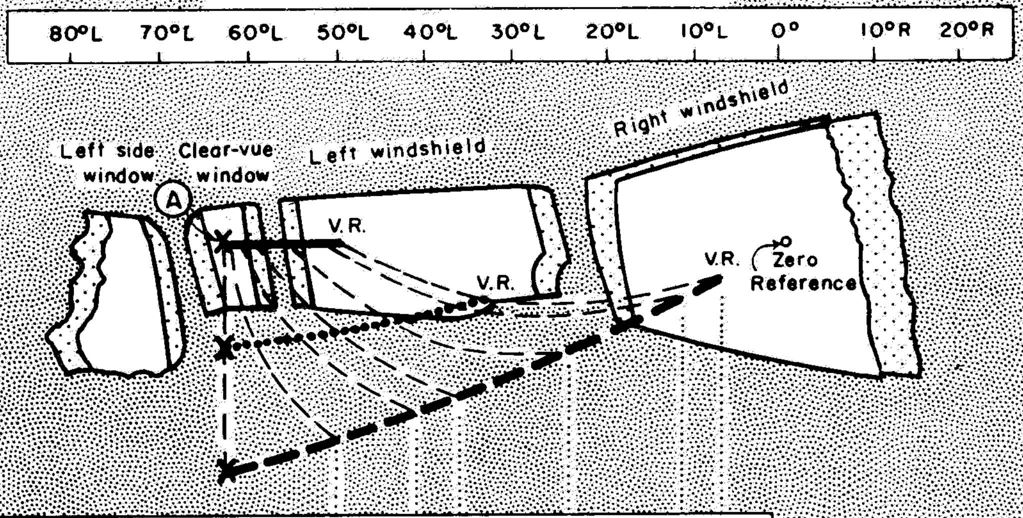
VIEW FROM CAPTAIN'S SEAT



Cloud diameter — Miles	△	1	2	5	10	-
Approx. time to collision — Seconds	12	21	27	38	50	60
Approx. distance between aircraft — Miles	.8	1.5	2	3.3	4.8	54

VIEW FROM CO-PILOT'S SEAT



Cloud diameter — Miles	△	1	2	5	10	-
Approx. time to collision — Seconds	12	21	27	38	50	60
Approx. distance between aircraft — Miles	.8	1.5	2	3.3	4.8	5.4

TABLE: Ⓐ This applies only when both the DC-7 and L-1049 fly straight and level and converge at approx 25°. Position on window is constant at point Ⓐ until instant before collision.

Cloud condition and limitation	No clouds and V. R. 5-6 miles	5 miles diameter	2 miles diameter	1 mile diameter	△
Approx. time to collision — Seconds	120	109	57	27	17
Approx. distance between aircraft — Miles	5.3	4.9	2.5	1.7	4000'

━━━━ DC-7 straight and level and L-1049 in left turn at 25° bank
●●●●●●●● DC-7 in right turn at 12.5° bank and L-1049 in left turn at 12.5 bank
▬ ▬ ▬ DC-7 in right turn at 25° bank and L-1049 straight and level
X L-1049 position instant before collision
V.R. Point at which the L-1049 first appears assuming a visual range of 5 to 6 miles and with crew positions in cockpit assumed as average
░ Monocular vision area — where crew members can see with only one eye
☐ Clear area within windshield or window outline — crew members can see with both eyes
▩ Opaque area — area around windshield and side windows with no outside vision
– – – – Dash lines connect corresponding points on three paths shown
△ Elongated cloud or cloud shelf diminishing eastward to a point

L-1049 PATHS ON DC-7 COCKPIT WINDOWS
TWA-UAL COLLISION GRAND CANYON, ARIZONA, JUNE 30, 1956

FIGURE 16

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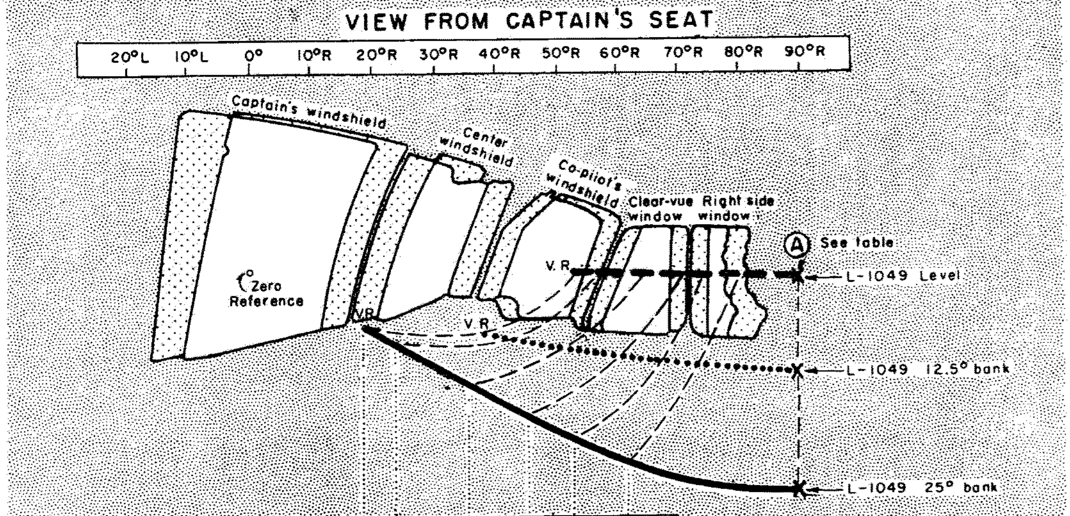
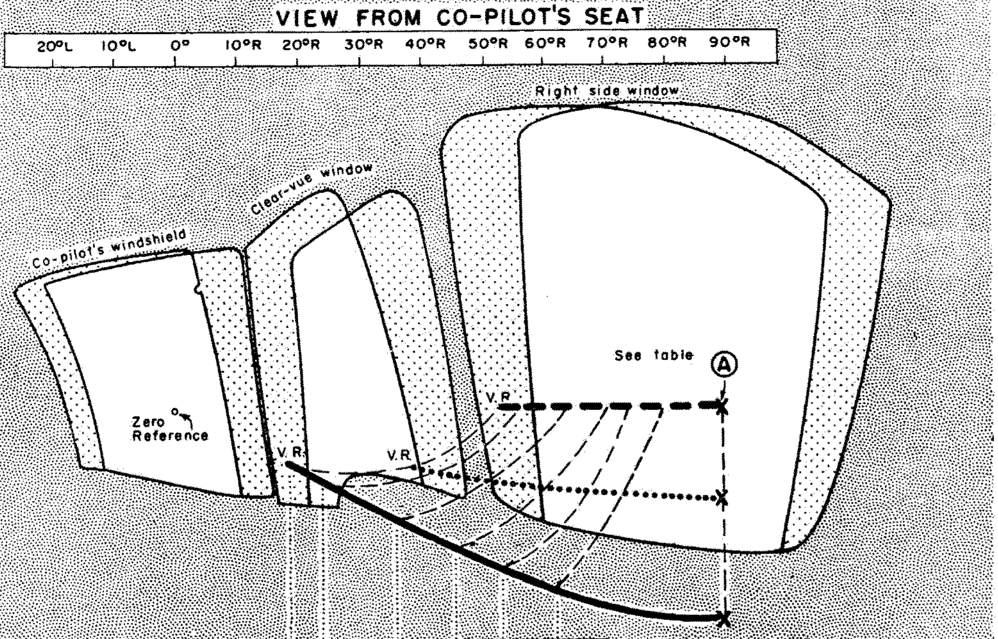

VIEW FROM CAPTAIN'S SEAT

Cloud diameter — Miles	-	10	5	2	1	△
Approx. time to collision — Seconds	60	50	38	27	21	12
Approx. distance between aircraft — Miles	5.4	4.8	3.3	2	1.5	.8


VIEW FROM CO-PILOT'S SEAT

Cloud diameter — Miles	-	10	5	2	1	△
Approx. time to collision — Seconds	60	50	38	27	21	12
Approx. distance between aircraft — Miles	5.4	4.8	3.3	2	1.5	.8

TABLE E: Ⓐ This applies only when both the DC-7 and L-1049 fly straight and level and converge at approx. 25°. Position on window is constant at point Ⓐ until instant before collision

Cloud condition and limitation	No clouds and V. R. 5-6 miles	5 miles diameter	2 miles diameter	1 mile diameter	△
Approx. time to collision — Seconds	120	109	57	27	17
Approx. distance between aircraft — Miles	5.3	4.9	2.5	1.7	4000'

▬ ▬ ▬	L-1049 straight and level and DC-7 in right turn at 25° bank
••••••••••	L-1049 in left turn at 12.5° bank and DC-7 in right turn at 12.5° bank
▬▬▬	L-1049 in left turn at 25° bank and DC-7 straight and level
X	This point indicates DC-7 position just before collision. Angle changes rapidly in last 1-2 seconds and moves to the right off cockpit window
V.R.	Point at which the DC-7 first appears assuming a visual range of 5 to 6 miles and with crew positions in cockpit assumed as average
░	Monocular vision area — where crew members can see with only one eye
□	Clear area within windshield or window outline — crew members can see with both eyes
▓	Opaque area — area around windshield and side windows with no outside vision
— — —	Dash lines connect corresponding points on three paths shown
△	Elongated cloud or cloud shelf diminishing eastward to a point

FIGURE 17

DC-7 PATHS ONL-1049 COCKPIT WINDOWS

TWA-UAL-COLLISION GRAND CANYON, ARIZONA, JUNE 30, 1956

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No. 23

Trans-Canada Airlines, Viscount, CF-TGR, lost propeller and part of engine near Flat Rock, Michigan, on 9 July 1956. Civil Aeronautics Board (USA) Accident Investigation Report, File No. F-111-56 released 11 March 1957. (Also released under Serial No. 56-12 by Dept. of Transport, Ottawa, Canada.)

Circumstances

Flight 304 was scheduled between Chicago, Illinois, and Montreal, Quebec, with stops at Toronto and Ottawa, Ontario. On board were a crew of 4 and 31 passengers. The pilot occupying the left-hand cockpit seat, a qualified Viscount captain, was being checked in route competency by the pilot-in-command who was occupying the right-hand seat. After departing Chicago on an IFR flight plan at 1304 hours Eastern Standard Time the aircraft was climbed to its cruising altitude of 19 000 feet, in accordance with its ATC clearance. At approximately 1345 hours in the vicinity of Flat Rock, powerplant difficulty developed. During an emergency descent the No. 4 propeller broke loose and one blade passed through the fuselage, killing one passenger and injuring 5 others. The flight continued to Windsor, Ontario, where an emergency landing was made at 1402 hours. Not until after landing did the pilots learn that a propeller blade had passed through the fuselage.

Investigation and Evidence

The pilots stated that at about 1345 hours they noted a momentary drop in r. p. m. of No. 4 engine - 200 to 300 below the normal cruise r. p. m. of 13 600. Engine r. p. m. then returned to and remained normal for 5 minutes. No. 4 engine r. p. m. was next observed to increase rapidly to approximately 13 900 or 14 000. Shortly thereafter and concurrently with attempting to feather the propeller, the overspeed increased appreciably and feathering attempts, using both the manual and automatic systems, were unsuccessful.

During and following attempts to feather, the airspeed decreased, as did the sound of the No. 4 engine overspeed. The crew increased power on the remaining three engines and with the resultant increase in airspeed the sound of No. 4 engine indicated its r. p. m. was rising. Because of this development an emergency was declared at approximately 1351 and clearance to descend was obtained from the Traffic Control Center at Detroit. Power was reduced on Nos. 1, 2, and 3 engines, then an emergency descent was started and was continued at nearly maximum airspeed. At some time during this phase of the descent the crew depressurized the cabin.

At approximately 1353, at an altitude of about 9 000 feet, the No. 4 propeller broke loose and all four blades separated from the hub. One of the blades struck No. 3 engine, then passed through the passenger-occupied portion of the fuselage. Descent was continued to about 3 000 feet, where power was again applied to Nos. 1, 2, and 3 engines. The r. p. m. of No. 3 engine did not go above 11 500 and the fire warning came on. Although no fire was observed, the engine fire procedure, which includes feathering of the propeller, was successfully accomplished.

Examination of the aircraft at Windsor revealed that the propeller and the front part of the No. 4 engine forward of the propeller reduction gear layshafts had broken away in flight. All of these parts were recovered in the vicinity of Flat Rock, Michigan.

The path of one propeller blade passed completely through the oil cooler of No. 3 engine and the forward portion of the passenger cabin. Major cabin damage occurred in the area of the two most forward rows of seats. A small piece of propeller blade that matched with the No. 2 blade was recovered from the cabin. The remaining propeller blades were found to be intact.

The No. 4 engine r. p. m. indicating system and propeller feathering system up to the point of separation of the nose case were checked, and both functioned satisfactorily. Subsequent checks at Winnipeg of the individual components which make up these systems showed them to be satisfactory.

The No. 4 engine revealed evidence of oil starvation throughout. Investigation disclosed that the driven bevel gear of the bevel box drive* had suffered a fatigue failure and rotation of the drive was completely disrupted. Laboratory study revealed the fatigue failure started on the load side of one tooth. Other than the fatigue fracture, this tooth was relatively undamaged, whereas the teeth that remained in place on the gear exhibited gross damage.

There is no known history of failure of driven bevel gears and a laboratory study showed no manufacturing or metallurgical defects in this one. The bushing within which this gear rotates had turned and worn panel material away until its thrust face was .030" below the machined surface of the panel on which the bushing flange normally beds. Damage resulting from the bushing turning in its panel precluded a determination of why the bushing was initially allowed to spin. The bushing flange was cracked. Displacement of the bushing resulted in a partial disengagement of the driven and driving bevel gears and thus altered the stresses in these parts.

The teeth of the high-speed pinion of the propeller reduction gearing were stripped to the extent that the propeller had become uncoupled from the engine. Discoloration from overheat was evident on the high-speed pinion and thrust bearing, with some deterioration having occurred to this latter part also.

The forward edges of the teeth of the high-speed pinion were displaced forward as the pinion progressively failed. The propeller oil transfer housing, which is located just forward of the high-speed pinion, had a circular groove cut into its aft face. This groove mated with the deformed pinion teeth which, by measurement, interfered with the propeller oil transfer housing. The circular groove was of sufficient depth to intersect the internal oil passages. Three successive tests to determine the oil pressure available for feathering subsequent to the described damage resulted in 300 p.s.i., 250 p.s.i., and 215 p.s.i.

The hub, with the propeller shaft, and the four propeller blades fell in five separate units and were found separately but in relatively close proximity to each other where they had fallen from the aircraft. The blades had pulled radially out of the hub bores, as evidenced by the shear pattern on the threads of the hub bore and on the blade retention nuts. All blades were intact except the previously reported tip portion of No. 2 which was found inside the fuselage. No irregularities of the propeller were evident except for impact damage.

The propeller control unit was functionally tested, disassembled, and examined. All was normal except that the pressure switch setting was 345 p.s.i. The specified setting is 460 plus or minus 20 p.s.i.

The crew reported that although cruise flight was conducted above a cloud layer, breaks in the clouds permitted the entire descent to be made with visual reference to the ground.

It was not possible to determine whether the momentary drop of 200 to 300 r.p.m. in No. 4 engine had any connection with events that followed. The initial overspeed of No. 4 engine to 13 900 or 14 000 r.p.m. undoubtedly occurred when the normally fixed bushing turned and failure of the driven bevel gear followed to the extent that rotation of the bevel box drive was completely stopped. At this stage of the engine difficulty the propeller could have been feathered.

Following failure of the driven bevel gear the engine was rotated with no pressure lubrication by the windmilling action of the propeller while the blades were at the inflight fine pitch angle. It was during this interval that the high-speed pinion progressively failed and was deformed so as to damage the propeller oil transfer housing, with the result that feathering oil at the required pressure could not be directed to the propeller; finally, the propeller became decoupled from the engine. No other reason for failure of the propeller to feather was revealed by the investigation. According to the crew the second overspeed occurred just as the first attempt was being made to feather the propeller. At this time, however, damage that precluded feathering had already occurred.

The matter of an uncontrolled decoupled propeller such as occurred in this instance had not been anticipated with respect to Viscount aircraft and was not treated in Viscount training or manual material. However, the fact that the sound of overspeed decreased with decreased airspeed and increased with an increase in airspeed should have alerted the crew to the necessity for maintaining a moderate airspeed during the descent. Maintaining a low airspeed to reduce r.p.m. of an

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* The engine fuel pump, propeller control unit, and oil pump are driven by the bevel box drive.

uncontrolled propeller has been for many years the basic procedure in use for reciprocating engine-propeller combinations and is widely known. Despite this, the captain ordered that an emergency descent be executed. The Board concludes that had a moderate airspeed been maintained, failure of the propeller as subsequently happened would not have occurred.

Blade retention failure of the windmilling No. 4 propeller occurred when the aircraft was at approximately 9 000 feet altitude and at nearly the maximum permitted airspeed. According to information from the propeller manufacturer, based on the calculated blade retention strength and tests of the propeller, failure of this nature would be expected under approximately these circumstances. There were no indications of faulty material or workmanship.

Failure to obtain power from the No. 3 engine and the subsequent fire warning after leveling off at the lower altitude were the direct result of damage inflicted by the No. 2 blade of the No. 4 propeller when it became detached.

Probable Cause

The probable cause of this accident was the inflight separation of the No. 4 propeller as a result of excessive loads induced by a descent at too high an airspeed while the propeller was windmilling decoupled from the engine and its rpm was known to be uncontrolled.

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ICAO Ref: AR/461

No. 24

Swissair, Convair 440, HB-IMD, crashed while approaching to land at Shannon Airport, Ireland, on 15 July 1956. Report released by Department of Industry and Commerce, Dublin, Ireland.

Circumstances

The aircraft departed from San Diego, California, at 0407 hours on 12 July for Zurich Airport, Switzerland, with two American pilots at the controls, on a delivery flight to Swissair. Intermediate stops included New York, Gander and Shannon. Having left New York at 1240 GMT on 14 July 1956, the aircraft landed at Gander at 1659 GMT. After a stop of 57 minutes, it left Gander for Shannon at 1748 GMT carrying the same crew of 4 members. Following an uneventful ocean crossing the aircraft at 0008 hours on 15 July was given initial descent clearance to Shannon and was then cleared into the Shannon Holding Pattern, where four other aircraft were holding. At 0125 hours the aircraft commenced a Ground Controlled Approach to runway 23 and on establishing visual reference to the ground broke off the approach for a left-hand visual circuit to runway 05. During the turn onto final approach to runway 05, the aircraft, while banking steeply was observed to drop. The aircraft was destroyed on impact with the ground at approximately 0135 hours and the 4 occupants were killed. There was no fire.

Investigation and Evidence

The weather conditions at Shannon at the time of the accident were - drizzle; cloud 2/8 at 600 feet and 6/8 at 900 feet; horizontal visibility 10 miles; surface wind 340/11 knots. The conditions experienced by the flight at Shannon were equal to or better than the conditions reported to it.

The aircraft was constructed in June 1956 and received a Certificate of Airworthiness on 10 July 1956. Its total flight time at the time of the accident was about 33 hours.

There was no evidence of any mechanical or structural failure of the aircraft and no operating difficulty was reported by the crew.

All appropriate procedures associated with the flight were carried out in a proper manner by the Ground Services at Shannon Airport.

The procedure adopted by the flight in effecting a visual circuit to runway 05 after establishing visual contact with the ground, following the completion of a Ground Controlled Approach to runway 23, was normal. The turns effected by the aircraft during the visual circuit were steeper than normal. The position on the approach from which a left-turn was commenced to align with runway 05 did not allow sufficient distance for a normal turn onto final approach to runway 05. The visual circuit and turn onto final approach to runway 05 were effected over terrain which, in the conditions prevailing at the time of the accident, provided poor visual reference to the ground plane.

Probable Cause

The probable cause of the accident was an error of judgment by the pilot, resulting in the execution of an abnormally steep turn onto final approach during which the aircraft slipped into the ground.

Possible contributory factors were:-

a) that for the successful execution of an approach involving a steep turn near the ground on a very dark night, there had been insufficient visual guidance from the terrain;

b) impairment of the pilots' proficiency due to the length of the period on duty.

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ICAO Ref: AR/463

No. 25

Saudi Arabian Airlines, Convair 340, HZ-ABA made a forced landing at Deir-ez-Zor, Syria, on 27 July 1956. Report by Commission appointed by the Director General of Civil Aviation, Republic of Syria

Circumstances

The non-scheduled flight departed Jedda for Damascus, Syria at 1430 hours Greenwich Mean Time. The pilot set a course of 346° magnetic at an altitude of 16 500. When abeam Medina the course was altered to a heading of 343° magnetic to correct for an estimated right drift of 6°. The pilot later tuned both the automatic direction finders to the Amman non-directional beacon and carried out a track and distance check while passing abeam. This indicated that the aircraft was either on track with a very strong headwind or was farther east of the track than it should be; the pilot accepted the former alternative. Amman was not visible at this time and there was no forward visibility. After passing abeam Amman both ADF's were tuned on an NDB which was assumed to be Damascus which gave a fairly steady QDM of 015° magnetic. Course was then altered from 343° to 015° to home on this station. After unsuccessful attempts to contact Damascus on VHF the pilot succeeded (at 1820 GMT) in making contact with Damascus on HF. He reported the aircraft's position as 5 minutes south of Damascus at 12 000 feet and stated that his VHF was out of order. The aircraft was cleared to descend first to 11 500, then at 1836 to 8 500 feet. At 1843 the FIC gave the flight the following information - landing runway 20, QNH 1005. 8 mbs., 29. 71 inches, report downwind. When the FIC asked (1850 GMT) whether the pilot could see the aerodrome, the pilot replied "... cannot see the aerodrome now but my approximate ETA Damascus in 10 minutes." The pilot was further convinced that he had a strong headwind. This was confirmed in his mind by the delayed arrival over the beacon and also based on his track and distance check when passing abeam Amman. The pilot flew 50 minutes beyond his ETA on the course of 015° magnetic and still homing on the same station which he thought was the Damascus NDB. At this time he said that he suspected that this radio bearing might be in error. He tried to tune his ADF's to Beirut NDB and Baghdad NDB but was only able to identify Beirut without obtaining a bearing. Many calls were made on the VHF but no replies were received. An emergency was then declared. When the pilot realized that he was lost and was planning an emergency landing, he sighted a river (the Euphrates) and decided to follow it eastbound. After 15 minutes flight a large town was sighted and the pilot decided to land there. An emergency wheels-up landing was carried out approximately 5 miles north-northeast of Deir-ez-Zor at 2010 GMT

Investigation and Evidence

No technical examination of the wreckage was made.

Adequacy of Ground Facilities

a) At Jedda, the point of departure, the facilities are considered adequate. After leaving a point abeam and 62 nautical miles west of Medina no radio facilities exist for a distance of approximately 500 n. m. until a point is reached abeam and 30 n. m. east of Amman.

It should be noted that the Amman NDB is usually weak, and the LUD NDB is generally reported strong and reliable.

b) For approximately 600 n. m. after leaving Jedda the pilot must rely on DR (dead reckoning) navigation and under the weather conditions described in the co-pilot's report for the flight in question it is considered that for this part of the flight the navigational aids were not adequate.

c) From Amman to Damascus, a distance of approximately 85 n. m., the navigational aids are considered adequate.

Navigational Procedures and Actions of Pilot-in-Command

From information and details received from the pilot during questioning and discussions which took place at the enquiry, the flight was reconstructed and plotted on Figure 19.

In addition to the information under "Circumstances" and with reference to Figure

19 the Commission considered that the course flown by the pilot to the point abeam Amman was routine and is acceptable.

When passing abeam Amman the pilot carried out a track and distance check on Amman NDB which indicated to him that he was within 10 minutes of his ETA and assumed he was on track, but was experiencing a strong headwind. He evidently did not consider the possibility that he might be at a considerable distance from the station rather than having a strong headwind, either one of which could be the indicated results with this type of check.

The pilot, satisfied that the flight was proceeding normally, tuned both his ADF's on what he assumed to be Damascus NDB (DS). This showed a QDM of 015° magnetic at this point. The pilot altered course to the right and proceeded to home on this QDM.

The subsequent course of the aircraft and the actual point of the forced landing as shown clearly on the map proved that this alteration of course was an error on the part of the pilot.

When the pilot made his track and distance check on his ETA Amman and believing that the wind was north-northwest at a high velocity with the knowledge that he was east of Amman and with only 85 n.m. to go before reaching Damascus, he elected to alter course towards the east making this decision only on the indication of the one bearing given by the ADF which he assumed to be DS NDB. Knowing he was already east of Amman with the assumed north-northwest winds would have required the aircraft to be west of Amman (see Figure 19) to justify homing on this heading to reach Damascus. Therefore, it is considered that the pilot was decidedly remiss in not double checking his position before altering his course to 015° when he did.

Probable Cause

The probable cause of the accident was inadequate navigational procedure on the part of the pilot.

Recommendation

It is recommended that the airline concerned ensure that its aircrews follow adequate flight procedures when navigating extensive areas not equipped with suitable navigational ground aids.

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ICAO Ref.: AR/479

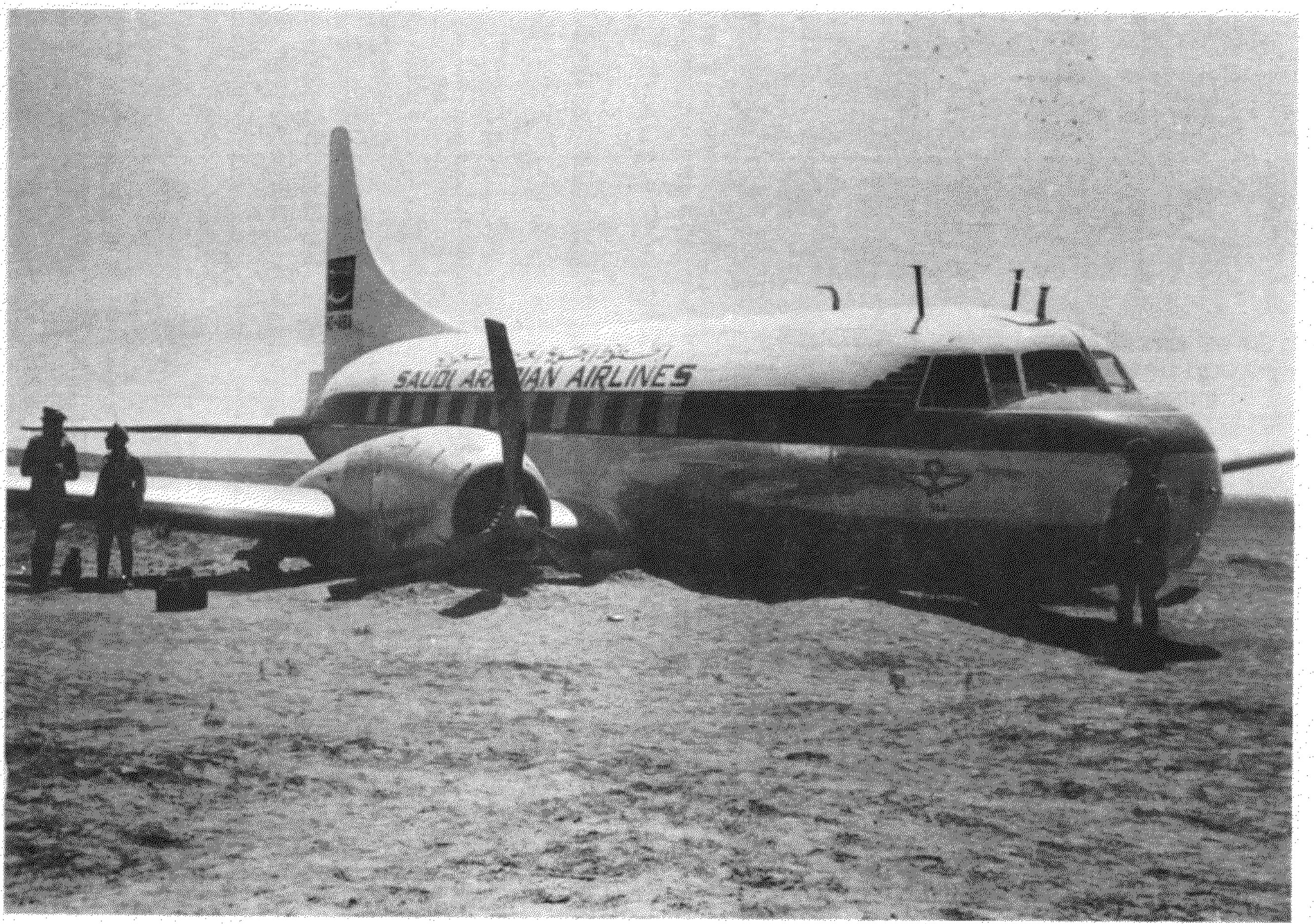
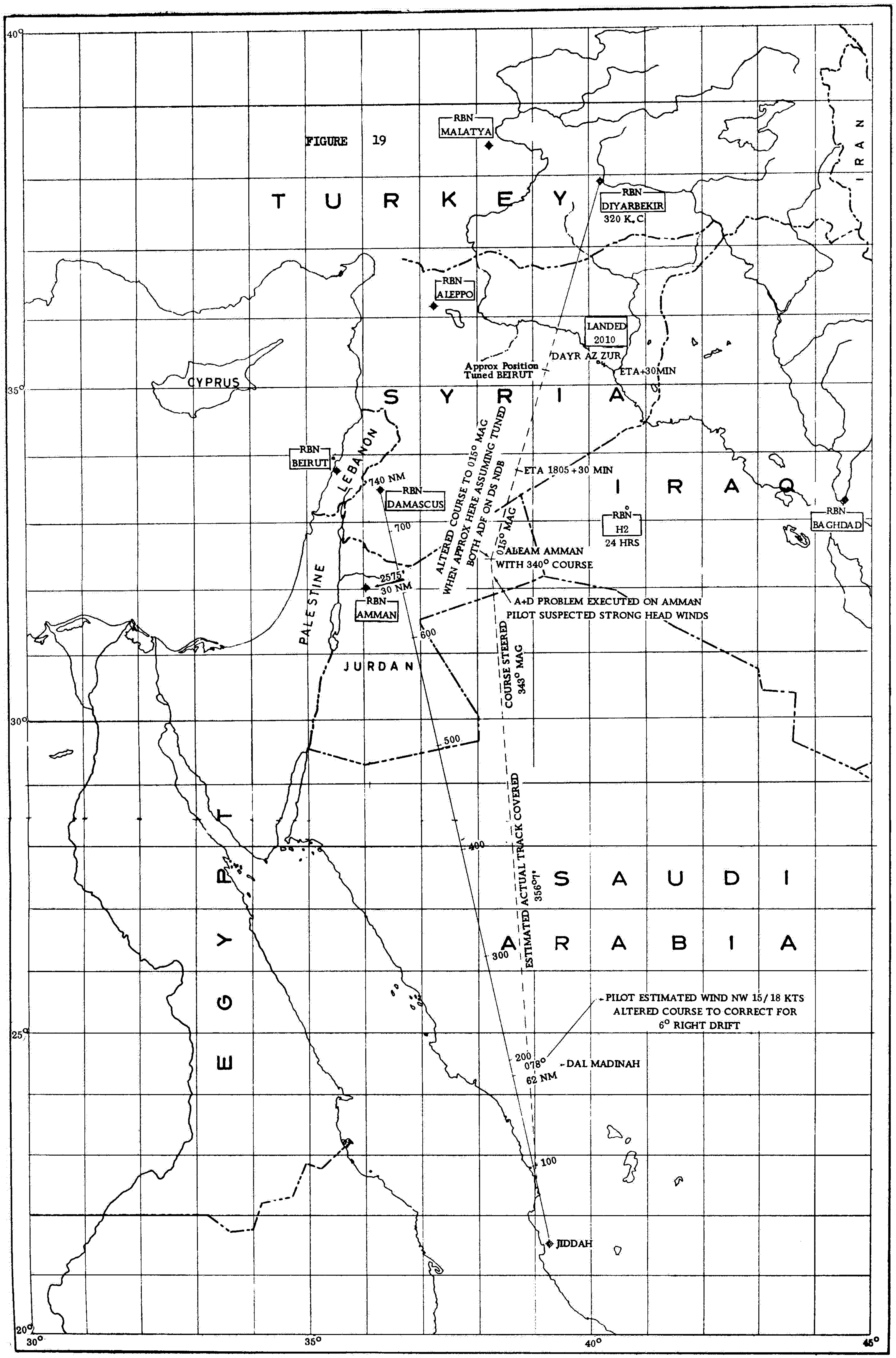


Figure 18

General view of Saudi Arabian aircraft, HZ-ABA which made a forced landing at Deir-ez-Zor on 27 July 1956

FIGURE 19


40°
35°
30°
25°
20°
30°
35°
40°
45°
RBN
MALATYA
TURKEY
RBN
DIYARBEKIR
320 K.C
RBN
ALEPPO
LANDED
2010
DAYR AZ ZUR
ETA+30MIN
Approx Position
Tuned BEIRUT
CYPRUS
SYRIA
RBN
BEIRUT
LEBANON
740 NM
RBN
DAMASCUS
ALTERED COURSE TO 015° MAG
WHEN APPROX HERE ASSUMING TUNED
BOTH ADF ON DS NDB
ETA 1805 + 30 MIN
IRAQ
RBN
H2
24 HRS
RBN
BAGHDAD
IRAN
700
015° MAG
ABEAM AMMAN
WITH 340° COURSE
257°
30 NM
RBN
AMMAN
A+D PROBLEM EXECUTED ON AMMAN
PILOT SUSPECTED STRONG HEAD WINDS
PALESTINE
600
JURDAN
COURSE STEERED
343° MAG
500
EGYPT
400
ESTIMATED ACTUAL TRACK COVERED
356°T
SAUDI
ARABIA
300
PILOT ESTIMATED WIND NW 15/18 KTS
ALTERED COURSE TO CORRECT FOR
6° RIGHT DRIFT
200
078°
62 NM
DAL MADINAH
100
JIDDAH

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No. 26

Canadian Pacific Airlines, Ltd., Douglas DC-6B, CF-CUP, crashed following a missed approach at Cold Bay Airport, Cold Bay, Alaska on 29 August 1956. Civil Aeronautics Board (USA) Accident Investigation Report SA-321, File No. F109-56 released 9 May 1957

Circumstances

Flight 307 departed Vancouver, British Columbia at 1347* hours Bering standard time en route to Hong Kong, China, with a refueling stop at Cold Bay, Alaska and an intermediate stop at Tokyo, Japan, carrying a crew of 8 and 14 passengers. At 2011 the flight reported 100 miles out, estimating Cold Bay at 2036. It reported being over the Cold Bay range station outbound on a standard instrument approach at 2035, and at 2042 as completing a procedure turn and proceeding inbound. This was the last transmission from the flight. At 2045 the aircraft was observed to descend from the overcast north of the airport for a landing on runway 14 and cross the field at low altitude to the intersection of the two runways. At this point a shallow left turn was started and the aircraft went out of sight southeast of the airport. Shortly afterwards a fire was observed and it was ascertained that the aircraft had crashed. Eleven passengers and 4 crew members were fatally injured. The aircraft was destroyed by impact and fire.

