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Docket No SA-53

REPORT OF THE CIVIL AERONAUTICS BOARD

Of the investigation of an accident  
involving civil aircraft of the United  
States NC 21712 which occurred near  
Moorhead, Minnesota, on October 30,  
1941

CONDUCT OF INVESTIGATION

An accident involving aircraft NC 21712 occurred in the vicinity of Moorhead, Minnesota, on October 30, 1941, about 2 04 a m <sup>1/</sup> while the aircraft was being operated in scheduled air carrier service between Chicago, Illinois, and Seattle, Washington, as Trip 5 of Northwest Airlines (hereinafter referred to as "Northwest") The accident resulted in the destruction of the airplane, death to the 12 passengers and 2 members of the crew, and injuries to one member of the crew The Washington office of the Civil Aeronautics Board (hereinafter referred to as the "Board") was notified of the accident by its Senior Investigator stationed at Chicago immediately after he had received notification of the accident by telephone at approximately 3 25 a m on October 30, 1941

Inspection and Preservation of the Wreckage

Immediately after receiving this notification, the Board 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") As soon as possible after receiving notification of the accident, the Board's Senior Investigator at Chicago called the County Attorney of Clay County, Minnesota, in which county the accident had occurred, and requested him to make arrangements to provide an official guard for the wreckage until the investigator could reach the scene of the accident This request was granted and the investigator proceeded to the scene of the accident, arriving there about 2 00 p m , October 30, 1941 He immediately took custody of the wreckage and ascertained that the guard which had already been provided by the Sheriff of Clay County would continue to guard the wreckage A preliminary investigation made by the investigator upon his arrival indicated that the wreckage had not been disturbed The guard was maintained until the inspection of the aircraft was completed and the aircraft released to Northwest

Public Hearing

In connection with the investigation of the accident, a public hearing was held at Moorhead, Minnesota, on November 3 and 4, 1941 Stuart G Tipton, Assistant General Counsel of the Board, was designated by the Board to preside as examiner at the hearing He was assisted by Frank E Caldwell, Chief of the Investigation Division of the Safety Bureau, William Butters, Senior Investigator for the Safety Bureau at Chicago, and B C Haynes, Air Safety Specialist in Meteorology of the Safety Bureau

All the evidence available to the Board at the time was presented at the hearing Testimony was given by 21 witnesses and 19 exhibits were received in evidence Since Captain Clarence Bates had received injuries in the accident and was confined in a hospital at the time of the hearing, the examiner adjourned the hearing to the hospital and took his testimony there

While the examiner and the representatives of the Safety Bureau were the only ones designated to ask questions directly of the witnesses, the examiner, acting under instructions of the Board, announced at the opening of the hearing that any person who had any evidence, questions, or suggestions for consideration in the proceedings might submit them to the examiner Accordingly, 19 written questions were submitted and were asked of the appropriate witnesses

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<sup>1/</sup> All times used herein are Central Standard unless otherwise indicated

Upon the basis of all the evidence accumulated in the investigation and hearing, the Board now makes its report in accordance with the provisions of the Act

## II

### SUMMARY AND ANALYSIS OF THE EVIDENCE

#### Air Carrier

Northwest, a Minnesota corporation, was operating at the time of the accident as an air carrier under currently effective certificates of public convenience and necessity and air carrier operating certificates theretofore issued to it pursuant to the Act, authorizing it to engage in air transportation with respect to persons, property and mail on various routes, among them being the route between Chicago and Seattle via numerous intermediate points including Minneapolis, Minnesota, and Fargo, North Dakota

#### Flight Personnel

On the flight in question the crew consisted of Captain Clarence F Bates, First Officer Alden Onsgard, and Stewardess Bernice Blowers

Captain Bates, who is 41 years of age, had, at the time of the accident, accumulated a total of approximately 7000 hours of flying time, of which about 6000 hours had been with Northwest. He had served as a first officer for Northwest from June 1, 1932, until November 17, 1935, when he was advanced to captain. Of his total time as captain, 2275 hours had been on DC-3's. Company records do not show the amount of Captain Bates' instrument time and since his personal log books were burned in the accident it is necessary to rely upon an estimate on that point. Captain Bates estimated that he had approximately 1500 hours of instrument flight time and company records show that he had about 21 hours of Link Trainer time. He had undergone an instrument check by the company check pilot on April 23, 1941, and a line check under contact conditions on October 21, 1941, from Minneapolis to Billings and in both cases he was reported as satisfactory. Captain Bates' last physical examination required by the Civil Air Regulations was taken on July 19, 1941, and showed him to be in a satisfactory physical condition.

First Officer Onsgard, who was 25 years of age, had, at the time of the accident, accumulated approximately 1300 hours. He had begun flying for Northwest on May 25, 1941, and his total time with that company was approximately 407 hours, of which 367 hours had been in DC-3 equipment. His personal log book also having been destroyed at the time of the accident, it is impossible to determine definitely the amount of his instrument time, but he had received an instrument rating from the Administrator of Civil Aeronautics on March 24, 1941, after successfully completing the required written and flight tests, and had passed an instrument flight test given by Northwest prior to his employment. He had accumulated 22 hours and 35 minutes of Link Trainer time. First Officer Onsgard's last physical examination required by the Civil Air Regulations was taken on June 25, 1941, and showed him to be in satisfactory physical condition.

Captain Bates had had a rest period of more than 89 hours, and First Officer Onsgard more than 30 hours, prior to going on duty October 29, 1941.

