File No. 1-0063

CIVIL AERONAUTICS BOARD

SUPPLEMENTAL

AIRCRAFT ACCIDENT REPORT 1/

ADOPTED: June 9, 1960 **RELEASED:** June 15, 1960

TRANS WORLD AIRLINES, INC., SANDIA MOUNTAIN, NEAR ALBUQUERQUE, NEW MEXICO, FEBRUARY 19, 1955

The Accident

Trans World Airlines Flight 260, a Martin 404, N 40416, struck Sandia Mountain, near Albuquerque, New Mexico, February 19, 1955, about 0713.2/ All 16 occupants were killed and the aircraft was destroyed.

Chronology of Investigation

An investigation was initiated by the Civil Aeronautics Board immediately after the accident. This included examination of the wreckage at the crash site which was discontinued because of deep snow and dangerous footing in the mountainous terrain. On May 3, 1955, a second trip was made to the scene of the accident and study of the wreckage was continued. On October 12, 1955, the Board's Accident Investigation Report was released. The probable cause was determined to have been lack of conformity with prescribed en route procedures and a deviation from airways at an altitude too low to clear obstructions ahead.

Because of controversy over certain elements of the report of October 12, 1955, additional study was given to the facts and circumstances of the accident and an amended report thereon was issued by the Board on August 26, 1957. The probable cause of the accident in this report was identical to that of the first report although the analysis portion was altered to revise the statement that the direct course was intentional. On October 10, 1958, the Air Line Pilots Association presented to the Bureau of Safety certain factual information and theories concerning the cause of the accident. On November 24, 1958, a third trip to the accident site was made. While there a new determination was made of the airplane's heading at the time of impact. Because of these developments since the August 26, 1957, accident report was issued, active investigation and study was resumed.

Additional testimony and documentary material were received from representatives of the ALPA, TWA, CAB, Eclipse-Pioneer Division of the Bendix Aviation Corporation, and the Collins Radio Company at Kansas City, Missouri, on January 15 and 16, 1959. In addition, a later study and presentation of facts concerning the instrumentation of the airplane and an analysis of tests made of the fluxgate compass system by Eclipse-Pioneer and ALPA were considered.

1/ This report is supplementary to the Board's report released August 26, 1957.

2/ All times herein are mountain standard based on the 24-hour clock.

Decision to Issue Supplemental Report

After an analysis of all new evidence and the original record, it is the Board's decision that a supplement to its accident report be issued. This is in conformance with the Board's policy and rule that accident investigations are never officially closed but are kept open for the submission of new and pertinent evidence by any interested party.

Discussion

The Board, in this supplemental analysis, has reviewed considerable testimony and information supplied by interested parties. The ALPA presented a detailed review of the Board's report and advanced several theories to account for the flight path deviation. In the light of additional information and further study, the Board believes that certain matters in the report need to be amended and are corrected in the discussion which follows:

1. Copilot Experience.

The Board's amended report of August 26, 1957, gave Copilot Creason's experience over the Albuquerque-Santa Fe route only for the month of the accident and for the previous month. It did not mention his flying that route during previous years. He had flown the Albuquerque-Kansas City route a total of 32 trips and the Albuquerque-Santa Fe route a total of 24 trips. Obviously, he was familiar with the route and the adjacent terrain, as was Captain Spong.

2. Airplane Heading.

During the third visit to the crash site, on November 24, 1958, the heading at the time of impact was determined to be 249 degrees magnetic. This direction was determined by a sun compass not subject to magnetic forces or their local variations. Previously the direction was believed to be 320 degrees as determined by a magnetic compass.

From this it is evident that the aircraft must have been turned to the left from about 35 degrees magnetic, the direction in which it approached the mountain, through some 145 degrees, when it struck. This is nearly a reversal of course and must have been brought about by the pilot's sudden realization of proximity to the high land. This realization could have come from a glimpse of the ground, from warning by the terrain warning indicator, or from sudden awareness of course error by reference to the flight instruments and the indications of radio navigational aids.