Investigation and Evidence

Examination of the wreckage and ground marks disclosed that the aircraft first struck the ground at an elevation of 10 feet on a heading of approximately 40 degrees magnetic and 4 300 feet east-southeast of the approach end of runway 26. The physical evidence indicates that at the time of impact the aircraft was descending in a slightly nose-down attitude with the left wing down about 15 degrees. Computed ground speed at impact was approximately 186 knots.

There was no indication of inflight structural failure or malfunction of the engines, propellers, or their related accessories. Examination revealed that the blades of all propellers were at a blade angle of approximately 40 degrees and that the engines were operating at an average speed of 2 460 r.p.m. at the time of impact. Computations show that each of the four engines was delivering approximately 1 385 horsepower at impact, which is slightly more than cruise power. Landing gear and flaps were determined to be in the retracted position at the time of impact.

The Canadian Pacific Operations Manual specifies that in the case of a missed approach, METO (maximum except take-off) power is applied, the gear is retracted, and the flaps are retracted to 20 degrees for the climbout. METO power of the aircraft involved was 1 900 h.p. and 2 600 r.p.m.

Ground witnesses testified that the aircraft, during its pass over runway 14, was flying at an estimated altitude of 100 - 200 feet above the ground, with the landing gear down, and landing lights on.

The company dispatcher, standing on the ramp east of runway 14, observed Flight 307 break out of the overcast, appear to be making a landing, and then he heard power applied. He next observed the aircraft turn to the southeast over the intersection of runways 14 and 26 in a shallow climb from its estimated height over the runway of 50 to 75 feet. The dispatcher held a microphone for VHF radio contacts with the flight and was on the point of asking if the pilot wanted the lights switched to runway 26 when he saw fire at ground level.

The surviving stewardess testified that she saw the runway lights a short time before the crash. None of the crew survivors recalled any aircraft operating difficulties prior to the impact. One flight crew member, who was resting in a crew sleeping compartment at the time of the accident stated that the approach from over the range station did not seem as smooth as usual, the power was changed frequently during the descent, and that the power applied for a missed approach seemed less than normal. He also said that he thought there was a feeling of "sink" just before the ground contact. The duty navigator stated that when power was being applied over runway 14 he observed a reading of 160 feet on his altimeter. This altimeter was set at 29.92 inches, which produced a reading approximately 30 feet higher than true.

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* 1747 Pacific daylight time

The Cold Bay Airport is located on the Alaskan Peninsula, 572 miles southwest of Anchorage, Alaska. Its elevation is 93 feet. The two runways are 7 500 and 5 000 feet in length and their intersection is on the south side of the airport. The control tower was not operative and there was no CAA Communications Station available. There were two private air-ground communications stations on the airport operated by Reeve Aleutian Airways and Northwest Orient Airlines. CPA utilized the facilities of Northwest to relay position reports, and to receive traffic clearances, weather information, and local traffic conditions.

Navigational facilities in operation at Cold Bay consisted of a low frequency range without voice, equipped with a VHF station location marker. The range is located 2.2 miles northwest of the airport. A privately owned (Reeve) nondirectional beacon is located off the approach end of runway 14 and is operated on request only. Such a request was not made by Flight 307. The low frequency range was flight-checked following the accident and found to be operating within allowable limits.

The airport is equipped with a rotating beacon and high-intensity runway lights that can be operated on only one runway at a time. During Flight 307's approach, the high-intensity runway lights were lighted on runway 14, as were the high-intensity approach lights to the runway. Runway 14 lights, and all other lights, were reported to have operated normally the evening of 29 August. In the vicinity of the airport, and in the quadrant in which the aircraft was flying when the accident occurred, there were few, if any, lights which would assist in orientation.

The ceiling and visibility landing minima for Canadian Pacific Airlines DC-6 flights at Cold Bay are 400 feet and one mile for straight-in approaches at night, and 500 feet and 1-1/2 miles for circling approaches.

The weather briefing received by the crew of Flight 307 at Vancouver included a forecast for Cold Bay for the period 1200 to 2200, 29 August, as follows: Ceiling 800 feet, overcast; visibility 3 miles; light drizzle and fog; wind west 16; after 2000, ceiling 1 200 feet, overcast; visibility 7 miles; wind northwest 12.

The actual weather en route appears to have been quite close to that forecast at the briefing, with the exception of the lower ceiling at Cold Bay. The 2024 Cold Bay report was: indefinite ceiling, 500 feet, sky obscured; visibility 1-1/2 miles; light drizzle, fog; temperture 47; dewpoint 46; wind west-northwest 21; and altimeter setting 29.89. This report was received by the flight before the arrival at Cold Bay.

It is probable that the intention of the pilot during the approach was to land on runway 14, a straight-in landing from the inbound overheading of the range station. The breakout, after descending through the overcast, may have been too close in and high and these factors, together with excessive groundspeed due to a quartering tailwind, may have caused the captain to decide to go around.

Whether the flight intended to turn and climb to 2 700 feet on the north leg of the Cold Bay range, as the missed-approach procedure prescribes, or to circle under the 500-foot ceiling and land on another runway is not known. However, the company dispatcher, who observed the aircraft and was in radio contact with it, thought the decision was for the latter course.

Considering that very little altitude was gained after the application of power it is probable that a circling approach had been decided upon when the left turn from runway 14 was made.

Since the wing flaps during the circling approach would be extended 20 degrees, and since they were found in the fully retracted position, it is believed that they were retracted shortly before impact. Fully retracted wing flaps at this time would explain the feeling of "sink" experienced by the off-duty flight crew member.

The Board believes that the airspeed of the aircraft at the time the flaps were retracted was approximately 130 to 140 knots. This is supported by several facts. According to company procedure it is normal on the downwind leg of an approach to a runway for the aircraft to fly at an airspeed of approximately 140 knots with wing flaps extended 20 degrees. Since the subject aircraft was in a clean configuration (gear and flaps up) immediately prior to the accident, with a tailwind of approximately 20 knots, it would be reasonable to assume that the speed of the aircraft increased during the final descent. In addition, when the aircraft passed over runway 14 it was in landing configuration. Since only slightly better than cruise power was applied at this time, and as the distance to the point of impact was approximately one mile, it is unlikely that the speed of the aircraft would have been much greater than 140 knots when the flaps were retracted.

It is evident that the aircraft struck the ground while descending in a slight left turn and while all four engines were not operating at the prescribed power settings necessary to execute a missed-approach procedure.

Probable Cause

The probable cause of this accident was the full retraction of the wing flaps at low altitude during a circling approach without necessary corrective action being taken by the crew.

Fire Aspects - Excerpt from NFPA Aviation Bulletin No. 190 dated July 1957.

Following a missed approach at an island refueling stop, this DC-6B crashed and burned in a tidal flat area about 7 200 ft. from the end of a runway. The contact with the ground was at a high rate of speed as the pilot was apparently attempting to "go around" for a second landing attempt (gear and wing flaps having been retracted following the initial missed approach).

The DC-6B literally disintegrated at impact, the wreckage consisting of the following sections: (1) remains of the center section and wings which burned furiously; (2) a small bit of aft fuselage; (3) a small bit of nose; and (4) countless small pieces along the path the aircraft took for a distance of approximately 2 000 feet. An initial flash fire occurred followed by a mushroom topped column of flame which rose to approximately 200 ft. When rescue personnel reached the scene (about 40 volunteers) the center section and wings were still burning and an oil tank exploded during the rescue operations. No fire fighting equipment was available at the site.

Fifteen of the 22 persons aboard perished. Of this number, 14 had no burns and only 1 had minor burns so it is felt that all died of impact injuries. Three of the 7 to escape, escaped unaided and the other 4 were rescued, only 1 having burn injuries. It is clear that this result was largely influenced by the impact disintegration effects. Four of the survivors were in the separated small aft section which was totally clear of the fire area. Three of these got out by themselves through an emergency exit while the fourth was helped out. Two flight crew members were found in ankle deep water along the shore having been thrown out - one sitting and the other standing. Both of these were helped to safety having suffered serious injuries. Another crew member was removed from the small separate piece of nose and this crew member also had been seriously injured. Thirteen of the dead were found along the wreckage path, two or three near the center section; one body was removed from the small nose section and the body of one infant could not be found.

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ICAO Ref.: AR/464

No. 27

Continental Air Lines, DC-3A and Cessna 170-B collided in flight approximately 2 miles southeast of Phillips Airport, Bartlesville, Oklahoma, on 9 September 1956. Civil Aeronautics Board (USA) Accident Investigation Report, File No. 1-0094, released 25 April 1957.

Circumstances

Flight 190 (the DC-3A) was scheduled between El Paso, Texas and Kansas City, Missouri, with planned stops including Tulsa and Bartlesville, Oklahoma. The flight departed Tulsa at 1418 hours central standard time and the trip to Bartlesville was planned and operated in accordance with visual flight rules at an altitude of 2 000 feet. Ten minutes after leaving Tulsa and in the vicinity of Ochelata, Oklahoma, the captain advised his company that the aircraft was in range of Bartlesville and then changed to Bartlesville Radio Frequency as advised. Some time after the captain initiated his first radio call, the first officer began the "in-range" cockpit check, which took approximately 30 seconds. Just as it was completed the collision occurred. At the time of collision, the DC-3 was continuing north and about to enter the downwind leg of the airport traffic pattern on a reciprocal heading to the intended landing on runway 17. (See Figure 20)

The Cessna took off from Dewey, Oklahoma, Hi-Way Airport, 3 miles northeast of Bartlesville Airport, at 1417 hours on a sightseeing trip, carrying the pilot and 4 passengers. The aircraft flew from Dewey to Bartlesville and as it completed a 45-degree right turn to the northwest it collided with the DC-3A at approximately 1432 hours.

Both aircraft landed safely at Bartlesville Airport and there were no injuries to the passengers or crew of either aircraft.

Investigation and Evidence

DC-3 damage

The right aileron lower fabric covering was cut a distance of 13 inches by the propeller of the Cessna. This cut began one-half inch in from the leading edge and extended diagonally inboard toward the trailing edge at an angle of 45 degrees from the lateral axis of the aircraft. This cut also damaged the seventh aileron rib and the spar lower cap. A second cut paralleled the first approximately 1-1/2 inches outboard from it. This cut began about two inches rearward from the inboard end of the first cut and extended in the same direction through the trailing edge cutting both lower and upper surfaces. The fracture of the trailing edge metal strip tore the fabric both top and bottom adjacent to the cut.

The right horizontal stabilizer and elevator were severed diagonally at an angle of 43 degrees with the fore and aft axis, inboard and rearward from the stabilizer tip through the elevator trailing edge. Both surfaces were cut upward and the lower surface of the tip contained red paint similar to that on the propeller hub spinner of the Cessna. The outboard elevator hinge bracket was broken and the lead counterweight was severed upward. The elevator torque tube and four ribs were cut and broken upward. All severed parts were recovered.

Cessna damage

The leading edges of both metal propeller blades were scarred, nicked and abraded, and one tip was curled forward. The propeller hub spinner was crushed and torn and the upper left nose cowl was crushed rearward. The upper left engine cowling was torn free along the centre hinge line and the upper engine baffling on that side was crushed. Sparkplugs from cylinders $N^{os.}$4 and 6 were torn from the cylinders and broken. The right side of the windshield was scuffed and cracked as if struck by the cowling when it left the aircraft. At a point about eight feet outboard from the root, the leading edge of the left wing was flattened somewhat for a distance of 10 inches and there were abrasion marks and scratches sloping inward at an angle of 25 degrees. There was no evidence of fire having occurred in either aircraft.

The impact between the two aircraft occurred about 1 000 feet over the southwest section of Bartlesville. Relatively small severed pieces fell to the ground but caused no injury to persons or damage to property. A group of witnesses on the ground, several with aeronautical experience, observed both aircraft prior to and at the time of collision. The consensus of their observations was that the Cessna was proceeding westward and then turned to the northwest just before the impact, and that the DC-3 was proceeding level laterally and longitudinally almost due north. The statements of the Cessna pilot and the DC-3 crew are in substantial agreement with regard to the headings of both aircraft when the collision occurred. Both pilots gave accurate estimates of their airspeeds at the time.

Computations, using the angles of the propeller cuts on the DC-3 aileron and tail surfaces, the Cessna propeller rpm and diameter, and the furnished airspeeds, produce the following results: Angle of convergence of the two aircraft - 44 degrees; rate of closure - 98 m.p.h. (144 feet per second); viewing angle of Cessna from DC-3 - 52 degrees to the right; viewing angle of DC-3 from Cessna - 84 degrees to the left.

At 1430 hours on 9 September, the altitude of the sun (angular elevation above the horizon) at Phillips Airport was 48 degrees. The azimuth of the sun (measured eastward from zero north) was 229.3 degrees. This placed the sun in front of the Cessna while it was on its westward heading.

The pilot of the Cessna had been visiting friends living in the southwest portion of Bartlesville and the purpose of this trip was to take four children for a short trip over Bartlesville. After taking off from Dewey, the Cessna proceeded about four miles due south and then turned westward at an altitude above the ground of 1 000 - 1 100 feet. According to the pilot, who was in the left front seat, after reaching a point where the home he had been visiting was seen to the right by occupants of the Cessna, a 45-degree turn was made to the northwest. While coming out of this turn, the collision occurred. The Cessna pilot stated that he did not intend to land at Phillips Airport and was not aware that he was nearing the airport traffic pattern. His two-way radio was not turned on. He also stated that the visibility was unlimited and that the sun did not interfere with his vision when on a west heading.

Testimony of the DC-3 flight crew disclosed that shortly after making the in-range report approximately ten miles south of Bartlesville, the co-pilot, seated on the right side, started the in-range cockpit check. This portion of the cockpit checklist consists of seven items, the last being a check of hydraulic fluid which requires that the co-pilot turn left towards the rear of the cockpit in order to see the fluid quantity indicator. The collision occurred at this time. The captain's scope of vision, from his seat on the left, is hampered by the compass and radio installation located over the centre of the instrument panel and at the bottom centre of the windshield. The DC-3 crew also testified that, although the bright sun did not hamper their vision, the form of haze present at low altitudes, coupled with the variegated background of the populated area of Bartlesville over which they were flying, would make it difficult to spot the small, aluminum-coloured aircraft. They were at the correct altitude to enter the downwind leg of the airport traffic pattern.

The airport at Bartlesville is operated by the Phillips Petroleum Company. Local traffic rules stipulate left-hand turns on two patterns - a larger, circular pattern for large aircraft to be flown at 1 000 feet, and a smaller rectangular pattern for small aircraft to be flown at 500 feet, for all aircraft in flight below 1 500 feet above the surface (2 215 feet m.s.l.) within a three-mile radius of the airport. Straight-in approaches may be made, providing Bartlesville Radio is in operation. This airport is classified as uncontrolled, i.e., there is no control tower.

Bartlesville Radio, owned and operated by the Phillips Petroleum Company, is in operation between 0600 and 1800. The radio operator is not licensed by the CAA as an airport traffic control operator - nor is he required to be - and only limited advisory service, to be used at the pilot's discretion, is furnished to flights operating into the airport. The radio room is located on the second floor of the Administration Building and its windows provide visibility on the west, north, and south sides only. It does not serve as a control tower.

It is apparent that the attention of the Cessna pilot was largely directed to his right as he approached over the area of his hosts' and passengers' homes. While the Cessna was proceeding westward, 60 seconds before the collision, the DC-3 was three miles away and about 45 degrees to the left of the forward view from the Cessna. Thirty seconds before the collision, the DC-3 was 1-1/2 miles away at the same bearing. The altitudes of both aircraft could not have differed more than 100-200 feet during this time. Regardless of the sun's position and the reported haze, it seems that regular scanning of the horizon by the Cessna pilot during the last minute or so before the collision would have revealed the DC-3.

This applies equally to the co-pilot of the DC-3 seated in the right-side pilot seat. If 30 seconds, ending at the time of collision, was required to complete the in-range cockpit checklist, there was at least a prior minute when the Cessna would have been visible on a bearing of about 45 degrees to the right and near the altitude of the DC-3. The compass at the bottom centre of the windshield would restrict the captain's field of vision to the right but a small movement of his body to either side would again place this area in his view. It is possible that the Cessna was in this sector during the minute or so before the collision. Other than the cockpit check, there were no duties requiring attention inside the aircraft at that time, according to crew testimony.

The Board is of the opinion that the DC-3 flight crew were aware of all restrictions to cockpit visibility and the necessity for continual outside scanning. Such a scanning is necessary even though it requires a break or interruption in cockpit duties. Both aircraft were flying VFR under weather conditions far better than VFR minima. Consequently, the Board believes that the entire responsibility for observing and avoiding other aircraft rested on the pilots of the two aircraft involved in the accident.

Probable Cause

The probable cause of this accident was the failure of the pilots of both aircraft to observe and avoid the other aircraft.

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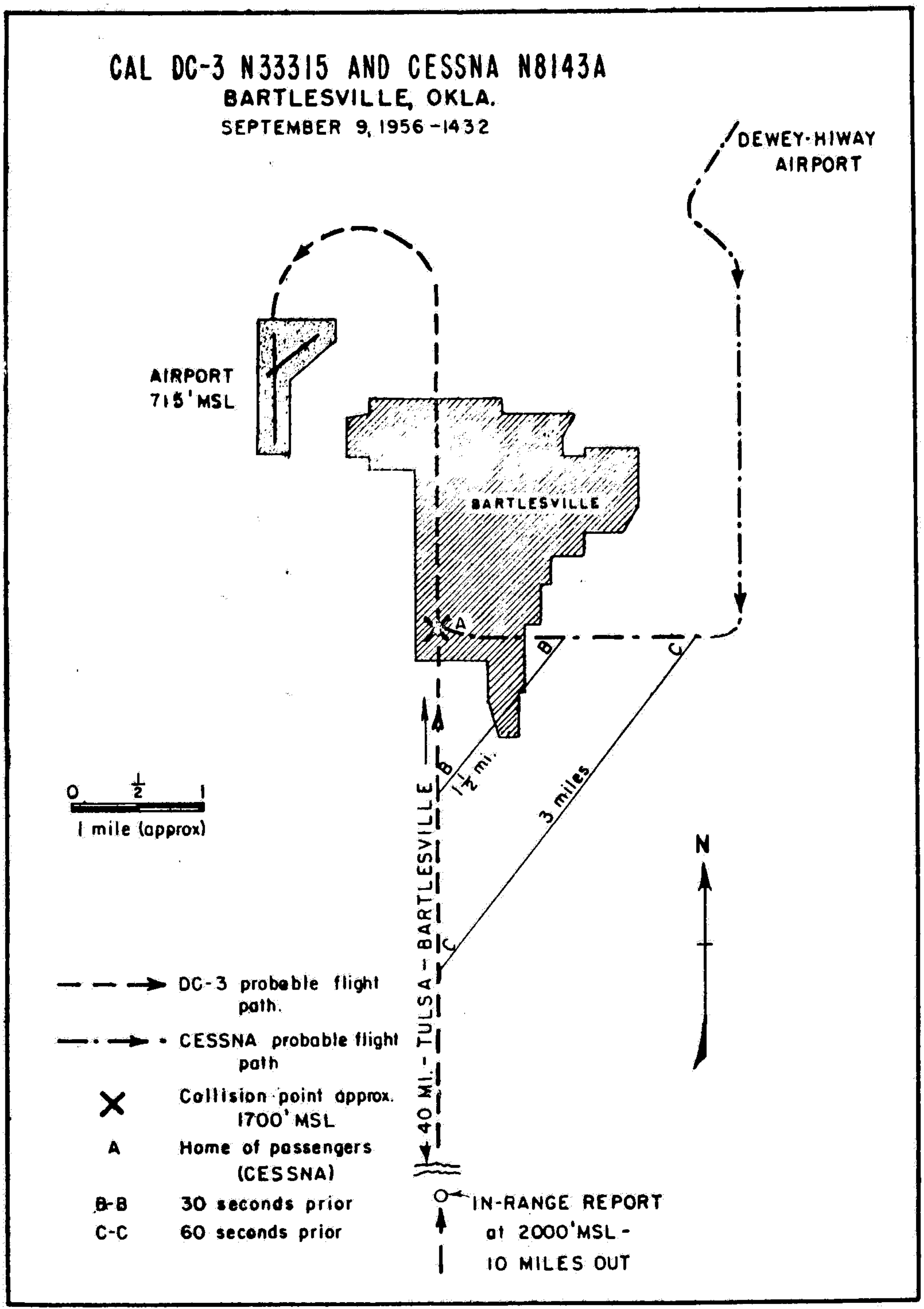
ICAO Ref.: AR/465



COMM-DC-29739

FIGURE 20

No. 28

Alaska Airlines, Inc., Stinson AT-19 crashed during a snowstorm near Nome, Alaska, on 2 October 1956. Civil Aeronautics Board (USA) Accident Investigation Report, File No. 1-0124 released 29 July 1957.

Circumstances

The flight, a scheduled one between Unalakleet and Nome, was restricted to day visual flight rule conditions and had left Unalakleet at 1321 hours Bering standard time. It was routine to Council, the last stop before its final destination, and departed Council at 1745 carrying 4 passengers and the pilot. The estimated flying time from Council to Nome was 40 minutes and the departure time of the flight indicated that it would not be completed before the end of civil twilight, which was of approximately 48 minutes duration, beginning at 1727. After take-off the aircraft was seen taking up a southwesterly heading toward the coastline route over low terrain to Nome. At 2023 as the flight was overdue and unreported, search procedures were initiated. The wreckage was found the following day on Cape Nome, 15 miles east-southeast of Nome. There were no survivors and the aircraft was demolished.

Investigation and Evidence

Initial impact was on level ground at an altitude of 25 feet m.s.l. at the eastern base of a 650-foot ridge of high ground running north and south. The southern end of this ridge is three-tenths of a mile north of the shoreline to which it descends in a steep slope. This ridge lies across the flight path between the point of impact and Nome. The point of impact is within the intersection of airways Amber 1 and Green 7.

The wreckage showed that the aircraft had struck the ground at a downward angle of more than 45 degrees while heading approximately 157 degrees true. The bearing from this point toward Nome is 284 degrees true.

Impact occurred while the left wing was low. A gouge in the ground 12 feet long at right angles to the centreline of the fuselage ended at the left wing. This wing, the nose, and the landing gear which had separated, had absorbed most of the impact forces.

The left wing remained attached to the fuselage by the aileron cables only, the structural attachments having failed in an upward and rearward direction. The aileron, although severely damaged, remained attached to the left wing as did the flap. The left wing tip was demolished by forces which included dragging contact with the ground. The leading edge of the wing was flattened along its length into a plane almost normal to its chordline.

Both fuel tanks, located in the wing butts, were severely buckled and ruptured by impact. Considerable fuel spillage had occurred. Flaps were in the retracted position with controls still connected. The powerplant was completely imbedded in the frozen ground. Gouges in the earth showed that the propeller was rotating at high rpm at impact. The elevator tab was set slightly to trim the nose downward.

Because of severe impact damage the only cockpit control positions that could be determined were: Fuel tank selector on "Right Tank," ignition switch "On Both," radio receiver set at 250 kc. Equipment included a complete set of blind flight instruments with artificial horizon, directional gyro, and bank and turn indicator, all operated from an engine-driven vacuum pump.

All components of the aircraft were accounted for in the wreckage and there was no evidence found to indicate fire, structural failure, or malfunction of equipment in flight.

The U.S. Weather Bureau forecast for the period 1400, 2 October to 0200, 3 October was available to the pilot before his take-off from Nome eastbound and before his take-off from Unalakleet westbound (returning to Nome) at 1321. The forecast for the southern Seward Peninsula (which included the scene of the accident), the remainder of the Koyukuk Valley, and the middle Yukon Valley west of Ruby, was: Ceiling 3 000 and scattered to broken clouds.

On 15 October an aftercast was made by the U.S. Weather Bureau Airport Station at Anchorage, Alaska as follows:

> "AFTERCAST OF WEATHER CONDITIONS IN THE VICINITY OF CAPE NOME, ALASKA, DURING THE AFTERNOON AND EARLY EVENING OF 2 OCTOBER 1956

"The weather maps for October 021830Z, 030030Z, and 030630Z showed an elongated trough of low pressure oriented north-south along a line from Bettles to Anchorage, with a complex low pressure system to the southeast of Kodiak Island. While the trough was moving slowly eastward during the day, a cold front that had passed over the Seward Peninsula the night before was moving southward over southwestern Alaska in the strong northerly flow behind the trough. By evening the front had passed to the south of Bristol Bay.

"The air mass in the vicinity of Cape Nome was cold and unstable, and there was scattered snow shower activity in the area. A study of available evidence indicates that there were broken to scattered clouds with bases at 3 500 to 4 000 feet mean sea level, tops general 6 000 feet, but with occasional cumulus build-up to 10 000 feet. The weather at the scene of the accident could have ranged from the above described condition to as low as 500 feet obscured, one half mile visibility, in moderate snow showers. The surface winds were very likely from the northwest at about 15 m.p.h., but could have been as strong as 25 m.p.h. The freezing level was at the surface, and light icing could have occurred in the clouds. Some low level turbulence undoubtedly existed; this would have resulted from the unstable air mass and the fairly strong low level winds."

On 2 October atmospheric conditions made radio communications difficult and no message was received from the aircraft although it was equipped with two-way radio.

The pilot had logged proposed details of this flight as a (day) VFR flight plan. He was not certificated to fly under instrument flight rules, nor was the company authorized to conduct instrument flight over this route with light aircraft. Also, as far as can be learned, the pilot had had no training or experience with instrument flight.

From Council to Nome along the coast is 74 miles, or 17 miles longer than the direct route. At the planned true cruising airspeed of 90 m.p.h. it would require some 11 minutes more than the direct route. The coastal route could be flown at near sea level whereas the 11 minute shorter direct route passed over rugged terrain. Also, the coastal route offered an occasional ground light.

When the flight departed Council at 1745 the weather there, and reported weather ahead, was above VFR minima. Sunset at Council on that date was at 1719; at Nome it was at 1726. Official civil twilight on that date and for that area lasted from 1727 to 1815. The operations specifications of the air carrier restricted its operation over this route to day only. By definition "day" ends at the end of civil twilight. There was an overcast in the crash area and it is probable that total darkness existed at the time of the crash. This condition is confirmed by a qualified witness who was in the area of the crash at 1745.

The restriction against night or IFR operations contained in the air carrier's operations specifications is provided in order to prevent the type of situation which occurred in this instance. The judgment of the pilot in planning and executing a flight under these circumstances is open to serious question. Having departed Council for Nome so short a time before sunset, he was committed to complete the flight at Nome since the lack of lighting facilities at Council made it impossible to return to his point of departure and no other suitable airports were available along the route for use as alternates.

It appears that the pilot, aware of the failing light, flew directly to the coastline and then proceeded westward along it toward Nome. He may well have seen no evidence of snow showers approaching from the northwest because of the overcast and failing light. As the flight, now in near total darkness, approached Cape Nome snow showers may have been encountered which further reduced visibility. However, the flight continued with the pilot probably attempting to fly contact by reference to the road or coastline. It appears likely that the pilot was not completely sure of his position when he reached a point near the scene of the accident. It is believed that at this time he completely lost visual contact, and without instrument training, lost control and struck the ground in a steep spiral. It is also possible that he had a fleeting glimpse of the ridge while at low altitude and in attempting to avoid it lost control of the aircraft.

Since the only icing conditions mentioned in the aftercast were "... and light icing could have occurred in the clouds" and since the flight was limited to day VFR conditions, it seems improbable that the icing conditions could have contributed to this accident.

Probable Cause

The probable cause of this accident was the action of the pilot in flying into conditions of darkness and adverse weather in which he could not maintain adequate control of the aircraft.

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ICAO Ref: AR/468

No. 29

Pan American World Airways, Inc., Boeing 377, ditched in the Pacific Ocean between Honolulu, Territory of Hawaii and San Francisco, California on 16 October 1956. Civil Aeronautics Board (USA) Accident Investigation Report released 11 July 1957.

Circumstances

Trip 6 of 13 October was a regularly scheduled "around-the-world" flight eastbound from Philadelphia, Pennsylvania to San Francisco, California with en route stops in Europe, Asia and various Pacific Islands. The aircraft departed Honolulu on the last leg of the trip on 15 October at 2026 hours Hawaii standard time, and was cleared to San Francisco Airport via Green Airway 9, then track to position 30°N. 140°W. at 13 000 feet, then 21 000 feet to San Francisco. On board were a crew of 7 and 24 passengers (including 3 infants). The flight was planned IFR and carried enough fuel for 12 hours, 18 minutes. At 0102, the approximate midpoint of the flight, a request for VFR climb to its secondary altitude of 21 000 feet was approved by Air Traffic Control and simultaneously with the reduction of power on completion of the climb, the No. 1 engine oversped. Airspeed was reduced by the use of flaps and reduction of power. It was impossible to control the engine or to feather the propeller and the captain decided to freeze the engine by cutting off the oil supply. Shortly after this was done there was a momentary decrease in the r.p.m., followed by a heavy thud. The propeller continued to windmill. At this time airspeed had slowed to 150 knots and the aircraft was losing altitude at a rate of approximately 1 000 feet per minute.

The captain contacted the U.S. Coast Guard weather station "November" * at 0122, alerted it to a possible ditching, and asked assistance. He also alerted the passengers to the emergency and told them to prepare for a possible water landing.

The flight course was altered to "home in" on station "November" and climb power applied to engines Nos. 2, 3, and 4 to check the rate of descent. At this time it was noticed that No. 4 engine was only developing partial power at full throttle. At 0125 the flight notified "November" that ditching was imminent and received a ditching heading from the cutter. During the descent the crew found they could maintain altitude at an airspeed of 135 knots with rated power on engines Nos. 2 and 3 and the partial power on No. 4. About 0137 the flight overheaded the cutter.

Prior to overheading the cutter the maximum range with the fuel remaining had been computed and it was determined to be insufficient either to complete the flight to San Francisco or return to Honolulu (over 1 000 miles either way). Mortar flares had been fired by the cutter and electric water lights laid to illuminate a track for the aircraft. However, it was decided to postpone the ditching until daylight, if possible, meanwhile remaining close to the cutter.

About 0245 the No. 4 engine backfired and power dropped off. Its propeller was feathered normally. The flight was still able to maintain altitude and continued to orbit "November" to burn the fuel aboard down to a minimum while awaiting daylight.

At 0540 the captain notified the U.S.S. Pontchartrain he was preparing to ditch the aircraft. A foam path was laid along the revised ditching heading of 315° by the cutter and the aircraft was ditched at 0615. Passengers and crew safely evacuated the aircraft, boarded life rafts, and were completely clear of the aircraft at 0632. The aircraft sank at 0635 at position 30°01.5'N. 140°09'W.

Investigation and Evidence

The weather and sea conditions at the time of ditching were as follows:

> wind calm; skies partly cloudy; major swells from 80 degrees, height 3 to 4 feet, speed 24 knots, distance between swells 500 feet; minor swells from 130 degrees, height 2 to 3 feet, speed 13 knots, distance between swells 75 feet; barometer 30.28; sea water temperature 74 degrees F.

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* "November" is a U.S. Ocean Station vessel located approximately midway between the Hawaiian Islands and the west coast of the United States. The U.S. Coast Guard Cutter "PONTCHARTRAIN" was "on station" at the time of ditching.

At 0119 the aircraft was levelled off at 21 000 feet and speed allowed to increase to 188 knots. When the first officer, who was flying the aircraft, called for cruise power he noted a vibration in the controls and an increase in the propeller noise. Upon noticing the tachometer for No. 1 engine reading about 2 900 r. p. m., he immediately depressed the feathering button for that propeller, and then lowered 30 degrees of flaps. The flight engineer actuated the No. 1 fire switch gangbar, closed the No. 1 throttle, and cut the mixture control. He then reduced power on the other three engines.

After several unsuccessful attempts to feather, the captain told the engineer to cut off the oil supply to the engine and to freeze it. This was followed by a momentary decrease in the r. p. m., a heavy thud and an immediate increase again in the propeller speed. They thought this indicated that the engine had frozen; that the propeller uncoupled through a failure in the propeller drive mechanism and was windmilling in the airstream.

Several attempts were made during the remainder of the flight to feather the No. 1 propeller. It was then noted that the tachometer indicated zero and that the circuit breaker in the No. 1 feathering system would not remain closed. The No. 1 oil quantity gauge indicated empty while prior to feathering attempts the quantity had been normal.

The aircraft's position was determined by radar aboard "November" to be approximately 38 miles from the ship on a bearing of 256 degrees.

About 0124 climb power was placed on engines Nos. 2, 3 and 4. No. 4 engine failed to respond with normal power. When full throttle was applied the engine instrument readings were as follows: 2 350 r. p. m.; 80 BMEP; 23 inches manifold pressure; oil and fuel pressures normal; fuel flow was 600 pounds per hour; oil temperature, carburetor air temperature, and cylinder head temperature were lower than normal; turbo supercharger operation appeared normal. There was a slight rise in manifold pressure and in cabin airflow when the No. 4 turbo calibrating control was rotated to the "full on" position. When the crew reduced r. p. m. to 1 750, closed the oil cooler and intercooler, and closed cowl flaps to one-half inch, the BMEP increased to 90 with 26 inches of manifold pressure at the same fuel flow. All patterns on the engine ignition analyzer were normal, oil temperature, carburetor air temperature, and cylinder head temperature increased slightly, and the engine continued to operate.

By this time the aircraft had descended to about 5 000 feet. It was found that this altitude could be maintained at an airspeed of approximately 135 knots with flaps up, rated power on engines Nos. 2 and 3, and the partial power available from No. 4. However, the aircraft was allowed to descend slowly to about 3 000 feet before overheading the cutter.