It appears from the evidence that both Captain Bates and First Officer Onsgard were physically qualified and held the proper certificates of competency covering the flight and equipment involved

#### Airplane and Equipment

Aircraft NC 21712 was a Douglas, model DC-3A, manufactured by the Douglas Aircraft Corporation of Santa Monica, California, and purchased by Northwest on April 25, 1939. It was powered with two Pratt and Whitney SC3G engines, each rated at 1050 horse power for take-off, and was equipped with Hamilton Standard, constant speed, hydromatic, full-feathering propellers. The hub model of these propellers was 23E50-109 and the blade design was 6153A-18. This model aircraft and its equipment had been approved by the Civil Aeronautics Administration for air carrier operation over routes flown by Northwest with 22 passengers and a crew of 3. The airplane had been certificated for operation with a standard weight of 24,400 pounds and provisional weight of 25,200 pounds 2/. The airplane and its equipment had received the overhauls, periodic inspections and checks which are provided for in company practice and approved by the Civil Aeronautics Administration.

#### History of the Flight

Northwest's Trip 5 of October 29, 1941, originated at the Chicago Municipal Airport, Chicago, Illinois, with Seattle, Washington, as its destination. Intermediate stops were scheduled at Minneapolis, Minnesota, Fargo, North Dakota, Billings, Montana, Butte, Montana, and Spokane, Washington. Captain Bates and First Officer Onsgard were assigned to operate the flight from Minneapolis to Billings.

Trip 5 was scheduled to depart Minneapolis at 12 midnight. In planning the flight, Captain Bates and Northwest's Minneapolis dispatcher had available the 10 30 p m airway forecast made by the United States Weather Bureau Station at Chicago, which included the area proposed to be traversed by the flight and the terminal forecast for Fargo. The area forecast reported the existence of a cold front which, at the time the forecast was made, had reached Fargo and was moving eastward at approximately right angles to the airway and predicted that the front would advance to near the Duluth, Minneapolis and Des Moines line by 6 30 a m, October 30. Snow was predicted over northern Minnesota during the period of the forecast with overcasts at about 500 feet in that area and from 600 to 1200 feet in the eastern Dakotas. It was predicted that in the snow areas of northern Minnesota visibility would be from 2 to 5 miles, increasing to over 6 miles to the rear of the cold front. Icing conditions were forecast in clouds in advance of the front in all parts of the area except northern Minnesota and Wisconsin where such conditions were expected above 5000 feet above sea level. The forecast also contained a general statement that there would be "icing in clouds to rear of front", indicating that icing conditions might be expected at any altitude behind the front. No attempt was made to predict the severity of these conditions.

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2/ The "standard weight" of an airplane is the maximum allowable weight for landing while the "provisional weight" of an airplane is the maximum allowable weight for take-off. When an airplane takes off with a weight in excess of the designated standard weight, the weight of the airplane must be reduced by gasoline consumption, prior to arrival at its next scheduled stop, to the extent necessary to bring it within the standard weight for landing. If sufficient gasoline has not been consumed between the time of take-off and any emergency landing, gasoline can be dumped by the use of tested and approved dump valves in order to reduce the total weight to the approved gross weight for landing.

The terminal forecast for Fargo predicted low ceilings of from 200 to 400 feet during the early part of the period covered by the forecast but lifting to 600 to 1200 feet about midnight and to about 1500 by 5 a m. Visibility was forecast to be from 2 to 4 miles, improving to 6 or more by 1 30 a m.

In addition, Captain Bates discussed the weather conditions over his proposed route with Captain DeLong of Northwest's Trip 2, who had arrived in Minneapolis while Captain Bates was preparing his flight plan. Captain DeLong stated that he had encountered light ice at 7000 feet above sea level over Fargo and had increased his altitude to 9000 feet above sea level in order to avoid it. Therefore, according to the testimony of Captain Bates and the Minneapolis dispatcher, they planned the flight to operate at lower altitudes than usual in order to avoid the possibility of icing conditions. The flight plan for the trip provided for operation between Minneapolis and Alexandria (about 100 miles southeast of Fargo) at 2500 feet above sea level and the remainder of the flight to Fargo at 2700 feet above sea level. The altitude usually flown along this route, westbound, is 4000 to 6000 feet above sea level.

Another problem involved in the planning of the trip resulted from the fact that the weather conditions reported from Fargo at the time the trip was being planned, were well below the company minimums for that point, i e , 600 feet ceiling and one mile visibility. References to the reported weather observations from the United States Weather Bureau Station at Fargo indicated that for several hours the ceiling at Fargo had been reported as 100 feet with visibility of half a mile. It had improved, however, until about 11 30 the weather was reported as 300 feet ceiling with 2 miles visibility.

In view of this improvement in weather conditions at Fargo and the indication in the Weather Bureau forecast that ceiling and visibility conditions would continue to improve, Captain Bates and the Minneapolis dispatcher agreed that it might be possible for the trip to land at Fargo. Because of the uncertainty as to whether the weather at Fargo would improve sufficiently to allow the trip to land, it was cleared by the Minneapolis dispatcher to land at Fargo upon condition that weather conditions would permit. The trip was also cleared to land at Bismarck, North Dakota, a stop not usually scheduled on Trip 5, in order that necessary arrangements could be made to provide for Fargo passengers and cargo in the event that no landing could be made at the latter place. The alternate designated for Fargo was Bismarck and the alternate designated for Bismarck was Dickinson, North Dakota. At the time the trip was being planned the ceiling at Bismarck was reported at 1400 to 1600 feet with unlimited visibility, while the reports for Dickinson indicated a ceiling of 800 to 900 feet and 7 miles visibility. The terminal forecast for Bismarck predicted an overcast at 1000 to 2000 feet and visibility greater than 6 miles.

The trip took off from Minneapolis for Fargo at 12 13 a m with 620 gallons of fuel, 44 gallons of oil, 12 passengers, a crew of 3, and certain cargo on board. The total weight of the airplane at the time of take-off was 25,008 pounds, and thus within the provisional weight 3/. From the evidence it appears that the airplane was loaded so that the center of gravity was well within the limitations prescribed by the Civil Aeronautics Administration.

