

January 29, 1938.

REPORT OF THE INVESTIGATING BOARD

Statement of probable cause concerning an accident which occurred to an aircraft of Northwest Airlines, Incorporated, near Bozeman, Montana, on January 10, 1938.

To the Secretary of Commerce:

On January 10, 1938, at 3:07 P.M., Mountain Standard Time, at a point in Bridger Canyon approximately 12 miles northeast of Bozeman, Montana, an airplane of United States registry, while being flown in scheduled interstate operation, carrying mail, passengers and express, met with an accident resulting in death to all on board and the destruction of the aircraft.

On January 12, 1938, the Secretary of Commerce issued an order appointing the undersigned as a Board to investigate this accident and hold a public hearing in relation thereto. Pursuant to said order, an investigation was made and a public hearing was held at Bozeman, Montana, January 18 to 21, 1938, inclusive. A transcript of the testimony obtained at said hearing is transmitted herewith for your information and for the records of the Department.

The pilot of the aircraft, Nick E. Mamer, held a current Federal transport pilot's license and the required ratings for the flight involved. The report of his last physical examination, as required by the Department of Commerce and taken on October 13, 1937, showed him to be in good physical condition for flying. Pilot Mamer had a record of approximately 10,000 hours of flying time and long experience over the route in question. The co-pilot, Frederick W. West, Jr., held a current Federal transport pilot's license and the required ratings as co-pilot for the flight involved. His flying experience over the route in question dated from April 1937. His latest physical examination, taken on July 27, 1937, showed him to be in good physical condition. The testimony showed that both pilot and co-pilot enjoyed excellent professional reputations with their company and fellow pilots.

Passengers on board were:

T. Anderson
St. Paul, Minnesota

I. E. Stevenson
Seattle, Washington

G. A. Anderson
Spokane, Washington

L. Levin
Detroit, Michigan

Walter Ton
Minneapolis, Minnesota

A. Croonquist
Billings, Montana

Douglas McKay
Winnipeg, Manitoba

W. E. Borgenheimer
Basin, Montana

The aircraft, a Lockheed, model 14-H, was owned and operated by Northwest Airlines, Incorporated, of St. Paul, Minnesota. It was inspected and approved for license by the Department of Commerce on November 30, 1937, and bore Federal license number NC-17388. The Lockheed model 14-H is a new high speed type of aircraft and was placed in scheduled air line operation about November 1, 1937. Several minor modifications of the aircraft were effected after placing this new model in operation, some made by the factory, some by the operators and all approved by the Department of Commerce. At the time of the accident, this aircraft was being operated between Seattle, Washington, and Billings, Montana, as a part of Trip 2 of January 10, 1938, which was scheduled to terminate in Chicago, Illinois. Scheduled intermediate stops between Seattle and Billings were Spokane and Butte.

Trip 2, scheduled to arrive at Butte at 2:30 P.M., MST., arrived at 2:31 P.M. Departure from Butte was made at 2:41 P.M., five minutes later than usual due to loading adjustments. Before this departure, clearance was given for the flight from Butte to Billings through the company dispatcher at Billings via radio contact and/or instrument flying was authorized by this clearance. The aircraft carried approximately 280 gallons of fuel and 30 gallons of oil. The gross weight at time of departure was approximately 14,500 pounds. The authorized gross weight for this model aircraft was 15,500 pounds. The United States Weather Bureau 1:51 P.M., MST., weather sequence reports for January 10, 1938, covering

the route to be flown and furnished to the pilot as a part of his clearance from Butte, were as follows:

