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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SYNOPSIS

Trans World Airlines, Inc., Flight 5787 (TWA 57875 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 tne Plight

The aircraft utilized on this flight was a being 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, German)., 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 alrcratt 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 NAFEC/Atlantic City Nrport, 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 acccmplished. TWA 5787 then requested, and the tower approved, clearance to taxi to the end of the runway, execute a 180° turn, and Cake 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 leveled 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 vere 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 5737 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 powr 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 war 124 knots.

flaps full down (50°); landing gear down and locked; engines 1, 2, and 3 at takeoff thrust; and engine No. 4 retnrded 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 of 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 Iollows, divided for tabulation purposes into three general areas; sounds heard before observation of the aircraft, pre-impact observations, and observations st 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 dascribed 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, OK 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 flightpath 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 OK 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," OK 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 ntraight 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.

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 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 dentroyed 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 cert, 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. Caines, 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 X-6, DC-7, and the Boeing 707/720 aircraft. On February 7, 1968, he was appioved 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. Caines, 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. 368[illegible]2, with ratings in the Douglas X-3 and DC-4, Lockheed Constellation, and Boeing 7071720.

He satisfactorily passed his last examination for an FAA first-class medical certificate on February 7, 1969, without vaivers. 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 Certiftcate 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 vas 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 Nrcraft 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 rime 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 vould 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 avitch was replsced. This work vas 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 JPK 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 leas 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 con- ridered to be a factor in this accident.

1.8 Aids to Navigation

TWA 5787 was using the Atlantic City ILS tor practice precision approaches. This facility is used for instrument approaches to the NAFEC, Atlantic City Airport, Pomona, New Jersey, and is aligned fox 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 Alrport 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 Plight Recorders

N787TW was equipped with a Lockheed 109CR flight data recorder. The recorder was recovered with superficial dents and smoke damage. The recording vas 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. Thit time period covers the flight of TWA 5787 from just inside the outer marker on the ILS approach through the missed-approach pro- redure 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, et 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 lost 20 seconds of the flight were as follows:

Time	Vertical Acceleration	Magnetic Heading	Indicated Airspeed	Altitude m.s.l.
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 Ieet

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

N787TW was also equipped with a cockpit voice recorder. This re- corder vas 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 N787TW vas 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 vere 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 tall cone section had separated from the empennage and was found near the main wreckage. (See Appendix C, Wreckage Distribution Chart.)

The vertical stabilizer vas intact from the tip to the fuselage attachment. The trailing edge of the rudder had burned away; hovever, the rudder control components in the vertical stabilizer vere undamaged. All hydraulic lines were complete and there was no evidence of hydraulic leaks found inside the vertical stabilizer. The rudder trim drum belov the vertical stabilizer indicated full left rudder; the rudder position transmitter was broken. The rudder shutoff valve waa 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 vere 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 he bottom of the sharp notch cut in the outside surface of the tube h he edge of the flarelcss coupling sleeve. Metallurgical examination of .. 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 aide of the main vreckage 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 vere examined aad 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 sxploded upon impact and was almost totally consumed by fire.

1.14 Survival Aspects

This accident was nonsurvivable.

1.15 Testa and Research

Subsequent to the accident, TWA conducted a series of tent flights in a Boeing i07-331C aircraft to determine the rate at which hydraulic pressure to the rudder would diminish vhen 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 vas 24°. A fixed rudder pedal position was maintained and lateral inputs vere 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 thtee 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 cse of rudder.

Conditions for tent 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 teat, 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 8° 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 rests 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" Vmca 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" ut the 177 knots airspeed. Subsequent to the shutof 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 vas no increase in the rudder pedal travel. Power had been reduced on the No. 1 engine in order tu 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 revernion had been achieved.

One further flight test was conducted. In this test, the aircraft was accelerated to 177 knots before the hydraulic pumps wore 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 malfuction was found. The internal leak rate wae determined to be 1,200 cubic centimeters per minute (cc./min.) with the ram extended. The normal lead 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 tne landing gear actuating handle. In the locked "dam" position, three green lights are illuminated. These lights may be dimmed to reduce glare during nighttime 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 being 707-331C was placed on jacks, end the landing gear cycled normally. With the landing gear in the locked down position and the three green dam 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 pear 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 preseure 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 lr-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 ruddef (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 folloving:

(1) Two auxiliary hydraulic system low-pressure warning lights.

(2) Two utility hydraulic system low-pressure varning 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 leveling 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 he turned off at airspeeds above 250 knots to provide structural protection.

In order not to have the low-pressure warning light associated with tha 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 vhat 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 /.8° for each 1° of rudder travel. Rudaer 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 vas 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 cab. The tab is moved in balance direction to position tho rudder aerodynamically through deflection angles to approximately 17°. In the mechanicnl 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 witch 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 Nrplane 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 sectionr are clearly identified as Aircraft. Flight Manual requirementa. This option was exercised by TWA and the required Airplane Flight Manual information vas contained in the TWA-published Boeing 707 Flight Handbook.

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

Section 121.315 of the FAR's further states that each certificate holder shall provide approved cockpit check procedures fur each type of nircrafe. 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 cheeked. 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 vhich operate a variety of aircraft and may haw a requirewnt 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 vere 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 vith the hydraulic system emergency procedures in the original FAA-approved Airplane Flight Manual for the being 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" checkliat.

The checklist in the TWA Flight Handbook used by the flight instructors contained tire same checklist as the TWA being 707 Flight Handbook carried in the aircraft. This checklist was not in accord with the procedure in the Boeing 701 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 witch was to be placed in the "OFF" position. Hydraulic fluid loss, per se, was not discussed.

(2) The N A "331C Other Emergencies Guide" provided that in the event any hydraulic fluid loss occurred, all pump. were to be turned off, (The fourth item on this check-list notes that "Vmca vithout rudder pover is 180 knots.")

