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REPORT OF THE CIVIL AERONAUTICS BOARD

Of the investigation of an accident involving civil aircraft of the United States NC 25678 which occurred near Chicago, Illinois, on December 4, 1940.

U.A.L.

[Note: In the body of this report the Board sets out not only its conclusions but also the reasons impelling it to arrive at those conclusions and gives a brief statement of the relevant evidence collected in order that those reading it may form their own conclusions. Those who desire only to consider the findings of fact and conclusion of the Board as to the probable cause may do so by turning to page 71 where they are set out in brief form.]

58-6

TABLE OF CONTENTS

I. Conduct of Investigation	1
Inspection and preservation of wreckage.....	1
Public hearing.....	1
II. Summary and Analysis of Evidence	3
Air carrier.....	3
Flight personnel.....	3
Condition of aircraft prior to take-off.....	6
History of the flight.....	9
Flight path just prior to crash	14
Weather conditions.....	27
Condition of airplane and equipment immediately prior to impact.....	36
Fuselage.....	37
Surfaces.....	38
Ice accumulation.....	38
Engines	40
Propellers.....	43
Controls and instruments.....	45
Radio equipment.....	46
Stall characteristics of the airplane.....	46
Effect of ice	47
Effect of uneven engine response.....	52
Chicago Municipal Airport.....	53
Conduct of the Flight.....	55
III. Conclusion.....	71
Findings.....	71
Probable Cause.....	75
Recommendations.....	75

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CONDUCT OF INVESTIGATION

Aircraft NC 25678, while operating between New York and Chicago as Trip 21 of United Airlines Transport Corporation, crashed within two blocks of the Chicago Municipal Airport about 5:48 p.m. (CST*) on the afternoon of December 4, 1940. As a result of the accident the aircraft was almost completely destroyed and the operating crew of three and seven of the thirteen passengers were fatally injured. The Civil Aeronautics Board (hereinafter referred to as the "Board") was notified of the accident at 6:10 p.m. of the same day.

Inspection and Preservation of Wreckage

Pursuant to section 702 (a)(2) of the Civil Aeronautics Act of 1938, as amended, the Board initiated an investigation at once. The Chief of the Investigation Division of the Safety Bureau of the Board immediately left for Chicago. Pending his arrival, the Chicago representatives of the Board took custody of the wreckage and arranged for a continuous guard. After a preliminary examination of the wreckage at the scene of the crash, the Safety Bureau authorized the removal of the aircraft to the United Air Lines hangar at the Chicago Municipal Airport for disassembly and inspection. Until the close of the public hearing, when the aircraft was released by the Board to United Air Lines, the wreckage was under continuous guard by the Chicago Police Department and all inspections, including the dismantling and tear-down of the engines and accessories,

* All times hereinafter mentioned will be Central Standard Time unless the contrary is indicated.

were completed under careful observation of staff experts of the Board.

Public Hearing

A public hearing was held in the City of Chicago beginning on December 11, 1940, and continuing through December 14, 1940, at which 48 witnesses were heard and 99 exhibits introduced. The Board designated G. Grant Mason, Jr., one of the five members of the Board, as Presiding Examiner, and S. G. Tipton, Assistant General Counsel of the Board, as Associate Examiner. Also participating in the hearing were Jerome Lederer, Director of the Safety Bureau; Robert D. Hoyt, Assistant Director; Frank E. Caldwell, Chief of the Investigation Division; Paul Gareau, Aerologist of the Safety Bureau; and Phil C. Salzman, Investigator in charge of the branch office of the Board in Chicago, Illinois.

In accordance with the policy of the Board, the Examiner at the opening of the hearing stated that any person who had any evidence, questions, or suggestions to present for consideration in the proceeding might submit them in writing to the Examiners. Pursuant to this announcement, 81 written questions were submitted to the Examiners by the audience and were asked of the witnesses during the hearing. Although the public hearing was indefinitely recessed on December 14 by the Presiding Examiner, the investigation of this accident continues and will not be closed until all possibility of further evidence has been foreclosed.

On the basis of all the evidence available at this time, the Board now makes its report in accordance with the provisions of the Civil Aeronautics Act of 1938, as amended.

SUMMARY AND ANALYSIS OF EVIDENCE

Air Carrier

The operator of aircraft NC 25678 was United Air Lines Transport Corporation,* a Delaware corporation, with main offices located at 59 South Cicero Avenue, Chicago, Illinois. This company operates as an air carrier under an air carrier operating certificate and a certificate of public convenience and necessity, issued pursuant to the Civil Aeronautics Act of 1938, authorizing it to engage in air transportation with respect to persons, property and mail over various routes including the route between New York (LaGuardia Field) and Chicago, Illinois (Chicago Municipal Airport) via Philadelphia and Allentown, Pennsylvania, and Akron and Cleveland, Ohio.

Flight Personnel

The flight crew of United 21 was Captain Philip Cramer Scott, First Officer George Sumner Young, and Flight Stewardess Florence Little.

Captain Scott, who was 33 years of age, received his early flight training in the United States Navy, serving for two years, and had been in the employ of United since July 7, 1933. He was a graduate of the University of Minnesota and of the Naval Aviation Training School at Pensacola, Florida.

* Hereinafter referred to as "United".

At the time of the crash Captain Scott was the holder of airline transport pilot certificate No. 28112 and had accumulated flying time of more than 5,000 hours, of which 1,535 hours were in Douglas DC-3 type equipment. He had served as a second pilot for United for four years before becoming captain, and his record indicates that he had logged 1,943 hours of flying time as captain, of which 735 hours were night flying time. He had accumulated 148 hours of instrument time and more than 63 hours under the hood. His record further indicates that he had flown as a check pilot for United and as such had taught instrument flying to younger officers of the airline. The record shows that in accordance with United's practice, Captain Scott was hood-checked on September 5, 1940, on both two-engine and one-engine operation under simulated instrument conditions and was found satisfactory.

A physical examination by a medical examiner of the Civil Aeronautics Administration on July 26, 1940, showed Captain Scott to be physically qualified as an airline transport pilot and, in addition, he had satisfactorily completed an examination given by a doctor of United's medical department on August 19, 1940.

First Officer Young was 30 years of age and a graduate in engineering of Purdue University. He had received his early flight training with the United States Navy, graduating from the Naval Aviation Training School at Pensacola, Florida, and had been four years with the service. He was employed by United on February 5, 1940, and the record indicates that he had served as a flight

instructor in the Naval Air Service at Glenview, Illinois, just prior to his employment. First Officer Young was the holder of commercial pilot certificate No. 40699 with an instrument rating and had logged 1800 hours of flying time at the time of the crash, of which approximately 700 hours were in DC-3 type equipment. First Officer Young was last examined by a medical examiner of the Civil Aeronautics Administration on August 6, 1940, which examination showed that he was physically qualified for duty as an air transport pilot. The company's physical examination, conducted on May 13, 1940, also indicated that he was in good physical condition. First Officer Young had been hood-checked just prior to his employment by United.

On the day preceding the accident, Captain Scott and First Officer Young were given a routine en route check between Chicago and New York by Mr. Walter J. Addems, Superintendent of Flight Operations of the Eastern Division of United. Although this flight of December 3 was the first flight of Captain Scott and First Officer Young together as a flight crew, the record of this check introduced in evidence indicates that their cooperation was good. Mr. Addems stated that at the time he was particularly pleased to see such smooth cooperation between two officers on their first trip.

From all the evidence, we conclude that both Captain Scott and First Officer Young at the time of the accident were qualified airline pilots, were in good physical condition, and held the proper certificates of competency.

Condition of Aircraft Prior to Take-off

Aircraft NC 25678, a DC-3A, was manufactured by the Douglas Aircraft Company of Santa Monica, California. This model was powered by two twin Wasp engines, models S1C3-G, manufactured by the Pratt and Whitney Aircraft Division of the United Aircraft Corporation, each rated at 1,100 horse power. The aircraft was delivered to United January 25, 1940, and was currently certificated as airworthy for operation with 21 passengers and a crew of three and with a standard gross weight of 24,546 pounds.

The procedure of United calls for an engine change overhaul at the end of each 625 hours of service and the record indicates that this engine change overhaul had been completed less than a week before the accident, the aircraft and engines having logged since that overhaul up to the moment of the crash only 21 hours and 15 minutes. When overhauled, the left engine (Serial No. 2621) had a total time of 2,772 hours and 44 minutes and the right engine (Serial No. 2624) had a total time of 2,932 hours and 57 minutes. They were installed on aircraft NC 25678 November 28, 1940.

Company procedure also provides, at the time of the 625-hour engine overhaul, for an inspection of the aircraft itself and the replacement and repair of all parts necessary to insure the safe operation of the aircraft for the next 625 hours of service. A major overhaul of the aircraft is required at the end of each 5,000 hours of flight time but this plane, having logged a total

time of only 2,456 hours and 59 minutes, had never undergone such an overhaul.

The propellers installed were Hamilton Standard, hydromatic, constant speed, full-feathering propellers, model No. 23E50-109. The maintenance records introduced at the hearing show that at the time of the engine overhaul on November 28, 1940, the left propeller hub, No. 34680, had a total service time of 4,980 hours and 53 minutes, and the blades approximately 1,790 hours, while the right propeller hub, No. 35767, had a total service time of 5,908 hours and 53 minutes and the blades approximately 1,200 hours. At the time of the last engine overhaul these propellers were dismantled, etched, and thoroughly overhauled.

The testimony taken at the hearing and the records introduced therein show that at the time of the engine overhaul a complete inspection of the aircraft was made and all necessary maintenance repairs and replacements of the radio equipment, de-icing equipment, instruments, cabin equipment, and accessories were completed and the airplane was thoroughly flight checked.

The record shows that since overhaul, the airplane had received the inspections and checks prescribed by United and approved by the Civil Aeronautics Administration.* An inspection by United's

* The "Civil Aeronautics Administration" is the term used to designate the Administrator of Civil Aeronautics and his staff, which includes the inspection, air traffic control, and airways personnel. The Civil Aeronautics Administration, an executive agency, is entirely separate and independent of the Civil Aeronautics Board, which is a quasi-judicial, quasi-legislative agency of Congress.

maintenance personnel is required at the end of each scheduled trip and the inspection reports do not show any serious malfunctioning of the aircraft, the aircraft engines, or equipment since engine overhaul. The turn-around, or No. 1, inspection report made at LaGuardia Field just prior to the departure of Trip 21 shows merely the replacement of several minor pieces of equipment.

In addition to the maintenance inspections, United requires its flight personnel to enter comments on the operation of the aircraft, engines, radio, and accessories in the trip log. A review of these pilots' flight reports indicates that the only irregularities reported had been eliminated by the replacements and maintenance operations completed at New York prior to the departure of Trip 21. A radio irregularity had been reported by the pilot who had flown NC 25678 into LaGuardia Field on December 3. He reported that on two occasions during the trip the radio had become noisy and that this condition had lasted for several minutes each time. The radio inspection report indicates that the radio mechanic at LaGuardia Field checked the radio equipment, made a minor adjustment, and reported the operation of the equipment as normal.

From all of the evidence, we find that aircraft NC 25678 and its equipment had been properly maintained and were in an airworthy condition at the time of the departure from Cleveland on the morning of the crash.

HISTORY OF THE FLIGHT

The flight plan prepared for Trip 21 by Captain Scott, First Officer Young, and Gentry W. Stuart, United Dispatcher at LaGuardia Field, provided for a flight from LaGuardia Field to Chicago, Illinois, with stops at Philadelphia and Allentown, Pennsylvania, and Akron and Cleveland, Ohio. Captain Scott estimated his total flying time from New York to Chicago as 5 hours and 38 minutes, plus 30 minutes for landings and take-offs at intermediate stops. He anticipated contact flight from New York to Philadelphia with northwest winds of 15 miles per hour at flight altitude; contact flight from Philadelphia to Allentown with the same wind conditions; contact flight from Allentown to Akron with southwest winds of 35 miles per hour; contact flight from Akron to Cleveland with southwest winds of 36 miles per hour; and instrument flight from Cleveland to Chicago with southwest winds of 40 miles per hour. Akron was designated as the alternate airport for the portion of the trip from New York to Cleveland and Moline, Illinois, as the alternate for Chicago.

Trip 21 was off the ground at LaGuardia Field at 9:05 a.m., cleared by the company dispatcher at that point to Cleveland in accordance with company procedure. The record shows that Captain Scott arrived at Cleveland with a notation in his flight log that the right motor was cutting out on the left switch. Captain Scott reported to the ground crew at Cleveland that this trouble had occurred on LaGuardia Field but had cleared up prior to take-off.

He also reported that he had tested the switch in flight between LaGuardia and Cleveland and that while the engine was a little rough at times, this trouble did not re-appear.* Inasmuch as an additional ship was available, the Acting Crew Chief in Charge of Maintenance at Cleveland decided to hold NC 25678 for a more complete inspection of the right engine. Accordingly, the passengers and cargo were transferred to the substitute aircraft and the trip departed from the ramp at 2:13 p.m.

Captain Scott, however, did not take off but returned to the hangar and reported that the right engine of the substitute airplane was also cutting out on one magneto. Upon examination by the ground crew and also by Mr. Donald W. Tyler, Superintendent of Mechanical Operations of the Eastern Division of United, who was on the field at the time, it was determined that in order to remedy the condition it would be necessary to replace some of the wiring, which would take at least an hour. Since the right engine of the original airplane had not cut out during the trip from LaGuardia Field to Cleveland, it was decided by Captain Scott, Mr. Tyler, and the ground crew to use the original plane if, after inspection, no trouble was indicated. Accordingly, the ground crew thoroughly checked the engines of this ship and Mr. Tyler personally checked over the right engine and they were unable to find anything wrong with the engine. After running it up to take-off power and testing all of the switches they "found the operation of the engine perfectly normal and smooth, and no signs of misfiring". The

* Further discussed on page 69.

passengers and cargo were then again transferred to the original ship for take-off from Cleveland. Captain Scott's approval of this action is indicated by an entry in his trip log that the right engine was "O. K." at Cleveland.

At 2:50 p.m., the United dispatcher at Chicago cleared the flight from Cleveland to Chicago, and the plane departed from that point at 2:59 p.m. At the time of take-off, the gross load was 24,306 pounds, including 13 passengers, baggage, mail, express, 620 gallons of fuel, and a crew of three.

