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REPORT OF THE CIVIL AERONAUTICS BOARD

On the investigation of an accident which occurred near Fairfield, Utah, on December 15, 1942, involving an aircraft of United States registry NC 16060, owned by Western Air Lines, Inc.

Flight Personnel

On Western Flight No. 1 ^{3/} of December 14, the crew consisted of Edward John Loeffler, captain; James Clifton Lee, first officer; Douglas Mortimer Soule, copilot-trainee; and Cleo Lorraine Booth, stewardess.

Captain Loeffler had logged approximately 2885 hours as pilot, 533 of which were as captain in DC3 equipment. He had also logged about 1518 hours as first officer in DC3 equipment. He held an airline transport pilot certificate with single and multi-engine land ratings, 160-3150 h.p. His last physical examination, required by the Civil Air Regulations, was taken on October 8, 1942 at Glendale, California. He had been employed by Western since July 11, 1940.

First Officer Lee had been employed by Western since August 31, 1942. He held a commercial pilot certificate with instrument and flight instructor ratings and had accumulated approximately 596 hours of flying time, 126 of which were accumulated while serving as first officer for Western. His last physical examination was taken in Los Angeles, California, on September 2, 1942.

Copilot-Trainee Soule held a commercial pilot certificate with an instrument rating. He had accumulated about 537 hours, including 11 hours while serving as copilot-trainee for Western. He received his last physical examination at Salt Lake City on November 19, 1942.

Stewardess Booth had been employed by Western since April 7, 1942.

It appears from the evidence that the flight crew of the airliner held the proper certificates, were in proper physical condition, and, by reason of their training and experience, were qualified for the flight with the equipment involved.

The Aircraft

The airplane, NC 16060, was a Douglas DC3A, powered with two Pratt and Whitney SIC3G engines, equipped with Hamilton Standard, constant speed full-feathering propellers. It was manufactured by the Douglas Aircraft Company, Inc. in December 1936 and was purchased by Western in May 1938. A total of 14,773 hours had been logged for the aircraft, of which 3266 were since the last major overhaul. The aircraft and its equipment had been approved by the Civil Aeronautics Administration for air carrier operation, with 21 passengers and a crew of four. The take-off weight at the time of departure from Salt Lake City was 24,478 pounds; the authorized maximum take-off weight was 25,346^{4/} pounds.

^{3/} Hereinafter referred to as "Western #1"

^{4/} The normal maximum is 25,200 pounds; however, where de-icer equipment is installed, the additional 146 pounds are allowable.

Flight No. 1 of Western Air Lines, en route from Salt Lake City, Utah, to Burbank, California, via Las Vegas, Nevada, met with an accident approximately 3 miles southeast of Fairfield, Utah, at about 1:22 a.m. (MWT) ^{1/} on December 15, 1942. Thirteen passengers and four crew members were fatally injured; while the remaining two passengers were seriously injured. The Douglas DC3A aircraft, NC 16060, operating in scheduled air carrier service, was completely demolished.

CONDUCT OF INVESTIGATION

The Santa Monica Office of the Civil Aeronautics Board (hereinafter referred to as the Board) received notification at approximately 9:30 a.m. on December 15 that the aircraft was missing and after the wrecked aircraft was located, the Board immediately initiated an investigation in accordance with the provisions of Section 702 (a) (2) of the Civil Aeronautics Act of 1938, as amended (hereinafter referred to as the Act). An air safety investigator of the Board arrived at the scene of the accident about 12:30 a.m., December 16. The wreckage of the airliner had been roped off and was under guard of the State Police and an armed guard of the United States Army. The Army guard remained there until December 17, the State Police until December 19, when civilian guards were employed and guarded the wreckage until the completion of the investigation.

Hearing

In connection with the investigation, a public hearing was held in Salt Lake City, Utah, on December 21 and 22, 1942. Mr. William K. Andrews, Chief, Investigation Section, Safety Bureau of the Board, served as presiding officer and the following personnel of the Safety Bureau participated in the hearing: R. A. Reed, Senior Air Safety Investigator; A. E. Cabana, Air Safety Investigator; and W. E. Koneczny, Aircraft Specialist. Upon the basis of all the evidence accumulated during the investigation, the Board now makes its report, in accordance with the provisions of the Act.

Air Carrier

At the time of the accident Western Air Lines, Inc., ^{2/} a Delaware corporation, was operating as an air carrier under a certificate of public convenience and necessity and an air carrier operating certificate, both issued pursuant to the Act. These certificates authorized it to engage in air transportation with respect to persons, property and mail between various points, including Burbank, California, Las Vegas, Nevada, and Salt Lake City, Utah.

^{1/} All time referred to herein is Mountain War Time, unless otherwise specified.

