CIVIL AERONAUTICS BOARD

ACCIDENT INVESTIGATION REPORT

Adopted: December 16, 1948 Released: December 21, 1948

UNITED AIR LINES, INC., BRYCE CANYON, UTAH, OCTOBER 24, 1947
AMERICAN AIRLINES, INC., GALLUP, NEW MEXICO, NOVEMBER 11, 1947

On January 2, 1948, and February 3, 1948, summaries of the Board's findings concerning the accidents involving Douglas DC-6 aircraft operated by American Airlines, Inc., at Gallup, New Mexico, November 11, 1947, and United Air Lines, Inc., at Bryce Canyon, Utah, October 24, 1947, were released however, the Board's analysis of the considerable amount of additional technical data compiled during the investigation of these accidents is being released in a combined report inasmuch as the major portion of the technical investigation and test activities were conducted simultaneously at Santa Monica, California, after the investigation at the respective scenes of these accidents had been completed.

Investigation

Because of the extensiveness of the disintegration of the DC-6 at Bryce Canyon, the two weeks following that accident were spent in gathering the thousands of torn and burned pieces of the aircraft and its contents, which were strewn about the impact area and back along the flight path for a distance of 28 miles, and transporting the pertinent parts to Santa Monica for reconstruction and evaluation. A building on the Douglas Aircraft Company grounds at Santa Monica was established as an Impound Area and during the first week in December identification of parts and reconstruction of the fuselage was started.

Preliminary findings at Bryce Canyon had made it possible to concentrate the major efforts of the investigation on the aircraft center section, however, the reconstruction of the entire fuselage shell from the leading edge of the wings to the rear pressure bulkhead was accomplished in order that the flame path be traced and the fire damage more completely appraised.

It had become apparent early in the course of the investigation that at least one of the barium nitrate flares had been ignited in flight and that a sizable area of the aircraft bore signs of burning resulting from this flare. As these parts were identified and the sequence of the fire damage determined, it became obvious that the ignition of the flare had not taken place until several minutes after the fire had started and the investigation was therefore directed toward the fire source which caused the flare to burn The extensiveness and the intensity of the fire in flight pointed toward the probability that large quantities of a highly combustible material must have been involved. It was therefore decided that smudge samples would be taken of representative areas of the aircraft and chemical analysis made to determine their metallic contents. The large percentage of barium nitrate contained in the flares rendered the barium content of these samples an excellent indication of the fire pattern of the burning flare. Similarly, since the gasoline carried aboard the aircraft was treated with tetraethyl lead, the lead content of the smudge samples proved an effective index of fire damage resulting from burning gasoline.

While plans were being executed for the further conduct of the investigation at Santa Monica, all DC-6 operators were required to conduct extensive inspections of this model aircraft with a view toward determining whether any conditions existed which might have been conducive to fire in flight. These inspections indicated clearly that considerable amounts of hydraulic fluid leakage in the belly cargo compartments had accumulated in the lining of these compartments. While it does not appear that this hydraulic fluid leakage could be ignited by any systems or components of the aircraft itself, there was no doubt that it would serve to intensify to a considerable degree any fire which might start from some other source. The Civil Aeronautics Administration therefore issued a directive November 5, 1947, to all DC-6 operators to remove all lining from the sides and under-floor areas of fuselage compartments and all other lining which had traces of hydraulic fluid saturation.

While the Bryce Canyon wreckage was being reconstructed and tests related to this investigation were being conducted, the Board was informed of the emergency landing which had been made by another DC-6 at Gallup, New Mexico, November 11, 1947, due to a fire in flight The similarity of the initial fire in this instance made it apparent that the investigation of the incident should be coordinated closely with the investigation then in process at Santa Monica A large group of government and industry personnel participating in the investigation was, therefore, immediately dispatched to Gallup.

Preliminary examination of the aircraft at Gallup, November 12, 1947, revealed a well-defined stain on the underside of the fuselage extending rearward in a fan shaped pattern from the No. 3 alternate fuel tank vent which is located on the fuselage near the lower right wing fillet and close to the leading edge. The stain gave the appearance of having been caused by a fluid leakage in flight and, since its point of origin seemed to have been the vent for the No 3 alternate fuel tank, it appeared to have been caused by gasoline overflow from this tank Approximately 10 feet aft of the air vent outlet, the stain was centered upon the cabin heater combustion air intake scoop in such a manner as to give strong indication that a considerable portion of such an overflow would have entered the scoop had the overflow occurred in flight. Subsequent analysis of this stain confirmed the fact that it resulted from aviation gasoline.

