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REPORT

OF THE CIVIL AERONAUTICS BOARD

Of the investigation of an accident involving aircraft of United States registry NC 21789, which occurred near Lovettsville, Virginia, on August 31, 1940

Note: This was the first formalized report of the CAB subsequent to Bureau of Air Commerce Act of 1938

CO Miller

IV.

CONCLUSION

The Board in this proceeding, in accordance with the statutory mandate, is reporting the probable, not the certain, cause of the accident. Undoubtedly the Board's statutory duty was thus defined in the Act in recognition of the fact, well known to the Congress, that due to the meager and inconclusive character of the evidence available, the circumstances surrounding air accidents have at times been enshrouded in obscurity. Probability flows from evidence which inclines the mind to a conclusion but leaves room for doubt. The Board in the present case is faced with just such evidence; evidence which suggests events but offers no basis for certainty with respect to them. Most of the subsidiary findings which follow, therefore; and certainly the conclusion as to the probable cause of the accident represent what appears to the Board to be the maximum of probability with respect to the several matters to which they relate. In some instances the conclusions lie in a twilight zone in which it has been extremely difficult to distinguish between probability and possibility.

Findings of Probable Fact

We find the probable facts to be as follows:

(1) The accident near Lovettsville, Virginia, on August 31, 1940, in which aircraft NC 21789 was destroyed and 25 lives lost, occurred at approximately 2:41 P.M. (EST).

(2) At the time of departure from Washington at 2:18 P.M., the aircraft, its equipment, and its personnel were in proper condition to undertake the flight, and all requirements of law, regulation, and company

practice had been complied with.

(3) A mechanical adjustment made immediately prior to departure, to correct lowered oil pressure on one engine, was without significance with respect to the accident.

(4) The flight was dispatched in accordance with normal procedure, and all information in the possession of the Weather Bureau and the company meteorologists had been taken into account in connection with the dispatch.

(5) The weather forecast contained nothing which would normally have raised any question about the advisability of dispatching a regular airline operation.

(6) The weather forecast was made in as much detail as the present state of meteorological knowledge permits, and proved to have been substantially accurate except for the omission of any reference to extraordinarily heavy rainfall.

(7) Immediately prior to the accident the airplane was proceeding on its normal course, and at normal altitude, in accordance with the flight plan.

(8) The airplane began its descent in the immediate neighborhood of, and immediately after, an intense flash of lightning.

(9) There were several other lightning flashes within a distance of two or three miles, and within a short space of time before and after the accident.

(10) The thunderstorm was accompanied, or immediately followed, by rainfall of extraordinary intensity, the heaviest known in the neighborhood

in several years.

(11) The descent of the aircraft began approximately at the time of its entering the area of intense rainfall.

(12) The air through which the airplane was flying at the time of the accident was turbulent.

(13) The airplane did not spin or undergo any substantial lateral deviation from its course during its descent.

(14) At some time during the descent the propellers were turning at substantially above their rated speed.

(15) The speed of the aircraft at the instant of striking the ground approached or exceeded 300 miles per hour.

(16) This speed could have been reached in a steady descent from cruising altitude along a path inclined 30 degrees to the horizontal.

(17) The aircraft at the time of take-off was loaded very nearly up to its maximum weight limit, but was clearly within that limit.

(18) The center of gravity of the airplane was in an intermediate position and the airplane would have had strongly positive longitudinal stability as a result.

(19) To maintain a path angle inclined as much as 30 degrees to the horizontal or any steeper angle, it would have been necessary to maintain a steady pressure of at least 40 pounds against the control columns, or to jam or block the controls in a fixed position.

(20) The altitude and position of the airplane at the time of the first indications of trouble was such that if the difficulty had been a power plant failure the pilot could have turned back completely out of

the storm area and made a forced landing under reasonably good conditions.

(21) Power plant failure had no causative relation to the accident.

(22) There was no structural failure prior to striking the ground.

(23) Immediately upon impact the fuel carried in the aircraft (about 400 gallons at the time of striking the ground) caught fire and burned with great rapidity. This was accompanied by an immense burst of flame and the production of rapidly rising currents of air.

(24) Individual parts of the aircraft continued to burn for some minutes before being completely extinguished by the rain which had its full intensity at the point of impact.

(25) The papers and pieces of cardboard found at distances up to 1-1/4 miles back along the flight path from the point of impact were carried there immediately after the accident by violent rising currents of air caused, in large part, by fire following impact and a light westerly wind.

(26) There was no fire in the aircraft prior to impact.

(27) There was no sabotage.

(28) The airplane was not actually struck by lightning.

(29) The airplane was in some fashion affected, or the pilots disabled, by some effect incidental to a stroke of lightning, such as its mechanical effect on the airplane, or acoustical shock, concussion, or optical impairment of the pilots.

In view of the absence of persuasive evidence that the accident was cau by structural failure of the airplane, mechanical failure of its motors, fire, heavy rainfall, or sabotage, we are left with turbulence and lightning as the two major possibilities on the present record. While it has been found that the airplane was flying through turbulent air at the time of the accident, it seems highly improbable that turbulence alone could account for the loss of 5000 feet before recovery of level flight. It is possible, of course, that involuntary interference by the jump seat occupant, who may have been thrown into the cockpit, could have accounted for the inability of the pilots to regain control once it had been lost. (The Board has under consideration a regulation prescribing the technical qualifications of any person who may be permitted to occupy the jump seat.)

Especially in view of the absence of persuasive evidence indicating any other probable cause of the accident, we are greatly impressed by the evidence of the coincidence of the lightning flash seen to be in close proximity to the airplane and the immediate descent of the airplane. Nor is this impression altered by the fact that all-metal aircraft are commonly struck by lightning with no injurious results and that the character of the lightning discharge, as well as its effect upon the airplane and crew, in the present instance must be regarded as an extremely unusual occurrence.

Probable Cause

Upon the basis of the foregoing findings of probable fact and the entire record in this investigation, we find that the probable cause of the accident to aircraft NC 21789, which occurred at Lovettsville, Virginia, on August 31, 1940, was the disabling of the pilots by a severe lightning discharge in the immediate neighborhood of the airplane, with resulting loss of control.

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I.

CONDUCT OF INVESTIGATION

An accident involving aircraft NC 21789, while operating in scheduled air carrier service as Trip 19 of Pennsylvania Central Airlines Corporation, occurred in the vicinity of Lovettsville, Virginia, on August 31, 1940, at approximately 2:41 p.m. (EST), resulting in the destruction of the airplane and fatal injuries to everyone on board. The accident was reported to the dispatch office of Pennsylvania Central Airlines in Pittsburgh at about 4:55 p.m. by a resident of Lovettsville, which report was relayed to personnel of the Civil Aeronautics Board at 5:45 p.m. (EST).

Inspection and Preservation of Wreckage

Immediately after receiving this notification, the Board initiated an investigation of the accident in accordance with the provisions of section 702(a)(2) of the Civil Aeronautics Act of 1938, as amended. Accident investigators of the Board arrived at the scene of the accident at about 7:30 p.m. and immediately took charge of the wreckage and secured the services of the Virginia State Police and the office of the Sheriff of Loudoun County, Virginia, to assist in guarding it. These investigators, who remained on duty throughout the night, were joined the following morning by additional investigators and the inspection of the wreckage was continued.

After a preliminary examination of the engines, propellers, and radio equipment, it was decided that disassembly of these parts would be necessary in order to make a complete inspection. Since it was practicable to disassemble and inspect these parts only at a shop especially equipped for handling this type of equipment, Pennsylvania Central Airlines was

directed to remove the parts to its overhaul shop at Pittsburgh which offered the nearest facilities available for the purpose. The parts were removed from the scene of the accident and transported in a Pennsylvania Central Airlines truck at the direction of the Chief of the Investigation Division of the Board. 1/

The Chief of the Investigation Division of the Board authorized the starting of the disassembly of these parts under the supervision of a maintenance inspector of the Civil Aeronautics Administration since the Board's power plant technician had been delayed in arriving in Pittsburgh from Dayton, Ohio. The power section of the right engine had been partially loosened before the arrival of the Board's technician. He then supervised the complete disassembly and inspection of all parts. Subsequent to this inspection, the propeller and parts of the engines were shipped to the National Bureau of Standards, Washington, D. C., for further inspection and study.

Since the remaining parts of the airplane wreckage were strewn over a large area, it was necessary, after the position and condition of the various parts had been established, to pick them up and place them in one group in order that they might be effectively guarded. This wreckage was guarded by the Virginia State Police and deputy sheriffs for a period of ten days, and then removed to the Washington-Hoover Airport, where it now remains in the custody of the Board.

Public Hearing and Subsequent Investigation

In connection with the investigation of the accident, a public hearing

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1/ The engines and other parts were examined at the scene of the accident prior to departure of the truck for Pittsburgh. Inspection subsequent to arrival and the evidence obtained at the time of disassembly showed the engines and other parts to be in the same condition as when examined at the scene of the accident.

was held in Washington, D. C., on September 6, 1940, through September 13, 1940. Fred M. Glass, Attorney of the Board, presided as hearing examiner, and in addition to the Members of the Board, the following personnel of the Safety Bureau of the Board participated: Jerome Lederer, Director; R. D. Hoyt, Assistant Director; Frank E. Caldwell, Chief, Investigation Division; and Paul E. Gillespie, Chief, Investigation Section. At the hearing all of the evidence available to the Board at that time was presented. One hundred and thirty-four exhibits were introduced and eighty-five witnesses testified, including witnesses from the vicinity of the crash and experts in various technical subjects involved in the investigation.