^{2/} Hereinafter referred to as "Western"

History of the Flight

Western #1 took off from the Salt Lake City Airport at about 1:05 a.m., cleared to Burbank with a scheduled stop at Las Vegas. The flight plan called for a cruising altitude of 10,000 feet to Enterprise, Utah, descending to 8,000 feet over Mormon Mesa, Utah, landing at Las Vegas; estimated flight time to Milford, Utah, 58 minutes; Enterprise, 1 hour 18 minutes; Las Vegas, 1 hour 50 minutes.

The first and only communication contact Western #1 made was with Western's radio and dispatch officer at Salt Lake at 1:07 a.m., at which time the flight reported "off the field at Salt Lake at 1:05 a.m."

When Western #1 failed to report over Fairfield, the Salt Lake dispatcher called the flight at 1:40 a.m. and received no answer. Then followed a series of communications between the Airways Traffic Control Center at Salt Lake City and the following stations in an effort to locate Western #1: Western's radio and dispatch office, the CAA Traffic Control Tower, the CAA Communications Station, and the U. S. Weather Bureau Airport Station, all at Salt Lake; the CAA Communications Stations at Delta, Milford, Fairfield, and Enterprise, Utah; and the Air Traffic Control Center at Burbank. None of these stations had received any report from Western #1. Two operators at the CAA Communications Station at Fairfield reported that they had observed an aircraft pass over, southbound, at 1:20 a.m., (approximately 15 minutes after take-off from Salt Lake City.) It is apparent that the plane was Western #1, that it was on schedule and on course over Fairfield, and that the trouble developed about 10 minutes after the flight was thus observed.

Discovery of the Wreckage

Ground fogs delayed and hindered aerial searches during the early morning hours of December 15. Western cancelled all of its scheduled runs to make their aircraft available for search for Western #1.

Casper William Wolfe, flight leader of the Provo, Utah Civil Air Patrol, learned of the missing plane at about 10:00 a.m. that morning. Accompanied by a mechanic, he took off at approximately 11:05 a.m. to search for the missing airliner and proceeded to the center of the radio beam which Western would ordinarily use. Shortly thereafter, while proceeding down Cedar Valley, he discovered the wreckage. He landed nearby at about 11:25 a.m. and with the help of his mechanic, removed the only two survivors from the cabin. The mechanic remained at the wreckage with the two injured men while Wolfe flew to Fairfield and summoned medical aid from Lehi, Utah. He waited at Fairfield in order to give a doctor and nurse directions to drive to the scene of the accident. Wolfe stated that he telephoned the CAA office in Salt Lake City at approximately 12:15 p.m. and then flew back to the scene of the wreckage, where he assisted in the rescue work.

Terrain

Fairfield is located about 35 miles almost due south of Salt Lake City, in the approximate center of Cedar Valley, at an elevation of between 4000 and 5000 feet. Cedar Valley is approximately 30 miles wide. The Lake Mountains lie due east of Fairfield and are approximately 7000 feet high; the Oquirrh Mountain Range lies north-northwest of Fairfield. The valley is rolling prairie land. Western #1 was observed in flight directly over Fairfield at 1:20 a.m. and the accident occurred about two minutes later, at 1:22 a.m. The barograph card showed Western #1 to have been flying at 10,200 feet and it had registered a sharp or immediate descent to the ground. It was determined, therefore, that it would have been impossible for the aircraft to have collided with any mountain peaks. Investigation did not reveal any other aircraft in the vicinity at or near the time of the accident.

Weather

The weather at Fairfield at 1:30 a.m. was: High broken clouds, ceiling and visibility unlimited, temperature 25°, dew point 22°, wind west estimated 4 m.p.h. Approximately three days previous to the time of the accident a cool dome of Polar Pacific air (high pressure) moved into Utah and adjacent states. This air mass immediately began undergoing subsidence resulting in diminishing winds, both on the surface and aloft, and a lapse rate becoming increasingly stable. By the time of the accident the air mass had become very stable and the wind generally light. The nearest measurement of wind aloft was at Salt Lake City where light to calm air was recorded from the surface to 8000 feet above sea level and with the velocity gradually increasing above that elevation. At 10,000 feet the wind was estimated to be northwest 15 m.p.h. There was no indication of a turbulent layer aloft resulting from wind shear. This type of air mass is favorable for rather rapid loss of heat at the surface at night producing shallow layers of cold air in the valleys. Where there is sufficient moisture available this results in ground fog. Ground fog did exist in some localities near Salt Lake City but had not formed in the Fairfield area. Such cloudiness as was reported within several hundred miles of the accident was the type connected with stable air conditions.