At 3:26 p.m., Captain Scott requested that his flight plan be changed to cruise at 500 feet above the overcast. This change was approved by Airway Traffic Control at Cleveland.* At 3:40 p.m. United Trip 21 reported over Toledo at 6500 feet and Captain Scott reported the weather he was encountering as follows:

* The Airway Traffic Control staff, a part of the Civil Aeronautics Administration, regulates the flow of traffic during instrument weather conditions in order to eliminate the possibility of collision between aircraft. Before flying on the civil airways under instrument weather conditions, approval must be secured from Airway Traffic Control for the flight, including the altitude at which it is to be flown. The Cleveland and the Chicago Airway Traffic Control centers were concerned with the flight of United Trip 21 between Cleveland and Chicago. The jurisdiction of the Cleveland center includes the civil airway between Cleveland and a point 25 miles east of Goshen, Indiana, and the jurisdiction of the Chicago center extends from that point to the Chicago Airport. Thus, Trip 21 was cleared by the Cleveland center to the Cleveland control boundary and by the Chicago center from that point. Airway Traffic Control does not contact air carrier airplanes directly. All communications are transmitted through the medium of company radio stations which are connected with Airway Traffic Control centers by interphone.

"Temperature 33°, wind from 280°, velocity 42 miles per hour."

At 4:06, the Chicago Airway Traffic Control cleared Trip 21 from the Cleveland boundary to cross the McCool fan marker (about 35 miles southeast of the Chicago Municipal Airport) at 6000 feet or 500 feet on top, whichever was the lower. At 4:07, the Chicago station of United questioned Captain Scott as to whether he wished to cross McCool fan marker at 4000 feet or 500 feet on top. Upon Captain Scott's reporting his election to stay on top, the station transmitted a message as follows:

"OK. They have reported light ice lower part of the overcast. Will advise Airways and get your clearance."

Captain Scott then elected to fly on top of the overcast, reporting as follows:

"United 21 OK. Will cross on top no matter what."

At 4:21 a change in clearance was requested and obtained from the Chicago Airway Traffic Control for Trip 21 to fly 500 feet on top, crossing McCool at 5500 feet. At 4:34, Trip 21 reported over Goshen 500 feet on top of the overcast, reporting an outside temperature of 33 degrees at this altitude. At 4:54 Chicago Airway Traffic Control advised the United dispatcher to instruct Trip 21 to hold at Lansing (about 20 miles southeast of the Chicago Municipal Airport) at 6000 feet and to expect an approach clearance at 5:25. At the time this was transmitted by the United dispatcher at 4:57, Captain Scott requested and was given the 4:35 weather observation at Chicago. This reported that the ceiling was 1000 feet with lower scattered clouds at 600 feet, the visibility was

one mile with a light drizzle, light fog and light smoke, the temperature was 33 degrees, dewpoint temperature 31 degrees, and the wind was west northwest 9 miles per hour. This observation also contained a pilot's report that the top of the overcast was 5,000 feet with light to moderate ice between 1,000 and 5,000 feet. At 5:02, Trip 21 reported over the McCool fan marker at 6,000 feet, flying in and out of the base of the upper overcast. At 5:09, Trip 21 was cleared from Lansing to the Chicago range station at 6,000 feet on the northwest leg. A special weather report for Chicago, issued at 5:10, was transmitted to Captain Scott at 5:15 from which it appeared that the ceiling was 600 feet with lower broken clouds, visibility three-quarters of a mile, with light snow, light fog and light smoke, the temperature 32 degrees, the dewpoint 31 degrees, and the wind west northwest 9 miles per hour.

At 5:22, United 21 reported over the Chicago range. At 5:24 Airway Traffic Control advised that United 21 was in No. 3 position to land and gave United's Chicago dispatcher the following message for Captain Scott.*

"And here's something for him now. Tell him that the ship before him picked up an inch and a half of ice down at four and three thousand feet. Tell him I think personally that he would do better to hold 6,000 until he is No. 1 approach. * * * * he can come down now as far as 4,000 feet if he wishes but I would prefer to have him stay at 6 account of the ice."

* When an aircraft arrives over an airport under instrument conditions and there is other traffic also operating in that area preparing to land at the airport, Airway Traffic Control assigns each aircraft an approach number. They are then permitted to land as quickly as is consistent with safety and, unless an emergency exists, no landing priority is given to any aircraft.

At 5:26, Captain Scott asked and obtained approval to descend to 5,000 feet and was informed that he was No. 2 to approach.

At 5:30 P. M., Trip 21 was cleared by the Chicago Airway Traffic Control to the Chicago airport control tower with instructions to report at each 1,000 foot level during descent. Accordingly, Trip 21 started to descend from 5,000 feet at 5:33 P. M. and at 5:41 reported contact at 1,500 feet.

Flight Path Just Prior to Crash*

The report of Captain Scott at 5:41 that he was contact at 1,500 feet was the last radio contact between the plane and the company radio station. At this point the airport control tower took over the control of the flight and the communications between Captain Scott and the airport control tower operator were recorded by a voice recorder connected with the control tower radio. According to the airport control tower log, the first contact with United 21 was made at 5:42 and the last contact before the crash at 5:47. The transcription of the record indicates that the clerk in the airport control tower dialed the Airway Traffic Control to report the crash at 5:48, placing the actual time of the crash at between 5:47 and 5:48.

The record indicates that the first contact with the tower must have been made by United 21 just prior to 5:42 when Trip 21 reported to the tower that he was contact at 1,500 feet. While the voice

* The aircraft was equipped with a flight recorder which was installed in the tail and which was undamaged in the crash. The flight recorder trace substantiates the progress of the flight as reported in the radio communications but provides no dependable evidence as to the last few minutes of flight, the trace ending in a blot covering the period for the last 15 minutes of flight.

recorder did not record this message, due to interference on the line, the control tower operator must have understood, inasmuch as his first recording at 5:42 is in answer to Captain Scott. The complete transcription of all communications between the airport control tower and United 21 are as follows:*

5:42 P. M. **

Tower: "O.K. United 21 on the northwest leg headed southeast. Wind is north northwest about 8 miles, land northwest and no traffic."

United 21: "Repeat that wind for United 21."

Tower: "The wind is north northwest about 8."

United 21: "North northwest about 8 and landing northwest. Is that right?"

Tower: "Yes, that is O.K., unless you have a lot of ice and wish to land west."

5:44 P. M.

United 21: "United 21 to control tower. We will have to circle to get some of this ice off of the windshield."

Tower: "That is O.K. That is all up to you. The wind now north, very slightly north northwest about 10."

United 21: "O.K., north northwest about 10."

~~5:46 P. M.~~

United 21: "United 21 will land west."

Tower: "Will land west. O.K. United 21."

United 21: "O.K. Thank you."

* In connection with discussion which follows see Figure A opposite page 24.

** The contact times shown are estimated from the time of first contact by a re-run of the airport control tower record.

5:47 P. M.

United 21: "United 21 will land northwest instead of west."

Tower: "That is O.K. United 21. It is still clear."

United 21: "O.K."

In attempting to determine the probable flight path of United 21 from the time it broke out of the overcast near the range station until it crashed just southeast of the airport, we have available, in addition to the control tower log, the statements of a number of eye witnesses to various portions of this flight.

Mr. Fred Brown, a mechanic for American Airlines, testified that he was standing in front of the airport Administration Building, which is located on the eastern boundary of the field about 650 feet north of the south boundary of the field. He first noticed the airplane to the northwest over the range station,* with its landing light on, travelling due south across the west end of the field at an altitude of 1,000 feet. At a point approximated by the witness as three-fourths of a mile south of the field, the aircraft was described as entering into a very shallow left turn and continuing in the shallow left turn its entire eastward course south of the field to a point again approximated by the witness as two miles southeast of the field. Another left turn was made into line with the northwest runway and the aircraft then proceeded toward the field on a straight approach. The witness stated that all maneuvers and the approach up to this point appeared

* The Chicago range station is at a point approximately two and one-half miles northwest of the center of the airport.

to be normal. About a block and one-half from the airport, at an altitude of about 150 to 200 feet, the left wing dropped slowly to an angle estimated by the witness as 10 to 15 degrees. At this point he heard a blast of the engines which was followed by an abrupt drop of the left wing. The aircraft then made a half turn of a spin to the left. He then observed it hit the ground, nose first, and bounce upwards and backwards, allowing him to see the tail, fuselage, and the trailing edge of the wing before it settled out of sight. The position of the aircraft was at all times indicated by the navigation and landing lights and at the point where the wing started to drop the aircraft was brilliantly lighted by the flood lights of a gasoline station located just across the street south of the point of impact. The witness estimated the visibility as two miles with a light mist falling and freezing on the wings of aircraft standing on the ground and a ceiling of 1,200 to 1,500 feet. On being questioned, the witness was unable to determine whether one or both engines took the throttle, but was certain that he heard a burst of power after the left wing began to drop.

Peter Farr, a cargo handler for United, testified that he was standing at a point about 175 feet north of the Administration Building when he first saw the aircraft at an altitude of 400 feet proceeding south on the west side of the field. Although he did not watch the plane continuously, he estimated that a turn was made about a mile southwest of the field, as he next saw it proceeding in an easterly direction about a mile south of the field. At a point about two miles from the airport the plane was aligned with the northwest

runway, proceeding on a straight approach for a period of 10 seconds, when suddenly the left wing dropped about 45 degrees and the plane turned to the west, going out of sight behind the Administration Building. At that time he estimated the aircraft to be at an altitude of 150 feet. The witness, on being questioned, stated that he was unable to hear the engines due to the noise of several engines being run up on the field.

Mr. John Farrell, a mechanic for Transcontinental and Western Air, Inc., was standing 400 feet south of the Administration Building when he saw the aircraft traveling west above the railroad tracks which form the northern boundary of the field. He sighted the aircraft again heading east about one-half mile south of the airport at an altitude of 600 feet and then again as it approached at normal altitude in line with the northwest runway about two blocks from the edge of the field. He saw the left wing suddenly drop, the airplane describe a 180-degree turn, and strike the ground vertically. The witness stated that he did not know whether the engines were idling or whether power was being applied, but was sure that the throttles were opened wide just as the left wing dropped. The witness is also quite confident that he would be able to distinguish the difference in sound if only one engine took the throttle, and was of the opinion that both engines responded. A light snow was falling at the time and the witness was certain the runways were icy, having driven a truck over the ramp just prior to the accident.

Captain Leonard H. Smith, who was scheduled to fly aircraft NC 25678 on a return flight to New York, was standing just north of the Administration Building when he first saw an airplane, which he

assumed to be United 21, proceeding southeast across the airport at a 400 to 500-foot altitude. He did not notice the flight of the aircraft again until he saw it in a shallow turn east of the field. The navigation and landing lights were on and the plane continued in this turn until aligned with the railroad tracks on the northern boundary of the field. The plane was losing altitude as though for a landing until it reached the eastern boundary of the field, at an altitude estimated by the witness to be 100 feet, when the pilot gunned the motors and the aircraft continued across the field climbing in a westerly direction just north of the railroad tracks. Captain Smith did not see the aircraft again, but did see the flare of the crash a few minutes later.

Mr. Raymond J. Dutch, a radio operator for Northwest Airlines, was in the companionway back of the pilot's compartment of a Northwest Airlines plane standing in front of the American Airlines hangar about 50 feet due west of the southeast end of the northwest runway. In this position he had a clear view of the approaching aircraft and first noticed it when it was about two or two and one-half miles directly southeast of the airport in line with the northwest runway. The aircraft was proceeding directly toward him and he assumed from the position of the landing and navigation lights that it was in a normal glide. A short distance from the airport at an altitude which he estimated as 175 feet, the aircraft seemed to level off, which the witness attributed to a thermal up-draft or rough air. The left wing whipped abruptly down and the right wing came up. The aircraft turned directly west and passed out of sight behind the American Airlines Hangar. When he last saw the aircraft it was still in a vertical position with the

right wing tip and green navigation light showing above the roof of the American Airlines Hangar. The witness was unable to state whether the engines were under power inasmuch as the engines of the aircraft in which he was standing were idling, although the approach appeared to him to be normal for a landing with power on. At the time a light wet snow was falling and, according to the witness, the visibility was about one mile and the ceiling about 1,500 feet and variable.

Captain William F. Richmond was seated in the co-pilot's seat of the same Northwest Airlines airplane. In this position he had a clear view of the approaching aircraft and first observed it in a normal approach position approximately two miles southeast of the field at an altitude of about 300 feet, in line with the northwest runway with the landing lights and navigation lights on. As the aircraft reached a point just east of the point of impact at an altitude of 150 feet, he noticed the left wing start to drop very slowly to an angle of about 7 degrees, then whip sharply down in a manner which he characterized as similar to a stall which has been aggravated by the use of the opposing engine. The aircraft turned left and disappeared out of his line of vision behind the American Airlines Hangar. The witness stated that the last thing he saw was the right wing tip above the roof of the hangar. Although he was unable to hear whether the aircraft was under power or not, he was under the impression that Captain Scott was making an ordinary drag approach.* The witness

* A drag approach was described by the witness as an approach with about 25 per cent horsepower, with 18 to 20 in. hg. manifold pressure and 2,100 r.p.m.

stated that at that time he thought the aircraft had made three-quarters of one turn of a spin before it struck the ground.

According to Captain Richmond, the wind at the time was northwest about 10 miles an hour, having veered from a westerly direction at 5:30 P. M. with a very light freezing mist falling and visibility up to two miles. The witness stated that the runways were so slippery that he had trouble taxiing down the ramp prior to the time of the crash and on his subsequent take-off was unable to run up his engines because of his inability to hold the plane under power by the applications of his brakes. He further stated that neither precipitation nor ice was apparent on his windshield after his take-off until an altitude of 3,400 feet was reached.

Mr. Richard Rocas, a hangar attendant for Northwest Airlines, was walking east on 63rd Street near the southeast corner of the airport and almost directly on the northwest runway approach. He first noticed the aircraft approaching at an altitude of 100 to 150 feet with the navigation and landing lights on and in a position characterized by him as lower than usual for an approach to the northwest runway. He stated that he heard the motors alternately throttled back and power applied at least twice before the engines roared with a sudden burst of power. The left wing dropped abruptly, and the airplane described a sharp turn to the left. During this turn the nose dropped and the airplane struck the ground on the nose and left wing, with the engines still roaring. The witness was under the impression that the airplane had gained altitude between the time he first saw it and the time the left wing dropped. He was also of the opinion that both engines caught. At the time a wet snow was falling and freezing under foot.