While the Members of the Board, the Examiner, and the representatives of the Safety Bureau were the only ones designated to ask questions directly of any witness, the presiding Examiner, acting under instruction of the Board, announced at the opening of the hearing that any person who had any evidence, questions, or suggestions to present for consideration in the proceeding might submit them to the Examiner. A number of such questions and suggestions were submitted, and at the close of the hearing the Examiner announced that every question submitted had been asked unless the subject matter of the question had previously been covered by the testimony. In the course of the investigation, many suggestions have been submitted to the Board orally or in writing, and all have been carefully considered.

Since the conclusion of the hearing, the Board and its staff have continued the investigation. Reports have been sought and received from the National Advisory Committee for Aeronautics, the Bureau of Standards, the Army Air Corps, and the Federal Bureau of Investigation

on technical questions arising out of the investigation, and additional witness statements have been secured. Most of the witnesses from whom such statements have been obtained had testified at the public hearing, but a consideration of their testimony indicated the necessity for securing more detailed and specific information from them. In addition, other witnesses who had not been discovered by the Board's investigators during the limited time between the accident and the public hearing were able to give statements pertinent to the issues involved in the investigation. The testimony contained in these technical reports and supplemental witness statements will be discussed later in this report.

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

II

SUMMARY OF EVIDENCE

There follows a summary of the evidence available to the Board at this time. This summary is made without comment. An analysis of the evidence is made under Part III of this report.

Air Carrier

Pennsylvania-Central Airlines, a Delaware corporation, was operating at the time of the accident as an air carrier under a certificate of public convenience and necessity and an air carrier operating certificate issued pursuant to the Civil Aeronautics Act of 1938. These certificates authorized it to engage in air transportation with respect to persons, property, and mail between various points, including Washington, D. C., and Detroit, Michigan, via Pittsburgh, Pennsylvania, Akron, Ohio, and Cleveland, Ohio.

Aircraft Personnel

On the flight in question the crew consisted of Captain Lowell V. Scroggins, First Officer J. Paul Moore, and Flight Hostess Margaret Carson. In addition, John B. Staire, Jr., secretary to the District Traffic Manager, was occupying the jump seat located just behind the pilots' seats.

Captain Scroggins had accumulated a total of 11,442 hours flying time, of which 619 hours were in Douglas DC-3 type airplanes. His last physical examination, required by the Civil Aeronautics Authority, was taken on June 28, 1940, and showed him to be in a satisfactory physical condition. A number of pilots who had flown with Captain Scroggins testified that he was a competent pilot who kept himself in excellent physical condition. First Officer Moore had accumulated a total of 6,018 hours flying time, of which 219 hours were in DC-3 type airplanes. His last physical examination, required by the Civil Aeronautics Authority, was taken on June 25, 1940, and showed him to be in satisfactory physical condition. Both airmen were possessed of the required ratings and certificates of competency for the flight and equipment involved. Miss Carson of Pittsburgh, Pennsylvania, was employed by Pennsylvania-Central Airlines Corporation on May 28, 1940, and had served as flight hostess since that date. Mr. Staire's experience was all of a clerical and administrative character, not connected with the actual operation of aircraft. He had been employed by Pennsylvania-Central Airlines on August 26, 1940.

Description of Aircraft and Equipment Prior to Take-off

Aircraft NC 21789 operated on the flight was a Douglas Model DC-3-A manufactured by the Douglas Aircraft Corporation of Santa Monica, Calif-

ornia. The airplane was received from the manufacturer by the Pennsylvania-Central Airlines Corporation on May 25, 1940. It was powered with two Wright Cyclone engines, Model G-102-A, each rated at 1100 horsepower for take off and was equipped with Hamilton Standard constant speed, hydromatic, full-feathering propellers, 11 feet 6 inches in diameter, Hub Models 23 E 50 and Blade Models 6153A. This type of aircraft, equipped with engines and propellers as above described, has been extensively and successfully used in commercial air transportation in this country and abroad for a number of years.

The records of the company show that the total flying time for aircraft NC 21789 and its engines and propellers at the time the airplane left the Washington-Hoover Airport on August 31, 1940, was 565 hours and 54 minutes. The overhaul period on this type engine prescribed by the Authority for Pennsylvania-Central Airlines is 600 hours.

The airplane arrived at Washington-Hoover Airport at 11:00 a.m. on Saturday, August 31, 1940, after having completed a scheduled flight from Detroit, Michigan. Nothing unusual was reported concerning its operation on this trip nor had anything unusual or any mechanical defect or adjustment of more than a minor nature, been reported with respect to any previous trip.

Following its arrival in Washington, the airplane was serviced with gasoline and oil and was given a routine "turn-around" inspection. This inspection consists of a general visual examination of the airplane, especially of the propellers, wing and tail surfaces, and the controls which are visible from the outside, and the testing of the controls, engines, instruments, and radio equipment. In addition, the interior of the airplane is cleaned and the outside surfaces wiped off. The record

shows that nothing unusual was discovered during the course of this inspection.

The airplane had been given the routine inspection to which it is subjected after every 60 hours of flight time on August 30, 1940. This inspection is much more detailed than the "turn-around" inspection and the record shows that nothing unusual was disclosed.

This model aircraft and its equipment had been approved by the Civil Aeronautics Authority for air carrier operation over routes flown by Pennsylvania-Central Airlines with an approved standard gross weight of 24,546 pounds. While the airplane had regular seats for 21 passengers and a crew of three, the company was authorized to carry an additional member of the crew, observer, or company employee in a jump seat located in the aisle directly behind the pilots' seats. The record shows that at the time of departure of Trip 19 from Washington, the gross weight of the airplane was 24,372 pounds, including mail, cargo, 460 gallons of fuel, 40 gallons of oil, 21 passengers[2/], a crew of three, and a company employee riding in the jump seat. The location of the center of gravity of the airplane at the time of take off was 23% of the mean aerodynamic chord of the wings.

The Flight

Trip 19 was scheduled to leave Washington-Hoover Airport at 1:50 p.m.(EST) on August 31, 1940, and, in accordance with regular company procedure, was cleared by the company dispatcher in Pittsburgh, Pennsylvania, prior to departure. The clearance was based on current sequence weather reports, United States Weather Bureau forecasts, and a trip forecast made by the company meteorologist. The pilot's flight plan stated that he would climb to an altitude of 6000 feet, cruise at 6000 feet over Martinsburg, West Virginia, and Frostburg, Maryland, and descend to 4000 feet over Scottsdale, Pennsylvania. The flight was cleared to cruise at 6000 feet by the Airway Traffic Control Center at Washington. Instructions as to the approach and landing at Pittsburgh were to

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2/ List of passengers is shown in Appendix A.

be given the pilot from Pittsburgh after he had reported his position over Scottsdale. The estimated time of arrival was 3:30 p.m.

The weather forecast made by the United States Weather Bureau for the Washington-Pittsburgh area for the period 11:30 a.m. to 7:30 p.m. was available to the pilot prior to take-off and the record shows that the forecast, together with sequence weather reports, was examined by the crew prior to preparation of the flight plan. The forecast predicted that overcast to occasionally broken clouds would exist from the mountains eastward, with scattered showers through the mountains and some mild thunderstorms in the afternoon. Winds aloft of 20 to 30 miles per hour at 250 to 270 degrees were forecast[3/].

The trip departed from the ramp at Washington-Hoover Airport at 2:05 p.m. having been delayed awaiting a local passenger. After taxiing out to the take-off position and running the engines up preparatory to taking off, the oil gauge for the right engine showed that the oil pressure in that engine was below normal. The airplane was then taxied back to the loading ramp where, at the request of the pilot, a Pennsylvania-Central Airlines mechanic made the appropriate adjustment to the oil filter to relieve it of any sediment which might be interfering with the oil flow. After this mechanical adjustment[4/] had been made, the co-pilot indicated that the oil pressure was normal, and the airplane again left ramp at 2:18 p.m. and following a run-up of the engines at the end of the runway, took off at 2:21 p.m.

At 2:31 p.m., Trip 19 made the following position report to the Washington-Hoover Airport:

"Trip 19 Herndon fan-marker 2:31; 4000; climbing; contact."

The airplane crashed about 2:41 p.m. (EST) at a point approximately 2-1/2 miles west of Lovettsville, Virginia, and approximately 25 miles northwest of the Herndon fan-marker. The crash occurred about one-half mile east of the base of Short Hill and approximately 5 miles to the right (i.e., northeast) of the on course signal of the northwest leg of the Washington radio range at an elevation of about 550 feet above sea level. The terrain in the immediate vicinity is rolling and consists mainly of farm land interspersed with wooded areas. Short Hill is a ridge, the crest of which rises in the neighborhood of Lovettsville to 1300 to 1500 feet above sea level and to about 750 feet above the level of the terrain at the point where the accident occurred. This ridge, which extends about 15 miles in a generally north and south direction, is the eastern most of the major ridges of the Blue Ridge Mountains.

3/ See Appendix B for weather analysis, official Weather Bureau forecast, and hourly sequence reports.

4/ To be discussed hereinafter on page 52.

Course and Position of Aircraft Immediately Prior to the Accident

While no further report was received from the airplane after it reported over the Herndon fan-marker,[5] a number of witnesses living near the scene of the accident testified that they saw an airplane within the last few minutes prior to the crash[6] which they believed to be the one which was involved in it.

