File No. 1-0160

CIVIL AERONAUTICS BOARD

ACCIDENT INVESTIGATION REPORT

Adopted: March 20, 1956 Released: March 23, 1956

FLYING TIGER LINE, INC., DC-4, N 90433, BETWEEN HONOLULU AND WAKE ISLAND, SEPTEMBER 24, 1955

The Accident

At 0641,[1/] September 24, 1955, a Flying Tiger Line Douglas DC-4, N 90433, operated as Trip 7413-23 (a Military Contract Cargo Flight), en route from Honolulu, T. H., to Wake Island, ditched in the Pacific Ocean, approximately 1,000 miles west of Honolulu, after a loss of power in three engines. Two of the crew of five survived; one crew member went down with the sinking aircraft, and two others subsequently drowned before the arrival of a rescue vessel the following day. The aircraft carried cargo only.

History of the Flight

Trip 7413-23 originated at Travis Air Force Base, California, its destination Tokyo, Japan, with scheduled refueling stops at Honolulu and Wake Island. The cargo load of 15,333 pounds was properly secured and distributed relative to the center of gravity. The flight departed Travis Air Force Base at 0958 and arrived at Honolulu at 2211, September 23, 1955, without incident. The crew consisted of Captain A. J. Machado, First Officer W. F. Gin, Copilot R. C. Hightower, and Navigators R. C. Olsen and D. Ventresca. No maintenance work was required at Honolulu and the aircraft was refueled to 3,016 gallons for the flight to Wake Island. There was no offloading or loading of cargo. Gross weight of the aircraft at the time of takeoff from Honolulu was 72,993 pounds; there was no change in the flight crew. The flight departed Honolulu at 0013, September 24, 1955, on an IFR (Instrument Flight Rules) flight plan to Wake Airport via Green 9, Rhumbline Track, to maintain 8,000 feet.

Routine hourly position, fuel remaining, and weather reports were made to Honolulu ARTC (Air Route Traffic Center) as the flight progressed and at 0630 control of the flight was transferred to Wake Island ARTC. At 0633 an emergency was declared to Wake ARTC, the flight advising of loss of power in three engines and inability to return to Honolulu. The aircraft was ditched during darkness, at approximately 0641 at position 20°20' N. latitude 175°45' W. longitude. Neither Wake nor Honolulu radio was able to maintain contact with the aircraft; therefore Air Search and Rescue was alerted and an extensive search was commenced using both aircraft and surface vessels. At approximately 1318 on September 25 the SS Steel Advocate sighted and picked up Captain Machado and Copilot Hightower who were floating in life jackets. The two survivors reported that Navigator Ventresca went down with the aircraft and First Officer Gin and Navigator Olsen died while in the water.

1/ All times referred to are Greenwich mean time. All distances are in nautical miles and altitudes are mean sea level.

Weather briefing at Honolulu indicated a low pressure trough to be crossed at about 165° W. longitude; there were no fronts to be crossed. The forecast indicated that scattered cumulus clouds would prevail over the intended route with tops mostly 12,000 feet and lower. Review of the weather indicates no rain showers at the time and place of ditching. Sea swells in the ditching area were probably 4 to 6 feet high with the sea surface intermittently in deep shadow and faintly illuminated by the moon, which was in its first quarter.

Investigation

The takeoff from Honolulu was made by First Officer Gin, who was seated in the left pilot seat. Captain Machado was sitting on the right in the copilot seat.

Captain Machado and Copilot Hightower stated that the aircraft took off from Honolulu with all main tanks full (total - 1,942 gallons), and these four main tanks supplied their respective engines on takeoff, climb, and cruise until the amount in each tank was down to 400 gallons. At takeoff the two outboard auxiliary tanks were full (412 gallons each) and the two inboard auxiliary tanks contained 130 gallons each (capacity - 362 gallons each).

