CIVIL AERONAUTICS BOARD

ACCIDENT INVESTIGATION REPORT

Adopted: July 9, 1953 Released: July 13, 1953

TRANS WORLD AIRLINES, INC., - FALLON, NEVADA,
DECEMBER 7, 1952

The Accident

Trans World Airlines' Flight No. 35 crashed during an emergency landing at Fallon, Nevada, about 1853 PST,[1] December 7, 1952. The aircraft, a Lockheed Model 1049, N 6904C, was extensively damaged. There were no personal injuries.

History of the Flight

Flight No. 35 originated at New York International Airport (Idlewild), for San Francisco, California, with one stop at Chicago, Illinois. The first leg of the flight was routine and at Chicago the crew was changed, as scheduled. This new crew consisted of Captain Irving S. Kravitz, First Officer J. S. Hager, Flight Engineer H. L. Burns, and Hostesses Lois Farley and Jacqueline Smith.

Departure from Chicago was at 1020, about 20 minutes behind schedule due to a servicing delay. There were 35 passengers. Clearance was in accordance with Instrument Flight Rules. The aircraft's center of gravity was within prescribed limits and its gross weight was 117,802 pounds. This compares with an authorized maximum of 120,000 pounds and an allowable weight of 118,000 pounds for the runway used.

The flight proceeded in routine manner until near Lovelock, Nevada, when, at about 1740 and at an altitude of 16,000 feet MSL, a complete power loss was experienced from No. 3 engine. While the flight engineer was attempting to restart that engine it overspeeded. The captain then reduced air speed to about 170 mph, and No. 3 propeller was feathered. Weather at Reno, about 95 miles ahead, was 2,000 feet scattered, overcast at 20,000 feet. San Francisco weather, about 260 miles ahead, was 20,000 feet and 10 miles.

Captain Kravitz decided to continue on three engines to San Francisco, the destination. Shortly, the flight passed abeam and a few miles to the north of the Naval Auxiliary Air Station at Fallon, Nevada. The crew noted that weather conditions there were good.

1/ All times referred to herein are Pacific Standard and based on the 24-hour clock.

About 25 minutes after the failure of No. 3 engine, No. 4 engine failed. Power could not be restored, and at 1829 No. 4 propeller was feathered and an emergency was declared. At this time the flight was about 10 minutes east of Reno, Nevada, and the weather there was checked at once. It was found to be 1,500-foot ceiling and 3 miles visibility with snow (below minimums) so the flight turned back for Fallon, about 40 miles away.

The flight contacted the CAA radio station at Fallon and ascertained the landing conditions. These included unlimited ceiling and visibility and a northeast wind of five or six miles per hour. This wind was nearly aligned with Runway No. 7, which was to be used, and which is 7,000 feet long.

Fallon Airport is at an altitude of 3,840 feet MSL, and the flight arrived in the area at an altitude of 9,000 feet MSL. The captain decided to use wing flaps at the takeoff position while circling Fallon, and sent the flight engineer to the cabin to crank the flaps down manually.2/ The flight engineer went to the cabin, but before he was able to locate the necessary crank, he was recalled to his station when the captain decided to dispense with flaps. Meanwhile, the first officer had manually pumped down the landing gear which extended fully and was locked.

On orders from the flight deck, the hostesses had reseated some passengers in accordance with the "Buddy" system for emergency landings. This, briefly, means placing an able-bodied male close to, and alerted to help in the evacuation of those who might need help, such as infants-in-arms, children, and elderly people. Passengers seated near emergency exits were briefed in their use. Six male passengers were reseated near the main rear cabin door and instructed in the use of the emergency evacuation chute. All safety belts were fastened and checked.

Previously alerted Navy fire trucks took up strategic positions on the airport as the aircraft approached Fallon.