Mrs. Dorothy Everhart testified that she was on the back porch of her home just south of Lovettsville and approximately 3-1/2 miles east of the scene of the accident when she saw an airplane proceeding normally in a northwesterly direction toward Short Hill, the northern portion of which was at that time obscured by dark storm clouds. She was looking in a southwesterly direction when she saw the airplane and she watched it proceed directly toward the storm. She stated that she was momentarily blinded by the brilliance of a lightning flash "just a little bit ahead" of the airplane and lost sight of it. Shortly thereafter she heard a "low rumble" of thunder and after a few seconds an "awful roaring". She testified that airplanes passed in the vicinity of her home quite frequently and that this one was "lower than most of them go". As she watched the airplane she did not hear its motors but she was sure that the "awful roar" which she had heard after the lightning flash and the rumble of thunder was the sound of the airplane. She further testified that at the time of this occurrence it was not raining at her home but that shortly thereafter the storm which had been in the vicinity of Short Hill "came on over". She described it as a very bad storm with lightning, some thunder, and extraordinarily heavy rain, but no wind. She testified that when she first saw the airplane the black clouds

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5/ See Appendix E for radio messages in connection with the flight.

6/ See Appendix C for a map of the Lovettsville area showing the scene of the accident and location of the witnesses.

obscured the mountains to the west and northwest but that she could see blue sky toward the south.

After the hearing investigators for the Board further questioned 7/ Mrs. Everhart as to the weather conditions during that day prior to the accident. She stated that the sun had been shining off and on during the forenoon and early afternoon at her home but that the sky was overcast when she saw the airplane pass. Mrs. Everhart testified that another stroke of lightning had preceded the one she saw while watching the airplane and she believed that the former had struck the chandelier in one of the rooms of her home. After this had occurred, she turned off the electricity in the house and went out on the back porch. She said that it was while she was on the back porch that she saw the airplane and the flash of lightning which blinded her. With the assistance of the investigators as described in Footnote 7 she estimated that the time intervening between the second lightning flash and the

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7/ A number of witnesses residing in the vicinity of Lovettsville testified at the hearing that they had seen an airplane or heard sounds which they believed had come from an airplane in that vicinity at about the time of the accident and which they associated with it. After a consideration of their testimony subsequent to the hearing, it appeared that it would be in the interest of a full and complete investigation to secure more precise statements from them as to the weather conditions on the day of the accident, the position and altitude at which they had seen the airplane to which they referred, and the time intervals which elapsed between the various events or sounds to which they had testified, such as the stroke of lightning, the sound of thunder and the sound of motors. For this reason investigators of the Board called upon these witnesses again, took additional statements from them, and in almost all cases attempted to assist them in estimating the elapsed time during particular periods in question by having them retrace the movements they had made during those periods and recording the time with a stop watch. In order to determine the position at which the witnesses stated they saw the airplane, they were requested to stand at the place at which they were standing when they saw it and indicate as best they could the point at which they had seen it. Then, through the use of a transit, the investigators determined the direction of this point from the witness and its angle above the horizontal.

beginning of the "roaring noise" was 7 seconds. The point designated by her as the one at which she had seen the airplane just before she was momentarily blinded by lightning was 3-1/2 degrees above the horizontal on a bearing of 255 degrees magnetic.

Mr. Carroll McGaha testified that he and his son were standing in the yard of their home located about 4-1/4 miles southeast of the scene of the accident and approximately 4 miles to the right of the on course signal of the northwest leg of the Washington radio range when they observed an airplane pass over flying in a northwesterly direction. He stated that the airplane was proceeding normally at about the altitude at which he usually observed transport airplanespass over flying in a northwesterly direction. His attention was particularly attracted to the plane because it was proceeding directly toward the dark storm clouds then in the vicinity of Short Hill. As the airplane approached the storm he saw a sharp "streak of lightning" which appeared "directly ahead" and "in line" with the airplane and saw the airplane go "straight down". After starting down, the witness stated that the plane "made a roar" which was distinctly heard by him and his son at the point where they were standing. After the roar had stopped, he heard a "rumble" of thunder. He then ran to the back of his farm, thinking that the airplane had crashed there.

Investigators for the Board again questioned Mr. McGaha at his home some time after the hearing and he explained in more detail his observation of the action of the airplane immediately following the lightning flash. He stated that the airplane seemed to go straight down until it passed from his view behind corn growing on a knoll located between the point where he was standing and that at which the airplane struck the ground. He said that he could see the flat surfaces of the wings and the tail of the airplane above them. In answer to questions asked by the investigators he also stated that the sun had been shining at his place late in the morning of the day of the accident, but

that a little after 2:00 or 2:15 p.m. black clouds gathered in the northwest, heavy rain appeared to be falling there, and the sky overhead became overcast to a point just east of his home. Although the rain storm approached within 1/4 mile, the witness stated that there was no rainfall at his house that afternoon.

Questions were also asked of the witness as to the flight path of the airplane he had seen. The point at which he said he first observed it was almost directly west of him (280 degrees magnetic) and at an angle above the horizontal of approximately 80 degrees. The point indicated by the witness as that reached by the airplane at the time of the lightning flash was at an angle of about 11 degrees above the horizontal on a bearing of 316 degrees magnetic and the point at which it passed from view was found to be approximately 4 degrees above the horizontal.

Mr. McGaha's son, Warren McGaha, corroborated the testimony of his father. Like his father, he stated that he often saw airplanes fly over and that this one was at just about the same altitude as such airplanes usually flew. He also testified to seeing the flash of lightning just ahead of the airplane and stated that it immediately "went right straight down".

At the time the investigators were questioning Mr. McGaha at his home, two large twin-motored airplanes similar to the one involved in the accident passed over, proceeding in a northwesterly direction, one at an altitude higher than the other. Both Mr. McGaha and his son were asked as to whether either of these airplanes was at the approximate altitude of the one concerning which they had testified. They stated that the lower one appeared to be about at that altitude. Subsequent inquiry revealed that one of these airplanes was an Army B-18 bomber which had left Bolling Field, Washington, D. C. at 4:55 p.m. enroute to Patterson Field, Dayton, Ohio, and the other was Pennsylvania-Central Airlines Trip 7-1 which had departed Washington for Pittsburgh at 4:59 p.m. Upon inquiry the Army pilot stated that he was cruising at about

6000 feet altitude at the time of passing in the vicinity of Lovettsville and the Pennsylvania-Central Airlines' pilot said that he had just about reached his cruising altitude of 6000 feet when he reached that area.

Mrs. Fannie Ridgeway testified that at about 2:30 on the afternoon of August 31, 1940, she was sitting on the porch of her home which is approximately 3-3/4 miles southeast of the scene of the accident and saw an airplane fly over, headed in a northwesterly direction toward heavy storm clouds gathered over Short Hill. These clouds obscured her view of Short Hill. She was looking toward the south when she saw the airplane. She paid little attention to it since, as compared with other airplanes which she had seen pass over, there was nothing unusual in its operation either as to the sound of the motors or the altitude at which it was flying. Mrs. Ridgeway testified that after seeing the plane pass over she re-entered the house and a few minutes thereafter heard a "roaring noise". However, she was unable positively to identify this noise, describing it only by the statement that it sounded like a "truck going down the pike". She stated that while she saw no lightning, she did hear thunder.

Investigators for the Board again questioned Mrs. Ridgeway at her home subsequent to the hearing as to the weather on the day of the accident. She stated that the sun had been shining at her home all morning and that it had been very warm with very little wind blowing. At about 1:00 p.m. she observed a dark cloud in the southwest in the vicinity of Short Hill and it appeared to be raining in that direction. The point at which she said she saw the airplane was at an angle of 37 degrees above the horizontal on a bearing of 201 degrees magnetic.

Mrs. Mattie Hickman testified that she was standing in the yard of her home, which is located about 2-1/2 miles southeast of the scene of the accident, when her attention was directed to an airplane which was flying much lower than such airplanes usually flew near her home. She stated that the plane was going

northwest toward Short Hill which at that time was covered by a dark storm cloud. Shortly thereafter she went to the house and while inside, she heard an unusual noise. She was unable to identify the noise precisely, stating that it "sounded like an old truck". The witness testified that about 10 or 15 minutes after the airplane passed over, an unusually heavy rainstorm began but that there was not much wind and she heard only one clap of thunder.

Subsequent to the hearing, the Board's investigators again questioned Mrs. Hickman and in the manner described in Footnote 7 assisted her in estimating the elapsed time between the various events recounted in her testimony. According to her statement she saw the airplane, saw lightning, heard thunder and then this unusual noise. The time recorded was 50 seconds between the sight of the airplane and the lightning, 4 seconds between the lightning and the thunder, and 12 seconds between the thunder and the unusual noise. The point at which Mrs. Hickman said she saw the airplane was at an angle of 36 degrees above the horizontal on a bearing of 301 degrees magnetic.

H. O. Vincell testified that he was sitting on the front porch of his home, which is located about 2-1/2 miles southeast of the scene of the accident when his attention was drawn to a large airplane flying "a little lower than common." He stated that he watched the airplane proceed toward Short Hill which was then obscured by a dark storm cloud until it "disappeared into a fog". Shortly thereafter he saw a "pretty sharp" stroke of lightning, heard thunder, and then a "devil of a noise" which he later described as a crash. Thinking that the airplane was going to fall on his house, Mr. Vincell ran out into the yard. Testifying with respect to the weather at this time, he stated that it was overcast at his home with a dark cloud hanging over Short Hill. The Hill was "white with fog". Mr. Vincell stated that a heavy rain started about five or ten minutes after he saw the airplane.