Plans were immediately made for a test flight in a Model DC-6 in order to ascertain the flow pattern of fuel which is forced through this vent in flight and in order to determine whether the overflow would enter the cabin heater air scoop. The No. 3 alternate fuel tank was filled with a water and dye mixture and the underside of the fuselage was covered with a commercial feldspar in order to facilitate identification of the flow pattern This test indicated clearly that, when the No. 3 tank was filled to capacity and the cross-feed to any other tank opened, the booster pump of the other tank was capable of forcing fuel through the vent at a rate of approximately 12.5 gallons per minute. Examination of the aircraft after this flight showed dye stains on the underside of the fuselage from the No. 3 vent outlet to the tail cone. A considerable quantity of water had entered the cabin heater combustion air intake scoop and some water had leaked through the ducting and covered the floor of the air conditioning compartment. This scoop also served the supercharger air aftercooler and it was noted that, when the aftercooler exhaust valve was open, the dyed water passed through the aftercooler and exhaust outlet.

Although flight tests were also conducted through every possible combination of attitude, airspeed and configuration of normal operation while the water and dye mixture was being pumped out of No. 4 alternate tank vent, none of this overflow passed closer than 20 inches to the cabin heater combustion air intake scoop

Additional tests were conducted to determine the effect of the aftercooler door position on the airflow to the cabin combustion heater. These tests revealed that the static pressure in the combustion air intake duct showed no change with any alteration of the aftercooler door position.

The cabin heaters of both the Bryce Canyon and the Gallup aircraft were carefully examined in order to ascertain whether any leaks had existed prior to the moment of contact with the ground. In each instance it was found that holes and deformations in the heaters were the result of some external force which had been applied after the fire had progressed to an excessive intensity. No indications were observed in the investigation that the heaters themselves were not functioning properly prior to the fire.

Having determined that gasoline could enter the cabin heater combustion air intake scoop from the No. 3 alternate tank vent in flight, tests were conducted on the effect of the introduction of a fuel/air mixture into the combustion air ducts. Pertinent components of the cabin heater systems from each aircraft involved in these accidents were repaired so as to render them serviceable for these tests In each of five test runs, severe backfiring resulted followed by fire in the combustion air intake ducts. During one of the test runs a particularly severe backfire burst the aluminum ducting upstream from the heater, and during a later test a violent explosion occurred which ruptured the heater combustion chamber Almost without exception these tests revealed an intense burning in the combustion air intake duct. Subsequent tests disclosed that the airflow through the combustion air duct in normal flight was less than 40 mph and generally below the maximum airflow which will permit upstream flame propagation with aviation gasoline

Both flight tests and ground tests were conducted to determine the rates of flow during transfer of fuel and to ascertain the pressures within the tanks during transfer and overflow These tests indicated that fuel could be transferred from the No. 4 alternate tank to the No. 3 alternate tank when the latter tank was not full without developing pressures sufficiently high to damage the tank structure. However, when the tank became full and fuel began to overflow through the vent the pressure in the tank began to rise. Under high boost the No 3 alternate tank will fill from the No 4 alternate tank at a rate of 20 gallons per minute. After the tank is filled, however, the rate of flow out of the tank vent is approximately 12 5 gallons per minute. It was determined that overflow could be continued for approximately 60 seconds under high boost without resulting in damage to the No 3 tank The difference between the rate of inflow and the rate of outflow, however, eventually creates pressures which would distort the tank and supporting structure

Inspection of the No 3 alternate tank of the Gallup aircraft revealed considerable structural deformation which had resulted from internal pressures in excess of seven PSI. However, no leaks in this tank were observed.

The captain of the flight immediately preceding the flight which terminated at Gallup had reported an internal leakage between tanks in this aircraft. Examination of the aircraft and several tests conducted on its fuel system failed to disclose any leaking selector valves or cross-feed valves It was subsequently determined that the float in the "E" chamber of the No 3 engine carburetor was full of gasoline (a condition known as "logged") The logged float resulted in the carburetor vent return valve remaining open Since the carburetor vent return line from the No. 3 engine is routed to the No. 3 main tank, the flow through the return line would pass to that tank regardless of the source of the fuel to the engine. During one test operation this condition resulted in a return of 31.2 gallons per hour. According to the testimony of the captain of the Gallup aircraft, the volume of fuel in the No 3 main tank increased at the rate of approximately 50 gallons per hour when the engines were drawing fuel from their respective alternate tanks Considering the inaccuracy of the fuel gauges, and the unpredictable positioning of the valve, this rate of increase compared favorably with the probable rate of return of the fuel from the "E" chamber of the No 3 carburetor as a result of the defective float It does not appear, however, that this condition was directly contributory to the fire in this instance.