	Ceiling	Sky condition	Visibility	Temp. & Dew Point	Wind direction	Barometer
Drummond, Montana	E 3500	Overcast	25	44/29	W 24	29.50
	Remarks:	Ceiling variable, storming mountains W & SW				
Missoula, Montana	E3200	Broken	10	44/31	SW 16	29.75
	Remarks:	None				
Superior, Montana	E3500	Overcast	10	44/37	SE 2	--
	Remarks:	Sprinkling, ceiling and visibility variable				
Mullan Pass, Idaho	Zero	Dense fog	Zero	28/28	W 22	--
	Remarks:	Blowing snow, light snow, wind variable				
Coeur d'Alene, Idaho	E 2000	Broken	10	42/37	WNW 15	--
	Remarks:	None				
Spokane, Washington	Unlimited	Scattered with lower scattered at 2500	20	45/37	WSW 15	29.88
	Remarks:	None				
Butte, Montana	E 4000	Broken	15	40/30	SW 21	29.63
	Remarks:	Frequent squalls surrounding mountains				
Billings, Montana	E 4000	Broken	1 1/2	50/28	WNW 37	29.45
	Remarks:	Blowing dust				
Livingston, Montana	E 4500	Overcast	20	47/24	SW 34	29.45
	Remarks:	Storming all mountains, occasional sprinkles, few small breaks, sky condition rapidly changeable.				

The 2:31 weather sequence reports, available to the pilot enroute, were as follows:

Billings, Montana (Special)	4000	Broken	5	49/26	WNW 23	29.46
	Remarks:	Blowing dust, visibility variable				
Livingston, Montana	E 4000	High broken Lower broken	15	45/27	W 31	29.45
	Remarks:	Storming all directions, intermittent sprinkles, conditions changeable.				

The United States Weather Bureau forecast for the period of 8:30 A.M. to 4:30 P.M., MST, on January 10, 1938, for the route covered by this flight out of Butte, was as follows:

MILES CITY - MISSOULA STOP SCATTERED TO BROKEN SOUTHERN UTAH AND EXTREME SOUTHERN WYOMING TO OVERCAST NORTHERN UTAH CEILINGS 4 TO 6 THOUSAND STOP BROKEN TO OVERCAST REMAINDER WYOMING WITH OCCASIONAL LIGHT SNOW OR SNOW FLURRIES CEILING GENERALLY 3 TO 5 THOUSAND BUT LOWERING AT TIMES IN SNOW TO 1 THOUSAND STOP OVERCAST MONTANA WITH OCCASIONAL SPRINKLES OR SNOW FLURRIES EXCEPT SQUALLS IN MOUNTAINS CEILINGS 2 TO 4 THOUSAND LOWERING AT TIMES TO 1 THOUSAND IN PRECIPITATION AND ZERO MOUNTAINS STOP OVERCAST EASTERN IDAHO AND BROKEN TO OVERCAST REMAINDER IDAHO CEILINGS NORTHEAST PORTION 6 TO 1000 AND SOUTH PORTION GENERALLY 2 TO 4 THOUSAND STOP VISIBILITY OVER DISTRICT OVER 6 EXCEPT IN PRECIPITATION AREAS VARIABLE 3 TO 6 THOUSAND

The terminal forecasts for Butte, Helena, Great Falls and Billings during the same period were:

OVERCAST WITH OCCASIONAL SPRINKLES OR SNOW FLURRIES EXCEPT SQUALLS IN MOUNTAINS STOP CEILINGS 2 TO 4 THOUSAND BUT LOWERING AT TIMES TO 1 THOUSAND IN PRECIPITATION AND ZERO MOUNTAINS STOP VISIBILITY VARIABLE IN PRECIPITATION 2 TO 6 THOUSAND OTHERWISE OVER 6 THOUSAND

Lay witnesses on both east and west sides of Bridger Mountain Range testified that there were strong, gusty and violent wind conditions on the ground the afternoon of January 10, 1938.

After departing Butte, Trip 2 was contacted by the company radio operator at Billings at 5:05 P.M., MST., for the purpose of giving the pilot the 2:51 weather. In response, the pilot replied at 3:05, "Cruising 2:53. 9000 feet", which meant that after taking off from Butte at 2:41, the airplane reached an indicated pressure altitude of 9000 feet at 2:53 P.M. As nearly as can be determined, the airplane struck the ground approximately two minutes after the 5:05 contact.