They further stated that after the captain retired, about one hour out of Honolulu, Copilot Hightower took the seat vacated by the captain. When the main tanks were down to 400 gallons each, First Officer Gin put No. 1 and No. 2 engines on No. 2 auxiliary tank and Nos. 3 and 4 engines on No. 3 auxiliary tank, with the crossfeed control positioned to each pair of engines. When the fuel in the inboard auxiliary tanks (Nos. 2 and 3) was down to approximately 20 gallons in each tank, the fuel selectors were positioned to the outboard auxiliary tanks (Nos. 1 and 4). This was the position of the fuel selectors when Captain Machado returned to the cockpit, after approximately five hours of rest, and took the left seat. First Officer Gin then relieved Copilot Hightower in the right seat. At that time there were 40 gallons in No. 1 auxiliary tank supplying Nos. 1 and 2 engines, and 100 gallons in No. 4 auxiliary tank supplying Nos. 3 and 4 engines. Nos. 2 and 3 auxiliary tanks were empty as First Officer Gin had positioned the selectors to transfer the fuel remaining (20 gallons each) in the inboard auxiliary tanks after switching to use of the outboard auxiliary tanks.2/

Approximately ten minutes after the captain had returned to the flight deck No. 1 engine quit and its fuel pressure dropped to zero. Captain Machado immediately moved the No. 2 and No. 3 fuel selectors from off to the full forward position (No. 1 and No. 4 fuel selectors were already in the forward or auxiliary tank position), mistakenly thinking this was the position for the

2/ Transfer of fuel, except in emergency, is contrary to an existing Airworthiness Directive (48-9-1) and the Flying Tiger Line Flight Manual which in Section VI, Paragraph 1 (e) reads: "Fuel System Management. The fuel system is not designed for fuel transfer between tanks and must not be operated in this way since excessive tank pressures causing structural damage may result, as well as loss of fuel due to overfilling. For these reasons the crossfeed system should be used only to supply fuel from tank to engine and not to transfer fuel from tank to tank."

main tanks. He also shut off the crossfeeds. The No. 3 engine then quit and its fuel pressure dropped to zero. The captain realized his error and pulled all four selectors to the center or main tank position and moved the four mixture controls to the auto-rich position.

During the operation No. 2 engine quit and its fuel pressure went to zero. Each fuel selector was then checked for main tank position and they were found to be so positioned with crossfeed valves off and main boost pumps on. Captain Machado then moved the crossfeed controls to the "all engines to crossfeed" position, which resulted in the fuel pressure of No. 4 engine fluctuating. The crossfeed valves were then shut off and No. 4 fuel pressure became immediately stabilized. The propellers of Nos. 1, 2, and 3 engines continued to windmill with their respective fuel selectors on main tanks, main boost pumps on, and crossfeeds off for a period he considered sufficient for restarting. The engines did not start and their fuel pressures remained at zero. Captain Machado then feathered Nos. 1, 2, and 3 propellers and used full power on No. 4 engine.

During the descent at an airspeed of 135-140 knots, engines Nos. 1 and 2 were unfeathered in separate attempts to restart; both were unsuccessful. After refeathering and while attempting to restart No. 3 engine, the aircraft struck the water in a slightly nose-high attitude.

On impact the cargo broke loose and came forward trapping First Officer Gin and Copilot Hightower, who was sitting in the radio operator's seat. Navigator Olsen opened the astradome while Captain Machado assisted the two trapped crew members from their seats. The four men left the aircraft through the astradome. Navigator Ventresca had been in the cargo compartment unsuccessfully attempting to jettison the bulky cargo and before the cabin door could be opened by the crew members who were on top of the fuselage the aircraft sank. Three of the remaining crew members had life jackets on, but Captain Machado could not locate his jacket and states he had none until after First Officer Gin and Navigator Olsen died in the water during the more than 30 hours awaiting rescue. Both survivors, in addition to the injuries received at impact, were bitten repeatedly by sharks during their many hours in the water.