After leaving Minneapolis Trip 5 proceeded toward Fargo on instruments at the assigned altitudes. According to Captain Bates' testimony, he anticipated ice constantly during the

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3/ See Footnote 2, page 3. It was anticipated that approximately 135 gallons of gasoline would be consumed between Minneapolis and Fargo, thus reducing the total weight of the aircraft at the time of the anticipated landing by 810 pounds. The airplane would therefore be brought well within the standard weight by the time it reached Fargo.

flight and checked the leading edges of the wings frequently by the use of a flashlight. He turned on the propeller anti-icers long before reaching the Fargo area because, as he explained, they must be turned on before encountering ice in order to be completely effective. He did not turn on his de-icer boots at this time.

When he had reached a point about 25 miles southeast of Fargo, he noticed that the airplane was picking up very light ice "but not any amount to even be bothered about." He stated that about this time the air-speed indicators "started letting up and didn't read accurately." The air-speed indicator needles indicated about 130 m p h. Although he did not know what the exact reading had been prior to that time he said that it had been somewhere around 165 m p h and that at any rate the reading had been normal for the altitude involved. He concluded that the pitot tube had iced up and decided that he would disregard his air-speed indicators from that point on.

As is shown by the radio log of Northwest's Fargo station and by Captain Bates' testimony, the trip arrived over the Fargo radio range station at 1 47 a m at an altitude of 2700 feet above sea level. Since Fargo is 890 feet above sea level, the airplane was approximately 1800 feet above the ground at this time. A short time prior to his arrival over the range station, Captain Bates had received the report of the current Fargo weather observation which stated that the ceiling was 500 feet and the visibility 8 or 9 miles. Thus, at this time the ceiling was 100 feet below Northwest's authorized ceiling minimum at Fargo. Nevertheless, Captain Bates began a standard let-down-through procedure. He explained this action by saying in effect that in view of the constant improvement, which had taken place during the past few hours in weather conditions at Fargo, he decided to let down to his authorized minimums to see if the ceiling had risen in the interim sufficiently to permit him to land.

After passing over the range station at 1 47 a m, he made a left turn to go out on the west leg of the Fargo radio range in accordance with standard procedure. A procedure turn was made on the west leg, the ship again passed over the station, and proceeded out the east leg. A gradual descent was begun after passing over the station a second time and was continued for about 3 or 4 minutes, according to Captain Bates' estimate, until he had reached an altitude of 2000 feet above sea level. During this descent he encountered light ice. He made a procedure turn to the right at this altitude and just as he was returning to the leg at the completion of this turn, he again began descending. At this point he directed First Officer Onsgard to let the landing gear down and turn the de-icer boots on. While the rate of ice accumulation had increased to some extent at the 2000-foot altitude level, Captain Bates still did not consider the icing conditions existing to be serious enough to cause any great concern. He stated that the air temperature was about 30 degrees and identified the ice as rime ice, "the type that forms in irregular chunks and irregular chips, little extensions out on the windshield."

He continued his descent from 2000 feet above sea level at about 400 feet per minute proceeding toward the station in the "A twilight" of the east leg until he reached an indicated altitude of 1500 feet above sea level, when, according to Captain Bates, "we did start to pick up quite a lot more ice." However, having on previous flights experienced what he considered heavier ice accumulation, he still was not unduly concerned.

Upon reaching 1500 feet above sea level, he had not broken out of the overcast, and since he had reached his minimum altitude of 600 feet above the ground, he leveled out intending to proceed over the station at this altitude and if he did not break out of the overcast, to proceed to Bismarck. However, as Captain Bates described his experience, just

as he leveled out "the airplane started to act peculiarly and I knew something was the matter I yelled, 'Gear up', to the co-pilot, the idea being to keep all the speed I could possibly get, and I increased to full horsepower to fly straight ahead at 1500 feet until I could find out what was the matter the airplane started to flutter or shake, and the controls worked hard I had difficulty turning the wheel and the yoke worked hard fore and aft About this time we must have settled, because I started seeing lights (probably of Moorhead), saw all the lights on the horizon, and I knew we were in a level position from the instruments, and from the fact that the lights were all on the horizon, and it was just a few seconds after that we crashed I don't remember anything from that time on " Captain Bates also stated that he had the carburetor temperature set at about 120 degrees and that when he "increased to full horsepower" the engines responded and he "got all the power that it had" He was unable to recall definitely whether he had pushed forward the propeller pitch controls (thus reducing pitch and increasing r p m ) at the same time he opened the throttles, but he thought that he had

About the time Captain Bates leveled out at 1500 feet above sea level, the indicated air speed reached 90 m p h , but because of his earlier conclusion that the air-speed indicators were inoperative he disregarded this reading entirely

From the examination of the marks the airplane made on the ground, it appears that it struck the ground in an open field in almost a level attitude, with power on, and at a speed of approximately 90 m p h The tail wheel and the tips of the left and right propeller struck the ground almost simultaneously After making contact with the ground, the airplane proceeded forward on a bearing of 206 degrees magnetic and left marks of the propellers, the tail wheel, and the rear radio masts It then jumped over a ravine approximately 16 feet deep and 80 feet wide and struck the bank on the opposite side head-on It bounced over the top of this bank to come to rest on level ground just beyond it, right side up and on a bearing of 235 degrees magnetic The point at which the airplane came to rest is 1-1/4 miles north of Moorhead, about 2-1/2 miles east of Hector Field the Fargo airport, and about 1/2 mile directly south of the centerline of the east leg of the Fargo radio range The east leg of the range, in the "A twilight" of which Captain Bates had been flying, has a magnetic bearing of 259 degrees

