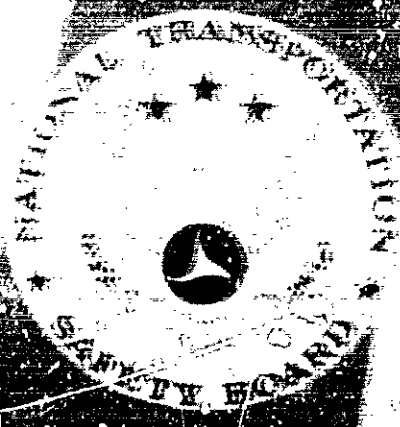


NATIONAL TRANSPORTATION SAFETY BOARD

AIRCRAFT ACCIDENT REPORT

TRANS WORLD AIRLINES, INC
BOEING 707-331C, N787TW
NATIONAL AVIATION FACILITIES
EXPERIMENTAL CENTER
ATLANTIC CITY AIRPORT
POMONA, NEW JERSEY
JULY 26, 1969



NATIONAL TRANSPORTATION SAFETY BOARD
Bureau of Aviation Safety
Washington, D. C. 20591

NATIONAL TRANSPORTATION SAFETY BOARD

DEPARTMENT OF TRANSPORTATION

WASHINGTON, D.C. -- 20591

Safety Information

For Release:

SB 69-72
(202) 382-7273

Office of the Chairman

ADVANCE For

AM Newspapers
Friday, Sept. 26, 1969

The National Transportation Safety Board today released the attached preliminary report of its investigation of the fatal crash of a Trans World Airlines Boeing 707 at the Atlantic City (N. J.) Airport last July 26. The training flight accident took the lives of all five crewmembers aboard.

The Safety Board's preliminary reports of major accidents make public the known accident facts on an interim basis while its investigation continues. Additional or revised information and the formal finding of probable cause will be incorporated in the Board's final accident report.

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AIRCRAFT ACCIDENT PRELIMINARY REPORT

TRANS WORLD AIRLINES, INC.

BOEING 707-351C, N787TW

NATIONAL AVIATION FACILITIES EXPERIMENTAL CENTER

ATLANTIC CITY AIRPORT

PONCA, NEW JERSEY

JULY 26, 1969

ADOPTED: SEPTEMBER 3, 1969

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D. C. 20591

AIRCRAFT ACCIDENT PRELIMINARY REPORT

TRANS WORLD AIRLINES, INC.

BOEING 707-331C, N7871W

NATIONAL AVIATION FACILITIES EXPERIMENTAL CENTER

ATLANTIC CITY AIRPORT

POMONA, NEW JERSEY

JULY 26, 1969

NOTE: This report covers the facts, circumstances, and conditions of the accident as they are known to this date. It is released in order to provide as much information as possible to the aviation industry and the public on an interim basis, pending completion of the investigation and the issuance of a formal Board report. The information herein is preliminary in nature and subject to change in the light of additional disclosures that may be made as the result of the Board's continuing investigation of this accident.

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D. C. 20591

NATIONAL TRANSPORTATION SAFETY BOARD

AIRCRAFT ACCIDENT PRELIMINARY REPORT

ADOPTED: September 3, 1969

Trans World Airlines, Inc.
Boeing 707-330C, N737TW
National Aviation Facilities Experimental Center
Atlantic City Airport
Pomona, New Jersey
July 26, 1969

SYNOPSIS

Trans World Airlines, Inc., Flight 5787 ((TWA 5787)), a pilot recurrency training flight of July 26, 1969, crashed at approximately 1233 e.d.t. while executing a simulated three-engine, missed approach to Runway 13 at the National Aviation Facilities Experimental Center ((NAFEC)), Atlantic City Airport, Pomona, New Jersey. All five persons on board were fatally injured.

The aircraft impacted the ground on the aircraft parking ramp adjacent to the NAFEC hangar. The aircraft was in a nosedown, right-wing-low attitude at impact. Initial contact with the ground was made by the right wingtip, followed almost simultaneously by the nose section. The point of impact was approximately 1,250 feet south of the centerline of Runway 13.

The investigation of this accident is continuing.

I. INVESTIGATION

I.1 History of the Flight

TWA 5787, of July 26, 1969, was scheduled to conduct aircrew recurrency training. The flight originated at John F. Kennedy International Airport (JFK), and was to terminate at JFK. The required training maneuvers were to be conducted at the NAHEC, Atlantic City Airport, at Pomona, New Jersey.

The aircraft utilized on this flight was a Boeing 707-331C, Cargojet, N787TW, and was powered by four P&W JT-3D fanjet engines. The aircraft had previously operated as Flight 602-26, a regularly scheduled cargo flight originating in Frankfurt, Germany, and terminating at John F. Kennedy International Airport, New York, with intermediate stops at London, England, Shannon, Ireland, and Boston, Massachusetts. The flight departed Frankfurt at 2010 e.d.t. 1//, July 25, 1969, and arrived at JFK at 1003 e.d.t., July 26, 1969. The aircraft was refueled to a fuel weight of 70,000 pounds, and released as TWA 5787.

TWA 5787 departed from JFK at 1146 e.d.t.. The captain receiving the proficiency check occupied the left seat, and the instructor-pilot (I.P.) occupied the right seat. The flight operated from JFK to the NAHEC, Atlantic City Airport, Pomona, New Jersey, under routine ATIS control, and was handed off upon arrival in the Atlantic City, New Jersey, area to the Atlantic City Approach Control facility. The aircraft was then vectored by Approach Control in accordance with the crew's request to the Instrument Landing System (ILS) outer marker for an approach to, and a full stop landing on, Runway 13. The approach and landing were accomplished. TWA 5787 then requested, and the tower approved, clearance to taxi to the end of the runway, execute a 180° turn, and take off on Runway 3L.

Prior to takeoff, the I.P. briefed the captain to expect a simulated engine failure after V_1 (critical engine failure speed) 2//, to execute a three-engine climbout, and to request vectors for a precision ILS approach to Runway 13.

1// All times herein are eastern daylight, based on the 24-hour clock.

2// Critical engine failure speed -- the minimum calibrated airspeed to which the aircraft on takeoff can be accelerated, lose the critical engine, and either safely continue the takeoff, or bring the aircraft to a stop on the runway.

Pretakeoff and takeoff checklists were accomplished and the takeoff was executed as stated. The No. 4 engine was retarded to flight idle thrust after V_L had been reached. The takeoff was continued and emergency procedures were executed in accordance with the TWA emergency checklist. The aircraft was levelled off at 1,500 feet and vectored to intercept the ILS course in the vicinity of the outer marker. The No. 4 engine remained in idle thrust. The instructor-pilot directed the captain to execute a simulated three-engine ILS approach, and to expect a missed approach at the decision height. 3//

TWA 5787 proceeded towards the outer marker. The prelanding, and final landing checklists were called for and completed. The landing gear was extended and locked down, and after the aircraft passed the outer marker flaps were placed full down (50°). The approach was flown with the No. 4 engine still retarded to idle thrust. At this point, the tower cleared TWA 5787 to land. The I.P. answered, "OK, we'll take the option." The Tower replied, "Roger, cleared."

At the decision height a missed approach was announced. The captain advanced power on engines 1, 2, and 3 and called for, in proper checklist sequence, "25 Flaps," "Takeoff Power," "Up Gear." These commands were acknowledged and complied with. Neither the Flaps nor the Landing Gear moved from their previous positions. The aircraft was accelerated to 130 knots (minimum indicated airspeed for this maneuver pursuant to TWA flight manual procedures) 4// and a missed approach climb was instituted. The configuration of the aircraft at this moment was: flaps full down (50°); landing gear down and locked; engines 1, 2, and 3 at takeoff thrust, and engine No. 4 retarded to idle thrust. Approximately 16 to 18 seconds after the start of the missed approach, the crew noted the hydraulic fluid level had dropped to zero, and the conclusion was that all hydraulic systems had been lost. The captain, in accordance with the emergency procedures

3// Decision height -- the height specified in feet above mean sea level at which a missed approach shall be initiated if the required visual reference has not been established.

4// TWA Flight Handbook (FHB) p. 03.10.10, Paragraph Q(d). "Maintain Bug to Bug + 5 Knots to 800" (max bank 15°). If speed below 130 KTS, slowly accelerate to 130 KTS." Bug or reference speed for this aircraft as computed by the crew on this approach was 124 knots.

checklist, ordered all hydraulic pump switches "off." 5// This was done. At this moment the tower asked, "Trans World, you gonna work approach control?" They answered, "Standby, we're having a hydraulic problem here."

Following this communication, the aircraft controller saw the aircraft in a climb attitude with the right wing beginning to drop until a steep bank had been achieved. At a point approximately 8,000 feet down the runway, the aircraft veered from the runway heading, executed a descending right turn of approximately 90°, and impacted the ground. The right wingtip made the initial contact with the ground, followed almost simultaneously by the nose.

The geographic coordinates of the crash site are 39° 26' 56" N., 74° 33' 50" W.

Twelve witnesses were interviewed. Eleven saw the aircraft in flight, just prior to impact, three observing it at the moment of impact. The twelfth witness described actions taken after impact, and did not observe the aircraft either before or at impact. A summary of the comments of the 11 witnesses are set forth below, divided for the purpose of clarity into three general areas: pre-observation sounds, pre-impact observations, post-impact observations.

5// TWA's Hydraulic Fluid Loss Emergency Check List is as follows:

1. All Pumps Off.
2. If Loss Continues, Utility Pumps Depressurize.
3. If Loss Stops, Utility Pumps One at a Time to Depressurize and check quantity.
4. Vmc without Rudder Power is 180 KTS.
- *5. See 03.12 FHB System Restoration Procedures.
- *((Neutralize rudder trim before restoring power rudder))

P. 03.12.06 FHB. The amplified checklist discusses each of the above items in detail. Paragraph 4 lists the Vmc for each of the 707 models in the TWA fleet.

a. Pre-Observation Sounds

Nine of the 11 witnesses commented on noises coming from the aircraft prior to impact. Four described a double boom, or explosions; three described the sound as one boom. One witness described a sputtering sound. Three witnesses described either a flash or flames emanating from engines No. 3 and No. 4. One witness placed the flames as emanating from the No. 3 and No. 4 engine inlets. Another witness observed the aircraft veer to the right and stated, "At this time I saw a flash, and heard what sounded like a compressor stall." The aircraft then corrected the right veer.

b. Pre-Impact Observations

Nine witnesses described the aircraft during this part of the flight. All were in agreement that TWA 5767 continued along the runway heading in a climbing attitude with the right wing low. The right wing continued to drop, and the aircraft made a right descending turn toward the point of impact. The angle of bank was described as increasing from wings level, through 60° to 70°, to the vertical. Three witnesses described a nose-low attitude prior to the point of impact, one witness fixing the nosedown angle at 45°.

c. Post-Impact Observations

Three witnesses described the aircraft at impact. One described the aircraft as impacting on the right wing and cockpit. Another stated that the aircraft nosed to the right and went straight into the ground. The third described the aircraft's attitude preceding impact as nosedown, right wing low.

1.2 Injuries to Persons

All five persons aboard the aircraft were TWA crewmen, and all received fatal injuries. Post-mortem and toxicological examination of the fatally injured flight crewmembers did not reveal any evidence of pre-existing disease or physical impairment that would have adversely affected the performance of their duties.

1.3 Damage to the Aircraft

The aircraft impacted on the NAFEC ramp on a heading of 219° magnetic. The aircraft was in a right-wing-down, nosedown attitude at impact. The first part of the aircraft to make contact with the ramp

was the right wingtip, followed by the No. 4 engine, the No. 3 engine, right main gear, nose gear. The ensuing fire destroyed the majority of the aircraft structure.

The wreckage scatter was approximately 399 feet wide and 900 feet long.

Examination of the wreckage revealed no evidence of in-flight fire, or structural separation caused by any condition other than ground contact forces.

1.4 Other Damage

The impact caused minor damage to the NAFEC aircraft parking ramp. A U. S. Army Otter (576-109), located approximately 550 feet from the point of impact, was destroyed by fire. An FAA DC-3 (N-7), located approximately 487 feet from the point of impact, was damaged by flames. A light pole 235 feet from the point of impact was broken off by the wreckage. Miscellaneous ramp equipment including aircraft towbars, refuelling ladders, maintenance stands, an electric power cart, and a mobile passenger boarding ramp were destroyed.

1.5 Crew Information

The seat positions in the cockpit on this flight were as follows: Captain Donald Sklarin, instructor-pilot, was in the right seat. Captain Harry D. Gaines, the pilot receiving the proficiency check, was in the left seat. Second Officer Frank J. Jonke occupied the flight engineer's seat. These positions were established by TWA personnel, based on the conversations recorded on the cockpit voice recorder (CVR) during the flight.

Captain Sklarin, aged 38, the instructor-pilot, was employed by TWA on October 8, 1956. He was upgraded to captain February 1, 1967. He held Airline Transport Pilot Certificate No. 134852, with ratings in the Douglas DC-6 and DC-7 and the Boeing 707/720 aircraft.

He satisfactorily passed his last examination for an FAA First-Class Medical Certificate on July 20, 1969, without waivers. He had accumulated 6,080 flying hours, of which 1,314:20 were in Boeing 707 aircraft. His total instrument time was 1,216 hours. His total flight

time the last 30 days was 10 hours. His last proficiency check in the Boeing 707 was satisfactorily accomplished on February 13, 1969, and his last line check was satisfactorily completed January 6, 1969.

Captain Gaines, aged 56, was employed by TWA on May 14, 1940. He was upgraded to captain on March 7, 1946. He held Airline Transport Certificate No. 36802, with ratings in the Douglas DC-3, Douglas DC-4, Lockheed Constellation, Boeing 707/720.

He satisfactorily passed his last examination for an FAA First-Class Medical Certificate on February 7, 1969, without waivers. He had accumulated 27,436 hours, of which 4330:50 were in Boeing 707 aircraft. His total instrument time was 5,487 hours. His total flight time in the last 30 days was 45:39 hours. His last proficiency check was satisfactorily accomplished on January 8, 1969, and his last line check was satisfactorily accomplished on November 19, 1968.

Second Officer Jonke, aged 29, flight engineer, was employed by TWA on November 29, 1968. He was upgraded to flight engineer on April 9, 1969. He held Commercial Pilots Certificate No. 1574678 with ratings, airplane single-engine land, multiengine land (limited to center thrust) instrument dated December 7, 1963, and Flight Engineer Certificate No. 1916947 with turbojet powered rating dated March 17, 1969.

He satisfactorily passed his last examination for an FAA First-Class Medical Certificate on November 26, 1968, without limitations. He had accumulated 3772:12 flying hours, of which 142:12 were in Boeing 707 equipment. His total flight time in the last 30 days was 68:10 hours. His last proficiency check was accomplished satisfactorily on March 17, 1969, and his last line check was accomplished satisfactorily on July 16, 1969.

1.6 Aircraft Information

N787TW, manufacturer's serial No. 18712, was originally certificated as a Boeing 707-331C on May 26, 1964. A Standard Airworthiness Certificate was issued on May 28, 1964.

The total time on the aircraft was 17,590:05 hours. Elapsed times since the last major inspection and the last line maintenance were 4,258:23 hours and 645:23 hours, respectively.

An examination of the maintenance records for N787TW disclosed that the aircraft had been maintained in accordance with TWA and FAA procedures. Required inspections had been accomplished and nonroutine items received corrective action.

The maximum certificated takeoff weight for N787TW was 334,000 lbs. The maximum landing weight at the NAEEC, Atlantic City Airport, Pomona, New Jersey, was 247,000 lbs. The actual weight at departure from JFK was 204,740 pounds computed as follows:

Dispatch Empty Weight	
((Includes three crewmembers))	134,400
Crew Weight	340
Fuel Weight	70,000
Total Gross Weight	204,740

The computed center of gravity in percent of mean aerodynamic chord was 28 percent. Fuel burnoff en route to the NAEEC Atlantic City Airport was not computed, as the departure weight of the aircraft was substantially below the maximum landing weight of 247,000 pounds.

On the basis of these computations, N787TW was within the center-of-gravity limitations, below the permissible takeoff weight upon departure from JFK, and below the maximum landing weight at Atlantic City.

1.7 Meteorological Information

The surface weather observation at the NAEEC, Atlantic City Airport, at 1233 e.d.t. was: Ceiling, measured 2,000 feet broken, 4,500 feet overcast, visibility 10 miles, temperature 74° F., dewpoint 67° F., wind 130° 7 knots, altimeter setting 29.91. Weather conditions are not considered to be a factor in this accident.

1.8 Aids to Navigation

TWA 5787 was using the Atlantic City Instrument Landing System for practice precision approaches. This facility is used for instrument approaches to the NAEEC, Atlantic City Airport, Pomona, New Jersey, and is aligned for approaches to Runway 13.

Atlantic City ILS operates on an assigned frequency of 110.5 MHz. The glide slope is at 2° 35" angle with an interception altitude of 1,400 feet m.s.l. The outer marker is 4.3 miles from the runway threshold, and the middle marker is 0.5 miles from the threshold.

1.9 Communications

Communications between TWA 5787 and all ATC facilities were routine throughout the entire flight.

1.10 Aerodrome and Ground Facilities

Runway 13 is 10,000 feet long and 200 feet wide. It is equipped with high-intensity runway lights. The runway is equipped with U. S. Standard Configuration A approach lighting and high-intensity strobe lights.