Witnesses

Lieutenant Arthur G. Gardner, U.S.M.C.R., one of the two survivors of the accident, is a qualified military pilot and had accumulated approximately 250 hours of flight time and an estimated 150 hours as observer in military service. Part of this 250 hours included one month of advanced training in DC3 equipment at the American Airlines Naval Training School at Fort Worth, Texas, and about two months of additional experience as copilot with American Airlines in cargo operations between El Paso, Texas, Memphis, Tennessee, and New York, New York. This cargo experience was in DC3 and C-46 type equipment.

Lieutenant Gardner was en route to San Diego and had boarded the plane at Salt Lake City. He was seated in the third seat from the front on the left hand side. He testified, in part, as follows:

"I remember that the plane seemed to have settled down to a smooth cruising level, and my recollection is that the seat belt sign had been turned off, and I know the 'No Smoking' sign had been turned off. That was turned off rather promptly after take-off.

"I had just loosened my seat belt -- I hadn't taken it off entirely, but I had loosened it to give myself a little more room to settle in my chair, and was just about to doze off to sleep when I noticed this sudden acceleration as from the nose of the plane being pulled upward very sharply. Immediately I figured that there was something wrong, because I knew that transport planes weren't handled in that fashion, except in emergency.

"So, I reached down and pulled my belt as tight as it would go, again, and ripped open the curtain and looked out to see what I could see, if anything, and it proved I couldn't see anything at all that was rewarding.

"So then I just sat back and relaxed, with my arms on the arms of the seat, and it was about this time that the plane seemed to reach its peak in the climb. It had reached by that time a nearly stalled position. I could feel it beginning to shake just a little bit, ready to give way, and then almost simultaneously, I felt a very sharp thud, and a scraping noise that seemed to come from the left side of the plane, where I would describe as under the left engine. My reasoning was that we had collided with something about in the vicinity of the left engine.

"Then after that nothing was apparent, exactly, except that the plane continued and it yawed around to the left as though it was slightly out of control, and I noticed that the pilot shoved the nose forward, to stop the stall. It seemed as though we might have just squeezed over the top of the ridge, or whatever it was we hit, and then it continued in a left turning flight, very unsteadily, for some time.

"It seemed about that time that I noticed a very rough sound in the left engine, but I wouldn't want to swear to it one way or the other, because sounds can be so confusing in a case like that, when you haven't the benefit of sight. I did think that the left engine was out, because of that shock.

"Then it seemed like a matter of thirty seconds wherein we continued in a very partially controlled flight, in an almost stalled attitude, turning slightly to the left, although not continually to the left, from then on right to the point of final contact with the ground.

"At that time I was knocked unconscious, and I didn't have any recollection of what went on until I came to in what seemed a matter of a minute, or so."

There were no known witnesses to the accident from the ground. John Raymond Wilcher, mill foreman, whose home is located in Cedar Valley, about 8 miles north of the scene of the wreckage, testified that he had gotten out of bed on the night of the accident to ascertain whether his son had come home, and he had reason to observe the time, which was 1:05 a.m. He stated that he returned to bed and stayed awake for a time he estimated to have been 10 or 15 minutes when he heard an airplane. From his testimony, it is quite apparent that he heard Western #1 when it was in trouble as he stated that the engines were being operated irregularly, with full power off and on, and then off; then he heard them no more. He stated that he had remarked to his wife at the time that he believed there was something wrong with the plane. The two CAA communication operators at Fairfield observed the aircraft and logged the time at 1:20 a.m. two minutes prior to the accident.

Description of the Wreckage

Examination of the wreckage indicated that the airplane struck the ground in a practically level attitude at a relatively high rate of vertical descent and turning slightly to the left.

The right outer wing panel was found partially separated from the center section and rotated forward with respect to the main portion of the wreckage. The right wing tip was severed almost entirely from the remainder of the outer panel some six inches outboard of the connecting rivet line, and was held only by twisted de-icer boot wires. The material at the fracture was badly mutilated and therefore it was not possible to establish with any degree of certainty the circumstances under which failure had occurred. Numerous marks on both the top and bottom surfaces indicated repeated contact of the tip with the ground. The presence of these marks on the top surface and the twisted de-icer boot wires revealed that the detached tip was rolled along the ground edge over edge for about two and one-half turns. The outer portion of the wing showed signs of having made contact with the ground along practically the entire chord. The aileron was torn from its attachments at the two outboard hinges.