Investigation revealed only one eye-witness to the crash, Mr E M Gregory A short time prior to the accident he was driving south on United States Highway No 75, which runs directly north and south and passes within a quarter of a mile west of the scene of the accident He first saw the airplane when he reached a point about 1-1/2 miles north of the scene of the accident His attention was directed to it by the sound of motors which appeared to him to come from a point almost directly overhead, but on looking out the side window of his car to his left, he saw the lights of an airplane which he thought to be flying in an easterly direction less than a mile southeast of him At this time the airplane appeared to be flying at a normal altitude He proceeded on for approximately one mile when he saw the airplane again, directly through his front windshield, flying a few feet above the ground and a few seconds later he saw it crash It immediately burst into flames so that by the time he reached the airplane the heat from the fire, fanned by a northwest wind, prevented him from reaching the cabin door on the south side of the plane He was unable to testify as to the condition of the airplane at this time except to say that he believed that the nose of the airplane had been broken off He found Captain Bates, who probably had been catapulted from the cockpit at the time of impact with the bank of the ravine, close to the wreckage in a dazed and injured condition

Condition of the Wreckage

The fuselage of the airplane was completely burned back to the leading edge of the stabilizer and the wing butts were partially melted. The leading edge of the left wing and the de-icer boot were burned and melted and the fabric had been burned off the left aileron but the aileron hinges and controls appeared to be in operating condition. While the out-board section of the right wing had not been burned, the leading edge had been damaged from the wing tip section to a point about 6 feet in toward the fuselage (apparently caused by striking trees). The right aileron was intact and undamaged and the controls appeared to be in operating condition. The flaps were in the up position and the landing gear was retracted. The tail assembly was only slightly damaged.

While the fire had destroyed most of the cockpit instruments and controls, it was possible to determine the settings or indications of some of them. The throttles were in closed position, the mixture controls at cruising position, the right propeller pitch control in the 2050 r p m position, and the left in the 2450 r p m position. The pilot's air-speed indicator showed 83 to 85 m p h and the dial reading of the directional gyro was 220 degrees. Both cockpit clocks were damaged and burned but it was possible to determine that they both had stopped about 2 04 a m. The propeller de-icer gauge and valve and the de-icer valve for the wings and stabilizer were completely burned and melted so that it was impossible to determine their settings.

The left engine rested on its nose in front of the engine mount with all cylinder heads in the rear bank completely destroyed by fire. The propeller was attached with one blade melted off about 8 inches from the hub, another blade was bent and the tip melted, and the third blade was bent in approximately a 75-degree curve and was twisted.

The right propeller and the nose section of the right engine had broken off and remained at the point at which the airplane had struck the bank of the ravine and at the time the airplane came to rest the remainder of the right engine apparently broke free from the engine mount and nacelle and rolled approximately 15 feet forward of the nose of the airplane.

After examination at the scene of the wreckage, the engines and propellers were removed to Northwest's shops at St Paul, Minnesota, where they were disassembled and inspected by Mr Earl L Smith, Air Safety Investigator for the Civil Aeronautics Board, Mr Ralph E Geror, Superintendent of Maintenance for Northwest, Mr R Paul O'Neal, Service Representative for United Aircraft Service Corporation, and Mr Chester M Brown, Propeller Division Superintendent for Northwest. The examination and inspection revealed very little evidence which would indicate whether the engines were producing power at the time of impact, but nothing was found which would indicate any failure or malfunctioning of either engine prior to the accident. The left engine was so badly damaged by fire that it was impossible to determine whether it had been operating at the time of the accident. With respect to the right engine, the condition of the reduction gear splines and of the propeller governor, and a sheared generator, indicated that the propeller was rotating at the time of impact. Whether this rotation was under power, or merely windmilling, could not be determined from the inspection of the engine.

Damage to the gear segments, blade bushings and rotating cams of the propellers, and spider arms bent from 0 002" to 0 010" out of their planes, indicated that breakage had occurred as a result of sudden stoppage of rotation.



The gear segment on the end of each blade of each propeller was broken between the fourth and fifth teeth, indicating that the propellers were in low pitch at the time the breakage occurred

Careful inquiry was made of persons who arrived at the scene of the accident shortly after it occurred in order to determine, if possible, the extent of ice accumulation on the airplane at that time. Mr. Henry Olson, a mechanic for Northwest, stationed at Fargo, was found to be the first person to have made a careful observation of ice accumulation. He arrived there at approximately 2:30 a.m. and observed that there was a coating of rough ice on the de-icer boot of the right wing ranging from 1/2 to 2 inches thick and extending from a point about 8 feet outboard of the landing light to the wing tip. He described the ice as "white and snowy". He also observed some ice of the same type lying beneath the right aileron but was unable to testify with respect to any ice which may have been accumulated on the stabilizer. Mr. Olson did not believe that the ice he observed had been affected by the fire since it had been on the windward side. Mr. Olson's testimony was corroborated by Mr. Floyd Berglund, an apprentice mechanic of Northwest at Fargo. During the period from the time of the accident until the arrival of these witnesses at the scene the temperature was about 32 degrees.

#### Weather Conditions

Reinhart C. Schmidt, Supervising Forecaster at the United States Weather Bureau Station in Chicago, and B. C. Haynes, Air Safety Specialist in Meteorology for the Board, testified with respect to analyses they had made of the weather conditions existing in the area traversed by the flight about the time of the accident. From this testimony it appears that the cold front which had been moving eastward at 15 to 20 m.p.h. had reached St. Cloud, Minnesota, about the time of the accident with the frontal surface sloping back westward so that over Fargo it lay at an altitude of approximately 3000 feet above the ground at this time. In advance of the front, the wind direction was south-southwest and to the rear of the front northwest, Fargo reporting a northwest wind of 17 m.p.h. about the time of the accident. In advance of the front the temperatures were above freezing up to approximately 4000 feet above sea level. At Fargo in the rear of the front, the ground temperature at 1:30 a.m. was 33 degrees, lowering to about 32 degrees at 300 feet above the ground, 30 degrees at 900 feet, and to a minimum of 28 or 29 degrees between 1500 feet and the frontal boundary, where the temperature probably increased to above freezing.

