CIVIL AERONAUTICS BOARD

ACCIDENT INVESTIGATION REPORT

Adopted: September 11, 1956 Released: September 14, 1956

TRANS WORLD AIRLINES, INC., MARTIN 404, N 40403, NEAR GREATER PITTSBURGH AIRPORT, PITTSBURGH, PENNSYLVANIA, APRIL 1, 1956

The Accident

Trans World Airlines' Flight 400 of April 1, 1956, a Martin 404, N 40403, crashed and burned immediately following takeoff from the Greater Pittsburgh Airport on April 1, 1956, about 1920.1/ The hostess and 21 of the 33 passengers were killed; both pilots survived. The aircraft was destroyed by impact and fire.

History of the Flight

Flight 400 was regularly scheduled between Pittsburgh, Pennsylvania, and Newark, New Jersey, with stops at Harrisburg, Reading, and Allentown, Pennsylvania. Captain Raymond F. McQuade, First Officer Harlan V. Jesperson, and Hostess Mary Jane Fanning, comprised the crew.

Prior to departure the pilots were briefed on the en route weather and received the sequence and forecast reports. Although the en route weather was generally good the flight was dispatched to Newark on an IFR flight plan via airways as is customary.

Upon departure the gross weight of the aircraft was 41,822 pounds (the certificated allowable takeoff gross is 44,900 pounds and TWA's own limit is 43,650 pounds) and the center of gravity of the loaded aircraft was located within the prescribed limits. Scheduled departure time was 1915; the flight asked for and received taxi clearance at 1916, was then given the wind as calm, and was cleared to runway 23.

Takeoff clearance was requested and granted at 1919. About one minute later tower personnel observed a seemingly normal takeoff and initial climb immediately followed by a left turning descent, crash, and erupting fire just beyond the southwest boundary of the airport.

Passengers extricated themselves from the jumbled wreckage through and ahead of the fire as best they could; some helped others while a few found themselves thrown out through tears and rents in the shattered fuselage. Although airport based fire fighting equipment was dispatched with no loss of time some 20 minutes elapsed before it reached the site because of the necessity of traversing circuitous country lanes. Once there, the conflagration, which by that time had nearly consumed the wreckage, was quickly smothered.

1/ All times herein are eastern standard and based on the 24-hour clock.

Investigation

The subject aircraft had arrived at Pittsburgh from Newark as TWA Flight 403 approximately one hour and 15 minutes before starting back to Newark as Flight 400. The crew was the same on both flights and during both First Officer Jesperson was in the left seat being line-checked for captaincy by Captain McQuade, a company-qualified line check captain. Flight 403 was completely routine and no entries (squawks) were made in the ship's log.

While on the ground at Pittsburgh, the aircraft received the usual cleaning and servicing and the terminal check, with fuel being added until each main tank held 310 gallons, or a total of 620 gallons.

Runway 23, the one used, is 5,766 feet long and at an elevation of 1,151 m. s. l. on the northeast end and 1,126 feet on the southwest end (down gradient in direction of takeoff). Runway lights are of the cone type and were set at No. 3 position (medium intensity) at the time of takeoff. The runway was dry at that time.

Before takeoff the customary pretakeoff check was made, including a check of the functioning of manual propeller feathering and turning on the autofeathering switch. Engines were run up normally and takeoff from runway 23 followed. First Officer Jesperson, on the left, made the takeoff. Both pilots testified that the takeoff was normal in all respects without skip or bounce.

After becoming airborne, a sharp yaw to the left was experienced at the time of the first power reduction by the first officer. Almost simultaneously he saw the left engine No. 1 zone fire warning light flash on and off and then stay on. He did not hear a fire warning bell. Captain McQuade, on the right, was performing the duties of the first officer. Captain McQuade stated that at the time he had operated the gear up handle and was toggling the r. p. m. to the proper engine speed following the first power reduction. The captain, at the time of feeling the aircraft yaw left, did not see the zone 1 fire warning light nor hear an alarm. However, he did observe a rapid drop in the left BMEP gauge, which went to zero, and reached under the right arm of the first officer, then on the throttles, to retard the left engine mixture control to idle cutoff which action is item No. 2 on the emergency checklist under the heading "Power Plant Fire-Failure." The first officer stated that he then removed his right hand from the throttles and reached for the manual feathering button, whereupon the captain informed him that the automatic feathering device would cause the propeller to feather. Jesperson then, without actuating the feathering button, placed his right hand on the control column and reached forward with his left hand for the zone 2 firewall shutoff lever. The aircraft continued to yaw to the left and stayed sharply banked to the left despite attempted strong corrective control. At about that time the left wing struck the ground and the crash resulted. The maximum altitude reached from takeoff to impact was variously estimated as in the neighborhood of 100 feet; the total elapsed time was about 40 seconds, of which about 25 seconds were used in the takeoff roll. The time interval from the start of the difficulty to the crash was only approximately 10 seconds.

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

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

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

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

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

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

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

The crash site was about 1,260 feet beyond the runway and about 1,140 feet to the left of its extended centerline, i. e., about 1,690 feet from the end of the runway at an angle of about 42 degrees to the left. The ground at that point is generally rolling and the aircraft struck on the far or upsloping side of a slight hollow.