1.11 Recorders

N787TW was equipped with a Lockheed 109CR flight data recorder. The recorder was recovered with superficial dents and smoke damage. The recording was in good condition. The recording produced the following in-flight information: pressure altitude, magnetic heading, indicated airspeed, and vertical accelerations against a time base. An examination of the recording was made covering a period from 1:45 minutes prior to impact. This time period covers the flight of TWA 5787 from just inside the outer marker on the ILS approach through the missed-approach procedure to impact. The altitude readout shows a descent to 230 feet at 50 seconds prior to impact, then a steady climb reaching a maximum altitude of 666 feet at 111 seconds prior to impact. At 10 seconds prior to impact the altitude was 650 feet, at 5 seconds it was 250 feet, and a last reading of 81 feet at impact. (Published field elevation at the NAFAC Airport is 76 feet.)

The indicated airspeed on the recording varies from a low of 128 knots to a high of 136 knots.

The heading information reveals that beginning 1:40 minutes prior to impact, the headings thereafter varied from 128° to 136° and were generally between 133° and 129°.

These readings, in part, through the last 20 seconds of the flight showed the following:

<u>Time</u>	<u>G</u>	<u>Heading</u>	<u>Indicated Airspeed</u>	<u>Altitude m.s.l.</u>
0:20	1.15	132°	133 knots	450 feet
0:15	1.10	132°	135 knots	525 feet
0:11	1.00	132°	136 knots	666 feet
0:10	1.00	134°	136 knots	650 feet
0:05	1.15	160°	135 knots	250 feet
0:00	1.15	190°	132 knots	81 feet

N7871W was also equipped with a cockpit voice recorder (CVR). This recorder was recovered intact and the tape examined for pertinent information.

11.12 Aircraft Wreckage

The airplane structure and all flight controls were found in the wreckage area. Examination of the flight control system did not reveal any evidence of failure or malfunction prior to impact.

The empennage (including both horizontal stabilizers, both elevators with tabs, vertical stabilizer, and rudder) separated from the fuselage at the leading edge of the horizontal stabilizer. This section was found relatively intact. The upper end of the stabilizer jackscrew had sheared, with the remainder retained between the stops. The screw measured 10 inches from stop to stop. This distance was determined to indicate two units aircraft noseup.

The rudder was found fully attached to the vertical fin. The rudder itself and lower actuator piston showed full deflection to the left. The actuator piston was fully retracted indicating full left rudder.

The components of the main landing gear were found in the main wreckage area. The wheels and tires had received severe impact and post-impact fire damage. Wheels and wheel rims were broken off by the impact. The severe damage to the gear and the rubber-like deposit on the concrete indicated that the gear was extended at impact.

Both wings were severely damaged and melted down from the post-impact fire. The flap jackscrews were recovered and were found fully extended. The actuator pistons of the leading edge devices were recovered and were found fully extended.

The hydraulic pressure line to the down side of the left outboard spoiler actuator had failed just forward of the fitting. Metallurgical examination of the parts indicated that the failure was due to metal fatigue.

All engines separated from the aircraft structures. Engines Nos. 1, 2, and 4 came to rest in a line across the wreckage centerline, approximately 300 feet forward of the main wreckage area. Engine No. 3 came to rest in the right side of the main wreckage area.

All four engine inlet cowls were crushed aft on a measured angle of 45°. The No. 4 inlet crushed area exhibited scores running upward and inboard on a measured angle of 45°.

Engine No. 3 showed signs of a compressor stall. Subsequent examination at the carrier's overhaul base disclosed that all engines were capable of producing power at impact. Engines Nos. 1, 2, and 3 had sustained substantial rotational damage usually associated with high r.p.m. at impact. The No. 4 engine sustained considerably less rotational damage at impact.

The cockpit and flight deck area were recovered within the main wreckage area. Almost all components showed evidence of impact and fire damage.

The first officer's lower instrument panel was badly burned and distorted. All pressure gauges and lights were missing. The hydraulic panel was examined and the following noted:

1. Utility pump switches No. 2 and No. 3 were found "off."
2. The rudder spoiler pump switch (auxiliary system No. 1) was found "off."
3. The rudder pump switch (auxiliary system No. 2) was broken off, but the position indicated "off."
4. The interconnect switch appeared to be midway between the "off" and the "system" position. However, the switch itself was bent to the lower right side of the panel.

The center instrument panel (engine instruments) was recovered. The entire panel was badly burned with most of it covered by melted aluminum. The following components were examined:

1. The No. 2 engine fuel/flow gauge read 5,500 lbs.
2. The No. 1 engine N₂ compressor gauge read zero.
3. The No. 2 engine N₂ compressor gauge read zero.

The throttle quadrant was recovered, examined, and the following noted:

1. All four start levers were in the "idle" position.
2. All four thrust levers were full forward.
3. The speed brake handle was full "down."
4. The flap handle indicated the 25° position. It was approximately 2-1/2 inches from the center of the handle to the bottom of the flap handle quadrant.
5. The stabilizer trim appeared to be two units aircraft noseup.
6. The landing gear handle was in the "down" detent.

The following flight instruments were recovered:

1. One airspeed indicator reading 128 knots.
2. One radio magnetic indicator with the heading reading 221°. The No. 2 needle read 265°, and the No. 1 needle was missing.
3. One horizon direction indicator indicating a 40° nosedown attitude. This instrument was severely bent.
4. One horizon direction indicator case with the index at the 45° right bank position.
5. One OMNI bearing indicator reading 330°.

6. One rate of turn indicator showing a standard rate turn to the left. This instrument was damaged badly, the glass was missing, and the turn needle was welded to the face plate.

7. The cockpit pneumatic brake pressure gauge, intact, and reading zero.

The rudder control trim wheel was found reading approximately 6° to 8° left rudder.

The utility hydraulic system fluid quantity gauge was found with the needle in the six o'clock position, between the zero and full marks.

The pilot's center overhead panel was found and examined, the following was noted:

1. The antiskid switch was in the "on" position.
2. The rudder power switch was in the "on" position.
3. The emergency flap switch was on the "off" position.
4. The flap selector switch was in the neutral or "off" position.
5. The spoiler switch was in the "normal" position.
6. The spoiler selector switch was in the "off" position.

1.13 Fire

There was no evidence of pre-impact in-flight fire. The aircraft exploded upon impact and was almost totally consumed by fire.

1.14 Survival Aspects

This accident was considered as nonsurvivable.

1.15 Initial Accident Prevention Actions

1. On July 29, 1969, the Federal Aviation Administration, after discussions with the National Transportation Safety Board, issued a general notice to all FAA Regional Offices, Air Carrier District Offices, Flight Standards District Offices, and International Field Offices as follows:

THIS IS NOTICE N 8430.107. CANCELLATION DATE NOVEMBER 1 1969. SUBJECT: CIVIL AIR CARRIER OPERATIONS ALERT NO. 69 DASH 5. LOSS OF HYDRAULIC FLUID OR PRESSURE DURING FLIGHT WITH A SIMULATED OR ACTUAL FAILURE OF AN OUTBOARD ENGINE. DASH ALL JET TRANSPORTS DASH PRELIMINARY INVESTIGATION OF A RECENT B DASH 707 DASH 300C TRAINING ACCIDENT REVEALED THAT WHILE CONDUCTING A MISSED APPROACH WITH THE SIMULATED FAILURE OF AN OUTBOARD ENGINE CMA THE AIRCRAFT EXPERIENCED A LOSS OF HYDRAULIC PRESSURE. WHILE CONDUCTING THE EMERGENCY PROCEDURE RELATING TO THE HYDRAULIC PROBLEM CMA CONTROL OF THE AIRCRAFT WAS LOST AND IT CRASHED RESULTING IN FATALITIES TO ALL PERSONS ABOARD. PRINCIPAL OPERATIONS INSPECTORS SHALL ASSURE THAT THEIR ASSIGNED AIR CARRIERS INCLUDE IN THEIR AIRCRAFT OPERATIONS MANUAL THE OPERATIONAL CONSIDERATIONS INVOLVED WHEN CONDUCTING ENGINE OUT OPERATIONS AND ENCOUNTERING A HYDRAULIC FAILURE CMA SPECIFICALLY CMA THE INCREASE IN VMCA WITHOUT RUDDER BOOST. VMCA WITHOUT RUDDER BOOST IN THE B DASH 707 DASH 300C IS APPROXIMATELY 177 KTS. IN THE EVENT AN AIRCRAFT HAS A RUDDER BOOST MALFUNCTION OR ENCOUNTERS A LOSS OF HYDRAULIC PRESSURE DURING AN ENGINE OUT OPERATION CMA THE CREW SHOULD AVOID HIGH YAW ANGLES CMA HIGH ANGLES OF ATTACK CMA AND MAINTAIN RUDDER BOOST OUT VMCA PRIOR TO SHUTTING OFF THE HYDRAULIC PUMP PART S PART POWERING THE RUDDER. SHOULD THE ENGINE FAILURE BE SIMULATED CMA THE ENGINE SHOULD BE RESTORED PRIOR TO TROUBLE SHOOTING THE HYDRAULIC SYSTEM.

2. Upon confirmation by the Safety Board that a metal fatigue failure was found in one of the outboard spoiler actuator down lines, the FAA sent another general notice to the above-listed offices, as follows:

THIS IS NOTICE 8340.57. SUBJECT: BOMBING 707 AIRCRAFT ALL SERIES-SPOLLER ACTUATOR PRESSURE LINES. CANCELLATION DATE 1 NOVEMBER 1969. A BROKEN OUTBOARD SPOILER DOWN PRESSURE LINE (BETWEEN THE SWIVEL FITTING AND ACTUATOR) IS BELIEVED TO HAVE CAUSED LOSS OF HYDRAULIC FLUID AND PRESSURE MOMENTS BEFORE A RECENT B-707-331C FATAL ACCIDENT. SUBSEQUENT REVIEW OF SERVICE HISTORY INVOLVING B-707 AIRCRAFT SHOWS THE SUBJECT LINES IN THE VARIOUS SPOILER POSITIONS TO BE THE FREQUENT CAUSE OF FLUID LEAKS AND MECHANICAL DELAYS. AS A PRECAUTIONARY MEASURE AND TO FACILITATE FURTHER INVESTIGATION IT IS REQUESTED: (1) B-707 OPERATORS BE

ASKED TO COMMENT AND RECORD THE RESULTS OF A VOLUNTARY ONE-TIME SPECIAL INSPECTION OF ALL B-707 FLIGHT SPOILER INSTALLATIONS TO DETECT AND CORRECT FLUID LEAKS OR OTHER DISCREPANCIES. SUCH INSPECTION SHOULD INVOLVE CLOSE VISUAL CHECKS OF THE ENTIRE SPOILER HYDRAULIC PLUMBING INSTALLATION FROM AND INCLUDING SWIVEL FITTINGS TO THE SPOILER ACTUATORS. THE INSPECTION SHOULD BE DONE IMMEDIATELY AFTER A COMPLETE GROUND OPERATIONAL CHECK OF THE SPOILERS IN BOTH THE LIFT AND SECOND BRAKE MODES AND WITH FULL HYDRAULIC SYSTEM PRESSURE BEING APPLIED. ALSO, THE INSPECTION SHOULD BE DONE SO AS TO DETECT EVIDENCE OF EXCESSIVE TORQUE IN SWIVEL FITTINGS AND TURNING MISALIGNMENT OR STRAIN DURING SPOILER OPERATION. (2) A REPORT CONCERNING THE SPECIAL SPOILER INSPECTIONS BE PREPARED AND SENT VIA PRIORITY DESPATCH TO WE-100 WITH A COPY TO ES-300. TITLE THE REPORT "B-707 SPOILER HYDRAULICS INSPECTION (RIS: FSE340-01)". THE REPORT SHOULD INCLUDE AS A MINIMUM: (A) OPERATOR NAME, (B) NUMBER OF AIRCRAFT INSPECTED, (C) LISTING OF DISCREPANCIES INCLUDING EXISTING PART NUMBERS AND IF POSSIBLE TIME IN SERVICE ON DISCREPANT PARTS, (D) RELATED INSPECTOR COMMENTS INCLUDING EXPLANATION OF OPERATOR'S ACTIONS - PAST OR PLANNED - TO IMPROVE SPOILER HYDRAULICS RELIABILITY.

3. The National Transportation Safety Board, by letter dated August 1, 1969, recommended that the Federal Aviation Administration also take the following actions:

- a. A detailed review should be made of the emergency procedures of all operators of Boeing 707 series and like aircraft to clarify troubleshooting of hydraulic system malfunctions with respect to the operation of the hydraulic pump control switches;
- b. The rudder pump low-pressure light circuitry should be modified to remain on any time the rudder pump pressure is lost, regardless of the rudder hydraulic pump switch position.

By the National Transportation Safety Board:

//s/ JOHN H. REED
Chairman

//s/ OSCAR M. LAUREL
Member

//s/ FRANCIS H. McADAMS
Member

//s/ LOUIS M. THAYER
Member

September 3, 1969

SA-None

File No. 1-0017

AIRCRAFT ACCIDENT REPORT

TRANS WORLD AIRLINES, INC.
BOEING 707-331C, N787TW
NATIONAL AVIATION FACILITIES
EXPERIMENTAL CENTER
ATLANTIC CITY AIRPORT
POMONA, NEW JERSEY
JULY 26, 1969

Adopted: March 25, 1970

NATIONAL TRANSPORTATION SAFETY BOARD
Bureau of Aviation Safety
Washington, D. C. 20591

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TRANS WORLD AIRLINES, INC.
BOEING 707-331C, N787TW
NATIONAL AVIATION FACILITIES
EXPERIMENTAL CENTER
ATLANTIC CITY AIRPORT
ROMONA, NEW JERSEY
JULY 26, 1969

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NATIONAL TRANSPORTATION SAFETY BOARD
DEPARTMENT OF TRANSPORTATION
AIRCRAFT ACCIDENT REPORT

Adopted: March 25, 1970

TRANS WORLD AIRLINES, INC.
BOEING 707-331C, N787TW
NATIONAL AVIATION FACILITIES
EXPERIMENTAL CENTER
ATLANTIC CITY AIRPORT
POMONA, NEW JERSEY
JULY 26, 1969

SYNOPSIS

Trans World Airlines, Inc., Flight 5787 (TWA 5787) of July 26, 1969, a Boeing 707-331C, N787TW, crashed at approximately 1233 e.d.t. during a simulated three-engine, missed approach to Runway 13 at the National Aviation Facilities Experimental Center (NAFEC), Atlantic City Airport, Pomona, New Jersey. There were three TWA line captains, a flight engineer, and an instructor pilot on board the aircraft. All five were fatally injured.

The flight originated at John F. Kennedy International Airport (JFK), New York, New York, for the purpose of providing recurrent training of three TWA captains in accordance with the provisions of Part 121 of the Federal Aviation Regulations.

The required training and proficiency check maneuvers were to be accomplished at the NAFEC/Atlantic City Airport at Pomona, New Jersey.

One of the required proficiency check maneuvers included a simulated instrument approach and the execution of the missed-approach procedure, with a critical engine reduced to training idle in order to also simulate engine failure. While this simulated approach was in process, and after the landing gear and full flaps had been extended, fatigue failure of the left outboard spoiler actuator downline caused the loss of hydraulic fluid from the aircraft's utility hydraulic system.

The TWA emergency procedures for Boeing 707-331C aircraft provided that in the event of hydraulic fluid loss, all pumps were to be turned off. Consequently, when the fluid loss came to the crew's attention, the command, "All of them out, pumps off" was called and obeyed. At this time, the aircraft was approximately 300 feet above ground level.

((AGL)), and at an indicated airspeed of 127 knots. Takeoff power was being produced by engines Nos. 1, 2, and 3. Power for flight was not being produced by the No. 4 engine because the power lever had been retarded to the training idle position in order to simulate engine failure.

Power on the No. 4 engine was not restored, and approximately 21 seconds after the call "pumps off" was issued, directional control of the aircraft was lost. Eleven seconds later, the aircraft struck the ground in a right-wing low, nosedown attitude.

The Board determines that the probable cause of this accident was a loss of directional control, which resulted from the intentional shutdown of the pumps supplying hydraulic pressure to the rudder without a concurrent restoration of power on the No. 4 engine. A contributing factor was the inadequacy of the hydraulic fluid loss emergency procedure when applied against the operating configuration of the aircraft.

1. INVESTIGATION

1.1 History of the Flight

The aircraft utilized on this flight was a Boeing 707-331C, Cargojet, N787TW, and was powered by four Pratt and Whitney JT-3D fanjet engines. The aircraft had operated previously as Flight 609-26, a regularly scheduled cargo flight originating in Frankfurt, Germany, and terminating at John F. Kennedy International Airport (JFK), New York, with intermediate stops at London, England, Shannon, Ireland, and Boston, Massachusetts. The flight departed from Frankfurt at 2010 e.d.t. 1//, July 25, 1969, and arrived at JFK at 1003, July 26, 1969. No mechanical discrepancies were noted at the end of this flight, and maintenance on the aircraft was neither required nor performed at JFK. A walk-around inspection did not disclose any indication of hydraulic fluid leaks. The aircraft was refueled to a fuel weight of 70,000 pounds, and released as TWA Flight 5787 for the purpose of providing recurrent training and proficiency checks for three TWA line captains.

