CIVIL AERONAUTICS BOARD

ACCIDENT INVESTIGATION REPORT

Adopted: July 28, 1949 Released: August 2, 1949

UNITED AIR LINES, INC., NEAR MT. CARMEL, PENNSYLVANIA, JUNE 17, 1948

The Accident

United Air Lines' Flight 624, a DC-6 airplane, NC-37506, en route from Chicago, Ill , to New York, N. Y., crashed three miles east-northeast of Mt. Carmel, Pa., at 1241,[1] June 17, 1948 All 43 occupants were killed and the airplane was destroyed

History of the Flight

The airplane arrived in Chicago, Ill., at 0952, June 17, 1948, en route from Los Angeles, Calif., to New York City At Chicago the airplane was given a routine station inspection, serviced, loaded, and the flight departed for New York with a new crew at 1044. Aboard were 39 passengers, a crew of four, 2,568 pounds of cargo, and 1,800 gallons of fuel, all properly loaded. The resulting total airplane weight was within the certificated gross weight The airplane climbed en route to its planned altitude of 17,000 feet, proceeding on course, and at 1155 the captain reported to the company radio at LaGuardia Field, N Y , that the airplane was mechanically "okay" for a return trip. A routine report was made over Phillipsburg, Pa , approximately 500 miles east of Chicago, at 1223, and at 1227 the crew made a routine acknowledgment of a clearance to descend en route to an altitude between 13,000 and 11,000 feet. Four minutes later, at 1231, the company radio operator at LaGuardia Field heard a voice which did not identify itself calling loudly and urgently. Another United crew in a DC-3, flying over the same route behind Flight 624 and at a different altitude, heard what they termed "screaming voices" calling "New York." Then, after an unintelligible transmission, "This is an emergency descent." Inasmuch as all other air carrier flights in the vicinity at this time were accounted for, this transmission undoubtedly emanated from Flight 624

The airplane was first observed by ground witnesses 31 miles northwest of the scene of the accident flying a southeasterly heading toward Shamokin, Pa. The airplane flew over the Sunbury Airport, Sunbury, Pa., at approximately 4,000 feet above the ground on a southeasterly heading. Immediately north of Shamokin the airplane, then only 500 to 1,000 feet above the ground, described a shallow left turn. The course was toward constantly rising terrain, the hills around Sunbury being 900 feet in elevation and the hills around Shamokin being approximately 1,600 feet in elevation Five miles east or beyond Shamokin the airplane, flying only 200 feet above the ground, entered a right climbing turn. As it passed to the north of Mt. Carmel, the climbing turning attitude increased sharply. The airplane then struck a hillside at an elevation of 1,649 feet. Within ten miles of the flight path and the scene of the crash there were areas on which an emergency landing could have been made.

Investigation

NC-37506 crashed approximately three miles east-northeast of Mt Carmel, Pa., in a power line clearing on wooded mountainous terrain The airplane struck a 66,000 volt transformer and severed power lines. The time at which this occurred was automatically recorded at the Culpment, Pa. steam electric station at 1241.

An explosion just after impact scattered the wreckage over an area 580 feet long and 175 feet wide. A flash fire followed, scorching and smudging parts of the wreckage throughout the entire area.

A considerable number of the pieces of the airplane were identified

[1] All times noted in this report are Eastern Standard and based on the 24-hour clock

The smoke detector and five of the six fire detectors installed in the forward baggage compartment were found. The inlet duct adapter (detector manifold) installed in the boiler room, which receives air from the smoke detector, was also found. Inspection of the fire detector units revealed no soot, smoke or evidence of burning, and smudge tests made on the interior of the smoke detector adapter showed no trace of smoke The normal complement of six 15-pound CO_2 bottles was found in a damaged condition from the impact. The six CO_2 discharge valves were also accounted for, however, they had been broken from their respective bottles by impact, thus allowing the contents, if any, of the bottles to be released. The bottles when found were empty Other pieces from all sections of the airplane were examined for indications of in-flight fire or smoke, and many of these were also subjected to laboratory tests for indications of gases or of smoke from various sources. On the basis of these tests and the testimony of the ground witnesses, we conclude that no fire had existed aboard the airplane prior to the time of impact.