Prior to overheading "November" the flight had called Honolulu and notified them of the situation. It was also in constant contact with "November" and had received the latest weather, wind, and sea conditions for the probable ditching. The cabin attendants had issued instructions to all passengers to remove eye glasses, shoes, and sharp objects from their pockets, and to put on life jackets. Adult-sized life jackets were improvised for the children. Locations of life rafts were pointed out and several passengers assigned to assist in launching them. All loose gear was stowed in the lower lounge. Passengers were relocated in the safest seats, forward of the tail section (which the captain believed would break off upon landing), and were instructed to bend over with arms clasped around their legs. The children aboard were placed on the floor and held tightly between their parents' feet.

It was found that the r. p. m. of the windmilling propeller could be kept under control if the airspeed was kept below 140 knots (20 knots less than that required for efficient two-engined flight). The range of the aircraft was seriously impaired by the additional drag of the windmilling propeller and necessarily low airspeed. With the remaining fuel aboard, maximum range under these conditions was computed to be 750 miles.

A shuttle pattern had been set up over "November" on the ditching track of 240 degrees during the latter part of the descent. The cutter had laid out a string of electric water lights along the track and was standing by for the rescue.

About 0245 (when No. 4 engine backfired and its power dropped off) an engine analyzer check showed many low resistance shorts and no combustion pattern on the "B" row of cylinders. Engines Nos. 2 and 3 at this time were maintaining the aircraft at 2 000 feet at an airspeed of 140 knots, with 2 550 r.p.m., 190 BMEP, and 2 000 pounds per hour fuel flow.

As the fuel weight burned off the aircraft was allowed to climb to about 5 000 feet, where several practice approaches were made to determine the controllability of the aircraft at low speeds.

As daylight arrived Coast Guard personnel removed the water lights and requested that they be notified 10 minutes prior to the time when the flight intended to ditch.

At 0540 the captain notified the cutter of the intended ditching time, notified the passengers to take their ditching positions as instructed and then descended to 900 feet to establish a landing pattern. A final warning was given to the passengers one minute before landing.

Touchdown was made at 0615 with full flaps at a speed of 90 knots with the landing gear retracted. First contact with the water was slight, followed almost immediately by a tremendous impact. The aircraft was partially driven under water but bobbed quickly to the surface and stopped with very little forward travel.

As anticipated, the fuselage broke off aft of the main cabin door. After the aircraft stopped, members of the crew and the passengers assigned to assist removed the emergency doors. Two 20-man life rafts were launched through the emergency exits over the wing and one raft was launched through the main cabin door. All occupants then evacuated the aircraft successfully through these exits. The life raft that had been launched from the main cabin door was trapped against the wing and fuselage by the broken tail section, which had swung to the left. The raft launched between Nos. 1 and 2 engines did not inflate properly and filled with water while it was being pulled clear by a Coast Guard rescue launch. All of the occupants of this raft were immediately transferred to the rescue boat. The remaining passengers and crew, who evacuated the aircraft on the starboard side, were then transferred from the raft to the cutter Pontchartrain. The aircraft sank three minutes later.

Since there was no opportunity to examine the aircraft engines and propellers, an analysis must be based on the most logical conclusions drawn by experience and knowledge from the evidence available.

No discrepancies were noted in any of the records of the aircraft.

The Board is of the opinion that two separate and unrelated mechanical malfunctions occurred during this flight and the relationship of each failure to the accident should be treated separately.

The aircraft was powered by four Pratt and Whitney R4360-B6 engines and equipped with Hamilton Standard, model 24260, propellers. The initial difficulty encountered resulted in the overspeed of No. 1 engine and inability to feather its propeller. Engine r.p.m. is normally maintained by engine oil at boosted pressure which is directed by the propeller governor to either side of a piston in the propeller dome. Movement of this piston changes propeller blade angle to maintain the desired r.p.m. Feathering is normally accomplished by auxiliary pump oil taken from the engine oil supply tank and directed by the governor through passages used for r.p.m. control to the outboard side of the piston. Consequently, a portion of the governor and the increased pitch side of the dome piston are common to both feathering and constant speed operation. It is considered most likely that the inability to feather was caused by the same malfunction which resulted in the original overspeed. If the auxiliary pump had failed there would have to have been a second near-simultaneous failure in the propeller system. This possibility is considered to be remote. Furthermore, depletion of the oil supply from the No. 1 tank, subsequent to the overspeed, with no external signs of leakage, is most logically attributed to operation of the auxiliary pump during attempts to feather following the stoppage of the engine by freezing.

The most likely causes of the overspeed and inability to feather are that oil was being misdirected at the governor pilot valve or that there was insufficient oil pressure at the dome piston. Improper direction of the oil would involve governor malfunctions, caused either by a fault within the unit itself or by contaminated oil being supplied to the governor.

Contaminated oil would indicate some failure within the engine which would most likely be of a progressive nature. No such failure was evident to the crew prior to the overspeed. Insufficient oil pressure at the dome piston is most generally due to excessive leakage. Leakage usually involves seals, passages, transfer tubes, or bearings in the propeller, propeller control, or the engine.

The Board believes that a single failure occurred which affected the portion of the system common to the constant speed and feathering portion of the propeller control system. Oil was being delivered to the system by the feathering pump and then dumped into the engine. A more specific reason for the overspeed cannot be determined.

Subsequent to this accident PAWA Pacific-Alaska Division experienced two uncontrollable engine overspeeds and inability to feather propellers due to failure of the propeller oil transfer bearing. A redesigned propeller oil transfer bearing has been provided by the manufacturer and its use was made mandatory by CAA Airworthiness Directive issued 25 March 1957.

From the information available concerning the No. 4 engine, it would appear that the initial power loss resulted from a reduction of the airflow through the carburetor. Fuel to the engine is metered by the carburetor in proportion to the air mass flow through the throttle body. Engine instrument readings reported by the crew indicate oil and fuel pressures were normal but that temperature indications and fuel flow were low. Turbo supercharger responses indicated that that system was at least partially operating. These conditions could result from an obstruction caused by a deformation or partial breakup and displacement of the carburetor inlet air duct system, or a failure of the engine-driven impeller drive assembly. Although the first possibility cannot be completely discounted, the latter appears to be more probable.

PAWA records indicate three engine-driven impeller drive failures on like engines prior to this accident. The BMEP and manifold pressure readings, taken subsequent to one of these failures, were almost identical to those on No. 4 engine in this accident. Also, in the prior engine failure the crew reported light backfiring approximately one minute after the impeller drive failure and the propeller was feathered immediately. In the subject accident the engine continued to run at reduced power for some time before backfiring commenced. Then, indications of many low-resistance shorts and the lack of combustion pattern on the "B" row of cylinders were observed on the engine analyzer. This evidence is not inconsistent with an impeller drive failure. With the failure of the impeller drive assembly, impeller rotation would stop thus reducing the airflow which in turn would reduce the fuel flow. Turbo supercharger air and normal engine breathing would provide a limited combustible air-fuel mixture to the cylinders; however, distribution of the mixture to the cylinders would be impaired. It is believed, therefore, that all of the indications reported by the crew of Flight 6 could result from the engine-driven impeller drive assembly failure.

Following these failures, the basic design of the Pratt and Whitney R-4360-B6 impeller drive was re-evaluated by the manufacturer and the CAA. No design deficiency was found to exist and it was concluded that this type of failure is not chronic with this model engine. As a result of this study, the Board concluded that the design of the impeller drive is adequate and that no corrective measures are necessary.

Required fuel for the subject flight was computed on the basis of two-engine operation; therefore, only if the crew had been able to feather the No. 1 propeller and maintain the most efficient two-engine airspeed (165 knots) could it have reached land.

Data received from Hamilton Standard and Boeing, and derived from calculation and tests of the subject type propeller, indicate that the drag resulting from this propeller with the blades on the low pitch stops, 21.3 degrees, at 145 knots, 2 000 feet m.s.l., would be:

a.	Uncoupled windmilling	520 lbs.
b.	Coupled windmilling	1,880 "
c.	Frozen	2,320 "

The additional power necessary to compensate for the additional drag in each of the above conditions is:

		(Brake Horsepower)
a.	520 lbs.	295 BHP
b.	1,880 "	1,060 "
c.	2,320 "	1,380 "

Since drag resulting from these conditions varies as the square of the velocity, it is evident that exceedingly higher drag forces would be encountered at speeds greater than 145 knots.

This drag information is extremely important because prior to the investigation of this accident it was not widely known. In fact, it is believed, many thought that the drag with the propeller windmilling and coupled was greater than that with the engine and propeller frozen, whereas the drag condition is greatest with the engine and propeller rotation stopped. It is noted, however, that the above data apply only to the subject aircraft and propellers.

The Board highly commends the crew members for their ability in recognizing the malfunctions and taking correct emergency actions consistent with all known procedures. Their calm and efficient control of the situation averted what could have been a major air disaster.

In addition, the prompt response by the Coast Guard to the emergency and the immeasurable assistance rendered to the flight are deserving of particular praise.

Probable Cause

The probable cause of this accident was an initial mechanical failure which precluded feathering the No. 1 propeller and a subsequent mechanical failure which resulted in a complete loss of power from the No. 4 engine, the effects of which necessitated a ditching.

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ICAO Ref: AR/469

No. 30

Britavia Limited, Hermes G-ALDJ, crashed while approaching to land at Blackbushe Airport on 5 November 1956. Report by Ministry of Transport and Civil Aviation (UK) C.A.P. 144

Circumstances

The aircraft was flying under charter to the Air Ministry and had flown from Idris Airport, Tripoli with a crew of 6 and 74 passengers, nearly all members of servicemen's families. Shortly before midnight, on landing at Blackbushe in poor visibility, the aircraft undershot the runway, hit a beech tree 3 617 feet short of the threshold, swung sharply to port, came down among pine trees about 3 000 feet from the beech tree and caught fire. Three crew members were killed by the impact and four children lost their lives due to fire.

Investigation and Evidence

The aircraft left Blackbushe at 0130 hours Greenwich Mean Time on 4 November on a flight to Malta, Cyprus and Tripoli. It was expected to return direct from Tripoli to Blackbushe during the afternoon of 5 November. A fresh crew took over the aircraft in Malta and it was planned that this crew should have a 12 hour rest period in Tripoli before returning to Blackbushe. Due to unforeseen delays the aircraft arrived at Tripoli about 5 hours late and the rest period before departure was reduced to about 10 hours. The aircraft took off from Idris (Tripoli) at 1525. The flight to Blackbushe was uneventful until very near the end. There is no direct evidence that the captain or any other member of the crew was exceptionally fatigued. The flight engineer said in evidence that he felt tired and strained but it was hard to say whether he felt more tired than usual after such a trip. The captain spoke to him often in the course of the flight and seemed quite normal and there was nothing to indicate that he was exceptionally tired. The steward said that he spoke to the captain about a quarter of an hour before the accident and the captain seemed perfectly normal though he did look tired and may have remarked that he was tired.

The question arises why the captain elected to leave Idris after a rest period (even assuming that all the time at Idris can be counted as rest) of only 10 hours following the duty period of over 19 hours. There is no evidence that he was in any way pressed to leave, though it is only natural to assume that both he and the R.A.F. authorities were anxious that the evacuation should not be delayed. Moreover, the captain probably took the view, shared by all three survivors who gave evidence, that a longer stay offered little prospect of real rest.

The rules laid down by Britavia in their Operations Manual with regard to the periods of duty and of rest are as follows:-

> "1. No air crew member of the Company's staff shall accumulate more than 120 flying hours in any one period of 30 consecutive days.
>
> 2. Normal duty hours will not be scheduled to exceed 16 hours except in cases where a higher fatigue factor would result e.g. unsuitable night stop facilities etc. In these cases only duty hours of up to 20 hours are permissible at Captain's discretion.
>
> 3. The minimum rest period following a 16 hour duty is 12 hours. The minimum rest period following a 20 hour duty is 16 hours or pro rata."

The crew had had over 19 hours on duty (including nearly 13-1/2 flying hours) on the 4th/5th November and something between 8 and 12 hours on duty (including about 8 flying hours) on the afternoon and evening of the 5th. The rest between these two periods of duty had been not more than about 10 hours spent in unhappy conditions at Idris. There can be no doubt that the crew were tired, but it does not necessarily follow that this caused the accident.

The flying hours of the crew in the 30 days before the accident did not total more than 80 hours so that provision (1) above was complied with. From details given in evidence it is clear that in the 30 days in question there had been some long periods of duty interspersed with periods of several days rest. There was no suggestion in the evidence that the crew were not quite fresh and in good health on the morning of 4 November. As to (2) duty hours did exceed 16 on 4 and 5 November, but they did not exceed 20. As there were no night stop facilities at Nicosia the long period of duty was within the limit allowed by this paragraph. As to (3) since the duty period had been 19 hours, the rest period required was at least 15. This paragraph unlike paragraph (2) does not expressly leave any discretion to the captain. The Operations Manager and the Air Superintendent of Britavia both said in evidence that under abnormal circumstances they would expect the captain to exercise his discretion under (3) as under (2). This is certainly not made clear by the manual but as this is the view taken by the Company, the captain cannot be blamed for not adhering to the letter of the printed instructions.

Blackbushe Airport has a datum level of 329 feet above sea level. The runway with which the report is concerned lies roughly East and West and when approached from the western end is known as runway 08. It is a concrete runway about 6 000 feet long. The main London - Southampton road lies at a small angle with the extended runway, the intersection being about 2 000 feet west of the threshold. The beech tree previously mentioned is on the edge of the extended runway 3 617 feet from the threshold and with its top (before the accident) about 59 feet above the threshold level. (It was well below the 1 in 50 "approach surface" recommended by ICAO). On the north side of the extended runway are plantations of pine trees intersected by fire breaks.

The runway has the ordinary white runway lights along each side. The system consists of alternate high intensity and low intensity lights and these were all on at their full brilliance on the night in question. Across the threshold there is a high intensity bar and a low intensity bar of green lights, both of which were on. Extending back from the threshold is a line of 5 approach lights 300 feet apart so that the first approach light from the point of view of an approaching aircraft is 1 500 feet from the threshold. These are composite lights made up of a high intensity white light beamed upwards and away from the runway and a low intensity red light. The white lights can be set to full intensity or a reduced intensity. They are usually set to the reduced intensity at night and the evidence was that they were so set on the night in question. There is a sodium light on each side of the runway about 60 yards from the threshold and there are the usual red obstruction lights marking various objects around the airfield. The beech tree was not marked by a light as it did not constitute an obstruction within ICAO recommendations.

The system of approach lights is of a much less elaborate kind than is specified in Annex 14 (ICAO) for an approach lighting system and does not comply with the provision of that Annex in relation to a lead-in lighting system that the lights shall be not more than 200 feet apart. It is clear from the foreword to that Annex that none of these standards is applicable to installations commenced before 1 April 1954 (as Blackbushe was) and it is clear from the supplement to the Annex that the United Kingdom may use a wider spacing than that laid down in the Annex. The Council of ICAO has, however, urged Contracting States to take early action to bring all approach lighting or lead-in lighting systems into conformity with the international standards now adopted.

The weather conditions at Blackbushe at the time of the accident were as follows:-

> cloudless, poor visibility, light surface wind of 2 or 3 knots from the west, i.e. a tail wind for an aircraft approaching runway 08, visibility on the ground was 1.1 nautical miles at 2200, 1 500 yards at 2230, 1 000 yards at 2301 and 900 yards at 2330. Immediately after the accident an observation was taken at 2356 and showed a visibility of 900 yards except to the southeast where it was 700 yards. The pilot of another aircraft who made an approach

to Blackbushe only a few minutes behind G-ALDJ saw the airport lights from about 10 miles away and could distinguish the runway lights at 3 or 4 miles. He came down to a height of 600 feet and saw no mist or fog.

Arrangements have been made at Blackbushe for the ascertaining of Runway Visual Range i.e. the distance along the runway that a pilot should be able to see the runway lights at the point of touchdown. The method depends on a line of goose-neck flares situated on the south side of the runway which are observed from an observation point just north of the runway. The observer notes how many flares he can see, multiplies the figure by 100 and so obtains the R.V.R. in yards.

The positions for the flares were computed by the Meteorological Office who were informed that the runway lights at Blackbushe were of the same strength as at Northolt. After the accident, tests were made at Blackbushe which disclosed that the system did not give an accurate result. This was partly due to the flares not having been placed quite accurately in the positions recommended by the Meteorological Office and partly to some other factor which has not been ascertained. Possible explanations put forward in the evidence were that the runway lights at Blackbushe might have recently diminished in intensity because of a reduced power output at the runway lights, or that the beaming of the runway lights might have been altered. At any rate the effect of the discrepancy was that an observer would over-estimate the R.V.R. and the discovery of this since the accident is accepted by the M.T.C.A. as showing the necessity for periodical checks at each aerodrome where the system is in use.

The observer on the night of the accident took observations from about 2325 up to shortly before the accident and found that the number of flares he could see was at first 4, then 5, then 7 and then 12. The number then remained steady at 12. Thus, on his reports to the Control Tower, the R.V.R. at the time when G-ALDJ was making its approach was given as 1 200 yards whereas on account of the discrepancy mentioned in the last paragraph it should have been 920 yards. The improvement in visibility along the runway observed by this witness finds no parallel in other visibility observations and is an indication that there was probably patchy and shifting mist or fog which made visibility variable and uneven. The error involved in giving the pilot the figure of 1 200 yards instead of 920 yards is of no great significance since the important thing for him was to know that the R.V.R. was above the new company minimum of 800 yards. It should also be made clear that R.V.R. relates to vision along the ground and is no criterion of the distance at which lights can be seen from the air.

The landing aids provided at runway 08 at Blackbushe are Ground Controlled Approach and Instrument Landing System. GCA was available but not without some delay and was not in fact used. ILS was in operation and there is every reason to believe that the captain was using it.

The ILS system depends on two transmitters of radio energy stationed on the airfield. The first is called a "localiser transmitter" and sends out an indication of the centre line of the runway. The second is called a "glide path transmitter" and sends out an indication of the glide path, a notional path vertically above the line of the runway and sloping down at an angle of 3 degrees with the horizontal to a point 20 feet above the runway and 875 feet along the runway from the threshold. The Hermes is fitted with ILS receivers and indicators. There are two indicators, one for the pilot and one for the copilot. The function of each receiver is to pick up the energy radiated by one of the transmitters and pass an impulse to the indicators. Each indicator then shows by the movements of two needles whether or not the aircraft is on or off the centre line of the runway or the glide path as the case may be.

The glide path transmitter was in working order and in operation at the time of the accident. The receivers and the pilot's indicator were so much damaged by the accident that there is no direct evidence as to their condition but at least there is nothing to suggest that they were not working properly. Assuming that they were, if the aircraft left the glide path the needle on the indicator would move from a horizontal position, reaching the full extent of its swing ("five dots") when the aircraft was about half a degree off the glide path (measured from the transmitter). If the needle was deflected to its full extent the pilot would know if he looked at the indicator that he was considerably off the glide path. If there were a failure of any part of the equipment in the aircraft or on the ground, a small red flag would appear on the face of the indicator. Over the beech tree which the aircraft struck the 3 degrees glide path was at a height of about 197 feet above the top of the tree and the maximum divergence of the needle would be obtained when the aircraft was about 100 feet (or allowing for acceptable instrumental error say 120 feet) lower than this.

The ILS transmitters are checked daily and the beacons are checked weekly; all were found to be in order both before and after the accident.

The following are excerpts from the messages recorded between the aircraft and Blackbushe Airport:

2335 from the aircraft	- I am descending to join Blackbushe beacon 2 000 feet E. T. A. Four zero (2340 hours)
to	- . . . runway visual range now 400 yards
to	- G. C. A. on thirty minute call at the moment
2336 to	- . . . cleared to the beacon at 2 000 feet. No delay expected to your approach . . . London runway visual range just received two eight right 700 yards and two eight left nil . . . Blackbushe actual weather for 2330 was 270 2 knots 900 yards in fog with sky clear.
2338 to	- . . runway visual range now 600 yards on zero eight
2339 to	- . . . runway visual range now passed as 1 000 yards
2340 from	- Could you give me the QNH please
to	- The QFE 1021 millibars
to	- . . you will be landing probably if any tail wind at all it'll be about 270 to 290 at about one or two knots
2341 to	- confirm you are westbound now
from	- negative, we're doing a racetrack now I'll give you a call westbound over beacon
2342 to	- runway visual range now 1 200 yards
2344 from	- just passed over the beacon at 2 000 feet and westbound
to	- clear descend to 1 500 feet on the QFE 1021 advise completion procedure turn
2346 from	- turn complete inbound 1 500 feet
to	- advise over the outer marker for information the visibility still holding 1 200 yards range on the runway

2349 from	- outer marker
to	- clear to continue descent and clear to land wind indicating 290 about two knots
2350 from	- we've got the runway lead-in lights in sight (it is calculated that at this time he was a little over two miles from the threshold and therefore about 2 miles or a little less from the outermost approach light).
to	- clear to land wind 290 now almost indicating calm mostly one to two knots
2351 from	- Juliet This was the last message from the aircraft. It was clear from the evidence of the Air Traffic Controller that this was merely acknowledgement and not an interrupted message. It will be observed that there is no indication that up to this time the pilot felt himself to be in any difficulty or danger. Other evidence shows that the aircraft had crashed to the ground with a sound of explosion within the next minute and three-quarters.

The only survivor from the aircraft who had any knowledge about the management of the aircraft during the approach was the flight engineer. He had head-phones on and could hear the radio telephone communications and also the inter-com. His story was as follows:-

"We had made a routine descent and the captain called for a field approach check, that is a routine check which I performed and it was satisfactory. I heard the captain tell control that he wanted a GCA approach. I believe he said it would take half an hour before GCA could be available. He said he was going to make his approach on the ILS system. All the necessary checks had been carried out quite some time before reaching the outer marker. We made a descent at 1 800 r.p.m. and 30 inches of boost and he then called for 2 100 r.p.m. and subsequently he called for 2 400 r.p.m. 2 400 r.p.m. is the normal r.p.m. to make an approach. Then he asked for 35 inches of boost, that is also quite normal. He subsequently asked me for 25 inches of boost and then he called for his throttles. Up to that point I was operating the throttles and when he called for his throttles it meant he took over command of them. As soon as he called for his throttles he increased the boost to 30 inches and a few seconds later to 37 inches. A few seconds later I felt the first bump." This bump was the impact with the beech tree. After it the captain turned the control column hard over to raise the port wing and raised the power. There was bumping and crashing and very soon the aircraft came to rest and caught fire

It was not possible to discover from the flight engineer how the various calls upon him fitted in with the R.T. log. The most he could say was that the descent from 4 000 feet to the airfield was at 1 800 r.p.m. and 30 inches of boost. It appears from the R.T. log that this was between 2325 and 2343. The investigator was advised by his assessors that the r.p.m. and boost called for indicate nothing exceptional, except that 25 inches of boost is rather a low figure and would result in a steeper descent than is usual when using ILS. They also advised that the higher rates of boost called for later are not such as to indicate that any emergency action was being taken. The flight engineer said that the captain made no remark during the descent to indicate that he thought anything was wrong with the ILS equipment or with the way that things were going and from his previous experience of the captain he thought that if anything had been wrong the captain would have said so.

It is evident that the aircraft must have been well below the glide path for some appreciable time before striking the tree and no satisfactory explanation was put forward as to why the captain failed to realize this, or if he did realize it why he took no action to gain height. A theory was put forward that the ILS receiver might have failed shortly before the accident. It was, however, clear from evidence that if this occurred the flag would come up on the indicator unless by an extraordinary coincidence the indicator had failed too - and even if it had "the needle would look dead" and the pilot would know that the system was not working properly. The investigator considered this theory and rejected it.

Examination of the beech tree showed that a considerable amount of the top, about 10 feet, was broken off the tree, so that the impact with it must have been quite severe. The initial damage to the port wing was sufficient to cause the aircraft to bank and turn sharply to port and lose height. The engines, propeller, landing gear and flaps were in such a condition and in such positions as to suggest no mechanical failure before the impact. The captain's altimeter was too much damaged for any conclusion to be drawn from it. The first officer's was set to 1023 millibars; the navigator's to 1022 and the engineer officer's to 1023. The fact that all the settings were so close to each other suggests that they were set before the accident at something very close to the figures mentioned. Examination of these altimeters and of the captain's air speed indicator and climb and descent indicator revealed no evidence of failure before the accident in any of these instruments. As to the ILS equipment, again the captain's indicator was damaged beyond useful testing but the first officer's indicator and the control unit were still able to work satisfactorily.

The evidence of the flight engineer as to the engine settings and behaviour of the aircraft point to its having come considerably below the glide path for some appreciable time before the accident rather than to a sudden dive. Either the captain did not realize this or realized it but was not perturbed. Because of the slight tail wind the captain might decide to come in a little lower than usual in order to touch down near the threshold and give himself a longer run along the runway but this could not account for the very low level reached so early. The magnitude of the eventual departure from the glide path was such that if he had realized it he could hardly have been indifferent to it, and the strong probability is, therefore, that he was unaware of it. If he was watching the ILS indicator or the altimeter and if these were working properly (and the altimeter was properly set) they must have given him warning. The same applies to the copilot. What arrangements may have been made between the two for a division of duties is not known. Another pilot who made an approach to Blackbushe only a few minutes behind G-ALDJ said in evidence, "I think it is desirable to have one pilot looking at his instruments solely and the other pilot looking out visually for the runway lights, and that in fact is normal practice in the Airline for which I work". The investigator was informed by his Assessors that other Airlines give instructions that the copilot in addition to maintaining a lookout for the lights should make periodical checks on his altimeter and call out the height shown by it. There was no evidence that Britavia had any such practice and nothing to show to what extent the captain was relying on his first officer for assistance.

The evidence points towards the instruments having been in such a condition as to work properly and it seems improbable that any of them was at fault. If (as seems not unlikely from the altimeters that could be checked) all the altimeters were set at 1023 millibars instead of 1021, this would lead anybody who took the height from his altimeter to believe that the aircraft was about 60 feet higher than it really was. The investigator was advised that it is not unusual for an error of a millibar or two to be made in setting an altimeter and thinks this may well have occurred, but the departure from the glide path was much more than 60 feet; at the beech tree it reached about 197 feet.

A pilot using ILS should not come below a certain "critical height" unless he then has the airfield lights clearly in sight. The critical height laid down by Britavia in its Operations Manual for a Hermes using ILS at Blackbushe is 400 feet. Once a pilot has the aerodrome lights clearly in his sight it is normal practice for him to rely on his vision of these rather than on the ILS indicator, though he should still check his height from time to time by glancing at his altimeter or getting his copilot to do so. The R. T. log indicates that the captain had, or believed he had, the approach lights in sight when he was still about two miles from the threshold. It is likely that very soon after this he would see the runway lights and the threshold lights and he may well have believed that he was getting from them a good indication of his height and direction. He might have had a better indication if there had been at Blackbushe an approach lighting system more in accordance with the latest recommendations of ICAO.

Conceivably the captain was misled by the lights of vehicles on the main London - Southampton road, but it is unlikely that at midnight in November there would be much traffic on the road and in any case these lights would be so different from the aerodrome lights that he could hardly mistake them for more than a moment.

The misty weather with variations in visibility in different directions, and in the same direction within short periods, may have led the captain to draw a wrong inference from the view that he had of the lights. The investigator is advised that the meteorological reports spoken to in evidence are consistent with there being a layer of fog or very low cloud, not very dense and not evenly spread, on or near the ground. This might cause the pilot to see the lights as being further away and at a greater distance below him than they really were. This theory receives no support from the evidence of the pilot who was approaching very soon after G-ALDJ but it is not disposed of by that evidence since that pilot never came below 600 feet at Blackbushe.

It is possible that the accident was caused by a misjudgment which no reasonable care, skill and alertness could have avoided, but after considering the whole of the evidence carefully with his Assessors, the investigator formed the opinion that it is much more probable that the captain did make one or more of the following errors:-

1. failing to set his altimeter accurately when given the QFE by R.T.;
2. giving up reference to his ILS indicator before he had a sufficiently clear view of the lights;
3. not checking his height by glancing at his altimeter.

If the captain was relying on the first officer for guidance about altimeter or indicator readings, the error may have been that of the first officer and not of the captain.

If any of these errors was made, it was probably due at least in part to some loss of alertness brought about by fatigue. The investigator was satisfied by the evidence of the survivors that the officers were not suffering from any extreme degree of fatigue, but they were probably tired enough to make their mental reactions a fraction slower and less accurate than they would normally have been.

The long period of duty on the 4th/5th November was due to a magneto failure not caused by any negligence and to military requirements which nobody could control. The poor accommodation at Idris was the inevitable result of the state of emergency in Tripoli. The period of rest taken there was substantially shorter than that laid down by Britavia and was too short to prepare the captain and crew properly for another eight hours' flight; the captain alone was responsible for the decision to take off without further rest and it is impossible to say that he was to be blamed for his decision or even that it was the wrong decision to take in the circumstances.

Probable Cause

The most probable cause of the accident is that in difficult conditions and while suffering from a degree of fatigue above the normal, the captain, relying on his vision of the airport lights to assess his height, judged his height to be higher than it actually was.

Recommendations

The question of what regulations should be laid down for the government of hours of duty and rest of aircraft crews is one of great importance which has been occupying the attention of the proper authorities for some time. Nothing has emerged in this Inquiry which would enable the investigator to make any recommendation as to the form that such regulations should take. He recommends that if any discretion is to be left to the captain this should be clearly stated.

When an ILS approach is being made (and the same may apply when other aids are in use) the pilot has to make a series of rapid decisions based on a judgment depending on what he has been told by R.T. from the ground, what he can learn from his instruments and what he can see outside the aircraft. He has the assistance of a copilot whose share of the responsibility is such as the pilot thinks fit to give him unless some directions on this matter are given by his employers. Consideration should be given by all operating companies to the question of whether any definite allocation of duties should be laid down so as to reduce the risk of any possible checks on height, direction and speed being omitted as the approach to land is made.

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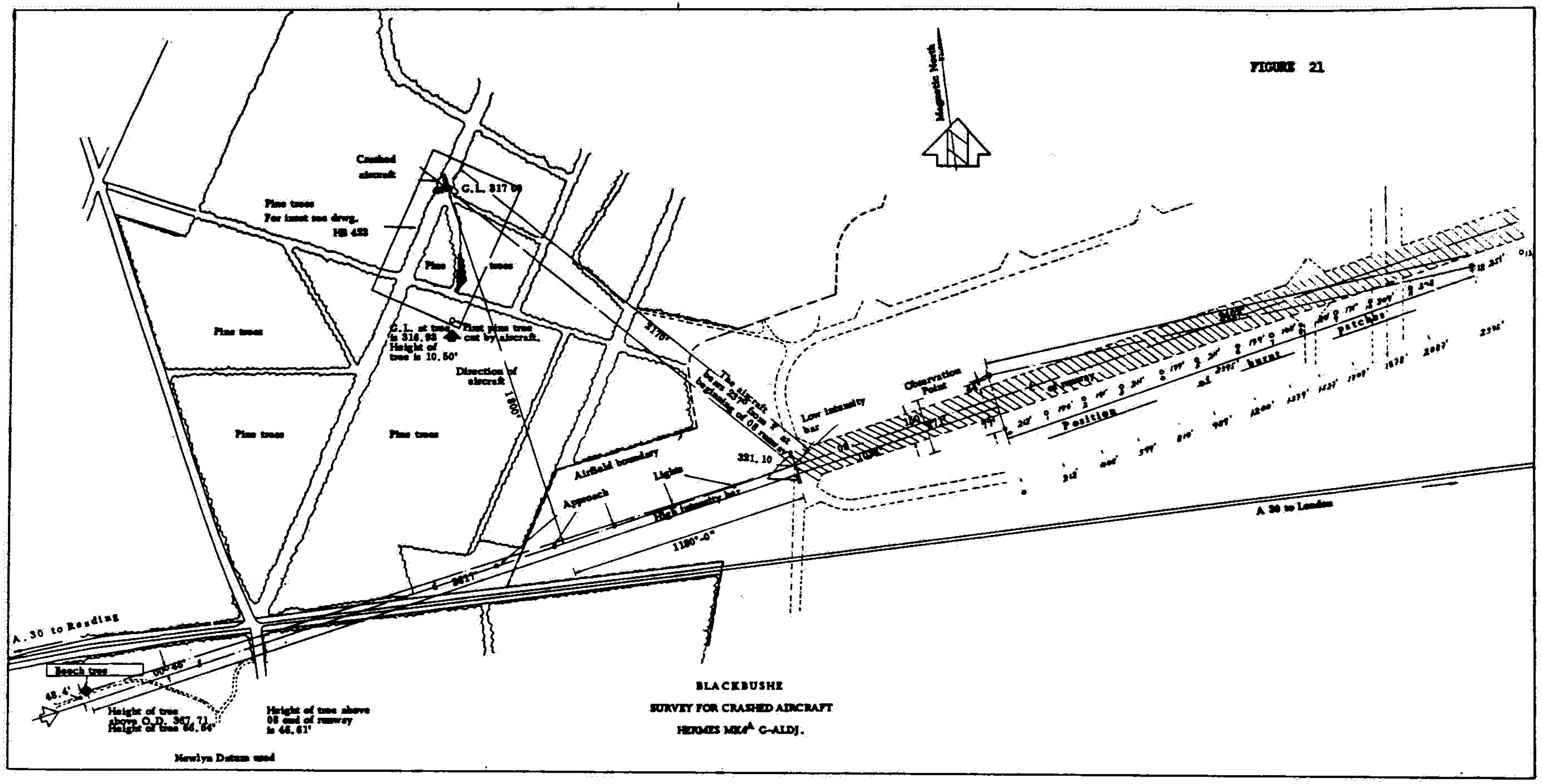
ICAO Ref: AR/471

FIGURE 21



BLACKBUSHE

SURVEY FOR CRASHED AIRCRAFT

HERMES MK4A G-ALDJ.