TWA 5787 departed from JFK at 1146. The first captain to receive the proficiency check occupied the left seat, the instructor-pilot (I.P.) occupied the right seat, and a flight engineer occupied the flight engineer's position. The other two captains occupied the flight deck as observers while awaiting their turn at the controls.

The flight operated from JFK to the NAECC/Atlantic City Airport, Pomona, New Jersey, under routine air traffic control, and was handed off upon arrival in the Atlantic City, New Jersey, area to the Atlantic City Approach Control facility. The aircraft was then vectored by Approach Control, in accordance with the crew's request, to the Instrument Landing System (ILS) outer marker for an approach to, and a full-stop landing on, Runway 13. The approach and landing were accomplished. TWA 5787 then requested, and the tower approved, clearance to taxi to the end of the runway, execute a 180° turn, and take off on Runway 31.

Prior to takeoff, the I.P. briefed the captain to expect a simulated engine failure after V_1 (critical engine failure speed), 2//to execute

1// All times herein are eastern daylight, based on the 24-hour clock.

2// Critical-engine-failure speed -- the minimum calibrated airspeed to which the aircraft on takeoff can be accelerated, lose the critical engine, and the pilot can either safely continue the takeoff, or bring the aircraft to a stop on the runway. Critical engine means the engine whose failure would most adversely affect the performance or the handling qualities of an aircraft.

a three-engine climbout, and to request vectors for a precision ILS approach to Runway 13, using the aircraft's flight director system.

Pretakeoff and takeoff checklists were completed and the takeoff was executed as stated. The No. 4 engine was retarded to training idle thrust after V_1 had been reached. The takeoff was continued and emergency procedures were executed in accordance with the TWA engine failure emergency checklist. The aircraft was levelled off at 1,500 feet and vectored to intercept the ILS course in the vicinity of the outer marker. The No. 4 engine remained in idle thrust. The I.P. directed the captain to execute a simulated three-engine ILS approach, and to expect a missed approach at the decision height. 3//

As TWA 5787 proceeded toward the outer marker, the prelanding and final landing checklists were called for and completed. The landing gear was extended and, after the aircraft passed the outer marker, flaps were placed full down (50°). The approach was flown with the No. 4 engine still retarded to idle thrust. At this point, the tower cleared TWA 5787 to land. The I.P. answered, "OK, we'll take the option." 4// The tower replied, "Roger, cleared."

At the decision height, a missed approach was announced. The captain advanced power on engines 1, 2, and 3, and called for, in proper checklist sequence, "25 Flaps," "Takeoff Power," "Up Gear." These commands were acknowledged and complied with. However, neither the flaps nor the landing gear moved from their previous positions. The aircraft was accelerated to 130 knots (minimum indicated airspeed for this maneuver, pursuant to TWA flight manual procedures) 5// and a missed-approach climb was instituted. The configuration of the aircraft at this moment was:

3// Decision height -- the height specified in feet above mean sea level at which a missed approach shall be initiated if the required visual reference has not been established.

4// "Option" means that the pilot could elect to make a full-stop landing, a touch-and-go landing and takeoff, or only a low approach.

5// TWA Flight Handbook (FHB) p. 03.10, Paragraph Q(d). "Maintain Bug to Bug # 5 Knots to 800" (max bank 15°). If speed below 130 KTS, slowly accelerate to 130 KTS." Bug or reference speed for this aircraft as computed by the crew for this approach was 124 knots.

flaps full down (50°); landing gear down and locked; engines 1, 2, and 3 at takeoff thrust; and engine No. 4 retarded to idle thrust.

Approximately 16 to 18 seconds after the start of the missed-approach procedure, one of the observer pilots commented, "Oh!! Oh!! Your hydraulic system's zeroed." When this information was verified by the I.P., the captain receiving the proficiency check commanded, "All off them out, pumps off." At this moment the tower asked, "Trans World, you gonna work approach control?" The I.P. replied, "Stand by, we're having a hydraulic problem here." Following this communication, the conversation in the cockpit concerned the circumstances which might have caused the loss of the hydraulic fluid. The emergency checklist 6//relating to hydraulic fluid loss was not called for, and other than the accomplishment of the first item, these procedures were not followed.

The local controller observed N787TW midfield, at an altitude estimated to be 500 to 600 feet. Approximately 10 to 15 seconds later, he observed the aircraft in a steep, descending right turn which terminated in impact with the aircraft parking ramp adjacent to the NAFEC hanger. The controller working the ground control position also saw the aircraft start a right turn and dive toward the ground. He activated the emergency crash alarm while the aircraft was still in the air.

Eleven other witnesses observed the aircraft at impact or in flight just before impact. A summary of their comments follows, divided for tabulation purposes into three general areas; sounds heard before observation of the aircraft, pre-impact observations, and observations at impact.

6// TWA's Hydraulic Fluid Loss Emergency Checklist was as follows:

1. All pumps off.
2. If loss continues, utility pumps depressurize.
3. If loss stops, utility pumps one at a time to depressurize and check quantity.
4. Vmca without rudder power is 180 kts.
- *5. See 03.12 FHB system restoration procedures.
- *(Neutralize rudder trim before restoring power rudder)

P. 03.12.06 FHB. The amplified checklist discusses each of the above items in detail. Paragraph 4 lists the Vmca for each of the 707 models in the TWA fleet. (Vmca means the minimum control speed, airborne, with a critical engine inoperative.)

a. Pre-Observation Sounds

Nine of the witnesses commented on noises coming from the aircraft prior to impact. Four described a double boom, or explosion; four described the sound as one boom; one described a sputtering sound. Two of these witnesses described the sounds as "compressor stall"; one likened the sound to "a flame-out." Three witnesses described a flash, or flames coming from the aircraft. Two of these placed the flames as emanating from engines No. 3 and No. 4. Two of the witnesses described complete silence, or a lack of engine sounds following the boom.

b. Pre-impact Observations

Nine witnesses described the aircraft during flight prior to impact. Four of these described the flight path as normal at first observation, followed by a turn or veer to the right. Four described the aircraft in a right turn, or right wing low, at first observation. One witness described the aircraft as "weaving erratically." Four of these witnesses also indicated a climb attitude of the aircraft prior to a rapid change in direction or bank attitude. All agreed that the right wing continued to drop and the aircraft made a right descending turn toward the point of impact. The bank angle was described variously as "60° to 70°," "vertical," or simply "right wing low." Three witnesses described a nose-low attitude prior to impact, one fixing the nosedown angle at 45°.

c. Impact Observations

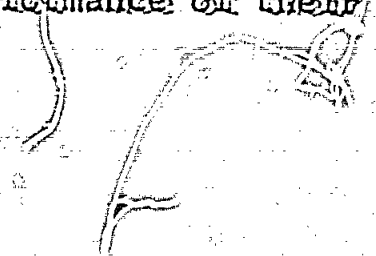
Three witnesses described the aircraft at impact. One described the aircraft as striking the ground on the right wing and cockpit. Another stated that the aircraft nosed to the right and went straight into the ground. The third described the aircraft's attitude preceding impact as nosedown, right wing low.

The geographic coordinates of the crash site were:

Latitude 39° 26' 56" N., Longitude 74° 33' 50" W.

11.2 Injuries to Persons

All five persons aboard the aircraft were TWA crewmen, and all received fatal injuries. Post-mortem and toxicological examination of the fatally injured flight crewmembers revealed no evidence of pre-existing disease or physical impairment that would have adversely affected the performance of their duties.



1.3 Damage to the Aircraft

The aircraft was destroyed by ground impact and ensuing ground fire.

1.4 Other Damage

The impact caused minor damage to the NAFEC aircraft parking ramp. A U. S. Army Otter (576-109), located approximately 550 feet from the point of impact, was destroyed by fire. A Federal Aviation Administration (FAA) DC-3 (N-7), located approximately 487 feet from the point of impact, was damaged by flames. A lightpole, 235 feet from the point of impact, was broken off by the wreckage. Miscellaneous ramp equipment including aircraft towbars, refueling ladders, maintenance stands, an electric power cart, and a mobile passenger boarding ramp were destroyed.

1.5 Crew Information

The seat positions in the cockpit on this flight were as follows: Captain Donald Sklarin, instructor-pilot, was in the right seat. Captain Harry D. Gaines, the pilot receiving the proficiency check, was in the left seat. Second Officer Frank J. Jonke occupied the flight engineer's seat. These positions were established by TWA personnel, based on the conversations recorded on the cockpit voice recorder (CVR) during the flight.

Captain Donald Sklarin, aged 38, was employed by TWA on October 8, 1956. He was upgraded to captain January 31, 1967. He held Airline Transport Pilot Certificate No. 1348582, with ratings in the Douglas DC-6, DC-7, and the Boeing 707/720 aircraft. On February 7, 1968, he was approved by the FAA as a Check Airman on Boeing 707 aircraft.

He satisfactorily passed his last examination for an FAA first-class medical certificate on July 20, 1969, without waivers. With TWA, he had accumulated 6,080 flying hours, of which 1,314:20 were in Boeing 707 aircraft. His total instrument time was 1,216 hours. His total pilot time in the last 30 days was 10 hours; in the last 60 days, 28 hours 55 minutes; and in the last 90 days, 39 hours 40 minutes.

His last proficiency check in the Boeing 707 was satisfactorily accomplished on February 13, 1969.

Captain Harry D. Gaines, aged 56, was employed by TWA on May 14, 1940. He was upgraded to captain on March 7, 1946. He held Airline Transport Pilot Certificate No. 36802, with ratings in the Douglas DC-3 and DC-4, Lockheed Constellation, and Boeing 707/720.

He satisfactorily passed his last examination for an FAA first-class medical certificate on February 7, 1969, without waivers. He had accumulated 27,436 hours, of which 4330:50 were in Boeing 707 aircraft. His total instrument time was 5,487 hours. His total flight time in the last 30 days was 45:39 hours. His last proficiency check was satisfactorily accomplished on January 8, 1969.

Mr. Frank J. Jonke, aged 29, was employed by TWA as a student flight engineer on November 29, 1968, and upgraded to flight engineer on April 9, 1969. He held Commercial Pilot Certificate No. 1574678 dated December 7, 1963, Flight Engineer Certificate No. 1916947 dated March 17, 1969, and an FAA first-class medical certificate dated November 28, 1968.

His total flight time was 3772:12 hours, of which 142:12 hours was in Boeing aircraft. He had acquired 128:48 hours of flight in the 90 days immediately preceding the accident, all in Boeing aircraft, and 68:10 hours in the last 30 days. His last proficiency check was completed satisfactorily on July 16, 1969.

1.6 Aircraft Information

N787TW, a Boeing 707-331C, manufacturer's serial No. 18712, had a date of manufacture of May 20, 1964. At the time of the accident, the aircraft had accumulated a total operating time of 17,590:05 hours. The aircraft time since the last major inspection (5,000-hour base overhaul, completed on May 9, 1969) was 4,258:28 hours. The accumulated time since the last 1,000-hour inspection was 645:33 hours.

A review of the aircraft logs for the 90-day period prior to the accident did not disclose any uncorrected maintenance items that would have affected adversely the flight safety of the aircraft. However, there were eight reports of intermittent illumination of the No. 2 auxiliary hydraulic system tank low-level light while the aircraft was descending. Corrective action in each instance was to bleed the No. 2 auxiliary hydraulic system tank. There were no indications of hydraulic fluid quantity loss in connection with any of the low-level light indications.

The aircraft log sheets for July 25, 1969, contained a writeup concerning the illumination of the No. 2 utility hydraulic pump low-level pressure warning light and the No. 2 auxiliary tank low-level light. There were no indications of any fluid loss associated with these events. As a precautionary measure, the pressure filters and case drain filters on the Nos. 2 and 3 engines were replaced, the No. 2 hydraulic pump was changed, and the low-pressure switch was replaced. This work was accomplished in Frankfurt, Germany, prior to the return of N787TW to the United States as TWA Flight 609 of July 26, 1969. There were no

discrepancies noted, or maintenance writeups on the aircraft following this precautionary service.

The aircraft had been serviced with 7,937 gallons of Turbine A fuel at JFK prior to the release of the aircraft as TWA Flight 5787.

On departure from JFK, the aircraft had a gross takeoff weight of 204,740 pounds, which was 33,260 pounds less than maximum landing weight. The center of gravity was within limits, computed by slide rule to be at 27.5 percent mean aerodynamic chord. Both weight and balance were within limits at the time of the accident.

1.7 Meteorological Information

The surface weather observation at the NAFEC, Atlantic City Airport, at 1233 was: Ceiling, measured 2,000 feet broken, 4,500 feet overcast, visibility 10 miles, temperature 74° F., dewpoint 67° F., wind 130° 7 knots, altimeter setting 29.91 inches. Weather conditions are not considered to be a factor in this accident.

1.8 Aids to Navigation

TWA 5787 was using the Atlantic City ILS for practice precision approaches. This facility is used for instrument approaches to the NAFEC, Atlantic City Airport, Pomona, New Jersey, and is aligned for approaches to Runway 13.

Atlantic City ILS operates on an assigned frequency of 110.5 MHz. The glide slope is at 2° 35" angle with an interception altitude of 1,400 feet m.s.l. The outer marker is 4.3 miles from the Runway 13 threshold.

1.9 Communications

Communications between TWA 5787 and all Air Traffic Control facilities were routine up to the final communication of "Stand by, we're having a hydraulic problem here."

1.10 Aerodrome and Ground Facilities

The NAFEC/Atlantic City Airport is located at latitude 39° 27" north and longitude 74° 35" west at a published elevation of 76 feet.

Runway 13 is 10,000 feet long and 200 feet wide. It is equipped with U. S. Standard Configuration "A" approach lighting and high-intensity strobe lights.

1.11 Flight Recorders

N787/TW was equipped with a Lockheed 109CR flight data recorder. The recorder was recovered with superficial dents and smoke damage. The recording was in good condition. The recording produced the following in-flight information: pressure altitude, magnetic heading indicated airspeed, and vertical accelerations, against a time base. An examination of the recording was made covering a period from 2:45 minutes prior to impact. This time period covers the flight of TWA 5787 from just inside the outer marker on the ILS approach through the missed-approach procedure to impact. The altitude readout shows a descent to 230 feet m.s.l. at 50 seconds prior to impact, then a climb reaching a maximum altitude of 666 feet m.s.l. at 11 seconds prior to impact. At 10 seconds prior to impact, the altitude reading was 650 feet, at 5 seconds it was 250 feet, and at impact, 81 feet.

The indicated airspeed for the last 1 minute ranged from a low of 127 knots to a high of 136 knots.

The headings varied from 128° to 136° and were generally between 133° and 129° until a rapid change in heading occurred approximately 11 seconds prior to impact.

These readings, in part, through the last 20 seconds of the flight were as follows:

<u>Time</u>	<u>Vertical Acceleration</u>	<u>Magnetic Heading</u>	<u>Indicated Airspeed</u>	<u>Altitude m.s.l.</u>
0:20	1.15g	132°	133 knots	450 feet
0:15	1.10g	132°	135 knots	525 feet
0:11	1.00g	132°	136 knots	666 feet
0:10	1.00g	134°	136 knots	650 feet
0:05	1.15g	160°	135 knots	250 feet
0:00	1.15g	190°	132 knots	81 feet

(See Appendix A for detailed readout of flight data recorder.)

N787/TW was also equipped with a cockpit voice recorder. This recorder was recovered intact and the tape examined for pertinent information. A transcript of the last 2 minutes of recorded conversation in the cockpit is contained in Appendix B.

1.12 Wreckage

The initial impact of N787IW was at a point 1,190 feet to the right side of Runway 13 centerline. The main wreckage came to rest 580 feet from the initial impact point. Distribution of the wreckage was along a path on a general heading of 220° magnetic.

Portions of the aircraft structure were destroyed by ground fire. The wings separated from the fuselage, and the engines and flaps separated from the wing structure.

The fuselage had separated into three large sections: The forward fuselage, including the cockpit area; the fuselage center; and the vertical stabilizer and rudder section. Each was heavily damaged by ground impact and the subsequent ground fire. The horizontal stabilizer and tail cone section had separated from the empennage and was found near the main wreckage. (See Appendix C, Wreckage Distribution Chart.)

The vertical stabilizer was intact from the tip to the fuselage attachment. The trailing edge of the rudder had burned away; however, the rudder control components in the vertical stabilizer were undamaged. All hydraulic lines were complete and there was no evidence of hydraulic leaks found inside the vertical stabilizer. The rudder trim drum below the vertical stabilizer indicated full left rudder; the rudder position transmitter was broken. The rudder shutoff valve was found in the normal position. The vertical stabilizer and rudder section were resting on the ground on their right sides. The rudder was in the full left position.

Both wings were damaged severely and melted from the post-impact fire. The flap jackscrews were recovered and were found fully extended. The actuator pistons of the leading edge devices were recovered and were found fully extended.

The hydraulic pressure line to the downside of the left outboard spoiler actuator had failed at the bottom of the sharp notch cut in the outside surface of the tube by the edge of the flareless coupling sleeve. Metallurgical examination of the break indicated that the failure was due to metal fatigue. (See Appendix D.)

All engines separated from the aircraft structures. Engines Nos. 1, 2, and 4 came to rest in a line across the wreckage centerline, approximately 300 feet forward of the main wreckage area. Engine No. 3 came to rest in the right side of the main wreckage area.