These witnesses agreed that the atmospheric conditions near Fargo, as above described, were favorable to the formation of ice just above the base of the overcast, since the temperature was below freezing and, by reason of the relatively strong northwest wind, some turbulence could be expected. However, neither could express an opinion as to the severity of the icing conditions to be encountered there.

Mr. Haynes testified that icing is usually greatest in a freezing rain area or in a long and active cold front and that the high moisture content of the clouds near the base of the overcast would render conditions there similar to those encountered in a freezing rain. Mr. Haynes was of the opinion that the ice accumulated in this area would be a soft type of clear ice but would accumulate in a jagged form.

#### Flight Tests

The behavior of the airplane, as described by Captain Bates, suggested stalling of the inner sections of the wing, with buffeting as a result, but it gave no clue to the reason

for the apparent development of violent buffeting after the power was applied, or to the failure of the application of power to check the descent of the aircraft. With throttles fully open, an aircraft with the general characteristics of the DC-3 would ordinarily be expected not only to maintain altitude but to climb, even at a speed very near the stall, and it is the common characteristic of multi-engine aircraft of this general form that they are much less susceptible to buffeting with power on than with power off. It is for that very reason, indeed, that such aircraft as the DC-3 are more liable to stalling of the wing tips, with resultant uncontrollable cropping of the wing, in the power-on condition than in that with power off. In the latter case, buffeting due to stalling of the inner part of the wing gives the pilot a warning which is ordinarily much less apparent, if not entirely lacking, when the aircraft approaches the stall with power on.

Captain Shank, check pilot for Northwest, testified that he had encountered similar conditions in his experience with Douglas aircraft. Captain Shank has logged a total of approximately 13,500 hours solo flight time. He has had between 2000 and 2500 hours in DC-3 airplanes, of which approximately 1600 hours were spent checking pilots. He has checked between 50 and 60 pilots in stalls and recoveries, the check for each pilot including a minimum of 48 stalls and recoveries and for most of them a check in about 75 stalls and recoveries.

Captain Shank testified that in this pilot checking experience he had observed that, in attempting to reduce loss of altitude to a minimum, occasionally a pilot would apply full power when the airplane had reached a nearly stalled condition and rapid descent had begun. Occasionally in these instances, at an air-speed indicator reading of from 55 to 90 m p h, a terrific buffeting occurred about concurrently with application of full power. During this lateral and directional control were retained, although with difficulty, but an uncontrolled descent took place. In order to avoid a prolonged and severe strain on the airplane, this condition was not permitted by Captain Shank to continue for any great length of time, recovery being effected by dropping the nose of the airplane, thereby increasing air speed. Little had been known about this tendency or characteristic of the airplane, according to Captain Shank, Mr. Marshall and Mr. Ferguson, and it had been believed that the application of power would pull the airplane out of the condition described without it being necessary to drop the nose.

A series of flight tests were accordingly planned, with the object of simulating the behavior of NC 21712 immediately prior to the accident, as described by Captain Bates, and discovering any relation which might exist between the behavior during the accident and that which had previously been encountered in test and check flights by Captain Shank. The tests were made on November 28 and December 2, 1941, at Minneapolis, Minnesota, and were witnessed and participated in by Frank E. Caldwell, Chief, Investigation Division of the Safety Bureau, and the following personnel of Northwest: Captain Clarence F. Bates, Captain Eugene S. Shank, W. Fiske Marshall, Division Superintendent, Kenneth R. Ferguson, Assistant to the Vice President in Charge of Operations, Karl Larson, Chief Engineer, and Don Jones, First Officer. The data accumulated in these tests and testimony of the participating witnesses were incorporated in depositions taken at St. Paul, Minnesota, on December 1 and 3, 1941, which thereafter were made a part of the record of the investigation. The tests have not been fully worked up as yet, and are to be amplified by further studies, but certain general conclusions can be drawn, and will be discussed herein.

The airplanes used were DC-3's, owned by Northwest, and they were piloted by Captain Shank. The gross weight and C. G. Location were kept as nearly as possible identical with those of the airplane involved in the accident. The general procedure in the tests was to

bring the airplane up gradually toward the stall, while flying with reduced power (20 to 29 in manifold pressure), until slight buffeting became apparent. The landing gear was then retracted and full power applied to both engines, the controls being used to maintain approximately a level attitude with respect to the horizon.

Following the application of power, the buffeting increased sharply, and in some cases became quite violent. Instead of flatterring out the flight path and beginning to climb, as would normally have been expected, the airplane lost altitude rapidly, the rate of descent seeming typically to stabilize at about 1500 feet per minute, though rising at times to 1800. The airplane could be kept in a constant attitude with respect to the horizon, and on its course, by normal use of the three controls, although the maintenance of lateral equilibrium required constant alertness and much rapid and extreme movement of the ailerons, and the elevator also required constant manipulation to hold a constant attitude.

Subject to this necessity for constant use of the controls, it appeared that the airplane could be kept for an indefinite length of time in the attitude that produced the buffeting and the rapid descent despite the use of full power. The readings of the air-speed indicator during the descent varied between approximately 65 m p h and slightly over 80 m p h, <sup>4/</sup> and the artificial horizon maintained an indication of approximately level flight. To regain normal flight it was found necessary to push the control column forward enough to change the attitude of the airplane with respect to the horizon by approximately 4 to 5 degrees.