The left wing was found separated locally at various points in the vicinity of the engine nacelle. There was no major failure along the attachment between the outer panel and the center section. The wing tip was bent upward slightly past the vertical along a line about a foot outboard of the rivet line joining the tip to the outer wing panel, the attachment itself remaining substantially intact. The condition of the bent tip was such that with little effort it could be folded completely over the top surface of the wing. There were no marks on the bottom surface of the bent tip to indicate any contact with the ground. The skin on the lower surface inboard of the break had definite indications of ground contact. The navigation light was intact, minus the lens. The bottom surface of the wing tip from the break outboard showed a considerable number of oil spots. There were no signs of similar oil spots on the top surface of the wing for a distance of approximately 55 feet inboard of the failure, but the remaining inboard top surface of the wing showed numerous spots.

spots. The wing was collapsed and deformed appreciably. The lower surface indicated contact with the ground, evidenced by scratches, cuts and local collapse of the ribs at various points. The aileron was partially torn from the wing and its outboard portion was bent upward, together with the wing tip. The presence of small tears in the aileron fabric gave evidence of flapping.

The wing flaps on both sides of the airplane were found lowered to an angle of approximately 25° . The condition of the flap actuating mechanism and the flap indicator in the pilots' compartment revealed that they were in a lowered position prior to the impact of the airplane with the ground.

The fuselage was extensively damaged along its entire length, the rear portion having sustained practically the same degree of damage as the nose portion.

The tail surfaces were found to have sustained a number of major breaks. There was relatively little damage to the left side of the horizontal surfaces. The lower surfaces of the left elevator and stabilizer showed signs of having scraped the ground. This stabilizer was fractured along the side of the fuselage, and the attachment of the corresponding elevator to the torque tube within the tail cone was found severed. The right stabilizer was also fractured along its intersection with the fuselage, this fracture being more pronounced than the corresponding one on the left stabilizer. There was an additional major failure which ran diagonally, starting at the inboard portion of the rear spar and extending outboard to a point at the leading edge. This failure was evidenced by tearing of the upper skin and by pronounced wrinkling on the lower surface. No apparent signs were found of contact of the right stabilizer with the ground. The rubber de-icer boot along the leading edge was in relatively good condition, although there was a small cut on the upper portion near the tip. The condition of the tail assembly was such that the right stabilizer could be bent by hand upward and against the rudder. The right elevator was found broken into one small and two large pieces. There were three major breaks, one at the connection of the elevator to the torque tube at the tail cone, the second adjacent to the inboard hinge, and the last at the outboard hinge. The break adjacent to the inboard hinge included a complete fracture of the torque tube. At a number of points on the elevator the fabric indicated that it had been frayed by flapping at one time or another. The vertical fin was in fairly good condition, with the antenna and its fin attachment intact. The rudder, apparently jammed by impact, was found deflected to the left approximately 30° . It had sustained damage as if hit from the right side, the fabric being torn and some of the ribs crushed. Pieces of fabric from both sides of the rudder were found at various points a few hundred yards from the wreckage and the fabric remaining with the surface showed signs of flapping. Slight scratches and black marks on the right side of the rudder registered with the small cut in the rubber boot at the leading edge of the stabilizer when the latter was bent up against the rudder.

There was no indication of malfunctioning of the control system during flight.

Both sides of the landing gear were badly crushed and the tail wheel was folded up underneath the fuselage. The main gear was found to have been in its retracted position at the time of impact.

Both engine nacelles were broken off at the engine mounts and were resting on the ground in an inverted position underneath the leading edge of the wing. The engines proper sustained damage upon impact with the ground. The throttles were found in the two-thirds open position and both magnet switches were in the "on" position, which tends to indicate that both engines were operating at the time of impact with the ground. Both propellers were fastened to their shafts and all blades were in the hubs. In both instances, two of the three propeller blades were bent considerably. Although no definite conclusions could be reached from their condition as to whether or not power was being developed at the time of impact, it is possible that due to the high rate of descent, the relatively slow forward speed and the flat attitude with which the airplane struck the ground, the propellers might have been stopped almost instantaneously without damaging the third blades.

Most of the instruments in the pilots' compartment were damaged to the extent that their readings had no significance.

A review of the aircraft's history indicated that no repairs had been made which could have had any adverse effect on the airworthiness of the airplane. No signs of weakening of any other parts of the airplane were found.

The barograph card recovered from the plane showed a normal rate of ascent to an altitude of 10,200 feet in approximately 15 minutes. It indicated also that very shortly thereafter a rapid descent began from this altitude to approximately 8400 feet. At this point there was noticed a break in the graph, then a resumption of descent from about 8700 feet after an indicated lapse of 6 minutes. The descent continued at an increased rate until the airplane hit the ground (5000 feet above sea level). Since the interruption of the descent graph was evidenced by a complete discontinuity of the line, it is assumed that this was the result of lag or jarring of the instrument, or both, and that the descent from 10,200 feet to the ground actually was without major interruption. It should be noted also that no statement was made by Lieutenant Gardner which would indicate that there was any such interruption. The time scale on the barograph card was too small to make accurate measurements of the rate of descent. Furthermore, it appears that considerable instrument lag existed which would also affect the interpretation of the card. Therefore any measurements made from the barograph card must be considered a rough estimate only. The average rate of descent was thus estimated to have been around 2000 feet per minute.