All four engine inlet cowls were crushed aft on a measured angle of 45°. The No. 4 inlet crushed area exhibited scores running upward and inboard on a measured angle of 45°.

Engine No. 3 showed signs of a compressor stall. Subsequent examination at the carrier's overhaul base disclosed that all engines were capable of producing power at impact. Engines Nos. 1, 2, and 3 had sustained substantial rotational damage usually associated with high r.p.m. at impact. The No. 4 engine sustained considerably less rotational damage at impact. Compressor surge bleed valves on all four engines were found jammed in the full open position.

The cockpit and flight deck area were recovered within the main wreckage area. Almost all components showed evidence of impact and fire damage.

The first officer's lower instrument panel was burned badly and distorted. All pressure gauges and lights were missing. The hydraulic panel was examined and the following noted:

1. Utility pump switches No. 2 and No. 3 were found "off."
2. The rudder/spoiler pump switch (auxiliary system No. 1) was found "off."
3. The rudder pump switch (auxiliary system No. 2) was broken off, but the position indicated "off."
4. The interconnect switch appeared to be midway between the "off" and the "system" position; however, the switch itself was bent to the lower right side of the panel.

The center instrument panel (engine instruments) was recovered. The entire panel was burned badly, with most of it covered by melted aluminum. Useful information was not obtainable.

The throttle quadrant was recovered, examined, and the following noted:

1. All four start levers were in the "idle" position.
2. All four thrust levers were full forward.
3. The speed brake handle was full "down."
4. The flap handle indicated the 25° position. It was approximately 2-1/2 inches from the center of the handle to the bottom of the flap handle quadrant.
5. The stabilizer trim appeared to be two units aircraft noseup.
6. The landing gear handle was in the "down" detent.

The following flight instruments were recovered:

1. One airspeed indicator reading 128 knots.
2. One radio magnetic indicator with the heading reading 221°. The No. 2 needle read 265°, and the No. 1 needle was missing.
3. One horizon direction indicator indicating a 40° nosedown attitude. This instrument was severely bent.
4. One horizon direction indicator case with the index at the 45° right bank position.
5. One OMNI bearing indicator reading 330°.
6. One rate of turn indicator showing a standard rate turn to the left. This instrument was damaged badly, the glass was missing, and the turn needle was welded to the face plate.

The rudder control trim head was found reading approximately 6° to 8° left rudder.

The utility hydraulic system fluid quantity gauge was found with the needle in the six o'clock position, between the zero and full marks.

The pilot's center overhead panel was found and examined, the following was noted:

1. The antiskid switch was in the "on" position.
2. The rudder power switch was in the "on" position.
3. The emergency flap switch was on the "off" position.
4. The flap selector switch was in the neutral or "off" position.
5. The spoiler shutoff switch was in the "off" position.
6. The spoiler selector switch was in the "normal" position.

The system interconnect and brake interconnect motor-driven valves were recovered and found in the "off" position.

Only the No. 2 utility system hydraulic pump was recovered. It had separated from the engine and the drive shaft sheared at the shaft undercut. Examination of this pump verified the "off" position of the pump switch.

The two auxiliary hydraulic system pumps were recovered in the wheel well area, where fire had occurred. Examination of these pumps disclosed no evidence of failure or malfunction. A large quantity of baked Skydrol 7// was found inside the pump housings.

The No. 2 auxiliary system reservoir was recovered away from the main wreckage area, and had not been affected by the fire. The reservoir was crushed; however, the low-level switch and float mechanism were examined and determined to be operable.

The two auxiliary system accumulators were recovered. Both had been exposed to ground fire. The end caps and pistons were missing. The cap threads on the cylinder were stripped in a manner that might be expected if the caps were blown from the cylinders. The accumulator volume is approximately .217 gallons each, for a total of .433 gallons.

1.13 Fire

There was no evidence of pre-impact in-flight fire. The aircraft exploded upon impact and was almost totally consumed by fire.

1.14 Survival Aspects

This accident was nonsurvivable.

1.15 Tests and Research

Subsequent to the accident, TWA conducted a series of test flights in a Boeing 707-331C aircraft to determine the rate at which hydraulic pressure to the rudder would diminish when the hydraulic pumps were turned off. The in-flight configuration of N787TW, with respect to aircraft weight, engine power, airspeed, flap and landing gear situations at the time of the accident, was approximated on the test aircraft.

In the first test, initial rudder deflection was 24°. A fixed rudder pedal position was maintained and lateral inputs were not used. Directional drifting was allowed to develop to 3° per second before rudder power was restored. The rudder pressure dropped from 3,000 pounds per square inch (p.s.i.) at pump shutoff, to zero in 41 seconds.

7// Skydrol is the trade name for the hydraulic fluid used in the TWA Boeing 707-331C aircraft. It becomes a rubber-like substance when exposed to high temperatures.

Conditions for test number two were essentially the same as for test one, with the exception of the use of lateral control inputs to control directional drift. In this test, the pressure dropped from 3,000 p.s.i. to zero in 53 seconds.

Conditions for test number three were essentially the same as the others, with the exception of four rudder input cycles instead of a fixed rudder pedal position. In this test, the pressure dropped from 3,000 p.s.i. to zero in 18 seconds. This test was considered unrealistic because of the excessive use of rudder.

Conditions for test number four were essentially the same as for the previous three except that rudder activity consisted of one input-output-input cycle, and thereafter the rudder pedal was held in fixed position. In this test, the rudder hydraulic pressure dropped from 3,000 p.s.i. to 1,000 p.s.i. in 3 seconds. The 1,000 p.s.i. pressure was maintained for 7 seconds, and then dropped to zero in an additional 17 seconds. The total elapsed time from pump shutoff to zero pressure was 27 seconds.

To summarize, the drop in hydraulic pressure from pump shutoff to zero pressure ranged from a low of 18 seconds to a high of 53 seconds, and varied as a result of rudder use.

In each instance, the rudder deflection angle reduced to approximately 5° without any additional rudder pedal travel that would have indicated reversion to the manual system when the auxiliary system hydraulic pumps were turned off. Therefore, similar tests were again conducted with the rudder pedal pressure maintained at a constant level and the rudder pedal position marked. Although the rudder hydraulic pressure again bled off as before, there was no additional movement of the rudder pedal noted.

Subsequent to this series of tests, a Boeing 707-331C was again flown by TWA in a similar series of tests, with the exception that the aircraft was accelerated to the "rudder power off" V_{mc} of 177 knots before the hydraulic pumps were turned off. An initial rudder deflection angle of 13° was recorded in maintaining directional control with the hydraulic power "on" at the 177 knots airspeed. Subsequent to the shutoff of the hydraulic pumps, the pressure reduced gradually over a 4 minute period to 250 p.s.i. The rudder angle reduced to 3° , the tab did not unlock, and there was no increase in the rudder pedal travel. Power had been reduced on the No. 1 engine in order to maintain directional control. At this point, the rudder pedals were centered, the rudder control tab lock released, and it was then possible to achieve 12° of rudder angle in the manual mode. The rudder pedal travel increased, demonstrating the fact that manual reversion had been achieved.

One further flight test was conducted. In this test, the aircraft was accelerated to 177 knots before the hydraulic pumps were turned off. Immediately thereafter, the rudder power switch was placed in the "off" position. In this position, hydraulic pressure in the power unit was released by movement of the motorized valve to a position in which fluid in the power unit is ported to the return line to the auxiliary No. 2 system reservoir. In this instance, the rudder tab lock released nearly concurrent with the movement of the rudder power switch to the "off" position, manual reversion occurred without further pilot action, and a rudder deflection angle of 11° was achieved in the manual mode.

The cockpit voice recorder, in correlation with the flight data recorder for the last 1:45 minutes of the flight of TWA 5787, demonstrated a time interval of 21 seconds between the command "pumps off" and a subsequent abrupt change in aircraft heading. (See Appendix E for additional details.) The flight data recorder vertical acceleration trace showed excursions to approximately $1.25g$ in the interval between the command "pumps off" and the rapid change in heading.

The rudder power hydraulic unit was removed from the vertical stabilizer, functionally tested, and no evidence of any malfunction was found. The internal leak rate was determined to be 1,200 cubic centimeters per minute (cc./min.) with the ram extended. The normal leak rate tolerance is 1,700 cc./min.

The position of the landing gear on Boeing 707-331C aircraft is displayed by lights on the instrument panel adjacent to the landing gear actuating handle. In the locked "down" position, three green lights are illuminated. These lights may be dimmed to reduce glare during night-time operations. In flight, when the landing gear handle is moved from the "down" to the "up" position, a red warning light illuminates to indicate an unsafe landing gear situation and remains illuminated until the gear is in the up and locked position. This light cannot be dimmed.

In order to determine the in-flight indications in the cockpit, when the landing gear handle was moved from the "down" to the up position and hydraulic power was not available, retraction tests were conducted at TWA's overhaul base. A Boeing 707-331C was placed on jacks, and the landing gear cycled normally. With the landing gear in the locked down position and the three green down light indicators illuminated, the hydraulic pumps were turned off and hydraulic pressure removed from the utility system. The landing gear handle was then placed in the "up" position. The three green down lights remained illuminated, the red warning light did not illuminate, and the landing gear did not move. The landing gear handle was then moved from the "up" to the "down" position without any change in the instrument panel landing gear light indications.

1.16 Other Information

a. TWA Boeing 707-331C Utility and Auxiliary Hydraulic Systems

Basically, the Boeing 707 has two independent hydraulic systems which permit a failure to isolate itself to one system.

The fully serviced hydraulic system contains approximately 38 gallons of hydraulic fluid. Of this amount, 5.4 gallons are contained in the utility system reservoir, and this is the amount shown on the hydraulic fluid quantity gauge on the flight engineer's instrument panel. The reservoir is pressurized by engine bleed air. The auxiliary system reservoirs (1.4 gallons capacity each) are supplied from the utility system reservoir through a standpipe type of arrangement until the fluid level in the utility reservoir falls to, or below, the 3.2-gallon level. Thus, a fast leak will quickly isolate itself to either the utility system or the auxiliary systems. If the fluid quantity indicator shows no further loss beyond the 3.2-gallon level, the leak would be in the auxiliary systems. Conversely, if the fluid quantity continued to diminish beyond the 3-gallon level, the leak would be in the utility system. A hydraulic fluid quantity gauge reading of zero, therefore, would identify a leak in the utility system.

Two engine-driven (engines Nos. 2 and 3) pumps supply the pressure for the utility system. The No. 1 auxiliary and No. 2 auxiliary systems pressures are provided by two hydraulic pumps driven by alternating current electric motors. Normally, the operating pressure in all systems is 3,000 p.s.i.

Four amber warning lights, one for each system, are used to monitor pump pressure output. A light will come on anytime its associated pump output pressure drops below 1,200 p.s.i., and will extinguish whenever the pressure is above this value. Thus, if all fluid is lost from a particular hydraulic system, the associated low-pressure warning light would illuminate. In the instance of complete loss of fluid in the utility system, the lights associated with both Nos. 2 and 3 engines would illuminate. These amber low-pressure warning lights for each system are located on the lower section of the copilot's instrument panel, immediately above the hydraulic pump "on-off" switches. (See Appendix F.)

In the event of loss of pressure in any system (possible pump failure) and without a fluid loss, the two systems may be interconnected by means of an interconnect valve, actuated by a switch located on the copilot's forward instrument panel. Also on the copilot's instrument panel are hydraulic system pressure gauges, as follows:

- (1) A utility system pressure gauge which indicates the hydraulic pressure available above the system's 2,000 p.s.i. preload.
- (2) A brake hydraulic pressure gauge indicating brake pressure available above the 750 p.s.i. preload.
- (3) A rudder hydraulic pressure gauge showing the pressure available to operate the rudder (3,000 p.s.i. at airspeeds below 250 knots and 2,250 p.s.i. at airspeeds above 250 knots).

On the upper portion of the copilot's forward instrument panel is a rudder low-pressure, red warning light. This light will illuminate any time the hydraulic pressure to the rudder is below 2,500 p.s.i. and the airspeed is 250 knots or less.

On the flight engineer's panel there are the following:

- (1) Two auxiliary hydraulic system low-pressure warning lights.
- (2) Two utility hydraulic system low-pressure warning lights.
- (3) Reservoir low-level warning lights for the No. 1 and No. 2 auxiliary hydraulic systems.
- (4) A hydraulic oil overheat light.
- (5) The utility reservoir quantity gauge.

In normal operation, the utility hydraulic system provides power to operate the flaps, landing gear, outboard spoilers, brakes, main landing gear levelling cylinders, and nosewheel steering. The No. 1 auxiliary system supplies hydraulic power to operate the inboard spoilers and the rudder. Through an interconnect valve mechanism, it may be connected to either the brake or utility system if necessary. The No. 2 auxiliary system supplies hydraulic power for the rudder only. Either of the two auxiliary systems will supply full rudder power. In the TWA Boeing 707-331C aircraft, the auxiliary systems each have a separate reservoir, with the No. 2 auxiliary tank supplied through the No. 1 auxiliary system reservoir. Hydraulic fluid from the rudder power unit, however, is recirculated directly to the No. 2 auxiliary reservoir. Power from the No. 2 auxiliary system is not routed through a pressure reducer valve and, consequently, must be turned off at airspeeds above 250 knots to provide structural protection.

In order not to have the low-pressure warning light associated

with the No. 2 auxiliary hydraulic system illuminated at all times in cruising flight, this light is deactivated when the pump switch is placed in the "off" position. The operation of this switch is a checklist item, identifying at what point in the climb the pump will be turned off and at what point in the descent it will again be returned to service.

b. Boeing 707-331C Rudder Control System

Directional control of the aircraft is provided by the rudder, rudder control tab, and rudder control system. Rudder positioning may be accomplished hydraulically through the rudder control hydraulic power unit or mechanically through the rudder control tab and balance panels. Rudder trim is available to provide a means of maintaining directional heading without applying continuous pressure on the rudder pedals. The rudder trim system is a cable-operated linkage that functions through a power trim gearbox during rudder operation in the power mode, or through a manual trim gearbox during rudder operation in the manual mode.

Under normal operating conditions, the rudder is hydraulically positioned through full travel (up to 25° of rudder deflection angle). With hydraulic power available, the rudder pedal motion is transmitted by the control linkage to the power control unit actuating valve. An artificial feel unit is incorporated in the powered rudder configuration to provide the pilot with a sensing of the amount of rudder pressure that is being applied. In the power mode, the rudder control tab is made to operate in anti-balance direction through the incorporation of a tab linkage lock in the hydraulic power unit. The tab is thus deflected in the direction of rudder motion on a ratio of 1.8° for each 1° of rudder travel. Rudder pedal motion, with rudder power available, is 2 inches fore and aft of neutral with zero trim. In the power mode, the three-engine minimum control speed for TWA 5787 was approximately 117 knots.

In the mechanical mode, rudder pedal motion (4 inches fore and aft with zero trim) is transmitted by cables and pushrod directly to the rudder control tab. The tab is moved in balance direction to position the rudder aerodynamically through deflection angles to approximately 17° . In the mechanical mode, the minimum three-engine control speed for TWA 5787 was 177 knots (180 knots according to the FHB).

With the rudder in the streamlined position, reversion to the mechanical mode is accomplished automatically upon turning off the auxiliary system pumps, or in the event of any failure of the auxiliary hydraulic systems. However, if the rudder has been deflected hydraulically to maintain a directional heading with an asymmetrical

power configuration, reversion to the mechanical system will not occur automatically. The tab lock will not release unless the rudder pedals are operated to streamline the rudder or the power switch is turned to "OFF", thus relieving the internal pressure. In the absence of either action the tab lock will not release until the internal leak rates in the power unit result in aerodynamic streamlining of the rudder, and a degrading hydraulic pressure.

c. TWA Boeing 707 Flight Handbook, Cockpit Checklists, and Flight Instructors Manual

Part 121 of the Federal Aviation Regulations (FAR's) provides, among other things, that each domestic and flag carrier must prepare and keep current a manual for the use and guidance of flight operations personnel. Instructions necessary to allow personnel to perform their duties with a high degree of safety must be included. A copy of the appropriate parts of the manual, and changes or revisions thereto, must be provided to crewmembers.

The FAR's also require that an Airplane Flight Manual must be furnished by the manufacturer and carried aboard each transport category airplane.

Information and instructions in the Airplane Flight Manual relating to the peculiarities of normal operations, and certain emergency conditions, must be approved by the Administrator of the FAA, and must be segregated, identified, and clearly distinguished from each unapproved part of that manual.

In lieu of the Airplane Flight Manual, sections of the required information from it may be incorporated in a company manual and carried aboard the aircraft, provided that the appropriate sections are clearly identified as Aircraft Flight Manual requirements. This option was exercised by TWA and the required Airplane Flight Manual information was contained in the TWA-published Boeing 707 Flight Handbook.

The Airplane Flight Manual may be revised from time to time when changes are made to the aircraft, or when operating procedures are revised. With respect to the Boeing Company, a revision service was provided to aircraft purchasers in accordance with specific contracts for this service. Two types of pages were involved. One was a standard page that applied to all of the 707/720 fleet without regard to the specific model aircraft or operator. The other was a special page that applied only to a specific operator or airplane model, because of operator or model differences.