Mrs. Josephine Davis was a resident of the top floor of an apartment house on the northeast corner of 64th Street and Keating Avenue.* This house is approximately 880 feet from the boundary of the airport and about 200 feet east of the point of impact, and is a few feet south of the projected line of the northwest runway. Planes landing on the northwest runway ordinarily pass slightly to the east and north of the apartment house, with the left wing tip practically over the northeast corner of it. Mrs. Davis, the wife of an aviation mechanic working for the American Airlines at the Chicago Municipal Airport, has occupied the same apartment for three years and has often watched airplanes coming in for a landing on the northwest runway. As United 21 approached, she was seated in her living room. This room, approximately 35 feet from the ground, has seven windows, two of which face directly south and a bay with three windows facing directly west, one southwest and one northwest. The witness stated that she was looking southeast through one of the south windows when she was attracted by the bright glare of the landing lights of an aircraft. This glare particularly attracted her attention because it struck the window furthest to the east at a position near the bottom of the window lower than the lights usually struck when planes were landing on the northwest runway. The witness, thinking that the aircraft was very low, arose from her chair to look out of the northwest window to see the airplane land. In this connection she stated that she and her husband very often watched the airplanes land on the northwest runway "because they do sometimes have to land awfully short."

* See Figure B opposite Page 25.

When she first heard the aircraft, the motors were idling, which in her opinion was very unusual "because they generally keep working them as they come in for a landing." According to the witness, just as the airplane passed the building, the pilot "gunned the motors." The witness was particularly sure that the pilot gunned the motors because for the first time since she had been living in that apartment, the windows rattled when a plane was passing over the house to make a landing, although they always rattled when planes were taking off in that direction. By the time she turned around, the aircraft had passed over the building and out of her line of vision, and she next saw the aircraft as it settled to the ground after the impact.

Mr. Dee Davis, the husband of Mrs. Josephine Davis and an airplane mechanic working for American Airlines, was lying on the davenport in the sitting room of his apartment about to take a nap when he was attracted by the popping noise of idling engines. He stated that he next heard his wife scream and the sound of the crash, and jumped up in time to see the tail of the aircraft settling back at the point of impact. Mr. Davis stated that he did not hear the motors being gunned, and also that he could not recall any previous occasion when an aircraft came in for a landing on the northwest runway with the engines idling.

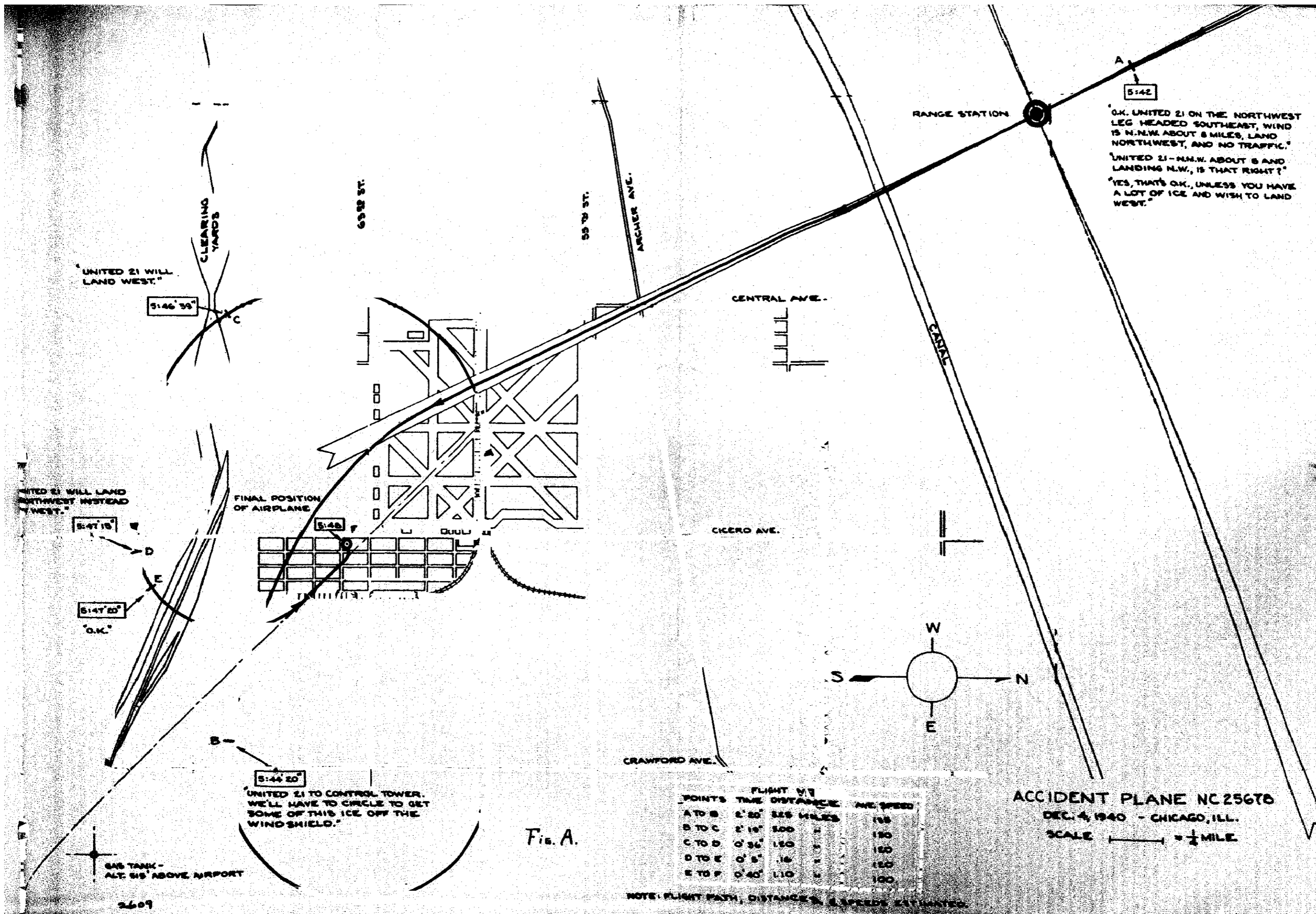
While the testimony of these witnesses is conflicting as to altitudes and distances estimated by them, it does serve to indicate generally the path followed by the airplane after it established contact northwest of the field. In addition, Mr. Walter Addems, Superintendent of Flight Operations for the Eastern Division of United, who had made

an investigation of the probable flight path of the airplane for his company, presented a sketch (Figure A) of the probable flight path correlating the testimony of the eye-witnesses with the various contacts between United 21 and the airport control tower. Careful examination of all evidence bearing upon the question indicates that Mr. Addems' sketch reflects with substantial accuracy the probable flight path of the airplane.

From Mr. Addems' testimony and the sketch he presented it appears that Trip 21 broke out beneath the overcast northwest of the airport and crossed the airport headed in a southeasterly direction. At a point near the south boundary of the field a turn was made to the left and the airplane proceeded to a point about one and one-half miles east of the airport.

At this point a 180-degree turn was made to the left and the plane headed due west across the airport directly over the railroad tracks which border the present field on the north. Just west of the center of the field a 90-degree turn was made to the left, the airplane proceeding south to a point about one mile south of the southwest corner of the field where a further turn was made and the flight proceeded east to a point about one mile south of the southeast corner. At this point, the airplane made a final left turn which aligned it with the northwest runway at a point approximately one-half mile southeast of the end of the runway.

During these maneuvers the airplane probably descended from the 900-foot level (above the ground) at which contact was first established to about 300 feet as it completed the left turn toward the landing



5:42
 "O.K. UNITED 21 ON THE NORTHWEST LEG HEADED SOUTHEAST, WIND IS N.N.W. ABOUT 8 MILES, LAND NORTHWEST, AND NO TRAFFIC."
 "UNITED 21 - N.N.W. ABOUT 8 AND LANDING N.W., IS THAT RIGHT?"
 "YES, THAT'S O.K., UNLESS YOU HAVE A LOT OF ICE AND WISH TO LAND WEST."

"UNITED 21 WILL LAND WEST."

5:46 33"

"UNITED 21 WILL LAND NORTHWEST INSTEAD OF WEST."

5:47 18"

5:47 20"
 "O.K."

FINAL POSITION OF AIRPLANE

5:48

5:44 20"

"UNITED 21 TO CONTROL TOWER. WE'LL HAVE TO CIRCLE TO GET SOME OF THIS ICE OFF THE WINDSHIELD."

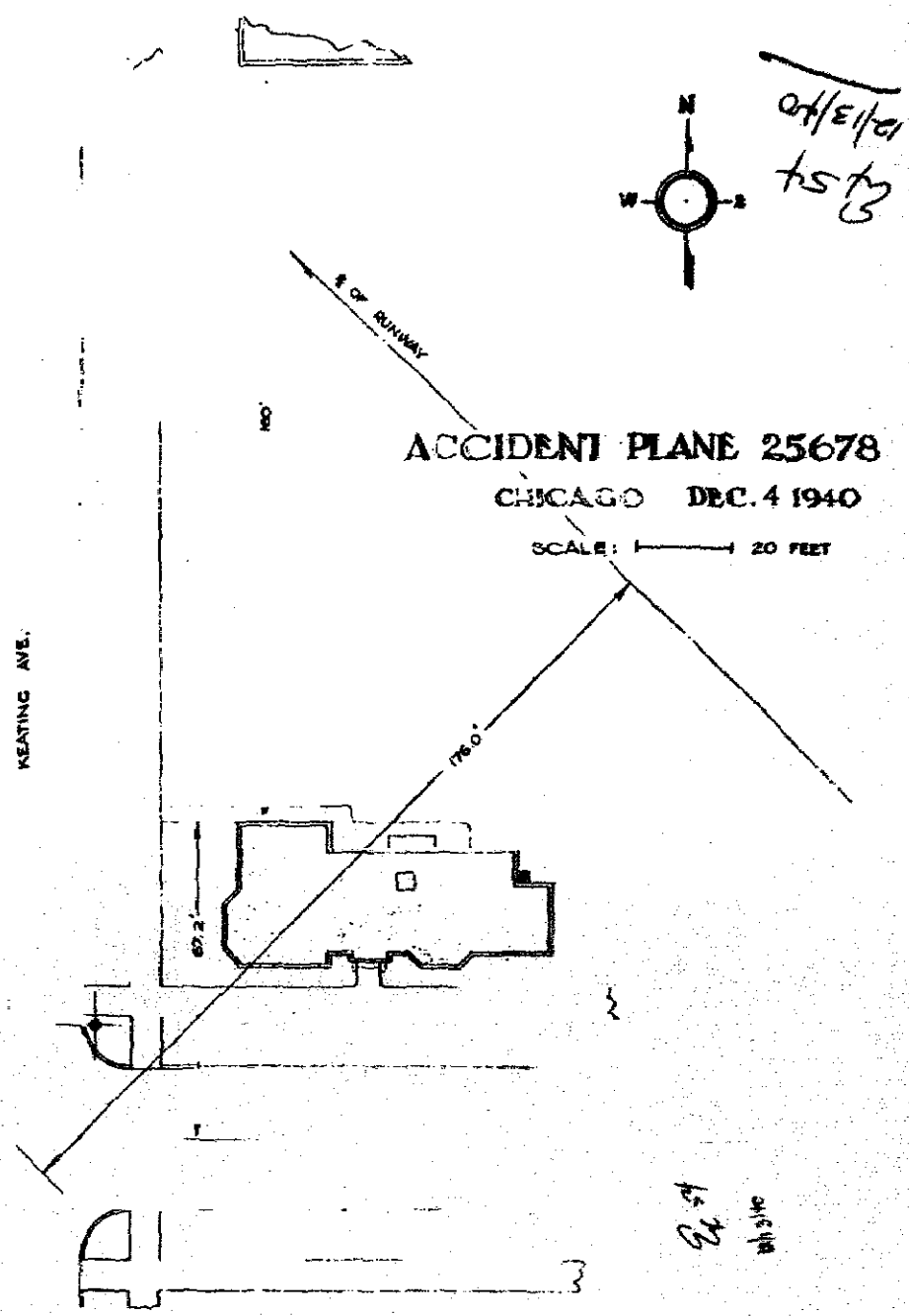
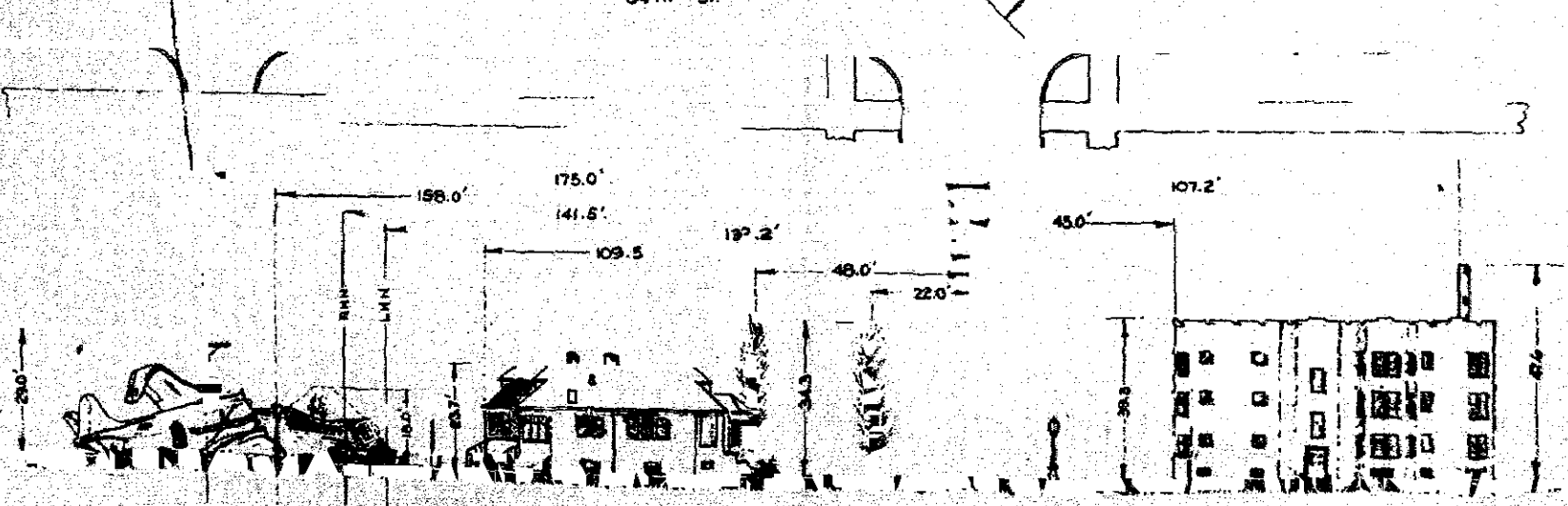
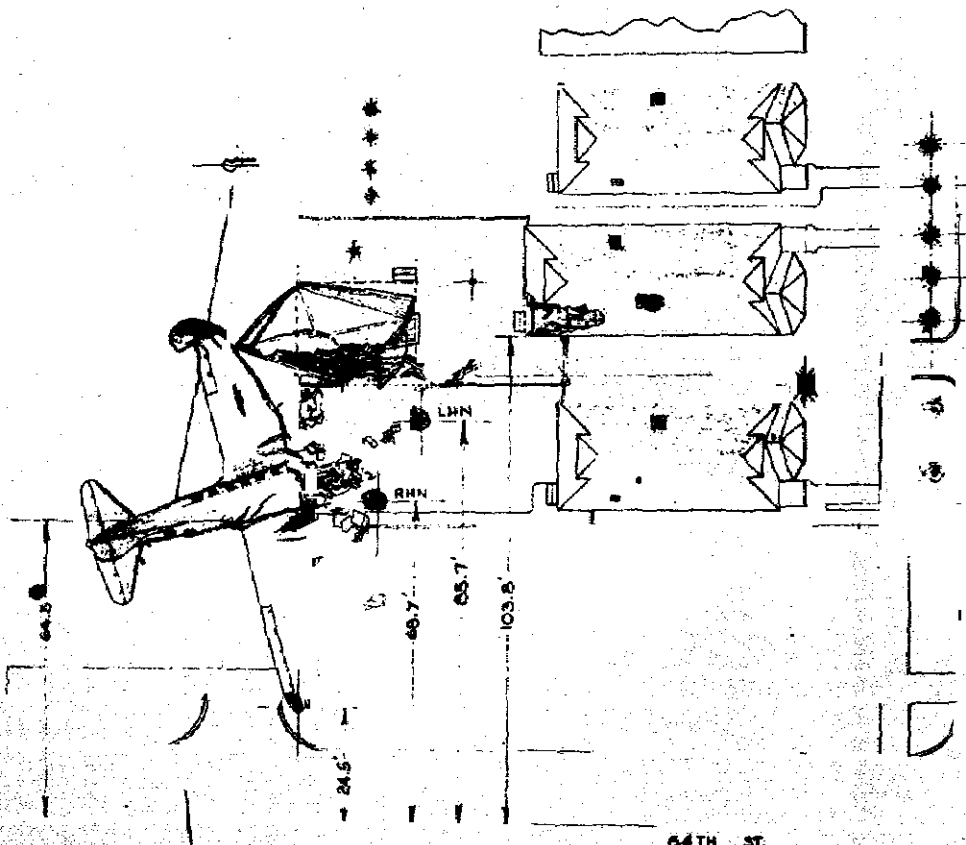
GAS TANK - ALT. 515' ABOVE AIRPORT