Captain Shank identified the maneuver as the one that he had previously experienced in checking pilots on stalls. Captain Bates, who took the controls during one of the tests, testified that the feeling during the tests was quite like that shortly before the accident. "In the accident at Fargo," he said, "I do not remember this severe fighting of the controls to keep the airplane level, but I do remember the similarity between the way the airplane felt according to my last recollection in the accident at Fargo and in the way the airplane felt in our test the other day. That buffeting was very similar to what I experienced at Fargo." He stated also that the approach to the stall and the beginning of the buffeting in the tests were very similar to the beginning of the condition which he experienced preceding the accident.

The tests included trials with the de-icer boots in operation, and with power applied on one engine only. The results in those cases did not differ, in any substantial respect, from those previously recorded.

As the failure to realize the anticipated checking of the descent by the application of power suggested a failure to secure the expected increase in propeller thrust when the throttles were open, the propeller performance was made the subject of special investigation. The propeller pitch was measured during the various stages of the maneuver of stall and recovery, and with various settings of the propeller pitch control. Certain of the test data are tabulated in an appendix to this report, and indicate a substantial increase in the pitch angle of the propeller after power was applied.

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<sup>4/</sup> The power-off stalling speed of a DC-3 with flaps up is approximately 80 m p h. The power-on stalling speed would be appreciably lower, but it is well known that air-speed meters are prone to read somewhat low at speeds near the stall, because of the manner of installation of their recording element, and the readings during the tests may also have been affected by the violent vibrations of the airplane.

The analysis of the problem, as previously indicated, has not proceeded to the point of making any final conclusion possible, but two alternative explanations of the behavior of the aircraft are immediately apparent. The explanation might lie either in that (1) the airplane was so completely stalled, at such a large angle of attack, that the power required to maintain level flight would have been more than the power plant could supply even with the engine and propellers functioning perfectly, or (2) the particular conditions of the maneuver may have so adversely affected the functioning of the propellers as to prevent them from developing the thrust which would normally be anticipated.

Each of these alternative explanations presents certain difficulties. If the wing had been stalled to the degree that the first explanation would have required, it is hard to conceive of the airplane having been kept continuously under control during the descent. The normal consequence of such a complete stall would be the dropping of one wing tip, with the recovery of normal attitude only after a dive to gain speed and escape the stalling attitude. Also, the first of the alternative explanations would fail to account for the violent increase in buffeting as power was applied.

The second explanation, that related to the propeller, presents the difficulty that if the propeller blade sections had been stalled and the propeller efficiency correspondingly lowered during flight at stalling speed, at full power, and with the r p m of the engine equal to the r p m normally used in a take-off, the same phenomenon would be expected to appear in an even more severe form during the take-off itself, and it would become almost impossible to gain the speed necessary for take-off. There is no immediately apparent explanation for a loss of propeller thrust at an intermediate speed, i e , at the stalling speed without any corresponding difficulty being encountered either at lower or at higher speeds. In view of these difficulties of explanation, we arrive at no definite conclusion here, but merely present the facts as so far encountered.

#### Conduct of the Flight

As indicated previously in this report, we have determined that the aircraft had been properly maintained and inspected in accordance with the requirements of the Civil Air Regulations. The evidence has disclosed no indication of structural or mechanical failure of the aircraft until it crashed with power on in the vicinity of Moorhead, Minnesota, and we conclude that it was in an airworthy condition prior to that time. It has been determined, also, that the aircraft was properly loaded and it appears that it had ample fuel for the flight. It is clear from the evidence that the radio range and other radio facilities involved, operated and maintained by the Civil Aeronautics Administration, were operating normally during the flight.

In seeking to determine the cause of the accident, we must consider first whether, under the weather conditions which existed at the time, it was proper to dispatch the flight from Minneapolis to Bismarck with clearance to land at Fargo in the event that weather improved to permit a landing under ceiling and visibility conditions at or above prescribed minimums. It appears from the evidence that the observed weather information and current weather forecasts gave sufficient indication at the time of clearance that the ceiling and visibility at Fargo probably would be at or above the prescribed minimums when the flight should arrive at that point. We conclude, therefore, that the clearance was accomplished in accordance with Civil Air Regulations and that it is not subject to criticism.

It remains to be determined whether the dispatcher, in failing to direct the pilot to proceed to his alternate prior to the arrival of Trip 5 in the vicinity of Fargo, and Captain

Bates, in letting down to the prescribed minimum altitude to determine whether he might land, exercised sound judgment and a proper degree of caution

In considering this question it should be observed at the outset that it has become a rather common practice for airline pilots to engage in what is descriptively known as "taking a look" In brief, this practice consists of letting down, when approaching an airport at which the United States Weather Bureau has reported the ceiling or visibility below minimums for which landings are permitted, to the altitude prescribed as such minimum ceiling for the purpose of enabling the captain to observe the condition of visibility and ceiling from the cockpit If, upon reaching the minimum prescribed ceiling altitude, the captain finds that he has visual contact with the ground sufficient for a safe landing, a landing may be effected If that proves not to be the case, the captain returns to cruising altitude and continues on to an approved alternate This practice has not been expressly prohibited by the Civil Air Regulations or otherwise It is evident, therefore, that neither the failure of the dispatcher to direct Captain Bates to proceed to his alternate, nor the action of Captain Bates in descending at Fargo, constituted a violation of regulations