The aircraft made contact about 126 feet down the runway and at an air speed of about 150 mph. Captain Kravitz immediately put the nose wheel on the ground to effect steering and attempted to apply brakes. He discovered at once that he had neither nose wheel steering nor brakes. The hand pump selector valve was set on "Brakes," the brake selector valve was left on "Normal" and the first officer used the hand pump in an attempt to get hydraulic pressure.

Almost concurrently the captain placed Nos. 1 and 2 propellers in reverse pitch. The aircraft veered to the left and off the runway. Propeller controls were moved to restore forward pitch on Nos. 1 and 2 propellers.

2/ With Nos. 3 and 4 engines of this model aircraft inoperative there is no hydraulic pressure to extend wing flaps or landing gear, for nose wheel steering or for wheel braking. There is an emergency method of obtaining wheel braking; it will be discussed later.

The aircraft continued to the left of the runway, into soft dirt, through a ditch two and one-half feet deep and through several piles of gravel. The right wing with the right landing gear was torn from the fuselage at the wing fillet. A part of the right empennage was torn free as it passed over the right wing.

As the right wing stub dragged on the ground the aircraft swerved to the right. It came to rest a short distance beyond on its nose wheel, left main wheel and the aft part of the fuselage. The crash occurred after dark at 1853; all airport lighting facilities functioned properly.

Fire trucks were alongside the aircraft within a matter of seconds and prevented a possible fire by applying fire extinguisher (Foamite) at places where fire might develop. The cabin lights had gone out but the emergency lights were turned on manually and the main cabin door was quickly opened. Because of the aircraft's tail low attitude, the bottom of the door was close to the ground. This allowed most of the occupants to leave from that door without need of ladders or chutes. The other occupants left through the forward right hand door via chute. The entire evacuation was orderly and lasted about two minutes despite the fact that the aircraft's attitude — tipped laterally down about 30 degrees to the right and also tipped down aft -- created somewhat adverse conditions in reaching the exits.

Investigation -- Part I - Power Plants

Nos. 3 and 4 engines were disassembled. This model engine has two cam drive gear trains for each of the front and rear row cams. Each train consists of a drive, intermediate and pinion gear. Teeth of the intermediate gears of both front cam gear trains of both of these engines had failed causing immediate and full power loss. Other gears in these drive trains suffered damage to a lesser degree. These engines had accumulated a total time since new of 52:43 hours and 31:27 hours, respectively. The failures appear to have been due to the design, the manufacturing and the inspection of these gears. The specific cause of the teeth breakage was the faulty configuration and/or the surface finish of root radii of the teeth.3/

There had been similar failures, previously, in other engines of this model. As a result, the engine manufacturer had started, prior to this accident, a modification program to incorporate a four pinion cam drive for the original two pinion drive. Its purpose is to distribute the load and thus lessen the stress on individual gears.

Currently, the engine manufacturer has a four-part program aimed at eliminating or minimizing the subject type of gear failure as follows:

3/ These gears are about 5-1/2" in diameter, about 1/8" thick and have a large number of small teeth. An earlier design had fewer and larger teeth; the change was made to allow more continuous and greater overlapping of teeth engagement.

1. Continuing the change to a four pinion cam drive.

2. Increasing the backlash limit on all gears in the cam drive train from .006" - .010" to .010" - .016" and also reducing the height of the teeth of the small cam drive pinion further to insure against tooth interference at meshing conditions.

3. Incorporating an .080" 45° chamfer on both ends of the teeth of the cam ring gear to improve the load distribution on the cam ring gear teeth.

4. Strengthening the gears of the entire train as much as possible within the present forging limits of the parts. This part of the program is the most complicated and will require at least six months before parts are available.

Operators using the subject model engine are currently making continuous frequent checks of oil sumps where evidence of gear failure (gear teeth or parts of teeth) may be found. This failure was similar in nature to some 46 other instances of failure of the cam drive gears in the same model engine experienced in operation by two U. S. carriers and one by the aircraft manufacturer during test.