The Flying Tiger Line operates various types of aircraft; among them are DC-6's, 6-tank DC-4's, and 8-tank DC-4's which have different fuel selector positions. The fuel selector positions on the DC-6's and 6-tank DC-4's are: REAR - OFF; CENTER - AUXILIARY TANKS; FORWARD - MAIN TANKS. The DC-4 8-tank positions for the fuel selectors are: REAR - OFF; CENTER - MAIN TANKS; FORWARD - AUXILIARY TANKS. Captain Machado pilots all three types of aircraft for the company.

Captain Machado had flown DC-4 aircraft 8,895 hours and this amount of time included both 6-tank and 8-tank systems. First Officer Gin had flown DC-4 aircraft 380 hours, and this time included both 8-tank and 6-tank systems. Copilot Hightower had flown DC-4's 20 hours. Captain Machado passed his six-month instrument check on June 8, 1955, and his six-month equipment check on DC-6's and DC-4's on June 8, 1955, and September 9, 1955, respectively. First Officer Gin passed an instrument check on May 19, 1955, and a DC-4 equipment check on the same date.

To investigate further the functioning of the fuel system under conditions reported by Captain Machado, flight tests were conducted on November 8, 1955, at the request of the Board and were observed by Board personnel. These tests, conducted in a DC-4 equipped with the same 8-tank fuel system as installed in N 90433, were for the purpose of duplicating, if possible, the reactions of the equipment to each and every combination of control positions Captain Machado listed in his report of this occurrence, including those before and those after he "realized his mistake" in his first positioning of the fuel tank selectors. (See Attachment A.)

Analysis

The flight tests proved conclusively that if the Nos. 1, 2, and 3 propellers had been allowed to windmill with the fuel system and engine controls in the configuration described by Captain Machado, the engines would have restarted. The conditions described in the captain's statement were: Ignition on; fuel selectors positioned on the main tanks for each respective engine; main tank boosts on; mixture auto-rich; crossfeeds off.

Further confirmation of this conclusion is shown by reference to the original certification tests conducted by the Douglas Aircraft Corporation in 1945. Their report E-169, page 5, indicates that after two engines failed because of fuel exhaustion, recovery time after tank shift was 13.2 seconds without boost pumps. In the same type test recovery time after tank shift was 10.0 seconds with boost pumps "on."

While feathering the three propellers would slow the rate of descent, the action definitely removed any possibility of restarting the engines while in that condition. The separate unfeathering of the propellers and the starting attempts probably consumed more time and altitude than the original feathering may have gained.

The probability of simultaneous failure of three engine-driven fuel pumps is remote. However, even with the three pumps inoperative, full pressure would have built up immediately, if the fuel selectors had been positioned on the main tanks, each containing approximately 400 gallons, and an electric boost had been used on these tanks.

It is evident that if the remaining fuel (20 gallons each) in Nos. 2 and 3 auxiliary tanks had not been transferred by First Officer Gin, the loss of power would not have occurred when it did even though the Nos. 2 and 3 fuel selectors were incorrectly positioned for an indefinite period after the loss of power on the three engines.

If the fuel transfer had not been made, the additional normal flight time would have allowed the captain to make a thorough survey of the fuel situation and then an unhurried routine switching of each main tank to its respective engine. According to six hourly radio reports from the flight prior to the emergency, fuel consumption had been a uniform 200 gallons per hour for the four engines. Each main tank contained 400 gallons at the time of Captain Machado's return to the flight deck, according to his statement, and this amount of fuel was sufficient for approximately eight hours of flight. The flight tests also showed that even though the fuel transfer was made and the

three engines subsequently stopped, there was more than sufficient time from the altitude of 8,000 feet to restart the engines. The practice employed by the crew in allowing two engines to be operated on one auxiliary tank down to 20 gallons of fuel is considered poor operating practice.

By reason of the positive results obtained in the flight tests, the Board concludes that the captain's and copilot's recollection of events occurring after the loss of power, as described in their statements, was incorrect as to action and/or sequence. This absence of accurate recollection is understandable when consideration is given to the stress of the emergency and subsequent events after the ditching and before rescue.