Testimony of C.A.A. inspectors, who assisted in removing the bodies, indicated that First Officer Lee had occupied the captain's seat on the left side at the time of impact; Copilot-Trainee Soule had occupied the first officer's seat on the right; while Captain Loeffler had been in the companionway, either seated on the jump seat or standing. This indicates that either the first officer or the copilot-trainee was piloting the aircraft at the time of the accident.

ANALYSIS OF EVIDENCE

The results of the examination of the wreckage pointed quite definitely to a failure in the air of one or more elements of the airplane's structure. The condition of the left wing indicated that a failure of the tip occurred prior to impact of the airplane with the ground. This conclusion was reached on the basis of a number of significant clues. Firstly, the break along the wing chord, evidenced by predominantly tensile failure in the bottom skin, indicated bending of the tip in the upward direction. It is highly improbable that such a mode of failure would have resulted from impact when the inertia of the wing tip would tend to produce downward forces. Secondly, there were absolutely no signs of the tip's contact with the ground. Although the soil at the scene of the accident was very light in texture and free from stones, it seems inconceivable that the wing tip could have struck the ground without suffering some scratches from contact, or without leaving particles of soil at some of the numerous rivet heads, edges of overlapped skin, etc. Finally, the very obvious pattern of oil spots on the wing is significant. These oil spots apparently were the result of damage to the engine lubricating system incurred at the time of impact. Their location along the span of the left wing indicates that almost instantly after impact the tip was in a folded position on top of the wing. Additional clues found in the examination of the wreckage also supported the contention that failure of the left wing tip did occur in the air.

No signs were found which would point to any additional failures of the wings in the air, except perhaps that of the right wing tip. Since this wing hit the ground more violently, and the tip sustained appreciable damage from contact with the ground, it was difficult to ascertain its condition prior to impact. However, the fact that it was found detached from the remaining portion of the wing panel and had rolled over a few times after the original impact is regarded as significant. Had the wing tip been intact before hitting the ground it is improbable that it would have sustained damage of the type actually incurred by contact with the ground. It is entirely possible therefore that the right wing tip also failed in the air, although there is less evidence to that effect than exists for the failure of the left wing tip.

A study of the condition of the tail surfaces, as found after the accident, led to the belief that the horizontal surfaces also had failed in flight. Although the evidence in this respect was not quite so conclusive as in the case of the left wing tip, nevertheless it was sufficient to warrant further study. In view of the somewhat unusual multiple fractures in the right elevator, parts of this assembly were submitted by the Board to the Division of Metallurgy at the National Bureau of Standards. The Bureau's findings confirm the conclusion that the right elevator had failed prior to impact with the ground, indicating further that the failures were the result of excessive air loads ^{5/} imposed on the structure, and that no signs of fatigue were noticed in the examined parts. The Bureau of Standards' conclusion that the right elevator had failed in flight was based on the fact that both up and down forces of appreciable magnitude had acted successively on the elevator. The forces in the up direction deflected the elevator torque tube, broken in two places, through a total angle of over 90°, which would not be expected to happen if the forces were due to impact of the structure with the ground.

^{5/} "Air loads" are the external forces imposed upon the airplane by reason of its movement through the air.

Three other recent cases are known wherein the wings of similar models failed at the same location. However, none of these was in scheduled airline operation and they seemed under circumstances which would not be expected in such operation. In at least one of these cases the speed of the airplane at which failure occurred was in excess of normal. In each instance the pilot was able to control the airplane sufficiently to effect a safe landing. From these experiences and from analysis it appears that such failure of the structure in this type aircraft may result either from air loads occasioned in encountering gusts of extraordinary intensity, or from violent use of the controls. In one of these three instances, the stabilizer also sustained slight damage, insufficient however to render the surfaces inoperative. This damage was evidenced by wrinkling of the bottom skin along a line almost identical to the diagonal line of failure found on the stabilizer of the subject aircraft. This is considered quite significant inasmuch as it identifies this type failure with air loads rather than with impact loads, thus supporting further the contention of stabilizer failure in the air. It also indicates that the line of least strength extends from the trailing edge of the stabilizer at its root to the leading edge near the tip.

In studying the failures in the horizontal surfaces, it appears much more probable that the initial failure, or failures, occurred in the stabilizer, and that the failures in the right elevator were the result thereof. As described previously, both sides of the stabilizer sustained breaks running approximately chordwise and located adjacent to the fuselage. The break on the right side of the stabilizer was more pronounced and this side also sustained an additional major fracture running more or less diagonally, starting at the inboard portion of the rear spar and ending at a point outboard near the leading edge. The appearance of the two described breaks on the right side of the stabilizer is consistent with the assumption that the stabilizer first failed along the diagonal fracture in the downward direction, and that a subsequent failure occurred in the upward direction along the chordwise fracture. Such a sequence of events can be expected during a pull-up ϕ maneuver, sufficiently severe to impose loads in excess of the design.