ICAO Circular 54-AN/49

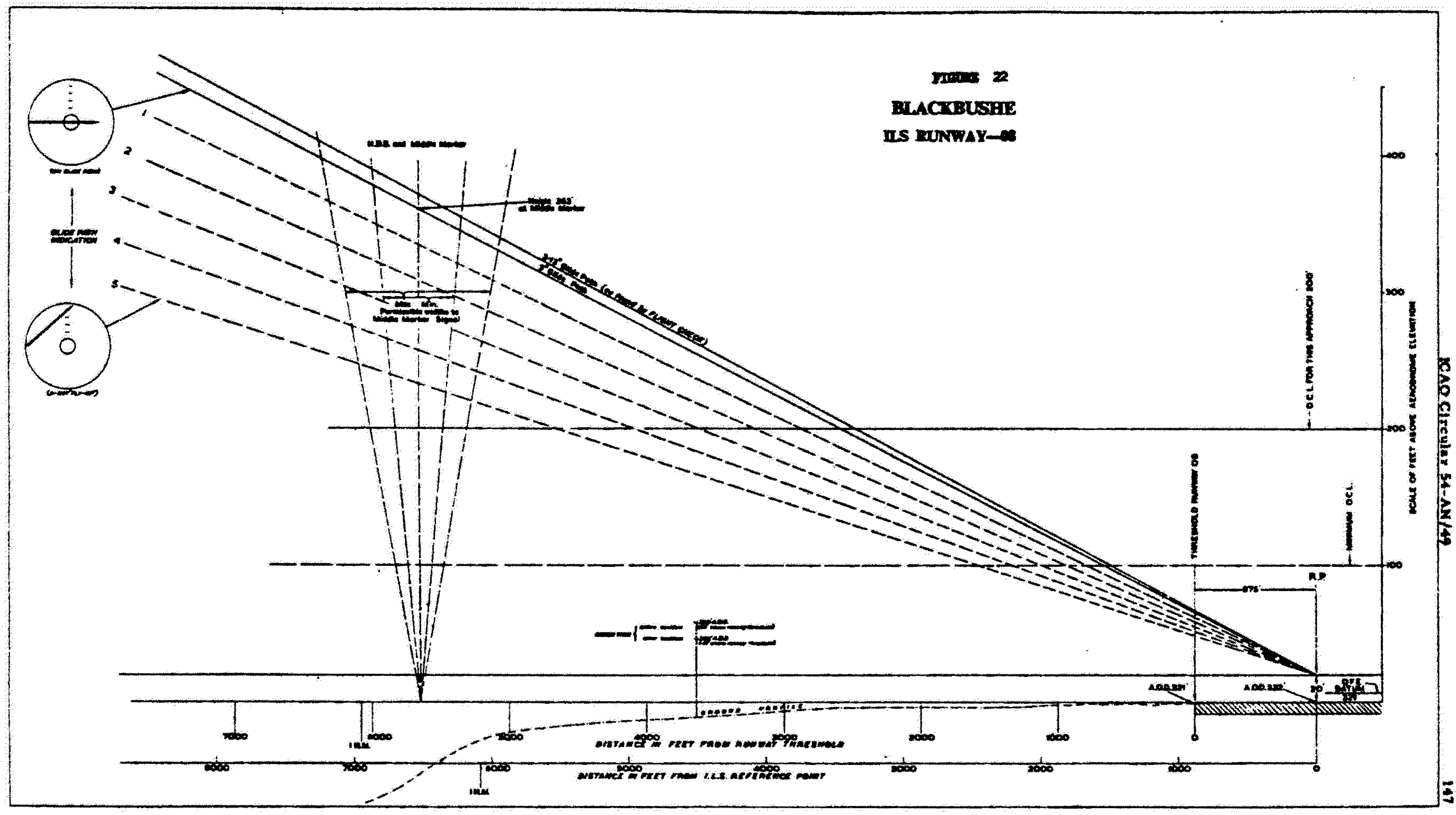


FIGURE 22

BLACKBUSHE

ILS RUNWAY—08

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No. 31

Trans World Airlines, Inc., Martin 404, N 40404, crashed at McCarran Field, Las Vegas, Nevada during attempted single-engine go-around on 15 November 1956. Civil Aeronautics Board (USA) Accident Investigation Report, File No. 1-0150 released 1 July 1957.

Circumstances

The flight was a regularly scheduled one between Kansas City, Missouri and Los Angeles, California with numerous stops, the last being Las Vegas, Nevada. The aircraft landed at Las Vegas at 1440 hours Pacific standard time, was serviced, and the crew performed routine duties for continuation of the flight to Los Angeles. An Instrument Flight Rules flight plan was prepared and filed because of instrument weather conditions over the latter portion of the flight segment to Los Angeles. At 1449 the captain taxied the aircraft to run-up position beside runway 7 where the required pre-take-off checks were carried out. The aircraft and equipment responded normally. The flight was issued an instrument clearance by Air Route Traffic Control. Take-off was at 1456 hours. A routine take-off was followed by a climbing left turn to gain altitude and establish a southwesterly course toward Los Angeles. At 1501 the first officer radioed the Las Vegas tower that the flight was returning to the airport, engine out. All other traffic was told to remain clear and emergency equipment was made ready. The flight was cleared to land on any runway. The aircraft was soon observed on a wide base leg for runway 7 and as it turned onto final approach. As it passed over the runway threshold its alignment, position and altitude seemed good; however, excessive speed was apparent. The aircraft floated 2 749 feet before touching the runway and bounced several times after which an application of power was heard, obviously in an attempt to go around. The Martin climbed, veered to the left and its left wing gradually lowered. It seemed to "struggle" to continue flight and its airspeed decreased visibly. Seconds later it struck the ground, left wing low, just inside the airport boundary. Two of the crew of 3 and 14 of the 35 passengers received minor injuries.

Investigation and Evidence

Ground marks showed that the left wing tip of the aircraft made the initial contact with the ground and this was followed closely by the left engine nacelle and aircraft fuselage. The aircraft then slid on its belly in an upright position for 225 feet along a northeast heading. While sliding, the aircraft turned left around its vertical axis so that when it stopped the aircraft was headed northwest. The aircraft received irreparable damage from the ground impacts and the subsequent sliding forces.

The left engine was found turned outboard 40 degrees by forces which bent and broke its engine mounts. The right engine was torn out during initial forces and as the aircraft slid forward on the ground this engine was rolled inward toward the fuselage. It then struck and penetrated the right side of the fuselage floor.

The main and nose components of the landing gear were found fully retracted. The wing flaps were found in a slightly extended position; however, numerous fractures in the hydraulic lines would have allowed the flaps to move from the position which existed at the instant of impact.

The left engine was torn down to determine the reason for its failure. All rocker box covers were removed and the rocker arms checked for clearance. The No. 2 cylinder exhaust valve rocker arm was found to have excessive clearance. Its push rod was then removed and examined. The ball end assembly was found to be loose and the spacer between the push rod and the ball end was broken into several pieces and completely displaced. The end of the push rod was worn, with pieces broken away. The ball end socket was belled out and polished. Evidence indicated, therefore, that the push rod failure occurred where the ball end is press fitted to the push rod. Crew testimony, in addition to the physical evidence, fully supported the push rod failure.

New or reconditioned push rods are installed during engine overhaul. Because the ball ends and rods are purchased separately, whether new or reconditioned, the ball ends are press fitted to the rods as a TWA overhaul operation.

Examination of both propellers and the right engine disclosed no evidence that they were in other than good condition prior to impact. Furthermore, there was no fault with respect to the anti-detonation injection system.

There was no record of any in-flight push rod failure on TWA Martin aircraft prior to the subject accident.

The investigation of this accident included an examination and bench check of the major components of the hydraulic system. Test procedures were set up in advance, using as a guide the manufacturer's acceptance tests for each of the units. This inspection disclosed no significant discrepancies.

To protect wing and flap structure, the wing flap system of the Martin 404 incorporates a wing flap unloading valve. According to test flight data published by Trans World Airlines and distributed to its pilots, the unloading valve will not permit a flap extension beyond 35 degrees, throttles fully retarded, unless the airspeed of the aircraft is at 120 knots or less. As airspeed is decreased, the flap extension is progressive until full extension, 45 degrees, is reached at or below 104 knots with throttles fully retarded. The approach flap setting is 24 degrees. This amount of extension can be obtained at 120 knots by selecting the approach flap position. Therefore, at this airspeed about 10 degrees more flap extension could be obtained by positioning the cockpit flap control in the full flap detent than in the approach position. Examination of the various components of the flap system indicated the system of N 40404 would operate, prior to impact, according to the data described.

The engine dificulty was in the form of an appreciable power loss, backfiring, and engine roughness. Attempts to correct the trouble were unsuccessful and when heavy and visible vibration began, the captain feathered the left propeller, taking that engine out of operation. The crew established single-engine operation, notified the McCarran tower of the emergency, and turned toward the airport. The landing gear was lowered and approach flaps were extended during the final approach.

The captain said that power was reduced on the right engine and that the flight crossed the threshold at a normal height, or slightly above. At this time the airspeed indicator showed 115 - 120 knots. The captain testified that this airspeed was excessive and that 95 -100 knots would be normal at the threshold. He added that at this time he had not called for full flaps because he thought they would not extend appreciably beyond the approach position until the airspeed had reduced to about 105 knots. The captain said, however, that when the first officer asked if he wanted full flaps he answered in the affirmative. The first officer immediately positioned the flap control to the full flap detent.

The captain said that after the last bounce the aircraft was still airborne and its airspeed was 100 - 105 knots. He called for take-off power on the operating engine and up gear. Flaps were retracted to the take-off position, 12 degrees. The captain testified that at the time he decided to discontinue the landing and execute the go-around he was firmly convinced the performance of the Martin 404 on single-engine would enable him to do so. He stated he believed that such go-around was possible provided the airspeed of the aircraft was appreciably above minimum control speed. He stated that the airspeed, when he initiated the go-around, was 100 - 105 knots and the minimum control speed of the aircraft in the existing configuration was 91 knots. He further stated that his impression was obviously in error because as the flaps retracted it was necessary to raise the nose to prevent settling into the ground, and airspeed was sacrificed to the extent that continued flight became impossible.

The captain was questioned about his training with respect to the Martin 404 single-engine performance capabilities. He said that prior to the accident his training included familiarization with various single-engine situations; however, this training did not stress single-engine balked landing or go-around with various aircraft configurations and speeds. The captain added that subsequent to the accident he had received a refresher training course which included the Martin 404 single-engine performance capability in the balked landing situation. He learned from this that the performance he had expected at the time of the accident was beyond the performance capability of the aircraft.

Training personnel at Kansas City stated that flight simulating the configuration of the Martin 404 in the accident showed it was necessary to sacrifice about 300 feet of altitude while retracting the flaps to the take-off position. They stated that on single-engine the flap retraction is necessary in order to allow the aircraft to accelerate. It was stated that following the accident a demonstration of this loss of altitude was given to key operations pilot personnel for dissemination to line captains and the demonstration was added to the company training program. Further, it is stressed during training that when full flaps are extended at an altitude below 300 feet during a single-engine approach the aircraft is committed to a landing. Training personnel said that although a balked landing procedure was in preparation it had not as yet been made a part of the Trans World Flight Operations Manual. A company instructor-pilot testified that perhaps the company pilot training had not stressed the single-engine balked landing situation enough prior to the Las Vegas accident. He added that this was probably because the program intended to teach the pilots to make the single-engine approach and landing without overshooting. He stated this proficiency and ability was expected of a line captain and that in all of the transitions he had given in the Martin 404 over a period of several years he had never seen an overshoot on a simulated single-engine.

The failure of the No. 2 cylinder exhaust push rod caused the exhaust valve to remain closed, thereby trapping exhaust gases under pressure which would normally be dissipated through the exhaust port. Therefore, when the intake valve opened these exhaust gases entered the induction system of the engine causing loss of power, backfiring, and engine roughness. The Board is of the opinion that these conditions would be of such severity that the pilots, as in this instance, would be expected to take the engine out of operation by feathering its propeller. It is recognized that thereafter the pilots operated the aircraft under the stress and demands of an emergency situation. Under this situation the aircraft was handled properly during the downwind leg and until the flight was positioned on the final approach for landing on runway 7.

The captain stated that on the final approach the airspeed was about 120 knots. It is not unusual to maintain a higher than normal approach speed under such conditions. However, this speed must be dissipated at a point when the landing is assured and in time to preclude overshooting. The Board believes that the captain did not properly judge this position. As a result he continued with excessive speed beyond a reasonable position for a safe landing. Contributing to his misjudgment the captain erroneously believed that with 115 - 120 knots he could not get additional flaps beyond the approach extension. Although only about 10 degrees more extension could have been obtained, this difference and its cumulative effect may well have been the difference between the overshoot and a safe landing. Notwithstanding the testimony of the captain to the contrary, the Board does not discount the possibility that he forgot to call for the full flap position until the first officer reminded him.

Following a series of attempts to force the aircraft on the runway, the captain believed he would be unable to stop the aircraft in the remaining runway and decided to go around. Because the distance consumed during the bounces is unknown, the Board is unable to determine whether or not the aircraft could have been stopped and considers such a determination speculative.

When the captain decided to go around he believed the performance of the Martin 404 on single-engine would enable him to do so. He thought that 10 - 15 knots above the minimum control airspeed was sufficient although the aircraft was on one engine, it was in a decelerating condition, and the landing gear and approximately 45 degrees of flaps were extended. All of these conditions existed with no altitude to sacrifice. Based on these factors, the Board is of the opinion that the captain's belief was unreasonable.

The Board concludes that the training program of the company with respect to the single-engine balked landing situation was inadequate prior to the accident. This was reflected in the captain's decision and the Board believes this was in a substantial degree responsible for the decision. It is felt that the type of situation which confronted the captain should have been foreseen by the company and the performance capabilities of the aircraft in such a situation fully covered as a training subject.

The importance of training in this potential accident cause area is reflected by the

Board's air carrier statistical data. These show there have been nine accidents since 1946 involving an engine out or engine malfunction during which the pilot attempted to go around after an overshoot. These data also reflect 80 accidents during the same period in which overshoot was a principal causal factor.

The modifications and additions to the training program subsequent to the accident appear to be adequate corrections to the previously inadequate situation.

Probable Cause

The probable cause of this accident was that during an emergency situation the captain failed to reduce speed during the latter portion of a single-engine approach; this excessive speed resulted in an overshoot and an attempted go-around which was beyond the performance capability of the aircraft under existing conditions.

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ICAO Ref.: AR/470

No. 32

Líneas Aéreas Aerovías Guest, DC-4, XA-HEG, crashed near Puerto Somoza, Nicaragua, on 15 November 1956. Report released by Ministry of Aviation, Managua, Nicaragua.

Circumstances

The aircraft was on a flight from Tocumen Airport, Panama, to Central Airport, Mexico City, with a stop at La Aurora Airport, Guatemala City. The flight reported "all well" over Managua, Nicaragua, at 2053 hours GMT (1453 hours local time). Somewhere between Managua and the eastern part of León Department an unknown trouble originated. Fire in flight resulted and the aircraft crashed eight miles north-northwest of Puerto Somoza. All 25 persons aboard, 20 passengers and 5 crew members (including one supernumerary pilot) were killed.

Investigation and Evidence

It is extremely unfortunate that the wreckage of the crashed aircraft did not remain undisturbed and was not immediately placed under guard. This gave rise to looting by prowlers, which made accurate determination of the causes of the accident extremely difficult. For example, a number of instruments and other parts of the aircraft which might have been of value to the investigation had been moved or removed by persons unknown.

Reconstruction of the flight from the statements of witnesses indicates that the aircraft flew over Managua in a northwesterly direction and continued in this direction approximately as far as Nagarote or to a point between Nagarote and La Paz Centro at 8 500 feet, where it changed to a southwest heading and lost altitude. It has been confirmed that the aircraft flew over the area of Puerto Somoza, and changed heading to the right by about 10° to follow the coastline to a point about 8 miles northwest of Puerto Somoza, then changed to a northeast heading of about 60°. The aircraft flew near the coast and over a series of salt flats on which a forced landing was feasible in an emergency.

Weather was not a contributing factor to the accident.

The aircraft crashed on a heading of approximately 60° magnetic and most of the wreckage was strewn along a path of 70° magnetic. The point of impact was on a magnetic heading of approximately 160° in relation to León, about one mile from the Pacific Coast and eight miles north-northwest of Puerto Somoza.

The right wing of the aircraft hit a tree on first impact, tearing off the wing tip and the greater part of the wing including the aileron which was broken, as evidenced by recovered parts of the structure and covering fabric; the aircraft then swerved to the right, travelled sideways for some 100 feet on a heading of 70° and then struck a large tree. Following this second impact, which was the most violent, the rest of the right wing and other parts of the central section broke off, and the aircraft carried away branches of the tree measuring 8 inches in diameter. From this point, the aircraft was observed to move on in a vertical position dragging on the ground for about 200 feet, and to finally strike a third tree; it is believed that the aircraft then overturned several times along a distance of 400 to 500 feet, the disintegration of its major components occurring simultaneously with explosion and fire. Parts of the nose, wheels, doors, engine housings, right wing and portions of the left wing constituted the original evidence of the impact with the third tree. Traces of combustion on the ground indicated that the fire broke out immediately after impact with the third tree.

Parts of the inside of the cabin which were found far from the ground fire area were smoke-blackened. Also the trailing edge of one of the right wing flaps was found at some distance from the ground fire area, bearing indications of having been subjected to fire in the air.

Investigation of the electric wiring in the area of the heating plant and around the right engine showed that the wires were fused together and burned to a point which suggests the possibility of an electrical fire.

There was evidence of a major explosion either near the ground or immediately upon impact with the second tree. The condition of the fuel tanks and breakage of rivets in the tank and wing area clearly indicates that the tanks exploded upon catching fire.

The positions of the pilots' bodies indicated that, at the time of impact, two were seated gripping the control wheels of the aircraft and the third was standing in the passageway to the cockpit.

Other important factors determined during the investigation are as follows:-

1. The flap of the right wing was burned although it was lying at quite a distance from the area of the ground fire.
2. The wiring was badly burned and fused in engines 3 and 4 and in the main cabin heater area the wires were melted together, thus indicating electrical fire rather than ground fire.
3. The setting of both altimeters was 29.92 inches of mercury (altitude above sea level).
4. The wing flaps were in the "up" position.
5. The landing gear was in the "up" position.
6. The magnetic compass needle was jammed at 90°.
7. The gyroscopic direction indicator showed 120°.
8. All fuel tanks exploded - (bulged out and rivets gone).
9. Intense fire on the ground.
10. The elevation at the point of the accident is about 70 feet.

Witnesses who observed the aircraft before the accident stated in their written testimony that the aircraft appeared to be on fire before the accident, as clouds of black smoke were issuing from both sides of the fuselage and the central section of the wing, and they could observe smoke within the passenger cabin, as the windows appeared black; this is quite possible in view of the low altitude of the aircraft when it passed about 15 metres above the witnesses.

The pilot chose the flat and sandy part of Salinas Grandes (great salt flats) from southwest to northeast to make a belly landing, but, no doubt because of circumstances within the aircraft and other factors which prevented the operation of the flaps, the approach speed was too great and when the pilot tried to level off for a landing, the aircraft remained airborne, overshooting the landing area and crashing into the trees as described above.

The fact that the aircraft was attempting a forced landing is evidenced by the condition of the blades of the four propellers, which show by the manner in which they are folded back that the engines were idling or set for landing in order to reduce speed.

Probable Cause

It was not possible to determine the origin of the fire in the main section of the hydraulic and fuel distribution systems; this determination will depend upon the results of laboratory tests and maintenance reports; when these are in, a reasonable conclusion can be reached regarding the probable cause of fire in flight. This may have been occasioned by a number of causes, for example, breaking of a hydraulic pressure line, short circuits in the eletrical wiring or leakage of fuel lines or tanks, etc.

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ICAO Ref.: AR/447

I = point of intended landing
O = " " actual crash

PUERTO SOMOZA
(EL TAMARINDO)

FIGURE 23

HOJA 2852

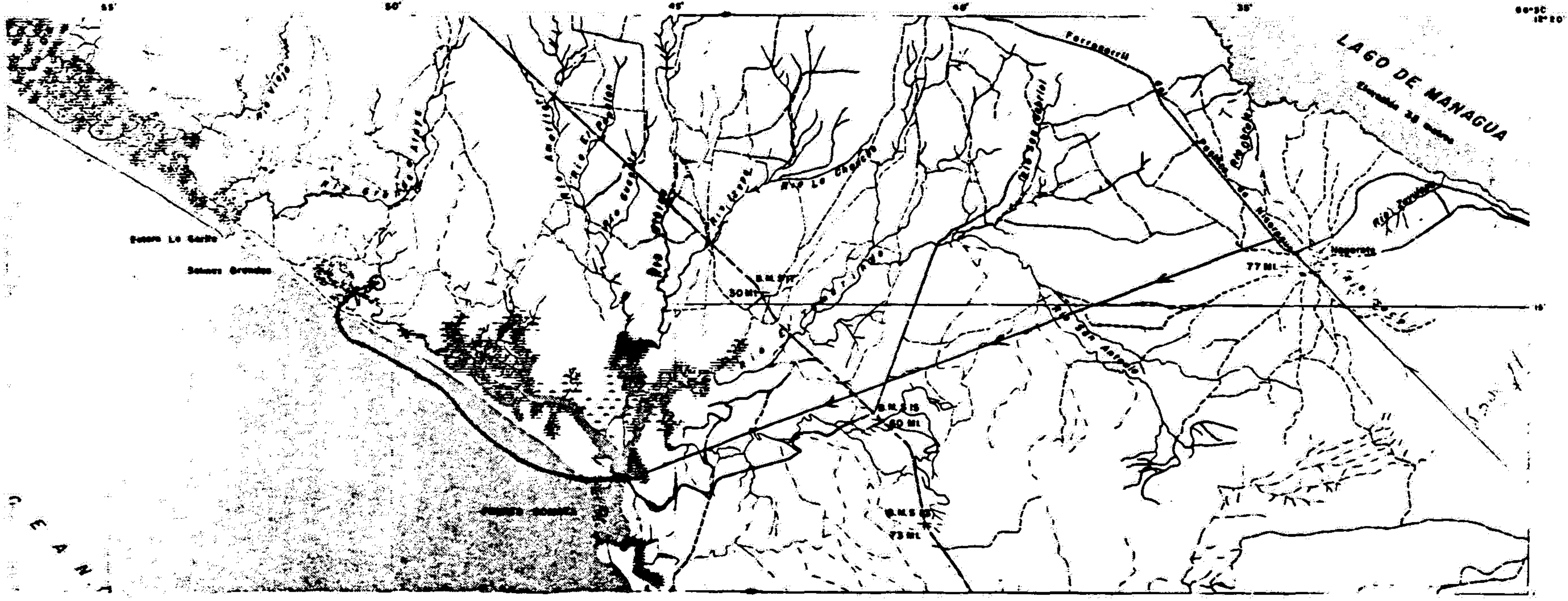

Figure 24

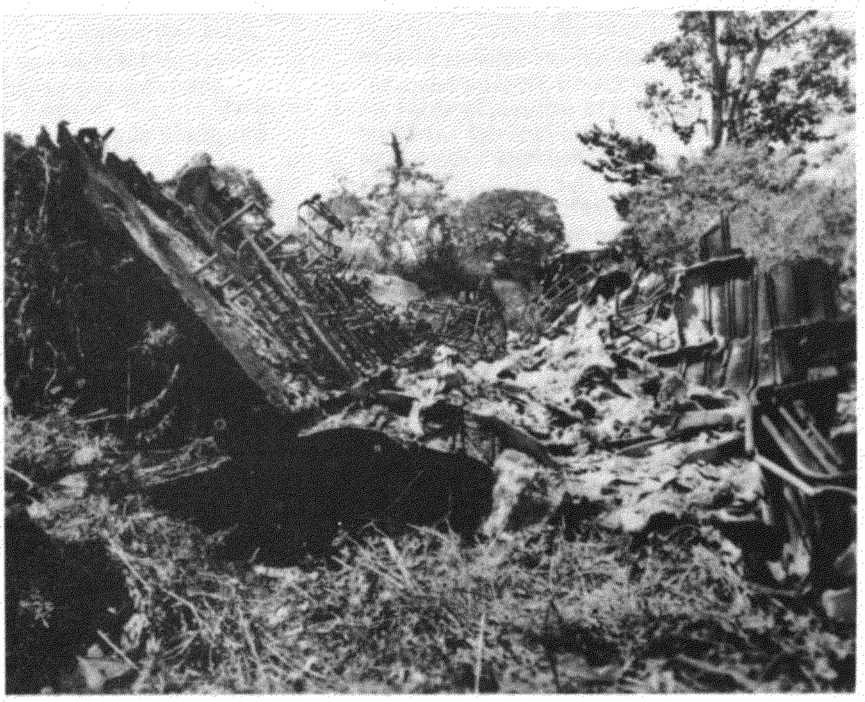

Figure 25

General views of wreckage area - DC-4 aircraft of Líneas Aéreas Aerovías Guest which crashed near Puerto Somoza, Nicaragua on 15 November 1956. All 25 persons aboard were killed.

No. 33

Aerovías del Pacifico "ARPA", DC-3-G, HK-385, crashed and burned on the side of a mountain known as El Rucio in the Cordillera Occidental, on 17 November 1956. Report released by Department of Civil Aviation, Ministry of War, Republic of Colombia.

Circumstances

The aircraft took off from Buenaventura at 1630 hours local time on a return flight to el Guavito aerodrome, Cali. Expected time of arrival at Cali was 1700 hours. On board the aircraft were the pilot, a steward (who held no licence to act as such), a flight engineer (who on this occasion was acting as co-pilot), and 33 passengers. When 1700 hours passed with no sign of the aircraft's arriving at Cali, a search was initiated. The aircraft was located the same evening on the side of "El Rucio". All passengers and crew members were killed.

Investigation and Evidence

From documents and testimony obtained it was ascertained that the aircraft flew without the co-pilot for the following reasons:

The co-pilot assigned for 17 November served on the flights from Cali to Buenaventura and Buenaventura to Cali. On return to the base the pilot asked his co-pilot for the latter's medical certificate. When the co-pilot explained that the certificate had been left at the office of the Civil Aviation Department for revalidation, the pilot (according to a statement signed by the co-pilot) instructed the latter to cease flying. On this occasion, the flight engineer acted as co-pilot.

When the co-pilot was interrogated and asked why he did not inform the management of ARPA regarding the captain's decision not to let him fly as co-pilot, he declared - "I was so disgusted, I went home and forgot to inform the airline management."

According to statements of several pilots who flew in the area a few minutes before and after the accident, the weather conditions were as follows:

ceiling over Buenaventura was unlimited and the wind was variable but not strong;

ceiling over Cali was also unlimited and there was practically no wind.

The Cordillera Occidental in the area of the valley or canyon between Cisneros and Dagua was covered by scattered stratocumulus which sometimes covered mountain peaks between 6 000 and 7 500 feet. The route generally flown by the aircraft was along the Dagua canyon to the town of that name. The top of the ridge called El Rucio, which was covered by some scattered stratus cloud, lies a short distance from a point where the 105° track flown by aircraft leaving Buenaventura changes direction. The flight was carried out in not very severe IFR conditions and at an altitude which appeared to be the same as that flown in visual conditions.

The following aids were available along the route:

radio beacon and radio service on 5589.5 kc/s at Cali;

radio beacon at Condoto.

These aids could have been useful if the flight had been conducted at the prescribed altitude for instrument flights.

Two inhabitants of the area made a written declaration which may be summarized as follows:

> "At 4.45 p.m. we heard the noise of an aircraft. The mountain on the right of the Dagua valley (on the Buenaventura-Cali route) was covered with cloud. Shortly after hearing the noise of the aircraft, we heard the sound of a crash and we later were able to identify the place where the accident occurred by the fire which broke out."

The aircraft had crashed into the mountain side at an elevation of approximately 6 200 feet. Fire had destroyed the central part of the aircraft but the two wings were perfectly distinguishable, as well as the tail surfaces. The fuselage was burned up to the level of the rear cargo door.

The port propeller was found near the port engine and set at approximately cruising pitch. The starboard propeller and reduction gear were hanging from the nose cowling and one of the blades was missing. Another blade was in perfect condition while the third blade had several dents. The propeller hub had been struck, causing oil to escape from the forward portion. The blow was sufficiently strong to displace the gears controlling the blade pitch and these could easily be turned by hand. It should be noted that one of the blades was found with its rear surface facing forwards, which could only be explained by the movement of the propeller after the crash. Through the hole in the hub it was possible to see the pitch control piston which was in the cruising position. As a result of the impact, the piston was displaced to the maximum cruising position but did not actually raise the feathering cam. The position in which the throttle lever was found indicated that the engines were operating at cruise power. As a result of the impact and the fire, the instruments had lost their covers and pointers and it was impossible to determine their readings prior to the accident. The fact that the pilot had not reported an emergency situation confirms the conclusion that the aircraft was operating normally at the time of the accident The angle at which the trees were broken and the position in which the aircraft was found indicate that the latter was flying horizontally when it crashed. The flaps were in the raised position and, although the tab position indicators were not found, the position of the tabs on the tail appeared normal and there was no indication that they had been used to counteract an abnormal condition. To sum up, therefore, there is every indication that the aircraft crashed at cruising speed and that the pilot was not aware that an accident was imminent. When efforts were made to obtain copies of the passenger manifest and load and trim sheet, the investigators were informed that the company's agent at Buenaventura had given the pilot all the copies. He later certified under oath, before a competent judge, the accuracy of a copy of the original load and trim sheet and included the names of five passengers who arrived at the last minute and were accepted by the pilot.

Apart from the cause of the accident, there are two points which require initial consideration. First, the aircraft was flown without a co-pilot. According to the investigation, it was known that the individual who was scheduled to fly on 17 November as co-pilot actually did so on the first flight Cali-Buenaventura-Cali. The captain of the aircraft, contrary to the provisions of the Colombian Civil Aviation Regulations, decided to fly the aircraft alone. If there was no co-pilot available, for any reason, the pilot should have postponed the flight and informed the company. Second, the aircraft was carrying a number of passengers in excess of the number permitted under the Civil Aviation Regulations. This point must be considered solely in the light of Sections 40. 9. 6 and 41. 5. 12 of these Regulations which specify that: "In accordance with the provisions of Article 31 of Law 89 of 1938, the commander of an aircraft is in charge of that aircraft and is responsible for maintaining order and discipline on board. He must comply and secure compliance with all laws, regulations and other official orders and is entrusted with the same powers as are given to captains of maritime vessels", and in the light of the section entitled "Authority of Pilot-in-command", which reads: "The pilot-in-command of an aircraft shall be directly responsible for its operation and shall have absolute authority in all matters connected therewith while he is in command". Consequently, the individual responsible for all matters connected with the operation of an aircraft is the captain thereof. In other words, the captain, in the present instance, assumed responsibility for flying without a co-pilot and with an excessive passenger load, knowing that he was thereby rendering himself liable to sanctions under the Civil Aviation Regulations.

From the investigation and the statements obtained, there is nothing to indicate that the Company had authorized operation of the aircraft in the manner mentioned. From the copy of the load and trim sheet which was submitted it is assumed that the aircraft was loaded within the specified limits. The runway at Buenaventura which measures 1 000 metres between threshold markings but which actually has a shorter usable length, does not permit operation of DC-3 aircraft when they are overloaded. Obviously, therefore, weight was not a factor in the accident.

The testimony of the inhabitants of the area and the statements signed by the owners of the farm near the spot where the accident occurred indicate that the ridge into which the aircraft crashed was covered with dense mist. The low altitude at which the aircraft was flying, in conditions reported to have been intermittent IFR conditions, was the most probable cause of the accident.

The route normally followed by aircraft flying from Buenaventura to Cali runs along the Río Dagua canyon. The flight time between Buenaventura and Cali is normally 30 minutes. The aircraft crashed approximately halfway along this route and the passengers' watches indicated that the impact occurred after 15 to 20 minutes of flight. On a time basis, the pilot must have known that he was at the highest point on his route. As regards flight altitudes, the Colombian Civil Aviation Regulations provide in Sections 41.6.2 and 41.7.3 that for visual flight an altitude 1 000 feet above mountainous terrain must be maintained and that for instrument flight this margin must not be less than 2 000 feet. It is further specified that these altitudes must take into account obstacles within 5 miles on either side of the route of the aircraft.

Probable Cause

The most probable cause of the accident was - flight on instruments at an excessively low altitude for the route.

Contributory Cause

Lack of discipline on the part of the pilot.

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ICAO Ref: AR/475

No. 34

Linee Aeree Italiane, DC-6B aircraft, I-LEAD crashed after take-off at Paray-Vieille-Poste, France on 23 November 1956. Report by Commission of Inquiry set up by Order of the Secretary of State for Public Works, Transport and Tourism, France. Report released 24 April 1957.

Circumstances

The aircraft was flying on the regular Rome - New York service and had stopped at Orly for two hours prior to taking-off for Shannon, Ireland, in darkness at 2317 hours Greenwich Mean Time in cold and slightly misty weather. Between 10 and 15 seconds after a normal take-off, the aircraft lost altitude and struck a house located approximately on the extended centre line of runway 26 (the take-off runway), about 600 metres from the runway end. The aircraft broke up and crashed in flames (at 2318 hours) destroying two buildings. All 10 crew members and 23 of the 25 passengers were killed. Both surviving passengers were seriously injured, one subsequently died.

Investigation and Evidence

The local weather was misty with a visibility of 2.2 kilometres, wind 320° at 6 knots, and a ceiling of 4/8 at 240 metres. The temperature was -2°C and the dewpoint -4°C. White frost was forming on the ground.

As the conditions were bordering on icing, the Commission asked the National Meteorological Service to carry out a special study.

The area in which the accident occurred is located in the part of the Commune of Paray-Vieille-Poste which is now being expropriated (Orly airport extension plan).

Most dwellings in that area have been torn down for ground levelling purposes; a few houses and the Town Hall still remain and are occupied. Contrary to the indications given on the visual landing chart, these obstacles were not lighted, but since none of them penetrates above the 1.25 per cent slope, there is no regulation which requires that they be lighted.

Between runway 26 and this area lie the existing Highway 7 and the cutting through which this road will pass after it has been relocated to run under the airport.

The wreckage was strewn over a distance of 200 metres. The main wreckage covered an area measuring approximately 30 by 15 metres only and had been greatly damaged by the fire which broke out following the crash.

The airframe began to break up with the impact on the house, at the foot of which large fragments of the main longeron were found.

Large units (such as the outer engines, the forward landing gear, the tail unit, etc.) then broke off the main body of the aircraft which came to rest at a point 200 metres from the point of first impact.

The cabin and the cockpit were particularly damaged by the crash and by the fire. Only part of the controls and instruments could be identified, and few could yield any useful information.

The examination of the wreckage revealed no structural defect.

One element of the right stabilizer and its elevator flap, including the controlled trim tab, were the only parts of the control surfaces that could be usefully examined. These parts revealed no defect.

Examination of the hydraulic jacks of the flap control mechanism showed that the shafts of those systems were in different positions:

- one short jack, the shaft of which was retracted;
- one long jack, the shaft of which was fully extended, but not bent;
- the shafts of the other two jacks had come out of their casing and were folded as a result of the impact.