Findings

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

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

2. According to company records, the load was within specified limits and properly distributed.

3. Weather or navigation was not a factor in the accident.

4. There was sufficient fuel aboard the aircraft to reach the destination.

5. Loss of power was experienced in three engines because of the positioning of fuel selectors on empty or nearly empty tanks.

6. The failure to restart the three engines was due to incorrect technique or improper method of using fuel selectors and associated controls.

Probable Cause

The Board determines that the probable cause of the accident was the loss of power in three engines due to incorrect fuel system management and faulty restarting methods which resulted in the ditching of the aircraft.

BY THE CIVIL AERONAUTICS BOARD:

/s/ ROSS RIZLEY

/s/ JOSEPH P. ADAMS

/s/ CHAN GURNEY

/s/ HARMAR D. DENNY

SUPPLEMENTAL DATA

Investigation

The Civil Aeronautics Board was notified of the accident at approximately 0855, September 24, 1955. An investigation was immediately initiated in accordance with the provisions of Section 702 (a) (2) of the Civil Aeronautics Act of 1938, as amended. The surviving crew members were interviewed and their statements taken at Burbank, California, on October 17, 1955. Flight tests that simulated fuel tank selection as described by the pilot were conducted from Lockheed Air Terminal, Burbank, California, on November 8, 1955.

Air Carrier

The Flying Tiger Line, Inc., is a scheduled air carrier incorporated in the State of Delaware with its principal business office at Burbank, California. 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 cargo by air over numerous routes within the continental limits of the United States. The subject flight was conducted under an exemption granted by the Civil Aeronautics Board which authorizes the carrier to engage in interstate, overseas, and foreign air transportation of persons and cargo, pursuant to contracts with any department of the military establishment.

Flight Personnel

Captain Anthony J. Machado, age 40, was employed on January 1, 1947, by Flying Tiger Line, Inc., as a qualified captain. He held a valid airman certificate with an airline transport rating and type ratings for DC-3, DC-4, DC-6, C-46, and airplane single-engine rating with commercial privileges. Captain Machado had, according to company records, a total pilot time of 13,450 hours, of which 8,895 were acquired in DC-4 aircraft. His last first-class physical examination was successfully passed on April 1, 1955.

First Officer Warren Fong Gin, age 34, was employed as a pilot by Flying Tiger Line, Inc., on December 20, 1951. He held a valid airman certificate with airline transport, airplane multi- and single-engine land, DC-4, flight instructor, and instrument ratings. He had, according to company records, a total pilot time of 7,603 hours, of which 380 hours were acquired on DC-4 aircraft. He successfully passed a first-class physical examination on July 20, 1955.

Copilot Robert Carl Hightower, age 22, was employed as a copilot by Flying Tiger Line, Inc., on May 1, 1955. He held a valid airman certificate with airplane single- and multi-engine land and instrument ratings. According to company records he had 1,328 hours of pilot time, of which 20 were acquired in DC-4 aircraft.

Navigator Dominic Ventresca, age 43, was employed as a navigator by Flying Tiger Line, Inc., January 1, 1947. He held a valid flight navigator certificate and radio telephone and telegraph licenses. He passed a medical examination on January 20, 1955, with no waivers.

Navigator Richard Carl Olsen, age 43, was employed by Flying Tiger Line, Inc., as a navigator on July 5, 1950. He held a valid flight navigator and flight radio operator certificate with radio operator examiner designation. His position was Chief Navigator and Radio Officer for Flying Tiger Line, Inc. He passed a medical examination on April 18, 1955, with no waivers.