After the hearing, the Board's investigators again questioned Mr. Vincell and he stated that the airplane was silver and very bright. He said that he could see the landing wheels extended below the airplane and the windows of the cabin and that the sound of the airplane as it passed over was smooth and not very loud, with no drumming.

Mr. Charles Bailey testified that he was standing near his home which is located on the west side of Short Hill about one-half mile from its base (the scene of the accident is on the east side of Short Hill, 2-1/2 miles east of Mr. Bailey's home) when he saw what he described as a three-motored airplane cross over Short Hill at a low altitude going west and make a sharp left turn back east. He stated that he could see the landing wheels of the airplane and noticed particularly the revolving propeller in the nose motor. Shortly after seeing this airplane turn back over the mountain, he heard a loud roar of motors and a crash. He testified that at the time he saw this airplane a storm was approaching from the west.

Mrs. Lydia Jacobs, who lives about 390 yards west of the scene of the accident, testified that she was sitting in her home at approximately 2:30 on the afternoon of August 31, 1940, when she saw a "flash of lightning", heard a "hard clap of thunder", and then heard a noise which she described as a "siren" or "scream". She then went to the door looking out in the direction from which the noise came and saw what looked like "a fire in the sky" or a "a streak of fire" or"a burnt up building floating through the air". She described the flame as "blue looking". Then an explosion occurred which jarred her almost off her feet. She testified that the object went through the air from southeast to northwest

slanting downward. At the time this occurred she stated that it was raining harder than she had ever seen it rain before.

Accident investigators for the Board again questioned Mrs. Jacobs after the hearing and she stated that it had been overcast all day in the vicinity of her home and some rain had fallen in the morning. The investigators also attempted to assist Mrs. Jacobs in estimating the time which elapsed between the flash of lightning and the crash by having Mrs. Jacobs retrace her movements between those two events. The time recorded was 10 seconds.

Her son, Garland Jacobs, testified that during this torrential rainstorm he was sitting in his car near their home and saw a "hard streak of lightning", heard thunder, and then a loud roar of motors "like the plane was taking a nose dive". He thought that the roar of motors continued for as much as 30 seconds. He looked in the direction from which the sound came just in time to see a streak of fire slanting downward toward the spot at which the airplane crashed. He heard the crash and an explosion.

Mrs. Viola Thompson, who lives about 400 yards west of the scene of the accident, testified that she was in the kitchen of her home watching the rain, which she described as being the hardest that she had seen in several years, when she heard a "terrible roaring" which sounded as if it were very near her home. She recognized the sound as that of an airplane and, fearing that it would hit her house, ran upstairs and looked out of the window. She testified that she heard the crash and a loud

explosion, and saw an accompanying blaze. She saw what she described as "balls of fire" rolling across the alfalfa and corn fields directly ahead of the point at which the airplane crashed.

Following the procedure previously described, investigators for the Board, who called upon Mrs. Thompson after the hearing, recorded the length of the period during which she said she heard the roaring noise and the crash and saw the "balls of fire" as 19 seconds.

Mr. Richard Thompson, the husband of Mrs. Viola Thompson, stated that he was standing in the kitchen of their home when he was startled by an "awful racket, the motor running just about as fast as I thought it could run". He said that he saw the airplane passing by the house and immediately heard the crash. Both he and Mrs. Thompson testified that they had not seen any lightning or heard thunder immediately preceding the crash. Mr. Thompson subsequently stated to investigators of the Board that he had seen no fire around the airplane prior to the crash. 8/

The testimony of these witnesses is conflicting in some instances but it is set out here without comment. It will be discussed in Part III of this report.

8/ The testimony of other witnesses from the Lovettsville area will be set out under the section entitled "Weather Observations".

Location of the Wreckage

Aircraft, Engines, and Equipment

Investigation conducted at the scene of the accident revealed that the airplane had struck the ground on the edge of an alfalfa field in a nose-down attitude. The character of the impression made in the soft ground and the fact that the corn standing about eight feet high and about twelve feet behind the point of impact was not affected by the passage of the airplane, indicated that the angle at which the airplane struck was between twenty and forty degrees to the horizontal. The impression made in the ground and the condition of the left wing showed that that wing was slightly lower than the other. The form of the impression and the distribution of the wreckage also indicated that the heading of the airplane at the time of impact was approximately 310 degrees magnetic, the course on which it would normally be flown at that point on the airway between Washington and Pittsburgh. This conclusion is further supported by the fact that the directional gyro when found was jammed at a heading of 310 degrees.

The wreckage was thrown forward and scattered thickly over a distance of approximately 1000 feet, with isolated pieces even further. No parts of the airplane structure or power plants were found behind the point of impact.[9/] The fuselage, except for the extreme rear portion, was disintegrated, and the area forward of the point of impact was showered with pieces of various sizes and shapes.

9/ Appendix D, attached hereto, is a sketch showing the relative positions of the major components of the aircraft following impact.

The engines and nose portion of the fuselage plowed into the ground to a depth of approximately six feet. The nose section of the right engine, propeller hub, and one blade of the propeller, still attached to the hub, and the nose section of the left engine, propeller hub, and two blades of the propeller, broken off at the shank, remained in the hole.

The right and left landing wheels and landing gear were about 50 feet beyond the point of impact. The left elevator and part of the left stabilizer were about 150 feet forward of the point of impact and about 30 degrees to the left. The right stabilizer, right elevator, fin, rudder, a portion of the left stabilizer, and the extreme rearward portion of the fuselage to which they were still attached, were about 150 feet directly ahead of the point where the airplane first struck the ground.

The power section of the right engine with some cylinders and pistons broken off was about 300 feet forward and slightly to the right of the direction of flight at the time of impact. The power section of the left engine was about 325 feet forward and slightly to the left of the point of impact. Portions of the rear sections and accessories of both engines were strewn along the way.

The left wing was about 350 feet forward and slightly to the left of the point of impact. The right wing was about 300 feet forward and slightly to the right of the point of impact. Other parts of the aircraft structure were found near both wings. Comparatively large portions of the forward part of the passenger cabin were about 450 feet forward of the point of impact.

Pieces of fuel tanks, numerous parts of the aircraft skin and structure, and parts of the flaps were strewn for a distance of approximately 1000 feet from the point of impact. The major portion of the left aileron, the tip of which was detached, was about 260 feet forward and slightly to the left of the point of impact. All seats in the cabin and pilots' compartment were scattered over a distance of about 800 feet forward of the point of impact.

One blade from the right propeller, which had broken off at the shank, was approximately 150 feet forward of the point of impact. Another blade from the same propeller was approximately 250 feet forward, while the remaining blade from the left propeller was forward about 1800 feet and 35 degrees to the left of the line of flight.

The radio transmitter, receivers, and the antenna systems were scattered over a distance of about 500 feet forward of the point of impact.

Contents of Aircraft

Almost all of the contents of the aircraft were strewn forward of the point of impact. However, a number of pieces of paper believed to have been in the plane were found to the southwest, south, and southeast of the crash. A threshing crew of ten men were in a barn about 1-1/4 miles southeast of the scene of the accident waiting for the rain to stop when they heard a loud roar of motors and, according to some of them, a crash. Shortly thereafter they saw a piece of paper come fluttering down and one of them retrieved it. It was found to be a manila envelope with the name "Pennsylvania-Central Airlines" printed on it. It was burned around the edges. The time interval estimated by the witnesses between the crash and the appearance of the envelope was from 2 to 30 minutes but most of them believed it to have been less than 5 minutes.

Another piece of paper, also burned around the edges, was found in a cornfield located a little less than a mile southeast of the scene of the accident. The piece is about 3 inches wide and 5 inches long. One of the Pennsylvania-Central Airlines flight calculators furnished for the convenience of the passengers was found in a stubble field about 7/8 of a mile southeast of the point of impact. This flight calculator, which weighs .11 of an ounce, is composed of two circular pieces of light cardboard, one about 1-1/2 and the other about 3-1/2 inches in diameter, held together by a pin through their centers. It was badly soiled but not burned. Two Pennsylvania-Central Airlines passenger manifest forms were found about 3/8 of a mile almost due south of the point of impact. These forms are 13 inches long by 8 inches wide, and when found were folded once and were burned around the edges. Two other passenger manifest forms were picked up nearby. These were folded twice and burned around the edges.

A light piece of cardboard, approximately 11 inches in length by 4 inches in width, was found about 1/8 mile southeast of the point of impact. It was identified as Pennsylvania-Central Airlines Form No. 248, with the words "Sorry, this seat is occupied" printed thereon. This paper was burned around the edges.

A number of pieces of paper, all identified as coming from the wreckage, were found about 300 yards southeast of the point of impact. Some of these pieces of paper showed indications of fire, while others showed none.

The bodies of the passengers and crew were all found forward of the point of impact beginning at a distance of about 250 feet and extending

to about 1240 feet. Several timepieces, including a number of watches and one alarm clock, were found among the wreckage. They were all badly damaged, and only three were in such condition as to show the time at which they had stopped. One of these had stopped at 2:39, one at 2:40 and the other at 2:42.