Although the recording of the crew's last transmission to New York at 1231 is intelligible only in part, it is clear from the recording that one or both pilots were reporting that fire extinguisher had been released in the forward cargo pit (the forward underfloor baggage compartment), and that the flight was making an emergency descent Inasmuch as this report indicated the possibility of fire, it is pertinent to note in evaluating this fact that from January 1, 1948, through June 30, 1948, 22 false warnings of fire detectors in fuselage compartments, and 285 false warnings of smoke detectors were reported on air carrier airplanes.[2]

[2] In view of the large number of false warnings being reported by the carriers, some of which had resulted in precautionary landings at unscheduled stops, the CAA, on April 28, 1948, authorized operators to disconnect the smoke detector units where their records showed that false alarms were being caused by the detector units themselves and not by faulty installation or maintenance On June 30, 1948, the Administrator authorized the carriers to disconnect all smoke detectors without showing the necessity therefor, the Board concurred in this action United had experienced 44 false smoke detector warnings from January 1, 1948, through the first week in May, 1948, but elected not to disconnect the units Research and tests are now in progress to improve the reliability of the smoke detectors Efforts are also being exerted to improve the reliability of the fire detectors

Operating and maintenance records indicate that the airplane was in good mechanical condition at the time of its departure from Los Angeles and Chicago. Since the crew reported the airplane to be "okay for turn around" less than an hour before the accident, and since no report of mechanical difficulty was received subsequently, it would appear that the airplane was operating satisfactorily during the flight.

Examination of the power plants and their components disclosed no evidence of malfunctioning during flight The lacerations on the propeller blades, the blade pitch settings, and the twisted front main power cases showed that the engines were developing power at the time of impact. The investigation disclosed that the landing gear was fully retracted at the time of impact, but, because of the extensive breakage of the aircraft, the position of the flaps could not be determined

The manual control which actuates the cabin pressure relief valves, and which is located to the right of the copilot's seat, was found in the wreckage. The control handle is attached to a drum over which an operating cable is wound When the cabin relief valves are open, there are about one and one-quarter complete turns of cable winding on the drum. When the valves are closed, only one-quarter turn of winding appears on the drum. The drum as found had only 90 degrees of cable winding. This, in addition to the marks left on the parts of the control mechanism and tests conducted on cabin emergency relief valves and control mechanism, leads us to the conclusion that the cabin pressure relief valves and the cockpit control were in the closed position at the time of impact The cabin superchargers attached to the Nos 1 and 4 engines were examined by metallurgists No evidence that these parts were rotating at the time of impact was found and it appears therefore that the cabin superchargers had been declutched by the crew in flight.

When the DC-6 airplane is pressurized, air escapes from one fuselage compartment to another since all pressurized compartments are not air tight Consequently, when CO_2 gas is discharged into an under-floor fuselage compartment to extinguish fire, some of the gas will escape into the cockpit and cabin. To prevent a concentration hazardous to

crew personnel and passengers, the following procedure was established for operation of the fire extinguisher system.[3]

"1 Cabin superchargers—DECLUTCH.
2 Emergency pressure control—Rotate fully open, this will open relief valve also WARNING—Failure to open valve may result in excessive amounts of CO_2 in cockpit and cabin.
3 Compartment CO_2 selector—Pull fully out
4 Discharge one CO_2 selector—Pull out (15 seconds after declutching)
5 Descend immediately to minimum safe altitude
6. If by inspection a second CO_2 discharge is necessary, repull compartment selector and then discharge second CO_2 supply
7. If fire is not under control at this point—LAND IMMEDIATELY "

NC-37506 was manufactured in March 1947. The DC-6 as a model received a type certificate on June 23, 1947. At the time it was type-certificated, the DC-6 incorporated the fire precautions prescribed for aircraft certificated under the transport category by sections 04b 49 and 04b.38251 of the Civil Air Regulations The pertinent parts of these sections read as follows

"04b 49 *Power plant fire protection* Unless it can be demonstrated that equivalent protection against destruction of the airplane in case of fire is provided by the use of fire resistant materials in the nacelle and other components that would be subjected to flame, fire extinguishers shall be provided. These shall be provided for the accessory sections, installations where no isolation is provided between the engine and accessory compartments, auxiliary power plants, fuel burning heaters, and other combustion equipment. Such regions shall be referred to as designated fire zones.