The flight Instructor's manual elro contained the following:

(1) The instructor shall keep his deet 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 cpplication as my ha 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. <u>The Boeing 707 Airplane Flight Manual Hydraulic System Emergencies Procedures. and Changes Thereto</u>

The procedure8 relating to in-flight hydraulic system emergency operation initially In the being 707 PM-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 valva 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 requfred."

Subrcquently. 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 vith 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 rhe "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 LO 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 changed 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 outboard spoiler actuator hydraulic line. Failure of this line would not have caured 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 ir likely, however. that the I.P. either misspoke or vas referring to only those systems :hat 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 axuiliary 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 quantitien in the pump housings. demonstrating the presence of hydraulic fluid when the pumps vere expooed 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 Leading 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 lease one of the auxiliary hydraulic system was operating satisfactorily.

For normal flight purposes, failure of the utility system would not have seriously affected lateral control capability sicce the inboard spoilers are operated by the No. 1 auxiliary system. Pull 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.

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 vas self-made by the IP. in the simulated failure of the No. 4 eogine. The second was the actual fatigue failure of the hydraulic line and the genuine loss of the utility system hydraulic fluid. However. System failures. vhich 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, vas contained in the TWA Flight Handbook information, the Plight Instructor's Hanual, and noted in the FAA-approved emergency checklist, by the identification of the 180 knots Vmca in the absence of hydraulic pover 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 crev 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 vhich 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 being 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 levelr vith rudder and spoiler boost inoperable, and climb capability calculations were not made for this condition. However, since the first 20 neconds of the climb (after the "missed approach" was called) vas made before the auxiliary pumps were turned off, the 2.6-percent gradient calculation provides a reasonable basis for comparison of predicted climb capability vith 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 ftct 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 fur 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 :here any indication of an abrupt pullup on the vertical acceleration trace.

According to an engineering analysis performed by the being 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 s 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 examlnation 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 rtall speed until impact, and there was no evidance 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 consiscent 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 vas 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 paver 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. vith 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 basts 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, vas 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 landicg 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 responsibiiities of monitoring the pilot's instruments and calling out any significant deviations from programmed airspeed, descent rate, or altitude. This proceaure was followed by TWA. Thus. at the time of failure of the spoiler actuator hydraulic line, and the subsequent rapid loss of hydraulic fluid, the flight engineer's attention probably vas directed away from the engineer's panel.

There were several indications of utility hydraulic system failure available to the I.P. vhich could have alerted him to the problem. First, there vera 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 vas 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 vhen the selector vas placed in the "up" position. Why these indications were not observed is not known. Among possible explanations is that while Captain Caines was making a simulated instrument approach vith the training hood in place, he would have been unable to see outside the cockpit. Thus. it vould be necessary for the I.P. to direct his attention outside the cockpit in order to prevent conflict vith other aircraft operating on and in the vicinity of the airport. If the hydraulic line failed Just prior to tha command for the missed-approach. Captain Sklarin might vcll have been occupied vith observing outside events. and vould not have looked at the instrument panel until his attention was directed to the hydraulic system problem by the obaerver-pilot's comment, "Oh: Oh: Your hydraulic system's zeroed."

Because of the daylight conditions. the various varning lights might not have been intense enough to attract attention that was directed elsevhere. This vould be particularly true of the landing gear position lights if the switch had been placed in the "dim" position. Also, the low-pressure varning lights are concealed to some degree behind the control wheel, which might result la the lights not being observed until a pilot in the right seat shifted hls body position. By the time Captain Sklarin was aware of the fluid loss. the aircraft was climbing and vas 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 vas 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 conridered in tvo ways. First, in keeping with a basic tenet of flight instruction, the pseudo-enginr failure emergency should have been removed as the first action vhen the real emergency situation became knovn. Had the No. 4 engine been restored to takeoff power, tne asymmetrical thrust situation vould have ceased to exist and the rudder vould 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 hrve 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 dircussion 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 disasterous situation was set when the I.P. complied vith 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 being 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 systea 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 prevfously 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 vas reducnd 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 vas 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 nosedown 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 vas 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 cpproach.

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 waa 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 hydreulic 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 vith the National Transportation Safety Board, issued General Notice 138430.107 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 vas called specifically to the requirement to restore engine pover prior to trouble-shooting the hydraulic system in simulated engine failure situation. (See Appendix G.)

(2) Upon confirmation by the Safety Board that a metal fatigue failure vas found in one of the outboard spoiler actuator down-lines, the FAA issued General Notice N8340.57 to the above-listed offices. This notice suggested a voluntary. one-time inspection of the spoiler actuating system on B-707 aircraft. This inspection vas 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 pover 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 vas 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 ruggested 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 cbaractcristics be included in air carrier training programs. and that these characteristics be considered in establishing operacing procedures related to asymmetrical thrust or directional control problems in particulat aircraft. (See Appendix G.)

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

1. All maneuvers requiring simulated engine(s)-out operation of aircraft close to the ground should be conducted in end, 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