Condition of the Wreckage

Aircraft Structure and Controls

Following the inspection of the wreckage at the scene of the accident, the remains of the airplane structure were moved to the Washington-Hoover Airport where a more complete inspection of all parts was made. All major component parts of the airplane were accounted for but because of the large area over which numerous small pieces of the wreckage were scattered, it was impossible, under the circumstances, to prevent souvenir hunters from carrying some of the smaller fragments away. A number of pieces so taken were subsequently recovered.

The right and left landing wheels and landing gear were in a badly broken condition, both tires had been blown out by impact, and the right tire was partially burned.

The left elevator and the rear portion of the left stabilizer were badly damaged and a small portion of the fabric on the elevator was burned just forward of the center hinge. The forward portion of the left stabilizer, the right stabilizer, vertical fin, rudder, and the extreme rear portion of the fuselage were still attached. The stabilizers and vertical fin had apparently been damaged by contact with the ground following impact. These parts had been thrown forward about 200 feet from the point of impact. The rudder showed very little damage except that part of the fabric had been burned away. The trim tabs on the elevators were in cruise position, taking into consideration the distribution of the load carried on the airplane.

The left wing was badly damaged. It was broken in several places and the tip was detached. The main portion of the right wing was intact but badly damaged and the tip of this wing was also detached. The left aileron was broken in two and otherwise badly damaged.

The upholstering on some of the seats and on the forward portion of the passenger cabin had been partially burned. Some of the seat belts were broken in two, others had pulled loose at their attachment fittings, and others were still attached to pieces of the seat structure.

Although the fire extinguishers in the engine nacelles and passenger cabin were badly damaged, it was possible to determine with certainty that they had not been used.

A complete inspection of the remains of the control system showed the control columns and rudder pedals in the cockpit to have been badly broken and damaged, and in tracing out the controls, many breaks were found. The throttle and propeller pitch controls were found in full forward position and bent over the control column. The ignition switches and fuel valves were found in the "on" position. Other switches, valves, and controls were so damaged as to make it impossible to determine their position at the time of impact.

The instruments which were located were, with the exception of the gyroscopic compass, damaged to such an extent that no readings could be taken. The front of this instrument had been dented so as to hold the compass card in a fixed position. The heading indicated was 310 degrees.

Such glass as was found, both cockpit and cabin, had been broken into small bits. A great many small pieces which were found immediately ahead of the point of impact were identified as having come from both the windshield and cabin windows. Some glass was also found from 300 to 400 feet forward of the point of impact.

Engines

The engines were badly damaged and broken. The entire nose section of the right engine, including the reduction drive gear, cam, propeller shaft, and pinions had been sheared off and were in one group. The forward end of the crankshaft was broken off just in front of the reduction drive gear lock nut. The bolts holding the stationary gear to the front section were sheared off, permitting the stationary gear to revolve. The reduction gear drive splines were damaged when the reduction gear came off. All cylinders were damaged and a number of the heads broken off.

The rear section was broken away from the power case and all parts were badly damaged. The supercharger was broken off adjacent to the cap screws which held it to the main section. The power section of the crank case (steel) was badly distorted. The master rod assembly and the internal portions of the crankshaft, together with the articulating rods, were intact although badly bent. The kelmet material in the master rod bearing was in good condition. However, the lead plating on the master rod bearing shell showed indications of heat. The master rod bearing shell was loose in the rod, but there was no indication of galling. The end seal disc was battered, and a considerable quantity of lead from the master rod bearings had redeposited itself on the face of the seal disc. The end seal spacer was very badly damaged by the forces resulting from the sudden stoppage of the propeller. Knuckle pins Nos. 2, 5, 6, 7 and 8 were discolored near the oil flats. The crankshaft main bearing journal showed signs of overheating on the inner side of the crank throw. This indication of overheating covered the entire length of the bearing surface over an area approximately 180 degrees

around the shaft. The supercharger impeller was badly damaged and practically all of the blades had been broken off. The thrust bearing was badly broken, apparently due to impact.

The condition of the left engine was very similar to that of the right engine. In fact, the condition of the master rod bearings, the crankshafts, knuckle pins, impellers, and gears from the two engines were so nearly identical that it would be almost impossible to distinguish between them.

Both engines showed metal to metal contact between the master rod bearings and the crank pins, the oil film usually separating them apparently having broken down. The National Bureau of Standards, after examination of the engine parts sent to it, reported that no evidence of mechanical, structural, or fatigue failure or lightning strike prior to impact had been found.

Propellers

Upon disassembly of the right propeller it was found that the dome section was not badly damaged, except that the breather cap had been broken off. The piston and rotating cam assembly was intact and not badly broken. The gear segments of all three blades had been split at a point near the 4th, 5th, and 6th teeth from the low pitch end. The condition of the bevel blade races indicated that heavy loads had been applied. Several of the rollers still remaining in the retainers were split. Cracks were apparent in the micarta barrel blocks at the shoulders. The blade butts from which the two blades had been broken off were intact at the hub. These two blades had also been fractured near the tips, apparently by impact. The one blade remaining with the hub was not fractured but showed indications of power bends.

The dome of the left propeller had an impression in it about six inches in diameter, apparently caused by impact. All three blades of this propeller had been broken off close to the shank. Two blades had the tips torn off and were otherwise badly bent and twisted. The third blade was located some 1800 feet from the point of impact and, while it was intact, it was quite badly twisted in the form which would indicate a power bend. The gear segments on all three blades of the left propeller were split in the same way as those on the right. The rotating cams on both propellers had stopped in a position which would indicate a pitch angle of the blades of about 24 degrees.

The National Bureau of Standards examined the propeller parts and reported that there was no evidence of mechanical, structural or fatigue failure or lightning strike prior to impact.

Radio Equipment

All radio equipment, including receivers, transmitter, accessories, and antennae systems, was badly damaged. Careful inspection failed to reveal any arcing or burning effect which might be expected from a lightning strike. The anti-static discharge cartridge had not been discharged. The anti-static loop antenna was adjusted in the anti-static position (parallel with the fuselage). The loop tuning dial was tuned to the Richmond radio range[10/]. Minute inspection of all wiring did not indicate any burning or fusing. Only one of the pilots' radio headbands was found and it was badly twisted. None of the radio earphones was found. These parts, composed of hard rubber, may have completely disintegrated at the time of impact.

10/ The evidence showed that a company mechanic at Washington had tuned it to this position prior to departure.

Weather Observations

As we have stated previously, the weather forecast predicted overcast to occasionally broken clouds from the mountains eastward with scattered showers through the mountains and some mild thunder storms to the east of the mountains.

In addition to the Lovettsville witnesses, whose testimony has been set out previously, a number of other witnesses testified at the hearing, or gave statements after the hearing, with respect to the actual weather conditions existing on August 31, 1940, in the vicinity of the accident. The testimony of the residents in the vicinity of Lovettsville presents a consistent picture of the weather conditions in that area at the time of the crash, as observed from the ground. A rain storm was passing over Short Hill, which several described as extraordinary in its intensity.

A number of these witnesses stated that, while they had not noticed much lightning in connection with the storm, they recalled a violent flash of lightning and the sound of thunder which was immediately followed by an extraordinarily loud roar of motors. Some of these witnesses in the immediate vicinity of the point of impact testified that the loud roar of motors was followed by a "crash" or "blast".

Mr. I. W. Baker, who lives about 3-1/4 miles almost due south of the scene of the accident watched the storm with "rolling and tumbling" clouds come across Short Hill. Shortly thereafter it began to rain and then he saw a "terrific strike of lightning with a very loud explosion like thunder". One minute and twenty seconds later he heard a "terrific racing of engines like something had dropped from the sky". He computed the elapsed time between

the lightning flash and the sound of the engines by retracing the movements he had made during that period. He later found that this stroke of lightning had struck and damaged his barn and had shattered the butt of a rifle which had been standing inside the barn.

After the hearing, investigators for the Board questioned Harry E. Everhart who lives about 1-1/2 miles southeast of the scene of the accident. He stated that at about 1:30 P.M. he noticed a dark cloud on the west side of Short Hill coming toward the east. At that time it was overcast over his home but to the east broken clouds appeared. At some time after 2:30 P.M. he asw a "fierce flash of lightning" followed immediately by a "fairly loud clap of thunder" and then he heard " a roaring of engines" which was so loud that it sounded as if it were over his house. By retracing the movements he had made while these events were occurring, he determined that the time which elapsed while he saw the flash of lightning, heard the thunder, and the roaring of engines was about 15 seconds.

Miss Virgie Mentzer, who lives almost 1-1/4 miles southeast of the scene of the accident, stated that a torrential rainstorm began near her home about 2:30 P.M. on the afternoon of August 31. She said that a short time after the rain began she saw a "blinding flash of lightning" and immediately thereafter heard a "terrible crash" which "shook the house". George Pendley, a boy who was working for Miss Mentzer on the day of the accident, corroborated her statement with respect to the lightning flash and the crash. In addition, he stated that he was standing with his hands on the zinc top of a table in the kitchen when "the lightning came in the kitchen" and "stung me three times before I could get them off the table".

Mrs. Leila Shoemaker, whose home is located on the east side and right at the base of Short Hill about 1/4 mile west of, and somewhat above, the scene of the accident, stated that a torrential downpour began about 2 o'clock in the afternoon of August 31. She saw some lightning and heard some thunder during the rain storm and she said that about 2:45 p.m. she heard a strange noise, so loud that she put her hands over her ears. The sound was over in less than a minute. She stated that just after she heard this sound the wind was blowing "fairly strong" in an easterly direction from the mountain. She noticed the treetops were bending over.