As revisions were made, the letter "R" was placed in the right-hand margin of the affected page to identify revised material. The changes to an existing procedure were also discussed in a "Revision Highlights" sheet associated with the revised section and page of the Airplane Flight Manual. Such revisions were issued routinely according to an established rotating schedule. There was a contract in existence between Boeing and TWA for this service at the time of the accident. TWA used the "R" symbol on the revision sheets to identify required changes to their own Boeing 707 Flight Handbook.

Section 121.315 of the FAR's further states that each certificate holder shall provide approved cockpit check procedures for each type of aircraft. The approved procedures must include, inter alia, each item necessary for flight crewmembers to check for safety in systems emergencies. These procedures must be designed so that a flight crewmember need not rely on his memory for items to be checked. The procedures must be readily usable in the cockpit of each aircraft and the flight crewmembers must follow them when operating the aircraft.

These procedures may differ from those provided in the Airplane Flight Manual, if they are approved for use by the FAA. This is not an uncommon practice among airlines which operate a variety of aircraft and may have a requirement to modify the procedures to fit their particular operations. TWA, for example, operated eight different models of Boeing 707 aircraft, and attempted to keep the checklist procedures as standardized as possible between aircraft.

The TWA 707-331C checklist in use on July 26, 1969, containing procedures related to hydraulic fluid loss, was approved by the FAA on April 17, 1969. This checklist provided that in the event of hydraulic fluid loss, all pumps were to be turned off. The "Other Emergency Guide Amplification" section of the TWA Boeing 707 Flight Handbook relating to hydraulic fluid loss contained the following instructions:

"As soon as the loss is noted the Engineer shall advise the Captain. The Captain shall command that all hydraulic pumps be turned OFF as soon as possible. This must be done rapidly if any system fluid is to be retained."

Both the checklist and the emergency guide amplification in the Flight Handbook note that the Vmca without rudder power is 180 knots for the 331C aircraft. This section also notes:

"1. In the event the rudder boost system is in operative, avoid high yaw angles. Use caution when executing "missed approach" procedures with an engine out."

These procedures were in conformance with the hydraulic system emergency procedures in the original FAA-approved Airplane Flight Manual for the Boeing 707-331C aircraft purchased by TWA in 1964. Changes in the procedures relating to hydraulic system emergencies were subsequently made by the Boeing Company in 1966 and approved by the FAA, but not incorporated in the TWA Flight Handbook, or the TWA "331C Other Emergencies Guide" checklist.

The checklist in the TWA Flight Handbook used by the flight instructors contained the same checklist as the TWA Boeing 707 Flight Handbook carried in the aircraft. This checklist was not in accord with the procedure in the Boeing 707 FAA-approved Airplane Flight Manual current at the time of the accident. The difference was:

- (1) The Boeing FAA-approved Airplane Flight Manual Procedure, revised in 1966, provided that if any hydraulic pump low-pressure warning light came on, the corresponding pump switch was to be placed in the "OFF" position. Hydraulic fluid loss, per se, was not discussed.
- (2) The TWA "331C Other Emergencies Guide" provided that in the event any hydraulic fluid loss occurred, all pumps were to be turned off. (The fourth item on this checklist notes that "Vmax without rudder power is 180 knots.")

The flight instructor's manual also contained the following:

- (1) The instructor shall keep his feet on the rudder pedals and his hand close to the control wheel at all times.
- (2) During all "engine out" or engine out maneuvers the instructor shall keep his feet on the rudder pedals, prepared to block any improper rudder application and to make such rudder application as may be required, should it not be made by the trainee.
- (3) The instructor is warned to "be prepared to pull off remaining engine thrust should uncontrollable yaw develop during engine out maneuvers."

d. The Boeing 707 Airplane Flight Manual Hydraulic System Emergencies Procedures, and Changes Thereto

The procedures relating to in-flight hydraulic system emergency operation initially in the Boeing 707 FAA-approved Airplane Flight Manual provided to TWA in 1964 were, in part, as follows:

"HYDRAULIC SYSTEM CAUTION LIGHTS ON OR PRESSURE OR QUANTITY LOW
PHASE I AND II

1. System Hydraulic Pump(s) - OFF
2. Landing Gear Lever - Check OFF

PHASE III

1. Isolate the fault, if possible, then use any part of the system which can be operated normally.

NOTE: In the event of failure of the utility system or auxiliary system hydraulic pumps, the system with the failed pump(s) can be pressurized by the other system through the interconnect valve. Do not use the interconnect valve when system failure is the result of leakage as complete loss of both system's hydraulic fluid may occur.

2. Use landing procedure as specified under HYDRAULIC QUANTITY OR UTILITY PRESSURE FORM ON LANDING if required."

Subsequently, TWA was furnished revision No. 7, dated March 18, 1966, to the above section of the manual which identified a revision to the Phase III section only, as follows:

"NOTE: (Applicable to airplanes with system interconnect valve operable in flight.) R"

Revision No. 8 to the TWA Airplane Flight Manual, dated April 21, 1967, changed the procedure to read as follows:

"ANY HYDRAULIC PUMP LOW PRESSURE LIGHT ON
PHASE I AND II

1. Corresponding Hydraulic Pump Switch - OFF."

PHASE III was also changed by the addition of a sentence stating that "If the auxiliary system was deactivated, do not pressurize for landing."

The previous statement concerning the procedure for landing was modified by the deletion of the words "hydraulic quantity."

These revisions did not have the letter "R" in the right-hand margin indicating changed material, nor were the reasons for deletion of any reference to "hydraulic quantity low" discussed in the Revision Highlights associated with manual Revision No. 8. One revision was

Flagged with the letter "R" in the "Notes" associated with the Phase III section, and related to BRAKING ACTION only.

The Boeing Company advised that the procedure was changed to eliminate the need to turn off the pump(s) in the event of loss of system fluid quantity. The reasoning behind this change was that shutting down pumps to prevent loss of hydraulic fluid after hydraulic fluid was low, did not offer sufficient advantage to outweigh the complications that might result from turning off hydraulic systems unnecessarily.

The above revisions were provided to TWA, but because of the absence of the "R" symbol to identify the changes when the revisions were received, the comparable revisions were not made to the procedure contained in the TWA Boeing 707 Flight Handbook, or to the emergency checklists.

The "R" designator for the Phase I and II changed material was omitted inadvertently from the revision sheets sent to TWA because of the cycle interval existing in the method used by the Boeing Company to mail out revision service material to the many purchasers of Boeing aircraft. By the time the changed page was to be mailed to TWA, another change had been made to that same page, but to the Phase III Section. Accordingly, the "R" symbol was placed opposite the Phase III change. Since Phase I and II had been changed previously, the "R" was deleted from the Phase I and II Sections. In the absence of the "R" symbol, TWA was not alerted to the changes in Phase I and II, and the Flight Handbook Procedure was not revised.

The checklists approved by the FAA on April 17, 1969, were not changed for similar reasons. The emergency procedure for hydraulic fluid loss was consistent with the procedure established originally by the Boeing Company, and approved by the FAA. The subsequent revisions to the TWA Boeing 707 Airplane Flight Manual, which were provided to the FAA's Air Carrier District Office responsible for monitoring TWA's operations, were also minus the "R" symbol, as discussed previously. Accordingly, the Air Carrier District Office was not alerted to the changed procedure, and continued the approval of the previous procedure.

2. ANALYSIS AND CONCLUSIONS

2.1 Analysis

Examination of the airframe, control systems, powerplants, and other aircraft components did not reveal any evidence of structural failure, malfunction, or abnormality other than the fatigue failure of the out-

board spoiler actuator hydraulic line. Failure of this line would not have caused a loss of directional control, since only the components operated by the utility system would have been affected. Hydraulic fluid would not have been lost from the No. 1 auxiliary system, powering the rudder and inboard spoilers, unless the interconnect valve was open. This valve was found in the closed position. Further, on TWA B-707-331C aircraft, hydraulic fluid from the rudder power unit is returned by a separate line directly to the auxiliary No. 2 system reservoir. Thus this system operated as a closed loop, virtually independent of either the utility or No. 1 auxiliary systems.

Notwithstanding, the I.P.'s response to the query, "What's that, got no hydraulics?" was "They're all out." This response would seem to indicate failure of the auxiliary systems as well as the utility system. It is likely, however, that the I.P. either misspoke or was referring to only those systems that are operated by the utility system (e.g., flaps and landing gear). This is concluded since it can be demonstrated that there was no failure of the auxiliary systems prior to pump shutdown. The circumstances that lead us to this conclusion are:

a. The hydraulic pumps are lubricated by the hydraulic fluid. They may be damaged if allowed to operate for any appreciable time after fluid loss occurs. There was no evidence of such damage to either auxiliary system pump. Baked Skydrol was found in large quantities in the pump housings, demonstrating the presence of hydraulic fluid when the pumps were exposed to ground fire after impact.

b. More significant is the fact that difficulty was not encountered in maintaining aircraft directional control when the missed-approach procedure was initiated. At that point, power on engines Nos. 1, 2, and 3 was increased to takeoff thrust. At the 135 KIAS shown by the flight data recorder, this power addition would have required nearly full rudder capability in the power mode, or substantially beyond any degree of rudder deflection that could be obtained manually. Precise directional control, including a heading correction to the left, was maintained after the power was increased and until the pumps were turned off. This precise directional control would have been possible only if at least one of the auxiliary hydraulic systems was operating satisfactorily.

For normal flight purposes, failure of the utility system would not have seriously affected lateral control capability since the inboard spoilers are operated by the No. 1 auxiliary system. Full aileron capability would have been available since the flaps were extended. However, these controls alone would not have been sufficient to maintain control of the aircraft at 135 KIAS in the absence of hydraulic rudder power.

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In view of these findings, the causal area of this accident is related to the operational procedures used by the crew subsequent to the discovery of the complete loss of the hydraulic fluid from the utility system reservoir.

In assessing the operational factors involved, it is notable that, in effect, two emergencies were present. One was self-made by the I.P. in the simulated failure of the No. 4 engine. The second was the actual fatigue failure of the hydraulic line and the genuine loss of the utility system hydraulic fluid. However, system failures, which may occur infrequently and are independent in nature, are characteristically not considered as multiple failure probabilities in the certification of aircraft. Consequently, the emergency procedures relating to particular failures do not address the problems of a simultaneous failure situation--nor, in fact, would it be realistic or feasible to attempt to cover all such possible situations with pre-established procedures. However, recognition of the hazard incident to engine failure (or more precisely, to the effect of asymmetrical thrust) concurrent with the loss of hydraulic rudder power, was contained in the TWA Flight Handbook information, the Flight Instructor's Manual, and noted in the FAA-approved emergency checklist, by the identification of the 180 knots Vmca in the absence of hydraulic power to the rudder. The Vmca notation on the checklist is discussed further in the accident prevention section of this report.

Other factors of particular significance include:

- a. The apparent high rate of climb shown by the flight data recorder for the 3-second interval immediately preceding the rapid change in heading information.
- b. The stage in the execution of the approach at which the utility system hydraulic line failure occurred.
- c. The amount of time available to the crew to discover the hydraulic system failure.
- d. The number and adequacy of various devices to alert the crew to failures in the hydraulic systems.
- e. The probable effect on this flight if the revised Boeing emergency procedure for hydraulic system failure had been incorporated in the TWA operating procedures and emergency checklist.
- f. Actions which could have been taken, both before and after the auxiliary systems pumps were turned off, to preclude loss of directional control.

Each of these elements is discussed in detail in the following sections of this report.

The Boeing Company calculated that N787TW would have climbed at a 2.6 percent gradient under the conditions existing at the time of the accident, so long as rudder and spoiler boost were operable. Data are not available as to yaw drag levels with rudder and spoiler boost inoperable, and climb capability calculations were not made for this condition. However, since the first 20 seconds of the climb (after the "missed approach" was called) was made before the auxiliary pumps were turned off, the 2.6-percent gradient calculation provides a reasonable basis for comparison of predicted climb capability with the actual climb data shown on the flight data recorder. The 2.6-percent gradient calculation translates into an altitude gain of approximately 241 feet in 40 seconds, or 362 feet per minute (f.p.m.) in this instance. The flight data recorder shows an actual altitude gain of approximately 326 feet in the 40 seconds following the command for the missed approach, and up to within 3 seconds of the abrupt change in heading. It is apparent, therefore, that the abrupt climb indication of 120 feet in the 3 seconds immediately preceding the rapid change in heading (2,400 f.p.m.) cannot be met without a concurrent reduction in airspeed. No such reduction in airspeed was recorded on the flight data recorder, nor was there any indication of an abrupt pullup on the vertical acceleration trace.

According to an engineering analysis performed by the Boeing Company at the request of the National Transportation Safety Board, the abrupt altitude increase shown on the recorder data is indicative of a sideslip which progressed to between 18° and 28° before the altitude indication began to decrease. An abrupt altitude increase indication of this type could be caused only by reduction in static system pressure as a result of the sideslip. In turn, a sideslip of this magnitude would cause a rapid roll, a subsequent change in heading, and a loss of altitude. The compressor stall in engine No. 3, heard and observed by ground witnesses and verified during the examination of the engines, would in all probability result from the high sideslip angle. The stall warning (stick shaker) sounds heard on playback of the cockpit voice recorder tape were also in all likelihood the result of the high degree of sideslip, since the airspeed indication remained well above the aircraft stall speed until impact, and there was no evidence of an abrupt pullup on the vertical acceleration trace of the flight data recorder.

The loss of directional and lateral control occurred approximately 20 seconds after the command for "pumps off." Considering the internal leak rate determined during the examination of the rudder power hydraulic unit from N787TW, this time interval is consistent with the time intervals for loss of hydraulic pressure demonstrated by the TWA test flights.

Accordingly, the Safety Board believes that the loss of directional control was caused by turning off the auxiliary system pumps, the resulting loss of rudder power, and the continued application of asymmetrical thrust.

The loss of directional control occurred at a phase of flight in which takeoff power was required. It is pertinent, therefore, to determine when the fatigue failure of the hydraulic line actually occurred in order to assess properly the crew's opportunity to discover the failure and to take appropriate action at some less critical segment of the flight. In this regard, it can be shown that the utility system was functioning properly when the aircraft was inbound, near the ILS outer marker, some 3:19 minutes prior to impact. At that time, the flaps were extended from 40° to the 50° position, the position in which they were found in the wreckage.

Thereafter, when the aircraft was in the vicinity of the ILS middle marker, 50 seconds prior to impact, the flap selector was placed in the 25° detent. However, the flaps did not move from the 50° position, nor did the landing gear retract when the selector was placed in the "up" position 8 seconds later. The fact that neither the flaps nor the landing gear moved in response to the control movements demonstrates that hydraulic pressure was not available at that time.

At the 3,000 p.s.i. system pressure, maximum fluid flow rate through the spoiler control valve is approximately 14 gallons per minute. Thus, with complete separation of the spoiler actuator line from the fitting, the 5.4 gallons of reservoir fluid could be lost in as few as 23 seconds. On basis of the foregoing information, it is apparent that the spoiler actuator hydraulic line failed sometime after the aircraft passed the ILS outer marker, prior to passage of the ILS middle marker and the I.P.'s command to execute the missed-approach procedure.

Had the loss of hydraulic fluid been noted at this stage of the approach, a straight-in landing on Runway 13 could have been executed without difficulty since the aircraft was in landing configuration, was properly positioned on the approach, and had been cleared for a landing by the tower. The questions which then follow concern the reasons for the failure of all crewmembers to note the loss of the fluid until it was called to their attention by the pilot-observer on the "jump seat." Normally, the flight engineer would be the first crewmember to be aware of hydraulic fluid loss since the quantity gauge is on his instrument panel. However, the flight engineer's duties are relatively few once the aircraft is in landing configuration and the landing checklist has been completed. Accordingly, and in consequence of concern among Government and industry groups regarding high descent rates, altitude awareness, and approach speeds during low visibility approaches, flight engineers frequently have been assigned the responsibilities of monitoring the pilot's instruments and calling out any significant deviations from programmed airspeed, descent rate, or altitude. This procedure was followed by TWA. Thus, at the time of failure of the spoiler actuator

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hydraulic line, and the subsequent rapid loss of hydraulic fluid, the flight engineer's attention probably was directed away from the engineer's panel.

There were several indications of utility hydraulic system failure available to the I.P. which could have alerted him to the problem. First, there were the pressure gauges and pump low-pressure lights on the instrument panel. Second, the flap position indicator gauge, located on the copilot's instrument panel adjacent to the landing gear lever, would have shown that the flaps did not move when the flap selector was placed in the 25° position. Third, the landing gear position lights could have alerted him to the fact that the landing gear did not move when the selector was placed in the "up" position. Why these indications were not observed is not known. Among possible explanations is that while Captain Gaines was making a simulated instrument approach with the training hood in place, he would have been unable to see outside the cockpit. Thus, it would be necessary for the I.P. to direct his attention outside the cockpit in order to prevent conflict with other aircraft operating on and in the vicinity of the airport. If the hydraulic line failed just prior to the command for the missed-approach, Captain Sklarin might well have been occupied with observing outside events, and would not have looked at the instrument panel until his attention was directed to the hydraulic system problem by the observer-pilot's comment, "Oh! Oh! Your hydraulic system's zeroed."