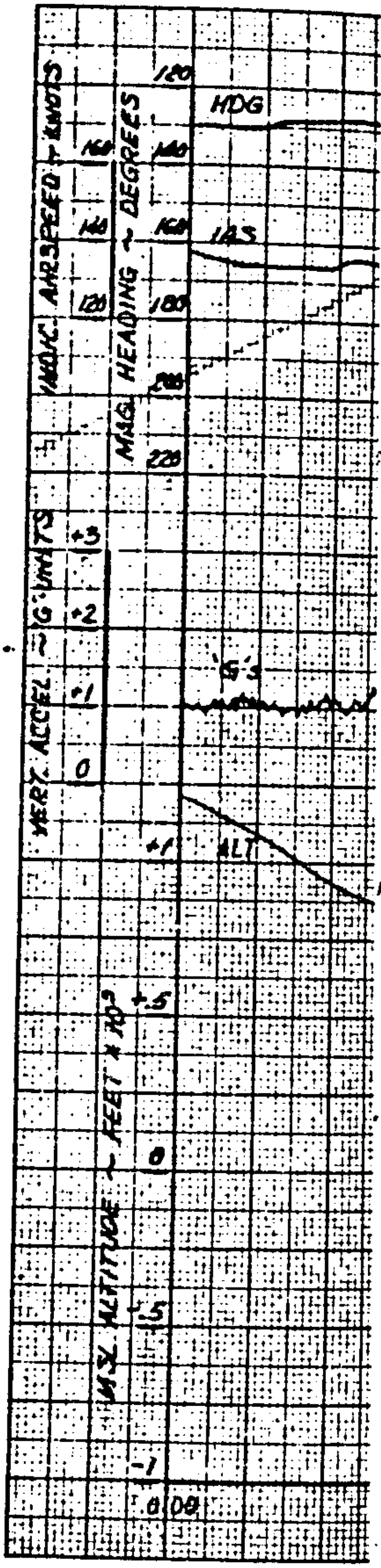
/s/ OSCAR M. LAUREL
Member

/s/ FRANCIS H. McADAMS
Member

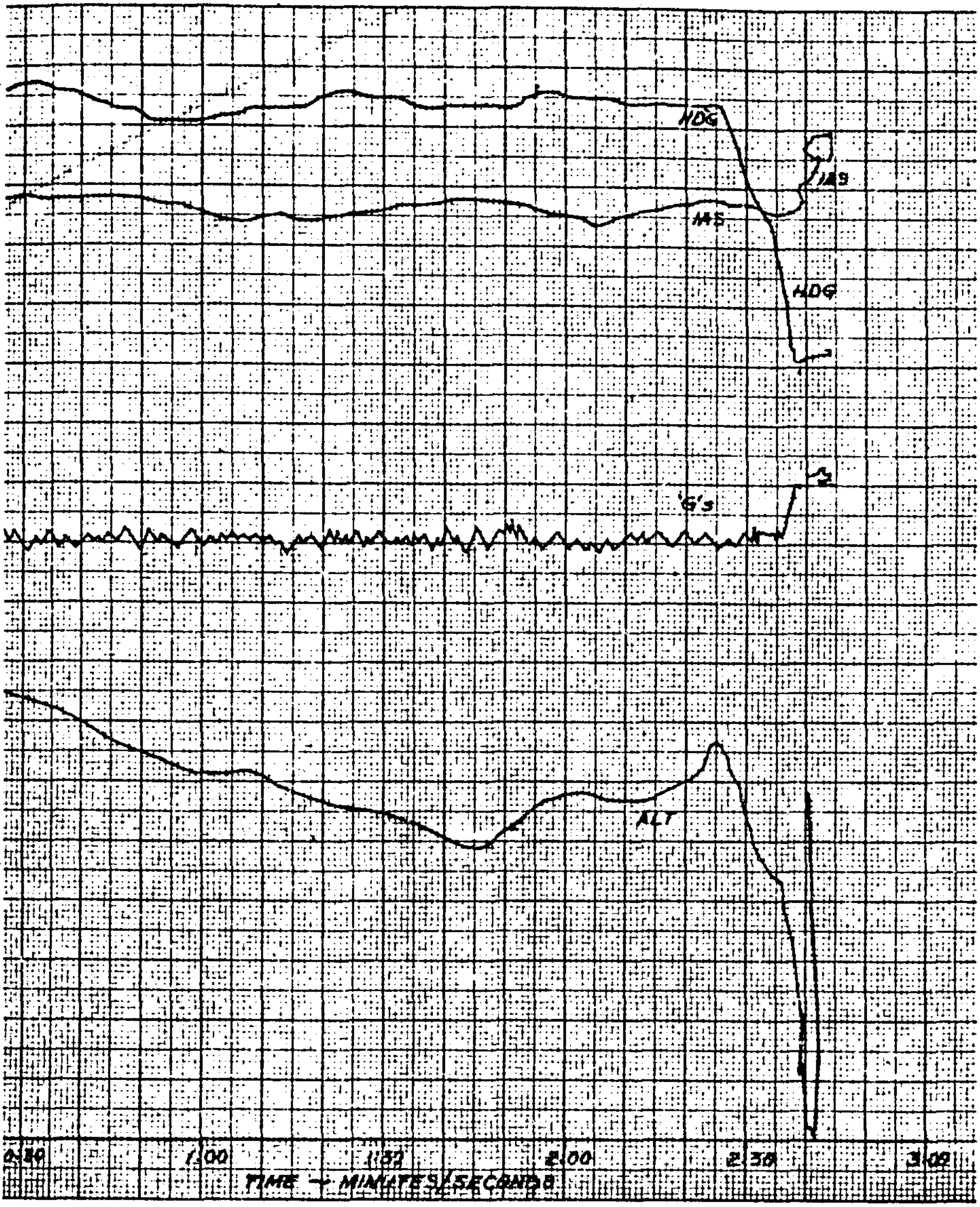
/s/ LOUIS M. THAYER
Member

/s/ ISABEL A. BURGESS
Member

'March 25, 1970.


IND.IC. AIRSPEED ~ KNOTS
MAG. HEADING ~ DEGREES
VERT. ACCEL ~ 'G' UNITS
MSL ALTITUDE ~ FEET × 10³
HDG
IAS
'G's
ALT
120
140
160
180
200
220
+3
+2
+1
0
-1
+.5
-.5
0:00