The record contains statements by several pilots who were flying the Washington-Pittsburgh airway near the scene of the accident within a few minutes of the time it occurred. Two of these pilots were operating Pennsylvania-Central Airlines Trips 8 and 8-1, the former reaching a point about 10 miles south of the scene of the accident at approximately 2:35 p.m., and the latter at approximately 2:50 p.m. Both of these pilots stated that with the exception of about two or three minutes of instrument flying shortly after leaving Pittsburgh they flew by visual reference to the ground approximately as far as Charles Town, West Virginia. As they approached Charles Town they saw a cloud formation which extended several thousand feet above the altitude at which they were flying. They were descending at this point and entered the cloud formation at 6000 feet, Trip 8 breaking out under the overcast at 3000 feet about five miles west of Leesburg, Virginia, and Trip 8-1 breaking out at 3000 feet about three miles southwest of Leesburg. When they broke out Trip 8 was about 10 miles south of the scene of the accident, and Trip 8-1 was about 14 miles southeast. Both stated that they encountered

heavy rain while in the overcast. While Trip 8-1 experienced no turbulence, Trip 8 reported "slight choppiness" just as he broke out of the overcast. There was no precipitation after breaking through the clouds west of Leesburg.

An American Airlines pilot, operating between Cincinnati and Washington, followed the same descending course at about the same altitudes, passing a point about 10 miles south of the scene of the accident at approximately 2:10 p.m. He reported light rain, light turbulence, but no indication of lightning.

An Army airplane on route from Wright Field, Dayton, Ohio, to Bolling Field, Washington, D. C., passed about 12 miles south of the scene of the accident about 2:35 p.m. The pilot reported that after passing the south leg of the Buckstown, Pennsylvania, radio range flying at 5000 feet above sea level on instruments, heavy rain and extraordinarily rough air conditions were encountered. This condition continued until he emerged from the overcast at an altitude of 1500 feet about five miles east of Leesburg, Virginia, and 15 miles southeast of the scene of the accident. He stated that he saw lightning to the north while passing the Lovettsville area.

Flight reports by other pilots which were received in evidence serve to indicate weather conditions in the general area south and southwest of Lovettsville on the afternoon of August 31. A pilot flying a Luscombe airplane departed Washington-Hoover Airport at about 12:09 p.m. on August 31, en route to Los Angeles, California, with Pittsburgh as his first intended intermediate stop. This airplane was all metal, single-engined, and of natural aluminum color with a red stripe along the fuselage and around the nose. The flight was to be made solely by visual reference to the ground

and not by instrument navigation. He stated that he encountered an overcast condition with about a 1500-foot ceiling in the vicinity of Lovettsville, Virginia, and could see a well-defined front of a thunderstorm in the mountains to the west. He was unable to see the northern limits of the thunderstorm area but he estimated that it extended about 50 miles to the south of him. He attempted to skirt the storm area by going north but finally was forced to land near Middletown, Maryland, at about 12:54 p.m. due to low ceiling and poor visibility. He took off again at 1:22 p.m. and returned to Washington, arriving at about 2:05 p.m. This pilot again departed Washington-Hoover Airport at 3:21 p.m. (EST). He stated that he encountered a severe storm in the vicinity of Leesburg, Virginia, and flew under the clouds to the vicinity of Hillsboro, Virginia, where contact flight became impossible and he was forced to return to Washington, landing the second time at 4:22 p.m. (EST).

Approximately three hours prior to the accident, an Army B-18 bombing plane, when approximately 25 or 30 minutes outside of Washington en route to Pittsburgh, encountered turbulence at 10,000 feet above sea level which the pilot described as exceptional in his experience. Lightning was encountered in close proximity of the plane. At approximately 1:45 p.m., after landing at the Pittsburgh Airport, the pilot reported this experience on the flight from Washington to the clerk on duty at the Air Corps Operations Office at Pittsburgh.

An Army pilot departed Bolling Field at 2:55 p.m., August 31, en route to Wright Field, Dayton, Ohio. The flight proceeded on the Washington-Pittsburgh airway to a point approximately twelve miles northwest of

Washington, at which time the pilot altered his heading and took a direct course to Dayton. At about 3:15 p.m., this flight passed some twenty miles south of the scene of the accident and the pilot stated that he maintained contact with the exception of a short period of instrument flying, during which there was a very heavy downpour of rain, slight turbulence, and no lightning.

III.

ANALYSIS OF FACTS - DISCUSSION OF POSSIBLE CAUSES

In the preceding section of this report we have set out a summary of the evidence disclosed by the investigation. From the facts previously discussed, it appears that the flight of Trip 19 proceeded normally until 2:31 p.m. when it reached the Herndon fan-marker at 4000 feet, climbing. We also know that the crash occurred approximately 25 miles northwest of the Herndon fan-marker about ten minutes later. In searching for the probable cause of this accident, it is necessary to analyze all of the facts in an effort to discover what event or combination of events occurred during that ten-minute interval which resulted in the crash of the airplane.

In seeking to determine the course of events that led to this accident, in the absence of any direct testimony from any actual observer on board the aircraft and in view of the circumstantial evidence of record, we are obliged to look for the extraordinary, and to examine into the possibility and probability of occurrences that are so rare in practical operating experience as to be highly obscure, if not virtually unknown. Nothing within the ordinary range of experience, and no combination of events of which the occurrence could be regarded as at all likely, would have sufficed to produce this

accident. The past record of safety of air transportation within the United States, extending to over 130,000,000 miles of transport flying without serious injury to any person in the 17-month period immediately preceding the present accident and to thirteen years of operation without fatal accident by Pennsylvania Central Airlines and its predecessors, is a sufficient evidence that only the highly exceptional or the hitherto unknown would produce so tragic an effect. Since we are here necessarily dealing with occurrences of extreme rarity and consequent unfamiliarity and in some instances are considering phenomena of nature wherein the knowledge of man still remains extremely limited, it is inevitable that much of what follows must appear highly speculative. However, the inherent difficulties presented by the limited evidence available in the present case must not deter us from a full exploration of every possibility and an attempt to reach a conclusion as to what probably occurred to produce the accident.

Dispatch of the Flight

No reason has been discovered for believing that Trip 19 should not have been dispatched on August 31, 1940. The airplane had received a "60-hour" inspection at Detroit the day before the flight and had received the required "turn-around" inspection in Washington just before taking off and nothing unusual had been reported as a result of either of these inspections. The pilots who had brought the airplane down from Detroit to Washington that morning had not reported anything unusual in its operation. It was adequately serviced with fuel and oil. The load on board at the time of take-off was 174 pounds below the approved gross weight for the airplane and, according to the record,

the load was properly distributed, the center of gravity of the airplane being well within approved limits. At the time of take-off there was a company employee riding in the jump seat in addition to the 21 passengers and crew of three. Under existing regulations this is permissible so long as the approved gross weight of the airplane is not exceeded.

The weather information at the time of take-off did not indicate that unusual weather conditions would be encountered. An overcast condition was reported over a portion of the route but this is not unusual in air carrier operation. The captain and first officer were fully capable, by training and long experience, of flying solely by the use of instruments. Inspection had shown that the navigation instruments on board were in serviceable condition and monitoring reports showed that the radio ranges along the course to be flown were operating normally. The flight was cleared by the Airway Traffic Contr Center in Washington in accordance with applicable regulations. Mild thunderstorms along the course were forecast but such conditions are often encountered in this area during the summer and are not regarded as a reason for cancelling flights. Innumerable trips are made with safety in a perfectly routine manner through thunderstorm areas. Due to the local nature and varied character of thunderstorms, the manner of operating in such areas is left to the judgment of the captain.

Two flights of Pennsylvania Central Airlines were dispatched from Pittsburgh for Washington on the same weather forecast as Trip 19, and although they passed within 10 miles of the scene of the accident within a few minutes of the time it occurred, they encountered no severe weather conditions. In addition, a flight of American Airlines passed 10 miles south of the scene of the accident at 2:10 p.m. and encountered no unusual weather conditions.

Local Weather Conditions

From the evidence it appears that during the forenoon of August 31, 1940, there were broken clouds and scattered showers in the vicinity of Short Hill and Lovettsville. Early in the afternoon this broken cloud condition changed to a solid overcast extending at least 4-1/2 miles east of the scene of the accident. At about 12:30 p.m., heavy storm clouds were seen around Short Hill. It was impossible to reach a definite conclusion as to the length of this storm area in a northerly and southerly direction. The pilot of the Luscombe who attempted to fly through this area to Pittsburgh at about 12:30 p.m. estimated that the storm extended about 50 miles south of Lovettsville and an unknown distance to the north. He attempted to skirt the storm to the north and proceeded in that direction to a point 5 miles northwest of Myersville, Maryland, about 20 miles north of Lovettsville, without reaching the northern limits of the storm area.

One person from whom a statement was taken after the hearing stated that at about 2:25 p.m. on August 31, 1940, he was at Bluemont, Virginia, which is about 15 miles southwest of Lovettsville, and that the southern limit of the storm area appeared to be just south of Bluemont. He said that the storm was proceeding slowly in a northeasterly direction up the Shenandoah Valley and that he could see it extending far to the north. Upon the basis of the evidence available to us, it appears that at about the time the accident occurred, the southern limit of the storm area was about 15 miles southwest of Lovettsville and that the northern limit was at least that far and probably much farther to the north.