Because of the daylight conditions, the various warning lights might not have been intense enough to attract attention that was directed elsewhere. This would be particularly true of the landing gear position lights if the switch had been placed in the "dim" position. Also, the low-pressure warning lights are concealed to some degree behind the control wheel, which might result in the lights not being observed until a pilot in the right seat shifted his body position. By the time Captain Sklarin was aware of the fluid loss, the aircraft was climbing and was no longer in a position to execute a landing. Accordingly, it was necessary to continue flight while an assessment of the problem could be made. Unfortunately, Captain Sklarin's attention to the immediate problem was at that moment interrupted by the query from the Air Traffic Controller, "Trans World, you gonna work approach control?" Precious time was lost during the reply "Ah, stand by, we're having a hydraulic problem here."

The appropriate procedure for handling the emergency may be considered in two ways. First, in keeping with a basic tenet of flight instruction, the pseudo-engine failure emergency should have been removed as the first action when the real emergency situation became known. Had the No. 4 engine been restored to takeoff power, the asymmetrical thrust situation would have ceased to exist and the rudder would have returned to a neutral position. In this situation, the rudder control system would have reverted to manual operation and directional control would have been possible with all hydraulic pumps turned off. Troubleshooting to

locate the source of the failure could then have been accomplished in accordance with established checklist procedures without infringing on the safety of flight. When the failure in the utility system was identified, hydraulic rudder power could have been restored if needed. However, the Safety Board believes it worthy of comment that at that time none of the three qualified captains in the cockpit considered the false emergency or gave any thought to the fact that the aircraft was operating on three engines, when confronted with a real emergency.

In the absence of restoring power on the No. 4 engine (or in the situation of a genuine engine failure), the appropriate TWA procedure would have been to execute the prescribed troubleshooting procedures and to accelerate the aircraft to the 180 knots Vmca. However, Captain Gaines called out only the first item on the checklist, "All pumps off." Immediately following pump turnoff and Captain Sklarin's discussion of the hydraulic problem with the Air Traffic Control Tower, his attention was again diverted, this time to the landing gear, by the comment of Captain Wyker, "Must have been, ah, after the gear was down already." This was followed by a discussion between the three captains of the position of the landing gear. Before the ambiguity of the landing gear situation (wheels down, but the selector handle in the "up" position) could be resolved, the residual pressure in the auxiliary system's accumulators and in the rudder power unit dissipated to the point where directional control could not be maintained with the asymmetrical thrust condition.

The stage for this disastrous situation was set when the I.P. complied with the captain's callout from memory of the first item on the checklist, without taking further action to restore symmetrical power.

In this respect, the Board believes that if the new procedure contained in revision number 8 to the Airplane Flight Manual had been adopted, in all probability the accident would not have happened. It is recognized that even if TWA and the Air Carrier District Office monitoring their operations had been aware of the revised Boeing procedure, compliance with it would not have been mandatory. In fact, there were other operators of Boeing 707-300 series aircraft who had not adopted the revised procedure. However, under this procedure, the emergency action would have been initiated as the result of a low-pressure warning light "on," rather than by the loss of fluid. The first action item, by memory or otherwise, would have been a call for "Corresponding Hydraulic Pump Switch-OFF," rather than "all pumps off." Captain Sklarin would therefore have been forced to identify the system that had failed before taking any action to shut down any pumps. In this instance, only the utility system would have been shut down. Accordingly, even though the crewmembers may have forgotten the self-created emergency under the stress of the real one, there would not have been any directional control problems while the crewmembers attempted to find the source of the leak.

It is apparent that the asymmetrical thrust situation was recognized belatedly by Captain Gaines, as evidenced by his command, "Give me that engine."

It is also likely that the situation was recognized by Captain Sklarin nearly simultaneously. As previously noted, TWA instructor pilots are warned to "...be prepared to pull off remaining engine thrust should uncontrollable yaw develop during engine-out maneuvers."

Witnesses noted a lack of engine noise following the "boom" or compressor stall sounds, which would indicate that the power had been reduced on the operating engines.

The engine spool-down sounds on the CVR, 6 seconds prior to impact, also indicated that this action was taken. The discovery that all engine bleed valves were open at impact further confirms the fact that engine power was reduced on all engines prior to impact. However, by the time this action was taken, the aircraft had achieved a steeply banked, nose-down attitude from which recovery was not possible at that low altitude. As shown by the 45° angle of the crushed areas of all four engine cowlings, and the 45° upward and inward score marks on the No. 4 engine inlet, the bank angle and nose-down angle were still 45° at impact.

2.2 Conclusions

a. Findings

1. The flight crewmembers were properly certificated and approved for the operation involved.
2. None of the crewmembers was incapacitated, or otherwise unable to perform his assigned duties.
3. The aircraft was airworthy. Gross weight and center of gravity were within limits.
4. Fatigue failure of the left outboard spoiler hydraulic actuator downline occurred when the aircraft was on the final segment of an ILS simulated instrument approach.
5. Failure of the hydraulic line caused the loss of the hydraulic fluid in the aircraft utility system.
6. The captain, instructor pilot, and flight engineer were not aware of the hydraulic fluid loss until it was called to their attention by the third pilot in the cockpit.

7. All hydraulic pumps were turned off in accordance with the existing emergency procedures for hydraulic fluid loss.
8. There was no failure of the auxiliary hydraulic systems providing power to the rudder.
9. Power was not restored on the No. 4 engine.
10. The aircraft was not accelerated to the 180-knot, three-engine minimum control airspeed upon discovery of the hydraulic fluid loss. 8//
11. A high degree of sideslip was generated by the loss of rudder power and the continued use of asymmetrical takeoff thrust.
12. The high sideslip angle resulted in loss of lateral control, causing a rapid roll and loss of altitude.
13. The use of the Boeing revised procedure, specifying that only the hydraulic system displaying a low-pressure warning light was to be turned off, in all likelihood would have prevented this accident.

b. Probable Cause

The Board determines that the probable cause of this accident was a loss of directional control, which resulted from the intentional shutdown of the pumps supplying hydraulic pressure to the rudder without a concurrent restoration of power on the No. 4 engine. A contributing factor was the inadequacy of the hydraulic fluid loss emergency procedure when applied against the operating configuration of the aircraft.

3. RECOMMENDATIONS AND CORRECTIVE MEASURES

a. Initial Accident Prevention Measures

- (1) On July 29, 1969, the Federal Aviation Administration,

8// Attaining the 180-knot airspeed, per se, would not have been sufficient to maintain directional control. (See Appendix G.) However, it may have resulted in a less rapid and less severe loss of directional control and a longer period of time for the crewmembers to assess the true nature of the problem and either restore symmetrical power, or return the auxiliary hydraulic systems to service.

after discussions with the National Transportation Safety Board, issued General Notice N8430.107 to all FAA Regional Offices, Air Carrier District Offices, Flight Standards District Offices, and International Field Offices. This notice required FAA Principal Operations Inspectors to assure that all air carriers were aware of the problems incident to concurrent engine-out flight and hydraulic system failure. Attention was called specifically to the requirement to restore engine power prior to troubleshooting the hydraulic system in simulated engine failure situation. (See Appendix G.)

(2) Upon confirmation by the Safety Board that a metal fatigue failure was found in one of the outboard spoiler actuator downlines, the FAA issued General Notice N8340.57 to the above-listed offices. This notice suggested a voluntary, one-time inspection of the spoiler actuating systems on B-707 aircraft. This inspection was to be conducted by the users of Boeing 707 equipment. (See Appendix G.)

(3) The Board, by letter dated August 1, 1969, recommended that the FAA also take the following actions:

(a) A detailed review should be made of the emergency procedures of all operators of Boeing 707 series and like aircraft to clarify troubleshooting of hydraulic system malfunctions with respect to the operation of the hydraulic pump control switches;

(b) The rudder pump low-pressure light circuitry should be modified to remain on any time the rudder pump pressure is lost, regardless of the rudder hydraulic pump switch position.

b. Followup Recommendations and Corrective Measures

(1) As previously noted in Section 1.16(b) of this report, the rudder control system of the Boeing 707-331C aircraft will not automatically revert from hydraulic power mode to manual mode in the event of shutdown or failure of the auxiliary systems pumps. This situation was disclosed by the Safety Board's investigation of this accident, and was a condition previously unknown to most pilots and operators of these aircraft.

Although not a causal factor in this instance, a lack of understanding of this feature and the specific actions necessary to achieve manual reversion could result in a loss of directional control even at the appropriate three-engine minimum control speed.

Accordingly, in the interest of immediate accident prevention measures, the Board discussed this peculiarity of the rudder operation with the FAA, and suggested that the air carrier training programs and emergency operating procedures be revised to alert the pilots to the need for specific actions if engine failure were to be followed by the auxiliary hydraulic system failure. On January 8, 1970, General Notice N8430.115 was issued to all FAA Regional Offices, Air Carrier District Offices, and International Field Offices. This notice required FAA Principal Inspectors to assure that information on powered rudder characteristics be included in air carrier training programs, and that these characteristics be considered in establishing operating procedures related to asymmetrical thrust or directional control problems in particular aircraft. (See Appendix G.)

(2) By letter to the Administrator of the FAA dated December 18, 1969, the Safety Board made the following additional recommendations:

1. All maneuvers requiring simulated engine(s)-out operation of aircraft close to the ground should be conducted in and, to the maximum extent possible, limited to flight simulator training devices.
2. The Administrator should establish a minimum altitude above the terrain for those simulated engine(s)-out maneuvers which must be performed in flight.
3. Equally qualified crewmembers not directly involved in the training operation should be prohibited from the flight deck area on all proficiency flight checks.

The Administrator's response to these recommendations is contained in Appendix H.

By the National Transportation Safety Board:

//s// JOHN H. REED
Chairman

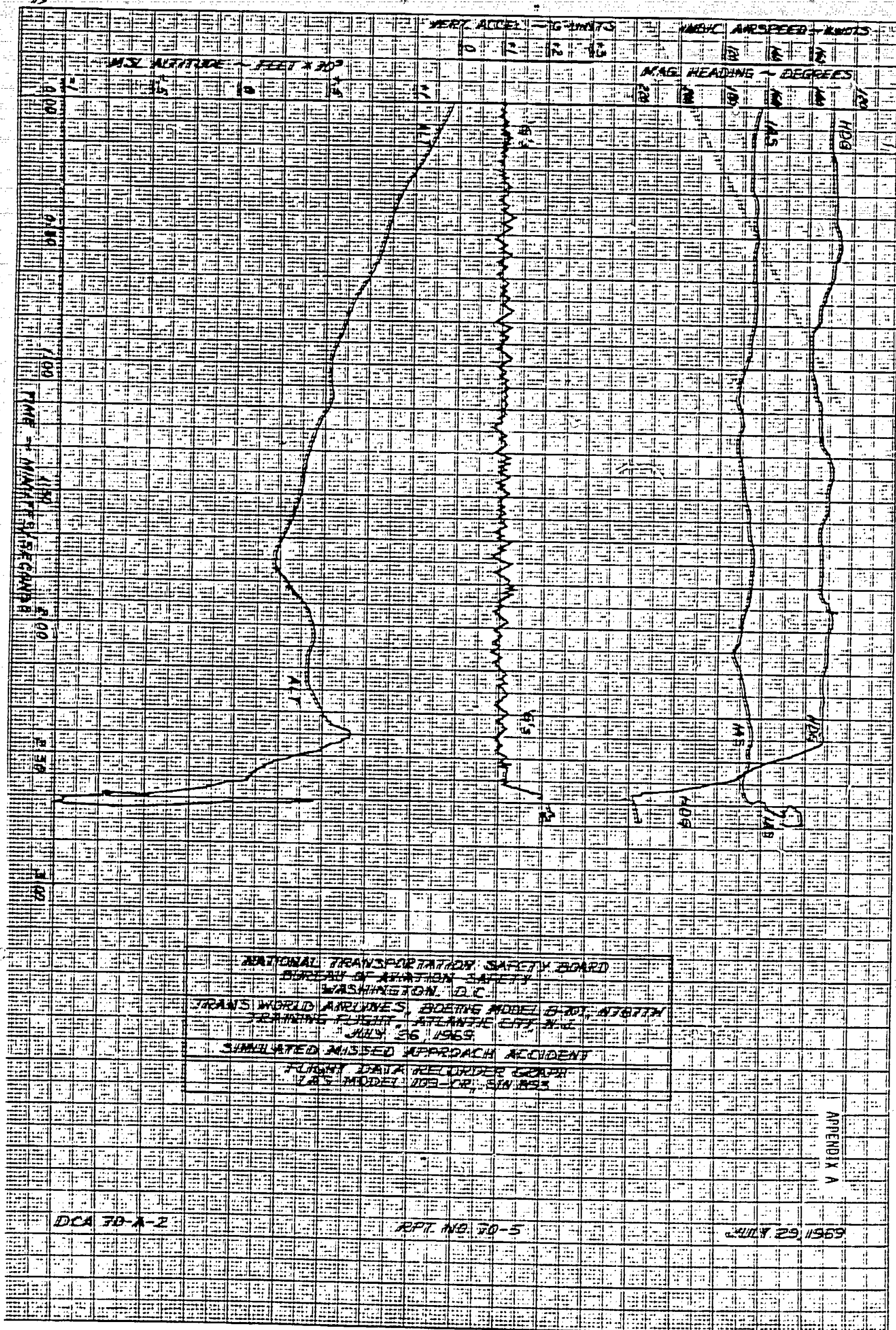
//s// OSCAR M. LAUREL
Member

//s// FRANCIS H. McADAMS
Member

//s// LOUIS M. THAYER
Member

//s// ISABEL A. BURGESS
Member

March 25, 1970.



APPENDIX B

NATIONAL TRANSPORTATION SAFETY BOARD
Department of Transportation
Bureau of Aviation Safety

TRANSCRIPT OF VOICE COMMUNICATIONS RECORDED ON THE LAST APPROXIMATE TWO MINUTES OF THE COCKPIT VOICE RECORDER TAPE FROM TRANS WORLD AIRLINE TRAINING FLIGHT 5787, N787TW, B-707-331C, WHICH CRASHED AT ATLANTIC CITY AIRPORT, POMONA, N. J., ON JULY 26, 1969

Legend

- CAM - Cockpit Area Microphone sound source
- RDO - Air-to-ground transmission from N787TW
- TWR - Ground-to-air transmissions from Atlantic City Tower
- 1 - Voice identified as Instructor Pilot
- 2 - Voice identified as Captain
- 3 - Voice identified as Flight Engineer
- 4 - Voice identified as ACM Wyker
- ? - Voice unidentified
- * - Unintelligible word or phrase
- % - Non-pertinent radio transmission on tower frequency
- ## - Non-pertinent intra-cockpit word or phrase
- (()) - Words enclosed in parentheses are subject to interpretation

TIME(EDT)	SOURCE	CONTENT
1231:10.5	TWR	And fifty seven eighty seven is cleared to land, the wind one three zero degrees at five.
1231:15	RDO-1	Okay, we'll take the option.
1231:17	TWR	Roger, cleared.
1231:19	CAM-2	Five hundred feet
1231:20	CAM-1	Okay
1231:23	CAM-1	Airspeed good, ...sink rate good,slightly right... of course.
1231:38	CAM-1	Right on the money, Harry %%
1231:55	CAM-?	(Minimums coming up)
	CAM-?	%%

<u>TIME(EDAT)</u>	<u>SOURCE</u>	<u>COMMENT</u>
1231:58	CAM-2	Hundred to go
	CAM-1	Okay, missed approach ///
1232:02	CAM-2	Twenty-five flap
	CAM-1	Twenty-five flap
1232:05	CAM	Sound similar to engine spool-up begins
1232:08	CAM-2	Takeoff power
1232:09	CAM-1	Okay
1232:10	CAM-2	Up gear
	CAM	Sounds similar to trim actuation and movement of landing gear lever
1232:12	CAM-1	Straight ahead to fifteen hundred feet.
	CAM-2	Right
	CAM	Sound similar to trim actuation
1232:16	CAM-4	Oh! Oh! Your hydraulic system's zeroed
1232:17.5	CAM-2	What was that? ---
1232:18	CAM-1	Oh, # !
1232:18	CAM-2	Got no hydraulics?
	CAM-3	(Just) went down
	CAM-1	They're all (out)
	CAM-2	All of em out?
	CAM-1	Yeah
1232:20	CAM-2	Pumps off
	CAM-?	*
1232:21	TWR	Trans World, you gonna work Approach Control?
1232:24	RDC-1	Ah, stand by, we're having a hydraulic problem here.

TIME(EDT) SOURCECOMMENT

1232:27 CAM-2 (all out?)
CAM-3 Just went down
CAM-2 Yeah
1232:29 CAM-4 Must have been, ah, after the gear was down already.
1232:32 CAM-1 Well, the gear is still in the up (position)
CAM-2 No gear's up.
CAM-3 (Yeah)
1232:35 CAM-2 It may be that gear, ah, --
CAM-4 ...might be pumping it out in the up position
1232:38 CAM-1 Let's see, the gear is down.
CAM Sound similar to that of landing gear lever movement.
CAM-1 I'm gonna put it down again
CAM-2 Yeah
1232:41 CAM-1 You got that?
1232:42 CAM Sound of "pop" similar to that caused by engine compressor stall.
1232:43 CAM-1 What happened?
1232:43.5 CAM-2 (What the hell ya do?)
CAM Background voices heard. Sound similar to that created by stall warning alarm ("stick shaker") begins and lasts for five seconds.
1232:44.5 CAM-2 Give me that engine!
CAM #:
1232:46 CAM Sound of engine spool-down audible
1232:46 CAM-1 Harry, ...We're over !
1232:48 CAM-2 Give me the engine!
1232:48.4 TWR Ah, look out!