A study and analysis of the Type Test Inspection Report of the subject engine, Wright Aeronautical Division 975 C18OB1, revealed that a failure of the cam gear had occurred during the CAA observed 150 hour type certification test along with several other failures of major components of a nature that would render engine operation unreliable. In all cases of the reported primary failures the manufacturer furnished an explanation as to the cause and indicated corrective measures which were being initiated. Notwithstanding the various failures which occurred during the type certification test, including failure of the crankcase, the rear supercharger section, the clutch support housing, an exhaust valve spring and the cam ring gear, the engine received its approval without any penalty tests as authorized by CAR 13.21 (h) (2), August 1, 1949, which was effective at the time. Section CAR 13.21 (h) (2) reads:

> "If any part shows evidence of fatigue or impending failure or is otherwise not in a condition for safe operation, the engine will not be considered satisfactory unless appropriate corrective measures are taken and proven satisfactory by suitable testing: provided, that the Administrator may accept other substantially equivalent proof."

The CAA certificated the engine, without further testing to prove the corrective measures, by accepting what it considered equivalent proof in the form of identical gears satisfactorily run in several other but different model engines.

Investigation -- Part II - Hydraulic System and Crew Training

It may be pertinent here to explain some of the facts concerning the hydraulic system of the Lockheed Model 1049. Each of the four engines has a hydraulic pump. Those on Nos. 1 and 2 engines furnish jointly (or individually, in the event of failure of either Nos. 1 or 2 engines) hydraulic pressure to supply boost for the aircraft's flight controls and for certain other purposes. This is known as the primary hydraulic system.

Pumps on Nos. 3 and 4 engines furnish jointly (or individually, in the event of failure of either Nos. 3 or 4 engines) hydraulic pressure to effect wheel braking, nose wheel steering, wing flap motion, landing gear extension or retraction, and certain other purposes. This is known as the secondary hydraulic system. It can supplement the primary hydraulic system but the reverse is not possible. If Nos. 3 and 4 engines are inoperative there is no means of obtaining nose wheel steering, wing flaps must be cranked down manually, and landing gear must be lowered with the hydraulic hand pump. However, normal wheel braking can still be effected by pressure from two accumulators instantly available by merely positioning the brake selector valve from "Normal"to "Emergency." TWA's Model 749 Lockheeds had two positions for the brake selector valve marked 'Accumulator #1" and "Accumulator #2," enabling the crew to divert pressure from the hand pump to either accumulator as needed simultaneously supplying pressure directly to the brakes commensurate with the demand.

Lockheed's Airplane Operating Manual for the 1049 aircraft, which has CAA approval and was aboard the aircraft, includes the following relative to emergency use of brakes:

"f. BRAKES, EMERGENCY OPERATION . . .

(2) The brakes may be applied in the following ways:

(a) On secondary hydraulic system, brake selector in NORM.

(b) On secondary hydraulic system, brake selector in EMER.

(c) With secondary hydraulic system inoperative, brake selector in EMER., pressure supplied by accumulators . . ."

The accumulators, mentioned above, were noted by the crew to be fully charged (1500-1700 pounds per square inch) prior to landing. It was also found that they were nearly charged when checked a few days after the accident.

The proper braking procedure, therefore, as stated under (2) (c) above, was to have placed the brake selector on "Emergency". This was not done, the captain attempting to obtain braking pressure from the hand pump rather than from his fully charged and instantly available accumulators. These accumulators store enough for 10 full applications of brakes if the system

is free of air; in practice, with the system not completely bled, there are at least six brake applications available.