"04b 38251 (c) Cargo and baggage compartments shall be classified in the "C" category...(if not accessible to the crew during flight.) Each compartment of the "C" category shall be equipped with (1) a separate system of an approved type smoke detector or fire detector other than heat detector to give warning at the pilot or flight engineer station, and (2) an approved built-in fire-extinguishing system controlled from the pilot or flight engineer station. Means shall be provided to exclude hazardous quantities of smoke, flames, or extinguishing agent from entering into any compartment occupied by the crew or passengers. Ventilation and drafts shall be further controlled within each such cargo or baggage compartment to the extent that the extinguishing agent provided can control any fire which may start within the compartment. All cargo and baggage compartments of this category shall be completely lined with fire-resistant material, except that additional service lining of flame-resistant material may be employed."

All DC-6 aircraft were withdrawn from service in November 1947 for extensive modification. Inasmuch as such modifications were deemed to constitute major alterations of the aircraft, the Civil Aeronautics Administration considered that the provisions of section 04b.38251 of the Civil Air Regulations were applicable to the modified aircraft and that the aircraft was therefore subject to the proof of compliance requirements of section 04b.38252,[4] as well as to the requirements of section 04b.4910 [5] At the completion of the modification program flight tests were made in January 1948 for CO_2 concentrations in the habitable compartments of a modified DC-6. During one of these tests, the concentration of

[3] This procedure was set forth in the "CAA Approved Airplane Operating Manual," revised, p 47, dated Feb 26, 1948, and was in effect at the time of this accident (Sec 4b 62 of the Civil Air Regulations)

[4] *04b 38252 Proof of compliance* Compliance with those provisions of § 04b 38251 which refer to the compartment accessibility, the entry of hazardous quantities of smoke or extinguishing agent into compartments occupied by the crew or passengers, and the dissipation of the extinguishing agent in category "C" compartments shall be demonstrated by tests in flight It shall also be demonstrated during these tests that no inadvertent operation of smoke or fire detectors in adjacent or other compartments within the airplane would occur as a result of fire contained in any one compartment, either during or after extinguishment, unless the extinguishing system floods such compartments simultaneously

[5] *04b.4910 Fire extinguishing agents* Extinguishing agents employed shall be methyl bromide, carbon dioxide, or any other agent which has been demonstrated to provide equivalent extinguishing action If methyl bromide or any other toxic extinguishing agent is employed, provisions shall be made to prevent the entrance of harmful concentration of fluid or fluid vapors into any personnel compartments either due to leakage during normal operation of the airplane or as a result of discharging the fire extinguisher on the ground or in flight when a defect exists in the extinguisher system If carbon dioxide is used, it shall not be possible to discharge sufficient gas into personnel compartments to constitute a hazard from the standpoint of suffocation of the occupants

CO_2 which occurred in the cockpit was sufficient to cause partial incapacitation of the crew. On board the airplane at that time was an official representative of the Civil Aeronautics Administration and a representative of the Air Line Pilots Association.