3. Weather.

A detailed review of the official weather observations as taken at Kirtland Field, Albuquerque, and the observations of ground witnesses indicate that weather conditions directly over Kirtland Field and throughout the western semicircle (from Kirtland) were good. The 0708 weather observation showed scattered clouds at 4,000 feet with thin broken clouds above based at 7,000 feet and a prevailing visibility of 40 miles. The Sandia Mountains were obscured by clouds during

virtually the entire duration of the flight. Various ground witnesses described the cloud conditions over and near the mountains as covering all but the bases or foothills of the mountains with slightly more of the mountain bases visible along the extreme northern end of the Sandias. The cloud bases adjacent to the mountains were further characterized as ragged and there were snow showers present near the mountains, further restricting visibility in this quadrant. In summary, the only weather of any consequence near Albuquerque was the clouds and snow showers which had developed owing to orographic effect over and in the immediate vicinity of the Sandia Mountains.

4. Fluxgate Compass System.

The ALPA has suggested several theories which it believes can account for the flight path of the aircraft, all of which are based fundamentally on a malfunction of the fluxgate compass system. A detailed discussion of these follows:

Upon takeoff from Albuquerque, a right turn was made which carried the aircraft around the airport until it reached a position in the vicinity of the northwest corner of the airport at which time the aircraft took up a heading toward the mountains. The aircraft was observed flying on this heading until lost from view upon entering the clouds that concealed the mountains.

Since deviation from the prescribed route occurred at the beginning of the flight, while the aircraft was in the immediate vicinity of the airport of departure, attention must be focused on this segment of flight to determine the most probable condition or set of conditions present at the time that could cause the crew to continue the turn after takeoff beyond the proper point and assume and maintain a heading that resulted in a course leading to the mountains.

Clearly, the crux of the matter lies in the reason for the initial departure heading. Since the crew receives heading information through two fluxgate compass systems, consideration must be given to the possibility of the crew's having responded to erroneous information from these systems. Also, in view of the clear weather in the immediate vicinity of the airport, consideration must also be given to the possibility of the crew's having taken up the initial heading visually by rolling out of the turn after takeoff on a course approximately parallel to what was mistakenly thought to be the north-south runway, but was the northeast-southwest runway. This proposition presupposes a considerable period of visual reference with the airport during the turn after takeoff. Whether this be continuous or intermittent observation, it would provide an opportunity for the crew to detect its error through reference to familiar landmarks on the airport and sections of the city adjacent to it. Further, if valid heading information was being furnished by the compass systems, the substantial disparity between desired heading and indicated heading would serve to alert the crew to the error when they subsequently checked aircraft heading by reference to the RMI or MDI.3/

Considering the first possibility, that of erroneous heading information from the aircraft's compass systems, we find a more plausible explanation for the assumption of an erroneous heading as well as the failure to detect the error quickly. Further, as will be detailed, erroneous information from but one of the two compass systems need be assumed.

3/ RMI - Radio Magnetic Indicator; MDI - Master Direction Indicator.

The misinformation envisioned is of the type produced as the result of a tilted fluxgate transmitter gyro. Proper heading information is dependent upon the sensing element being held at all times in a horizontal plane. Stability of the element is obtained through the use of a small gyro within the fluxgate transmitter. The gyro is of the self-erecting type and an additional quick erection feature is provided in the form of a caging mechanism electrically operated and controlled by a switch in the cockpit. This latter mechanism, employed prior to takeoff, erects the gyro to the nearly vertical position, leaving its final position to the self-erection feature.

Although malfunctioning of a fluxgate transmitter can produce a gyro tilt condition, the operating conditions of the transmitter assemblies on the subject aircraft remain unknown since only parts of one assembly were recovered.

It has been demonstrated that it is possible that when first energized the gyro can assume a tilt angle that will produce correct heading information when the aircraft is on the takeoff runway, but will indicate erroneously as the aircraft assumes other headings. Thus failure to erect the gyro by means of its caging system before takeoff can result in varying degrees of indicated heading error dependent upon actual aircraft heading, relative strengths of horizontal and vertical components of the earth's local magnetic field, and upon the degree and direction of gyro tilt. Eventually, these errors diminish in magnitude until they become nonexistent as the gyro responds to its self-erection mechanism. However, at the relatively low self-erection rate of the gyro (averaging approximately two degrees per minute) it is possible that an aircraft could become airborne before the gyro is fully erected.

Also to be considered is the possibility of gyro tilt as the result of a caging cycle taking place while the aircraft is banked. Had such an action occurred during the period that the aircraft was in its turn after takeoff, either as the result of crew action or system malfunction, erroneous heading information would be displayed until the gyro had again been erected by its self-erection feature. Further, the error produced under these circumstances is one that would necessitate the aircraft being flown on a northeasterly heading in order for the compass system to indicate a northerly heading.