In tracing the course followed by Trip 2, several witnesses were located who saw the airplane pass on course over Belgrade, Montana, which is to the west of Bridger Mountain Range and approximately 12 miles west of the scene of the accident. From this point on, a sufficient number of witnesses were found to definitely trace the flight path of the airplane eastward. Bozeman Pass is immediately south of the Bridger Mountain Range, on course for visual contact flying, and at the time of this flight was obscured by a dust storm. As the airplane proceeded toward Bozeman Pass, it was seen to turn toward the northeast to avoid the dust storm and to cross the Bridger Range at a point slightly north of Bridger Mountain Peak. The range is approximately 8,500 feet above sea-level at the point of crossing. From the testimony of witnesses, it is apparent that the airplane went out of control in turbulent air conditions almost immediately after it cleared the Bridger Mountain. It was observed to assume a stall attitude, then a glide, and what was variously described as a spin, a tight spiral or dive to the ground. Fire followed immediately. No witnesses, however, saw the airplane during the last 200 to 400 feet of descent due to uneven wooded terrain. The ground elevation at the scene of the accident is approximately 6,000 feet.

Witnesses who immediately rushed to the scene of the accident were prevented from rendering any possible assistance by the intensity of the fire. Local authorities were notified at once and investigating officials reached the scene that night and the following morning.

The first thorough examination at the scene disclosed that all of the component parts of the airplane were accounted for in the wreckage except upper portions of both the right and left vertical fins and both upper rudders were missing. These parts could not be found in or near the wreckage and a search for them in the surrounding terrain was in progress during the public hearing and still continues. A minute examination of the remaining structure adjacent to the horizontal stabilizer at the points where the major parts of the vertical

fins separated from the airplane disclosed that there had been severe vibration and bending of the fins both to the right and left. The rudder tab control cables had parted in tension, bending pulley brackets and bending and cutting a guide post as they failed and pulled away. These findings leave no room to reasonably doubt that the upper portions of the right and left vertical fins and rudders separated from the airplane while in flight. The propellers were found to be in high pitch, intact and bent backwards toward the engines with all indications that they were turning over very slowly at the moment of impact. A tear-down inspection of the engines indicated that they were in normal working order and turning over slowly at the time of striking the ground. The aircraft radio equipment was destroyed beyond possibility of checking on its use in flight. However, radio communication between the airplane and the ground approximately two minutes before the accident, as well as two-way communication throughout the flight, indicates that the radio equipment had been functioning normally. All of the evidence indicates that the airplane contacted the ground at an angle of between 80 and 90 degrees.

A check of the teletype circuits involved disclosed that all stations were functioning normally except the drop at Livingston which was printing messages illegibly. All of the radio ranges involved were functioning normally and aligned as advertised except the east leg of the Belgrade Range which was found to be 5° south of its advertised course alignment. Neither of these things affected the flight in question as all teletype messages sent through or from the Livingston station were received correctly at their destinations and the pilot of the flight was definitely flying by visual contact method.

In reviewing the facts and circumstances surrounding this accident, there was nothing unusual about the dispatch of the airplane out of Butte. When the flight passed over Belgrade, approximately 12 miles west of the accident, it was on the regular course and appeared and sounded normal. Between Belgrade and Bridger Mountain Range, the airplane was seen to turn to the northeast to avoid flying through a dust storm centered in Bozeman Pass. This and the radio message from the airplane that they were flying at 9,000 feet established the flight as visual contact. The weight of the evidence leads the Investigating Board to the conclusion that the loss of the upper vertical fins with the upper rudders in flight was the result of flutter. The loss of these surfaces deprived the pilot of sufficient control of the airplane to avoid the resulting crash.