A


HDG
IAS
IAS
HDG
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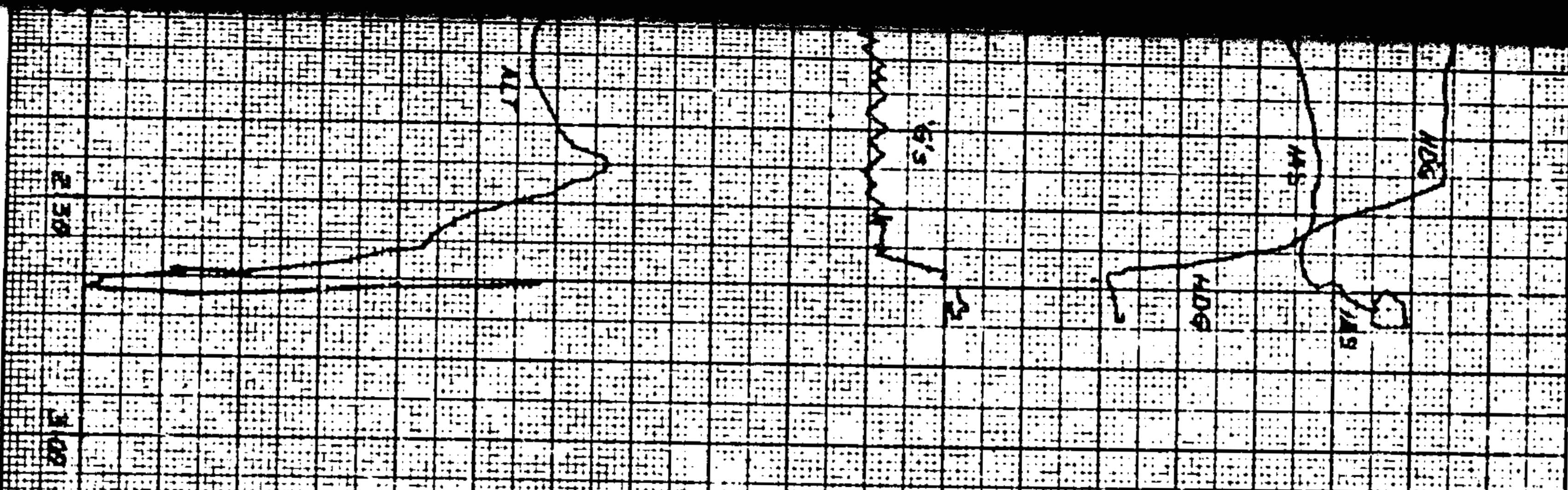
TIME → MINUTES/SECONDS

B



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

TRANS WORLD AIRLINES, BOEING MODEL B-707, N787TW
TRAINING FLIGHT, ATLANTIC CITY, N.J.
JULY 26, 1969

SIMULATED MISSED APPROACH ACCIDENT

FLIGHT DATA RECORDER GRAPH
LAS MODEL 109-CR, S/N 1453

DCA 70-A-2 RPT. NO. 70-5 JULY 29, 1969

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-?	%%%

TIME(EDT)	SOURCE	CONTENT
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 pover
1232:09	CAM-1	Okay
1232:10	CAM-2	Up gear
	CAM	Sounds similar to trim actuacion 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) vent down
	CAM-1	They're all (out)
	CAM-2	All of em out?
	CAM-1	Yeah
1232:20	CAM-2	pumps Off
	CAM-7	*
1232:21	TWR	Trans World, you gonna work Approach Control?
1232:24	RDO-1	Ah, stand by, we're having a hydraulic problem here.

TIME(EDT)	SOURCE	CONTENT
1232:27	CAM-?	(all out?)
	CAM-3	Just went down
	CAM-?	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 d m again
	CAM-2	Yeah
1232:41	CAM-1	You got that?
1232:42	CAM	Sound of "pap" similar to that caused by engine compressor stall.
1232:43	CAM-1	What happened?
1232:43.5	CAM-?	(What tha 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(EDT)	SOURCE	CONTENT
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

<u>ACCIDENT</u>: TWA 5787, B707-331, ATLANTIC CITY AIRPORT, JULY 26. 1969. CHRONOLOGICAL SUMMARY OF SELECTED VOICE COMMUNICATIONS RECORDED ON THE CVR TAPE 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	CONTENT
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) SOURCE

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.

Flight maintaining 1,900 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 renched final checklist.

CAM-? :OK that's complete.

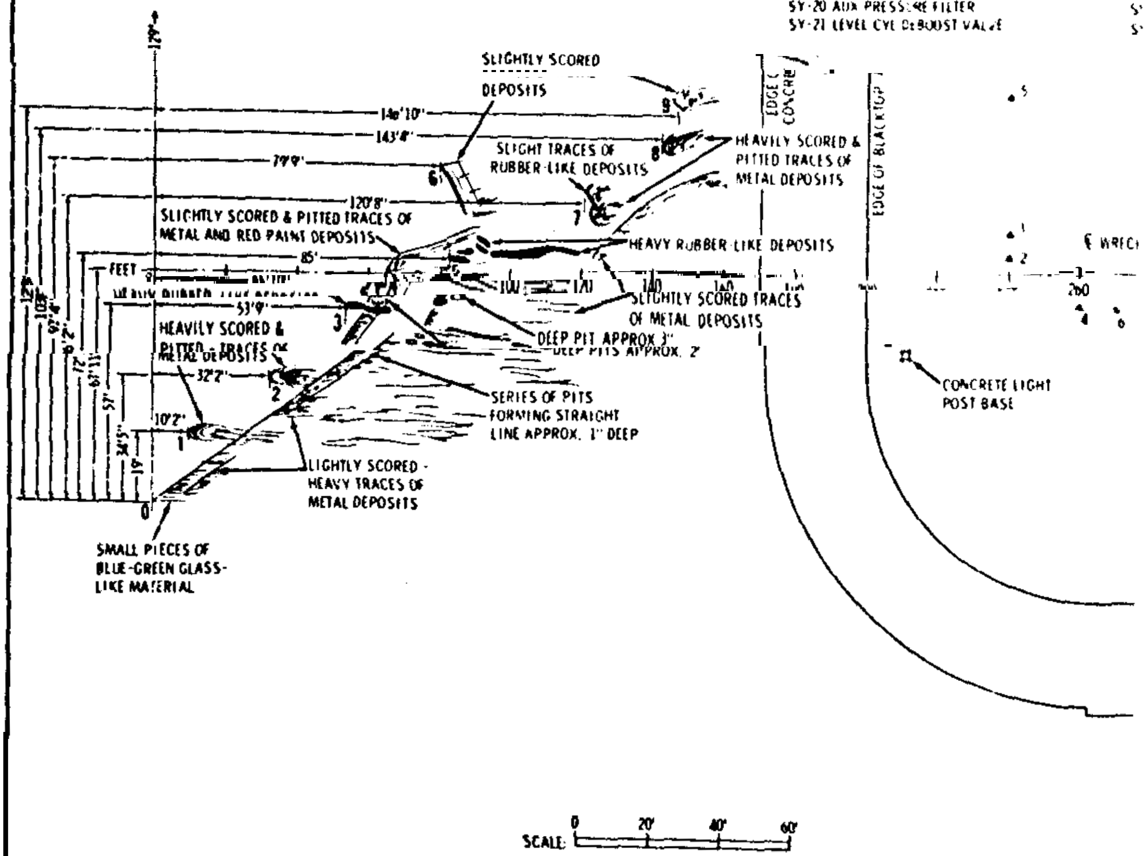
CAM-2 :ah - roger.