A reconstruction of the setting of the flaps at the time of the accident was attempted with a DC-6 aircraft belonging to T.A.I. but the varying positions of the jack shafts made it impossible to reach any valid conclusion.

The varying positions of the shafts can only have been the result of an interruption in hydraulic pressure in the jacks due to the breaking up of the aircraft.

The folding of the shafts may lead to the belief that the flaps were out, but cannot be regarded as sufficient proof thereof.

The two main landing gear legs and the forward landing gear were found in the locked and "up" position, which is the correct position for that phase of the flight.

The bottles of CO_2 and oxygen which were carried on board were recovered, but their examination did not reveal any breakage which would indicate that there had been an explosion before the accident.

The engines were examined by experts at the Air France maintenance center at Courbevoie. All the damage and failures observed were the result of the impact at the time of the aircraft's crash. Dismantling revealed no traces of overspeed, jamming or inadequate lubrication.

The oil filters were clean.

The injectors of engines Nos. 1,2 and 4 were tested and found in working order. The injector of engine No. 3, twisted by the impact, could not be tested.

The compressor starting selectors of engines Nos. 1,2 and 3 were found in their normal first gear position. The selector of No. 4 engine could not be checked because of damage sustained in the accident.

In short, nothing was found to indicate that the engines were not in sound working order.

Only three fuel pumps were found, namely, pumps Nos. 1,3 and 4. These were examined by experts at the Air France maintenance center at Orly. This equipment was properly assembled and the component parts were in good shape. No traces of jamming or scratching were found.

The cross-feed valves of the fuel tanks were found connected with the main tanks, which is the normal take-off position.

The four (Stromberg Bendix PR 58 E5) carburettors with which the engines were equipped were examined by experts at the Zenith works at Levallois-Perret.

These carburettors were considerably damaged by the impact and fire, and could not be bench-tested. All evidence pointed to the damage having been caused by the accident. As the carburettors of engines Nos. 1 and 2 were found with perforated poppet valve membranes, comparative tests were carried out with a stock Zenith carburettor, first with a membrane in working order and then with a perforated one.

The tests showed that damage to the membranes did not affect the fuel flow at take-off power. When the regulator is fully open and the pressure is at its maximum, the flow is limited by the jets. At all other power settings, rupture of the membrane increases the richness of the mixture and causes faulty operation of the choke.

Furthermore, the "derichment" membrane was torn in carburettor No. 4. Since it was felt that such an anomaly could affect the operation of the engine, a comparative test was carried out with Pratt & Whitney R. 2800 CB 17 engine No. 35741 at Bouviers. The split membrane was not found to have any effect on the functioning of the engine with water injection at 2 600 or at 2 800 rpm.

Examination of the take-off water injection regulators gave no indication of malfunctioning.

The four (type 43 E 60) propellers were examined by experts at the Air France maintenance centre at Orly. These propellers had broken away from the engines at the time of the accident as a result of the failure of the reduction gear.

Of the twelve blades, only one remained whole, although even this one was bent. The eleven others were broken and twisted. They appeared to have been developing power when they struck the obstacles.

The pitches at the time of the impact were ascertained with reasonable accuracy by noting the position of the mobile cams in the case of propellers Nos. 1, 2 and 3 and by the marks left on the "shim plates" at the blade anchorage in the case of all four propellers.

The average pitches thus ascertained were as follows:

Propeller No. 1: 32°; propeller No. 2: 35°; propeller No. 3: 38°; propeller No. 4: 30°.

The lower pitch setting of propellers Nos. 1 and 4 may have been due to two reasons:

- the fact that these engines drive accessories and that for a given number of engine revolutions the torque of the propellers is smaller;
- the fact that these engines touched ground some time after the impact of engines Nos. 2 and 3 against the house.

In short, it may be concluded that the governors for propellers 1, 2 and 3, and very probably No. 4 as well, were on.

Only two propeller governors, those of engines Nos. 1 and 2, and an electric head belonging to engine No. 3 or engine No. 4 were sufficiently well preserved to be examined.

In the case of governors 1 and 2, tests were carried out with their own springs and their electric heads in their position at the time of the accident. The results of these tests were as follows:

Engine No. 1: 2 514 rpm.

Engine No. 2: 2 586 rpm.

These were probably the rates at the moment of impact. For the same governors, the bench rpm in low pitch stop position, gave the following figures for take-off: 2 807 and 2 839.

The electric head of one of the starboard engines was tested on an Air France governor with the following results:

- in the position of the head at the time of the accident: 2 473 engine rpm;
- in low pitch stop position, three different tests with the Air France governor and then with the springs of the governors of engines Nos. 1 and 2 of aircraft I-LEAD gave the following results: 2 701, 2 876 and 2 904 engine rpm.

Taking into consideration the differences in spring calibration, there is ample reason to believe that the governor and engine to which that head belonged had been functioning normally.

The result of the examination seems to indicate that the first reduction had already been carried out.

The cockpit was completely crushed and destroyed by the fire. Nevertheless, it was possible to note a few facts of interest -

- The elevator controls parking lock was found unlocked;
- Contacts: engine 1, contact on left magneto; engine 2, contact on right magneto; engine 3, contact on both magnetos; engine 4, contact on both magnetos;
- "BMEP" - Only the indicators of engines Nos. 1,2 and 3 were found. Their pointers had stopped at 251, 169 and 190 PSI. These indications cannot be accurately interpreted because of the heavy damage sustained by these dials;
- Automatic feathering: switch in the "on" position;
- Manual feathering: engines 1, 2 and 4 in normal position. In the case of engine No. 3, the button was pushed in, but its protective casing was bent. Consequently, this position cannot be taken into account.
- Pilot-in-command's altimeter: This altimeter was found set at the QNH (30.29): the pointer showed 820 feet; this anomaly was the result of the impact;
- Course indicator: on the panel of the pilot-in-command, the pointer of the flux-gate showed 260°;
- The pointer of the ammeter for the de-icer heating elements left a mark on the dial at 10 amperes. It was impossible to determine from the state of the connections which of the heating element circuits was connected with the ammeter, but, judging by the intensity value registered, it would appear to have been the pitot heating element;

- Cockpit lighting: the white lighting potentiometer closed the circuit and was, therefore, used at the time of the accident. The red lighting potentiometers were destroyed as was the emergency lighting control switch panel.

Analysis of fuel samples from the tank from which the aircraft was refuelled at Orly showed no abnormal characteristics.

Reconstruction of the configuration of the aircraft at the time of the impact

A 1/50 scale model was made in order to reconstruct with the greatest possible degree of accuracy the configuration of the aircraft at the time of its impact against the first house.

Sufficient characteristic signs were left to permit determination of the attitude of the aircraft in the three dimensions:

1) The lower cable of a sheet of overhead power cables was found intact, while a piece of a broken conductor, torn off during the aircraft's passage, was found caught in the cabin air intake.

2) The very clear outline on the upper surface of a propeller blade of several layers of bricks on the side of a chimney.

3) A notch in a roof purlin made by a section of the blade of a working propeller.

It would appear that, at the time of the initial impact, the aircraft was flying more or less on course without bank, on the take-off heading and about 15 metres to the left of the extended runway centre line.

The bottom of the fuselage was 10 metres above the ground.

The four engines must have been running normally.

Study of the flight path

Only two points of the aircraft's flight path are known with certainty: the spot where the pilot opened the throttle, that is at the beginning of runway 26, and the point of impact against the house at Paray-Vieille-Poste, 600 metres from the runway and in line with the centre of the left half of that runway.

Nevertheless, the information gathered during the investigation from many witnesses makes it possible to reconstruct an approximate flight path.

According to the controller on duty in the tower, the take-off was made from a point between runways 21L and 21R, about 1 500 metres from the beginning of the runway. Furthermore, a qualified witness who was on the highway believes that the aircraft flew over the latter at a height of about 30 metres. This probably represents the highest point of the flight path because witnesses had the impression that the aircraft lost altitude from that point on.

The total time which elapsed from the opening of the throttle was about 35 seconds, so that the aircraft must have flown for about 15 seconds at most. This gives some idea of the extremely narrow limits within which the event which could have brought about the accident must be sought.

Discussion

The accident occurred some 15 seconds after a night take-off which apparently entailed no special difficulties. The aircraft was relatively light(6 tonnes below the authorized maximum weight). The load sheet indicated that the centre of gravity was properly located, well within the authorized limits. The night was opaque, but, despite a slight mist, the visibility was about 2 km; the temperature was near 0° and the wind slight.

The investigation showed that, at the time of the accident, the aircraft was on course, approximately over the extended centre line of the runway, with landing gear up. The aircraft struck one of the unlighted obstructions which were in the take-off path.

It is again pointed out that the existing regulations did not require that they be lighted.

The Commission found no evidence whatever to support any suggestion of malicious intent, or of fire or explosion on board.

In the circumstances, the Commission concentrated its study on the following points:

Failure of one or more powerplants

There was no indication that either the fuel systems or the quality of the fuel was involved.

Expert examination of the engines and their accessories did not reveal any mechanical defect or faulty adjustment prior to the accident.

Examination of the propellers indicated pitches corresponding to operation with normal setting for that phase of the flight.

Tests carried out with governors showed that, most probably, the first reduction had already been carried out.

Lastly, it should be emphasized that the aircraft was well in the line of the take-off path.

Faulty operation of landing gear or flaps

The landing gear was up and locked.

There was no mechanical indication that the flaps were raised, while the position of the jacks seemed to indicate that they were down. It is probable, therefore, that they were still in the take-off position, and that, even if the order to raise them was given, there was not time to carry it out.

Malfunctioning of controls

The elevator controls were not locked for parking.

Icing of wings

The aircraft appears to have taken off within a normal distance and to have initiated its climb at the usual rate. The presence of a film of white frost on the upper surface of the extremity of each wing, which had been reported by the refuelling employees at Orly, does not seem, therefore, to have affected the take-off.

It seems improbable that this condition could have deteriorated in the prevailing weather and in so short a time, and such an assumption is contradicted by the first reduction of engine power.

Inaccurate instrument indications

An incorrect airspeed indication or a malfunctioning of the Sperry horizon can mislead the pilot.

Indeed, the pilot might be misled into easing pressure on the control column either upon seeing an airspeed reading which is less than the actual value, or upon seeing a maladjusted miniature, which appears to be on the flight path when the aircraft is actually coming down.

As regards the airspeed indicators, examination of aircraft I-LEAD showed that the pitot tubes and the static pressure intakes were heated at the time of the accident. Furthermore, the dynamic and static circuits of the DC-6B are protected against the risk of obstruction. Moreover, it may be assumed that if the airspeed reading had been lower than the normal value, the crew would not have been likely to reduce power.

As regards the gyro horizon, if the pilot used a badly adjusted bar which tended to cause descent, the speed must have been increased much faster than usual. At night, however, it is imperative to maintain optimum climbing airspeed during the initial climb.

Lighting failure

Several witnesses reported that they had not seen any cabin lights and the surviving passenger reported that the light was off before the impact. The investigation showed that the white lighting circuit was connected at the time of the accident.

In the circumstances, and assuming that there was a failure of the cabin and cockpit lighting, the (radium) luminescence of the dials in the DC-6B is such that the second pilot, if he had looked only inside the aircraft, should not have been incovenienced by the disappearance of the red lighting or a failure of the white lighting, as the emergency lighting can be obtained very rapidly and the eyes of an observer who has not looked at the runway lights can accommodate almost instantly.

Nevertheless, it is necessary to bear in mind the difficulties inherent in an instrument take-off, especially when the crew finds itself suddenly and unexpectedly in these conditions.

Finally, the incident which caused the observed loss of altitude occurred during a phase of the flight, in which the numerous manoeuvres that immediately follow take-off are carried out at an extremely rapid tempo and in a sequence which requires perfect co-ordination in its execution.

Therefore, especially at night, the slightest incident occurring at this critical moment may have the most serious consequences unless immediately detected and remedied.

Conclusions

The Commission found:

- that the crew was qualified to carry out its assigned duties on this type of aircraft and on the Rome-Paris-New York route, and had had sufficient rest before leaving Rome;
- that the aircraft was used in conformity with operational regulations, particularly with regard to load carried, load distribution and flight planning;
- that the ground installations were in conformity with the standards in force.

The Commission was unable to find any malfunctioning of the aircraft or its equipment which would make it possible to determine why the aircraft followed the observed flight path.

The Commission, therefore, believes that:

- the aircraft's slight loss of altitude soon after take-off was the main cause of the accident. There is no explanation for this loss of altitude.
- although the regulations in force were observed, the presence of unmarked obstructions in the take-off path constituted an aggravating factor;
- the initial and direct cause of the accident remains unknown.

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ICAO Ref: AR/482

Figure 26

Wreckage area of Linee Aeree Italiane DC-6B, I-LEAD, which crashed following take-off from Orly Airport, Paris, on 23 November 1956.

No. 35

Asociación Interamericana de Aviación, (AIDA), Ltda., PBY-5A, HK-133, crashed on the side of Quetame Hill, Vereda de "Cubia", Bojacá, Cundinamarca Department, Colombia on 8 December 1956, Report released by Department of Civil Aviation, Colombia.

Circumstances

The aircraft departed Santa Cecilia Airport, Bogotá at 0647 hours local time bound for Medellín and Quibdó, carrying a crew of 5 and 11 passengers. Take-off was made at a time when the airport was closed due to poor visibility. While flying on instruments a few moments after take-off, the starboard engine failed. The aircraft continued its flight over the Sabana de Bogotá for approximately 23 minutes, following which, while flying on a magnetic heading of approximately 280 degrees, it crashed violently (at approximately 0705 hours) against Quetame Hill, 25 km. northwest of Santa Cecilia airport at an elevation of 2 790 metres (9 170 feet). With the exception of the flight engineer and one of the passengers, all the occupants of the aircraft were killed.

Investigation and Evidence

At the time when the accident occurred, the aircraft had flown 48 minutes since its last 100-hour inspection and 7 891 hours 58 minutes since its last general overhaul. It was last inspected by the Colombian Civil Aviation Authorities on 30 November 1956 and was found airworthy by the inspector. It was given a temporary 10-day certificate of airworthiness valid until 9 December 1956.

The starboard engine had flown 184 hours, 51 minutes since its last general overhaul. On 14 November this engine was installed in HK-133 following its removal from aircraft HK-1001, another PBY-5A, belonging to the same company, which was undergoing repairs. Following the flights made by HK-133 on 6 December the aircraft log book carried an entry by the pilot who noted that this engine was losing power. In order to remedy the defect noted by the pilot, the maintenance service did the following work on the engine on 6 December:

> Corrected the basic adjustment of both carburetors; corrected an air leak into the line to the supercharger pressure indicator; adjusted the inlet tubes and checked the adjustment of the carburetor air intake.

When this work was completed, the engine was tested on the ground. The turbine was found to be still making a noise and the same loss of power reported by the pilot was observed. On the same day, the carburetor was dismantled in order to inspect the turbine. It was found that the latter had been displaced to the rear part, which caused rubbing against the jet section. The mechanics therefore removed the engine in order to dismantle the turbine section.

On 7 December another turbine was installed. This work was done under the supervision of the owner and manager of the Tadecol Workshops and of AIDA's Chief of Maintenance. The technical assistance given by the manager of the Tadecol Workshops was limited to checking that the mechanical distribution of the engine was correct. After verifying this, he withdrew and the AIDA mechanics continued the work. When installation of the turbine was completed, the engine was reinstalled on the starboard side of the aircraft, following replacement of the starboard magneto and an oil change. The engine was ground tested by the captain of the aircraft and the flight engineer for approximately 20 minutes. The aircraft was declared to be in satisfactory working order by the personnel who repaired it but the necessary test flight was not made before commencement of the scheduled passenger flight, 4 hours and 47 minutes later.

Only the following facts are known concerning the accessories of the the starboard engine:

> Before flights on 14 November, the fuel pump had been replaced and the carburetor support adjusted. Also before flights on 15 November the thermo-couple had been adjusted. On 5 December, the nuts fastening the carburetor to the engine were adjusted and an air leak into the boost pressure gauge line was corrected.

The weather conditions at Santa Cecilia field at the time when HK-133 took off were as follows:

"Horizontal visibility reduced to 300 metres in all directions owing to low cloud. The ceiling was at approximately 400 feet above the airport, with 3/8 stratocumulus". The dispatcher stated emphatically that the airport was closed and that he said to the captain before the take-off that he should wait for better visibility and ceiling conditions since Techo airport was also closed owing to low visibility - he had called Techo Flight Control at 0610 and they had communicated the conditions at that airport. Another captain, a pilot of Pato Gold Mine, who flew over the Sabana de Bogotá approximately 10 minutes after the accident, stated that that area was completely covered by cloud up to approximately 9 000 feet. He stated that Madrid, Techo and Santa Cecilia airports were closed owing to low visibility but that Guaymaral Airport, where he landed a few minutes later at 0725 hours, was open. He also stated that from Guaymaral northwards the visibility was unlimited and that the summits of El Tablazo, El Yunque and of the Andes were clear of cloud. From the communications log of Techo Control Tower it was also noted that the airport was closed owing to low visibility at 0545 hours local time and that it was reopened at 0820 hours.

HK-133's radio equipment was inspected by the Civil Aviation Department on 30 November (8 days before the accident) and all the equipment was found to be in satisfactory operating condition. At 0604 hours local time the pilot established control on the route control frequency of 6589.5 kc/s, requested information concerning the weather at Medellín and tested his radio equipment. This was the only radio contact made by the pilot prior to and during the flight.

It is noted that the pilot failed to make the required radio contacts with Techo Control Tower. As regards the ADF equipment, both radio compasses were found to have been functioning, as the readings of the left-hand and right-hand instruments were respectively 175° and 185°. All the switches of the HF transmitters and receivers were in the "on" position. It was noted, moreover, that the radio equipment of the Techo Control Tower was functioning normally as borne out by the reports of flights which preceded and followed that of HK-133, and the communications log of that station.

It was found that fire did not threaten either during the flight or on impact and that the fire extinguishing equipment carried was not used. However, it was noted that the selector valve of the CO_2 bottles for extinction of engine fires was set for discharge of the bottles on to the starboard engine.

A witness who was 3 kilometres from the point of impact states that the crash occurred at approximately 0700 hours local time when there was cloud in all directions and the visibility was estimated to be 20 metres. He heard the aircraft pass overhead at low altitude and presumed that it was going to crash.

A statement was also obtained from another aircraft captain, a pilot (previously mentioned) of Pato Gold Mine, who took off from El Bagre for Bogotá at 0555 hours local time on the day of the accident and began to fly over the Sabana de Bogotá at 0715 hours at an altitude of 11 500 feet. He states that the station at Techo informed him that that airport was closed with ceiling and visibility zero. He noted that the Sabana was covered with cloud to an altitude of approximately 9 000 feet. He was able to see the peaks of the hill parallel to Madrid landing field, but the latter was completely closed. This captain flew above the ceiling and arrived over the city of Bogotá hoping to land at Santa Cecilia airfield. However, there was no visibility at Santa Cecilia and he proceeded to Guaymaral. He also states that from Suba to the north of the Sabana the ceiling and visibility were unlimited, furthermore, there was no high cloud over the Sabana but only low lying cloud. He states that the hills El Tablazo, El Yunque and Los Andes were clear of cloud but that he was unable to see Quetame Hill or the other hills in the vicinity of Bojacá. When asked if there was sufficient visibility over La Sabana to make an emergency landing owing to the low visibility, the captain replied: "It was impossible to make an emergency landing owing to the low visibility". It is therefore concluded that, ten minutes after HK-133 crashed into Quetame Hill, the Sabana de Bogotá was completely covered by cloud up to an altitude of approximately 9 000 feet or that a blanket 340 feet thick covered the Sabana level. Furthermore, according to the statements of the aircraft captain and the witness, Quetame Hill and the range adjacent thereto were completely covered by cloud. According to these statements, it is presumed that the Sabana de Bogotá was completely covered by thick cloud at the time of the accident and that HK-133 was flying in IFR conditions immediately after take-off.

Upon arrival at the scene of the accident the Investigating Commission found the wreckage of HK-133 lying on one of the slopes of Quetame Hill at an elevation of 2 790 metres, its magnetic heading being 235°.

On examination of the aircraft the following facts were noted:

1) All the wing panels had detached themselves from the hull and were found lying 8 metres away. Examination of the starboard wing indicated that the wing had not been subjected to any excessive loads in flight. The port wing was broken at two points: at the level of station 24 and at the level of station 19. According to the tracks found on the ground, at the level of the port wing float and 15 metres away on the left, it is assumed that the first impact of the aircraft on the surface was taken on this wing, which pressed upon the float, causing the breakage of the wing at the two points mentioned. By force of impact and the centrifugal force of a slight turn (about 5° bank) to port, the aircraft revolved about 30° to port round its vertical axis. Careful examination of the structural elements of this wing shows that it had not been submitted to overloading in flight.

2) On examination of all control surfaces no evidence was found of structural breakage in flight. It was considered that had a structural failure occurred in flight, the broken portion or an adjacent part of the structure would probably have detached itself from the aircraft before the crash and would have been found at some distance from the accident site.

3) The control surface tabs were found in the following positions -

a) the rubber control tab was about 6 to 8° to starboard;
b) the elevator tabs were down;
c) the aileron tabs (port aileron) were about 3° to the rear;

4) The aircraft hull was completely destroyed up to station 367.

5) The hull section from station 388 to the tail was found in apparently good condition, with evidence of rearward bending stress between stations 546 and 576 and stations 367 and 388.

6) The starboard engine was found practically detached from the nacelle and twisted about 30° to the left. Inspection of this engine revealed the following:-

The propeller was detached with part of the nose housing and the entire reduction system, the whole being found behind the engine and level with the trailing edge of the central section. Examination of the teeth of the reduction gear showed that this area had been submitted to temperatures much higher than normal. The propeller blades were bent at a 19° angle and their folding back and the traces of impact on the ground indicated that the engine was idling or turning at a very low rpm at the time of the crash. The cooling vanes were found in the open position. All the steel tubes of the engine mounting were found broken close to the support of the former with the nacelle. All the connections between the oil tank, the radiator and the engine pump were found broken, and it was impossible to determine whether any of the pipes were broken or had come loose before the crash. Unsuccessful attempts were made to find the oil valve. The fuel valve was found in the closed position, yet it is doubted whether it was in that position before the crash, as the twist of the motor to port side could have closed it. On the outside, the crank cases of the power and accessory sections showed signs of having been subjected to high temperatures, judging by the scorched and cracked paint. Cylinders Nos. 1, 3, 12, 13 and 14 were dismantled at the site of the accident, and the following details were noted: Cylinder No. 12 had a completely melted-down piston, and broken piston rings; the connecting rod was broken at the point of juncture with the piston, and showed signs of having been subjected to excessively high temperatures. The piston of Cylinder No. 11 was also melted down to a large extent and seemed to have supported temperatures above normal. The remaining pistons were melted to a lesser degree and had some broken piston rings. Owing to seizure it proved impossible to dismantle cylinders and pistons Nos. 2, 4, 5, 6, 7, 8, 9 and 10. The oil filter was removed and numerous metal particles were found (tin, aluminium, brass and steel). The oil pan was dismantled, and inside were found a large number of piston, piston ring and rod fragments. All the spark plugs were dismounted, and it was noted that they were all of the type recommended for the engine and appeared to have been operating normally, although some of them seemed too tightly compressed owing to the high temperatures they had undergone. Nothing was found to indicate a malfunctioning of the ignition system. The turbine and accessory sections were dismantled a few days after the accident, and it was found that the gears, the shafts and the hubs underwent temperatures well above normal, owing to lack of lubrication. On the starboard side of the tail unit, a large quantity of oil was observed; it had escaped from the starboard engine, which could have been due to filtration into the turbine section through misalignment, to failure of the internal return system, or to a break in one of the connections of the external oil line. The accessories of this engine showed no evidence of failure. The engine's feathering system was examined, particularly the electric motor and the pump; none showed evidence of failure. The electric circuit of this system could not be examined as it had been totally destroyed.

7) The port engine was in satisfactory working order.

8) It is presumed that the landing gear was extended by the violent crash of the aircraft against the hill, which loosened the gear from its retracted position.

The starboard leg was found unlocked in the "down" position, which shows that at the time of the crash the gear must have been retracted.

9) The cabin and instrument controls -

Cockpit - the master magneto switch was in the "on" position. Starboard engine - both on. Port engine - both on. The clock showed 0729 hours. The pilot's airspeed indicator - 72 knots. The pilot's radio compass - 175°. Co-pilot's - 185°. It proved impossible to determine the readings of the other instruments or the position of the other controls, all of which had been completely destroyed. Flight Engineer's station. Starboard engine tachometer, 2 600 rpm. Precision indicator of the supercharger: 26.5" Hg. fuel mixture controls: "full rich"; altimeter: 12 240 feet and 29.92" Hg.

Analysis of Evidence

The aircraft took off from Santa Cecilia airport with an overload of 525 kgs over the maximum gross weight permitted by the Colombian Civil Aeronautics Authority for take-off at sea level, and with an overload of 1 505 kgs over the operational maximum gross weight recommended for Bogotá. According to the graphs on take-off weight limitations shown in CAA Manual No. 42, at a standard altitude of 8 260 feet and with a runway of 5 414 feet (Santa Cecilia) the maximum operating gross take-off weight is 11 339 kgs. According to the load and trim computations the aircraft took off from Santa Cecilia with 12 845 kgs, and the maximum gross weight at sea level authorized by the Colombian Civil Aeronautics was 12 320 kgs.

The company had not established an adequate technical system for aircraft loading, and it was therefore impossible to determine the point of the aircraft's centre of gravity at take-off and at the moment of the accident.

The aircraft dispatcher showed that he lacked the technical knowledge necessary for the proper discharge of his functions, since he had not even known either the empty weight of aircraft HK-133 or the maximum gross operating weight for Bogotá. Moreover, he was working without a technical system for loading or for determining the aircraft's centre of gravity.

The failure of the starboard engine was conclusively proved; it was caused by serious damage to the lubricating system, due to either of the following causes:

a) the severance of a connection in the external oil line to the engine;
b) the misalignment of the turbine section, which might have produced an obstruction in the internal lubricating passages of the engine.

It proved impossible to determine the condition of the connections of the oil line serving the starboard engine, owing to the considerable damage suffered by the radiator, the pipes and the hoses.

It was impossible to determine exactly why the pilot did not feather the damaged engine. However, it is assumed that this may have been due to either

a) exhaustion of the oil supply for the pitch control system; or
b) failure of electrical system of the feathering circuit.

The weather conditions at Techo and Santa Cecilia Airports were completely adverse at the time of HK-133's take-off, for which reason the take-off was effected under IFR conditions as shown by the Meteorological Report and the Route Control and Techo Approach Control logs.

On establishing radio contact with Techo Control Tower, the pilot merely tested his radio equipment and enquired about weather conditions at Medellín, which would suggest that his take-off was deliberately undertaken in spite of unfavourable weather and the prohibition of Techo Control Tower. Apart from this radio contact the pilot did not contact any ground station, notwithstanding the relatively long flight time and the satisfactory working order of the aircraft's radio equipment.

Santa Cecilia Airport was approved by the Civil Aeronautics Authority, for operational use, subject, however, to control by Techo Tower.

The journey log book was not kept in conformity with the recommendations of the Colombian Civil Aeronautics Authority.

The Company forms covering ground testing of the engines do not include a specific item relating to the checking of the pitch control system. It is, therefore, not known whether the testing of the starboard engine, accomplished some hours before the accident, included this check, and, consequently, whether the aircraft took off with the system in good working order.

The aircraft did not undergo the necessary flight test after the replacement of the turbine section of its starboard engine. This appears to have been the Company's practice in its maintenance work on HK-133, as it was found moreover that the proper test flight was not performed after the replacement of the port engine.

The facts which follow give evidence of serious shortcomings in the Company's maintenance Service as well as in its Operations Section:

a) The pilot discharged the functions of Maintenance Superintendent, and was in charge of some technical aspects of the work entailed by such functions without being duly licensed for this by the Colombian Civil Aeronautics Authority;

b) There was no responsible Maintenance Department to plan and take decisions on the various kinds of work to be performed on the aircraft as these functions were assigned to the Chief of Operations;

c) The chief maintenance officer was unable to perform his duties successfully as he did not have sufficient experience with PBY-5A equipment and as part of his functions were being discharged by the pilot.

The role of the owner and manager of the Tadecol Workshops in the installation of the starboard engine's turbine was limited to seeing that the engine's mechanical distribution was correct; he did not, however, assume total responsibility for this work.

AIDA was operating without taking the precaution of having available a spare engine in good working order, which would have ensured maximum safety. In its absence, the starboard engine of HK-133 was repaired hastily and without conforming to technical standards, a few hours before the accident. This is further borne out by the fact that the Company had to ask the Colombian Air Force for the loan of the port engine used on the aircraft at the time of the accident. Previously this engine was installed on a PBY-5A that had not been in service for some time.

The fact that the Company did not have an aircraft available that could have replaced HK-133, led to the excessive haste with which this aircraft was reconditioned to enable it to perform the flight of 8 December, carrying passengers.

Two mechanics were on board the aircraft to advance their flight mechanic's training course. They were flying as additional crew without holding the appropriate licences. The Civil Aeronautics Authority had not been informed of this training being given by the Company to the mechanics.

The pilot reported at Santa Cecilia Airport on 7 December at 0630 hours local time to assist in getting HK-133 ready for flight. He remained at work all day, the night of the 7th and part of the early morning hours of the 8th (until 0230 hours local time) when he retired, only to return for the flight at 0545 on the same day. This suggests that, at the time of the accident, the pilot was tired owing to the continuous work he had performed on the 7th and 8th. The same may be said of the flight engineer, who had worked to service the aircraft before as well as during the flight.

Reconstruction of the flight until the time of the accident

On 6 December at 1350 hours local time HK-133 landed at Santa Cecilia Airport from Miraflores, Comisaria del Vaupes, piloted by a captain who was also Chief of Operations and Maintenance Superintendent of the Company (AIDA). After this flight the pilot stated in the aircraft log that the starboard engine was losing power. The Company's maintenance service proceeded, on the same day, to determine what was wrong with the engine. The fault was found in the turbine section and consisted of an inadequate tolerance between the turbine and the distribution section, which produced appreciable friction between the two parts. The starboard engine was taken down, the turbine section was removed and replaced by another one in working order. The work on the starboard engine continued throughout the whole of 7 December and part of the morning of the 8th until, at about 0150 hours, the engine was tested on the ground for some 30 minutes. The aircraft was declared airworthy and ready for the start of the scheduled passenger flight a few hours later.

At 0604 hours the captain called Techo Route Control Centre from the aircraft in order to test the aircraft radio equipment and to inquire about the weather conditions at Medellín. Route Control informed him that the radio signal was fairly good and very clear but did not give him the Medellín weather information. There were no further contacts from the aircraft with any ground station. At 0610 the dispatcher called Techo Control Tower to inquire about weather conditions both at Techo and at Medellín airports. He was told that Techo airport was completely closed due to poor visibility. This information was passed on to the pilot of HK-133. Ignoring the weather conditions prevailing at the time at Techo airport and at Santa Cecilia, the captain gave orders for passengers to board HK-133 at 0630 hours local time. Take-off was started at 0647 hours local time. At take-off Santa Cecilia airport was still completely covered by thick, low fog and, therefore, as soon as the aircraft became airborne it was under IFR conditions. A few minutes after the aircraft had begun to climb, the starboard engine became damaged following complete failure of the lubricating system. As the aircraft was overloaded and the engine was not feathered it was impossible to maintain the rate of climb required to break through the 340 foot thick fog blanket covering most of the Sabana de Bogotá. This circumstance forced the aircraft to continue flying under IFR conditions. It is thought that the pilot was trying to find a way to Magdalena Valley in order to be able to fly at a lower altitude and obtain better performance from the engine still functioning as well as better visibility, but that

1) he tried to do so at an inadequate height (due to failure of the engine which prevented his climbing to a higher altitude) or,

2) thinking he was on the border of the Sabana he started descent too early.

The Chief, Technical Control and Investigation Branch also believes that the aircraft was not turning at the moment of impact (opinion of Chief, Technical Section, Investigator). He believes that owing to the slope of the hill and the heading of the aircraft, the latter was struck on the port wing float which made it turn to the same side. It may be, however, that there was a slight bank to the left due to the fact that the only engine functioning was on that side and that a twin-engined plane when it is stabilized for flight with only one engine leans on the latter.

Probable Cause

The probable cause of the accident was complete failure of the starboard engine due to the breakdown of the lubricating system.

Contributory causes included:

1. Recklessness of the pilot in taking off from a closed airport while aware of the poor weather conditions prevailing throughout the Sabana - a circumstance which prevented returning to the airport of departure when complete breakdown of the starboard engine occurred;

2. The 1 506 kilograms overload of the aircraft above the maximum gross operating weight for Bogotá according to the performance curves of the aircraft;

3. The adverse weather conditions prevailing from the moment of take-off until the moment of the accident;

4. An error of judgment on the part of the Operations and Maintenance Sections of the Company in failing to provide for a test flight of the aircraft after the turbine section had been changed and in finding aircraft HK-133 airworthy for the purpose of a scheduled flight with passengers under such conditions;

5. The lack of competent air traffic and weather authorities at Santa Cecilia airport in a position to check civil aviation regulations and to prohibit take off from a closed airport;

6. Faulty internal organization within AIDA which should have defined exactly the duties of the Maintenance Superintendent, of the Maintenance Chief and of the Dispatcher;

7. The failure of the Company to have available a spare engine which would have avoided carrying out such delicate repair work in a hasty manner.

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ICAO Ref: AR/476

No. 36

Columbia-Geneva Steel Company, Lockheed Lodestar, N 1245V, crashed near Tyrone, Pennsylvania on 20 December 1956. Civil Aeronautics Board (USA) Accident Investigation Report, File No. 2-0065, released 8 November 1957

Circumstances

The aircraft departed Greater Pittsburg Airport, Pittsburgh, Pennsylvania at 1850 hours eastern standard time on an IFR flight plan to New York International Airport, Jamaica, New York. On board were 2 crew members and a company official. At 1921 the CAA Communications Station at Philipsburg, Pennsylvania received a call from the flight giving its position as over the Coalport intersection at 1916, estimating Philipsburg at 1930. Philipsburg radio then requested the flight to change over to the frequency of the New York Air Route Traffic Control Centre and this message was acknowledged.. This was the last radio contact with the aircraft. It crashed at 1923 hours approximately 5 miles north of Tyrone, Pennsylvania. There were no survivors.