Fig. A.

POINTS	TIME	DISTANCE	AVE. SPEED
A TO B	2' 20"	325 FEET	150
B TO C	2' 18"	500 "	150
C TO D	0' 36"	150 "	150
D TO E	0' 5"	16 "	150
E TO F	0' 40"	110 "	100

NOTE: FLIGHT PATH, DISTANCES, & SPEEDS ESTIMATED.

ACCIDENT PLANE NC 25678
 DEC. 4, 1940 - CHICAGO, ILL.
 SCALE $\frac{1}{4}$ MILE



24
 15
 14

area, and continued to lose altitude slowly until it reached a point about 700 feet southeast of the southeast corner of the airport at an altitude estimated between 150 and 200 feet. At this point the airplane whipped off violently to the left and plunged to the ground.

The northwest runway upon which the airplane was intending to land begins at the intersection of West 63rd Street and Cicero Avenue and extends in a northwesterly direction to the railroad which now forms the northern boundary of the airport. South Keating Avenue lies one block east of South Cicero Avenue and West 64th Street lies one block south of West 63rd Street. Facing east on South Keating Avenue between West 63rd Street and West 64th Street is a row of single-family houses (See Figure B). Damage to the roof of the second of these houses from the corner of West 64th Street and South Keating Avenue indicated that the aircraft had struck first at a point about 25 inches from the front peak of the roof, then dragged across the roof in a general westerly direction bearing slightly south and tore out the rear corner of the roof. The airplane was apparently moving in a westerly direction with the wings in a vertical or nearly vertical position, the left wing tip striking first, digging in and curling up as it progressed across the roof, the airplane yawing about 60 degrees. It struck the ground nose down in a nearly vertical attitude in the back yard of the house on the corner of West 64th Street and South Keating Avenue. Upon impact the nose section, the pilot's cockpit, and compartments forward of the passenger cabin were completely demolished. The engines were torn loose from the structure and left partially buried at the point of

impact when the main structure fell back into a vacant lot, coming to rest pointing about 15 degrees north of east. Small fires broke out on the ground around the right nacelle and in the demolished portion of the nose section immediately following impact. These were promptly extinguished by firemen.

WEATHER CONDITIONS

The sky conditions which prevailed in the vicinity of the Chicago Municipal Airport at the time of the accident consisted of a stratus cloud deck the ragged base of which afforded a variable ceiling of from 600 feet to 1200 feet, above the field level. The evidence indicates that this ceiling was modified by a secondary layer of lower scud at 600 feet which persisted when the primary cloud layer lifted to the maximum within this range of variability. Intermittent snow flurries of light intensity were falling which, in conjunction with a light fog and occasional freezing drizzle, resulted in a changeable horizontal visibility, the average being officially reported as about one mile. Surface temperature and dewpoint observations were indicative of icing conditions. The top of the cloud layer was reported at 5000 feet above sea level approximately one hour prior to the accident, but evidence adduced during the investigation indicated that this changed in the interim to an ill-defined upper limit to the cloud mass with a still higher layer above. Partial merging of these cloud systems made positive between-layer flight erratic.

These conditions were produced as attendant phenomena associated with the passage of a low pressure system southeastward across the Great Lakes from the Alberta region. The weak cold front of this disturbance moved past Chicago at about 4:00 p.m., the air mass to the rear of this discontinuity being of a conditionally unstable type. Convergence effects within this air mass were sufficient to bring about saturation, and, since the temperature was within the critical range, conditions were favorable for ice accretion upon the exposed surfaces of an aircraft flown within or slightly below the main cloud layer. Icing conditions of this type ordinarily would produce a rough opaque ice which might be considered an intermediate phenomenon between glaze and rime.

The United States Weather Bureau accurately forecast the weather conditions which prevailed over the route and these forecasts were available to United's meteorologists and to the flight crew both before the start of the flight and en route. Prior to the departure of United 21 from New York, a trip forecast was prepared by a United meteorologist which was accurate in predicting the weather conditions to be expected during the flight. An overcast was expected in the Chicago area with a base at 1000 feet and a top at 4000 to 5000 feet. Light and moderate snow and possible light freezing drizzle was expected below 5000 feet with an inversion of temperature above 32 degrees existing over 5000 feet. According to United's procedure, the captain of the flight is required to prepare his own forecast upon the same form as the meteorologist. Captain Scott's forecast indicates he expected to find a mild to moderate icing condition with ice of both rime and glaze types in the region between Toledo and Chicago.*

* United's Flight Operations Manual, which may be considered as the general understanding of United's pilots, defines light, moderate and heavy ice as follows:

"Light Ice: Describes an icing condition that will not affect engine operation, normal control and performance of aircraft. This degree of ice is encountered in stable clouds and flight may be continued with very slow accumulation of ice.

"Moderate Ice: Describes an icing condition that will affect engine operation, control and performance of the aircraft. This type of ice is associated with fronts where convection is present and clouds are unstable. Accumulation is fairly rapid and flight cannot be safely continued under this condition for extended periods.

"Heavy Ice: Describes severe icing conditions that form rapidly and in such degree as to destroy normal control and performance of the aircraft, either through loss of power or aerodynamic force. This type of ice occurs above the ice crystal level when a moist unstable air mass has been lifted along a well-defined front, or by orographic lifting over mountainous regions so that a large amount of liquid water drops are suspended in the air above the ice crystal level. Occasionally this type of ice will also occur in moderate or heavy rain falling through sub-freezing temperatures."

Weather observations were made by the Chicago Weather Bureau Airways Station at intervals of about 15 minutes from 3:35 p.m. until after the accident. These reports were available over the teletype circuits to United's dispatchers and meteorologists and were available to Captain Scott by simultaneous radio range broadcasts.*

The 3:35 weather observation reported the ceiling at 1000 feet, an overcast sky with scattered clouds at 600 feet, a visibility of 2 miles with light smoke, a temperature of 33 degrees, a dewpoint temperature of 31 degrees, with a wind from west northwest of 11 miles per hour.

The 3:55 weather observation reported no change from the 3:35 report. The 4:10 weather observation reported the ceiling at 1000 feet, an overcast sky with scattered clouds at 600 feet, a variable visibility of 1-1/4 miles, with a light freezing drizzle and light smoke, a temperature of 33 degrees, a dewpoint temperature of 31 degrees, with a wind from the west northwest of 11 miles per hour, and included a pilot report locating the top of the overcast at 5000 feet and light to moderate icing existing between 1000 and 5000 feet.

The 4:20 weather observation reported no change since the 4:10 report. The 4:35 weather observation reported the ceiling at 1000 feet, an overcast sky with scattered clouds at 600 feet, a visibility of 1 mile, with light drizzle, light fog and light smoke, a temperature of 33 degrees, a dewpoint

* The Chicago radio range is a simultaneous broadcast and range station over which radio voice messages may be transmitted at the same time range signals are broadcast. The weather observations made by the Weather Bureau Station at Chicago are broadcast by this station. It is to be expected that Captain Scott received this weather when tuned to the range.

temperature of 31 degrees, with a wind from west northwest of 9 miles per hour, including a pilot report locating the top of the overcast at 5000 feet and light to moderate icing existing between 1000 and 5000 feet.

The 4:53 weather observation reported the ceiling at 1000 feet, an overcast sky, with scattered clouds at 600 feet, a visibility of one mile, with light snow, light fog and light smoke, a temperature of 33 degrees, a dewpoint temperature of 31 degrees. The 5:10 weather observation reported the ceiling at 600 feet, an overcast sky with lower broken clouds, a visibility of 3/4 of a mile, with light snow, light fog and light smoke, a temperature of 32 degrees, dewpoint temperature of 31 degrees, and wind from the west northwest of 9 miles per hour. The 5:20 weather observation reported no change since the 5:10 report. The 5:31 weather observation reported the ceiling at 1200 feet, with an overcast sky and lower scattered clouds at 600 feet, a visibility of one mile, with light snow, light fog and light smoke, a temperature of 32 degrees, a dewpoint temperature of 31 degrees, with a wind from the north northwest of 9 miles per hour. The 5:35 weather observation reported no change since the 5:31 report. The 5:50 weather observation reported a ceiling of 900 feet with an overcast sky and lower scattered clouds at 600 feet, a visibility of one mile, with light snow, light fog and light smoke, a temperature of 32 degrees, a dewpoint temperature of 31 degrees, with a wind from the north northwest of 9 miles per hour.

According to the airport control tower log there were thirteen arrivals and eighteen departures of airline flights of seven different airlines during the period between 3 o'clock and 8 o'clock of the afternoon of December 4,

Of the eight airlines serving Chicago out of the Chicago Municipal Airport, only one, Chicago and Southern Air Lines, cancelled any of its operations during the afternoon of December 4 because of the weather conditions existing at Chicago. Several airline pilots who operated flights into and out of the Chicago Airport testified as to the weather conditions encountered by them.

Captain Lawrence H. Holsinger landed a United plane at 5:14 on a trip from New York to Chicago. This trip was in the overcast for a period of 25 minutes and Captain Holsinger estimated the overcast extended to within 600 feet above the ground with low-lying scud clouds at 400 feet. The visibility was approximately one mile and the wind was reported from the northwest with a velocity of 5 miles an hour. He landed on the west runway but said that with a higher wind velocity he might have used the northwest runway, although not estimating the minimum velocity which would determine his landing on that runway. While he encountered light ice all the time he was in the overcast, this ice appeared to melt off of his windshield as soon as he broke out under the overcast. Ice began to form in his carburetors about a mile from the field, disappearing on the application of carburetor heat. He estimated the temperature as a few degrees above freezing. The ship landed normally, showing no characteristics of icing, and on inspection on the ground just a few spots of rough ice remained clinging to his de-icer boots. He used his de-icing equipment while in the overcast, not shutting his boots off until he passed over the range station. The windshield de-icer worked effectively and on landing his windshield was free of ice. Captain Holsinger described the windshield de-icer used on United planes as a hot air blower equipped with a booster pump having two fixed outlets, one in front of each pilot.

Captain Holsinger said that he has encountered conditions when the de-icer did not effectively clear his windshield and when the sliding portion of the front windshield was frozen tight, in which cases it was his practice to open the side window and scrape off the ice with a putty knife.

Captain Edward Couples, piloting Trip 106 of Pennsylvania Central Airlines, took off from Chicago at 3:30 on a scheduled trip to Grand Rapids, Michigan. After flying half way across Lake Michigan, he encountered an icing condition which he believed would have made it dangerous to continue and he returned to Chicago. At 4:32 he checked in over the Chicago range station at 6000 feet, flying between layers, and cruised close to the range station awaiting a clearance to land. During this period he was cruising in and out of the overcast and only picking up light ice while in the overcast, which was effectively taken care of by the de-icer boots. At 5:08 he was cleared to 4000 feet and reported to Airway Traffic Control at 5:15 that he was unable to maintain his position at that altitude on account of the extremely heavy icing condition he was encountering. He was then cleared back to 5000 feet but did not climb to that altitude because he expected an approach clearance within a few minutes. Captain Couples testified that he reported he would be able to hold at 4000 feet for only about 5 minutes on account of the icing condition. At 5:20 he was cleared to 3000 feet, at which time he reported it would be necessary to obtain his approach clearance "pretty quick" due to the heavy ice. He was cleared to the tower at 5:25, made contact at 5:27, and landed at 5:32. The tower reported the wind as north northwest, 10 miles per hour, and gave him the option of landing on either the northwest or the west runway. Captain Couples advised the tower that he was choosing

the west runway because of the load of ice he was carrying. He estimated that he was in the icing condition for 24 minutes during which time he continuously operated his de-icing equipment. The de-icer boots operated effectively, breaking the ice off the boot itself while rough ice accumulated on the wing behind the boot. He stated that while descending through the overcast, he was using 30 inches of manifold pressure and 2300 rpm with an indicated air speed of 120 miles per hour when normally the indicated air speed would be between 150 and 160 miles per hour. After lowering his landing gear and flaps to full down position, he increased his manifold pressure to 37 inches, using his motors until within 200 feet of the runway, at which time he dove onto the field in a steep glide. Captain Couples definitely placed the landing speed at 90 miles per hour as called out by his first officer, and was of the opinion that the air speed indicators were functioning in a normal manner. Although his windshield was iced over except for a small space cleared by his de-icer while in the overcast, all the ice melted from his windshield beneath the overcast within two minutes. However, his visibility was impaired by a heavy mist.