It is obvious, however, that even in the absence of any prohibitory regulation the question whether it is proper, under any given weather conditions, to let down for the purpose of determining whether a landing might be made must be decided in the light of all weather factors existing at the particular time and place When Trip 5 reached the vicinity of Fargo, the continued existence of a critical ceiling was not the only adverse weather factor involved The existence of a cold front moving eastward had been well established and was known by the dispatcher and Captain Bates They knew, or should have known, that Fargo was to the rear of this cold front and that icing conditions and perhaps freezing rain would occur at various points, particularly near the base of the overcast in the rear of the front With only slight variations the temperature at Fargo had remained at, or close to, the freezing point for a considerable period and in addition the dew point had been approximately the same as the temperature Moreover, the dispatcher and Captain Bates must have realized that the temperature which would be encountered near the base of the overcast in the vicinity of Fargo would be lower than the ground readings at that point Furthermore, Captain Bates had already encountered ice The dispatcher and Captain Bates should have realized that a marginal ceiling in combination with icing conditions constituted a very great hazard to any attempt to land Under all these circumstances, therefore, the dispatcher, in failing to direct Captain Bates to proceed to his alternate, and Captain Bates, in descending for a possible landing, failed to exercise sound judgment and a proper degree of caution

Thus far we have determined that the descent for a possible landing at Fargo was unjustified and that Captain Bates and the dispatcher were at fault in that regard This may be considered to have contributed to the cause of the accident, but in order to determine precisely the probable cause of the accident, we must go further and inquire into the cause of the partial loss of control of the airplane A careful consideration of the evidence has satisfied us that the partial loss of control was not caused solely by the ice which had been accumulated on the airplane A collection of ice upon airplane surfaces is not an uncommon experience and, while it is to be avoided to the fullest extent possible by the exercise of great caution, in the nature of things it cannot be eliminated entirely Although the amount of ice which had been accumulated on the airplane was substantial, experience has demonstrated that aircraft may safely be flown with a far greater accumulation of ice than that which obtained in this case The testimony in the record of this accident, as well as general knowledge previously acquired, convincingly shows that the accident was not caused solely by ice It is equally clear, however, that the amount of ice which had been gathered

by the airplane was sufficient to affect materially the flight characteristics of the plane. The effect of such ice is to reduce air speed and increase the stalling speed.

Considering all the evidence, it is our conclusion that the uncontrollable descent of the aircraft was primarily caused by a stall of the type which was repeatedly produced in the tests made following the accident and described herein. Captain Bates, during the tests, noticed only two features for which he recalled no strict parallel during the experience at Fargo: (1) the necessity for constant rapid movement of the aileron controls, and (2) the sensation of loss of speed. With respect to the first point, however, Captain Bates recalled a sensation of uncontrollability of the airplane immediately prior to the accident and that his "main idea was to keep it level". His absence of any specific recollection of having made vigorous use of the controls for that purpose does not seem significant in view of the obvious difficulty of recalling every detail from a time of such stress, and immediately prior to the pilot's having suffered a staggering blow on the head.

With respect to the loss of speed, the pilot's sensations alone, while flying in a closed cockpit, could hardly be a reliable guide, and Captain Bates, having concluded that his air-speed indicators had been disabled by ice, was disregarding their indications.

The increase of power, from the amount ordinarily used during an approach to the maximum possible, would ordinarily be expected to change the rate of vertical motion of a DC-3 airplane, at a constant air speed, by at least 800 feet per minute <sup>5/</sup>. The attempt to fly straight ahead, using full power to check the descent, was consistent with the normal practice of highly skilled pilots, although the violent shaking of the airplane, typically characteristic of close approach to a stall, might well have suggested, without any reference whatever to the conditions under which the propellers may have been operating, that the rate of descent could have been reduced by increasing the speed to a value nearer that corresponding to the best angle of climb (at least 25 percent above the stalling speed). It must be admitted, however, that it is not easy even for a skilled pilot when already at a low altitude and approaching the ground rapidly, to overcome the instinctive tendency to try to pull the nose of the airplane up away from the ground, and follow instead the correct course of pushing the control forward and nosing the airplane down with respect to the horizon in order that the flight path may be brought nearer to the horizontal.

### III

#### CONCLUSION

##### Findings

We find upon all of the evidence available to the Board at this time that the facts relating to the accident involving NC 21712 which occurred approximately 1-1/4 miles north of Moorhead, Minnesota, on October 30, 1941, are as follows:

1. The accident which occurred at approximately 2:04 a.m. on October 30, 1941, to Northwest Airlines' Trip 5 resulted in complete destruction to aircraft NC 21712, fatal injury to the 12 passengers and 2 members of the crew, and injury to one member of the crew.

2. At the time of the accident, Northwest Airlines held a currently effective certifi-

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<sup>5/</sup> e.g., to convert a rate of descent of 500 feet per minute into a rate of climb of 300 feet per minute.

cate of public convenience and necessity and an air carrier operating certificate authorizing it to conduct the flight

3 Captain Bates and First Officer Orsgard were physically qualified and held proper certificates of competency to operate as air carrier pilots over the subject route

4 Aircraft NC 21712 was currently certificated as airworthy at the time of the accident

5 Trip 5 was cleared in accordance with company procedure from Minneapolis, Minnesota, to Bismarck, North Dakota, with clearance to land at Fargo, North Dakota, if weather conditions there would permit. The alternate designated for Fargo was Bismarck and the alternate designated for Bismarck was Dickinson, North Dakota

6 At the time of departure from Minneapolis, Minnesota, and at the time of the accident, the gross weight of the airplane did not exceed the permissible gross weight and its load was properly distributed

7 At the time of departure from Minneapolis, Minnesota, the aircraft carried sufficient fuel to permit flight at normal cruising power to Fargo, North Dakota, or to Bismarck, North Dakota, and thereafter to permit it to proceed to its alternate airport with sufficient fuel still remaining in the tanks for about 3 hours of flight