TIME(EDIT) SOURCE

COMMENT

1232:50 CAM-1 We're over

1232:52 CAM Sound of impact and end of recording.

NATIONAL TRANSPORTATION SAFETY BOARD
Department of Transportation
Bureau of Aviation Safety

ACCIDENT: TWA 5787, B707-331, ATLANTIC CITY AIRPORT, JULY 26, 1969.
CHRONOLOGICAL SUMMARY OF SELECTED VOICE COMMUNICATIONS: RECORDED ON
THE OVER TALK WHICH BEGINS JUST PRIOR TO THE FLIGHT'S DEPARTURE ON
RUNWAY 31 AT ATLANTIC CITY.

Note: Small letters "a" through "i" denote various phases of flight.

(a) Tower's clearance for takeoff on Runway 31 issued at 1218:22.

TIME(EDT) SOURCE

COMMENT

1218:41 CAM :OK, one forty on the bug.

:One four zero.

:We'll go through the after landing checklist now.

:Read em out.

:Brake pressure.

:(I'll get it), checked.

:Interconnect.

:It's OK.

:Transponder!

:ah - okay

:Wing flaps!

:They're - ah - checked.

:Had it in system all the time.

:ah-OK.

:We'll go right on through here of course.

1219:06 CAM :Yeah, ***.

TIME(EDT) SOURCECOMMENT

1220:07 CAM :This'll be the engine failure after "V" one.

1220:22 (b) Takeoff begins. Engine spool-up audible.

1220:52 CAM-1 : "V" one, rotate, engine failure

CAM-2 :essential power.

CAM-? :essential power checked.

1221:01 CAM-? :Throttle's closed.

CAM-? :up gear.

(c) Flight maintaining 1,500 feet, Radar Vector Heading 240°, and thrust had been reduced for slower aircraft speed.

1223:09 CAM-2 :and fourteen flaps please

CAM-1 :OK and we should get the after takeoff check and ah -

CAM-? :-ah-it's (already) * * Unintelligible * *

CAM-1 :we have the throttle closed.

CAM-? :* * Unintelligible * *

1223:18 CAM-? :OK number four's secured.

1223:26 CAM-1 :OK we're all set, crew coordination is the same as before, everything is similar (to that advised) - ah - we are radar vectored for a three engine ILS flight director approach.

1223:39 CAM-2 :OK and (we need) a bug speed please.

-? :one two four.

1223:49 CAM-2 :and we've reached final checklist.

CAM-? :OK that's complete.

CAM-2 :ah - roger.

1225:16 (d) TWA 5787 on vector heading 310°, (downwind leg) has (just acknowledged new vector heading of 030°.) (right base leg runway 13). ACN#4 had gone to galley.

TIME(DDMM) SOURCECOMMENT

1225:22 CAM-? :and - ah - would you put your bird down please and
on heading mode and we're all set up this and - ah -
the markers are tuned.

CAM-? :all set.

CAM-? :everything set.

1225:30 CAM-1 :same (markers)..., same minimums..., same missed approach,
...straight ahead to fifteen hundred Harry.

CAM-2 :OK.

1226:41 (e) TWA 5787 seven miles from OM; new vector heading 100°;
cleared for ILS approach.

(f) TWA 5787 on Tower frequency

(g) Flight inbound to OM on localizer course. Crew dis-
cussing plan for VOR approach next and VOR requirements.

1228:52 CAM-2 :down gear please

CAM-? :((there ya go))

1229:15 CAM-2 :and - ah - forty flaps please

1229:19 CAM-2 :complete the final.

1229:21 CAM-? :OK it's all complete

1229:25 CAM-2 :glide slope please

CAM-1 :all right

1229:29 CAM-2 :ours sure do read differently

CAM-? :*

1229:33 CAM-2 :fifty flaps

CAM-1 :OK

1229:49 CAM-? :Outer marker

CAM-? :flags checked

1230:16 (h) TWA flight reports to Tower passing the OM.

1231:10.5 (i) TWA 5787 cleared to land.

SEQUENTIAL

FRAMES

OF

- OVERSIZED

DOCUMENT

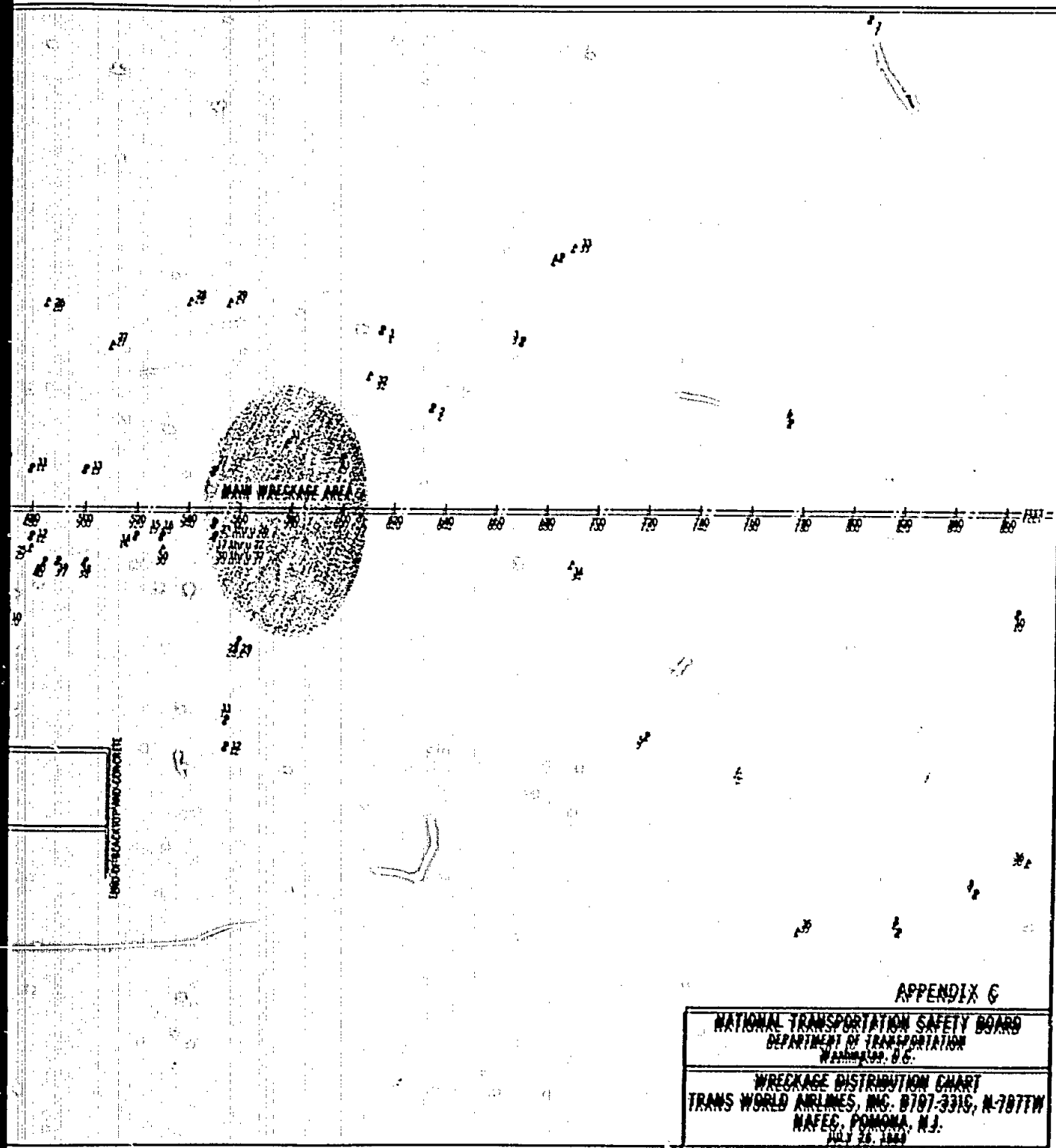
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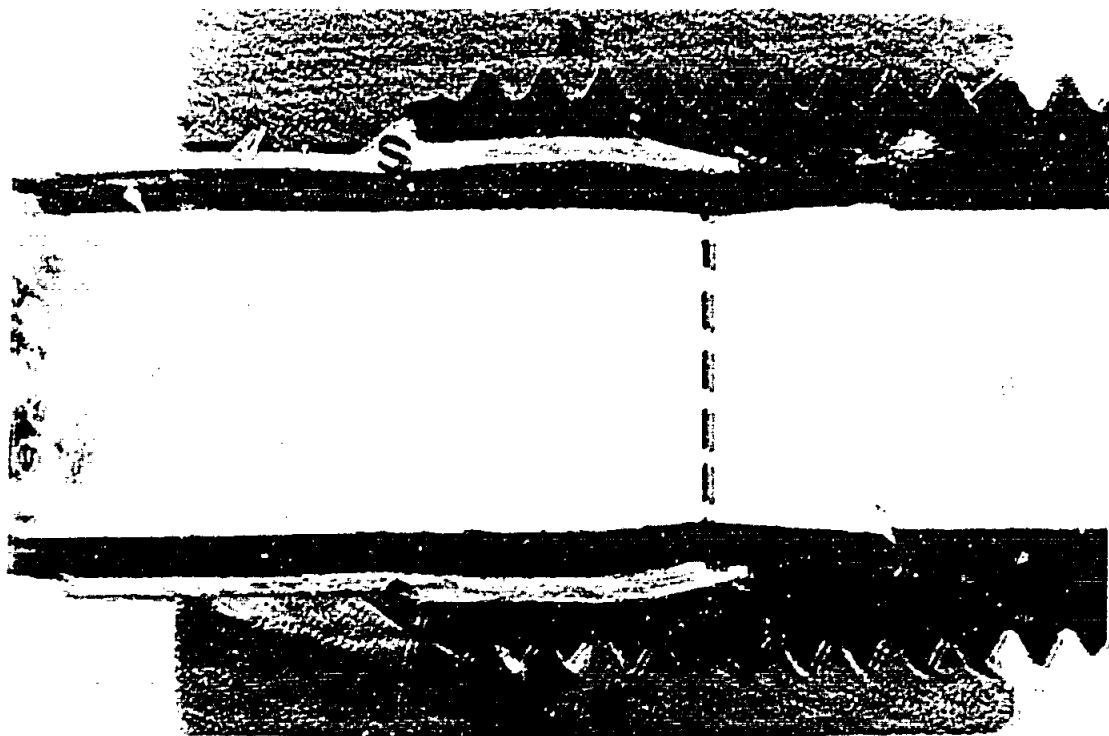
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A Thru B



654 11





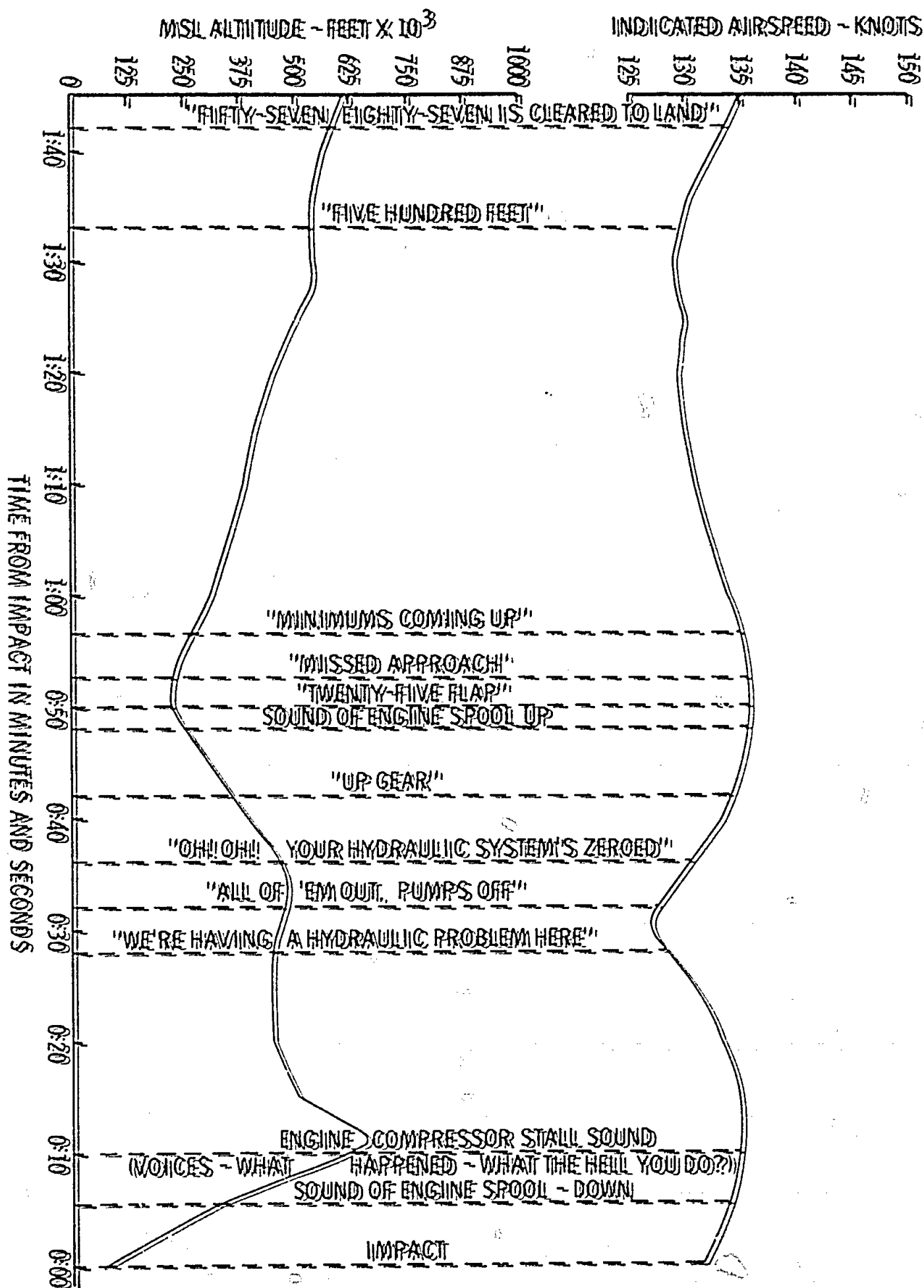
Longitudinal section through an assembled flareless coupling, illustrating the location of the fracture (dashed line) indicated by arrow "a", Fig. 1. X 4

J. Swivel joint fitting	S. Coupling sleeve
M. Coupling nut	T. Hydraulic tube



Tube removed from the assembly shown in Fig. 5. Arrows indicate the notches cut by the coupling sleeve. X 10

65



NATIONAL TRANSPORTATION SAFETY BOARD
BUREAU OF AVIATION SAFETY
WASHINGTON D.C.

TRANS WORLD AIRLINES, BOEING MODEL B-707, N7877W
TRAINING FLIGHT, ATLANTIC CITY, N.J.
JULY 26, 1969

EXTRACTS OF COCKPIT VOICE RECORDER
AND FLIGHT DATA RECORDER INFORMATION

66

RUDDER & SPOILER PUMP LOW PRESSURE LIGHT

When ON indicates rudder and spoiler pump pressure is low. Rudder and spoiler pump control switch must be ON to activate light.

P5 = RUDDER & SPOILER PUMP CONT.

UTILITY SYSTEM PRESSURE GAUGE

Indicates utility hydraulic pressure available above 2000 PSI preload.

P7 = HYD PRESS.

UTILITY PUMP LOW PRESSURE LIGHT

Indicates respective utility pump pressure is low. (light deactivated when Fire Control Handle is pulled).

P5 - HYD PRESS & DOOR WARN

BRAKE PRESSURE GAUGE

Indicates brake pressure available above 750 PSI preload.

P7 = HYD PRESS.

UTILITY PUMP CONTROL SWITCHES

ON = Pump is pressurized.

DEPR = Pump is depressurized by energizing a solenoid valve.

OFF = Pump is depressurized and motor operated fluid supply shutoff valve is closed.

P5 = PUMP VALVES & PRESS WARN.

P6 = HYD SHUTOFF

RUDDER PUMP CONTROL SWITCH

ON : Pump will deliver 3000 PSI.

OFF : Pump drive motor shutoff rudder and pump low pressure light deactivated.

P5 - RUDDER PUMP CONTROL.

P2 - RUDDER PUMP.

P1 - RUDDER PUMP (373C)

RUDDER & SPOILER PUMP CONTROL SWITCH

ON : Pump will deliver 3000 PSI

OFF : Pump drive motor shutoff and rudder and spoiler pump low pressure light deactivated

P5 - RUDDER & SPOILER PUMP CONTROL

P3 - RUDDER & SPOILER PUMP

RUDDER LOW PRESSURE LIGHT

Indicates hydraulic pressure to power rudder is low. (Approx. 1200 PSI on part time yaw damper, 2500 PSI on full time yaw damper). Operative only when airspeed is below 250 KTS or wing flaps extended.

P5 - OIL QUAN & RUDDER SEL.

RUDDER PUMP LOW PRESSURE LIGHT

When ON indicates rudder pump pressure is low. Rudder pump control switch must be ON to activate light.

P5 = RUDDER PUMP CONT.