Captain Couples testified that on examination after landing, the leading edges of the boots on the wings were covered by clear ice of 3/8 of an inch to an inch in thickness. One-half of an inch of very rough ice extended back of the de-icer boots for about 4-1/2 inches. Ice was all over the nose of the ship, except the windshield. About one inch of rough ice was built up back of the de-icer boots on the vertical fin and horizontal tail surfaces. The antennas had ice an inch to an inch and a half in diameter. The pitot tubes were clear of ice. Captain Couples believed that the clear ice which covered the boots had accumulated subsequent to the time the boots were shut

off about 4 minutes before landing. He thought that the absence of windshield ice resulted from cockpit heat and the windshield de-icer blower.

He proceeded to the scene of the accident immediately after the crash and inspected the ice on the fin antenna of United 21, which he described as 1-1/2 inches in diameter and similar to the ice on the fin antenna of his own ship. The policeman present at the scene of the accident did not allow him to examine any other part of the ship.

Captain Herman Carson piloted American Airlines Trip 15 from Detroit and landed at Chicago at 6:07, shortly after the crash. He checked over the range station at 8000 feet and reported rime ice, which was effectively disposed of by the de-icer boot, from that altitude down to 5000 feet. From 5000 feet until he broke out of the overcast at 1300 feet, a fair amount of clear ice was picked up which caused a sloppiness of the controls and instability of the ship and covered the windshield. As the plane entered the overcast, the indicated air speed fell off about 20 miles per hour without any change of the control setting. Preparatory to landing, Captain Carson increased his manifold pressure to 36 inches and reported an indicated air speed of 120 to 125 miles per hour, at which speed his manifold pressure under normal conditions would be about 25 inches. He came over the airport boundary at a speed of 115 miles an hour and dove onto the runway in a steep glide. He estimated that his actual landing speed was about 110 miles an hour, and that the ship stalled at this speed just above the ground. He was in the icing condition for 25 minutes and although part of the windshield was covered with ice about an inch thick, the hot air blower de-icer maintained an opening sufficient for visibility in landing. Although the tower gave him the option of landing either west or northwest with the wind reported as north

northwest about 8 miles an hour, he landed on the west runway. Captain Carson stated that as he broke out of the overcast a light snow was falling and he estimated that the ceiling was about 700 feet and the visibility about 3/4 of a mile. He did not examine the ship for ice after landing, however the mail-boy handed him a piece of ice which he had broken from the loop antenna described as about an inch in thickness.

Captain William F. Richmond landed at Chicago on a Northwest Airlines flight from Minneapolis at 4 p.m. and took off again from Chicago at 6:12 p.m. the afternoon of the crash. In making an approach for a landing he encountered an overcast with a definite top of 5000 feet with unlimited conditions existing above. He testified he encountered a very heavy icing condition between 5000 and 4500 feet, a light to moderate glaze icing condition between 4500 and 2000 feet, and that he broke out of the overcast at 1200 feet. Underneath the overcast a very light misting condition existed and the ice melted off. Captain Richmond described the icing condition in the overcast as "head on an ice condition as you could have". However, the de-icer boots were effective and the hot air windshield de-icer kept a spot clear on the windshield. He maintained heat on his carburetors and had no difficulty with carburetor ice.

Captain Richmond took off again for Minneapolis at 6:12 and testified that he encountered no ice or precipitation to an altitude of 3400 feet. Between 3400 and 4500 feet a light glaze icing condition existed and from 4500 feet to 6000 feet a moderate glaze ice condition existed. He stated that he was contact up to 6000 feet with the base of the overcast estimated at 7000 feet. He cruised at 4000 feet and encountered a light glaze icing condition for a distance of 43 miles northwest of Chicago.

Captain Richmond also testified that he had experienced conditions where the hot air blower system was not capable of freeing the windshield of ice. In these cases, he was forced to open the side window and scrape the ice off with a putty knife. However, he stated he was never prevented from opening the sliding part of his windshield because of ice.

From the evidence available, it is concluded that an icing condition existed in the overcast in the vicinity of the Chicago Municipal Airport at the time of the accident. This condition was variously described by pilots as light to heavy and of both rime and glaze types of ice, and was especially pronounced at the 4000 to 3000-foot level. Although the evidence is conflicting, it appears probable that a light icing condition existed under the overcast.

CONDITION OF THE AIRPLANE AND EQUIPMENT IMMEDIATELY PRIOR TO IMPACT

In seeking to determine the condition of the airplane and its equipment immediately prior to impact, we are particularly fortunate in that the trip log for United 21 between LaGuardia Field and Chicago was completed by First Officer Young, except for the insertion of the landing time at Chicago, prior to the accident and was recovered in the wreckage. It is impossible to reach a definite conclusion as to the exact point in the flight at which First Officer Young made his last entry in the trip log, but it is a reasonable assumption that the trip had at least reached the vicinity of the Chicago Airport before the final notations were inserted in the log. This log indicates that the airplane, engines, radio, and instruments were operating normally.

In addition, the flight crew of United 21 made a number of radio contacts just prior to the accident with the United radio operator and the airp

control tower and no malfunctioning of the airplane or its equipment was indicated in any of these contacts. The last contact was made at about 5:47, less than a minute before the accident occurred and not only did the record of this contact fail to reveal any report of abnormal operation, but also the control tower operator testified that in his conversation, no excitement or anxiety was revealed by the voice of First Officer Young.

From the testimony of the eye-witnesses who saw United 21 at various points while it was operating near the Chicago Airport, the airplane was apparently operating normally until it reached the point where the left wing dropped just prior to the crash. Therefore, all of the evidence appears to lead to the conclusion that from Cleveland to this point there had been no structural or mechanical failure or malfunctioning of the airplane or its equipment. The only evidence available to assist us in making a determination as to whether any such failure or malfunctioning may have occurred at this point and may have contributed to the accident was provided by an examination of the wreckage.

Fuselage

Inasmuch as the plane crashed on its nose, the pilot's compartment and the nose section of the fuselage were complete demolished. The passenger compartment was intact with a few impact failures of the fuselage back of the wing. The landing gear was fully extended, locked in the down position normal for landing, with the wheels intact and the tires fully inflated. Although there were evidences of fire in the right engine nacelle and certain portions of the forward part of the fuselage, it had not progressed to any extent and an examination of adjacent portions of the aircraft showed that

the fire took place after impact. Lack of fuel could not have contributed to the accident because the fuel tanks were found unbroken and contained about 335 gallons of gasoline.

Surfaces

Examination of the wings, tail surfaces and control surfaces disclosed only damage occasioned by the crash. No structural failure in the air was indicated and the flight controls were intact to the point where they obviously had been broken by the impact. The right wing was intact except for slight damage to the tip and at the trailing edge. The left wing was curled upward from the wing tip to a point about 5 feet outboard of the landing light. The wing flaps were extended to the three-quarter "down" position normal for landing. The tail surfaces were practically undamaged and all trim tabs were intact and in good working condition. The de-icing boots on all surfaces were in good condition except for a few cuts due to the impact.

Ice Accumulation

Inspection of the airplane for ice accumulation showed that ice remained on the nose of the de-icer boot on the right wing about $3/8$ of an inch thick, forming a cap extending backward on each side for a distance of 2 inches from the leading edge. This ice was of a rough granular nature. A clear, glaze ice formation of from $1/32$ to $1/16$ of an inch in thickness extended back of this cap to within one inch of the attachment strip of the de-icer boot. No ice was observed on either the de-icer attachment strip or on the wings back of the strip.

No ice was found on the left wing, probably because it had been

dislodged when the wing struck the house on Keating Avenue. There was an accumulation of about $3/8$ of an inch of rough, granular ice over the nose of the de-icer boot on the horizontal stabilizer extending backward for a distance of one inch on each side. The de-icer boot on the vertical fin was capped with ice about $3/8$ of an inch in thickness extending back about $3/4$ of an inch on each side. The ice accumulation on the fin antenna was reported to have been about $1-1/2$ inches in diameter and on the antenna underneath the center section to have been about $3/4$ of an inch in diameter. While there is testimony by a passenger that he observed the de-icer boots operating above the overcast, in the clouds and under the clouds, the ice on the leading edge of the de-icer boots showed no evidence of cracking such as would have been present if the de-icer boots had been operated. Moreover, this ice was of a type which the boots could have effectively broken off.

It seems clear from the record that Captain Scott had accumulated on his windshield a substantial amount of ice because, after breaking out of the overcast, he told the airport control tower operator that it would be necessary for him to circle the airport in order to get the ice off his windshield. However, there is no evidence from which we can determine as to whether he was successful in doing so. Since the pilot's compartment and nose section of the fuselage were completely demolished, the only part of the windshield remaining for examination was the frame, from which it appeared that the set screws which fasten the sliding panel of the windshield in front of the Captain's seat had been unscrewed.

The detailed inspection of the ice accumulation on the airplane was made about 7:15 p.m., almost $1-1/2$ hours after the accident occurred. Since the temperature during this period remained at or below the freezing point and an inspection of the ice showed no indication of melting, it is reasonable to conclude that no reduction in the ice accumulation on the wreckage occurred between the time when the plane came to rest and the time it was first carefully examined.

Engines

In view of the reported engine trouble earlier in the flight and of the actions of the airplane immediately prior to the crash, the question was presented whether engine failure might have contributed to the accident. Therefore, extreme care was taken in the handling, inspection and disassembly of the engines. After a preliminary inspection at the scene of the crash the engines, in the custody of Air Safety Investigators of the Board, were removed to the United hangar at the Chicago Municipal Airport for disassembly and minute inspection.

During the removal operations the engines were kept in the same position as that in which they struck the ground, in order to retain any water in the carburetors or in the blower sections which might indicate malfunctioning of the engines because of ice accumulation in the carburetors. The record indicates that the removal was accomplished with such care that water which had filled a hollow-headed plug on the outside of one of the cylinder heads on the left engine was still present at the time of disassembly. The carburetors were dismantled and tested for water by straining the gasoline remaining through a chamois. Two drops of water were found in a half pint of gasoline taken from the carburetor of the left engine. No water was found in one pint of gasoline taken from the carburetor of the right engine. The intake valve ports, cylinders and the blower section of the left engine were inspected for traces of water but none was found. A similar inspection of the right engine disclosed no evidence of water in the valve ports or the blower section but six drops of water were found in the No. 4 piston, six drops of water in the No. 4 cylinder, and about three drops of water in the

No. 5, No. 6 and No. 10 cylinders. A fire hose was played upon the engines following the accident and since the carburetor adapter of the right engine was cracked, it is probable that the water found in the right engine came from that source.

It was the opinion of engine experts* at the hearing that the water found in the engines did not indicate ice accumulation in the carburetors. They stated that if there had been ice in the carburetors sufficient to interfere with the operation of the engines, the inspection would have disclosed a substantial amount of water in the blower sections whereas none was found there.

Left Engine, Serial No. 2621

The generator, starter, and hydraulic pump of the left engine had broken loose and a corner of the carburetor adapter flange was broken off with the brace pulled loose from the rear case. The intake pipes and pushrod housings were all in place although some were badly crushed. The reduction gear housing had a crack extending from the thrust bearing seat to the attaching flange at the left of the nose section oil pump boss. On the inside, four small cracks were visible on the thrust bearing boss. The support plate assembly at the bottom showed a small crack in line with a similar crack on the nose case. The front side of the support plate bore a scar where the propeller shaft had driven back the governor drive gear indicating a rotation of about 30 to 40 degrees. The accessory drive shaft was sheared with a clean vertical break at the undercut in front of the rear splines. All

* John Lee Bunce, Engineer and Servicing Manager of the Pratt & Whitney Aircraft Division; Ray Dehority, Superintendent of Overhaul and Repair, United Air Lines; George W. Haskins, Safety Specialist, Civil Aeronautics Board.

crankshaft parts, pistons, piston pins, and piston rings were found in normal condition, while slight damage was done to the parts in the main, rear, and intermediate cases. The studs between the cases were bent with a slight chafing indicated at all stud holes, although none was sheared. The blower case showed indications that the impellers had struck the case after the shearing of the accessory shaft, and the impeller blades were scarred slightly. The rear case was cracked at three carburetor support stud holes and also at the hydraulic pump pad.

Right Engine, Serial No. 2624

The intake pipe on the No. 6 cylinder showed evidence of an after fire and the inter-rocker box line hose between cylinders No. 4 and 6 was charred. The intake pipes and pushrod housings were all in place although some were badly crushed. The reduction gear housing had a crack extending from the thrust bearing seat to the attaching flange at the left of the nose section oil pump boss. On the inside, five small cracks were visible on the thrust bearing boss. The support plate assembly showed a small crack at the dowel pin location at the top. The front side of the support plate bore a scar where the propeller shaft had driven back the governor drive gear, indicating a rotation of about 20 degrees. The accessory drive shaft was sheared in a clean vertical break at the undercut in back of the front splines. All crankshaft parts, pistons, piston pins, and piston rings were found in normal condition with very little damage done to the parts in the main, rear, and intermediate cases. The studs between the cases were bent with a slight chafing indicated at all stud holes although none was sheared. The blower case showed indications that the impellers had struck the case after the shearing

of the accessory shaft and the impeller blades were scarred slightly. The rear case was cracked at one carburetor support stud.

The carburetors, fuel pumps, propeller governors, vacuum pumps, spark plugs, and ignition harnesses from both engines were forwarded to United's shop at Cheyenne, in the custody of an Air Safety Investigator, for examination and bench-testing. The ignition harnesses were badly crushed by impact and while there was some damage to other parts, tests made in the laboratories proved that the functional characteristics were satisfactory and indicated that the parts were operating normally at the time of the crash. The two accessory drive shafts taken from the engines were forwarded to the National Bureau of Standards for examination. The report of the Bureau indicates that no metallurgical defect contributed to the failures of the shafts and that the fractures were caused by the sudden stoppage of the rotation of the shafts.

The condition of the parts of both engines was strikingly similar, from which it may be concluded that both engines were operating in the same manner at the instant of impact. However, it is not possible to determine from the condition of the engines whether they were operating under power at the time of impact, as the windmilling of the propellers would have been sufficient to cause the observed amount of damage.

Propellers

The plane struck with the propeller shafts approximately vertical. Disassembly and inspection of the propellers showed the dome assemblies, the spider assemblies, and the barrel assemblies to be in good condition.