Heading information from the fluxgate compass systems is supplied by four instruments; an MDI and an RMI on each pilot's instrument panel. The MDI's receive heading intelligence from separate fluxgate transmitters located in the left wing tip. The RMI is a slave instrument which receives its heading intelligence from an MDI. In the subject aircraft both RMI's were normally slaved to the copilot's MDI which in turn received heading intelligence from the inboard (No. 2) fluxgate transmitter. A selector switch was provided for emergency transfer of the RMI's to the captain's MDI, which receives its intelligence from the outboard (No. 1) fluxgate transmitter.

It is apparent that the aforementioned transmitter-indicator relationship would, in the event of a tilted gyro in No. 2 fluxgate transmitter, permit the display of erroneous but identical heading indications on three of the four heading indicators, the copilot's MDI and RMI, and the captain's RMI. The captain's MDI would, however, show a heading which was different from these three instruments.

The front end housing of one RMI was recovered at the accident site. Although its glass and pointers were missing, the bezel, mask, and dial were still in place. Careful study of these damaged parts indicated that the dial reading was approximately 272 degrees at the time of impact. This reading is 23 degrees from the recorded impact heading of the aircraft which, as previously mentioned, was measured as approximately 249 degrees magnetic. Considering such unknown factors as the amount of aircraft heading change after destruction of the RMI, and the accuracy of the aircraft centerline as established within the wreckage area, it may be concluded that the RMI heading indication was substantially correct at the time of impact.

This finding does not preclude the possibility that erroneous compass information due to gyro tilt caused the crew to take up a course toward the crash site. Such initial error could have been considerably reduced in magnitude by action of the self-erection feature of the gyro as the aircraft proceeded toward the mountains, or it could have been completely removed through operation of the caging mechanism. This latter might well have occurred if the captain noted a disparity between heading indications displayed on his MDI and RMI. It would be entirely reasonable to expect that he would, under these circumstances, actuate the caging mechanisms of both compass systems to determine which system was in error.

5. Use of Available Navigational Aids.

The Board believes that the crew intended to follow the route prescribed in the ATC clearance. This is confirmed by their care in verifying the location of the Weiler intersection, a reporting point in their clearance, by the airplane's radio receivers being found set properly for this route of flight and because the crash occurred at about 9,000 feet, the planned cruising altitude. Further, it is inconceivable that a crew familiar with the terrain features in the Albuquerque area, as was this crew, would have taken a direct route to Santa Fe at an altitude of 9,000 feet.

Each RMI is fitted with two rotatable pointers that may be used to display either ADF or VOR bearings.

Two ADF and two VHF navigation receivers were installed in the aircraft and were designated No. 1 (captain's) and No. 2 (copilot's). Each RMI was provided with a selector consisting of two toggle switches, one for each pointer. The single pointer indicated either No. 1 ADF or No. 1 VOR bearings depending upon the position of its toggle switch. Similarly, the double pointer could be used for either No. 2 ADF or No. 2 VOR.

Mounted directly below each RMI was a flight path deviation indicator (FPDI) the vertical needle of which responded to course displacement information derived from either the No. 1 or No. 2 VHF navigation receiver as selected by a toggle switch mounted adjacent to the instrument.

One omni bearing selector (OBS) was mounted on each pilot's panel; the one on the captain's side was used in conjunction with No. 1 VHF navigation receiver, and that on the copilot's side was used in conjunction with the No. 2 VHF navigation receiver.

Although the settings of the RMI and FPDI selector switches are not known, some understanding of the technique used by the crew in this departure and of the navigation aids available to them may be deduced from a study of the factual information obtained during the investigation.

The No. 2 VHF navigation receiver was tuned to the frequency of the Albuquerque ILS localizer and the No. 1 VHF receiver was tuned to the frequency of the Albuquerque VOR. Since the FPDI selector switches are typically positioned so as to connect the instruments to their respective receivers (captain's to the No. 1 and copilot's to No. 2) it may be assumed that the copilot was flying the aircraft with the en route information displayed on his panel while the captain's panel was set to display the crossing of the 026-degree radial of the ABQ VOR (Weiler intersection). This latter assumption is further strengthened by finding the captain's OBS set to either 026 degrees or its reciprocal 206 degrees.

In addition to course deviation information, each crew member could display on the single pointer of his RMI the magnetic bearing to the Albuquerque omni station.