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

TIME(EDT)	SOURCE	CONTENT
1225:22	CAM-?	:and - ah - would you put your bird down please and cn heading mode and we're all set up this and - ah - the markers are tuned.
	W-?	: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 discussing plan for VOR approach next and VDR 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.

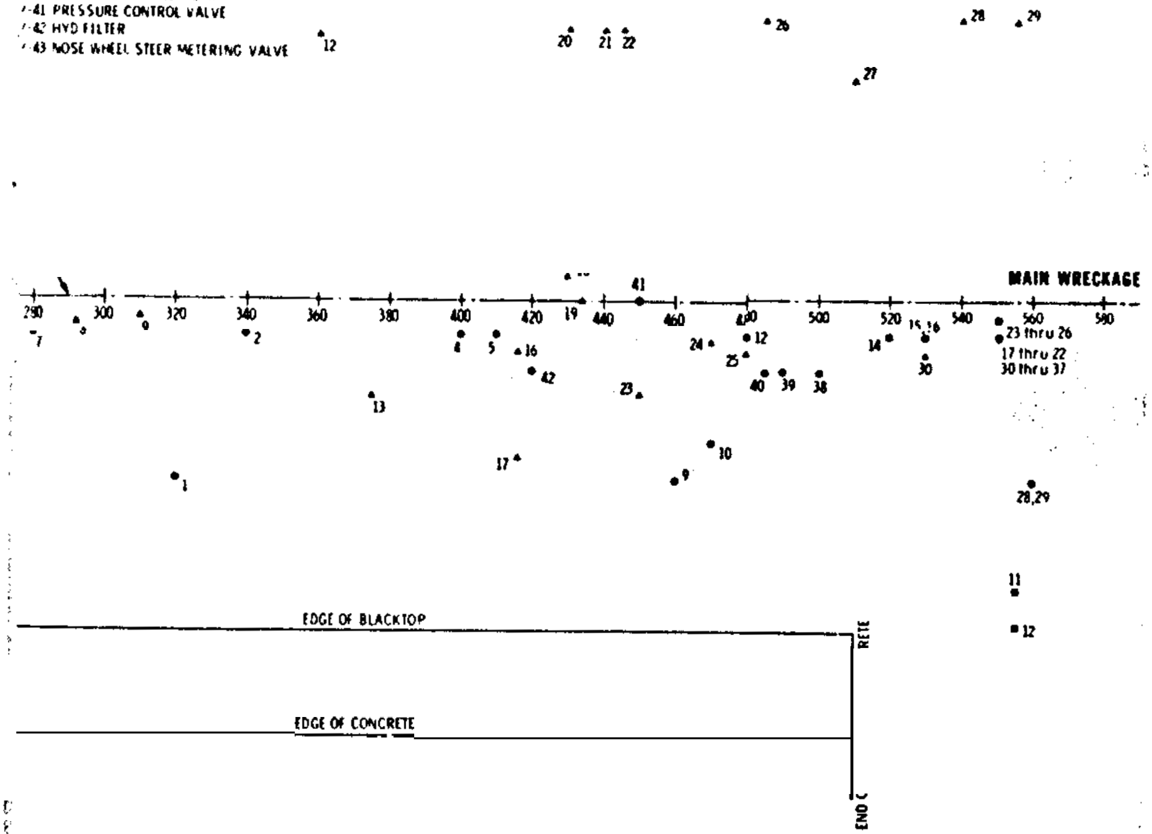
LEGEND

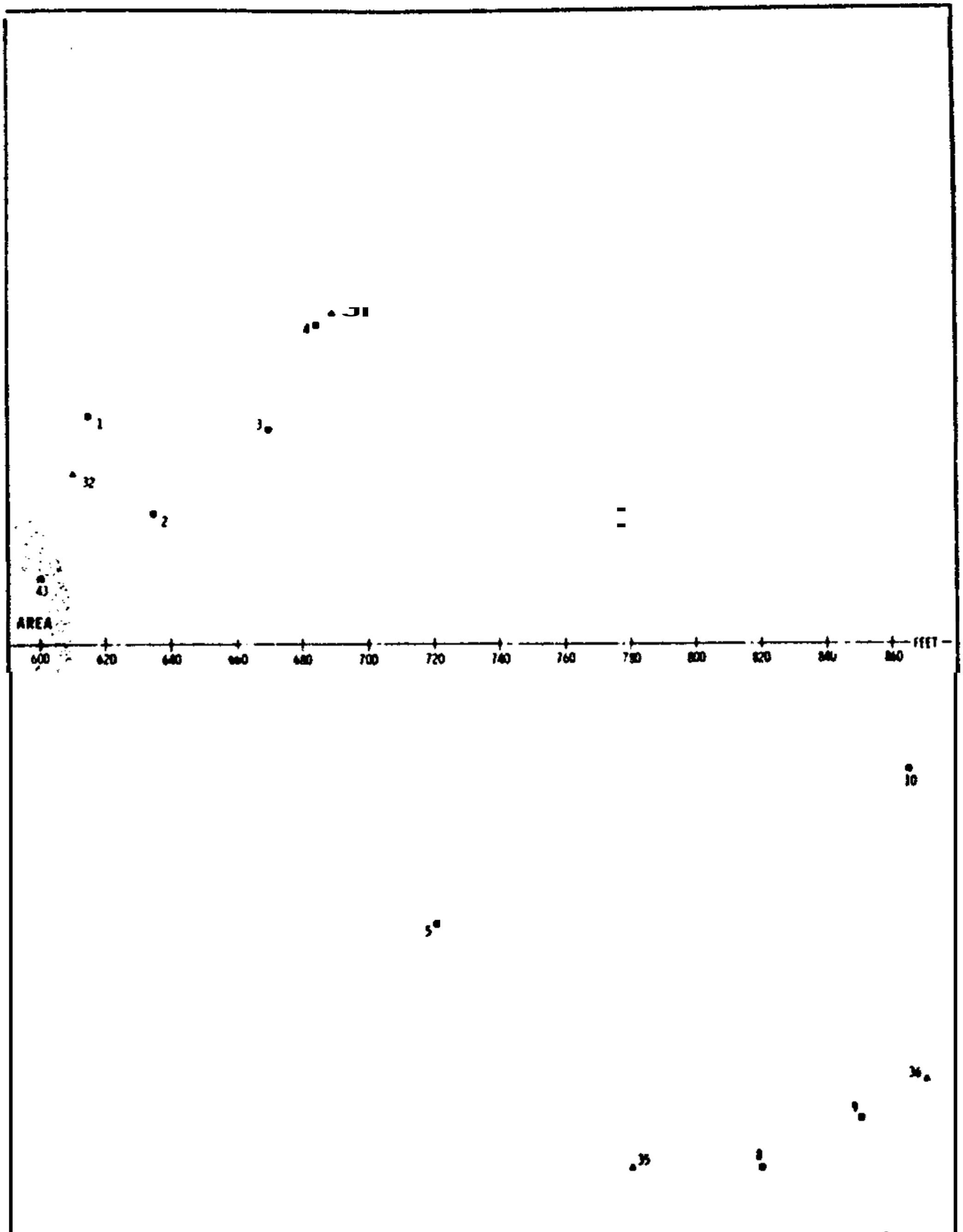
- ST-1 MAIN GEAR SHORT DOOR - P/N 65-6159-4
- ST-2 SECTION OF LEFT FUSELAGE
- ST-3 MAIN GEAR STEP DOOR
- ST-4 ENGINE REVERSER SECTION
- ST-5 TUBULAR SECTION
- ST-6 SECTION OF WING SURFACE
- ST-7 SECTION OF MAIN GEAR SIDE DOOR P/N 65-5796-2
- ST-8 FREON TANK
- ST-9 FILLET FLAP FENCE (RT. SIDE)
- ST-10 FLAP JACK SCREW
- ST-11 HF ANTENNA
- ST-12 SECTION OF LEFT INBD FLAP
- ST-13 SECTION OF FUSELAGE
- ST-14 MAIN GEAR TIRE
- ST-15 SECTION OF FUSELAGE (RT. SIDE)
- ST-16 SECTION OF KEEL BEAM
- ST-17 SECTION OF LEFT WING (LWR SURFACE)
- ST-18 SECTION OF KEEL BEAM P/N 65-3726-2
- ST-19 MAIN GEAR DOOR P/N 5863083146
- ST-20 SECTION OF EMPENNAGE
- ST-21 HORIZONTAL STAB JACKSCREW ATTACH POINT