The rotating cam setting for the left propeller was in low pitch of 18 degrees and the blades were at the same pitch. The No. 1 and No. 2 blades were not noticeably bent nor the segment gears broken. The blade surfaces were in good condition, showing no scratches and few nicks except one large nick at the tip of the No. 2 blade. The No. 3 blade was bent backward at the 27-inch radius about 30 degrees with the surface in good condition and the segment gear not broken. The shimplates of all three blades showed compression and small cracks.

The rotating cam setting for the right propeller was found at 24 degrees with the No. 1 blade in a feathering position, the No. 2 blade at 25 degrees. The No. 1 blade was bent forward at the 30-inch radius at an angle of approximately 30 degrees with the surface bearing numerous scratches and the entering edge badly nicked. The segment gear was cracked between the No. 4 and No. 5 and between the No. 5 and No. 6 teeth with the No. 7 tooth partially broken off and the segment split and spread. The No. 2 blade was bent back at the 30-inch radius at an angle of 15 degrees with the blade surface and the segment gear in good condition. The No. 3 blade contained a large nick at the tip and was bent slightly forward at the 42-inch radius and the segment gear was in good condition. The shimplates of all three blades showed compression and small nicks.

The examination of the propellers showed that they were rotating at the time of impact. However, it is not possible to state definitely whether they were absorbing power at the time of impact or whether they were windmilling without application of power.

Controls and Instruments

The controls and instruments located in the pilot's cockpit were either completely demolished or so badly damaged by impact that readings could not be taken or the indications could not be relied upon. The throttles were in a closed position. The ignition switches were in the "both-on" position, and the master switch was "on". The aileron and rudder tab controls were set at zero degrees, while the elevator tab control was set at 1 degree "nose-up" position. The flap valve handle was in the fully down position and the landing gear handle in the neutral position. All controls were checked and found to be intact from the cockpit to the point of attachment. All fuel and oil lines were intact from the nacelle to the fuel tanks and were checked for signs of water or foreign substances. The fuel valves were badly damaged but were found open to the main tanks.

Radio Equipment

The radio equipment was badly damaged and an inspection gave no satisfactory indication as to its condition prior to the crash. The aircraft was completely equipped with proper radio equipment and there is no reason to believe that it was not functioning properly. Two-way communication was maintained until less than one minute before the crash. In addition, the trip log bears a notation that the radio was operating "O.K."

STALL CHARACTERISTICS OF THE AIRPLANE

The maneuver which United 21 performed just prior to crashing was described by witnesses as an "exaggerated stall". In order to determine what might have caused the stall to develop, it is necessary to consider the flight characteristics of the airplane. In so doing we have available testimony of pilots at the hearing and reports of tests made of the DC-3.

The stall characteristics of the DC-3 with power off are considered to be quite satisfactory. When a stall occurs it develops at the center section before progressing to the wing tip and good lateral control is maintained almost to the stalling speed. An incipient stall is accompanied by vibration and tail buffeting which develops at a speed of about five miles per hour above the actual stalling speed. There is no marked tendency for the airplane to roll off in either direction, and it may be held in the stall without rolling unless the stall has been induced by pulling the nose up sharply. The recovery is quite readily made and may require between 100 and 500 feet, depending upon the severity of the stall.

Tests have shown that when a stall develops under the application of cruising power it does so rather abruptly and is accompanied by a violent

rolling motion which may be in either direction. The stall develops at the wing tip and there is little warning except for a slight "mushiness" of the controls. The slip stream effect delays the stall at the center section and also largely eliminates the tail buffeting and vibration present in the "power off" condition. In recovering, the plane usually loses a minimum of 500 feet of altitude. The speed at which the stall develops is variable depending upon many factors such as loading, flap position, and degree of bank. Pilots employed by air carriers using DC-3 equipment are given periodic flight checks which include both power on and power off stalls, so that all airline pilots using this equipment are familiar with its stall characteristics. United's procedure requires such checks of its captains every six months.

Effect of Ice

Since it has been definitely determined that some ice was present on the aircraft prior to the crash, the effect of ice accumulation on the stall characteristics must be considered. There have been few DC-3's intentionally stalled under icing conditions and the behavior of the airplane under these conditions must be largely deduced from general considerations. The results of wind tunnel tests, reports of pilots, and the general effect of ice on airplanes must all be considered in this regard.

No definite standards have been developed for describing the wide variety of types and degrees of accumulation of ice encountered under actual flight conditions. It is therefore difficult accurately to analyze the effect of various icing conditions. The accumulation of ice on aircraft depends upon atmospheric conditions which may be extremely variable. Ice may form under varying weather

conditions at temperatures hovering around the freezing point or below, or in any cloud the temperature of which is at or below freezing, and in precipitation below clouds even though no precipitation is evident on the surface of the ground. The rate of accumulation of ice is also dependent upon such factors as the size of the aircraft, its speed, the length of time in the icing condition, the rate of accumulation, the size, temperature and rate of descent of the water droplet and the angle at which it strikes the aircraft surfaces. This combination of variables makes it almost impossible for meteorologists or pilots to predict either the kind of ice or the rate of its accumulation under reported weather conditions. Also, it is often quite difficult during conditions in which ice is forming for the pilot to see, from the cockpit, the type or the rate of accumulation of ice. In addition, an examination of the aircraft after landing seldom gives any reliable indication of the type or amount of ice which the aircraft had accumulated at flight altitudes because of the effects of evaporation, temperature changes, and vibration.

Generally speaking, pilots classify ice as either "rime" or "glaze" ice. Rime ice is usually milky in color, of a rough uneven globular form, described as tending to build up very quickly but brittle in nature and easy to break off with de-icing equipment. Glaze ice is described as clear and smooth, tending to build up very rapidly but clinging to and preserving the form of the object upon which it accumulates. Glaze ice is harder to remove and when broken off by the action of the de-ice boot, tends to stick in patches and build up over the cap strip behind the boot. Glaze ice will not blow off as easily as does the more brittle and rough rime ice.

The increase in weight added by the weight of the ice itself is of relatively little importance. The important effect of the accumulation of ice is aerodynamic. Since the flight characteristics of the wing are very sensitive to the precise contour of the wing section, the accumulation of ice may be expected to have and does have pronounced effects.

Although pilots are not in agreement as to the degree of effect of ice upon the performance of the aircraft, they all agree that ice does raise the stalling speed. Wind tunnel tests under simulated icing conditions confirm this conclusion, which also follows from a consideration of the basic theory of wing action. The stall is not accompanied by the usual visual or mechanical warnings and may occur at an attitude which is not expected by the pilot. Tail buffeting is often decreased or entirely eliminated. The longitudinal stability of the ship is not ordinarily affected by ice, nor does the use of flaps in icing conditions appear to affect the stall characteristics adversely. The drag of the airplane is increased and the maximum lift decreased. The rate and angle of descent of the aircraft in a glide is also increased.

Several pilots who landed at Chicago on the afternoon of the crash after remaining in the icing conditions for various periods, reported an increase in the landing or stalling speed* and increased drag of the aircraft, requiring the use of considerable power. The

* Reported above under section "Weather Conditions".

ice accumulation described by these pilots was greater in amount and was in a more critical location than the ice which was found on United 21. It is reasonable to assume that this might be expected inasmuch as each of these aircraft was in the overcast for a period of approximately 25 minutes whereas United 21 was in the overcast for an estimated period of only 8 minutes.

In addition, Captain John L. Magden, a pilot for Transcontinental & Western Air, Inc., and Captain Charles A. Thompson, a United pilot, testified with respect to the flight characteristics of the DC-3. Captain Magden stated that on landing at Chicago at 3:52 on the afternoon of the crash with about 1/4 of an inch of clear, smooth ice on his wings, the ship stalled on landing at a speed of approximately 80 miles per hour, more than 10 miles per hour above what he considered to be the normal stalling speed. Captain Magden also reported an experience wherein he used full throttle to maintain flying speed because of ice. Several similar cases have been reported by airline pilots.

A few days after the accident Captain Thompson made several tests on a DC-3 under icing conditions to determine the effect of ice on the speed at which the stall develops. These tests were made at night in a freezing mist, using a regular United DC-3 loaded to 22,900 pounds with the center of gravity at the 17 per cent position. United 21 is thought to have been loaded at the time of the crash to 22,690 pounds with a center of gravity position located between 18 and 24 per cent, depending upon the seating arrangement of the passengers. United 21 was equipped with the new type of de-icer boot having a flap extending over the attachment strip at the rear of the boot designed to eliminate the building-up of a ridge of ice along this

strip. The ship tested was not equipped with this new type de-icer and the effect of ice may be greater than a corresponding accumulation on United 21. Captain Thompson accumulated a clear glaze ice of approximately 1/4 inch in thickness, extending back 2-1/2 inches on top and bottom of the center line of the leading edge of the de-icer boot, together with a mass of rough ice extending from a point behind the smooth ice over the cap strip and running back onto the wing proper for a distance of about 6 inches. In Captain Thompson's opinion, this icing condition was roughly similar to that on United 21 except for the rough ice over the cap strip and back on the wing proper. He testified that with wheels down, three-quarter flap position, 17 inches of the manifold pressure and a descent of 400 feet per minute, the ship reached the point which he considered to be just above the stall point at an indicated air speed of 70 miles per hour. He reported that at 75 miles per hour the aileron control was still present. The ship stalled just above the ground on landing at an indicated air speed of 70 miles an hour, only 6 miles above the normal stalling speed of this same airplane under similar conditions without ice.

Captain Thompson made two other tests the same evening and photographs of the ice accumulated on these occasions were introduced into the record. On the second trip he accumulated ice of from 5/8 of an inch to one inch in thickness, very rough in character, extending over the leading edge of the wing. With the same setting as the first test, the ship gave indications of being near the point of stall at 71 miles per hour with aileron control still effective at 75 miles per hour. Captain Thompson stated that the only indication he had of the approaching stall was the sluggishness

of the aileron control combined with a tendency of the airplane to wobble, without any tail buffeting being present. Inasmuch as Captain Thompson was primarily interested in finding out whether ice had the effect of greatly increasing the stalling speed, he did not care to carry the test through to a full stall, due to bad vision from the ice on his windshield and darkness.

Although pilots do not agree as to the effect of ice on the DC-3, it may be concluded that ice does raise the stalling speed to some unpredictable extent and that the effect cannot be stated in terms of the amount of ice alone, but is dependent upon both the amount of accumulation and its location on the wing.

Effect of Uneven Engine Response

Shortly after the accident, Captain Thompson, accompanied by representatives of the Board and of the Civil Aeronautics Administration, conducted several tests on a DC-3, one of which was to determine the performance characteristics of the ship without ice under stall conditions with power. With wheels up, three-quarter flap position and 400 feet per minute descent, the ship stalled at 68 miles per hour indicated air speed; with wheels down, three-quarter flap position, 400 feet per minute descent, the stall developed at 64 miles per hour indicated air speed; with wheels down, three-quarter flap position, manifold pressure of 17 inches, the ship trimmed for normal approach and brought to the point of stall, the left throttle closed and the right throttle jammed open, a roll of approximately 45 degrees resulted, combined with a momentary uncontrollable yaw of 20 degrees and 300 to 500 feet required for recovery.

CHICAGO MUNICIPAL AIRPORT

The Chicago Municipal Airport is owned and operated by the City of Chicago and, at present, is roughly rectangular in shape with one runway east to west, two runways north to south, one runway southeast to northwest, and two runways southwest to northeast.* The usable length of the east-west runway is approximately 4,200 feet, the north-south runways approximately 2000 feet, the southeast-northwest runway and the southwest-northeast runway approximately 2750 feet. Traffic on and in the vicinity of the airport is controlled from a control tower situated on the roof of the Administration Building on the east boundary of the field. At the present time the northern boundary of the airport is formed by a 125-foot railroad right-of-way, owned by the Chicago and Western Indiana Railroad, which is raised four feet above the level of the airport and is bordered on each side by a ditch. Since 1934 efforts have been made to obtain the railroad right-of-way and to enlarge the airport northward. In 1936 sufficient property north of the railroad was acquired by the City of Chicago to make a "mile square airport", and subsequently the construction of runways on this newly acquired property was begun. While this construction was substantially completed during the fall of 1939, the northern section has not been used because it has been impossible to acquire the railroad right-of-way.

The current semi-monthly Notice to Airmen, published by the regional offices of the Civil Aeronautics Administration, contained the following information:

* See Figure A opposite page 24.

"Chicago, Illinois. Until further notice the unfinished north portion of the Chicago Municipal Airport north of the railroad tracks cannot under any circumstances be used, even for emergency landings. Material used for concrete is piled upon the future runways and ditches extend all along the side of these future runways. Men are working and tracks operated during the day, making any use of this north portion impracticable and very dangerous either day or night. Only that portion south of the railroad tracks is available for use."

The record shows that the City of Chicago is at the present time constructing a right-of-way for the Chicago and Western Indiana Railroad around the airport and Mr. John Casey, the manager of the airport, testified at the hearing that he expected this construction work to be completed in March, 1941, at which time the railroad would relinquish its right-of-way across the field. Mr. Casey expected that the northern and southern portions of the airport would be connected and the airport completed by April 1, 1941. When completed, the usable length of the east-west runways will be approximately 4200 feet, the northwest-southeast runway approximately 6000 feet, and the north-south runways approximately 4300 feet.

David L. Behncke, President of the Air Line Pilots Association, testified that the airport as it now exists was designed for equipment much smaller than the equipment now being used, but that with the railroad tracks removed, it would rate as one of the best airports in the country.

From the testimony of several airline pilots who have been using the Chicago airport for many years, it appears that the southeast-northwest runway is too short for anything but normal operation under favorable

conditions with the airline equipment now in use.* Because of its shortness, the north-south runway is seldom used by the airlines and United has forbidden its pilots to land under any conditions upon this runway.

CONDUCT OF THE FLIGHT

In seeking to determine the cause of the accident to United 21, a careful inquiry has been made into the manner in which all those who were concerned with the flight performed their various duties. We have already concluded previously in this report that the aircraft had been properly maintained and was in airworthy condition when it took off from Cleveland. We have also determined that there was no structural or mechanical failure of the aircraft or any of its equipment at least until the instant before the left wing of the aircraft dropped just prior to the crash. The question of structural or mechanical failure at this time will be discussed hereinafter. It also appears that the weather forecasting by the United States Weather Bureau and by the United meteorologists was as accurate as could be expected in the present state of the art.