With two major exceptions the pattern of the fire in the center sections of these aircraft appeared very similar. The first of these exceptions was that a higher concentration of heat appeared to have been present in the trailing edge of the right wing fillet in the Bryce Canyon aircraft than was the case in the Gallup aircraft. This may be explained, however, by the fact that at least one of the flares was ignited in the former aircraft, no flares were carried aboard the latter aircraft.[1] Furthermore, because the burning was more extensive in the Bryce Canyon instance, it appears probable that fuel lines were consumed in the right side of the fuselage adding to the severity of the fire. The second exception is that the fire damage to the supercharger oil cooler and supercharger air aftercooler was more severe in the Gallup aircraft than in the Bryce Canyon aircraft, notwithstanding the more extensive damage in the latter This is adequately explained, however, in that the

[1] Note Immediately following the preliminary investigation of the Bryce Canyon accident the Civil Aeronautics Board promulgated a Special Regulation enabling air carriers operating this model aircraft to remove all landing flares until such remedial action necessary could be effected Thereafter, modifications were made in the aircraft which satisfactorily insulated the flares and their containers from external sources of fire

aftercooler exhaust valve was open in the Gallup aircraft at the time of the fire whereas this valve must have been closed in the Bryce Canyon aircraft This difference in positioning would determine whether or not there was any airflow through the coolers With the exhaust valve open any flames originating in the combustion air intake duct, from a fuel introduced externally, would be drawn into the cooler. The fire would, therefore, attack the cooler with greater severity if the exhaust door were open than would have been the case had this valve been closed

Although the disclosures of this investigation pointed directly toward the probability that gasoline overflow through the No. 3 alternate tank vent and into the cabin heater combustion air intake scoop was responsible for these fires, it was necessary that every other possibility be exhausted. Extensive examination and testing of other DC-6 systems and components were, therefore, accomplished. With the exception of the defective float in the No. 3 carburetor of the Gallup aircraft, no indication of powerplant or fuel system failure was observed in either instance. No evidence was disclosed that the electrical systems were involved in any manner. Some record of irregular operation of the cabin heater micropositioner was noted but, while this irregularity would have caused wider than normal variations in cabin temperatures, it could not have been contributory to the fire in either instance In all other respects the aircraft air conditioning systems appeared to be functioning normally. In neither instance were any deficiencies observed in the cabin supercharging systems, the bearings and oil seals of which were in good condition. Moreover, the supercharging system was not in use in the Gallup aircraft. The cabin heaters, their combustion chamber walls and fuel pressure diaphragms were tested and found to have been in a satisfactory condition prior to impact.

Furthermore, the quantity of fuel required to produce fires of the severity of those observed in these instances points clearly toward a gasoline source of which in excess of 3,000 gallons was carried aboard each aircraft. The location of the engine oil systems precludes the possibility that engine oil may have been involved. The condition of the hydraulic system as determined by the investigation does not suggest that hydraulic fluid may have been involved The small quantity of alcohol and the condition of the alcohol tanks and systems in both aircraft eliminate the possibility that this agent may have been the source of the fire. And, finally, the concentration of the fire in the aft portion of the wing center section indicates clearly that the origin of the fire and the major source of combustion could not possibly have been the baggage within the baggage compartments.

The model DC-6 was certificated by the Civil Aeronautics Administration in accordance with Civil Air Regulation 04b.00. This regulation permits the manufacturer to make application for certification of various aircraft systems and components in compliance with detailed requirements of either Part 04a or 04b. If, however, the manufacturer chooses to seek certification on the basis of Part 04a, he may apply for approval of a specific design detail or system in accordance with the appropriate section of Part 04b, providing that the Administrator finds the standard of safety of such section to be equivalent to the corresponding requirements of Part 04a. The fuel system of the DC-6 was certificated under Part 04b.