Investigation and Evidence

A detailed study of the wreckage indicated that the left wing and the empennage failed almost simultaneously. It was determined that the left horizontal stabilizer was the first empennage unit to separate, followed by the right horizontal stabilizer. This latter component showed evidence of having been struck on its leading edge during the in-flight break-up; the most logical striking object was the left aileron balance weight assembly, which also separated in flight.

Following the left wing and empennage failure, portions of the engines' cowlings and parts of the fuselage separated. Thereafter, both powerplant assemblies tore out and the right outer wing panel separated just before ground impact.

It could not be established if the de-icing system components were in operation at the time of the accident, as the setting of the de-icer control prior to impact is unknown. Impact forces caused deformation and binding of the de-icer distributor valve motor; however, it was found to be in good condition electrically and therefore is believed to have been capable of operation before impact. Except for the damage sustained during the accident, the wing and empennage leading edge de-icing boots were in good condition.

Examination of the entire wreckage disclosed no evidence of fatigue failure, nor was there any evidence to indicate that a foreign object struck the aircraft in flight. All parts of the aircraft were accounted for within the wreckage distribution area. The initial airframe failures were all the result of loads in excess of the design strength of the particular parts or components. There was no evidence which indicated that a fire or explosion occurred during flight.

The aircraft had flown 92 hours since the last 100-hour inspection on 3 October 1956 and 30 minutes since the last line inspection on the day of the accident.

The Philipsburg 1928 weather sequence was: ceiling measured 400 feet, overcast; visibility 2 miles; fog; temperature 40; dewpoint 40; wind calm; altimeter 30.04.

On the afternoon of 20 December an overcast existed over the entire State of Pennsylvania, with ceilings ranging from zero to about 1 500 feet in the southwestern portion with tops at approximately 11 000 to 12 000 feet. Fog and occasional light rain were occurring. At the time of the flight's departure the freezing level was about 10 000 feet at Pittsburgh and lowering to the east to near 9 000 feet in the Tyrone area. Forecasts available before departure of N 1245V indicated light to moderate rime icing above the freezing level, with the freezing level forecast to be 9 000 feet in western Pennsylvania sloping downward to about 6 000 feet in western New York. Meteorological conditions were conducive to the formation of carburettor or induction system icing.

There were several flights through the Philipsburg area at the approximate time of the accident. They reported no icing or turbulence however, their flight altitudes were below the 9 000 foot level of the Lockheed.

A number of witnesses in the accident area heard the aircraft. One witness, located approximately two miles south of the crash, heard the flight go northeast at low altitude and then turn back toward the crash site. Two other persons, several miles northeast of the impact, also heard the aircraft turn back. All witnesses told of hearing irregular engine sounds, followed by engine silence.

Because of the lack of certain tangible evidence much is unknown. It is known that the pilot was flying under IFR conditions and was assigned an altitude of 9 000 feet; also that his last position report was made at 1921, five minutes after reaching Coalport. Since this report was made in a normal tone of voice and since nothing was said to the contrary, it can be reasoned that an emergency situation was not recognized at that time. However, approximately two minutes after that report was made the aircraft struck the ground. Therefore, whatever happened did so quickly and shortly after the last report was made.

Ground elevation at the scene of the accident is 1 500 feet and this altitude, considered in relation to the assigned altitude of the aircraft, means that the aircraft descended 7 500 feet, at an average rate of descent of about 3 750 feet per minute. Although the exact pattern of the descent is not known, it is believed that the speed of the aircraft during the descent, coupled with manoeuvring loads, created forces beyond the design strength of the aircraft. This is undoubtedly true since no evidence was found to indicate any prior failure or defect of any of the components of the aircraft.

The witnesses unfortunately did not see but only heard the aircraft. Although some stated the direction of flight, the approximate altitude, and that the engines appeared to be functioning improperly, it must be remembered that these impressions were formed under conditions in which accurate estimates were not possible. To determine the direction or height above the ground, or both, from the sound would have been especially difficult in this instance because of probable reverberation and distortion among the hills. The engine sounds heard could have been caused either by a malfunctioning engine or engines, or as the result of the pilot's intentional throttling back of the engines during an uncontrolled descent.

The engines, when examined subsequent to the accident, did not show any indication of operational failure or malfunctioning prior to impact which could have caused or contributed to the accident. Because of the time interval involved during disintegration of the aircraft and final free fall of the engines, evidence obtained from the propellers was of no significance with regard to power being produced at the start of the emergency. However, it was concluded that neither propeller had been feathered.

Because the azimuth ring of the course indicator of the Collins Integrated Flight System was found stopped at 48 degrees (nearly the reciprocal of the heading at impact) and because this instrument is operated electrically, a possible electrical failure as a contributing cause to this accident was considered. It was determined, however, that the probability of such a failure occurring at cruising altitude was quite remote and that the failure must have occurred during the break-up of the aircraft with the stoppage of the azimuth ring where it did as merely a coincidence. Furthermore, even if an electrical failure had occurred while at cruise, the pilot had recourse to other instruments, not operated electrically, by which attitude and direction could be maintained.

Another possibility considered was that induction or carburettor ice could have caused a complete loss of power of the engines either separately or simultaneously and that this loss of power resulted in loss of control. This is believed not to have been the case for several reasons. Although the aircraft was probably in clouds at 9 000 feet and the weather conditions at cruising altitude were conducive to this type of icing, it must be remembered that the pilot had available the approved anti-icing devices which incorporated the use of heat and alcohol. Weather observations and forecasts for the area on this day indicated clearly the weather conditions which the flight would encounter. Even if the use of heat or alcohol had failed, it is inconceivable that a pilot with this one's experience would have allowed loss of power to result in loss of control of the aircraft.

There are possibly many unknown factors which might have contributed to loss of control. Unfortunately, the existence of such factors in this instance can neither be proved nor disproved because of lack of evidence.

Probable Cause

The probable cause of the accident was the loss of control for reasons unknown resulting in a rapid descent during which structural failure occurred.

ICAO Ref: AR/480

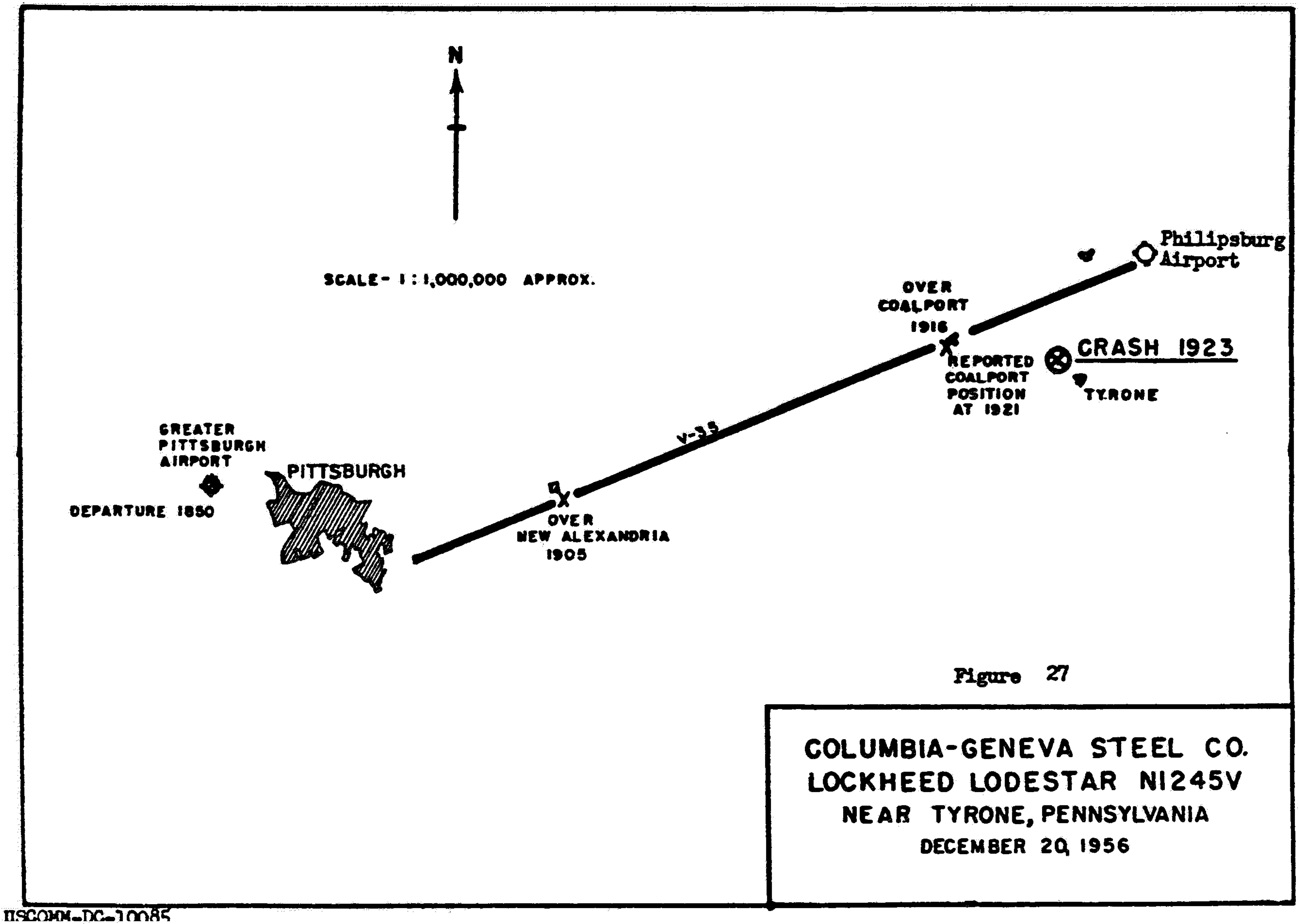

Figure 27

COLUMBIA-GENEVA STEEL CO.
LOCKHEED LODESTAR N1245V
NEAR TYRONE, PENNSYLVANIA
DECEMBER 20, 1956

No. 37

Linee Aeree Italiane, DC-3, crashed into Pale Perse (Monte Giner - Presanella Group) on 22 December 1956. Report released by Ministero della Difesa - Aeronautica, Italy.

Circumstances

The aircraft, I-LINC, took off from Ciampino Airport, Rome, at 1508Z on a VFR flight plan from Ciampino to Elba and an IFR plan from Elba to Milan-Malpensa along airways A3 and A9, which involve flight over the Elba, Genoa and Lombardia beacons. The cruising altitude was 10 500 feet. At 1520Z the flight plan was changed from VFR to IFR. The radio communications exchanged between the aircraft and Rome and Milan area controls were normal until approximately 1702Z when the aircraft confirmed that it was maintaining altitude 9 500 as instructed by Milan ACC. After 1714Z, attempts by Milan control to contact I-LINC were unsuccessful. The aircraft crashed at approximately 1720Z on the northern slopes of Monte Giner. All 4 crew members and 17 passengers were killed instantly.

Investigation and Evidence

From an analysis of the times reported for crossing of specific points, the route appeared to be that entered in the flight plan. As shown further on, however, the aircraft was not flying along the route it had given in the flight plan but was on a more easterly route which led it eventually into the Val di Nambrone. The crash occurred beyond this valley at latitude 46° 14' 45" N, longitude 10° 43' 53" E.

The weather conditions at the time of the accident were generally unsettled over Northern Italy.

From statements of witnesses, it appears that the weather at the scene of the accident was partly cloudy and that the flight over Val di Nambrone was conducted clear of cloud which leads to believe that there were large openings.

The meteorological information and the weather forecast for the route, the destination aerodrome, and the alternates were supplied to the pilot as usual before departure.

The actual weather conditions on the Rome-Milan route via Amber 1 - Amber 3 - Amber 9 between 1400Z and 1800Z on 22 December were as forecast.

The weather situation over central and northern Italy between 1400 and 1800 hours was such that navigation could be carried out between 1 500 and 3 000 metres in and out of clouds along the Rome-Elba sector. Over the second sector, Elba-Milan, cloud coverage increased and clouds in stratified formation occurred more frequently. Over the Valley of the Po, the cloud base was down as low as 500 - 600 metres.

Concerning icing, it is thought that after the report on icing (moderate to heavy) transmitted at 1648Z, by the aircraft, no such danger was feared since it would have been the subject of a further communication.

The efficiency of the radio aids over the Rome-Milan segment was checked by responsible authorities. No aircraft had reported any deficiencies or irregularities.

In addition to the communications between the aircraft and the Rome and Milan ACC's, no assistance was requested by the aircraft from other D/F stations. The aircraft transmitted routine position reports and no difficulties or complaints were mentioned.

Examination of the wreckage of the radio equipment did not yield any data of value. The 372 kc/s frequency setting found in the wreckage of the radio compass receiver panel of the radio operator does not correspond to any radio beacon frequency in use over the Po Valley.

Fires broke out following impact but were limited to the areas of the nacelles where fuel had spilled.

In view of the nature of the accident, the possibility of the aircraft's fire fighting equipment having been used must be excluded.

Wreckage was scattered in an area 30 metres in diameter at the same point where the aircraft crashed into the 45 degree slope.

The crew cockpit was completely crumpled against the slope and flattened against it. No technical data was obtainable from the instrument panel or from the position of the controls. The passenger cabin was completely destroyed. The tail assembly was found only slightly damaged, owing to the cushioning effect produced by the bending and failure of the forward part of the aircraft.

The condition of the wreckage and in particular that of the fuselage, completely destroyed up as far as the bulkhead level with the door to the lavatory, indicated the violence of the impact.

The absence of any trace along the area preceding that where the wreckage was found indicates that the aircraft did not come in contact with the ground before the impact.

The first part of the aircraft to strike the mountain was the nose and the left half wing, which were broken off approximately at the point of impact, while the other parts were thrown forward towards the right as a result of the rotation following the sudden stop of the left half wing.

No useful information was obtainable from the piloting and navigational instruments, from the radio equipment or from the controls, because of the condition of these parts. The only thing that it was possible to observe was that the magneto switch was in the "BOTH" position for both engines.

The technical examination of the wreckage did not reveal any data or information leading to the possibility of mechanical or structural failure.

Messages exchanged between the aircraft and Rome and Milan Area Controls indicate the following:

With Rome Control

1546Z ... gave its time of departure from Rome, destination, estimated time of arrival at Milan, flight conditions, flight altitude, true track of 330° and requested the QNH for Pisa and relay of the message to Milan ....

1552Z ... it had passed over Orbetello at 1551Z and was flying in and out of cloud at 10 500 feet

1614Z ... over the Elba radio beacon and flying in cloud

after 1614Z and before 1624Z

... the following message was entered in the aircraft station log (parts of which were recovered) for transmission to Rome Ciampino:

"NR2 ESTIMATES ARRIVAL ABEAM PISA RADIO BEACON 1628Z FLIGHT ON TOP CLOUD AT 10 500 FT IFR ACKNOWLEDGE - ETA MILAN/ MALPENSA 1730Z K"

(The time of transmission is not entered in the aircraft station log, which leads to believe that the message was never sent. In fact, there is no record of it having been received by Ciampino).

With Milan Control

1648Z ... had overflown the Pisa radio beacon at 1628Z and was flying through cloud with average to moderate icing at 10 500 feet

Milan ACC asked the aircraft whether it wanted a lower altitude - it replied that it wished a lower altitude after Genoa

1651Z ... was instructed to remain at 10 500 feet and to call back when over Genoa - aircraft asked whether after crossing the Genoa beacon it could fly directly to the Malpensa radio beacon without overflying VOR Lombardia

1653Z ... was informed by another aircraft (I-LOVE) that weather conditions over Genoa were such that lights of the city could be clearly seen

1659Z ... reported over Genoa radio beacon at 10 500 and requested permission to fly to VOR Lombardia at 6 500 feet

ACC Milan authorized descent to 9 500 feet and instructed the aircraft to maintain that altitude; it also gave the value for altimeter setting and the estimated time of the beginning of its approach (1728Z) to Malpensa.

1701Z ... I-LINC asked whether the ILS at Malpensa was operative

1702Z ... requested clearance from ACC Milan to descend to 6 500 feet on the VOR Lombardia. ACC denied the request.

1709Z ... the tape of channel 125.3Mc/s registered an unintelligible mutilated word, repeated twice; this word is inserted between an exchange of communications between an Air France aircraft and Milan Control and could not be identified nor therefore attributed with certainty to aircraft I-LINC;

1714Z onwards

repeated calls from Milan control and from I-LOVE were unanswered.

Until 1702Z communications with the aircraft were normal. After that time from evidence gathered, it appears that the position lights were on, which indicates that electric power was available. Witnesses who heard the aircraft did not notice any malfunctioning of the engine.

The place at which the aircraft crashed in relation to the duration of the flight and to the average speed of the aircraft leads to the belief that the track made good by the aircraft was altogether east of the planned track.

On the basis of messages sent by the pilot of I-LINC, it appears that the flight was conducted continuously in cloud. In particular, at 1648Z the aircarft reported moderate to severe icing. These meteorological conditions are in sharp contrast with those encountered and reported by other aircraft flying at about the same time on the airways indicated in the flight plan of I-LINC, which reported fair conditions. It must be assumed, therefore, that the aircraft followed a course further to the east where the weather conditions as reported in the forecast correspond to those reported by the pilot.

The message sent by the pilot, reporting that he was over Genoa at 1659Z cannot be accepted as accurate if it is considered that the impact occurred at approximately 1720Z in the Giner area, 250 kilometres distant from Genoa, a distance which could hardly be covered in 21 minutes.

It was reported by the D.A.T. Command* that two control radars observed traces of an unidentified aircraft on their scopes.

The first radar had observed at 1640Z a blip 20 kilometres west of Bologna and had followed it in its flight along a track to the north until 1658Z, south of Verona.

The second radar had observed a trace in the same area at 1659Z and had followed it until 1705Z in the vicinity of Mori.

In view of their position, the time of sighting and the direction of displacement of the two traces, the authorities concluded that they referred to the same aircraft.

Since the data concerning the position and the time which can be deduced from the reports are in agreement as to the hour and to the time of the crash, it is believed that the traces were those of aircraft I-LINC.

The second radar estimated the altitude of these traces at 14 000 feet and the speed at 210 knots.

These estimates do not appear acceptable, however, unless it is assumed that the aircraft, in contrast with the clearances received to maintain the cruising altitude of 10 500 feet, decided arbitrarily to climb first to an altitude of 14 000 feet and then to descent at a speed of 210 knots. This assumption appears entirely improbable.

In the message sent at 1546Z to Rome control, the aircraft reported that it was flying on a true heading of 330°. This heading does not correspond to that of airway Amber 1 which it should have been following, but corresponds closely to the direct route Ostia-Malpensa or Civitavecchia-Malpensa.

The request by the pilot at 1650Z to initiate descent after Genoa may indicate that he believed that he was in a mountain area presumably east of Genoa.

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* Difesa Aerea Territoriale

The request by the aircraft at 1650Z to fly to Malpensa without passing over Lombardia NDB-VOR may be explained only if the aircraft thought it was following a route which did not pass by Genoa, since Malpensa, VOR Lombardia and Genoa are on the same alignment.

At 1656Z the pilot of I-LOVE gave the weather conditions over Genoa to I-LINC.

At 1659Z I-LINC reported being over Genoa, whereas, on the basis of the considerations mentioned ..... re the crash occurring at 1720Z in the Giner area, 250 kilometres distant from Genoa, a distance which could hardly be covered in 21 minutes ..... it could not have been at that position and therefore, it could not observe Genoa as had I-LOVE.

The fact that the pilot was not concerned about this leads to the belief that he was aware that he was not over Genoa.

Analysis of the information available leads to the reconstruction of the route followed as:-

1508Z	take-off Rome
1516Z	Ostia
1640Z	20 kilometres west of Bologna
1643Z	Castelfranco Emilia
1659Z	Verona
1705Z	Mori
1720Z	crash.

(pressure altitude 9 500 feet corresponding to true altitude of 8 500 feet = 2 600 metres at temperature of -30°C.)

The route from Castelfranco Emilia to impact is confirmed by data available.

The fact that the aircraft crashed into Monte Giner on a southerly track is due to the change made by the pilot after flying over Val di Nambrone on a northerly track, as evidenced by statements of witnesses.

It appears that the sector Ostia (1516Z) to Castelfranco Emilia (1643Z) was covered in 1 hour and 27 minutes. This time on the basis of an average speed of 230 kilometres per hour represents a distance of 330 kilometres. Since this corresponds to the distance between Ostia and Castelfranco Emilia, it may be concluded that the track followed by the aircraft coincides approximately with the line joining these two points. It appears, therefore, that the track followed by the aircraft departed considerably from the route requested and authorized in the flight plan.

The pilot must have been aware that he was on a different route from that of the assigned airways, for the reasons already indicated and also because of the lack of radio checks over the compulsory crossing points. The pilot instead reported that he had flown over these points. Any failure of the radio compass would have been noticed at the latest upon overflying the first radio beacon along the route.

On the basis of his flight plan, the pilot should have followed three airways:

- AMBER 1 (radio beacon Ostia, radio beacon Civitavecchia, radio beacon Orbetello, radio beacon Elba);
- AMBER 3 (radio beacon Elba, beam radio beacon Pisa, radio beacon Genoa);
- AMBER 9 (radio beacon Genoa, radio beacon VOR Lombardia, radio beacon Malpensa).

Along this route he would have had available all the elements to check his route, speed, position, drift and therefore to correct any errors in his navigational instruments and of the airborne radio equipment. A reconstruction of the flight leads to the conclusion that the pilot, from the beginning of the flight, intended following a direct route from Ostia to Malpensa instead of that indicated in the above-mentioned flight plan.

It was ascertained that the pilot did not request any D/F fixes from the ground stations to establish his exact position along the route, nor, on the basis of the flight itself, does it appear plausible that he himself took any D/F bearings from the aircraft to ascertain his position.

While it is not improbable that the pilot did take lateral bearings in flight, these were not sufficient to permit him to determine his position along the route.

In all probability, therefore, the pilot navigated on the basis of an erroneously deduced reckoning and on the basis of the indications of his compass and directional gyro.

The crosswinds along the route, possibly of higher intensity than those reported to the pilot, the disturbed weather conditions which the aircraft encountered along the route and the simultaneous occurrence of irregularities in the functioning of the instruments (radio compass and directional gyro) may have caused the aircraft to deviate from the route selected by the pilot.

It should be pointed out that the D.A.T., after observing the presence of an unannounced aircraft in the Bologna-Modena area, and on the assumption that this was an aircraft that had deviated from airway AMBER 14 (Viterbo-Florence-Parma-Linate), communicated this information to Milan Control.

Milan, after analysing its traffic, excluded the possibility that this report could concern an aircraft under its control since at that moment all assisted aircraft, through the position reports, communicated that they were flying regularly along the assigned airways.

In particular, Milan could not imagine that the report concerned I-LINC, which a few minutes before had reported that it was flying on airway AMBER 3 along the Elba-Genoa sector.

It should further be pointed out that in this specific case, Milan control could not itself take any initiative on the basis of the communication received from the D.A.T., since its function is limited to providing assistance to reported aircraft flying under IFR conditions.

Probable Cause

The Commission concluded that the change in the route followed by the aircraft and the resulting accident may be attributed to the following:-

a) the pilot did not follow the airways assigned in the flight plan - which constitutes a violation of flight rules;

b) he did not check his direction and position along the new route;

c) unfavourable weather conditions and drift existed;

d) there was a possibility of error in the navigational instruments.

Recommendations

On the basis of the examination of the causes of the accident, the Commission recommended:

1) the instruction to all pilots to follow the airways assigned and entered in the flight plan should be enforced and pilots should be instructed to follow clearly the rules governing instrument flight;

2) that in all cases flight crews should avail themselves more fully of existing radio facilities and in particular the HF and VHF D/F aids available.

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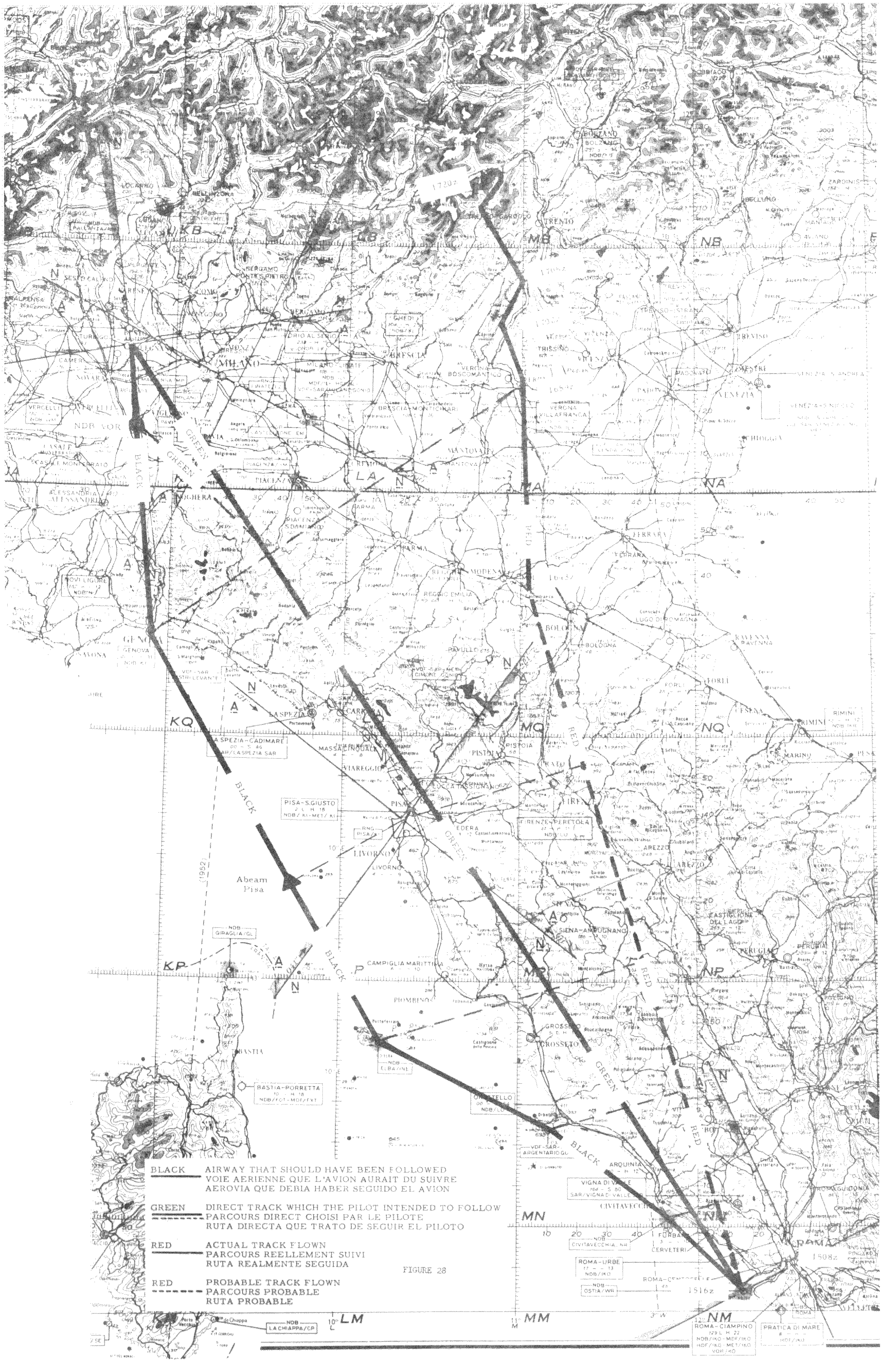
ICAO Ref.: AR/453



BLACK — AIRWAY THAT SHOULD HAVE BEEN FOLLOWED
VOIE AERIENNE QUE L'AVION AURAIT DU SUIVRE
AEROVIA QUE DEBIA HABER SEGUIDO EL AVION

GREEN — DIRECT TRACK WHICH THE PILOT INTENDED TO FOLLOW
PARCOURS DIRECT CHOISI PAR LE PILOTE
RUTA DIRECTA QUE TRATO DE SEGUIR EL PILOTO

RED — ACTUAL TRACK FLOWN
PARCOURS REELLEMENT SUIVI
RUTA REALMENTE SEGUIDA

RED — PROBABLE TRACK FLOWN
PARCOURS PROBABLE
RUTA PROBABLE

FIGURE 28

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No. 38

Jugoslovenski Aerotransport, Convair 340, YU-ADA, crashed on approaching Munich-Riem Airport, Germany, on 22 December 1956. Report released by Luftfahrt-Bundesamt, Federal Republic of Germany.

Circumstances

The aircraft was on a scheduled flight from Belgrade to Munich-Riem Airport with an intermediate refueling stop at Vienna. It departed from Vienna for Munich at 1837 hours, local time, with 30 people aboard. At 2033, after passing Munich NDB at 12 000 feet, the flight reported to Munich Area Control Centre and shortly thereafter was instructed to descend to 10 000 feet. The pilot was asked whether he wished an ILS approach monitored by GCA but he decided on a GCA approach. At approximately 2048, after overflying non-directional beacon DHR (35 km east of Riem airport), a further descent to 7 000 feet was carried out. A subsequent instruction to descend to 4 000 feet was also complied with and the pilot was asked to notify GCA when passing 6 000 feet. At 2053 the flight was cleared for a direct instrument approach to runway 25. At 2056 it reported passing 6 300 feet and at 2058 as having reached 3 500 feet. It was then cleared to descend to 3 000 - this altitude was to be maintained. The flight was then 7 miles east of the airport. At 2059 the pilot reported leaving 3 000 feet and was requested to carry out the necessary cockpit checks for landing. GCA ordered a course of 240 degrees and advised the pilot that he was 4.5 miles from touchdown. He was requested to maintain 3 000 feet and was ordered to pull up to this altitude as he was below the minimum height of his glide path. No answer was received. The aircraft struck the ground at approximately 2103 hours, killing 2 crew members and 1 passenger and injuring 12 others.

Note:- The above altitudes are above mean sea level. The Munich-Riem Airport altitude is 1 732 feet.

Investigation and Evidence

The captain, who was acting as an instructor on this particular flight, was seated in the right-hand seat of the cockpit and was listed as pilot-in-command of the aircraft. The co-pilot was in the left-hand seat.

The following weather conditions were observed by Munich Airport MET Office at 2050 hours and no appreciable change was noted before or around 2103 hours, the time of the accident:

surface wind -
approx. 210 - 230 degrees, 2 - 3 knots

visibility -
between 1.0 and 1.5 NM

moderate snowfall

8/8 FS at 700 ft., precipitation ceiling

QNH - 1017.6 mb. QFE - 955.6 mb.

The weather conditions at the scene of the accident at the time when the crash occurred were reported by Munich Airport MET Office to have been as follows:

wind close to ground -
approx. 210 - 240 degrees, 3 - 5 knots

visibility -
1.0 - 1.5 NM, possibly only 0.7 - 1.0 NM

moderate snowfall

cloud base approximately 600 - 800 feet

fluctuating QNH between 1017 and 1018 mb.

temperature on ground -1°C

The weather conditions en route between Vienna and Munich were normal.

The point of first impact was at a distance of 6.85 km from the runway threshold and 200 metres to the right (north) of the glide path.

The aircraft touched the ground with its left undercarriage and its left wing almost simultaneously. Both were destroyed at that point. Parts of the wing and the port engine, however, were still connected with the fuselage and were dragged along further. The aircraft then turned around its longer axis onto its back whereupon the right wing as well as parts of the rudder were also torn off. In this position the fuselage slid along until it came to a standstill. The distance from the first point of impact to the point where the wreckage came to rest was 400 metres. Only short stubs of both torn off wings remained attached to the fuselage as well as the damaged elevator unit.

The fuselage had split across on the left-hand side, the fracture being at the level of the second window. The panelling of the ceiling was ripped open. A passenger was thrown out of the aircraft while it was sliding along the ground. Whether he was properly fastened to his seat at the time of the accident could not be determined with certainty.

Objects in the cockpit obviously had had to be moved in order to remove the bodies, and this made it almost impossible to determine the exact position of levers and switches at the time of the accident.

The left-hand altimeter showed a setting of 28.33 inches, the right-hand one 30.03 inches. At 2034 hours Air Traffic Control gave the aircraft a QNH value of 1018 mb or 30.06 inches.

No traces of icing were noticed on any parts of the aircraft immediately after the accident.

No evidence of technical defects of any kind was found.

According to the position of one limit switch, the wing flaps were extended to approximately 20 degrees. The landing gear was down. Both propellers and one governor were carefully examined by experts. The Commission of Inquiry, after considering the outcome of the examination, came to the conclusion that these particular parts did not show any evidence of malfunctioning at the time of impact.

The ground ILS equipment was checked on 22 December before and after the accident and was found to be functioning normally on both occasions. The ILS was also used by three other aircraft on the day of the accident between 1908 and 2333 hours and no deficiencies were reported.

According to the recorded R/T communications, the captain confirmed that the cockpit check had been carried out. When asked (at approximately 2059 hours) by GCA for the present course, the co-pilot answered, but his reply was interrupted in the middle of the sentence and instead of "270 degrees", only the first digit (2) could be heard. At this point the tape only recorded a brief cracking noise. No further report was received from the aircraft. The co-pilot testified that further communication from GCA to the aircraft had been heard by him, referring in particular to the request to follow a course of 240 degrees.

At this moment, the aircraft was located somewhat north (in terms of the flight direction: to the right) of the outer marker, the light signals of which were noticed by the co-pilot on the receiving instrument. Based on the reported altitude of 3 070 feet above sea level, the aircraft was 420 metres (1 380 feet) above the ground.

Immediately after the request from GCA to follow a course of 240°, the aircraft rapidly lost altitude. The co-pilot testified that the nose of the aircraft dipped, and both the altimeter and rate of descent indicator showed a sudden loss of height.

The distance between the outer marker and the runway threshold is 8.47 km, while the distance between the first point of impact and the runway threshold was 6.85 km. The elevation of the site of the accident is 517 metres (1 705 feet) above sea level. The above factors show that the aircraft lost 420 metres (1 380 feet) in altitude over a distance of approximately 1.6 km. Considering the damage to the aircraft, caused by the impact, which must have taken place almost tangentially, it must have been travelling at a high rate of forward speed.

Assuming the true airspeed to have been 300 km/hr, it must be concluded that the average rate of descent must have exceeded 20 m/sec (4 000 feet/min) from the time the aircraft left 420 metres (1 380 feet) until the impact with the ground.

During the descent GCA noticed that the aircraft was dropping dangerously low. The attention of the pilot-in-command was immediately drawn to the fact by several calls in rapid succession, and he was urgently requested to pull up.