Following the January flight tests during the modification program, an additional cabin pressure relief valve below the floor and at the rear of the cabin was installed which provided greater ventilation and consequently lower concentrations of CO_2 in the cockpit and cabin. After this and other changes, flight tests were again conducted during which one and two banks of CO_2 were discharged at varying time intervals in the under-floor fuselage compartments with the airplane in a descent from 20,000 feet at 300 m.p.h. Concentrations in the cockpit were then found to be no greater than two percent. These tests, as observed and reported in a supplemental Type Inspection Report dated March 1, 1948, were accepted by the Administrator as satisfactory The above did not include tests for the simultaneous discharge of both banks of CO_2 in the under-floor forward baggage compartment. Moreover, no tests were made for discharge of one or two banks of CO_2 in the fuselage compartments when the airplane was in a descending configuration with flaps and gear fully extended, though such a descending configuration was authorized in the CAA Approved Airplane Operating Manual.

As a result of the flight tests following the modification, the Douglas Aircraft Company not only made changes in the ventilating system, as previously mentioned, but also revised the procedure for the operation of the fire extinguishing system. The language of this procedure specifically included the warning "Failure to open valve (cabin relief valve) may result in excessive amounts of CO_2 in the cockpit and cabins." This revised procedure was required to be placed in the DC-6 Approved Airplane Operating Manual by CAA Airworthiness Directives of March 8 and March 15, 1948. The manual was a part of the equipment required on the airplane. United Air Lines included the revised procedure in its own operations manual and in its airplane check list although the warning, as quoted above, was omitted.

Following the January flight tests, the Douglas Aircraft Company employed a medical specialist of the Lovelace Clinic to make a study of human tolerance to CO_2 gas. That study, which did not purport to be the result of an original research effort by the Clinic, but merely a compilation of known information on the subject, was completed on February 7, 1948. It showed that the maximum allowable CO_2 concentration at sea level for all operating personnel should not exceed five percent for more than five minutes and that the gas had a toxic effect on the body, increasing the rate of breathing, irritating the eyes, nose and mouth, creating muscular weakness and lack of coordination and causing dizziness, faintness and frontal headaches This report was under study by the Douglas Company during the subsequent months but was not released until after the date of the accident.

The Air Line Pilots Association on March 3, 1948, recommended to the Civil Aeronautics Administration and the Civil Aeronautics Board that "smoke masks type oxygen equipment be required available for all members of the crew on transport aircraft." The reason for the recommendation was to "assure that the crew would be able to carry on their work of landing the aircraft safely in spite of possible smoke interference in case of an aircraft fire." The proposal for the installation of smoke masks type oxygen equipment was considered by the CAA to be a proposal for safeguarding against smoke hazards which would be additional to the safeguard provided by the emergency smoke clearance procedures previously tested and approved for DC-6 aircraft. Because the CAA had witnessed the flight test for both smoke and CO_2 hazard in the cockpit of the DC-6 which had been conducted in February 1948, and had found that the smoke evacuation procedure and the emergency fire procedure were adequate to prevent hazardous concentrations of smoke and CO_2 in the cockpit, that agency considered that the additional protection of a smoke mask was unnecessary at that time. The CAA received a second letter, dated April 13, 1948, from the Pilot's Association relative to the need for smoke masks, which letter also mentioned for the first time the CO_2 hazard. Following receipt of this second letter the CAA instituted a

medical study of the effect of smoke and noxious gases on flight crews. This study was not completed until after the Mt Carmel accident [6]

Knowledge of human tolerance to CO_2 gas is still incomplete, particularly as to concentration and the period of exposure Medical testimony received during the course of the hearing was not entirely consistent One specialist fixed the hazard at three percent for any length of time at sea level, another at five percent for five minutes at sea level, and the third believed that the existing data were not sufficient upon which to base a standard. It is known, however, that individual resistance depends upon many factors, such as age, activity level of the individual, personality type, altitude, temperature, humidity, and the presence of other toxic gases It is also known that the effect of CO_2 gas is initially to stimulate, and then as the concentration grows higher, to depress If, thereafter, air free of CO_2 is breathed, recovery is rapid, and within one to two minutes sensible volitional behavior is possible But during the early part of the recovery the subject is apt to be confused and irrational Upon emerging from the effects, some individuals will continue the activity in which they were engaged prior to losing consciousness. Since CO_2, physiologically, displaces oxygen rapidly, it is possible for the subject to lose consciousness and recover without being aware of it. Although medical specialists differ regarding human tolerance to CO_2, and further research is necessary, one fact is well established CO_2, in addition to reducing the oxygen content of the air, produces a positive, anesthetic effect on the central nervous system.