- ST-22 TWO COMPLETE SECTIONS OF FORE FLAPS
- ST-23 SECTION OF RIGHT WING
- ST-24 RIGHT MAIN GEAR SERIAL #RS-1
- ST-25 SECTION OF FUSELAGE
- ST-26 AFT PASSENGER DOOR P/N 65-7998-1
- ST-27 SECTION OF WING FLAP
- ST-28 ENGINE REVERSER
- ST-29 SECTION OF WING LEADING EDGE
- ST-30 SECTION OF FUSELAGE (LEFT SIDE)
- ST-31 MAIN WALKAGE AREA
- ST-32 NOSE GEAR ASSEMBLY
- ST-33 FLAP JACKSCREW
- ST-34 SECTION OF LEFT WING
- ST-35 SECTION OF RIGHT WING (UPPER SURFACE)
- ST-36 MAIN GEAR TIRE
- SY-1 LEADING EDGE FLAP ACTUATOR
- SY-2 BRAKE DE BOOST VALVE
- SY-3 LOWER STAB TRIM JACKSCREW
- SY-4 HYD UTILITY SYSTEM S.O VALVE (OFF)
- SY-5 BRAKE DE BOOST VALVE (TRAC.
- SY-5 BRAKE DE BOOST VALVE (TRACK CENTER CYL)
- SY-6 STAB TRIM SERVO
- SY-7 ELECT MECH ACTUATOR (P/N 10-60165-3)
- SY-8 UPPER STAB TRIM JACKSCREW
- SY-9 LEADING EDGE FLAP ACTUATOR
- SY-10 THREE LEADING EDGE FLAP ACTUATORS
- SY-11 STAB TRIM ACTUATOR
- SY-12 PRESSURE FILTER
- SY-13 STAB CABLE DRUM
- SY-14 BRAKE ACCUMULATOR
- SY-15 THREE LEADING EDGE FLAP ACTUATORS
- SY-16 UTILITY HYD PUMP
- SY-17 UTILITY RESERVOIR
- SY-18 UTILITY SHUT OFF VALVE (OFF)
- SY-19 AUX HYD PUMP
- SY-20 AUX PRESSURE FILTER
- SY-21 LEVEL CYL DEBOOST VALVE