The Aircraft

N 90433, a Douglas C-54A, serial No. 10410, owned and operated by The Flying Tiger Line, Inc., was manufactured on September 23, 1944, and had a total of 25,590 hours. It was equipped with Pratt and Whitney R-2000-7M2 engines and Hamilton Standard model 23E50 propellers. This aircraft was acquired by The Flying Tiger Line, Inc., on January 14, 1955, and that company had not modified or changed the fuel system in any way. The Nos. 1, 2, and 3 engines had approximately 1,300 hours time since overhaul and No. 4 approximately 800 hours. Total time varied between 6,037 and 11,428 hours.

FLIGHT TESTS

Fuel loading of aircraft prior to takeoff:

Main Tanks	#1 300 Gal.	#2 415 Gal.	#3 400 Gal.	#4 400 Gal.
Auxiliary Tanks	#1 10 Gal.	#2 0 Gal.	#3 0 Gal.	#4 100 Gal.

TEST ONE:

Altitude 8,000 feet.

Fuel System Configuration:

Engines 3 and 4 drawing fuel from No. 4 Auxiliary Tank.
No. 3 fuel selector OFF.
No. 4 fuel selector AUXILIARY position
Right crossfeed CENTER POSITION, "Crossfeed between Engines 3 and 4."
Boost pumps OFF.

R. p. m. 1,950; Manifold Pressure 29.6".

Mixture controls engines 3 and 4 AUTO LEAN.

In the above configuration, engines 3 and 4 operated normally. The No. 3 fuel selector was moved to the AUXILIARY position, and the right crossfeed was shut OFF. After shutting off the right crossfeed, the No. 3 engine ran for 42 seconds before the fuel pressure dropped to 3-4 p. s. i. and the engine quit.

TEST TWO:

Altitude 8,000 feet.

Fuel Selectors

No. 1 - AUXILIARY position;
No. 2 - OFF;
No. 3 - OFF;
No. 4 - AUXILIARY position.

Crossfeed

Left - CENTER, "Crossfeed Between 1 & 2."
Right - CENTER, "Crossfeed Between 3 & 4."

Booster Pumps OFF.

Mixture AUTO LEAN.

R. p. m. 1,950; Manifold Pressure 29.6".

Fuel Pressure No. 1 $17\frac{1}{4}$# No. 2 $17\frac{1}{4}$#.

Engines No. 1 and No. 2 were allowed to run No. 1 auxiliary tank dry. Engine No. 1 quit at 1121 P. s. t. Fuel pressure dropped to 3-4 p. s. i. on No. 1 prior to engine quitting.

After No. 1 engine quit, the No. 2 fuel selector was moved to the AUXILIARY position, the left crossfeed was shut OFF, and the No. 1 and No. 2 main boost pumps were turned ON.

Engine No. 2 fuel pressure dropped to 3-4 p. s. i., and No. 2 engine quit at 1121½ P. s. t. After No. 2 engine quit, No. 1 and No. 2 engines were allowed to windmill for 42 seconds, at which time the No. 1 and No. 2 fuel selector valves were moved to the MAIN TANK positions. After moving the No. 1 and No. 2 fuel selectors to the main tank positions, engines No. 1 and No. 2 fuel pressures rose to 18-19 p. s. i. and the engines recovered cruise power in 3 to 4 seconds.

TEST THREE:

Altitude 8,000 feet.

R. p. m. 1,950; Manifold Pressure 29.6".
Engines No. 3 and No. 4 drawing fuel from No. 4 AUXILIARY tank.
Right crossfeed on CROSSFEED BETWEEN 3 & 4.
No. 3 fuel selector OFF.

Engine operation normal.

No. 4 fuel selector was shut OFF, and the No. 3 fuel selector moved to AUXILIARY position. Crossfeed not moved. Engine No. 4 fuel pressure dropped to 3-4 p. s. i. and No. 4 engine quit. One minute, 15 seconds later, No. 3 fuel pressure dropped to 3-4 p. s. i. and No. 3 engine quit.

Engines No. 3 and No. 4 were allowed to windmill three minutes, at which time the No. 3 fuel selector was moved to the MAIN TANK position, booster pumps OFF. Engine No. 3 recovered normal fuel pressure and cruise power in five seconds. No. 4 likewise recovered in seven seconds.