On May 13, 1948, a crew in a TWA Constellation, cruising at 19,000 feet, experienced a false fire warning in a forward cargo compartment. CO_2 was released in the compartment, and due to the design of the airplane, including a circulating booster fan, CO_2 gas entered the cockpit and partially incapacitated the crew.[7] An emergency landing was successfully made at Chillicothe, Missouri. Immediately upon receipt of notification of the Chillicothe incident on May 14, the Board transmitted by telephone to the Director of Aircraft Service of the CAA the information which it had obtained. This information was confirmed the following day by letter. Following this incident, tests were conducted on June 9, 1948, in the same airplane by the carrier involved, with representatives of the Administrator and the Board present. Under the same conditions as existed for the flight of May 13, a concentration of CO_2 in the cockpit was experienced sufficient to cause one of the crew members to lose consciousness.[8]

On June 10, 1948, the Air Transport Association sent the following telegram to all DC-6 operators "Following information received from TWA Flight tests simulating forced landing at Chillicothe revealed serious oxygen deficiency in cockpit when CO_2 bottles are pulled in cargo compartment. Recommendations to flight crews include following steps (1) De-pressurize, (2) open cabin window, (3) open cockpit window, (4) then pull CO_2. Under all circumstances oxygen should be used before releasing CO_2. It has been recommended to us by TWA that a similar situation may exist on DC-6 aircraft. Therefore, suggest if possible you carrying out necessary tests to determine if such can occur to DC-6. ."

A copy of this telegram was sent to the Douglas Aircraft Company, and subsequently thereto, by telegram dated June 14, but not received by Air Transport Association until approximately noon of June 15, Douglas replied as follows "Reference your telegram June 10 to DC-6 operators regarding CO_2 concentration in cockpit of Constellation Douglas made CO_2 smoke evacuation tests on DC-6 for CAA purposes in February of this year

[6] This study culminated in Aviation Safety Release No 295, issued by the CAA on July 22, 1948, which outlined the available remedial measures for the protection of crews against smoke and noxious gases, including the use of gas masks, gas-tight goggles, oxygen equipment and ventilation

[7] An investigator of this incident was conducted by the Board, and corrective action was taken by the Administrator

[8] On June 11, 1948, the Board notified officials of United, at its principal operating base in Denver, of the results of the Constellation tests The Board on June 9, 1948 also immediately transmitted the information concerning the tests to the Director of Aviation Safety of the CAA and to the Air Transport Association and all carriers using the Constellation aircraft The Director of Aviation Safety of the CAA on June 10, 1948, informed all CAA regional administrators by telegram that it had been reported that rapid descent following discharge of CO_2 in the forward belly cargo compartment of the Lockheed 49 aircraft (Constellation) causes a dangerously high concentration of CO_2 on the flight deck and that it had tentatively been established that utilization of emergency cockpit smoke clearance procedure would alleviate this condition

with entirely satisfactory results. Test summarized in Douglas report in DEV-133 report, dated February 20, entitled 'CAA Certification Tests, Fuselage CO_2 Concentration and Smoke Evacuation Procedure for a DC-6' Copies of this report are available upon request. Please contact all recipients of your June 10 wire and withdraw any reference to DC-6 aircraft as tests you recommended are extremely hazardous to conduct, requiring considerable emergency equipment. Also recommendation regarding smoke evacuation for other aircraft does not necessarily apply to DC-6. All recommendations presently in force by DC-6 operators based upon extensive tests made under varied conditions carrying CAA approval. Believe you should use extreme caution in issuing instructions of this nature on DC-6 aircraft without prior coordination with Douglas.. "

Subsequent to the receipt of that telegram and not having a copy of the report, referred to in the telegram as DEV-133, the Air Transport Association on June 15 dispatched another telegram to all DC-6 operators as follows. "Re mytel June 10, regard DC-6 CO_2 concentration possibilities Have been advised by Douglas this adequately covered by their report DEV-133 results of which were included on DC-6 Operations Manual..." However, on or about June 15 United decided to instruct all of its DC-6 crews to use oxygen masks when CO_2 is released. A company bulletin to this effect was being prepared at the time of the accident.