8 Weather forecasts reported the existence of a cold front which had reached Fargo, North Dakota, and was moving eastward. Before Trip 5 departed Minneapolis, the ceiling at Fargo had been reported as varying between 100 and 300 feet. The terminal forecast for Fargo predicted that the ceiling would lift to 600-1200 feet about midnight

9 At the time the trip was being planned the ceiling at Bismarck, North Dakota, was reported as 1400 to 1600 feet with unlimited visibility. The terminal forecast for Bismarck predicted an overcast at 1000 to 2000 feet and visibility greater than 6 miles

10 Trip 5 proceeded normally from Minneapolis, Minnesota, to Fargo, North Dakota, accumulating light ice on the airplane upon approaching that point. Upon the arrival of Trip 5 in the vicinity of Fargo, North Dakota, the ceiling remained about 100 feet below the prescribed minimum for landing

11 After arriving in the vicinity of Fargo, North Dakota, and descending from cruising level to about 2000 feet above sea level, it was noticed that the airplane was taking on considerably more ice and the de-icer boots were turned on

12 Captain Bates made a normal descent to approximately 600 feet above the ground, at which point, while still on instruments, he leveled out. Immediately the airplane "started to act peculiarly", and Captain Bates applied full power. A severe buffeting condition commenced and the airplane began an uncontrolled descent, continuing until it struck the ground in an almost level attitude with a forward speed of approximately 90 m p h

13 There was no structural or power plant failure prior to the accident

14 The engines were functioning normally at the time the aircraft struck the ground

15 While icing conditions existed over the route, the dispatcher failed to recognize the seriousness of that condition at the base of the clouds in the Fargo area and as a re-

sult did not direct Captain Bates to proceed to his alternate

16 The action of Captain Bates in continuing his descent over Fargo after encountering more severe icing conditions than had existed at cruising altitude was not consistent with good operating practices

#### Probable Cause

Upon the basis of the foregoing findings and of the entire record available at this time, we find that the probable cause of the accident to aircraft NC 21712 (Northwest Airlines' Trip 5) on October 30, 1941, was the failure of the aircraft, when the inboard portions of the wings were stalled, to respond to the application of full power in the manner reasonably to be expected in the light of the aeronautical knowledge then available

#### Contributing Factors

1 Accumulation of ice on the wings and other surfaces of the airplane, increasing the stalling speed and the drag of the airplane on the power required to maintain flight

2 Failure of the captain, due to his having lost confidence in the air-speed meters, to realize his close approach to a stalled condition

3 Action of the captain in descending to attempt a landing at Fargo with known icing conditions and critical ceiling conditions, instead of proceeding to an available alternate

4 Failure of the dispatcher to recognize the seriousness of weather conditions in the vicinity of Fargo and to direct the pilot to proceed to his alternate

#### Comment

1 Because the investigation of this accident, and the tests described herein, appeared to have revealed a flight characteristic of the DC-3 airplane which had not been recognized, the Board, shortly after the tests were conducted, circulated to the industry the information then available with respect to the observed effects of the application of full power under the conditions described and the apparent indispensability of depressing the nose of the airplane in order to reduce the rate of descent even after the application of full power. As we have indicated earlier herein, further studies are being made for the purpose of explaining the behavior of the airplane. Any further information, discovered during the study, which may appear to be helpful to the industry likewise will be circulated.

2 It appears that the practice of letting down to "take a look", when weather conditions at the point of intended landing are officially reported to be less than prescribed minimums, may at times create a serious hazard. Accordingly, the Civil Aeronautics Board is now considering a regulation which would prohibit that practice.



BY THE CIVIL AERONAUTICS BOARD

/s/ L. Welch Pogue  
L Welch Pogue

/s/ George P. Baker  
George P Baker

/s/ Harllee Branch  
Harllee Branch

/s/ Oswald Ryan  
Oswald Ryan

/s/ Edward Warner  
Edward Warner

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APPENDIX

Readings Manually Recorded During Second Series of Tests <sup>1/</sup>

	Altitude at commencement of buffeting (feet)	Altitude at which recovery was effected (feet)	Total loss of altitude (feet)	Altitude lost during recovery <sup>2/</sup> (feet)	Maximum rate of descent (feet per minute)	Stabilized rate of descent (feet per minute)	R.P.M. at which propeller pitch control was set to govern	R.P.M. setting to which propeller pitch control was advanced prior to application of full power	Highest indicated R.P.M.	Inches manifold pressure used until buffeting condition was reached	Indicated air speed during approach to stall (miles per hour)	Indicated air speed on entering buffeting condition (miles per hour)	Minimum indicated air speed (miles per hour) <sup>3/</sup>	Propeller pitch angle during approach to stall (degrees)	Propeller pitch angle when buffeting commenced (degrees)	Propeller pitch angle during descent (degrees)	Maximum propeller pitch during recovery (degrees)
First test	5,000	5,000	1,000	50	1,900	1,300	2,050		2,300	25	80	60	45	25	24	30	33
Second test	5,300	4,300	400	50	1,400		2,050	2,450	2,600		90	65		24 1/2	19	22	26
Third test	5,300	4,300	500	0	1,300	1,000	2,250		2,600		80	65		20	16 1/2	25	29
Fourth test	5,300	5,100	200	20	1,100		2,250	2,450	2,600	22	90			21	18	22	23
Fifth test	5,700	5,300	400	30	1,000	400	2,450			20	80			13	16	23	24
Sixth test	5,800	5,300	500	0	1,600		2,050	2,280		25	80			24	23	28 to 23	22

1/ Due regard must be had to the possibility of inaccuracy of the instruments as a result of the severe vibration.

2/ The period from the time that the nose was lowered until recovery was completed.

3/ See Footnote 1 above. It is unlikely that the air speed actually reached this extremely low rate.