TEST FOUR:

Altitude 10,000 feet.

R. p. m. 1,950; Manifold Pressure 29.6".

Fuel quantities

Auxiliary Tanks 1, 2, 3 EMPTY; No. 4, 110 gallons.

Fuel selectors 1, 2, 3, and 4 put in AUXILIARY position.

Crossfeeds OFF.

Engines No. 1, No. 2, and No. 3 allowed to quit and windmill for three minutes. Fuel pressure at time engines 1, 2, and 3 quit, 3-4 p. s. i.; engine No. 4, 18 p. s. i.

No. 4 auxiliary boost pump was turned ON HIGH, and both crossfeeds were moved to FULL FORWARD position, "All Engines to Crossfeed." No. 4 fuel pressure remained steady at 18½ p. s. i.

Engines No. 1, No. 2, and No. 3 recovered cruise power and normal fuel pressure in eight seconds. No. 2 engine came back in first, followed by Engines No. 1 and No. 3.

TEST FIVE:

Altitude 10,000 feet.

R. p. m. 1,950; Manifold Pressure 29.6".

Fuel loading Auxiliary Tanks

No. 1 Empty; No. 2 Empty; No. 3 Empty; No. 4 100 Gal.

Level flight, all engines on respective MAIN TANKS.

Engine operation normal all engines.

Booster pumps OFF.
Crossfeeds OFF.

All four fuel selectors were moved to AUXILIARY position. Engines No. 1, No. 2, and No. 3 allowed to quit due to fuel starvation, and to windmill for two minutes, at which time both crossfeed valves were moved to the FULL FORWARD position, "All Engines to Crossfeed;" booster pumps OFF.

No. 3 engine recovered normal fuel pressure and cruise power in ten seconds. Engine No. 4 was not affected. Engines No. 1 and No. 2 fuel pressure remained 3-4 p. s. i. with engines windmilling. Takeoff power was applied to the No. 4 engine. No. 4 fuel pressure fluctuated, No. 3 fuel pressure dropped to 3-4 p. s. i., and No. 3 engine quit, after which No. 4 fuel pressure dropped to 3-4 p. s. i., and No. 4 engine quit.

The throttles were closed on engines 1, 2, 3, and 4, and the No. 4 auxiliary boost pump was turned ON HIGH. All four engines fuel pressure returned to normal operating range, and all engines started in approximately three seconds after the No. 4 auxiliary boost pump was turned on.

TEST SIX:

Altitude 10,000 feet.

CRUISE POWER 1, 2, 3, 4 engines.
Fuel selectors 1, 2, 3, 4 on MAIN tanks.
Crossfeeds OFF.
Booster pumps OFF.
Fuel loading Auxiliary Tanks

No. 1 Empty; No. 2 Empty; No. 3 Empty; No. 4 80 Gal. (Approx.)

All four fuel selectors were moved to AUXILIARY positions, and engines 1, 2, and 3 were allowed to quit due to fuel exhaustion, and to windmill for two minutes. FULL POWER was applied to No. 4 engine. Left and right crossfeeds were moved to "ALL ENGINES TO CROSSFEED" positions. No. 4 fuel pressure remained steady and engine ran normally.

No. 2 engine came back in with normal fuel pressure in eight seconds, ran for 30 seconds, then quit as fuel pressure dropped to 3-4 p. s. i. No. 4 fuel pressure dropped to 3-4 p. s. i. 15 seconds later, and No. 4 engine also quit. Fuel pressure on engines 1 and 3 remained at 3-4 p. s. i. and the engines windmilled throughout this portion of the test.

The No. 4 auxiliary boost pump was turned ON HIGH, and all four engines recovered normal fuel pressure and came back in at reduced throttle settings in seven seconds.

During the tests described above, the ignition switches for all engines remained on BOTH at all times, and the mixture controls were set as noted or in AUTOMATIC RICH position.