"Flutter" as an aeronautical term refers to a vibration of increasing severity which sometimes occurs in the wings and control surfaces of an aircraft while in flight. A certain amount of vibration, due to airflow and engine vibration, is present in these and other parts of any aircraft while in flight. Ordinary vibration is normally of small amplitude and intensity and has no immediate damaging effect on the aircraft structure. In order that flutter may occur, the vibrations of one part of the aircraft must be at or close to the natural frequency (rate of vibration) of some related movable control surface. When influenced in this manner, the vibration of one part may continuously increase in amplitude (distance through which the vibration occurs) to a point beyond the capacity of any normal structure to withstand it and a structural failure will result. Further and detailed analysis of the phenomena of flutter may be obtained by referring to technical papers on the subject.

The Lockheed, model 14-H, was designed and constructed in accordance with the latest knowledge available at the time. The structure was carefully analyzed for strength and this analysis was checked by the Department of Commerce. Extensive

static tests were conducted by the factor, to further demonstrate that adequate strength existed to satisfy the minimum airworthiness requirements. In the process of factory tests, the vibration frequencies of the various component parts were carefully measured, using a vibration machine designed by the factory. The figures thus obtained showed a difference in the natural frequency periods which indicated that flutter would not occur. Both the static tests and the vibration tests were witnessed by representatives of the Department of Commerce. The results of these tests were accepted and used as a part of the basis for approving this type airplane as being airworthy and the subsequent assignment of Approved Type Certificate No. 657 by the Department of Commerce.

As soon as flutter became suspected as a factor in this accident, the Department of Commerce at mid-afternoon of January 11, 1938, grounded all airplanes of this model. Shortly thereafter, tests were started on another airplane of the model 14-H type as a check against the figures obtained in the original vibration tests. This check test, made with a more highly developed machine, definitely indicated the possibility of flutter and demonstrated that the vibration machine used by the factory and recognized by the Department of Commerce for measuring the natural vibration periods of the component parts of the airplane apparently gave misleading results.

It should be noted again that the upper half of the vertical fins and the upper half of the rudders have not been found as yet. An examination of these parts might disclose that through some previous occurrence of fatigue or distortion or through one or both fins having been struck while in flight by some object, the structure could have become weakened to the point that it became susceptible to flutter on encountering turbulent air. However, this is in the realm of possibilities rather than probabilities. It might be noted that one instance has been recorded where in this region a bird striking a vertical fin of a similar aircraft almost resulted in a serious accident.

In summation, the evidence indicates that this flight was dispatched out of Butte in accordance with normal company procedure, was progressing normally, flying by visual contact method, cleared the mountain range with a fair margin of safety and that the loss of control of the aircraft was in no way the fault of the pilot. The aircraft was carefully designed in light of all of the knowledge of the art at that time and constructed in accordance with the dictates of accepted safe practice. The vibration machine used in determining the natural frequencies of vibration of the various components appeared to be a practical one and its accuracy was not questioned by the factory or by the Department of Commerce. It had been in use for a long period of time and was of the type used by other aircraft manufacturers. The Department of Commerce is and has been making a research study looking to the elimination of structural failure as the result of flutter and in this study has had and undoubtedly will continue to have full cooperation from the industry. The Department of Commerce is acquiring new type machines for measuring natural periods of vibration. These machines or their exact equivalent will be made available to or by the industry. As an example of the industry's cooperation, it may be noted that the manufacturer's Assistant Chief Engineer testified as follows:

"In conclusion I wish to state for the benefit of the Board and any other interested parties that as soon as the Lockheed Company learned of the accident which occurred to Plane 36 and the consequent element of doubt which was raised as to the possibility of flutter being induced in the tail surfaces, it immediately took steps to eliminate such a possibility. This has been accomplished by re-designing the surfaces in such a manner that the normal frequencies of the component parts are as far apart as it is physically possible to make them."

As has been indicated, it is the opinion of the Investigating Board that the probable cause of this accident was structural failure of the upper vertical fins and rudders due to flutter which resulted in a loss of control of the aircraft.

Respectfully submitted,

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of Commerce, J. M. Johnson.

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