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

Examination of the airframe disclosed no indication of a mechanical failure prior to impact with the ground. The aileron boost control mechanism was bench checked and was found normal other than from impact and fire damage. The flaps were determined to have been at the takeoff position of approximately 12-1/2 degrees at time of impact. All three landing gears were found down despite the fact that the captain stated they were started up at the proper time after breaking ground. The right propeller blades were found in takeoff pitch position. The left propeller blades were found against the low pitch stops which would cause maximum drag (while windmilling).

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

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

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

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

These clamps are partially hidden by exhaust stack covers which remain in place when the accessory cowling is removed, with the result that the clamps are not open to thorough examination except at their scheduled 100-hour inspections when the stack covers as well as the accessory cowling are removed. The type or design of the welded bolt securing boss area is conducive to stress concentrations as evidenced by the laboratory analysis of this particular clamp. This was the only clamp broken even though the exhaust collector ring on the other engine was much more damaged by impact.

The official U. S. Weather Bureau records indicate that the last observation before the accident, at 1900, included an east wind of 8 knots. The official Weather Bureau special observation taken immediately after the accident, at 1923, included an east wind of 7 knots, both observations giving 5 miles of visibility with scattered clouds at 7,000 feet and 20,000 feet. The "calm" given the flight just before takeoff by the control tower was from the tower's own wind recording instrument and carried with it the arbitrary meaning that the wind was 6 knots or less. This slight difference had no bearing on the accident nor did other weather conditions.

Analysis

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

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

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

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

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

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

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

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

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

Findings

On the basis of all available evidence the Board finds that:

1. The crew, the aircraft, and the operator were currently certificated.

2. Dispatching was routine.

3. Engine runup and the takeoff roll were normal.

4. At the time of the first power reduction the first officer saw the left engine zone 1 fire warning light come on and retarded the left throttle to a point where autofeathering was deactivated.

5. The first officer then reached for the left manual feathering button but was dissuaded from using it by the captain, who, not knowing that the autofeathering was inoperative, attempted futilely to obtain it by pulling back the left mixture to idle cutoff.

6. This action did not comply with the emergency procedures prescribed by the carrier for powerplant fire or failure.

7. Although these were not the most desirable procedures, compliance without delay would have feathered the left propeller.

8. The windmilling left propeller, the extended landing gear, and the takeoff flaps produced sufficient drag to make the airplane lose altitude and strike the ground.

9. The cause of the fire warning was a failed exhaust connector clamp in the left engine which triggered an adjacent fire detecting unit.

10. After the accident the carrier revised its emergency procedures for powerplant fire or failure.

Probable Cause

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

BY THE CIVIL AERONAUTICS BOARD:

/s/ JAMES R. DURFEE
/s/ HARMAR D. DENNY
/s/ G. JOSEPH MINETTI

Adams, Vice Chairman, and Gurney, Member, did not participate in the adoption of this report.

SUPPLEMENTAL DATA

Investigation and Hearing

The Civil Aeronautics Board received notification of the accident at 1945, April 1, 1956. An investigation was immediately initiated in accordance with the provisions of Section 702 (a) (2) of the Civil Aeronautics Act of 1938, as amended. As part of the investigation a public hearing was held at Pittsburgh, Pennsylvania, on May 7 and 8, 1956, and depositions of the pilots were taken at Newark, New Jersey, on June 12, 1956.

Air Carrier

Trans World Airlines, Inc., a Delaware corporation, is a scheduled air carrier with its principal offices at Kansas City, Missouri. It possesses a currently effective certificate of public convenience and necessity issued by the Civil Aeronautics Board and an air carrier operating certificate issued by the Civil Aeronautics Administration. These certificates authorize the carrier to transport by air persons, property, and mail over various routes, including that between Pittsburgh, Pennsylvania, and Newark, New Jersey.

Flight Personnel

Captain Raymond F. McQuade, age 33, had been employed by TWA since 1944. He had satisfactorily completed a company course of training for first officer and was promoted to that position in 1945, and promoted to captain September 1949. He completed Martin equipment qualification as captain on October 6, 1953. Captain McQuade was appointed line check pilot in February 1956, after satisfactorily completing the requisite company course. He held a valid airman certificate with airline transport pilot and all other pertinent ratings and had flown a total of 12,000 hours of which 2,200 hours had been in Martins. Since becoming a line check pilot he had flown a total of 105 hours, of which 46 hours had been spent performing the duties of a line check pilot. His rest period prior to the flight had been in compliance with CAA requirements.

First Officer Harlan V. Jesperson, age 41, was first employed by TWA in 1944 as a pilot-navigator. He completed the requisite training and became a first officer February 20, 1946. He checked out as first officer on Martins December 13, 1955. He was assigned to the company's training department for upgrading to captain in February 1956. At the time of this accident Mr. Jesperson was being line-checked for captaincy. He held a valid airman certificate with airline transport pilot and all other pertinent ratings. His total flying time was 7,145 hours, of which 204 had been in Martins, and his rest period prior to the flight had been in compliance with CAA requirements.

Hostess Mary Jane Fanning, age 21, was first employed by TWA as a student hostess January 3, 1956. She had satisfactorily completed the requisite company training courses on emergency procedures.

The Aircraft

N 40403, a Martin 404, was manufactured in November 1951. It had a total time of 9,177 hours, of which 836 had been since overhaul. Times since overhauls of both engines and both propellers were within the CAA's time limits. A study of its log sheets for the preceding 30 days and the last eight line maintenance records disclosed no pertinent discrepancies.