From the evidence, it is clear that all air navigation facilities operated and maintained by the Civil Aeronautics Administration, including the radio range, airport localizer, radio broadcast and teletype

* Captain Richmond, who has been flying into the Chicago Municipal Airport for three years, testified that under the conditions prevailing at the time United 21 attempted to land on the northwest runway, it would be practically impossible "to bring her in and set her down, and get her in safely; because that runway is just too short for any type of landing but a normal operation". Captain Couples, speaking of the northwest runway, said: "It is entirely inadequate for this type of equipment from a safety angle." Other pilots expressed similar opinions.

equipment, approach lights, and marker beacons were operating normally at all times during the afternoon of the crash. The Airway Traffic Control personnel of the Civil Aeronautics Administration at Chicago handled the flight with marked diligence and efficiency. The basic responsibility of Airway Traffic Control is to prevent aerial collisions between aircraft operating under instrument conditions. Decisions on whether a flight is advisable, or may be made with safety, under the weather conditions existing are the responsibility of the pilot and the air carrier dispatcher. Notwithstanding this, Airway Traffic Control suggested to the United dispatcher that he advise Captain Scott that an air carrier airplane which had preceded him had accumulated an inch and a half of ice while coming through the overcast. In addition, while it is the usual Airway Traffic Control procedure to bring aircraft into an airport by stepping them down through 1000-foot levels, Airway Traffic Control varied this procedure in the case of United 21 in order to avoid holding the trip in icing conditions while awaiting a clearance to land. Captain Scott was told to hold at 6000 feet until Airway Traffic Control could give the trip an approach clearance so that it might descend through the overcast as rapidly as possible. Thus, when the trip was cleared to descend, it was necessary for it to spend only about 8 minutes in the overcast where icing conditions prevailed. Airway Traffic Control also attempted to expedite landings by giving incoming traffic priority over departures during this period.

A substantial amount of testimony was received at the hearing as to the handling of the flight by the Airport Control Tower, which is operated by the City of Chicago through its own employees. Mr. John N. Becker, Chief Control Tower Operator, was in charge on the evening of the crash.

Mr. Becker, who has been a control tower operator at the Chicago Municipal Airport for over 7 years, went on duty at 5:20 the afternoon of the accident but testified that he had been in the control tower for some time prior to the beginning of his tour of duty. During his contacts with United 21, he gave the trip the alternative of landing on the east-west runway or the northwest runway, having instructed the flight in the first instance to land northwest but later supplementing that instruction with the statement that the trip might land west "if you have a lot of ice and wish to land west."

The operation of the municipal control tower with respect to United 21 appears to have been adequate with one possible exception. The record indicates that none of the incoming aircraft was advised of the slippery condition of the runways. Although Mr. Becker testified that it was customary to advise incoming traffic of the condition of the runways, he stated that at that time he did not know or believe that the runways were slippery. In this connection, Captain Richmond testified that the runways at the time he landed about 4 p.m. were not slippery but that when taxiing just prior to the accident, he observed that the runways had become extremely slippery. The testimony of ground observers as to the condition of the ramps and other pavements near the airport is conflicting, but Captain Richmond's testimony with respect to the slippery state of the runways is confirmed by other pilots who landed within a short time before and after the crash. This condition should have been known to the airport control tower operator and given to all pilots to whom he gave landing instructions. The testimony indicates that the runways had had snow on them for several days and that on the evening in question a wet snow or freezing drizzle was falling. These conditions should have warned him that in all likelihood the runways were slippery.

and if there was any doubt in his mind as to the condition of the runways, he should have taken whatever means were available to him to determine definitely their condition. In addition, the pilots who actually observed the slippery state of the runways during this period should have reported their observations to the control tower in order to make certain that the control tower would have this information and be in a position to make it available to other pilots yet to land.

A substantial amount of testimony was also received at the hearing bearing upon the question whether the United dispatchers who were concerned with the flight performed their duties properly. Responsibility for the dispatch of a scheduled flight in air transportation is placed by the Civil Air Regulations on the company dispatcher.* The dispatcher must be convinced before clearing the flight that it may be completed with safety. In addition, under United procedure, a dispatcher is responsible for furnishing a scheduled trip, while en route, with all weather, traffic, and other pertinent information relating to the operation of the trip. Also, according to the testimony of one United dispatcher, such personnel have the power to direct a flight, while en route, to proceed to its alternate or take other appropriate action in the event that the dispatcher, subsequent to its clearance, determines that the flight may not be completed with safety. However, during flight the responsibility for the safety of the ship is primarily on the pilot. A dispatcher, insofar as his control of a

* A clearance for each trip is issued by the company dispatcher, who must be certificated by the Civil Aeronautics Administration, and is signed by him and by the pilot. The current weather reports, load manifests showing the amount of cargo and its distribution, are attached thereto, as is also a statement containing any known irregularities of field or radio equipment along the route to be flown. The original is delivered to the pilot and a copy is kept at the dispatching station. If either the pilot or the dispatcher does not believe that the trip can be completed with safety, it is cancelled. En route, a clearance may be changed or supplemented by the dispatcher.

flight permits, must make certain that it is conducted in accordance with the Civil Air Regulations. Pertinent in this case are the regulations forbidding an air carrier aircraft from landing or taking off from any airport along the route except under weather conditions above certain ceiling and visibility minimums set forth in the weather letter of competency issued to the air carrier operator by the Civil Aeronautics Administration. In the case of the Chicago Municipal Airport, the night landing minimums are a ceiling 400 feet and visibility of one mile. In addition, the Civil Air Regulations forbid the dispatch of an air carrier aircraft into any known or possible icing condition unless equipped with approved de-icing equipment " . . . adequate to assure the safety of the flight under the particular conditions to be encountered".

In accordance with the Civil Air Regulations and company procedure, two dispatch clearances were necessary for United 21 between New York and Chicago. The flight was cleared from New York to Cleveland by the United dispatcher at LaGuardia Field and the clearance contained all the required weather and other information. It also appears that the airplane was properly loaded and had ample fuel for the flight. The clearance from Cleveland to Chicago was made by the Chicago dispatcher by radio and a copy of the clearance, signed by a United employee at Cleveland on behalf of the Chicago dispatcher, shows that the latest weather information was available to Captain Scott. Here again it appears that the airplane was properly loaded and serviced and was in proper operating condition when it was cleared.

The dispatcher's duty of furnishing the pilot with current weather information was apparently well performed during the flight between Cleveland and Chicago, for it appears from company radio logs that during flight Captain

Scott was furnished with the 4:35 Chicago weather observation, the 5:10 special Chicago weather observation, and at 5:28 was advised by the United radio operator at Chicago that Airway Traffic Control had reported that a flight while in the overcast over Chicago had accumulated λ -1/2 inches of ice. From the evidence with respect to the operation of that portion of the flight between LaGuardia Field and Cleveland, it may be concluded that the dispatcher in charge of the flight performed his duties properly. Moreover, there is no evidence that the dispatcher at Chicago failed to perform his duty properly in clearing the trip from Cleveland to Chicago since the weather at that time at Chicago was not such as to require cancellation.

The question still remains whether after the present flight arrived at the Chicago Airport it should have been permitted by the dispatcher to land.

At the time Trip 21 arrived at the Chicago Airport, the ceiling was 900 feet and the visibility about one mile with occasional snow and drizzle present under the overcast. The conditions of ceiling and visibility were above the minimums prescribed by the Civil Aeronautics Administration for night landings at the Chicago Airport. It should be noted that these minimums, which are prescribed in the weather competency letter of the air carrier operating certificate, do not constitute a standard for the exercise of discretionary judgment by dispatchers or pilots; they provide an absolute prohibition against landing when the required conditions are not present, thereby precluding the exercise under such circumstances of any judgment by dispatchers or pilots.* United Air Lines correctly interprets the ceiling and visibility

* In case of an emergency the pilot may deviate from the prescribed minimums to the extent required for the safety of the flight. When this emergency authority is exercised, a written report must be submitted by him setting forth all the circumstances requiring the deviation.

minimums prescribed by the Civil Aeronautics Administration when its Flight Operations Manual directs its pilots and dispatchers as follows:

" . . . The approved minimums . . . are not intended as a guide for regular operations or to influence the reason and judgment of flight operations personnel. The approved minimums are intended to permit the dispatch and landing of flights when all factors are favorable, and the operation can be accomplished safely and conservatively. . ."

The unpredictability of icing conditions and the fact that such conditions may be hazardous under some circumstances and not under others, and the effect to be given to such conditions in conjunction with other circumstances such as the length and state of the runways and the conditions of wind direction and velocity, all make necessary a reliance upon human judgment acting upon all of the facts and circumstances available at the time. The Civil Air Regulations with respect to the flight and landing of aircraft under such conditions and the Flight Operations Manual of United necessarily require the exercise of such a judgment by the airline personnel.

The dispatcher in the present instance was aware that an icing condition existed in the overcast above the airport. In addition to reports of pilots and the weather observations which he had received during the afternoon, he had the information given to him by Airway Traffic Control at 5:24, that a flight in descending through the overcast had picked up 1-1/2 inches of ice at the 4000 to 3000-foot level. The dispatcher testified that he did not at the time consider this condition to be more than a light icing condition, since the report did not indicate the period of time in which this airplane had accumulated the ice (Captain Couples, the pilot of the airplane referred to, testified that he was in the overcast for about 25 minutes) and since he had obtained further information from the pilot of United's Trip 19,

which landed at 5:14, that during that trip's descent through the overcast it had encountered only a light icing condition. Notwithstanding this information received from United's Trip 19, the dispatcher transmitted without comment to Captain Scott the report he had received from Airway Traffic Control that a flight in descending through the overcast had picked up 1-1/2 inches of ice at the 4000 to 3000-foot level. The dispatcher also knew at the time that Airway Traffic Control had prepared to hold United 21 above the overcast and icing conditions until they were able to clear the air in order that United 21 might make its descent through the overcast to a landing as quickly as possible.

The dispatcher also knew the conditions existing on the ground at the time. He was aware, or should have been aware, that the wind had veered from a westerly direction and was from the north northwest at 8 to 10 miles an hour and that the pilot would have the choice of landing on either the northwest or east-west runway. He testified that he was also aware of the slippery condition of the runways. He knew, or should have known, that under the circumstances a landing on the northwest runway would be difficult and that a landing on the long east-west runway would have to be accomplished in a cross-wind. He also knew, or should have known, that it is the prevailing practice of airline pilots to land with increased speed when ice is present on the airplane.

All of these facts were before United's dispatcher when Trip 21 arrived at the Chicago Airport. On the other hand, the dispatcher knew that the airlines had frequently operated successfully into and out of the Chicago Airport under similar conditions and that a cross-wind landing on the east-

west runway under such conditions, while difficult, was not generally considered by the standards of airline practice to be so difficult as to preclude a safe landing where the aircraft was being flown by a careful and skillful pilot.

From all the evidence, we must conclude that while the conditions existing at the Chicago Airport, including wind, weather, and the state of the runways, created a situation which required the exercise of a higher degree of care, diligence, and skill than would be necessary under more favorable conditions, United's dispatcher cannot reasonably be said to have acted in disregard of safety in permitting Captain Scott to land.

Whatever we have said with reference to the decision of the dispatcher in permitting the descent of United 21 through the overcast applies equally to the conduct of the flight by the pilot. However, after having made his descent and broken out under the overcast, it appears that he exercised poor judgment in choosing the northwest runway for his landing rather than the long east-west runway. Incoming aircraft were given the option of landing either on the northwest or west runway. Of the several pilots who landed flights just prior to and after the accident, Captain Scott was the only one to choose the northwest runway. It is not clear why this choice was made. He first advised the Airport Control Tower that he was landing on the east-west runway and this choice was approved, but 40 seconds thereafter, he again contacted the Airport Control Tower and stated that he would land on the northwest runway. The evidence furnishes no answer to the question why Captain Scott changed his mind. Inquiry was made in order to determine whether some emergency occurring near the northwest runway and requiring

immediate landing caused him to make this choice. As was stated previously in this report, all the evidence leads to a contrary conclusion, particularly the testimony of the Airport Control Tower operator who said that in reporting that the northwest runway would be used, First Officer Young did not report any mechanical difficulty and his voice did not indicate any anxiety or excitement.

From the testimony of eye-witnesses, it may be concluded that the final approach of United 21 to the northwest runway was made normally until the left wing dropped and was followed by the crash. The maneuvers of the airplane as described by these witnesses also lead to the conclusion that for some reason the airplane stalled, whipped off to the left, and was in an incipient spin when it struck.

It is important to inquire whether this stall and the resulting crash were caused by an inadvertent act or failure on the part of Captain Scott or by occurrences beyond his control. The normal landing procedure for the northwest runway at Chicago is to make an approach for landing as low and with as little excess speed as possible. Mr. Addems, Superintendent of Flight Operations for United, testified that under normal conditions the approach to the northwest runway must be made with extreme accuracy. The pilot must come over the boundary with a minimum of speed and at a height of not more than 25 to 30 feet above the high tension wires bounding the field. It is reasonable to believe, therefore, that Captain Scott, after choosing the northwest runway under the unfavorable conditions existing, would attempt to make his approach at as low an altitude as possible and at a minimum possible flying speed in order to avoid overshooting the runway.

According to the testimony of the pilots, it appears that in landing on the northwest runway a drag approach is made with gear down, three-quarter flaps, and about 25 percent horsepower. We have previously discussed the stall characteristics of a DC-3 airplane. The stall characteristics of this airplane with gear down and three-quarter flaps and with 25 percent horsepower position are intermediate between those with cruising power and with power off, corresponding more closely to those obtaining in the case of a stall with cruising power on, giving slight warning to the pilot and being accompanied by a violent rolling motion to one side or the other.

The tests previously referred to, conducted by Captain Thompson on an iced-up DC-3, were made with approximately this setting and, although not carried to the stall point, indicate that when ice is present the approach to the stall is accompanied by little or no warning except for a slight sluggishness of the aileron control and a tendency for the airplane to wobble. In addition, there is some indication that under this condition the stability of the aircraft is not very positive and the stick forces and movements required to alter the attitude of the airplane are slight; although this is not conclusively established inasmuch as longitudinal stability is very sensitive to the location of the center of gravity and the center of gravity at the time of the accident is not precisely known. Thus, under all circumstances surrounding Captain Scott's approach to the northwest runway, it would require even greater attention and skill than is usually the case to effect a safe landing.

Careful inquiry was made in order to determine whether a fire in the cockpit or other parts of the airplane might have occurred to divert the

attention of Captain Scott during this critical period. The evidence contains no indication of fire in the airplane prior to the time of impact. The condition of the wreckage shows that the isolated fires which started did so after the crash and witnesses saw no fire in the aircraft prior to the impact.