The No. 1 ADF receiver was found tuned to the frequency of the compass locator at the outer marker of the Albuquerque ILS. Its function switch was in ADF position. No. 2 ADF receiver was tuned to the frequency of the Albuquerque low frequency range station; however, its function switch and sensitivity selector were both found in the "off" position.

This indicates that the crew was using No. 1 ADF during the flight and therefore that at least one of the crew members had selected his RMI single pointer to display the bearing to the outer marker. It is probable that the copilot would want such information displayed on his RMI to assist in his en route navigation while the captain would probably select No. 1 VHF navigation receiver for his single pointer to provide continuous relative bearing indication to the Albuquerque omni to assist in his identification of the Weiler intersection.

Any error in magnetic heading information received from the fluxgate compass system due to gyro tilt would also be introduced into the RMI pointer when selected to VOR. This would result in the pointer following the compass card so as to indicate the magnetic bearing to the station. Under such circumstances it would not point to the station. As a result, the crew would not initially see an incongruous presentation on the RMI despite the magnetic heading error. However, if the pointer were selected to ADF position, it would point to the station regardless of compass system error and should serve to alert the crew of any substantial heading error.

In summary, the aircraft's radio navigational receivers were determined to have been set as follows:

a. The copilot's VHF receiver was set to the Albuquerque ILS frequency. This would enable the pilot to utilize the back course of the ILS localizer.

b. The captain's VHF receiver was set to the Albuquerque omni station and his OBS was set at either 026, or 206 degrees, the reciprocal. This would enable a check to be made of the Weiler intersection as specified in the IFR clearance.

c. The No. 1 ADF receiver was tuned to the outer marker of the ILS. This would permit use of a tail bearing to determine when the aircraft was on the proper departure course.

The Board recognizes that the theory of the fluxgate compass error advanced by the ALPA can not be disproven. Such error may account for the initial directional error of the flight heading the aircraft toward the Sandia Mountains. However, it can not account for the continued flight long past time the crew should have noticed the error.

Several other factors must be considered along with this error to account for the continuance of this flight on the erroneous heading:

First: The magnetic compass could have been used as a cross-check for heading information.

Second: Terrain features such as the appearance of the city area, the river bed more or less paralleling the correct course, and the railroad track to the right of the correct course, could have been noted. The weather was quite clear for an ample period of time to alert the crew they were off course had they referred to ground features. In addition, it may be pointed out that this type of initial check immediately after departure might well be most pertinent inasmuch as the precipitous Sandia Mountains, then hidden by clouds, lie adjacent to the correct course and are, as a matter of fact, the highest terrain between Albuquerque and Santa Fe.

Third: The MDI on the captain's instrument panel would indicate a different heading from that of the RMI and could have been noted and should have alerted the crew that an error was present in one of the systems.

Fourth: The FPDI on the copilot's panel would have moved from the full fly-right position to the full fly-left position as the aircraft crossed through the localizer course north of the airport. This should have alerted the crew that they were proceeding away from the heading of the localizer and that it would be necessary to turn back to the left in order to arrive at the Weiler intersection in accordance with their clearance.

Again, in order to accept the theory offered, the Board must conclude that both crew members were completely oblivious to all these indications, that their attention was focused entirely on the RMI, and that they did not cross-check any other flight instruments.

One other possibility, advanced by ALPA, remains which the Board also considered in this study. It is the possibility that the pilot became confused with respect to the proper sensing of the FPDI during a back course departure on the ILS. On a back course <u>approach</u> the FPDI would indicate a reverse reading from the normal approach. However, in departing on the back course the

indications received in the FPDI would be exactly the same as an approach made normally on the front course. Even if this confusion did exist, the normal cross-checks outlined above were still available and should have alerted the crew, providing they were conducting the flight according to prescribed procedures and accepted good operating practices.

In view of the foregoing discussion, the Board believes that the former report did not accurately reflect all the circumstances of this accident. It is believed that insufficient evidence exists to substantiate the reason for the deviation from the prescribed flight path. The probable cause therefore will be changed accordingly.

Probable Cause

The Board determines that the probable cause of this accident was a deviation from the prescribed flight path for reasons unknown.

BY THE CIVIL AERONAUTICS BOARD:

/s/ WHITNEY GILLILLAND
Chairman

/s/ CHAN GURNEY
Vice Chairman

/s/ G. JOSEPH MINETTI
Member

/s/ ALAN S. BOYD
Member