At about 2 p.m. on August 31, 1940, an extraordinarily heavy rain began to fall along Short Hill. This rain gradually spread during the afternoon in

an easterly direction until it covered an area extending approximately 4 miles east and southeast of the scene of the accident. It is estimated that when the airplane arrived in this storm area, the rain had reached a point approximately 1-3/4 miles southeast of the scene of the accident.11/ This estimate was arrived at by a consideration of the testimony of Mr. Vincell and a statement made by Mr. Harry E. Everhart. Mr. Everhart, who lives 1-1/2 miles southeast of the scene of the accident, stated that it was raining heavily at his place at the time he heard the "roaring of engines". Mr. Vincell, who lives 2-1/2 miles southeast of the point of impact, said that it was not raining at his place when he heard the crash, but that the heavy rain reached his home shortly thereafter.

It is impossible to reach any definite conclusion as to the altitude of the ceiling immediately to the east and southeast of the storm area at the t the airplane reached that area. The two Pennsylvania Central Airlines pilots who flew near the scene of the accident within a few moments of the time it occurred stated that they entered an overcast near Charles Town, West Virginia, and descended through it almost to Leesburg before they broke out at 3000 feet. Other pilots flying further south and southeast of the scene of the accident came out of the overcast at altitudes as low as 1500 feet. On the other hand, Mr. McGaha stated that he saw the airplane flying through scud at an altitude which he later compared to that of a similar type airplane which was flying at a known altitude of 6000 feet. The testimony of the airline and other pilots flying farther south and southeast of the scene of the accident as to the

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11/ See Appendix C.

ceiling encountered is not, however, necessarily inconsistent with Mr.McGaha's testimony, since under the weather conditions prevailing on August 31, 1940, widely varying ceiling conditions could be anticipated within relatively small areas.

From the testimony of witnesses and from the physical evidence of clogged brooks, newly-filled reservoirs, and washed-out roads, it appears that the rainstorm was of really exceptional intensity, both at the scene of the accident, immediately west of Lovettsville, and for some distance to the north and south. It appears, in fact, to have been the heaviest rainfall known in the Lovettsville area for a number of years. The storm's electrical characteristics, on the other hand, do not seem to have been at all unusual. Many of the witnesses, however, recalled particularly an extremely violent stroke of lightning and clap of thunder immediately preceding the roar of motors which they associated with the accident; and other lightning flashes were noted in the neighborhood, but were not generally recalled as having been particularly vivid.

All of the witnesses in the vicinity of Lovettsville, except Mrs. Leila Shoemaker, testified that there was little or no wind on the ground during the storm. This testimony is corroborated by the fact that the storm was moving very slowly. Mrs. Shoemaker testified that at the time the accident occurred the wind appeared to be blowing from the west. It is probable, since she lives on the slope of Short Hill, that the air currents observed by her were currents within the storm.

The testimony of the Lovettsville witnesses would indicate that the storm

was very severe and of a type which would produce turbulence in some degree. The testimony of pilots flying in that vicinity during the afternoon, which has previously been referred to, is inconclusive in this respect. One of the Pennsylvania Central Airlines pilots reported slight roughness as he came out of the overcast just west of Leesburg. Neither experienced any turbulence in the vicinity of Lovettsville. An American Airlines pilot who passed in that vicinity about 2:10 p.m. reported only slight turbulence, but an Army pilot who flew through the Lovettsville area about 12 o'clock noon reported severe turbulence along the course, as did another Army pilot who passed about 14 miles south of the scene of the accident at about 2:35 p.m.

The experience of pilots flying in the vicinity cannot be relied upon completely in arriving at a conclusion as to the presence of turbulence. Experience shows that of two airplanes flying at the same altitude at the same time, a very short distance apart, one may encounter very severe turbulence while the other may be operating in comparatively smooth air. Therefore, it is impossible for us to arrive at a definite conclusion that the pilot of Trip 19 was flying through conditions of severe turbulence just prior to the crash. There is, however, a considerable likelihood that he was doing so in view of the general trend of the reports of other pilots, the violence of the storm as observed on the ground, and of the frequency with which turbulent conditions are associated with thunderstorms.

Probable Flight Path Prior to Impact

The pilot reported himself over the Herndon fan marker at 2:31 P.M. at an altitude of 4,000 feet and continuing to climb. The intended cruising altitude, as shown by the flight plan, was 6,000 feet. The time from the take-off at Washington to passage over Herndon was therefore ten minutes. The distance from the airport to the Herndon fan marker is 19 miles. The average speed over the ground, assuming the correctness of the pilot's report, was therefore 114 m.p.h.; the average rate of climb, 400 ft. per minute; figures that are reasonably consistent with one another, assuming a light headwind as forecast, and assuming the engines to have been operated during the climb at the power output customary during that part of a flight. If the same airspeed and rate of climb had been continued past Herndon (making a small allowance for the time lost in the take-off before getting into steady climbing flight, and assuming the increase of airspeed with altitude to be offset by an equal increase in the strength of the headwind) an altitude of 6,000 ft. would have been reached just before 2:36 P.M., and at a distance from Washington of approximately 28 miles. Had the airplane then leveled off at an altitude of 6,000 ft. in accordance with the flight plan, and proceeded at its cruising speed of 180 m.p.h. against a 15-mile wind, it would have arrived over the scene of the accident, 44 miles from the Washington airport, at exactly 2:41 P.M. The reported time and altitude at Herndon, and continued adherence to flight plan thereafter, are therefore entirely consistent with the apparent time of the accident. The time of the accident is, of course, not known with such accuracy as to permit depending on calculations of this sort to fix the flight path or airspeed with a

great degree of refinement, but at least they appear to exclude the possibility that the aircraft had wandered very far from its course, or that it had proceeded to the far side of Short Hill and then turned back, as one witness believed.

As there has been absolutely nothing, aside from the altitude estimates given by some lay witnesses who in turn were contradicted by others presumed to have viewed the same airplane at approximately the same time, to suggest that the pilot was not proceeding in accordance with his flight plan, and as any change of plan in approaching a region where instrument operation was anticipated would normally be the subject of immediate report by radio, we conclude that the flight was proceeding normally, that an altitude of 6,000 feet had been reached, and that no trouble had been experienced up to the time of reaching the Lovettsville area.

Seemingly the pilot elected to fly through the storm area rather than to make any attempt to circle it. The storm extended for a very considerable distance north of the airplane's path and for several miles to the south, and presumably it appeared to the pilot as he examined the horizon that there would be no gain in passenger comfort or otherwise by any detour of practicable extent, and no hazard in flying straight through.

With the airplane presumed to be on course, at an altitude of 6,000 feet, approximately two miles southeast of the scene of the accident at approximately 2:40 P.M., the analysis of the flight path concerns the course that the airplane may have taken from that point to the final contact with the ground less than one minute thereafter. The most direct evidence on that matter is that of Mr. McGaha and his son, who reported having seen the airplane go into a dive immediately after the lightning

flash, and shortly after the machine had passed over their home, Mr. McGaha, in fact, was so sure of his own observation that he had gone out of the house and walked to a considerable distance to look for the wrecked airplane, which he thought might have struck the ground on his own land. Proceeding from that observation, it must be concluded that the deviation from the normal path started at least 1-3/4 miles short of the point of impact, as it was approximately at that distance that the heavy rainfall began, and rain as heavy as clearly existed at the time and place of the accident would have made it impossible to see anything that the airplane might have done after it had entered the storm. Mr. McGaha pointed out to an investigator for the Board the point at which he had been standing when he saw the airplane and the angle above the ground at which he recalled it as having appeared to him when its dive began.[11a/] Analysis of that point, however, makes it appear impossible to depend on such a recollection of angles as a basis for analysis of the path. It is not surprising that it should be so, for it is of course extremely difficult to recall a line of sight exactly, especially after a considerable lapse of time. Mr. McGaha's recollection was that he had seen the airplane start its dive, immediately after the lightning flash, at a point found to be at an angle of 11 degrees above the horizontal. Since Mr. McGaha's home was at a distance of 2-1/2 miles from the easternmost edge of the rainstorm, the reported angle of his line of sight would have placed the aircraft approximately 2500 feet above the ground at the time of starting the dive. Since Mr. McGaha identified the airplane, by comparison with another machine of similar size subsequently seen at a known altitude,[11b/] as having passed over his house and continued at a height of about 6000 feet above sea level, his estimate of the angle at which he had seen the airplane go into a dive (a much more difficult point to fix in memory) must be considered as having been in error.

11a/ Chapter II, Section on Course and Position of Aircraft immediately prior to the Accident.

11b/ See Chapter II.