RUDDER HYDRAULIC PRESSURE GAUGE

Indicates hydraulic pressure available to the power rudder. Normal pressure is 3000 PSI when airspeed is below 250 KTS or wing flaps extended otherwise 1000 PSI on part time yaw damper and 2250 PSI on full time yaw damper.

P7 - RUDD BOOST.

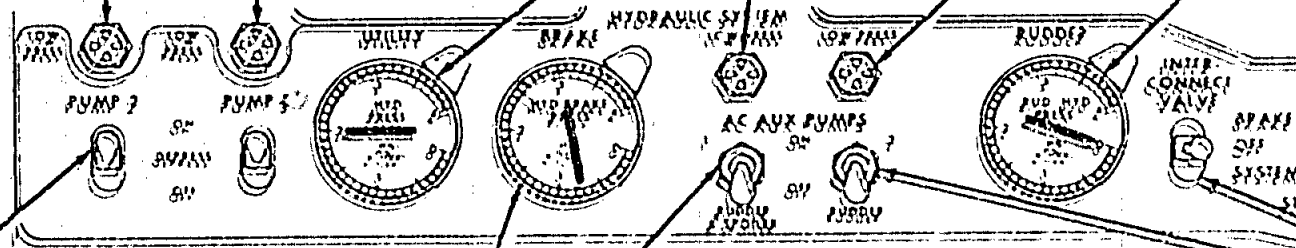
INTERCONNECT VALVE SWITCH

BRAKE = Motor operated valve open and rudder and spoiler pump pressure available to brakes.

OFF = Motor operated valve closed.

SYSTEM = Motor operated valve open and rudder and spoiler pump pressure available to utility system, or utility system pressure available to auxiliary system.

P5 - RUDDER & SPOILER PUMP CONT.



BRAKE PRESSURE GAUGE

Indicates brake pressure available above 700 PSI pre-load.
P7 = HYD PRESS.

UTILITY SYSTEM PRESSURE GAUGE

Indicates utility hydraulic pressure available above 2000 PSI preload.
P7 = HYD PRESS.



RUDDER LOW PRESSURE LIGHT

Indicates hydraulic pressure to Power Rudder is low. (Approx. 1200 PSI on part time yaw damper 2500 PSI on full time yaw damper). Operative only when airspeed is below 250 KTS or wing flaps extended.
P5 = OIL QUAN & RUDDER SEL.

RUDDER & SPOILER PUMP LOW PRESSURE LIGHT

Indicates rudder and spoiler pump pressure is low.
P5 = RUDDER & SPOILER PUMP CONT.

RUDDER PUMP LOW PRESSURE LIGHT

Indicates rudder pump pressure is low. Rudder pump control switch must be ON to activate light.
P5 = RUDDER PUMP CONT.

INTERCONNECT VALVE SWITCH

OPEN - Solenoid valve is energized open. Rudder and spoiler pump pressure available to utility system or utility system pressure available to auxiliary system.
CLOSE - Solenoid valve is spring-loaded closed.
P5 = RUDDER & SPOILER PUMP CONT.

UTILITY PUMP CONTROL SWITCHES

ON = Pump is pressurized.
OFF = Pump is depressurized by energizing a solenoid valve and pump low pressure warning light deactivated.

P5 = PUMP VALVES & PRESS WARN.

UTILITY PUMP LOW PRESSURE LIGHT

Indicates respective utility pump pressure is low. (Light deactivated when pump control switch is OFF).

P5 = PUMP VALVES & PRESS WARN.

RUDDER & SPOILER PUMP CONTROL SWITCH

ON - Pump will deliver 3000 PSI.
OFF - Pump drive motor shutoff.
P5 = RUDDER & SPOILER PUMP CONT.
P3 = RUDDER & SPOILER PUMP.

RUDDER PUMP CONTROL SWITCH

ON - Pump will deliver 3000 PSI.
OFF - Pump drive motor shutoff and rudder pump low pressure light deactivated.
P5 = RUDDER PUMP CONT.
P2 = RUDDER PUMP.

RUDDER HYDRAULIC PRESSURE GAUGE

Indicates hydraulic pressure available to the power rudder. Normal pressure is 3000 PSI when speed is below 250 KTS or wing flaps extended otherwise 1000 PSI on part time yaw and 2250 PSI on full time yaw damper.
P7 = RUDD BOOST & AIR BOTTLE.

GENERAL NOTICES ISSUED BY THE FEDERAL AVIATION ADMINISTRATION

THIS IS NOTICE N 8430.107. CANCELLATION DATE NOVEMBER 1 CMA 1969. SUBJECT CLN AIR CARRIER OPERATIONS ALERT NO. 69 DASH 5. LOSS OF HYDRAULIC FLUID OR PRESSURE DURING FLIGHT WITH A SIMULATED OR ACTUAL FAILURE OF AN OUTBOARD ENGINE. DASH ALL JET TRANSPORTS DASH PRELIMINARY INVESTIGATION OF A RECENT B DASH 707 DASH 300C TRAINING ACCIDENT REVEALED THAT WHILE CONDUCTING A MISSED APPROACH WITH THE SIMULATED FAILURE OF AN OUTBOARD ENGINE CMA THE AIRCRAFT EXPERIENCED A LOSS OF HYDRAULIC PRESSURE. WHILE CONDUCTING THE EMERGENCY PROCEDURE RELATING TO THE HYDRAULIC PROBLEM CMA CONTROL OF THE AIRCRAFT WAS LOST AND IT CRASHED RESULTING IN FATALITIES TO ALL PERSONS ABOARD. PRINCIPAL OPERATIONS INSPECTORS SHALL ASSURE THAT THEIR ASSIGNED AIR CARRIERS INCLUDE IN THEIR AIRCRAFT OPERATIONS MANUAL THE OPERATIONAL CONSIDERATIONS INVOLVED WHEN CONDUCTING ENGINE OUT OPERATIONS AND ENCOUNTERING A HYDRAULIC FAILURE CMA SPECIFICALLY CMA THE INCREASE IN VMCA WITHOUT RUDDER BOOST. VMCA WITHOUT RUDDER BOOST IN THE B DASH 707 DASH 300C IS APPROXIMATELY 177 KTS. IN THE EVENT AN AIRCRAFT HAS A RUDDER BOOST MALFUNCTION OR ENCOUNTERS A LOSS OF HYDRAULIC PRESSURE DURING AN ENGINE OUT OPERATION CMA THE CREW SHOULD AVOID HIGH YAW ANGLES CMA HIGH ANGLES OF ATTACK CMA AND ATTAIN RUDDER BOOST OUT VMCA PRIOR TO SHUTTING OFF THE HYDRAULIC PUMP PAREN S PAREN POWERING THE RUDDER. SHOULD THE ENGINE FAILURE BE SIMULATED CMA THE ENGINE SHOULD BE RESTORED PRIOR TO TROUBLE SHOOTING THE HYDRAULIC SYSTEM.

THIS IS NOTICE 8340.57. SUBJECT: BOEING 707 AIRCRAFT ALL SERIES-SPOILER ACTUATOR PRESSURE LINES. CANCELLATION DATE 1 NOVEMBER 1969. A BROKEN OUTBOARD SPOILER DOWN PRESSURE LINE (BETWEEN THE SWIVEL FITTING AND ACTUATOR) IS BELIEVED TO HAVE CAUSED LOSS OF HYDRAULIC FLUID AND PRESSURE MOMENTS BEFORE A RECENT B-707-331C FATAL ACCIDENT. SUBSEQUENT REVIEW OF SERVICE HISTORY INVOLVING B-707 AIRCRAFT SHOWS THE SUBJECT LINES IN THE VARIOUS SPOILER POSITIONS TO BE THE FREQUENT CAUSE OF FLUID LEAKS AND MECHANICAL DELAYS. AS A PRECAUTIONARY MEASURE AND TO FACILITATE FURTHER INVESTIGATION IT IS REQUESTED: (1) B-707 OPERATORS BE ASKED TO COMPLETE AND RECORD THE RESULTS OF A VOLUNTARY ONE-TIME SPECIAL INSPECTION OF ALL B-707 FLIGHT SPOILER INSTALLATIONS TO DETECT AND CORRECT FLUID LEAKS OR OTHER DISCREPANCIES. SUCH INSPECTION SHOULD INVOLVE CLOSE VISUAL CHECKS OF THE ENTIRE SPOILER HYDRAULIC PLUMBING INSTALLATION FROM AND INCLUDING SWIVEL FITTINGS TO THE SPOILER ACTUATORS. THE INSPECTION SHOULD BE DONE IMMEDIATELY AFTER A COMPLETE GROUND OPERATIONAL CHECK OF THE SPOILERS IN BOTH THE AILERON AND SPEED BRAKE MODES AND WITH FULL HYDRAULIC SYSTEM PRESSURE BEING APPLIED. ALSO, THE INSPECTION SHOULD BE DONE SO AS TO DETECT EVIDENCE OF EXCESSIVE TORQUE IN SWIVEL FITTINGS AND TUBING MISALIGNMENT OR STRAIN DURING SPOILER OPERATION. (2) A REPORT CONCERNING THE SPECIAL SPOILER INSPECTIONS BE PREPARED AND SENT VIA PRIORITY DISPATCH TO WE-100 WITH A COPY TO FS-300. TITLE THE REPORT "B-707 SPOILER HYDRAULICS INSPECTION (RIS: FS8340-07)." THE REPORT SHOULD INCLUDE AS A MINIMUM: (A) OPERATOR NAME, (B) NUMBER OF AIRCRAFT INSPECTED, (C) LISTING OF DISCREPANCIES INCLUDING BOEING PART NUMBERS AND IF POSSIBLE TIME IN SERVICE ON DISCREPANT PARTS, (D) RELATED INSPECTOR COMMENTS INCLUDING EXPLANATION OF OPERATOR'S ACTIONS - PAST OR PLANNED - TO IMPROVE SPOILER HYDRAULICS RELIABILITY.

THIS IS NOTICE N 8430.115. CANCELLATION DATE APRIL 8, 1970.
SUBJECT: BOEING 707 RUDDER SYSTEM. AIR CARRIER OPERATIONS ALERT
NO. 70-2.

AS A RESULT OF A RECENT ACCIDENT INVOLVING DIRECTIONAL CONTROL WITH
AN ENGINE OUT IN A LARGE FOUR-ENGINE JET TRANSPORT AN INVESTIGATION
AND CERTAIN TESTS WERE CONDUCTED ON THE POWERED RUDDER SYSTEM
CHARACTERISTICS OF BOEING 707 TYPE AIRCRAFT.

THE FOLLOWING IS A SUMMARY OF THE B-707 RUDDER CHARACTERISTICS UNDER
CERTAIN OPERATING CONDITIONS:

WHEN RUDDER PRESSURE IS LOST OR TURNED OFF USING THE AUXILIARY PUMP
SWITCHES WITH THE RUDDER DEFLECTED HYDRAULICALLY TO OFFSET ASYMMETRICAL
THRUST AND THE PEDAL FORCE OR POSITION IS NOT CHANGED, THE TAB LOCK
XXX LEVER WILL NOT RELEASE UNTIL SUCH TIME AS THE TRAPPED HYDRAULIC
PRESSURE HAS DISSIPATED TO A VERY LOW VALUE. THIS RESULTS IN A
GRADUALLY DECREASING RUDDER DEFLECTION TO POSITION CONSIDERABLY BELOW
THE RUDDER TRAVEL ATTAINABLE WHEN THE RUDDER TAB HAS REVERTED TO ITS
FUNCTION AS A CONTROL TAB. THE VMC FOR THE CONDITION INCREASES AND
DIRECTIONAL CONTROL CAPABILITY IS DETEIORATED.

EITHER OF THE FOLLOWING PILOT ACTIONS WILL IMMEDIATELY RELEASE THE TAB
LOCK LEVER WHICH MECHANICALLY LINKS THE CONTROL TAB TO THE RUDDER
PEDALS FOR MANUAL RUDDER OPERATION:

1. TURNING OFF THE RUDDER POWER SWITCH.
2. RETURN RUDDER PEDALS TO A NEUTRAL POSITION.

NOTE: CAUTION MUST BE USED IN TURNING OFF THE RUDDER POWER
SWITCH WITH THE RUDDER AT OR NEAR FULL DEFLECTION TO PREVENT A
RAPID CHANGE IN RUDDER POSITION WHICH MAY ADVERSELY AFFECT
AIRCRAFT CONTROL.

NOTE: THESE CHARACTERISTICS APPLY ONLY TO AIRCRAFT HAVING THE
SERIES YAW DAMPER.

PRINCIPAL INSPECTORS WILL ASSURE THAT INFORMATION ON POWERED
RUDDER SYSTEM CHARACTERISTICS IS INCLUDED IN THE AIR CARRIERS'
TRAINING PROGRAM (GROUND OR FLIGHT AS APPROPRIATE) AND THAT THESE
CHARACTERISTICS ARE CONSIDERED IN ESTABLISHING PROCEDURES INVOLVING
ASYMMETRICAL THRUST OR DIRECTIONAL CONTROL PROBLEMS IN A PARTICULAR
AIRCRAFT.

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

APPENDIX H

WASHINGTON, D.C. 20590



OFFICE OF
THE ADMINISTRATOR

30 DEC 1969

Honorable John H. Reed
Chairman, National Transportation Safety Board
Department of Transportation
Washington, D. C. 20591

Dear Mr. Chairman:

Thank you for your letter of 18 December 1969, concerning air carrier accidents involving simulated engine-out training.

Although the state-of-the-art of aircraft simulation provides, as you say, the capability for simulating almost all training maneuvers, an adequate visual system is required to simulate maneuvers such as engine failure on takeoff and the circling approach to landing. A very limited number of these simulators are in use today.

I believe you would agree that the regulatory history shows increasing training credit for aircraft simulators as the state-of-the-art has advanced. Beginning as early as July 1955, the Civil Aeronautics Administration initiated action which led to adoption of a regulation on 15 March 1957, which permitted the air carriers to substitute an approved simulator course for one of the required semi-annual pilot proficiency checks. This rule was subsequently amended so that only certain low altitude maneuvers need be accomplished in an airplane during the alternate proficiency check (e.g., ILS approach, engine failure on takeoff, circling approach), provided the balance of the required maneuvers were conducted in an approved aircraft simulator. More recently, regulations became effective on 15 April 1967, which for the first time allowed certain emergency maneuvers to be conducted in a simulator for the aircraft type rating check. On 1 May 1968, the rules were amended to change the in-flight requirements for turbojets relative to the approach and landing maneuver with the simulated failure of 50 percent of the available powerplants.

Simulating an engine failure during takeoff at altitude is not a satisfactory substitute for accomplishing the maneuver in an airplane during an actual takeoff or in a visual simulator since, when done at altitude, the realism of an actual engine failure during takeoff is lost. Recent amendments to Parts 61 and 121 of the Federal Aviation Regulations permit this maneuver to be conducted during type rating and proficiency checks,

in a simulator with an approved visual system which should encourage the air carriers to procure these systems. Since airplane performance is based on engine failure during takeoff, we must ensure that pilots can safely handle an engine-out situation during regular operations. The same rationale also applies to the engine-out missed approach. However, the recent amendments allow the person conducting the check the option of giving the pilot being checked either an all-engine missed approach or an engine-out missed approach, which has the advantage of introducing the element of surprise when the latter maneuver is given.

The amendments further provide for flight training and a flight check in an airplane simulator to the pilot in command or second in command level of proficiency, as appropriate, before the trainee advances to the actual airplane. Thus, the rule contemplates a thorough knowledge of each required maneuver and procedure and a predetermined level of skill prior to performing them in actual flight. Therefore, the performance of the maneuvers and procedures by the trainee on a one-time basis in the airplane during initial or transition flight training is, in practical effect, a determination that the proper transfer of learning from the simulator to the airplane has been achieved.

Although as you point out, one accident may have involved distraction of the pilot by an additional crewmember on the flight deck, there have been other cases during training flights where an additional crewmember has alerted the pilot to an unsafe condition. Flight training of crewmembers is usually accomplished in pairs so that each pilot may observe the other during their respective periods of flight instruction. Such training is highly desirable and advantageous to the pilots involved. Nevertheless, we will advise our Principal Operations Inspectors to see to it that their assigned air carriers have issued adequate instructions to ensure that other crewmembers on the flight deck do not interfere with the performance of the operating crewmembers during training flights.

Your interest in this matter is appreciated.

Sincerely,

D. D. Thomas

D. D. Thomas
Acting Administrator

INVESTIGATION AND HEARING1. Investigation

The Board received notification of the accident about 1315 e.d.t. An investigating team was alerted and dispatched to the scene via Government aircraft. Working groups were established for Operations/ATC, Witnesses/Weather, Powerplants, Systems, Structures, Human Factors, Maintenance Records, Flight Recorder, and Cockpit Voice Recorder. The recorders were recovered from the wreckage and transported to the Board's laboratory by 1830 e.d.t. on the day of the accident.

Interested parties to the investigation included: the Federal Aviation Administration, Trans World Airlines, Boeing Aircraft Company, Airline Pilots Association, Pratt and Whitney, and the International Association of Machinists.

The on-scene investigation was completed on July 31, 1969.

2. Hearing

There was no public hearing.

3. Preliminary Report

A preliminary report summarizing the facts disclosed by the investigation was released by the Board on September 26, 1969.