With respect to transfer of fuel between tanks, Civil Air Regulation 04b.423 states "In the case of systems with tanks whose outlets are interconnected, it shall not be possible for fuel to flow between tanks in quantities sufficient to cause an overflow of fuel from the tank vent when the airplane is operated as specified in 04b.4221(a) and the tanks are full." Notwithstanding the provisions of the above regulation, the DC-6 fuel system was capable of permitting flow between tanks and overflow of tanks in flight.

Civil Air Regulation 04b.42323 states "The vent shall be of sufficient size to permit the rapid relief of excessive differences of pressure between the interior and the exterior of the tank." Notwithstanding the above requirement, the investigation of these accidents disclosed that the fuel system of the DC-6 was capable of creating tank pressures exceeding by a considerable margin the pressures for which the tanks and surrounding structure were designed to withstand.

With respect to the venting of fuel tanks, Civil Air Regulation 04b.42323 also states "Vents and drainage shall not terminate at points where the discharge

of fuel from the vent outlet will constitute a fire hazard or from which fumes may enter personnel compartments " The Type Inspection Report, Form 283, for the DC-6 contains the following question "Do vents appear to terminate at points where the discharge of fuel vent outlet will not constitute a fire hazard, or from which fumes will not enter personnel compartments? Yes No "
The above question had been answered by the Civil Aeronautics Administration agent responsible for this portion of the type inspection by circling the "Yes" associated with the question Although the significance of such an answer was that the fuel vent outlets were satisfactorily located, it was established in this investigation that no tests were conducted to determine the pattern of fuel flow from the No 3 alternate tank vent, nor was any other attempt made to ascertain whether any hazard existed from the discharge of fuel from this vent. Representatives of both the Civil Aeronautics Administration and the manufacturer testified that the reason such tests were not conducted was that at no time was it contemplated that gasoline would discharge from this vent It was further stated that at no time in the operational history of the aircraft was gasoline known to have escaped from this outlet in flight from any cause.

It was disclosed, however, that gasoline flow from fuel tank vents had been experienced in the Model DC-6 during ground operation. Sudden turns during taxiing and accelerations during take-off were known to have caused gasoline to escape from the outlets In order to eliminate the fire hazard presented by such a condition, a spring loaded valve was installed in each vent system which prevented fuel or vapors from escaping through the vent at pressure below 2 1/2 pounds.

The two inboard alternate tanks in the Model DC-6 are of flexible cell construction. Since the DC-6 incorporates a suction type fuel system, it is necessary that the vent for these tanks be located at points on the aircraft which would provide positive aerodynamic pressure in order to prevent the cell from collapsing when the fuel level is low The points selected for the location of these vents, therefore, were on the under sides of the fuselage close to the leading edge of the left and right wing for the No 2 and 3 alternate tanks, respectively

From the test data available to the Board, it is apparent that the only reasonable cause of fuel flow through the vent in flight is the transfer to overflow of fuel under pressure from one tank to another This transfer may be accomplished by turning the appropriate selector valves to the tanks to which and from which the transfer is to be made, turning the cross-feed between these tanks on, and operating the fuel booster pump at the tank from which transfer is to be made The above adjustment of cockpit controls will result in an open line between two tanks through which gasoline will flow. It was common knowledge that fuel transfer in the DC-4, which possesses a similar fuel system, was widely practiced prior to the certification of the DC-6. Furthermore, the pilots who conducted the initial transition training of the air carriers' crews were in the employ of the manufacturer and these pilots demonstrated to the air carrier crews the methods of fuel transfer described above It was apparent from this investigation that a large proportion of the pilot personnel of DC-6 operators frequently transferred fuel in flight from tank to tank through the cross-feed system under fuel pressure boost Such a practice was known to the Civil Aeronautics Administration whose operation inspectors had frequently witnessed fuel transfer being practiced in air carrier operation

As has been described previously in this report, the failure of the pilot to stop the transfer process when the tank to which fuel is being pumped has been filled to capacity will result in the flow of gasoline out the vent line Since the capacity of the vent line will not permit overflow at the same rate as the gasoline enters the tank under pressures less than those which the tank is designed to withstand, damage to the tank structure or vent system may result Furthermore, because of the relative location of the vent and the cabin heater scoop such overflow would enter the scoop and thereby constitute an obvious fire hazard