The failure of both the left wing tip and the right stabilizer are of a character consistent with air loads imposed during a severe pull-up. The coincidence of two separate elements of the airplane's structure failing at the same time is unusual, therefore consideration was given to the possibility of the failure of one of them causing the failure of the other. However, analysis of the probable sequence of events in such a case seems to preclude that supposition. It is difficult to imagine how a failure of one, or even both wing tips, in itself could cause subsequent failure of any part of the horizontal tail surfaces, since the loss of the wing tip area would not be expected to have any appreciable tendency to alter the longitudinal balance of forces on the airplane. It is also highly improbable that the failure of the horizontal surfaces could have influenced to any marked degree the failure of the wing tips. The diagonal fracture of the right stabilizer apparently resulted from maneuvering down loads on the outboard portion of the elevator and the rear portion of the stabilizer near the tip. Consequently the distortion of the failed stabilizer would have the effect of an increased angle of ϕ a "pull-up", as used herein, refers to the maneuver of the aircraft, regardless of whether it is the result of operation of the controls by the pilot, or whether it is caused by some external forces acting on the aircraft.

attack of the horizontal tail surfaces. The resulting up loads acting together with damping forces might explain the failure in the up direction of the stabilizer at the fuselage. The latter failure would cause the horizontal surfaces to lose their effectiveness, thus upsetting the longitudinal static balance and inherent stability of the airplane. According to the loading records for the subject flight the center of gravity was located at $24\frac{1}{2}\%$ of the MAC. In this condition it is highly improbable that loss of the tail surfaces would cause the development of additional up loads on the wings, but rather the reverse. The center of pressure on the wings being aft of the c.g. at all normal angles of attack, a diving rather than a stalling tendency may be expected. From the above discussion it is concluded that the wing tip and the horizontal tail surface failures occurred during the same pull-up maneuver (mentioned by Lt. Gardner), and were not directly dependent upon one another.

The design of the DC3 and similar model wings reveals that their strength is sufficient to withstand the maximum air loads that the aircraft can normally be expected to encounter, but that the first to fail if the design loads are exceeded will be the structure just outboard of the wing tip connections, i.e., at the point where the subject left wing actually failed.

The condition of the tail surfaces after the accident seems to indicate failure in the air at the time of the severe pull-up. The fact that the airplane went out of control and remained so after the pull-up, contrary to the safe landings experienced in the other three cases, also suggests a loss of control, which would naturally result from a failure of some part of the tail. Furthermore the use of flaps during the descent suggests that normal longitudinal control of the airplane was no longer available. It is possible that the crew endeavored to restore longitudinal equilibrium by the use of flaps.

Although in view of all the evidence it appears highly probable that the stabilizer and elevator did fail in flight, the exact cause of the failure is not clear. The structure of the horizontal surfaces of the DC3 and similar models has been designed for loads substantially in excess of those which the Regulations require this type of civil airplane to sustain. Specifically, the horizontal stabilizer is designed to withstand a limit load (neglecting the factor of safety) which would correspond to the exertion by the pilot of a force of 380 pounds on the control column, provided that the actual load distribution was in exact accordance with the conventional distribution used in the stress analysis. Such a load, of course, would be beyond normal strength. Therefore, the stabilizer is considered sufficiently strong to preclude failure as a result of any action on the part of the pilot, providing no unusual and unexpected dynamic conditions exist at the time. Since a detailed examination of the horizontal surfaces did not reveal any weakened condition of the structure prior to the accident, it should not be expected to fail during a pull-up, even one sharp enough to cause failure of the wing tip. It is reasoned, therefore, that the stabilizer having actually failed, there existed during the pull-up forces other than, or additional to, those normally encountered in such a maneuver. Various theories have been explored to explain the presence of such forces.

An analysis of the weather prevailing in the vicinity of Fairfield at the time of the accident does not indicate conditions conducive to turbulence. Except for local ground fog near Salt Lake City, the ceiling and visibility were unlimited along the flight path. The air mass was very stable and precludes any probability of free convective currents. Only mild mechanical turbulence could have resulted from the rough terrain as the wind velocity was very light up to the height of the surrounding mountains. There is no evidence of wind shear turbulence. Considering all of the meteorological factors, there appears to be no reason to believe that the airplane could have been subjected even to a single isolated gust of sufficient severity to cause damage to the structure.