Captain Warner completed a company course in the operation of the DC-6 on May 28, 1948, and had accumulated approximately 30 hours on these airplanes. First Officer Schember completed a DC-6 course on June 12, 1947, and was given a refresher course on March 14, 1948, following modification of the airplane. Schember had accumulated approximately 129 hours in DC-6 airplanes.[9] It was the policy of the carrier to assign more experienced first officers with newly assigned captains on DC-6 equipment.

Following the Mt. Carmel accident, Douglas Aircraft Company conducted 59 individual flight tests for CO_2 concentrations in the cockpit and cabin. Some of those tests were made in accordance with the emergency fire procedure as set forth in the CAA Approved Airplane Operating Manual and it was found that in a descent from 20,000 feet at 300 miles per hour, flaps and gear up, no concentrations of CO_2 were found in excess of 4 2 percent. The 4 2 percent concentration occurred as a peak in one test, the average concentration for that test being only 2 percent for a period of three minutes When a descent was made from 20,000 feet with flaps and gear down at 160 miles per hour, a descending configuration authorized by the CAA Approved Airplane Operating Manual for the DC-6, again following the emergency procedure, a peak concentration was found of 7 8 percent. The average for this test was 6 3 percent over a period of six minutes The 6.3 percent concentration reduced to a sea level value resulted in an average of approximately 4.8 percent for the period of six minutes.

Analysis

The crew's last transmission reported the release of the fire extinguisher in the forward cargo pit (the forward underfloor baggage compartment). There can be little doubt that this discharge of CO_2 was due to the pilot's belief that a fire actually existed in an under-floor fuselage compartment. Yet examination conducted during the course of the investigation showed that no in-flight fire had actually existed in any of the fuselage compartments.

Ten minutes elapsed between the crew's last call announcing an emergency and the time of the accident. This period of silence, coupled with the fact that the airplane while descending passed over visible emergency landing areas, including Sunbury Airport, and flew toward mountainous terrain where safe landing could not be accomplished, admits of only one explanation that the pilots were physically unable to perform their flight duties Since the crew reported releasing CO_2 in the forward baggage compartment, and since it was established that the cabin pressure relief valves were closed, it is reasonable to conclude that a dangerous concentration of CO_2 existed in the cockpit. According to the expert medical testimony, a six percent concentration for three minutes would have reduced the pilots to a state of confused consciousness and a higher concentration or a

[9] This training included a study of the procedure for operating the fire extinguishing system as printed in the United Air Lines Operations Manual

greater time of exposure would have resulted in loss of consciousness.

The investigation disclosed that the cabin pressure relief valves were closed prior to the accident, indicating that the pilot and co-pilot had not followed the approved emergency procedure when discharging CO_2 gas into the forward baggage compartment As previously noted, the extensive breakage of the airplane did not permit a determination as to the position of the flaps at the time of impact However, the retracted position of the landing gear would indicate that the crew had elected to descend at the 300-mile per hour configuration. Had the crew followed the emergency procedure on such a descent configuration it appears that the accident would have been avoided Although the retracted position of the landing gear points toward a descent configuration of 300 miles per hour, we recognize the possibility that had the crew elected to make a descent at 160 miles per hour, with flaps and gear extended, according to the Douglas tests performed after the accident, a hazardous concentration of CO_2 gas would have existed in the cockpit even though the pilots had adhered strictly to the approved emergency procedure.