-22 FOUR BRAKE DEBOOST VALVES
-23 SYSTEM INTERCONNECT VALVE (OFF)
-24 BRAKE INTERCONNECT VALVE (OFF)
-25 INBD SPOILER VALVE
-26 AUX HYD PUMP
-27 LEADING EDGE FLAP ACTUATOR
-28 LEADING EDGE FLAP ACTUATOR
-29 #3 UTILITY HYD PUMP FLANGE
-30 INBD FLAP VALVE
-31 OUTBD FLAP VALVE
-32 LH WING OUTBD SPOILER VALVE
-33 LH WING INBD SPOILER VALVE
-34 RH WING OUTBD SPOILER VALVE
-35 RH WING INBD SPOILER VALVE
-36 LANDING GEAR SELECTOR VALVE
-37 FIVE UNIDENTIFIED HYD VALVES
-38 CARGO DOOR PUMP
-39 CARGO DOOR RESERVOIR
-40 CARGO DOOR HAND PUMP
-41 PRESSURE CONTROL VALVE
-42 HYD FILTER
-43 NOSE WHEEL STEER METERING VALVE

PP-1 #1 INLET COWL
PP-2 ENGINE STARTER
PP-3 #1 ENGINE FUEL PUMP AND FAN SECTION
PP-4 #2 ENGINE NOSE COWL
PP-5 #4 ENGINE COWL
PP-6 FUEL CONTROL S/N 54965
PP-7 #1 ENGINE
PP-8 #4 ENGINE
PP-9 #4 ENGINE CABIN COMPRESSOR
PP-10 #2 ENGINE
PP-11 #3 NOSE COWL
PP-12 #3 ENGINE



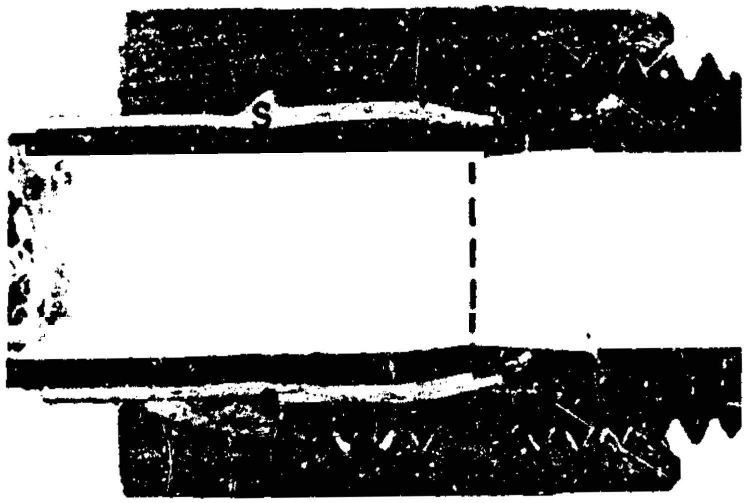


APPENDIX C

NATIONAL TRANSPORTATION SAFETY BOARD
DEPARTMENT OF TRANSPORTATION
Washington, D.C.

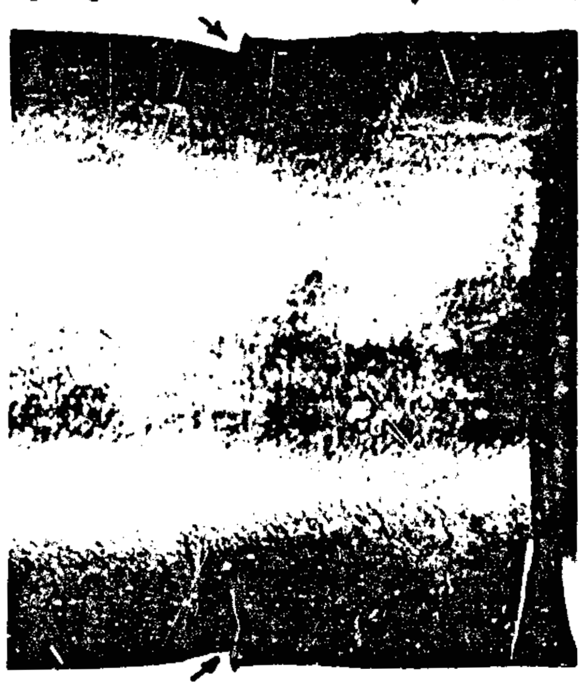
WRECKAGE DISTRIBUTION CHART
TRANS WORLD AIRLINES, INC. B707-331C, N-787T
NAFEC, POMONA, N.J.
JULY 26, 1969