Prior to the certification of the DC-6 the manufacturer had completed a DC-6 Operation Manual which contained a summary of the aircraft systems and components and an outline of the proper aircraft operating procedures. At the time of certification a CAA approved Aircraft Operating Manual was prepared for the DC-6 containing the detailed operating procedures for this aircraft which required the approval of the Civil Aeronautics Administration. Neither of the above manuals contained any description of fuel transfer procedures, nor did they contain any indication that transfer of fuel was an acceptable practice in this model aircraft. The testimony of the manufacturer indicates that fuel transfer was neither contemplated, nor intended in the design of the DC-6 fuel system. However, at no time were the air carriers cautioned against fuel transfer, nor was any indication given that fuel transfer could not be accomplished as a matter of routine practice with complete safety. In addition to these manuals both American Airlines and United Air Lines had prepared aircraft operation manuals for their respective pilot personnel which also contained the approved procedures for operating the DC-6. The American Airlines' manual refers to fuel transfer in its discussion of fuel dumping procedures, with this exception, however, no mention is made in any of the above manuals of fuel transfer. Neither of the above carriers had established elsewhere any procedures for fuel transfer, nor had they instructed their pilots concerning company policy with respect to the practice of fuel transfer

The return ducts of the cabin heating and air conditioning system all lead to and terminate in the air conditioning compartment, commonly referred to as the "boiler room " A pressure control valve is located on the lower left aft side of this compartment through which the air discharge of the heating and ventilating ducts is exhausted from the aircraft. Any fire extinguishing agent directed to the boiler room would immediately pass out the exhaust valve unless this valve was closed at the time of discharge. The closing of this valve is therefore an essential element in the sequence of emergency fire procedures in aircraft in which means for discharge of a fire extinguishing agent into this compartment have been provided. So long as this valve remains open and the ventilating system is in operation, a forced draft through the boiler room exists at a relatively high air replacement rate

In the instance of the Gallup fire, the aircraft was operating with the pressure control valve open because of the inoperation of the cabin supercharging system. A placard had been taped across the manual control door in the instrument panel which read, "Do not close door, do not push button " These instructions, unqualified as they were, would mean that the pressure control valve was to remain open at all times notwithstanding the fact that the fire extinguishing actuating switch for the boiler room was placarded, "Push increase cabin pressure button " Although the pilot directed the carbon dioxide to the boiler room in this instance, the pressure control valve was not closed and the effectiveness of the agent was, therefore, considerably minimized as it was rapidly exhausted through the open port.

Prior to these accidents, serious consideration had been given to the possibility of inadvertent ignition of photoflash bulbs in aircraft interiors as a result of radio short wave excitation. Other studies had been made concerning the possibility of igniting inflammable materials surrounding such bulbs under various means of ignition and conditions of packing and storage. Because of the public concern which had been demonstrated over the possible fire hazard resulting from inadvertent flashing or exploding of photoflash bulbs, and since it appeared that photoflash bulbs were being carried in the baggage compartment of at least one of the aircraft involved in these accidents, in the course of the investigation of these accidents, the Board initiated a study to determine whether such a hazard exists in fact. While it had been noted that under carefully controlled laboratory conditions ignition is possible through means other than those normally used when the bulbs are utilized for photoflash activity, the Board found that such conditions were not common to air transportation. Tests conducted in the Board's study of this problem indicated that the possibility of inadvertent ignition through any means is extremely remote when such bulbs are carried in an aircraft interior. Moreover, it has been clearly demonstrated that, even if such bulbs could be ignited within shipping containers or baggage, the amount and rate of heat dissipation is insufficient to ignite even the most highly inflammable material normally carried aboard aircraft.

Discussion

From the foregoing investigation it can be concluded that in both aircraft gasoline had overflowed the No 3 alternate fuel tank through the vent outlet in flight and had entered the cabin heater combustion air intake scoop An excessively rich mixture entering the cabin heater resulted in backfiring into the intake ducts and fire subsequently penetrated the air conditioning compartment. In both instances the cause for the overflow of the No. 3 alternate tank was without doubt the inadvertent failure of the flight crew to stop the fuel transfer process before filling the tank.

The Civil Air Regulations under which the DC-6 was certificated specifically required that vents such as that involved in these accidents should be so tested as to determine whether any hazardous condition exists upon the discharge of gasoline through such outlets. Such tests were not conducted. This particular hazardous condition was found to exist in this model aircraft, notwithstanding the fact that the Type Inspection Report required a determination to be made as to the location of the vent outlets

Fuel transfer procedures were not specifically authorized within either the Civil Aeronautics Administration's approved aircraft operating manual or the manufacturer's DC-6 operation manual Despite this fact, however, the air carriers were instructed by representatives of the manufacturer in the methods of fuel transfer, after which such practices were followed by their pilots There is no indication that the Civil Aeronautics Administration investigated the propriety of these air carrier fuel transfer practices.