Findings

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

1 The pilots, aircraft and carrier were duly certificated

2 One or both of the pilots of the aircraft, in a radio transmission received at 1231 on June 17, 1948, by the company radio at La Guardia Field, reported that fire extinguisher had been released in the forward cargo pit and that the flight was making an emergency descent

3 The aircraft, after descending to a low altitude, assumed an erratic course in the direction of constantly rising terrain and finally crashed into a transformer in a power line clearing on wooded mountainous terrain approximately three miles east-northeast of Mt. Carmel, Pa.

4 The aircraft in its descent flew over the Sunbury Airport, Sunbury, Pa at an altitude of approximately 4,000 feet On or within ten miles of the flight path and the scene of the crash there were other visible areas on which an emergency landing could have been made

5. A fire warning caused the crew to discharge at least one bank of the CO_2 fire extinguisher bottles in the forward cargo pit (the forward underfloor baggage compartment).

6 Six 15-pound CO_2 bottles and six discharge valves were found in the wreckage, however, both the bottles and the valves (which had become separated from their respective bottles upon impact) were so damaged that no conclusions could be drawn as to how many of such bottles had been discharged prior to impact.

7 At the time of impact, the emergency cabin pressure relief valves were closed, and the control mechanism for such valves was in the closed position.

8 Except for the apparent failure of the fire detection instrument referred to in finding No. 5, *supra*, the investigation revealed no mechanical failure of the aircraft or fire in flight.

9 The emergency procedure for the operation of the DC-6 fire extinguisher system was established after flight tests were conducted in a descent configuration of 300 miles per hour, with landing gear and flaps up, no flight tests were conducted prior to the accident in a descent configuration of 160 miles per hour with gear and flaps down, which configuration was also approved for DC-6 operations.

10 At the time of impact the landing gear was in the "up" position, thus indicating that the aircraft had descended in the configuration of 300 miles per hour. The extensive breakage of the aircraft precluded any positive determination as to the position of the flaps.

11. After the release of CO_2 gas hazardous concentrations of the gas entered into the cockpit.

12 Due to the physiological and toxic effects of high concentrations of CO_2 gas in the cockpit, which would probably not have occurred had the cabin pressure relief valves been open, the members of the flight crew of the aircraft were rendered physically and mentally incapable of performing their duties.

Probable Cause

The Board determines that the probable cause of this accident was the incapacitation of the crew by a concentration of CO_2 gas in the cockpit.

* * * * * *

A fire in flight permits little opportunity for the exercise of detached and thoughtful consideration of emergency procedure. Immediate action is required if a fire is to be controlled. Too little consideration has been given to the psychological and physical limitations of crew members in time of stress and danger as related to the complexity of emergency fire procedure. It is not safe to assume that the pilot and co-pilot, under emergency pressure, will always adhere rigidly to the sequence of steps outlined in the CAA Approved Airplane Operating Manual.

The possibility of human error under great mental stress is well documented in air transport experience and the design of aircraft controls, especially those of an emergency character, should take into consideration the natural limitations of human nature. These limitations argue against involved procedures applicable in emergencies. In harmony with this objective, the Douglas Aircraft Company has designed and is testing a modified fire extinguishing system which will permit all necessary steps to be executed by the movement of one control. An additional vent is also being designed to reduce CO_2 concentration in the cockpit. Seven days after the Mt Carmel accident, the Director of Aviation Safety of the CAA directed telegrams to all CAA regional administrators calling attention to his telegram of June 10, 1948, referred to above, and advising that further investigation had disclosed the existence of the CO_2 concentration condition found in Constellation aircraft by the Chillicothe tests in other makes of aircraft. The telegram concluded "Hence, flight crews of all aircraft should be advised to wear oxygen masks and utilize emergency cockpit smoke clearance procedures when carbon dioxide is released into any fuselage compartment from other than portable extinguishers." All scheduled U S air carriers operating DC-6s have equipped the airplanes with demand type full face oxygen masks for the use of the crew.

—15275

BY THE CIVIL AERONAUTICS BOARD

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

Harold A. Jones, Member of the Board, did not participate in the adoption of this report.