A substantial amount of testimony was also received as to whether ice was present on the airplane immediately prior to impact, and if so, what, if any, effect it could have had in contributing to the stall. It has been shown previously that ice on the wings raises the stalling speed of an aircraft to some degree, depending upon many varying factors. United 21 is known to have passed through an icing condition in the overcast and the examination of the aircraft after the accident showed ice on the wings. However, according to the testimony, the quantity of ice was not great and its position and type were not such as would ordinarily be expected to interfere substantially with the operation of the aircraft or to raise the stalling speed to any considerable extent. However, it is clear that the ice on the airplane did increase the stalling speed to some extent and that this condition was a contributing factor to the stall and the resulting crash in view of the other circumstances surrounding the approach which made all unfavorable factors affecting the approach, no matter how slight, extremely significant. In addition, the effect of the ice would be aggravated if Captain Scott did not know that he was carrying ice, or assumed that the ice was so negligible as not to affect the performance of his ship.

Testimony was also received as to the possibility that malfunctioning of the air speed indicators due to ice might have contributed to the accident.

by giving to Captain Scott readings which were erroneously high, thus permitting him inadvertently to stall the airplane. However, the testimony of pilots shows that the heating device now used by United is quite effective in keeping the air speed pitot tubes clear of ice. A test was conducted by Captain Thompson of United with a simulated build-up of ice on the mast supporting the pitot tubes, which is not protected by the heating device. Very little, if any, effect upon the reading of the air speed indicator was observed during this test. Although there are reports of interference with the pitot operation due to a build-up of ice on the mast supporting the pitot tubes, the effect of this ice would be, ordinarily, to make the air speed indicator read low. A low reading of the air speed indicator, according to pilots, may ordinarily be expected from the effect of ice on the air speed pitot tubes themselves with the effect of causing the pilot to maintain a higher speed than is actually indicated, thus operating as a safety factor.

It is definitely established that Captain Scott's windshield was covered with ice when he first broke out under the overcast, since he reported to the Control Tower that it would be necessary for him to circle the field before landing in order to get the ice off of his windshield. The record indicates that the hot air blower windshield de-icing equipment is not always entirely effective during heavy icing conditions in keeping the windshield clear of ice. Moreover, even if he had been successful in removing the ice from his windshield, his visibility might still have been interfered with by mist or wet snow. Other pilots who landed during this period testified that the visibility from the cockpit was poor after the windshield ice had melted due to the mist which collected. Therefore, at

the time Captain Scott made his approach, he probably had poor visibility from the cockpit due to ice, mist, or light snow.

The reported visibility was one mile but the visibility from the cockpit was probably much less. It is entirely possible that under these conditions Captain Scott was so intent upon endeavoring to see ahead or take some action to improve his visibility from the cockpit that he failed to give full attention to flying the airplane. This may also have contributed to his failure to perceive the warning, if any, of the incipient stall.

The testimony of eye-witnesses is fairly conclusive of the fact that as the left wing of the aircraft dropped, Captain Scott attempted to correct the stall by the use of power. Most of these witnesses saw the wing drop and then heard the power applied but the time interval was described by these witnesses as being very short, in most cases estimated to be less than one second. It is highly probable that the power was applied almost simultaneously with the dropping of the wing.

If the aircraft was being flown very close to its stalling speed and power applied suddenly, the failure of one engine to respond would be sufficient to precipitate a stall. If the aircraft had already stalled and one engine failed upon the application of power in an attempt to recover, the stall would be aggravated. However, even if both engines responded to the opening of the throttles after a power-on stall had developed, the effect would not be sufficient for recovery within the altitude available to Captain Scott. A stall induced by any of these circumstances would cause the airplane to execute the maneuvers described by the eye-witnesses and, therefore, we cannot conclude solely on the basis of the maneuvers executed by

the airplane just before the crash whether a power failure occurred. In any event, we can conclude definitely from the character of these maneuvers that if a failure occurred, it could not have been the right engine, with which Captain Scott had experienced some difficulty at LaGuardia Field, for if that engine had caused the stall, the airplane would have whipped off to the right instead of to the left.

The only evidence in the record which suggests that one motor might have failed at that time is the statement of one witness, an airline pilot, who thought that the maneuver performed by the airplane resembled a stall aggravated by the use of the opposing motor. However, this witness was not able to hear the motors and, as previously shown, the same maneuver could have been caused by an ordinary power-on stall. Although no witness was able to state definitely that both engines responded to the application of power, one witness, an airline mechanic who heard the burst of power, testified that he was certain that he would have detected the failure of one engine.

Moreover, the inspection and the condition of the engines upon disassembly disclosed no evidence from which it could be concluded that either engine was not functioning effectively immediately prior to the impact. The two most probable causes of a momentary refusal of an engine to take the sudden opening of the throttle are icing of the carburetors and normal cooling of the motors during a glide. The tear-down of the engines did not disclose any evidence of carburetor ice in either of the motors and, in addition, it may be assumed that Captain Scott was applying some heat to his carburetors in accordance with airline procedure. There is no evidence which would indicate that the carburetor de-icer in use by United is not effective, and

pilots testified that no difficulty was encountered in freeing the carburetors of ice almost instantaneously upon the application of heat. It is improbable that a momentary failure of one engine to take the throttle could have resulted from cooling of the motors, because, according to pilot testimony, one of the principal advantages of the drag approach under partial power is that the motors remain warm and available for an emergency.

The evidence indicates that at the time of impact both motors were under little, if any, power, and the similarity of their condition indicates that both engines were doing exactly the same thing at that time. However, this does not indicate that the engines were not used in an attempt to correct the stall or that both engines responded when that attempt was made because in all likelihood, after having attempted to avert the stall by a burst of power and realizing that his attempt was unsuccessful, Captain Scott did everything he could to minimize the crash by pulling back the throttles prior to impact.

Thus, while the evidence provided by the disassembly of the engines and by the eye-witnesses does not conclusively determine whether the left engine responded, it seems most probable that no engine failure occurred to cause the stall or to contribute to the accident.

From all of the evidence available to us, we conclude that the stall resulted from a failure of the pilot of NC 25678 to exercise that degree of caution and skill required to avert it and not from any condition or occurrence beyond his control.

CONCLUSION

FINDINGS

Upon all the evidence available to the Board at this time, we find the probable facts relating to the accident involving aircraft NC 25678 which occurred near Chicago, Illinois, on December 4, 1940, to be as follows:

1. The accident occurred at approximately 5:48 p.m., and resulted in major damage to aircraft NC 25678 and the death of the crew of three and seven of the thirteen passengers.
2. United Air Lines Transport Corporation, the operator of the aircraft, held a currently effective and appropriate certificate of public convenience and necessity and an air carrier operating certificate.
3. The flight crew, Captain Philip Scott and First Officer George S. Young, were physically qualified and held proper certificates of competency to operate as air carrier pilots over the route between New York and Chicago.
4. Aircraft NC 25678 was currently certificated as airworthy at the time of the accident and had been maintained in accordance with company procedure and the applicable maintenance competency letters issued to United.
5. United 21 was cleared in accordance with proper procedure from New York, New York, to Cleveland, Ohio, including stops at Philadelphia and Allentown, Pennsylvania, and Akron, Ohio, and from Cleveland, Ohio, to Chicago, Illinois.
6. Before take-off from LaGuardia Field, New York, the right engine was cutting out on one magneto but this difficulty cleared up prior to take-off and did not recur during the flight between New York and Cleveland.

7. At the time of departure from LaGuardia Field and at all intermediate stops between New York and Chicago, the gross weight of the airplane did not exceed the approved standard gross weight and its load was properly distributed.

8. After arrival at Cleveland, the right engine was carefully inspected and checked by maintenance personnel of United and found to be in proper operating condition, which finding was concurred in by Captain Scott.

9. The difficulty with the right engine did not contribute in any way to the accident.

10. At the time of departure from Cleveland for Chicago, the airplane carried sufficient fuel to permit flight at normal cruising speed to Chicago and thereafter for more than three hours.

11. At 5:22 p.m., United 21 reported over the Chicago radio range station and cruised in that vicinity at the 5000 and 6000-foot levels until 5:33 p.m., when Captain Scott began his descent to the airport for a landing.

12. The weather conditions existing at the airport were: Ceiling of 900 feet with low scattered clouds at 600 feet, visibility of one mile with light fog, occasional drizzle and light snow, wind from the north northwest of 8 to 10 miles per hour, and temperature of 32 degrees.

13. Icing conditions existed to varying degrees in the overcast in the vicinity of the airport, including both rime and glaze types of ice, being especially pronounced at the 3000 and 4000-foot levels. These conditions were known to both the flight personnel of United 21 and United's dispatcher at Chicago.

14. The weather conditions which existed were accurately forecast by both the United States Weather Bureau and by United's meteorologists.

15. The runways at the Chicago Municipal Airport were in a slippery condition.

16. Notwithstanding this condition, the east-west runway was sufficiently long and was adequate for a landing under the prevailing wind and weather conditions and had been used by a number of pilots landing at about this time.

17. The northwest runway was limited in length by a railroad embankment and a landing on it under the existing wind and weather conditions would permit little, if any, margin of safety.

18. Captain Scott cannot be adversely criticized for descending through the overcast for a landing, and United's dispatcher at Chicago cannot be adversely criticized for permitting him to do so.

19. United 21 received a traffic clearance from the Air Traffic Control Tower operator permitting the use of either the northwest or the east-west runway.

20. At 5:41 p.m., United 21 reported contact at an altitude of 900 feet above the ground near the Chicago range station.

21. At the time Captain Scott broke out of the overcast he had accumulated a quantity of ice on his windshield which impaired his vision sufficiently to cause him to circle the airport for the purpose of clearing his windshield.

22. After flying for a short period over, and in the vicinity of, the airport under the overcast, he reported to the Airport Control Tower that he

would land on the east-west runway, but 40 seconds later changed his plan and stated that he would land on the northwest runway.

23. No sudden emergency occurred which made it necessary for Captain Scott to land on the northwest runway.

24. Under all the circumstances Captain Scott made an error of judgment in choosing the northwest runway for a landing.

25. Upon reaching a point approximately 700 feet southeast of the southeast corner of the airport at an altitude of approximately 160 feet, the airplane stalled, fell off to the left, and crashed while in an incipient spin.

26. Up to the instant before the crash the approach path was normal for a landing on the northwest runway, no structural or mechanical failure or malfunctioning of any part of the aircraft had occurred, and the aircraft was trimmed for a normal approach with gear down, flaps in the three-quarter position, and operating under approximately 25 percent horsepower.

27. Power was applied almost simultaneously with the stall, and no engine failure caused the stall or contributed to the crash.

28. Visibility from the cockpit was impaired during the approach due either to an accumulation of ice or mist on the windshield.

29. The aircraft had accumulated ice of a rough granular nature on the de-icer boots on the leading edges of the wings about $\frac{3}{8}$ of an inch thick extending back for a distance of 2 inches on the top and bottom of the boots, and ice of a clear glaze type from $\frac{1}{32}$ to $\frac{1}{16}$ of an inch in thickness extending back on the boots almost to the attachment strip. Ice was also present on the de-icer boots on the tail surfaces.

30. The stalling speed of the aircraft was raised an undetermined amount by the ice accumulation on the leading edges of the wings.

31. Captain Scott failed under the conditions set forth above to maintain adequate flying speed.

PROBABLE CAUSE

Upon the basis of the foregoing findings of fact and upon all the evidence available at this time, we find that the probable cause of the accident to aircraft NC 25678 (United 31) on December 4, 1940, was the failure of the pilot to exercise that degree of caution and skill required to avert a stall while approaching for a landing on the short northwest runway. A substantial contributing factor to the accident was the error in judgment of Captain Scott in choosing that short runway for his landing.

RECOMMENDATIONS

1. An adequate stall-warning device has been recognized as much needed in connection with air carrier services and other aircraft operations for a long time. Some research has been conducted along this line, but to date nothing has been developed which appears to be reliable under all conditions, particularly under icing conditions. The Board recommends that the Administrator of Civil Aeronautics give this matter the utmost encouragement through appropriate channels, including the aviation industry, in an effort to accelerate the further development of an adequate stall-warning device. The Board also recommends the continuance of research into the more fundamental problem of developing wing surfaces which are not subject to critical behavior at or near the stalling speed.

2. The need for adequate windshield wipers or other devices for improving vision from the cockpit under adverse atmospheric conditions is self-evident and was especially brought out at the Chicago hearing. The need for such a device has been long recognized by the industry and research has been conducted by the National Advisory Committee for Aeronautics and by some operators in an effort to develop a satisfactory windshield wiper. In order to further this project, and to encourage the most rapid development of an adequate windshield wiper, the Board recommends that the Administrator of Civil Aeronautics take steps through appropriate channels, including air carriers, to expedite the development and adoption of an adequate device.

3. The Board recommends that the Administrator of Civil Aeronautics stimulate the development of a more accurate means of measuring the rate of ice accretion and the adoption of an appropriate device for this purpose. The Board recommends further that the appropriate governmental agencies be requested to determine the relation of ice accretion to the terms generally used when reporting ice, namely, "light, medium and heavy".

4. The testimony of several pilots indicates that the formation of ice in and on the pitot tubes and on the pitot tube mast may lead to erroneous readings. It is understood that this problem is the subject of study and research by the air carriers and various governmental agencies. The Board recommends accelerated research in connection with the development and adoption of an air speed indicator which is not susceptible to incorrect readings due to formation of ice.

5. The Board recommends that the National Advisory Committee for Aeronautics continue and intensify its research looking toward the development.

of an improved means to prevent the accumulation of ice on wings and other parts of aircraft without thereby interfering with aerodynamic characteristics.

6. The Board recommends that the Administrator undertake a study of measures that should be adopted at all air carrier airports to keep Airport Control Tower operators, or others responsible for the issuance of information to pilots, informed by reports from the field personnel, pilots or other sources, of hazardous field conditions in order that such information may be promptly relayed to incoming or outgoing pilots.

7. When the accident happened, the airplane severed power lines leading into the airport, causing discontinuance of the lighting and communication facilities needed to furnish information for the operation of aircraft. The Board recommends that an auxiliary power supply be installed at all airports used by air carriers for instrument or night approaches. The auxiliary power supply should be independent of any source outside the boundaries of the airport and should be applicable to the operation of radio transmitters, field lights and obstruction lights. The Board is considering a requirement to this effect.

BY THE CIVIL AERONAUTICS BOARD:

/s/ Harllee Branch
Harllee Branch, Chairman

/s/ Oswald Ryan
Oswald Ryan, Member

/s/ G. Grant Mason, Jr.
G. Grant Mason, Jr., Member

/s/ George P. Baker
George P. Baker, Member

(Edward P. Warner, Vice Chairman, participated in the preparation of this report but was absent from the United States on official duty at the time of its adoption.)