Before landing at Fallon the crew went through the company's cockpit check list for normal operation. It did not have emergency braking procedures specified, although the manufacturer's 1049 check list on the engineer's table included abbreviated emergency braking procedures. In the subject model aircraft, the flight engineer's station is several feet aft of the two pilot seats and at right angles to them. Thus the flight engineer cannot readily see either the accumulator pressure gauge or the brake selector valve. The positioning of the brake selector valve is primarily a pilot function. On this model aircraft the flight engineer has no specific duties in connection with use of the emergency braking system - during an emergency he acts upon the captain's order. Therefore, the flight engineer would have had no reason to believe, or way of knowing, that the emergency braking system was not being utilized properly.4/

On board the aircraft was TWA's Operating Manual for Constellations, but it applied primarily to the two earlier models. At the time of this accident TWA's Operating Manual for the Model 1049 did not contain instruction relative to correct braking under the subject condition. TWA was in the process of bringing this manual up to date for the Model 1049. However, there was a Lockheed operating manual and check list for the model 1049 aboard the aircraft. They contained explicit emergency braking procedures that if followed would have provided normal braking.

Analysis -- Part I - Power Plants

Obviously the pertinent provision of the CAR applicable to the subject engine gives the Administrator full authority to judge whether or not penalty runs and replacement of parts during the endurance tests should be required. It appears that the Administrator's judgment in the case of the subject engine was questionable and did not lead to appropriately conservative action since his judgment was based on the fact that parts identical to the failed parts had withstood the endurance tests when installed and tested on other engines but of a different model. As a matter of fact, engineering opinion is that local conditions of operation of different type engines, including what appears to be minor design changes and/or additions, may have an unforseen effect upon the reliability of individual components of the engine. A review of the service history of the subject model engine definitely indicates that the corrective measures which were initiated by the manufacturer subsequent to the type test were wholly inadequate.

Analysis -- Part II - Hydraulic System and Crew Training

The aircraft's secondary hydraulic system completely lost its source of energy with the feathering of Nos. 3 and 4 propellers. However, there was

---

4/ This check list was on a card, one side entitled "Model 1049 Cockpit Check List" and the other, red-bordered, entitled "Model 1049 Abbreviated Emergency Procedures."

no malfunctioning of that hydraulic system as such, nor was there malfunctioning of any component of that hydraulic system, including the mechanism for emergency braking. The simple fact of the case is that the emergency braking mechanism was not used.

The captain attempted to brake as he should have done, and as would have been proper and successful, with predecessor type Lockheeds (Models 049 and 749) on which he was highly experienced. His experience on Lockheed Constellations was: On Model 049, 3,524:01 hours; on Model 749, 310:04 hours, and on Model 1049, 104:10 hours.5/ His transition training for the Model 1049 included four days of ground training and four hours of flight. This flight training included a landing and braking with Nos. 3 and 4 propellers windmilling and consequently with the secondary hydraulic system operative, furnishing adequate braking pressure without use of the accumulators.

The reason the emergency braking system was not used can rest only in the fact that the company's transition training to Model 1049's was omissive in that it did not emphasize sufficiently the difference in the operation of emergency brakes. This is evidenced by the captain's statement that he tried to brake the aircraft with the brake selector in the "normal" position whereas it should have been in the "emergency" position. He demonstrated his unfamiliarity with the hydraulic system in that he attempted to brake the aircraft immediately upon touchdown and then, and only then, did he realize that he had no hydraulic pressure on his brakes.

The captain's unfamiliarity with the hydraulic system of the 1049 is further borne out by his statement that immediately after touching down he attempted to steer the aircraft with the nose wheel. On this model aircraft a loss of secondary hydraulic pressure results in loss of nose wheel steering.

Since the company's own operating manual for the 1049 was not complete and did not include emergency braking procedures, the company should have specifically instructed crews to use the Lockheed operating manual and check list, aboard the aircraft, which did contain the correct procedures. Had these latter been followed, the accident would probably have been avoided.

Although the company may be criticized for not issuing the aforementioned specific instructions relative to the new model aircraft, this in itself does not relieve the captain of his responsibility of assuring himself that he is thoroughly familiar with the aircraft he commands, its systems and their proper use.