C

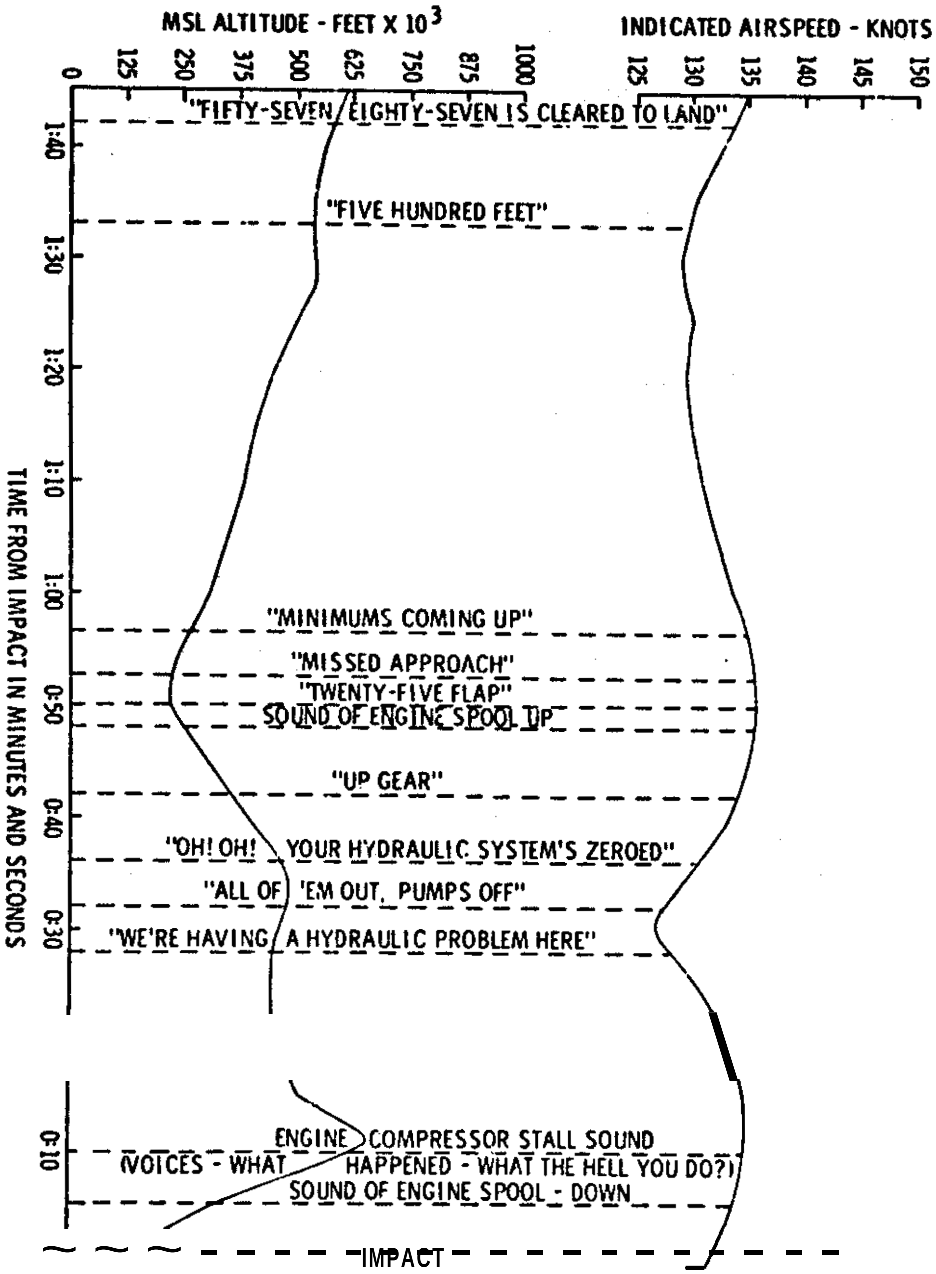


Longitudinal section through an assembled flareless coupling, illustrating the location of the fracture (dashed line) indicated by arrow "a", Fig. 1. X 4

J. Swivel joint fitting S. Coupling sleeve
N. 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



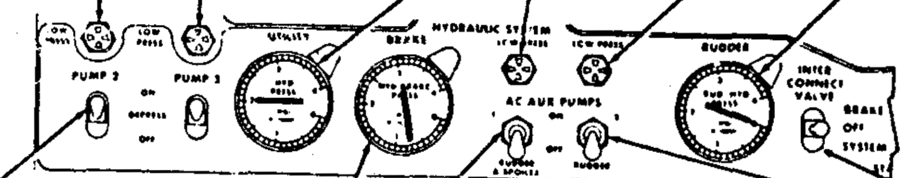
NATIONAL TRANSPORTATION SAFETY BOARD BUREAU OF AVIATION SAFETY WASHINGTON D.C.
TRANS WORLD AIRLINES, BOEING MODEL B-707 , N7877W TRAINING FLIGHT, ATLANTIC CITY, N.J. JULY 26.1969

EXTRACTS OF COCKPIT VOICE RECORDER
AND FLIGHT DATA RECORDER INFORMATION

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.

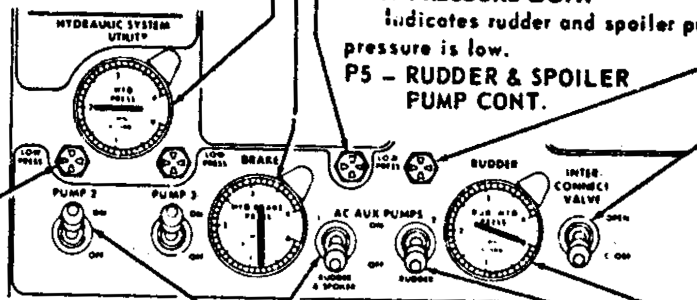
RUDDER LOW PRESSURE LIGHT
Indicates hydraulic pressure to Power Rudder is low. (Approx. 1200 PSI on part time yaw damper 2500 PSI on full time yaw damper). Operative only when airspeed is below 250 KTS or wing flaps extended.
P5 - OIL QUAN & RUDDER SEL.

BRAKE PRESSURE GAUGE
Indicates brake pressure available above 750 PSI pre-load.
P7 – HYD PRESS.

UTILITY SYSTEM PRESSURE GAUGE
Indicates utility hydraulic pressure available above 2000 PSI preload.
P7 – HYD PRESS.

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.

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 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.

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 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.
P3 - RUDDER PUMP

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 KT. 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-OT)." 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 DETERIORATED.

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 a n 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 advancad. Beginning as early as July 1955, the Civil Aeronautics Administration initiated Action vhich led to adoption of a regulation on 15 March 1957, which permitted the air carriers to substitute an approved simulator course fur one of the required semi-annual pilot proficiency checks. This rule was subsequently amended so that only curtain low altitude maneuvers need be accomplished in an airplane during the alternote proficiency chuck (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 • 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, w met ensure that pilots can safely handle an exine-out situation during regular operations. The same rationale also applies to the engine-out missed approach. However, the recent amendments allow the person conducting tha check the option of giving the pilot being checked either an all-engine missed approach or en angina-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 haw 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. Plight 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, w 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