The hydraulic-fluid-soaked condition of the baggage compartment lining is not novel in investigation of transport category aircraft accidents since the inspection of another transport aircraft, not a DC-6, in 1946, accomplished after an accident involving fire in the forward baggage compartment, revealed a condition very similar to the one found to exist in the Model DC-6 several months later. The gravity of this situation is amply reflected in the fact that in neither model was there found a single aircraft in operational service which was free from such hydraulic fluid accumulation. In both instances it was demonstrated that fires of great intensity resulted from the ignition of the hydraulic fluid due to the effective dissipation of the fluid through the non-combustible fibrous blankets of the baggage compartment lining Although considerable progress has been made during the past year in the further development of a non-inflammable hydraulic fluid, the urgency of expediting the operational use of such fluids is also clearly indicated.

As a result of these investigations, a thorough analysis of the Model DC-6 was made and agreement reached in the combined government-industry Modification Board concerning modification of DC-6 aircraft before they were returned to operational service. The DC-6 fuel system is being modified to prevent the transfer of fuel between tanks by the inclusion of check valves in the fuel lines. The Nos. 2 and 3 alternate tank vents have been relocated to areas from which no hazard could exist through possible egress of fuel or fuel vapors. A separate intake scoop has been provided for cabin heater combustion air Stainless steel combustion air intake ducting has been provided for all heaters The fuselage air outlet duct has been extended so as to exhaust air overboard and not into any fuselage compartment. Shrouds have been installed around all flare containers. Smoke detectors were installed in the air conditioning compartment[2] and additional fire detectors were provided in all fuselage belly compartments. Inspection openings in the cabin floor have been provided to permit visual inspection of all belly compartments in flight. A guard has been provided for the fuel booster pump switch. Redesign of the cockpit fire warning signals and actuating handles has been accomplished to simplify cockpit emergency procedures.

[2] The CAA, on June 30, 1948, authorized all carriers concerned to disconnect all cargo compartment smoke detector systems until such time as a more reliable unit could be provided The CAB concurred in this action

In addition to the above items, numerous modifications are being accomplished affecting the air conditioning system, the electrical system, the fuel system and the aircraft structure which are designed to minimize further the possibility of fire in flight The investigation has disclosed the cause of these accidents so precisely and the required modifications have been so extensively accomplished that there is no reason to doubt that the causes of these accidents have been effectively eliminated through such modifications

Findings

On the basis of the above investigation the Board finds that

1 The air carriers and crews were properly certificated

2 Both aircraft involved in these accidents were individually certificated in accordance with the type certificate issued by the Administrator of Civil Aeronautics for the DC-C

3. No power plant, fuel, electrical, or air-conditioning system failures were directly contributory to the accidents.

4. In each instance the flight crews of these aircraft transferred fuel either intentionally or inadvertently from the No 4 alternate tanks to the No. 3 alternate tanks and failed to stop the transfer process in time to avoid overflowing the No 3 alternate tanks.

5. Gasoline flowed through the No 3 alternate vent line, out the vent, and was carried back by the slip stream entering the cabin heater combustion air intake scoop

6 In both instances the cabin heaters were in operation before the accident and ignited the gasoline entering the scoop causing the fuel to burn in the intake ducting and thereafter to penetrate into the air conditioning compartment.

7 Although the fuel system of the Model DC-6 as initially designed and certificated was readily adaptable to fuel transfer in flight, no tests were conducted by the Civil Aeronautics Administration to determine the hazard of fuel overflow in flight through the No. 3 alternate fuel tank vent in the type inspection of the Model DC-6, nor were the operators of DC-6 aircraft advised of the possible hazard involved in transferring fuel between tanks during flight

8. While transfer of fuel between tanks in the Model DC-6 was a common practice and known to personnel of the manufacturer, the air carrier, and the Civil Aeronautics Administration, no fuel transfer procedure had been established by any of these parties

Probable Cause

The Board determines that the probable cause of these accidents was the combustion of gasoline which had entered the cabin heater combustion air intake scoop from the No 3 alternate tank vent due to inadvertent overflow during the transfer of fuel from the No 4 alternate tank