Of course the circumstances of this accident were extremely unusual. It was at night, on an airport with which the crew was not familiar and with

---

5/ Both the first officer and the flight engineer had practically the same amount of experience on the three Constellation models as had the captain. TWA's Model 749 Constellations had hydraulic systems, as far as emergency braking is concerned, the same as the earlier Model 049. Thus the captain had close to 4,000 hours experience with Constellations having a different emergency braking system.

two engines on the same side stopped and with their propellers feathered — a highly unusual contingency. Putting the aircraft on the runway as short as Captain Kravitz did was a creditable performance.

The Board also desires to commend both stewardesses for the most efficient manner in which they carried out the cabin emergency procedures.

Findings

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

1. All required certificates relative to the company, the aircraft and the crew were current and valid.

2. The CAA type-certificated the subject model engine following inadequate proof testing of a cam drive that had failed in the initial test run.

3. Complete loss of power from Nos. 3 and 4 engines forced a landing to be made at the Fallon Naval Auxiliary Air Station, Nevada.

4. The proper braking procedure was not used.

5. The carrier's transition training of the captain to the subject model Lockheed from earlier models was not adequate.

6. The aircraft's emergency braking mechanism and its source of energy were operable.

Probable Cause

The Board determined that the probable cause of this accident was improper use of the emergency braking system during the course of an emergency landing. This landing was necessitated by complete loss of power from the Nos. 3 and 4 engines due to the failure of their cam drive gears.

A contributing factor was inadequacy of the company's Lockheed 1049 transition training program from the former model aircraft concerning the difference in emergency procedures.

BY THE CIVIL AERONAUTICS BOARD:

/s/ OSWALD RYAN

/s/ HARWAR D. DENNY

/s/ JOSH LEE

/s/ JOSEPH P. ADAMS

/s/ CHAN GURNEY

SUPPLEMENTAL DATA

Investigation and Hearing

The Oakland, California, office of the Civil Aeronautics Board was notified of this accident by the Civil Aeronautics Administration a short time after occurrence. An investigation was immediately initiated in accordance with the provisions of Section 702 (a) (2) of the Civil Aeronautics Act of 1938, as amended. A public hearing was ordered by the Board and was held at Kansas City, Missouri, on January 12, 13 and 14, 1953.

Air Carrier

Trans World Airlines, Inc., is a scheduled air carrier incorporated in the State of Delaware with its principal business office at Kansas City, Missouri. It operates under 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 company to transport by air persons and property over numerous routes, including that between New York, N. Y., and San Francisco, California.

Flight Personnel

Captain I. S. Kravitz, age 45, held a currently effective airline transport pilot certificate with an appropriate rating for the subject aircraft. He had been continuously employed by Trans World Airlines, Inc., since 1936. At the time of the accident he had accumulated 14,969 hours of piloting, of which 104 hours had been in Lockheed Constellations Model 1049.

First Officer J. S. Hager, age 31, held a currently effective airline transport pilot certificate with an appropriate rating for the subject aircraft. He had been employed by the company since 1945. His total flying as of the time of the accident was 7,274 hours, of which 89 hours had been in Lockheed Constellations Model 1049.

Flight Engineer H. L. Burns, age 37, held a flight engineer certificate as well as a commercial pilot certificate. He had been employed by the company since 1948. His total flying time as of the time of the accident was 5,894 hours, of which 94 hours had been in Lockheed Constellations Model 1049.

Stewardess Jacqueline Smith had been employed by the company since 1950. She had completed various company training courses, including emergency evacuation training for the Constellation Model 1049.

Stewardess Lois Farley had been employed by the company since 1948. She also had passed the company's required training courses, including emergency evacuation training for the Constellation Model 1049.

The Aircraft

N 6904C was a Lockheed Constellation Model 1049. At the time of this accident its total flight time was 699 hours. Its four engines were Wright 975C18CB-1-2700 horsepower, and its four propellers were Hamilton Standard 43E60-6901-A.