The co-pilot testified in his written report of 27 December as follows:

> "I noticed a certain jerk as if the aircraft was suddenly descending in a steeper glide and had the impression that we were rapidly losing altitude.

> As far as I can remember, the altimeter and rate of descent indicator showed a very rapid loss of altitude at this moment. I presume that I reacted to the situation on the controls in the normal manner."

Considering the above statement, the suddenly increased speed of descent could have been caused by the fact that the aircraft was pulled up to too great an extent which resulted in a subsequent dive.

Even after a most thorough investigation of all reports, testimony and evidence, the Commission of Inquiry was not in a position to reach a final conclusion as to what caused the accident. The Commission is of the opinion that a further clarification would be possible if the surviving co-pilot, who is suffering from retrograde amnesia, could be questioned once more on certain points of his written declaration, in particular in regard to the question whether and how far piloting led to a fast let-down of the aircraft from which it could not be brought up again in time.

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ICAO Ref: AR/484

AIRCRAFT ACCIDENT REPORTS - GENERAL

The following accident reports have been requested by ICAO but were not received as of 31 December 1957, the deadline for receipt of material for inclusion in Digest No. 8. If forwarded to ICAO, summaries of these reports will appear in the next edition - No. 9.

Dakota aircraft
near Toryska, Czechoslovakia
18 January 1956

Dakota, VT-DBA
Gauchar Airport, Katmandu, Nepal
15 May 1956

Douglas DC-3
of la Empresa Guatemalteca de Aviación
crashed on a mountain near Panzos, Guatemala
25 May 1956

Super Constellation
of la Línea Aeropostal Venezolana
at Idlewild, N.Y., U.S.A.
20 June 1956

Union of Burma Airways
Dakota, XY-ADC
crashed 24 miles from Thazi, Central Burma
8 August 1956

Ceskoslovenske Aerolinie
Ilyushin
at Eglisau, Switzerland
24 November 1956

Constellation, YV-C-AMA
of la Línea Aeropostal Venezolana
in the Avila Mountains, Venezuela
27 November 1956

Trans Canada Airlines
North Star, CF-TFD
missing 100 miles east of Vancouver, B.C., Canada
9 December 1956

Air France
Viscount 708, F-BGNK
at Dannemois, France
12 December 1956

The following reports on accidents have been received by ICAO over the past year but for various reasons have not been summarized:

Swiflite Aircraft Corporation
Lockheed PV-1, N-2000C
near Smithtown, N.Y., U.S.A.
26 January 1956

R.A.F. (military)
Vulcan, B.L.XA. 897
London Airport, England
1 October 1956

The Crane Company
Lockheed PV-1
near Jeffersonville, Indiana
15 May 1956

United Heckathorn, Inc.
Fairchild C-82
Boca Raton Airport, Florida
8 August 1956

Braathens South American & Far East
Air Transport A.S.
Heron LN-SUR
east of Tolga, near Koppang, Norway

(being held over for Digest
No. 9)

Real, S.A., Transportes Aéreos
DC-3, PP-YQA
Congonhas Airport, São Paulo, Brazil
5 April 1956

Bonanza, PP-IPJ
Pampulha, Belo Horizonte,
M. Gerais, Brazil
30 April 1956

Phillips Petroleum Company
Lockheed Lodestar 18-14, N 28366
Bartlesville, Oklahoma, U.S.A.
12 December 1956

PBY-5A, PT-ASN
Rio Tocantins, State of Pará
Brazil
11 July 1956

Dragon Rapide, PP-AIA
Coroatá Airfield, State of Maranhão,
Brazil
10 May 1956

Lockheed PP-NBI
Arpoador Beach, 15 km. from Tutoia,
State of Maranhão, Brazil
20 May 1956

T-11, PP-CCF
Santana Farm, Itacurú Municipality,
M. Gerais, Brazil
11 October 1956

Syrian Airways
DC-3C
46 km. south of Aleppo Airport, Syria
24 February 1956

Nacional Transportes Aéreos
DC-3, PP-ANK
Pampulha, Belo Horizonte, M. Gerais,
Brazil
6 September 1956

Aerolíneas Argentinas
DC-3, LV-ACD
crashed 5 km. northwest of Pavín
station, Province of Córdoba, Argentina
16 July 1956

The following Contracting States have forwarded numerous reports on smaller aircraft accidents -

Argentina
Brazil
Canada
Ireland
Netherlands
New Zealand
Pakistan
Union of South Africa

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PART II

AIRCRAFT ACCIDENT STATISTICS 1956

INTRODUCTION

GENERAL COMMENTS

1. This section of the Aircraft Accident Digest No. 8 contains a detailed analysis of the statistics for the year 1956, as well as an historical record of selected data for the years 1925 to 1957 inclusive. Although figures for the years subsequent to 1951 were obtained largely from the ICAO Air Transport Reporting Forms G (Aircraft Accidents) filed by contracting States, other sources had to be used for those countries which have not yet filed the required reporting Form in order to arrive at as complete a picture as possible of accidents in which public aircraft were involved.

2. The statistics shown are the best available to date but are subject to adjustment when more accurate data is forwarded to this Organization on the Forms G (facsimile copy given on pages 195 and 196).

DESCRIPTION OF TABLES

3. Accident data has been recorded under the country in which the airline which suffered an accident is established and not in the country where the accident took place. Data for the years 1955 and 1956 cover the operations of 70 contracting States members of ICAO at 31 December 1956, while preliminary data for the year 1957 covers the operations of those and two additional States members of ICAO at 31 December 1957.

4. Three detailed tables follow for the years 1955 and 1956. The tables for the year 1955 are revisions to Aircraft Accident Digest No. 7. These tables give the following information:

TABLE A Fatality rate by contracting States whose airlines had an accident causing a passenger to be killed on a scheduled flight.

TABLE B Aircraft accident summary by country (70 contracting States of ICAO) of all operators engaged in public air transport.

TABLE C Aircraft accident summary by type of operation and by country.

SAFETY RECORD

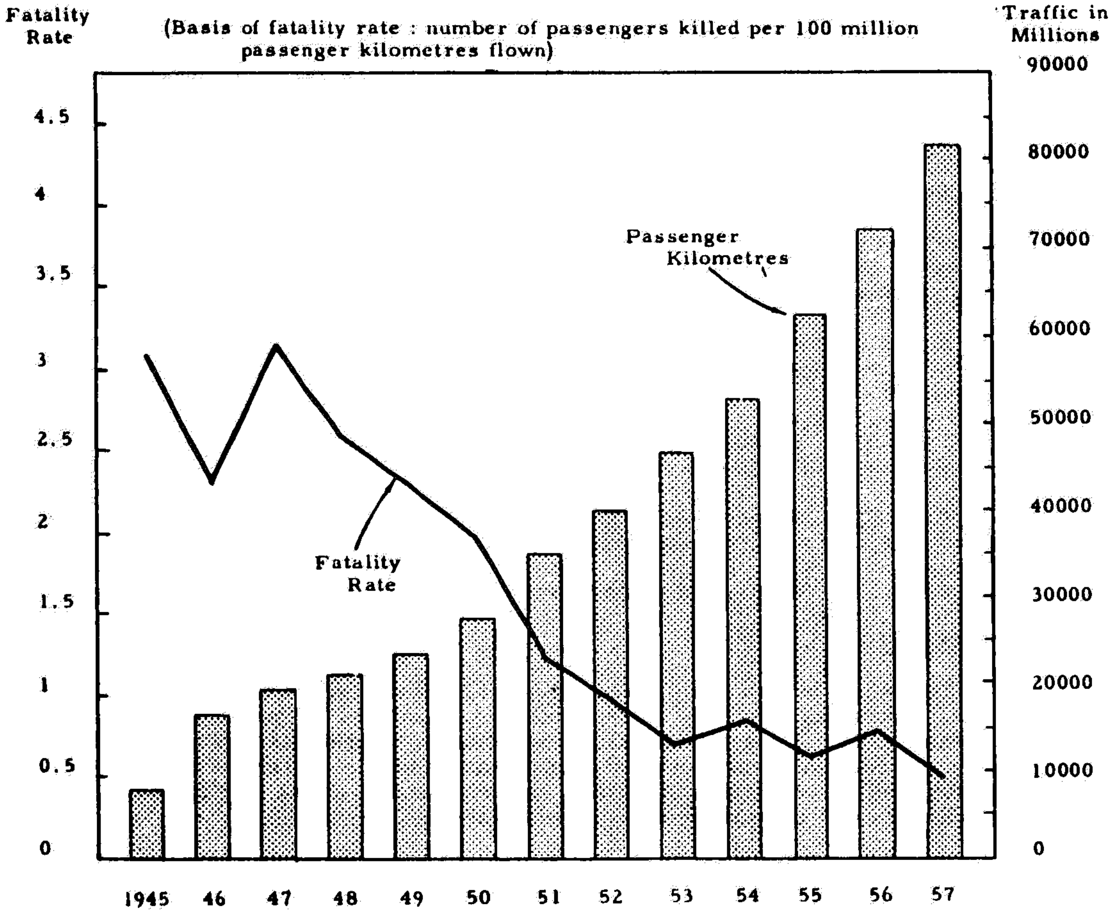
5. There has been a remarkable downward trend in passenger fatality rates since 1945, indicating a steady improvement in safety of commercial flying over the past thirteen years. Despite the increased speeds, weights and range of the aircraft flown today as compared with over a decade ago, and the increased traffic density on airways, the risk of accident occurrence has lessened over the period largely through technical changes and improvements in proficiency.

6. It is to be noted that all accident data prior to 1952 are to be regarded as the best available data only, because of the fact that accidents were not so widely or fully recorded in those years. With this in mind, if the safety record is extended to compare the pre-war period (1925 - 1939), with the war period (1940 - 1944), and the post-war period (1945 - 1957), it is found that the average fatality rate per 100 million passenger-kilometres has dropped from 12 in the pre-war period, to 3 in the war period, to 2.5 in the first six years after the war, and to 0.78 for the next seven years.

7. From a perusal of the chart and table shown on the following pages, it will be observed that the fatality rate per passenger-kilometre of 0.55 for 1957 is 18% of the 3.09 for 1945, a decrease of 29% from the rate of 0.78 in 1956. For the sixth consecutive year, the 1957 rate has remained at less than one fatality per 100 million passenger-kilometres flown. Although the number of passengers killed on scheduled flights over the period 1952 to 1956 ranged from a low of 356 persons in 1953 to a high of 552 persons in 1956, the extent of the increase in passenger traffic has more than offset the change in the level of passengers killed thereby maintaining the fatality rate below the mark of one.

PASSENGER FATALITY RATE TREND
COMPARED WITH GROWTH IN TRAFFIC
SCHEDULED AIR SERVICES 1945 - 1957

(Basis of fatality rate : number of passengers killed per 100 million passenger kilometres flown)



PASSENGER FATALITIES 1925 - 1957

ON

SCHEDULED AIR SERVICES

YEARS	Number of Passengers Killed	Passenger Kilometres Flown (millions)	Fatality Rate per 100 million Pass-Kms.	Millions of Passenger-Kilometres per Fatality
YEARLY AVERAGE				
1925 - 1929	36	130	28	4
1930 - 1934	80	445	18	6
1935 - 1939	133	1 475	9	11
1940 - 1944	114	3 795	3	33
YEAR				
1945	247	8 000	3.09	32
1946	376	16 000	2.35	43
1947	590	19 000	3.11	32
1948	543	21 000	2.59	39
1949	556	24 000	2.32	43
1950	551	28 000	1.97	51
1951	443	35 000	1.27	79
1952	386	40 000	0.97	104
1953	356	47 000	0.76	132
1954	447	53 000	0.84	119
1955	407	62 000	0.66	152
1956	552	71 000	0.78	129
1957	453	82 000	0.55	181

Exclusions: The People's Republic of China and USSR.

1956

TABLE A

CONTRACTING STATES OF ICAO
PASSENGER FATALITIES OCCURRING ON SCHEDULED INTERNATIONAL AND DOMESTIC OPERATIONS
YEAR 1956

Description	Country Total of Hours Flown	Number of Fatal Accidents	Number of Passengers Killed	Country Total of Passenger Kilometres	Fatality Rate per 100 Million Pass.-Kms.	Millions of Passenger-Kilometres per Fatality
	(thousands)			(millions)		
Total Scheduled Operations						
Argentina	72	1	14	439		
Brasil	418	1	1	1 850		
Burma	15	1	9	62		
Canada	254	3	71	2 353		
Czechoslovakia	36‡	2	36	117‡		
France	308	1	49	3 616		
Guatemala	7*	1	27	16*		
India	137	1	2	679		
Italy	56	2	40	429		
Mexico	225*	1	20	1 407*		
Norway	50	1	1	402		
Syria	6*	1	19	16*		
United Kingdom	528	1	29	3 817		
United States	4 030	6 a/	152	44 454		
Venezuela	97	2	82	324		
All other States	1 706	-	-	11 019		
Total	7 945	25	552	71 000	0.78	129
International Scheduled Operations						
Canada	67	2	12	860		
Czechoslovakia	14 ‡	1	18	50 ‡		
France	233	1	49	1 593		
Italy	36	1	23	356		
Mexico	57 *	1	20	501 *		
United Kingdom	366	1	29	3 211		
Venezuela	20	2	82	125		
All other States	1 501	-	-	16 304		
Total	2 294	9	233	23 000	1.01	99
Domestic Scheduled Operations						
Argentina	51	1	14	271		
Brasil	385	1	1	1 525		
Burma	10	1	9	38		
Canada	187	1	59	1 493		
Czechoslovakia	22 ‡	1	18	67 ‡		
Guatemala	7 *	1	27	16 *		
India	92	1	2	269		
Italy	20	1	17	73		
Norway	17	1	1	57		
Syria	3 *	1	19	7 *		
United States	3 370	6 a/	152	36 043		
All other States	1 487	-	-	8 141		
Total	5 651	16	319	48 000	0.66	150

NOTES:

Accident data have been recorded under the country in which the airline is registered and not in the country where the accident took place

Under "Total Scheduled Operations" are listed all countries with scheduled airlines which had aircraft accidents resulting in passenger fatalities. These data have been segregated as to those fatalities occurring on a scheduled international flight and/or a scheduled domestic flight.

Source of data: ICAO Air Transport Reporting Forms and outside sources.

* Estimated data.
‡ Includes non-scheduled flights.

a/ Includes mid-air collision accident between United and TWA. Shown as 1 accident.

CONTRACTING STATES OF ICAO
AIRCRAFT ACCIDENT SUMMARY FOR 1956
OF ALL OPERATORS ENGAGED IN PUBLIC AIR TRANSPORT

1956

TABLE B

Contracting States of ICAO	Number of Accidents		Passenger Injury			Crew Injury			Others Injured		By Operators With an Accident		Hours flown during year by all operators engaged in public air transport
	Total	Fatal	Fatal	Serious	Minor or None	Fatal	Serious	Minor or None	Fatal	Serious	Number of Landings	Hours Flown	
Afghanistan	-	-	-	-	-	-	-	-	-	-			
ø Argentina	1	1	14	-	-	4	-	-	-	-	37 509	71 219	
ø Australia	2	1	-	-	-	1	1	-	-	-	41 150	89 621	312 838
Austria	noa	noa	noa	noa	noa	noa	noa	noa	noa	noa			
Belgium	-	-	-	-	-	-	-	-	-	-			
Bolivia	-	-	-	-	-	-	-	-	-	-			
Brazil	3	1	1	-	18	2	2	2	-	-			
Burma	1	1	9	8	-	3	1	-	-	-			
Cambodia	-	-	-	-	-	-	-	-	-	-			
ø Canada a/	3	3	71	5	1	7	3	-	-	-	172 852b/*	254 217b/	254 217
ø Ceylon	-	-	-	-	-	-	-	-	-	-			6 364
Chile	-	-	-	-	-	-	-	-	-	-			
China (Taiwan)	-	-	-	-	-	-	-	-	-	-			
Colombia	1	1	33	-	-	3	-	-	-	-			
Cuba	-	-	-	-	-	-	-	-	-	-			
Czechoslovakia	2	2	36	4	-	9	-	-	-	-			
Denmark	-	-	-	-	-	-	-	-	-	-			
Dominican Republic	-	-	-	-	-	-	-	-	-	-			
Ecuador	-	-	-	-	-	-	-	-	-	-			
Egypt	-	-	-	-	-	-	-	-	-	-			
El Salvador	noa	noa	noa	noa	noa	noa	noa	noa	noa	noa			
ø Ethiopia	-	-	-	-	-	-	-	-	-	-			
ø Finland	-	-	-	-	-	-	-	-	-	-			27 345
ø France c/	35	5	51	5	10	9	1	8	1	-		354 526	354 526
Germany	-	-	-	-	-	-	-	-	-	-			
ø Greece	-	-	-	-	-	-	-	-	-	-			
Guatemala	1	1	27	-	1	3	-	-	-	-			
Haiti	-	-	-	-	-	-	-	-	-	-			
Honduras	-	-	-	-	-	-	-	-	-	-			
Iceland	-	-	-	-	-	-	-	-	-	-			
ø India	9	5	16	-	-	6	5	-	1	1		124 804	178 480
Indonesia	-	-	-	-	-	-	-	-	-	-			
Iran	-	-	-	-	-	-	-	-	-	-			
Iraq	-	-	-	-	-	-	-	-	-	-			
ø Ireland	-	-	-	-	-	-	-	-	-	-			
Israel	-	-	-	-	-	-	-	-	-	-			
ø Italy	2	2	40	2	-	14	-	-	-	-	25 140	34 584	56 970
ø Japan	-	-	-	-	-	-	-	-	-	-			48 443
Jordan	1	1	1	-	52	-	-	4	-	-			
Korea	-	-	-	-	-	-	-	-	-	-			
Laos	-	-	-	-	-	-	-	-	-	-			
Lebanon	-	-	-	-	-	-	-	-	-	-			
Liberia	-	-	-	-	-	-	-	-	-	-			
Libya	noa	noa	noa	noa	noa	noa	noa	noa	noa	noa			
Luxembourg	noa	noa	noa	noa	noa	noa	noa	noa	noa	noa			
Mexico	2	1	20	-	37	5	-	4	-	-			
Morocco	-	-	-	-	-	-	-	-	-	-			
ø Netherlands	-	-	-	-	-	-	-	-	-	-			
ø New Zealand	6	-	-	-	-	-	-	-	-	-	53 137	55 960	69 189
Nicaragua	-	-	-	-	-	-	-	-	-	-			
ø Norway	1	1	1	4	5	1	1	-	-	-	6 540	6 911	62 525
Pakistan	1	1	-	-	-	3	-	-	-	-			
Paraguay	noa	noa	noa	noa	noa	noa	noa	noa	noa	noa			
Peru	-	-	-	-	-	-	-	-	-	-			
Philippines	-	-	-	-	-	-	-	-	-	-			
Poland	-	-	-	-	-	-	-	-	-	-			
ø Portugal	-	-	-	-	-	-	-	-	-	-			11 173
ø Spain	1	-	-	-	-	-	1	-	1	-	9 112	12 923	
Sudan	-	-	-	-	-	-	-	-	-	-			
ø Sweden	26	-	-	-	1	-	-	-	-	-	67 652d/	98 168	102 851
ø Switzerland	1	1	-	-	-	4	-	-	-	-	41 592	63 296	
Syria	1	1	19	-	-	4	-	-	-	-			
ø Thailand	2	-	-	-	23	-	-	7	-	-	9 468	14 629	14 629
Turkey	-	-	-	-	-	-	-	-	-	-			
Un. of S. Africa	-	-	-	-	-	-	-	-	-	-			
ø United Kingdom e/	20	5	80	12	359	12	4	68	-	-	202 795	386 085	419 443
ø United States f/	105g/	9g/	156	17	1 523	18	8	296	-	2	2 962 378	3 888 004	4 566 595
Uruguay	-	-	-	-	-	-	-	-	-	-			
Venezuela	2	2	82	-	-	17	-	-	-	-			
Viet Nam	-	-	-	-	-	-	-	-	-	-			
Total for 70 States	229	45	657	57	2 030	125	27	389	3	3			
TYPE OF OPERATION													
Scheduled International	23	9	233	14	77	45	9	24	1	-			
Scheduled Domestic	102	19	319	38	1 618	49	8	232	2	3			
Non-Scheduled International	10	5	66	4	318	8	3	31	-	-			
Non-Scheduled Domestic	55	6	37	1	16	10	2	45	-	-			
Non-Revenue	39	6	2	-	1	13	5	57	-	-			
Total Operations	229	45	657	57	2 030	125	27	389	3	3			

NOTES: Source of data: Air Transport Reporting Form G filed by countries indicated with a ø.
All other country data collected from outside sources.

* Estimated.
noa - No Civil Aviation.
a/ Data for scheduled operations only.
b/ Data for total operations of all scheduled operators.
c/ Excludes all domestic flights in Indo-China.
d/ Includes some helicopter landings.
e/ Data for United Kingdom only. Excludes dependencies. Data incomplete for number of landings and hours flown except in last column.
f/ Data refer to all public air transport i.e. scheduled U.S. and Alaska airlines as well as irregular air carriers. Data incomplete for number of landings and hours flown.
g/ Includes mid-air collision accident between United and TWA shown as 1 accident.

1956

TABLE C

CONTRACTING STATES OF ICAO
AIRCRAFT ACCIDENT SUMMARY FOR 1956
OF ALL OPERATORS ENGAGED IN PUBLIC AIR TRANSPORT
BY TYPE OF OPERATION

Type of Operation Contracting States of ICAO	Number of Accidents		Passenger Injury			Crew Injury			Others Injured		By Operators With an Accident	
	Total	Fatal	Fatal	Serious	Minor or None	Fatal	Serious	Minor or None	Fatal	Serious	Number of Landings	Hours Flown
SCHEDULED INTERNATIONAL OPERATIONS												
ø Australia	1	-	-	-	-	-	-	-	-	-		
ø Canada	2	2	12	5	1	4	3	-	-	-	27 807 *	67 352
Czechoslovakia	1	1	18	-	-	5	-	-	-	-		
ø France	7	1	49	5	-	1	1	5	-	-		307 849c/
ø India	1	-	-	-	-	-	2	-	-	-		21 499
ø Italy	1	1	23	2	-	10	-	-	-	-	6 892	15 833
Mexico	2	1	20	-	37	5	-	4	-	-		
ø Spain	1	-	-	-	-	-	1	-	1	-	674	1 549
ø United Kingdom a/	2	1	29	2	15	3	2	3	-	-	111 579	290 321
ø United St-tes b/	3	-	-	-	24	-	-	12	-	-	168 422	618 762
Venezuela	2	2	82	-	-	17	-	-	-	-		
Total for 11 States	23	9	233	14	77	45	9	24	1	-		
SCHEDULED DOMESTIC OPERATIONS												
ø Argentina	1	1	14	-	-	4	-	-	-	-	115	199
Brasil	3	1	1	-	18	2	2	2	-	-		
Burma	1	1	9	8	-	3	1	-	-	-		
ø Canada	1	1	59	-	-	3	-	-	-	-	145 045 *	186 865
Czechoslovakia	1	1	18	4	-	4	-	-	-	-		
France	9	1	-	-	9	3	-	1	1	-		c/
Guatemala	1	1	27	-	1	3	-	-	-	-		
ø India	5	3	2	-	-	3	-	-	1	1		86 411
ø Italy	1	1	17	-	-	4	-	-	-	-	15 616	17 836
ø New Zealand	1	-	-	-	-	-	-	-	-	-	46 102	52 591
ø Norway	1	1	1	4	5	1	1	-	-	-		6 334
ø Sweden	1	-	-	-	-	-	-	-	-	-	6 716	9 537
Syria	1	1	19	-	-	4	-	-	-	-		
ø Thailand	2	-	-	-	23	-	-	7	-	-	5 904	6 089
ø United Kingdom a/	4	-	-	6	77	-	-	19	-	-	72 906	75 801
ø United States b/	69	6	152	16	1 485	15	4	203	-	2	2 759 003	2 996 243
Total for 16 States	102	19	319	38	1 618	49	8	232	2	3		
NON-SCHEDULED INTERNATIONAL OPERATIONS												
ø India	1	1	14	-	-	-	3	-	-	-		4 281
Jordan	1	1	1	-	52	-	-	4	-	-		
ø United Kingdom a/	7	3	51	4	264	8	-	25	-	-	1 112	3 842
ø United States b/	1	-	-	-	2	-	-	2	-	-	4 472	26 764
Total for 4 States	10	5	66	4	318	8	3	31	-	-		
NON-SCHEDULED DOMESTIC OPERATIONS												
ø Australia	1	1	-	-	-	1	1	-	-	-		
Colombia	1	1	33	-	-	3	-	-	-	-		
ø France	4	-	-	-	-	-	-	-	-	-		22 972d/
ø India	1	1	-	-	-	3	-	-	-	-		204
ø New Zealand	4	-	-	-	-	-	-	-	-	-	6 004	2 703
ø Sweden	24	-	-	-	1	-	-	-	-	-	44 618	32 303
ø United Kingdom a/	2	-	-	-	3	-	-	4	-	-	1 239	1 083
ø United States e/	18	3	4	1	12	3	1	41	-	-	30 334	79 185
Total for 8 States	55	6	37	1	16	10	2	45	-	-		
NON-REVENUE OPERATIONS												
ø France	15	3	2	-	1	5	-	2	-	-		23 705
ø India	1	-	-	-	-	-	-	-	-	-	-	6 123
ø New Zealand	1	-	-	-	-	-	-	-	-	-	1 031	667
Pakistan	1	1	-	-	-	3	-	-	-	-		
ø Sweden	1	-	-	-	-	-	-	-	-	-	3 777	3 332
ø Switzerland	1	1	-	-	-	4	-	-	-	-	8 630	2 824
United Kingdom a/	5	1	-	-	-	1	2	17	-	-	15 959	15 038
ø United States e/	14	-	-	-	-	-	3	38	-	-	-	115 100
Total for 8 States	39	6	2	-	1	13	5	57	-	-		

NOTES: Source of data: Air Transport Reporting Form G filed by countries indicated with a ø.
All other country data collected from outside sources.

* Estimated.
a/ Data for United Kingdom only. Excludes dependencies. Data incomplete for number of landings and hours flown.
b/ Data for all scheduled U.S. and Alaska airlines. Data incomplete for number of landings and hours flown.
c/ Hours flown for scheduled domestic operations included with scheduled international.
d/ Includes hours flown for non-scheduled international operations.
e/ Data for all scheduled U.S. and Alaska airlines as well as irregular air carriers.

FORM G

INTERNATIONAL CIVIL AVIATION ORGANIZATION

AIR TRANSPORT REPORTING FORM

COUNTRY...............

AIRCRAFT ACCIDENTS

YEAR ENDED............

Name of Operator	Type of Operation	Number of Accidents		Passenger Injury			Crew Injury			Others Injured		Number of Landings	Hours Flown
		Total	Fatal	Fatal	Serious	Minor/ None	Fatal	Serious	Minor/ None	Fatal	Serious		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	Scheduled International												
	Scheduled Domestic												
	Non-Scheduled International												
	Non-Scheduled Domestic												
	Non-Revenue Flights												
	Total Operations	—	—	—	—	—	—	—	—	—	—		
	Scheduled International												
	Scheduled Domestic												
	Non-Scheduled International												
	Non-Scheduled Domestic												
	Non-Revenue Flights												
	Total Operations	—	—	—	—	—	—	—	—	—	—		
	Scheduled International												
	Scheduled Domestic												
	Non-Scheduled International												
	Non-Scheduled Domestic												
	Non-Revenue Flights												
	Total Operations	—	—	—	—	—	—	—	—	—	—		
	Scheduled International												
	Scheduled Domestic												
	Non-Scheduled International												
	Non-Scheduled Domestic												
	Non-Revenue Flights												
	Total Operations	—	—	—	—	—	—	—	—	—	—		

Total hours flown during the year by all operators engaged in public air transport = ...

Remarks:

DOC 7357 - STA/529 - 1/53 The attention of ICAO should be drawn to any unavoidable deviation from the instructions.

INSTRUCTIONS

Reporting Period: This form is to be filed annually by each State in respect of aircraft accidents of operators, registered in the country, which are engaged in public air transport.

Filing Date: This form should be filed not later than 2 months after the end of the year to which it refers.

Notes:
1) Data for individual operators are required only in respect of those operators whose aircraft were involved in an accident - regardless of where the accident took place.
2) The total number of hours flown by all operators (whether involved in accidents or not) should also be inserted in the space provided. The form should be filed giving this information even if there are no accidents to report.

Aircraft Accident means an occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, in which:

a) any person suffers death or serious injury as a result of being in or upon the aircraft or by direct contact with the aircraft or anything attached thereto, or
b) the aircraft received substantial damage (Annex 13).

Notes:
1) An accident resulting in only minor injuries or damages need not be reported.
2) A collision between two or more aircraft should be reported separately for each operator involved, and additional details should be provided under 'Remarks'.

Type of Operation:

a) 'Scheduled International', 'Scheduled Domestic', 'Non-Scheduled International' and 'Non-Scheduled Domestic' operations relate to flights operated for the purpose of carrying revenue load.
b) 'Non-Revenue Flights' relate to positioning flights, test flights, training flights, etc..
c) Data should be reported in columns 3 to 12 opposite the type of operation in which the aircraft was engaged at the time of the accident.
d) Data should be reported in columns 13 and 14 relating to the total activities of the operator during the year, subdivided into the types of operation indicated.

Passenger Injury: Include the total number of passengers involved, both revenue and non-revenue.

Crew Injury: Include hostesses, stewards and supernumerary crew in addition to flight crew.

Others Injured: Include all persons injured other than those aboard the aircraft.

Number of Landings: If the number of landings cannot be ascertained without difficulty an estimate may be given and a note inserted under 'Remarks' indicating that the figure is an estimate.

Hours Flown: Report to nearest number of whole hours. Indicate under 'Remarks' basis used - such as 'block-to-block', 'wheels off-wheels on', etc..

PART III

"PILOTS SAFETY EXCHANGE BULLETIN 57-110
(Flight Safety Foundation Inc.)

Runaway Propellers

By
CAPT. T.J. SLAYBAUGH
Office of Safety, Hq MATS

"See that! You don't have to use but about half rudder and only a slight bit of aileron to correct for loss of an outboard engine. This is a good, stable airplane."

The instructor was talking. It was your first flight in the four-engine transport, several months ago. He was demonstrating the amount of control deflection required to offset the loss of an outboard engine. He said that you would have no control problems, even on take-off with the most critical engine failing at lift off. He demonstrated that the yaw was easily offset and had set the throttle at 15 inches manifold pressure to simulate the full-feather - no drag situation.

And you were convinced. You had been a little irked at yourself that you had let the heading get off 10 degrees and you edged back on heading. The indicated airspeed, you noted, had dropped gradually, but less than you had expected. After you had lost 20 knots, and had made gentle, get-the-feel turns in both directions, the instructor brought the engine back to cruise power.

A little later, at cruising speed, he REALLY convinced you, He eased the throttles back to 15 inches on both engines on one side. You handled the flight controls all the while as he eased power on the opposite side up to METO and when you rolled in trim you found that this wonderful airplane would fly on two engines - and the T.O. (Technical Order) says you can use METO power indefinitely. Your instructor had really beamed and sat there with arms folded as you made a turn in each direction on TWO engines.

Yes, this had been a convincing demonstration. And since then, on test hops and training missions, you had conducted both actual and simulated engine-out flight. And one day, number three had backfired and you had shut it down and made an actual three engine landing.

No Sweat.

You never had a runaway prop - but you know the procedure: Power off, feather, complete the engine out check list. You also know that a runaway is a function of true airspeed and you figure that if the prop won't feather just fly the bird above stall and land at the nearest suitable field. You also know the engine freezing procedures and in the back of your mind you feel you might use them as a last resort, thinking they might reduce drag. The main thing you fear about freezing an engine is that the prop might come off and go through the cabin. (That's why you move the passengers out of the prop line, you recall.)

You Should Also Know:

If a propeller runs away and cannot be feathered, you may not be able to maintain level flight at any altitude even with maximum power on the other three engines.

That drag of this propeller increases approximately as the square of the velocity and flight must be just above stall speed. The slower you can fly the better.

That if the engine is frozen and the propeller uncouples, the drag will be reduced considerably. However, if the engine is frozen and the propeller does not uncouple drag will probably be increased.

If the propeller is an outboard, you will probably need full rudder and aileron trim, full or nearly full rudder deflection and full or nearly full aileron deflection to maintain heading - and it is possible that power may even have to be reduced on the opposite side in order to keep the aircraft from turning into the bad engine.

Anything you can do to get the prop into higher pitch will help tremendously - but chances are you can do nothing.

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Information from the propeller and airframe manufacturers and data derived from tests and calculations on the Stratocruiser that ditched in the Pacific, October 1956, (see Report No. 29 in this Digest) depict the effects of an uncontrollable prop for this particular circumstance. Drag resulting from this propeller with the blades on the low pitch stops, 21.3 degrees, at 145 knots, 2 000 feet MSL, would be:

Uncoupled windmilling	520 lbs.
Coupled windmilling	1 880 lbs.
Frozen	2 320 lbs.

The additional power necessary to compensate for the additional drag in each of the above conditions is:

520 lbs.	295 BHP
1 880 lbs.	1 060 BHP
2 320 lbs.	1 380 BHP

In a C-54 accident in 1955 the plane crashed shortly after take-off and 2 1/2 miles from the take-off runway. The probable cause of this accident was determined to be due to excessively high drag resulting from the improperly indexed propeller blades and inability to feather No. 4. The pilot stated that No. 4 propeller drag felt "insurmountable" and it was impossible to gain or even hold altitude. Maximum power was being used on the other three engines.

A representative of the propeller manufacturer testified that according to engineering data for like conditions the drag would be 570 pounds if the three blades were properly indexed at 24 degrees whereas with two of the blades improperly indexed at 16 degrees, as was the case in this accident, the propeller drag was 1 360 pounds, or about 2.3 times greater. Both crew members stated that the aircraft hit tailfirst, full power on three engines and in a full power stall.

Several years ago an Air Force crew flying a B-29 out of a midwestern base had No. 1 propeller go out of control and into full low pitch. The tendency of the aircraft to roll into the dead engine was so great that the plane entered a continuous left turn. The only way that the left wing could be leveled and directional control regained was by cutting power back on number 3 and 4 engines. Using this system a series of descending spirals was made by the crew in directing their plane back toward the base. Finally, estimating they were in the best attainable position, they pulled off power on the right side and made a diving, semi-controlled approach. Touchdown was made on the overrun, two of the tires blew out, and the aircraft continued onto the runway with no further damage.