The failure of the manufacturer and the Civil Aeronautics Administration to exercise full caution in the analysis of the fuel system of the DC-6 relative to proper location of fuel tank vents to provide non-hazardous location for fuel drainage, as required by existing regulations, and the insufficient attentiveness on the part of the manufacturer, the Civil Aeronautics Administration, and the air carriers to the procedures of fuel management employed by pilots operating DC-6 aircraft, were contributing factors

BY THE CIVIL AERONAUTICS BOARD

/s/ *JOSEPH J O'CONNELL, JR*
/s/ *OSWALD RYAN*
/s/ *JOSH LEE*
/s/ *HAROLD A JONES*
/s/ *RUSSELL B ADAMS*

Supplemental Data

Investigation and Hearing

The Civil Aeronautics Board was notified of the accident involving United Air Lines at Bryce Canyon, Utah, at 1240,* October 24, 1947 Investigators from the Board's Santa Monica office proceeded to Bryce Canyon, arriving at the scene of the accident at 1810, the same day. A public hearing was ordered and the first session was held at Panguitch, Utah, November 4, 1947. This hearing was reconvened at Santa Monica, California, December 18 and 19, 1947

Notification of the accident involving American Airlines at Gallup, New Mexico, was received at 1415, November 11, 1947, and personnel from the Board's Santa Monica office arrived at the scene of the accident at approximately 1830, the same day Investigation of each accident was immediately initiated after notification in accordance with the provisions of Section 702(a)(2) of the Civil Aeronautics Act of 1938, as amended A public hearing was ordered and was held in Santa Monica, California, December 15, 16, 17, and 18, 1947

Air Carriers

United Air Lines was incorporated in the State of Delaware and maintains its headquarters in Chicago, Illinois United Air Lines possessed a certificate of public convenience and necessity and an air carrier operating certificate, both issued pursuant to Civil Aeronautics Act of 1938, as amended These certificates authorized United Air Lines to engage in the air carriage of persons, property, and mail between various points in the United States, including Los Angeles, California, and Chicago, Illinois.

American Airlines was incorporated in the State of Delaware and maintains its general offices in New york, New York. At the time of the accident American Airlines possessed a certificate of public convenience and necessity and an air carrier operating certificate, both issued in accordance with the Civil Aeronautics Act of 1938, as amended. These certificates authorize American Airlines to engage in the transportation by air of persons, property, and mail between various points in the United States, including San Francisco, California, and Tulsa, Oklahoma.

*All times referred to herein are Mountain Standard and based on the 24-hour clock

Flight Personnel

Captain F. L. McMillan, age 42, Los Angeles, California, was pilot of the United Air Lines' aircraft and at the time of the accident possessed an airline transport pilot rating He had accumulated a total of approximately 15,000 hours, of which 138 hours had been in DC-6 aircraft G G Griesbach, age 25, was co-pilot and possessed an airline transport pilot rating. Until the date of the accident he had accumulated a total of 3,046 hours, of which 66 hours had been in DC-6 aircraft. H F Morrissey, Shirley E. Hickey, and Sabina H. Joswich were stewardesses. Both pilots were properly certificated and the captain was qualified over the route.

E. W Chatfield, age 42, of Tulsa, Oklahoma, was pilot of the American Airlines' aircraft On the date of the accident he possessed an airline transport pilot rating and had accumulated a total of 9,747 hours, of which 435 hours had been obtained in DC-6 aircraft. V. B Brown, age 32, of Tulsa, Oklahoma, was co-pilot. He possessed an airline transport pilot rating and until the date of the accident had accumulated a total of 3,572 hours, of which 417 hours had been obtained in DC-6 aircraft Evelyn Apitz and Marilyn Humphreys were stewardesses. Both pilots were certificated and the captain was qualified for the route.

Aircraft

The United Air Lines' DC-6, NC-37510, had been operated a total of 933 hours since its original manufacture in March 1947 It was equipped with four Pratt and Whitney R-2800 engines, in which Hamilton Standard propellers were installed. At the time of departure from Los Angeles, California, the total weight of the aircraft was less than the maximum allowable and the load was distributed with respect to the center of gravity within approved limits

The American Airlines' DC-6, NC-90741, had been operated a total of 142 hours since its original manufacture in October 1947. It was equipped with four Pratt and Whitney R-2800 engines, on which Curtiss electric propellers were installed At the time of departure from San Francisco, California, the total weight of the aircraft was less than the maximum gross and the weight was distributed with respect to the center of gravity within approved limits