Supplemental Data

Investigation and Hearing

The Chief, Region I, Bureau of Safety Investigation, Civil Aeronautics Board, was notified of the accident at 1320, June 17, 1948. An investigation was begun immediately in accordance with the provisions of Section 702(a) (2) of the Civil Aeronautics Act of 1938, as amended A public hearing was held July 2 and 3, 1948, at Ashland, Pa., and was continued August 25, 26, 27, and 28, 1948, at New York, N Y.

Immediately upon notification of the accident, investigators from the New York office and the Washington office of the Bureau of Safety Investigation departed for the scene of the accident. Upon arrival an extensive investigation was initiated by the Board's personnel, assisted by representatives from the Civil Aeronautics Administration, United Air Lines, Douglas Aircraft Company and the United Aircraft Corp

Due to the almost total destruction of the aircraft and its components caused by the violent impact and subsequent fire, the initial investigation at the scene of the accident was extremely difficult and time consuming This investigation at the scene continued from June 17 until July 2 On July 2-3 a public hearing was held. During the hearing testimony was received from several observers of the flight immediately prior to the accident. Various exhibits were also presented A preliminary statement of facts then in possession of the Board was released on July 9, 1948

Following the above-mentioned hearing, several of the components of the aircraft were subjected to detailed study and analysis by the Federal Bureau of Investigation, the National Bureau of Standards and the Douglas Aircraft Company At the conclusion of these studies the hearing was reconvened at New York City, August 25, 1948 At this hearing the testimony of forty-one witnesses, including technical experts, was heard and numerous technical exhibits were placed in the record The testimony of various medical specialists was also received on the effect of and the human tolerance to CO_2 gas.

Following the New York hearing the Board's technical staff entered upon an analysis of the voluminous exhibits that had been received in evidence. In December 1948, United Air Lines requested the Board to withhold judgment on the accident until further tests could be conducted, with respect to the position of the cabin pressure relief valves, at the Massachusetts Institute of Technology (M I.T). This request was granted. Before the parts in question were released to M I.T they were disassembled and reexamined by the National Bureau of Standards, which issued its report on April 14, 1949 The study made on behalf of United by M I T. resulted in a preliminary report received April 26, 1949. Inasmuch as the parts in question had not been disassembled at the time of its original inspection, the Douglas Aircraft Company requested and received permission to reexamine the parts The Douglas report was received on June 21, 1949 The Board thereupon entered upon a final analysis and study of the evidence including the reports above described, only one of which, the M.I T report, concluded that the cabin pressure relief valves were open.

Air Carrier

United Air Lines, Inc., a Delaware Corporation with headquarters in Denver, Colo., was operating under a certificate of public convenience and necessity and an air carrier operating certificate, both issued under the authority of the Civil Aeronautics Act of 1938, as amended

Flight Personnel

Captain George Warner, Jr., age 35, of Westmont, Ill., held a valid airline transport pilot rating, and at the time of the accident had logged approximately 7,310 flying hours, of which about 30 hours were in DC-6 airplanes. First Officer Richard C Schember, age 26, of Elgin, Ill., held a valid airline transport pilot rating, and at the time of the accident had logged approximately 3,289 flying hours, of which about 129 hours were in DC-6 airplanes. Stewardess Lorena R. Berg, age 28, of Woodstock, Ill., and Stewardess Nancy L. Brown, age 24, of Fort Myers, Fla., completed the crew.

Aircraft

NC-37506, a Douglas DC-6 airplane, model 477-B, was delivered new to United Air Lines on March 25, 1947. It was

equipped with Pratt & Whitney R-2800 engines and Hamilton Standard 43D60-3 propellers. At the time of the accident, the airplane had been operated a total of 1,245 hours, of which 550 were since the last overhaul, 87 since the last No 3 check and 26 since the last No. 2 check Engines Nos. 1, 2, and 3 had been operated 550 hours since overhaul, and engine No. 4, 187 hours since overhaul Propeller No. 1 had been operated 320 hours since overhaul, No. 2, 118 hours, No. 3 and No. 4, 467 hours.