Last winter, on Guam, a pilot test-hopping a C-54 lost control of No. 1 upon unfeathering. The drag was so great, even at an airspeed of approximately 120 knots and at 2 800 rpm, that full trim was rolled in and the descent made with METO power on the three good engines. Upon entry into the traffic pattern it appeared that he might not be able to maintain level flight in this configuration without stalling, and he flew a gradually descending pattern. Though he had been flying transports for several years, he was so amazed at the drag caused by the uncontrollable outboard propeller in the low pitch condition that he kept checking to ascertain that cowl flaps, or some other parts of the aircraft were not out of order and causing some of the drag. Furthermore, the aircraft was empty and carried only a partial fuel load.

Since there is no way in which these tremendous drag and control forces can be simulated in either a simulator or an aircraft, the only emergency training that can be given in advance is to make aircrews aware of this problem in order to cut down panic and to provide them with the best possible information as to corrective action.

Panic could easily result from the high pitched whine of the runaway, the near uncontrollable yaw and rolling tendency and the fear that a blade might come through the cabin - especially since a runaway usually occurs with no advance warning.

The reason for the control problem is comparatively simple. For example, equivalent parasite drag expressed in square feet of flat plate area for a C-118 is slightly over 27 square feet. The flat plate drag area of a single uncontrollable prop on a C-118 is approximately half this and when you realize that this drag, equal to half the entire parasite drag of the airplane normally, is located well out on a wing, it is easy to understand why the turning moment is so great. Further, as power is added to the remaining engines to offset the drag the tendency to turn into the windmilling propeller is accentuated.

What should the man in the left seat do when a propeller suddenly runs away?

Here is what Hamilton Standard recommends, as reported by Mr. W.H. Furnivall of the Field Service Engineering Section, Military:

"Pull everything back but the feathering button - throttle, rpm, yoke; mixture on the bad engine - the works." He defines a windmilling, uncontrollable prop as one that has gone to the low pitch blade angle.

As a general rule the company states that the drag of a frozen propeller is greater than that of a windmilling propeller and freezing is not recommended. MATS crews put in a lot of air miles every day sitting next to the fans built by this concern, so let's examine one of their charts. This one (Fig. 1) applies to the C-118 prop at the normal low pitch blade angle of 30 degrees measured at the 42 inch station. These curves illustrate that windmilling engine RPM and drag are functions of airspeed. The slower the aircraft can be flown the better (within safe control limits).

From the specialists at WADC (Western Air Defence Command) we learn that if the low angle stop is not effective (this is most likely on props not equipped with mechanical low pitch stops) the blade angle will continue on down until centrifugal twisting, friction and aerodynamic moments are balanced.

In such a case, control of the aircraft may not be possible and freezing should be considered. As the RPM drops due to freezing action and reaches the governing range, try feathering.

It should be noted also that in the course of stopping the propeller through freezing, a peak propeller drag is reached which is greater than either the normal windmilling or fully stopped value.

Data indicate that below a blade angle of about 15 degrees the locked propeller will have less drag than the windmilling, whereas above that value the windmilling propeller will have less drag. The cross-over point is a function of propeller geometry and amount of friction and pumping torque required to turn the engine. The most favorable case for the windmilling propeller occurs when the engine becomes uncoupled from the propeller because the propeller does not have to pick up additional energy from the airstream, at the expense of drag, to overcome the friction and pumping of the engine. The only energy required from the airstream, in the uncoupled case, is that required to overcome the aerodynamic resistance of the propeller itself.

As a general rule, the people at WADC tell us, propellers equipped with mechanical low pitch stops can be expected to produce less drag (negative thrust) when windmilling than when frozen, while propellers not equipped with mechanical low pitch stops can be expected to produce less drag when frozen. This is because the mechanical low pitch stop is usually above the cross-over blade angle.

Approximately two weeks prior to the C-97 incident in which Major Samuel W. Tyson flew 1 000 miles into Hilo, T.H. with two engines out, Captain Fred L. Irwin, 48th Air Transport Squadron, flying a C-124 from Hickam to Travis on a scheduled cargo run, had a malfunction of the No. 1 propeller about three hours after take-off. He was unable to feather, change blade pitch, or in any way to control the propeller. The drag of this propeller was so great that he was unable to regain level flight until 24 000 pounds of cargo had been jettisoned. At this time he was down to 700 feet with maximum power on the other three engines. Capt. Irwin was able to climb back to 1 000 feet and flew approximately 250 miles back to Hilo at METO power. Drag from the malfunctioning propeller was so great that full aileron and full rudder trim were rolled in and level flight still required nearly full aileron deflection with the yoke. Flight was, at times, on the burble point of stall. Subsequently it was found that the blades had gone to approximately 5 degrees.

The chart showing the relationship between blade angle and drag (Fig. 2) indicates that drag of a windmilling propeller increases rapidly below about 15 degrees.

One of the most critical aircraft in the MATS stable, in so far as runaway propellers is concerned, is the WB-50. Indicative of the problems that can be encountered in this type aircraft is the following:

The WB-50 was cruising at 18 000 feet on a heading of 105° when the crew noticed the No. 4 propeller increase 25 RPM. The prop selector was immediately placed in fixed RPM but the RPM continued to increase. At 2500 RPM, feathering was attempted, the aircraft was pulled up and all power pulled off to slow the aircraft and counteract the drag.

The RPM increased to the maximum tachometer indication of 4500. The aircraft commander and co-pilot applied full left aileron and rudder but the flight instruments indicated a 90° bank and tight diving spiral to the right. Rate of descent was at more than 4 000 feet per minute, aircraft completely out of control.

At 11 000 RPM unexplainably decreased to 1200 and control was regained. The heading was now 75°. The oil shut off valve was closed. RPM again increased and at 3 000 RPM aircraft control was lost again.

The engine seized and control was regained at 7 000 feet and a landing accomplished at an emergency alternate. Subsequent inspection showed the prop had stuck at a flat pitch of approximately 4 degrees. When the engine was frozen at this configuration blade angle drag was sufficiently reduced for the crew to regain control.

WB-50

A mechanical low pitch stop modification program has been approved for the WB-50 and is to be instituted shortly after the first of the year as the aircraft go into IRAN (Inspection and Repair as Necessary). This program calls for the mechanical stop to be set at 16.5 degrees blade angle which will entail moving the low limit switch angle to 20.3 degrees. In substantiating information supporting this proposal the aircraft manufacturer pointed out that from 1949 through 1953 UR's (Unsatisfactory Reports) showed that in 54 overspeed cases in 97's no aircraft were lost. The C-97 propellers have mechanical low pitch stops. In nine cases reported of loss of propeller control in B-50 aircraft six of the aircraft were destroyed and in the three other cases the runaway propeller was either frozen or thrown clear. It is also pointed out that with a low pitch stop of approximately 16 degrees, power can be reduced without excessive windmilling RPM. A mechanical stop limit of 16 degrees, according to the manufacturer, is considered to be the minimum position which should be considered as consistent with safe aircraft control.

The following advantages are cited for the 16.5° low pitch mechanical stop:

a) Prevent excessive engine overspeed during take-off and climb.

b) Give a positive rate of climb at all gross weights under 163 000 pounds with one propeller windmilling.

c) Permit control of the aircraft inflight at all gross weights should an overspeed occur.

C-124's are also in line for modification to incorporate the mechanical low pitch stop, and the first of these kits should now be in the field.

Of the 54 C-97 propeller overspeed cases reported by UR's from 1949 to 1953, 45 were feathered normally. In one case the propeller was allowed to windmill and the aircraft landed with the prop rotating at 2400 RPM. In three cases feathering was not effective until partial freezing had been accomplished. In four cases the engines were frozen and in one case the pilot couldn't feather but whether the engine was frozen or allowed to windmill was not reported.

The aircraft are presently undergoing a modification in which new Dural propellers, featuring pitch locks, are being installed to replace the old props in which fatigue failures were occurring.

As to pitch lock on 34G60 Dural propellers on C-97's, this device hydraulically locks the blade angle as a function of overspeeding RPM. Locking pitch at a blade angle appreciably above the low pitch stops means lower windmilling RPM resulting in increased possibilities to feather. If feathering is unsuccessful, the prop can be operated as a fixed pitch propeller with windmilling drag and RPM substantially reduced over a non-pitch lock propeller due to the higher locked pitch blade angle.

Safety, engineering and operations personnel are giving a hard look at present emergency procedures for handling runaways when the propeller will not feather.

Currently, here are some considerations:

Slow the aircraft down to just above stall speed.

Fly at a low altitude where the density of the air is greater and the true airspeed can thereby be decreased.

Don't freeze the engine if the runaway propeller is the only consideration. Drag in most cases will be greater with the engine frozen and the propeller stopped than with the propeller windmilling. This applies in all cases to propellers with low pitch mechanical stops when the blade angle is at the limit or above. Of course, if other malfunctions exist, such as severe vibration or loss of oil, controlled freezing may be dictated. If so, freeze at the slowest possible airspeed and, if altitude and all other factors permit, consider feathering the adjacent propeller until freezing has been accomplished. (One engineer told us that if 6" is lost off one blade of an adjacent engine's propeller, that engine will vibrate itself completely off the wing before it can be shut down.)

Don't attempt intermittent freezing, but close the firewall shut off valve and leave it closed. Freezing will be accomplished in the minimum amount of time and there will not be the tendency for bearings to be washed away a little at a time as could be the case were intermittent freezing attempted. Other suggestions as to freezing are to move all personnel out of the prop line, depressurize, and as RPM's decrease keep trying to feather. The feathering motor may be able to overcome centrifugal turning moment working on the blade as the RPM decreases. It has been done just this way several times.

Consider dumping fuel and/or jettisoning cargo.

Remember the advantages of ground effect, as a last resort. Major Tyson, flying his C-97 approximately 100 feet above the water, realized a definite gain in airspeed and was thereby able to reduce power slightly on the two good engines and stretch his fuel to enable him to reach Hilo. In cases such as this, too, fuel becomes a consideration in what action should be taken to cope with the emergency. If the power required to counteract the drag of a windmilling propeller is such that fuel can be reached, freezing, in hopes that the prop will come off or uncouple from the engine and thereby reduce drag, may be the best choice.

Completely uncontrollable, high speed runaways are not everyday occurrences. Few pilots have experienced such major emergencies. They should not be misconstrued with prop overspeeds in which the procedure is: Reduce throttle; try decreasing RPM manually; if ineffective, try reducing RPM with intermittent feathering and if it doesn't hold, feather; if the prop will not feather, reduce airspeed by retarding all throttles and pulling the nose up.

Conclusion

The rules set out in this article represent the general procedures for coping with the uncontrollable, runaway propeller. They have been evolved from questioning of airframe and propeller manufacturers, military specialists in the field, and are based on flight and engineering test data, together with actual experiences. These general rules are thought to be the best available at this date. It should be remembered, however, that each emergency of this kind is an individual emergency that may require deviation from these generally recommended procedures. The decision as to the best way to handle each individual emergency must, therefore, lie with the crew involved. It is felt that knowledge of runaway characteristics and aerodynamic considerations as presented in this article will better enable the crew to analyze and handle the emergency. - Reprinted from "The MATS Flyer," October, 1957.

Randall H. Carpenter
Manager, Air Operations

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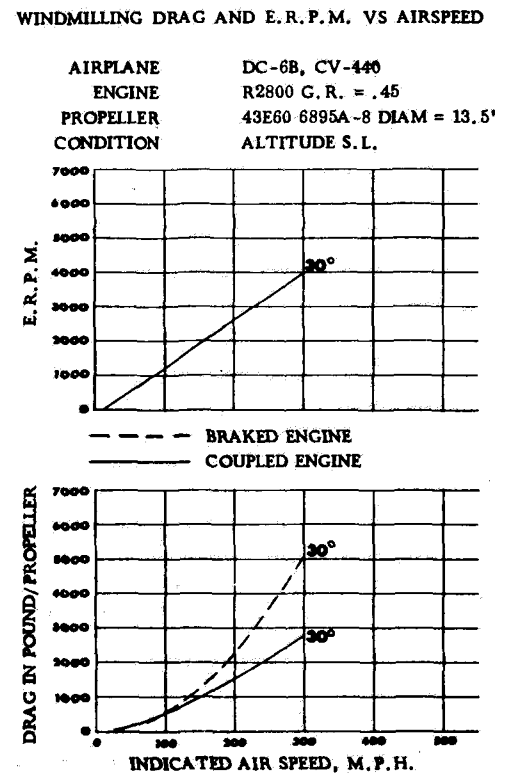

Figure 1

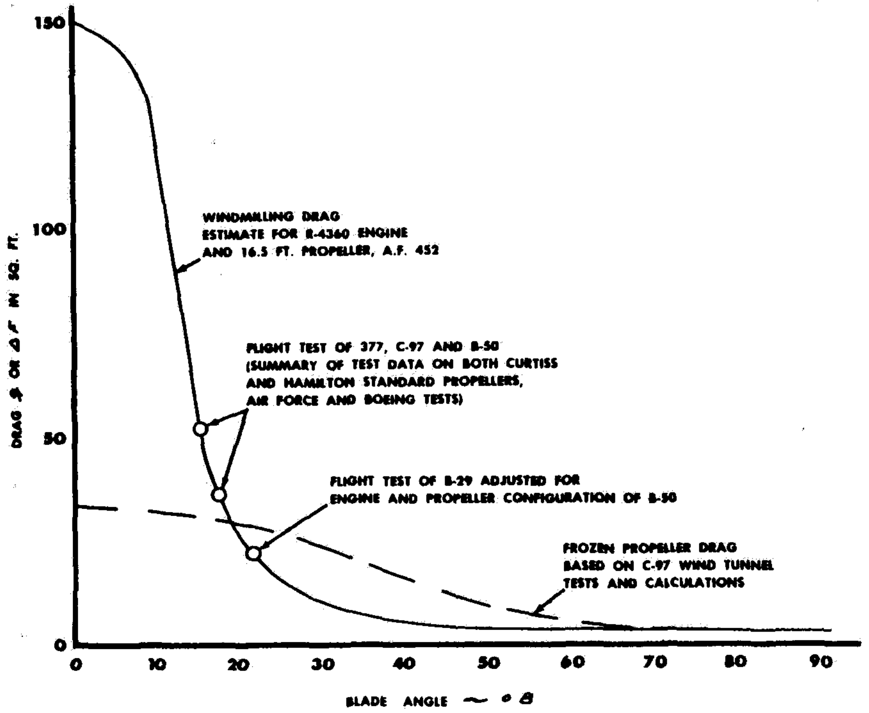

Figure 2

PART IV

List of Laws and Regulations of the Contracting States containing provisions relating to "Aircraft Accident Investigation"

(Replacing list in Digest No. 7)

ARGENTINA

1952	oct.	9	Resolución Núm. 100 (S.A.C.) - Normas para la investigación de accidentes de aviación civil y directivas generales para la investigación. Ampliada el 8 de enero de 1954.
1954	enero	12	Decreto Núm. 299 - Creación de la Junta de Investigaciones de Accidentes de Aviación y competencia de la Subsecretaría de Aviación Civil y Comando en Jefe de la Fuerza Aérea Argentina en la Investigación de Accidentes civiles y militares respectivamente.
	julio	15	Ley Núm. 14.307 - Código Aeronáutico de la Nación: Título XVIII. - Disposiciones varias (Art. 208).
1957	feb.	19	Normas para investigación de accidentes de aeronaves de propiedad particular.

AUSTRALIA

1947	Aug.	6	The Air Navigation Regulations, S.R. No. 112/1947, as amended up to 28 March, 1957: Part XVI. - Accident Inquiry (Reg. 270-297).

AUSTRIA

1936	Aug.	21	Regulations relating to air navigation, as amended up to 30 September, 1938: Sections 65 and 66.

BOLIVIA

1949	junio	18	Procedimiento para el informe de accidentes (Boletín Oficial Núm. 2 - Sec. OP-100).
1950	marzo		Reglas Generales de Operaciones (Provisional): Accidentes de Aeronaves, (02.46-02.52).

BRAZIL

1951	July	24	Portaria No. 280 - Recommendations relating to aircraft accident investigations.

BURMA

1934			The Union of Burma Aircraft Act, 1934 (XXII of 1934): Section 7. - Power of the President of the Union to make rules for investigation of accidents.
1937			The Union of Burma Aircraft Rules, as amended up to 13 March, 1956: Part X. - Investigation of Accidents.
1949	August		Notice to Airmen No. 5/1949 - Aircraft Accident and Incident Investigations.

CANADA

1954	Nov.	23	The Air Regulations, Order in Council P.C. 1954-1821, as amended up to 7 August 1957: Part VIII. - Div. III. - Accidents and Boards of Inquiry.

CEYLON

1950	March	29	Air Navigation Act, No. 15/1950: Part I. - Section 12 - Power to provide for investigation into accidents.
1955	May	4	Civil Air Navigation Regulations: Chap. XVI. - Accident Inquiry (Reg. 260-271).

CHINA (TAIWAN)

1953	Oct.	31	Civil Air Regulations No. 102 - Accident Reporting and Investigation.

COLOMBIA

1948	marzo		Manual de Reglamentos ejecutados por el Decreto Núm. 969 de 14/3/47 y el Decreto Núm. 2669 de 6/8/47: Parte IV - 40.13.0. - Accidentes.

CUBA

1954	dic.	22	Ley-Decreto Núm. 1863 por la cual se crea la Comisión de Aeronáutica Civil, Organización y Facultades: Art. 11, 17) Investigación de Accidentes.

CZECHOSLOVAKIA

1947			Decree of Ministry of Interior on accident investigation, No. 1600/47.

DENMARK

1920	Sept.	11	Air Navigation Regulations: Para. 22 - Notifications in case of certain aircraft accidents.

ECUADOR

1954	julio	8	Reglamento de Aeronáutica Civil del Ecuador, Núm. 7: Título II. Parte 8. - Investigaciones y encuestas de accidentes de aviación.

EGYPT

1941	May	5	Decree - Air Navigation Regulations: Article 10.

EL SALVADOR

1955	dic.	22	Decreto Núm. 2011 - Ley de Aeronáutica Civil: Cap. XV. - De la Investigación de Accidentes Aéreos (Art. 173-187).

FRANCE

1937	avril	21	Décret relatif à la déclaration des accidents d'aviation.
1953	jan.	3	Instruction 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.

GERMANY (FEDERAL REPUBLIC OF)

1936	Aug.	21	Regulations concerning air navigation, amended as of 21 June, 1955: Sections 65 and 66.

GHANA

1937	Feb.	17	Aircraft (Accident) Regulations, No. 5/1937.

GUATEMALA

1948	oct.	28	Decreto Núm. 563 - Ley de Aviación Civil: Capítulo X. - De los siniestros aeronáuticos (Art. 116-121).

HONDURAS

1950	marzo	14	Decreto Núm. 121 - Ley de Aeronáutica Civil: Cap. IV. - Sec. Cuarta - Accidentes y Emergencias (Art. 70-88).

INDIA

1934	Aug.	19	The Indian Aircraft Act, 1934: Section 7. - Powers of Central Government to make rules for Investigation of Accidents.
1937	March	23	The Indian Aircraft Rules, 1937, as corrected up to 24 May 1957: Part X. - Investigation of Accidents (Rules 68-77A).

IRAQ

1939	Aug.	6	The Air Navigation Law No. 41: Article 5 (h).

IRELAND

1936			The Air Navigation and Transport Act, No. 40: Part VII. - Section 60 - Investigation of Accidents. This Act has been amended by Amendment Acts No. 10, 1942; No. 23, 1946; No. 4, 1950.
1957	Feb.	9	The Air Navigation (Investigation of Accidents) Regulations, S.I. No. 19/1957.

ITALY

1925	Jan.	11	Decree Law No. 356 - Rules for Air Navigation: Chapter VII.
1942	April	21	The Navigation Code, approved by Royal Decree No. 327 of 30 March, 1942: Second Part. - Air Navigation - Investigation of Accidents (Art. 826-833).

JAPAN

1952	July	15	Civil Aeronautics Law No. 231, as amended up to 1 April, 1954: Chap. 9 - Article 132. - Investigation of Accidents.

LEBANON

1949	Jan.	11	Aviation Law: Chap. III. - Sub-Chapter 2 - Landing of Aircraft, (Art. 39).

MEXICO

1949	dic.	27	Ley de Aviación Civil (Libro IV de la Ley de Vías Generales de Comunicación): Cap. XIV. - De los accidentes y de la búsqueda y salvamento (Art. 358-361).
1950	oct.	18	Reglamento para Búsqueda y Salvamento e Investigación de Accidentes Aéreos (en vigor a partir del 1 de enero de 1951).

NETHERLANDS

1936	Sept.	10	Law - Investigation of Accidents to civil aircraft, amended by Law of 31 December, 1937, (concerns *inter alia* the greater part of the provisions of Annex 13).
1936	Sept.	22	Royal Decree: Application of paras. 8 and 9 of Article 1 and of para. 5 of Article 32 of the Law dated 10 September, 1936.
	Sept.	22	Royal Decree: Application of para. 2 of Article 6 of the Law of 10 September, 1936.

NEW ZEALAND

1948	Aug.	26	The Civil Aviation Act, 1948: Art. 8. - Power to provide for investigation of accidents.
1953	Nov.	11	The Civil Aviation (Investigation of Accidents) Regulations, Serial No. 152/1953,(made in accordance with ICAO Annex 13).

NORWAY

1923	Dec.	7	Civil Aeronautics Act, as amended up to 17 July 1953: Chapter XI.
			Royal Resolution - Regulations on aviation enacted by the Department of Defence, 15 October 1932, in accordance with the Civil Aeronautics Act of 7 December, 1923, and the Royal Resolution of 22 April 1932, as amended up to 1950: VIII. - Aircraft Accidents.

PAKISTAN

1934	Aug.	19	The Aircraft Act, No. XXII of 1934 (corrected up to 26 October 1950); Para. 7. - Power of Central Government to make rules for investigation of accidents.
1937	March	23	The Aircraft Rules, (corrected up to 24 February, 1956): Part X. - Investigation of Accidents. (Amended on 7 February, 1956.)

PHILIPPINES

1946	May	9	The Civil Aviation Regulations: Chap. XVI. - Aircraft Accident Investigation.
1952	June	20	The Civil Aeronautics Act of the Philippines, No. 776: Chap. V. - Section 32 - Power and Duties of the Administrator: (11) Investigation of Accidents.

PORTUGAL

1931	Oct.	25	Decree No. 20.062 - Air Navigation Regulations: Chapter VIII.

SPAIN

1948	marzo	12	Decreto del Ministerio del Aire sobre investigación de accidentes y auxilio de aeronaves.

SWEDEN

1928	April	20	Royal Proclamation No. 85 regarding Application of the Decree of 26 May 1922, (No. 383) on Air Navigation. Amended up to 1953 - (Code of Law 42: 1953): Para. 28. - Notification of aircraft accidents.
			Civil Aviation Regulations (BCL) - Operational Regulations (D): Aircraft Accident Inquiry - ICAO Annex 13.
1956	Sept.	21	Regulation No. 68 establishing a commission for the investigation of accidents.

SWITZERLAND

1948	déc.	21	Loi fédérale sur la navigation aérienne (entrée en vigueur le 15 juin 1950): Articles 23-26.
1950	juin	5	Règlement d'exécution de la loi sur la navigation aérienne: XIV. - Accidents d'aéronefs (articles 129-137).

THAILAND

1954	Sept.	1	The Air Navigation Act, (B.E. 2497): Chap. 7. - Accidents (Sections 63 and 64).

UNION OF SOUTH AFRICA

1923	May	21	The Aviation Act No. 16: Article 10. - Investigation of Accidents.
1950			The Air Navigation Regulations, G.N. 2762/1949, as amended up to 22 June, 1956: Chapter 29. - Investigation of Accidents (Regulations 29.1 - 29.7).

UNITED KINGDOM

1949	Nov.	24	The Civil Aviation Act, 1949 (12 and 13 Geo. 6. Ch. 67): Part II. - Section 10 - Investigation of Accidents.
1951	Sept.	5	The Civil Aviation (Investigation of Accidents) Regulations, S.I. No. 1653. Came into operation on 1 October, 1951.
1954	June	24	The Air Navigation Order, S.I. No. 829, as amended up to 31 July, 1957: Part IV. - Article 70 - Application of accident regulations to aircraft belonging to or employed in the service of Her Majesty.

UNITED KINGDOM COLONIES

1955

Article 69 of the Colonial Air Navigation Order, 1955, and Section 10 of the Civil Aviation Act, 1949, apply [the latter by virtue of the Colonial Civil Aviation (Application of Act) Order, 1952, as amended] to the undermentioned Colonies:

- Aden (Colony Protectorate)
- Bahamas
- Barbados
- Basutoland
- Bechuanaland Protectorate
- Bermuda
- British Guiana
- British Honduras
- British Solomon Islands Protectorate
- Cyprus
- Falkland Islands and Dependencies
- Fiji
- Gambia (Colony and Protectorate)
- Gibraltar
- Gilbert and Ellice Islands Colony
- Hong Kong
- Jamaica (including Turks and Caicos Islands and the Cayman Islands)
- Kenya (Colony and Protectorate)
- Leeward Islands -
  - Antigua
  - Montserrat
  - St. Christopher and Nevis
  - Virgin Islands
- Malta
- Mauritius
- Nigeria -
  - (a) Colony
  - (b) Protectorate
  - (c) Cameroons under United Kingdom trusteeship
- North Borneo
- St. Helena and Ascension
- Sarawak
- Seychelles
- Sierra Leone (Colony and Protectorate)
- Singapore
- Somaliland Protectorate
- Swaziland
- Tanganyika
- Trinidad and Tobago
- Uganda Protectorate
- Windward Islands -
  - Dominica
  - Grenada
  - St. Lucia
  - St. Vincent
- Zanzibar Protectorate.

UNITED KINGDOM COLONIES (Cont'd)

ADEN

1954			The Civil Aviation (Investigation of Accidents) Regulations (G.N. 125/54).

BAHAMAS

1952	Aug.	1	Air Navigation (Investigation of Accidents) Regulations.

BARBADOS

1952	April	29	Air Navigation (Investigation of Accidents) Regulations.

BERMUDA

1948	Dec.	18	Air Navigation (Investigation of Accidents) Regulations.

BRITISH GUIANA

1952	Aug.	18	Air Navigation (Investigation of Accidents) Regulations, No. 19/1952.

BRITISH HONDURAS

1953	Dec.	19	Air Navigation (Investigation of Accidents) Regulations, (S.I. 1/1954).

CYPRUS

1952	Nov.	17	Civil Aviation (Investigation of Accidents) Regulations (G.N. 517/1952).

FIJI

1952	May	1	Civil Aviation (Investigation of Accidents) Regulations (L.N. 90/1952).

GAMBIA

1937	May	1	Air Navigation (Investigation of Accidents) Regulations, (No. 8/37).
	Nov.	15	Air Navigation (Investigation of Accidents) Regulations, (No. 2) [No. 17/37].

GIBRALTAR

1952	Jan.	3	Air Navigation (Investigation of Accidents) Regulations, 1952.

HONG KONG

1951			Air Navigation (Investigation of Accidents) Regulations (G.N. A228/51).

JAMAICA

1953	March	24	Air Navigation (Investigation of Accidents) Regulations (G.N. 37/53).

LEEWARD ISLANDS

1952	July	31	Civil Aviation (Investigation of Accidents) Regulations (S.R.O. 18/52).

UNITED KINGDOM COLONIES (Cont'd)

MALTA

1952	Sept.	2	Civil Aviation (Investigation of Accidents) Regulations.

MAURITIUS

1952	Sept.	4	Civil Aviation (Investigation of Accidents) Regulations (G.N. 200/52).

NIGERIA

1953	April	28	Civil Aviation (Investigation of Accidents) Regulations (No. 15/1953).

NORTH BORNEO AND LABUAN

1950	Jan.	6	Air Navigation (Investigation of Accidents) Regulations (S. 8/50).

ST. LUCIA

1948	Nov.	27	Air Navigation (Investigation of Accidents) Regulations (S.R.O. No. 40/4

ST. VINCENT

1953	Jan.	8	Air Navigation (Investigation of Accidents) Regulations (S.R.O. No. 6/53

SARAWAK

1953			The Air Navigation (Investigation of Accidents) Regulations (G.N. S6/54)

SIERRA LEONE

1953	Dec.	30	Civil Aviation (Investigation of Accidents) Regulations (P.N. 114/53).

SINGAPORE

1953	Oct.	1	Civil Aviation (Investigation of Accidents) Regulations (G.N. 301/53).

SOMALILAND

1951	Nov.	7	Civil Aviation (Investigation of Accidents) Regulations (G.N. 48/1951).

TRINIDAD AND TOBAGO

1954	Nov.	23	Air Navigation (Investigation of Accidents) Regulations (G.N. 205/54).

ZANZIBAR

1937	Sept.	4	Air Navigation (Investigation of Accidents) Regulations (G.N. 41/1937).

UNITED STATES OF AMERICA

1938			Civil Aeronautics Act - Title VII (Air Safety).
1949	May	1	Civil Air Regulations - Part 62 - Notification and reporting of aircraft accidents and overdue aircraft, (as issued effective May 1, 1949, 14 F.R. 1516; revised effective February 11, 1954, 19 F.R. 891).

UNITED STATES OF AMERICA (Cont'd)

1950	Sept.	15	Economic Regulations - Part 303 - Rules of practice in aircraft acciden investigation information, (as issued September 15, 1950, 15 F.R. 6440; revised effective February 15, 1957, 22 F.R. 1026).
1950	Sept.	15	Economic Regulations - Part 311 - Disclosure of aircraft accident investigation information.
1951	May	14	Civil Aeronautics Board - Organizational Regulations - Description of Functions: Course and method by which functions are channeled - Scope and contents of documents - Hearings concerning accidents involving aircraft.
1952			Title 22 - Foreign Relations - Part 134 - Civil Aviation; Aircraft Accidents (issued in Department Regulations 108.164, effective October 1, 1952, 17 F.R. 8207).
1954			Public Notice PN 7 - Administrator of Civil Aeronautics: Delegation of certain accident investigation functions, (as issued, effective January 1954, 18 F.R. 7499; reissued as Public Notice PN 7 and amended, April 13, 1954, 19 F.R. 2133).
1954			Public Notice PN 8 - Delegation of final authority related to substantive program matters (as issued, effective October 27, 1954, 19 F.R. 741 Section 7. - Director, Bureau of Safety Investigation.
1955			Economic Regulations - Part 399 - Statements of General Policy, as issued, effective May 25, 1955: Section 399.26 - Investigation of Accidents involving foreign aircraft.
1957			Public Notice PN 11 - Statement of Organization (as issued effective July 18, 1957, 22 F.R. 6124, revoking Public Notice PN 10, effective Jan. 1, 1956, 21 F.R. 3481): Sec. 01.3 c) - Accident investigation and analysis; Bureau of Safety - Sections 05.1, 05.2, 05.6 - 05.9.

URUGUAY

1955	feb.	2	Decreto Núm. 23.826 - Reglamento para la Investigación de Accidentes de Aviación de Carácter Civil.

VENEZUELA

1955	abril	1	Ley de Aviación Civil: Cap. X. - De los accidentes y de la búsqueda y rescate.

- END -

ICAO TECHNICAL PUBLICATIONS

The following summary gives the status, and also describes in general terms the contents of the various series of technical publications issued by the International Civil Aviation Organization. It does not include specialized publications that do not fall specifically within one of the series, such as the ICAO Aeronautical Chart Catalogue *or the* Meteorological Tables for International Air Navigation.

INTERNATIONAL STANDARDS AND RECOMMENDED PRACTICES are adopted by the Council in accordance with Articles 54, 37 and 90 of the Convention on International Civil Aviation and are designated, for convenience, as Annexes to the Convention. The uniform application by Contracting States of the specifications comprised in the International Standards is recognized as necessary for the safety or regularity of international air navigation while the uniform application of the specifications in the Recommended Practices is regarded as desirable in the interest of safety, regularity or efficiency of international air navigation. Knowledge of any differences between the national regulations or practices of a State and those established by an International Standard is essential to the safety or regularity of international air navigation. In the event of non-compliance with an International Standard, a State has, in fact, an obligation, under Article 38 of the Convention, to notify the Council of any differences. Knowledge of differences from Recommended Practices may also be important for the safety of air navigation and, although the Convention does not impose any obligation with regard thereto, the Council has invited Contracting States to notify such differences in addition to those relating to International Standards.

PROCEDURES FOR AIR NAVIGATION SERVICES (PANS) are approved by the Council for worldwide application. They comprise, for the most part, operating procedures regarded as not yet having attained a sufficient degree of maturity for adoption as International Standards and Recommended Practices, as well as material of a more permanent character which is considered too detailed for incorporation in an Annex, or is susceptible to frequent amendment, for which the processes of the Convention would be too cumbersome. As in the case of Recommended Practices, the Council has invited Contracting States to notify any differences between their national practices and the PANS when the knowledge of such differences is important for the safety of air navigation.

REGIONAL SUPPLEMENTARY PROCEDURES (SUPPS) have a status similar to that of PANS in that they are approved by the Council, but only for application in the respective regions. They are prepared in consolidated form, since certain of the procedures apply to overlapping regions or are common to two or more regions.

The following publications are prepared by authority of the Secretary General in accordance with the principles and policies approved by the Council.

ICAO FIELD MANUALS have no status in themselves but derive their status from the International Standards, Recommended Practices and PANS from which they are compiled. They are prepared primarily for the use of personnel engaged in operations in the field, as a service to those Contracting States who do not find it practicable, for various reasons, to prepare them for their own use.

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AIR NAVIGATION PLAN documents detail requirements for facilities and services for international air navigation in the respective ICAO Air Navigation Regions. They are prepared on the authority of the Secretary General on the basis of recommendations of regional air navigation meetings and of the Council action thereon. The plans are amended periodically to reflect changes in requirements and in the status of implementation of the recommended facilities and services.

ICAO CIRCULARS make available specialized information of interest to Contracting States. This includes studies on technical subjects as well as texts of Provisional Acceptable Means of Compliance.

EXTRACT FROM THE CATALOGUE
ICAO SALABLE PUBLICATIONS

ANNEX

Annex 13 — Aircraft accident inquiry.
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MANUAL

Manual of aircraft accident investigation.
(Doc 6920-AN/855). 2nd edition, October 1951. 130 pp. . . . $0.75

ICAO CIRCULARS

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