The problem of forced vibrations of the tail surfaces, similar in origin to the phenomenon commonly termed "buffeting", was given careful study. Reference was made to the British report on the notable accident at Meopham, England (July, 1930), and to the various subsequent technical studies of that case. According to these studies, "buffeting", which occurs on most airplanes near the stalled attitude and results in a highly disturbed flow of air aft of the wings' trailing edge, may be of such magnitude as to impose appreciable vibratory deflections on the tail surfaces.

The DC3 is known to develop normal "buffeting" when the airplane is placed in a nearly stalled attitude. It has also been established that under certain conditions this "buffeting" may become quite pronounced. However, in no case known to the Board have the vibrations been of sufficient magnitude to cause serious damage to the aircraft.

The normal "buffeting" condition, being directly connected with the airplane's stalled attitude, occurs at comparatively slow speeds, and therefore the vibrations of the tail are confined to reasonable small amplitudes which, in turn, do not impose unduly severe stresses on the structure. Furthermore, at slow speeds the usual maneuvering loads on the tail are relatively small, so that the combination of the two can be expected to be well within the strength limits of the structure. However, if an airplane while flying at, or near, its cruising speed is suddenly placed in a stalled attitude, the "buffeting" might be so accentuated as to induce stresses in the tail structure, which when acting simultaneously with the maneuvering stresses due to gust, or pull-up, would cause failure. Such "high speed buffeting" is not necessarily an inherent feature of any particular model airplane, but may possibly occur in isolated cases under an unusual combination of flight conditions. Such conditions could have existed at the moment of pull-up during the subject accident. The fact that some vibration was present during the pull-up is supported by the testimony of Lt. Gardner, who described the action of the airplane as, ". . . beginning to shake just a little bit, . . ."

If the unusually high stresses on the horizontal tail surfaces during the pull-up were not due to a so-called "high speed buffeting" condition, it is still possible that some other combination of air loads existed which resulted in a condition severe enough to cause failure of the stabilizer. The horizontal tail structure is designed to withstand the air loads that would be

expected under reasonably unfavorable flight conditions, including the loads due both to gusts and to control forces. It is possible, however, for the aircraft under abnormal circumstances to be subjected to a combination of high loads, as a result of which stresses of unusual severity are developed.

The air load distribution over the stabilizer and elevator is dependent not only upon the prevailing flight condition, but also, to some extent, upon the shape of the surfaces and their location with respect to other parts of the airplane. As a consequence, even for the same flight condition, the air load distribution will vary with different aircraft. For design purposes, simplified distributions are conservatively assumed. It is conceivable, however, that the assumed distribution may not be conservative for every airplane and every possible flight condition. Unforeseen circumstances may result in a variation of load distribution on the surfaces, sufficient to reduce the apparent margin of safety by a noticeable amount without increasing the total load beyond that for which the structure was designed. The location of the diagonal failure in the stabilizer indicates that a considerable down load was acting near the tip of the elevator, or more probably, on the outboard portion of the stabilizer along the rear spar.

Whether the stresses which caused the failure of the horizontal surfaces were due to "high speed buffeting", a coincidence of high loads, an unusual air load distribution, or a combination of any of these, the Board is not able to state definitely at the present time. In any case, it seems apparent that the stabilizer failed under flight conditions which cannot be expected to occur except in very isolated cases. A study of this problem is being continued by the Board with the hope of obtaining more definite information.

The testimony of Lt. Gardner regarding the events which interrupted normal flight of Western #1 is in close agreement with other facts disclosed during the investigation. His description of the violent pull-up is especially valuable evidence because it confirms the conditions existing at the time the wings and the horizontal surfaces failed. Obviously, the important question is the reason for the pull-up, which, in the opinion of Lt. Gardner, was abrupt enough to develop loads in excess of 4G. The airplane either entered this maneuver as a result of some action beyond the control of the crew, or the pull-up/due directly to the operation of the flight controls by the crew.
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A detailed examination of the control system did not indicate that it had been malfunctioning at any time during the flight prior to the accident. Nothing was found which would lead to the belief that there had been, from within the aircraft, any interference with its normal operation. There were no signs in the wreckage of collision with a bird or with any other foreign object.

Investigation of the records of civil and military traffic control agencies revealed no evidence of any other aircraft, or free or captive balloons in the vicinity of Fairfield. Despite the fact that a diligent search revealed no such evidence, the Board nevertheless is fully cognizant of the possibility that there might have been an unrecorded aircraft, derelict balloon, or perhaps a large bird, the collision with which the pilot was seeking to avoid by the pull-up.

Although when inspected after the accident, the flight recorder indicated that the automatic pilot had not been in operation at any time during the flight from Salt Lake City, nevertheless consideration was given to the engagement of this device, inadvertently indexed for climb, after the airplane had attained level flight. However, tests conducted by the Douglas Aircraft Company to establish the violence of the pull-up to which the airplane would be subjected in such an event, showed that the acceleration did not exceed 2G. This obviously would not cause failure of either the wing or the tail surfaces.

It is not known whether or not the presence of the first officer and the copilot-trainee in the two pilot seats contributed in any way to the accident. There is at least a possibility that had the captain, with his greater experience, been at the controls, he might have either prevented the accident or minimized the results. This however, lies within the realm of speculation.

As a result of this accident it was revealed that the term "properly qualified company personnel", as it appears in Section 61.7802 7/ of the Civil Air Regulations, had not been uniformly interpreted. Subsequent to this accident the Administrator made it clear that the interpretation of this Section would render any company employee ineligible to occupy a pilot's seat, prior to manipulate the controls of a scheduled air carrier aircraft in flight, unless and until he was listed as a pilot in the Operations Specifications of the company. Any ambiguity in the subject Section would be eliminated by appropriate changes in the language now under consideration by the Board.

Summary of Analysis

The examination of the wreckage points conclusively to a failure in the air of the aircraft's structure. The analysis of the condition and of the type of fractures on the wings and tail surfaces indicates quite definitely that the right stabilizer had failed during a pull-up maneuver and that the wing failure was also consistent with pull-up loads. No indication was found that the failure had been due to any defect of material or workmanship. Furthermore, it was ascertained that the design strength of the stabilizer was such as to require more than a normal force by the pilot to cause failure in a pull-up, provided that the air load conditions during the pull-up were as anticipated in the design requirements. In view of the above it is concluded that during the subject pull-up unusual and abnormally high air loads prevailed, but the knowledge of their origin and exact nature is limited at the present time.

7/ "Section 61.7802 Manipulation of controls. No person, other than a first or second pilot, shall manipulate the controls of an air carrier aircraft while in scheduled flight: Provided, That at the discretion of the first pilot such restriction shall not apply to authorized inspectors of the Administrator or to properly qualified company personnel or to properly qualified personnel of other air carriers."

Findings

1. The accident occurred 3 miles southeast of Fairfield, Utah at about 1:22 a.m. on December 15, 1942, and resulted in fatal injuries to 13 passengers and 4 crew members and serious injuries to 2 passengers.

2. Western #1 originated at Salt Lake City, Utah with Burbank, California as its final destination. It departed from Salt Lake City Airport at 1:05 a.m. having been cleared to Burbank, in accordance with company procedure.

3. At the time of the accident Western held a certificate of public convenience and necessity and an air carrier operating certificate authorizing it to conduct the flight. Both certificates were currently effective.

4. Captain Loeffler and First Officer Lee were physically qualified and held proper certificates to perform their duties on the subject flight. Copilot-Trainee Soule was properly qualified and authorized to function in such capacity.

5. The aircraft, a Douglas DC3A, NC 16060, was currently certificated as airworthy at the time of the accident.

6. The evidence indicated that the weather conditions in the area at the time were satisfactory for the flight and were not a contributing factor to the accident.

7. The airplane apparently had been properly maintained and there were no indications that it was not in an airworthy condition immediately prior to the accident.

8. There was no indication of mechanical failure of the engines or propellers.

9. The operation of Western #1 was normal until about 1:22 a.m.

10. Normal flight was apparently interrupted at an altitude of approximately 10,200 feet by a failure of the aircraft's structure.

11. A subsequent study indicated that the left, or possibly both wing tips, and the horizontal tail surfaces had failed during a pull-up as a result of air load conditions which were sufficiently severe to impose stresses in excess of those for which these parts of the structure were designed.

12. The first officer and the copilot-trainee were at the controls at the time the airplane struck the ground while the captain had been in the companion-way, either seated in the jump seat or standing.

CONCLUSIONS

On the basis of all of the facts, conditions and circumstances known to the Board at this time, it is concluded that failure of the left, or possibly both wing tips, and of the horizontal tail surfaces occurred in the air during a severe pull-up. However, no definite conclusion can be drawn from the evidence as to whether the pull-up was caused by operation of the controls by the crew, or by some other forces beyond their control. Due to the lack of any plausible theory for the latter, it seems more probable that the maneuver was initiated by the crew, possibly in an attempt to avoid collision with a bird, another aircraft, or some object which they saw or thought they saw.

PROBABLE CAUSE: Failure of the left, or possibly both wing tips and of the horizontal tail surfaces as a result of a severe pull-up which caused unusual and abnormally high air loads. The reason for the pull-up maneuver was not determined.

APPROVED:

/s/ L. Welch Fogue
L. Welch Fogue

/s/ Edward Warner
Edward Warner

/s/ Harilee Branch
Harilee Branch

/s/ Oswald Ryan
Oswald Ryan

/s/ Josh Lee
Josh Lee