A similar difficulty arises in connection with Mr. McGaha's recollection that he had watched the airplane until his view of it was cut off by a knoll near his home. The elevation of that knoll fixed another angle, and for the airplane to have been watched until it had gone down behind the knoll would have brought it to a height above the ground (at a distance of 1-3/4 miles short of the scene of the accident) of only about 1000 feet. Still assuming that Mr. McGaha could only have seen the machine when it was short of the rainstorm (as to the continuous intensity and impenetrability of which, there was general testimony from those who were in it), the airplane would then have had to travel horizontally for a distance of 1-3/4 miles to reach the scene of final crash while losing only 1000 feet of altitude. That would have indicated a mean angle of path to the horizontal of only about 6 degrees, which does not represent a dive but a comparatively gentle descent. The full acceptance of Mr. McGaha's recollection on this point, combined with the facts that appear to have been definitely established with regard to the extent of the rainstorm, would therefore require the airplane to have started its dive at a point between two and three miles short of the final impact; to have continued the dive at least to within 1000 feet of the ground; to have come back nearly to level flight at that point; to have continued for one or two miles along the path descending at an average angle of not over 5 degrees; and then to have nosed over again, to an angle of at least 20 degrees to the horizontal and probably more, and continued on the path thus established to the point of impact.

Less extreme conclusions concerning the flight path are developed if it be considered as a possibility that the airplane may actually have disappeared from Mr. McGaha's view by diving into the rainstorm beyond the hill rather than by going down behind the crest of the nearby hill, and that he and his son were deceived on that point by the haze and the bad visibility

associated with the nearby storm and the general dullness of the day. In that case the airplane might actually have disappeared into the storm at a height considerably greater than 1,000 feet. If it had entered the storm at 4,500 feet above the ground, its path from that point to the point of impact would have been inclined to approximately 26 degrees to the horizontal, or at an angle about equal to that at which the airplane most probably struck the ground. Although the assumption of a steady dive at an angle of 30 degrees or thereabouts is in superficial conflict with Mr. McGaha's impression of the airplane as going down very steeply, the conflict is reduced by taking account of the angle to the horizontal of Mr. McGaha's line of vision on looking at the airplane. With the airplane in a 26-degree dive at a height of 5,000 feet (taking that as the altitude at which the dive might have become well established at a fixed angle), and at a distance of two miles short of the point of final impact, Mr. McGaha would have seen it at an apparent angle of 51 degrees to his line of sight. The apparent length of the airplane, as seen at that angle, would be foreshortened by less than a quarter of the true length, and even an observer quite familiar with the form of aircraft and their appearance during maneuvers might have difficulty in distinguishing the machine seen at such an angle from one diving very near to the vertical.

If the airplane had gone into a vertical dive at a height of 5,500 feet above the ground, while traveling at normal cruising speed, its speed would have increased to approximately 380 m.p.h. at the time of striking the ground. A similar study for a steady 30-degree dive from the same altitude indicates a speed at contact with the ground in that case of about 330 m.p.h. These figures are very approximate, but suggest the general order

of magnitude of the probable speed. Although it would be impossible to determine the speed at contact with any accurary from the condition of the wreckage, the completeness of the destruction at least indicated a speed far above that of ordinary flight. The damage, which technicians who have had past occasion to examine a great many wrecked airplanes that have made contact with the ground in all sorts of attitudes and at all sorts of speeds found almost unprecedented in their experience, would be difficult to reconcile with a speed of less than 300 m.p.h.

If the airplane had gone into a vertical dive at 5,500 feet, and had then continued the vertical path very nearly to the ground, with the machine in process of recovering from the dive when it hit, the time from the first deviation from the normal flight path to the impact would have been about 15 seconds. If the descent had been along a steady 30-degree inclination, the corresponding time would have been approximately 30 seconds.

The best estimates of the time interval that elapsed between the time of the lightning flash and the final crash of the airplane, obtained by reconstructing the movements of persons who saw the lightning and heard the crash and engaged in some definite activity in the interval, put it at about 15 to 20 seconds. Though that figure cannot be regarded as a very reliable one, if it be accepted as valid, it would require either that the airplane's first deviation from its path preceded the lightning flash with which the crash was so generally connected, or that the dive was very nearly a vertical one through the greater part of its length, and must in that event have started after the airplane was well into the area of the heavy rainstorm.

One difficulty with the assumption of a straight descent at a constant

angle is that it fails to provide the negative acceleration of the airplane which would be a possible explanation of the apparent over-speeding of the propellers.[12] A negative acceleration suggests inverted flight, and consideration has been given to the possibility that the flight path might have had the form of an S, the airplane having been on its back at a midpoint of the descent, and a recovery from that attitude having then been started but not completed before striking the ground. Such a path would be possible in the event of a temporary disabling of the pilots or a temporary interference with the control, a difficulty lasting only a few seconds and followed by resumption of control of the airplane. It would account for the negative acceleration, and consequent over-revving of the propellers. It would account also for the fact that several of the witnesses living near the scene of the accident spoke of the roaring noise that immediately preceded the crash as having seemed to come from the west, over towards the mountain,--for if the airplane had actually taken the S-shaped path downward, its first deviation from its normal attitude would have occurred when it was approximately over the point of final contact with the ground, and therefore well into the rainstorm area.

Another alternative is that the airplane might have spun from a considerable altitude, or descended on an irregular path after the wing had stalled. The reasons for discarding those hypotheses are explained elsewhere.[13] In addition to the reasons given there it would appear that there could not have been any large amount of side-slipping or turning on the way

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12/ This point is discussed in detail in the section of the present chapter dealing with Mechanical Failure.

13/ Section on Turbulence.

down, unless the turns had been extended into complete circles, since the airplane struck the ground substantially on a direct prolongation of the line of flight that it appears to have been following immediately before entering the storm.

In considering the implications of this and other possible flight paths, it must be remembered that the longitudinal stability of the airplane would give it a pronounced tendency to recover from a dive, even without the intervention of the pilots. Tests and calculations on a similar airplane have shown that with the center of gravity in the position that it had at the start of this flight, and with the tab control set for the airplane to trim at cruising speed, it would require a steady push of at least 40 pounds on the control column to keep the nose from rising when a speed of 300 m.p.h. had been reached. In this connection there is a possibility which is extremely remote, but may nevertheless be mentioned, in view of the difficulty of finding any combination of circumstances that seems at all probable as an explanation of the maintenance over a period of 15 seconds or more of a flight path of which the abnormality would be expected to have advertised itself to the pilots. If an airplane nosed over very abruptly and very steeply at a time when the occupants did not have their belts fastened, a number of them might have fallen or slid from their seats to the forward part of the cabin. The resultant shift of the center of gravity would make the machine trim at a considerably higher speed than that for which the tab controls were originally set, and so hold it in a dive (though probably a comparatively shallow one) if the pilots, having themselves been disabled by whatever cause produced the sudden change of course,

were exerting no force on the controls.

Aside from the complete disabling of the pilots or a shift of load in the airplane, two hypothetical explanations of the prolonged maintenance of a steady dive have been considered. If the pilots were blinded by a lightning flash their immediate concern would have been to avoid stalling of the airplane while their disability continued. In seeking to be perfectly safe on that point they might have over-corrected by pushing the machine into a dive, and with both pilots pushing on the control column together the force required might have been overlooked under conditions of such stress and the dive continued until the ground was reached. The other possibility considered is that the clogging of the airspeed indicator head with rain made the indicator read too low by a gradually increasing amount. The indicator would then have indicated a gradual approach to a stall which the pilot might have tried to off-set by thrusting the control column gradually forward to pick up more and more speed. This explanation does not seem at all likely to be a correct one since other instruments immediately in front of the pilot, notably the altimeter and the artificial horizon, would be supplying an obvious contradiction of the airspeed indicator's reading. Every experienced pilot would recognize the possible fallibility of airspeed indications in heavy rain or freezing weather and would check against his other instruments under such conditions.

Mechanical Failure

Investigation of the possibility that a mechanical failure might have been the cause of the accident was made extremely difficult by the condition of the airplane when it was found after the accident. It was in thousands of pieces.

The condition of the engines indicates that they were operating at very high speed at the time of impact but the amount of power being developed is unknown. The switches and the fuel valves were found in the "on" position (the throttles were in the full open position but it cannot be determined in what position they were at the time of the impact). The bends in the propeller blades were identified by experts as power bends and witnesses near the scene of the accident testified that they heard a loud roar of engines immediately prior to the sound of the crash.

An inspection of the engines revealed no indications of a mechanical failure prior to impact. The condition of the master rod bearings and crank pins of both engines showed that the oil film had broken down and the parts showed signs of overheating as did some of the knuckle pins. However, in view of the completely separate lubrication systems and the identical character of the damage to both engines, it appears that the damage was caused not by mechanical failure of the engines but by some factor inherent in the attitude or motion of the airplane after the initial difficulty and previous to the crash.

The evidence indicates that the condition of the master rod bearings, the crank pins, and knuckle pins could result only from a momentary interruption of the oil supply to the bearings or from an overloading of the bearings, either of which might have been caused by over-revving of the engines. 14/

14/ Over-revving is a condition which occurs when the engine speed exceeds the revolutions at which its governor is set. The maximum speed at which the governor is permitted to be set is the rotative speed which the engines are permitted to attain at takeoff, in this case 2350 rpm.

The nature of the damage incurred by the master rod bearings, crankpins, and other parts of the engines indicates that over-revving in excess of 3000 rpm took place on each engine. This is borne out by the testimony of an expert witness during the hearing that the slight indication of heating on the master rod bearings, knuckle pin bushings, piston pin bushings and knuckle pins was caused by overspeeding of the engine rather than by lack of lubrication. This testimony was later corroborated by an independent examination of the parts of one engine by an expert agency.

The expert who testified that over-revving in excess of 3000 rpm took place based his opinion on experience with similar engines which had been over-revved on a test stand. He found that marks made on various rotating parts of the engine, especially the crankpin, varied both in magnitude and direction in proportion to the amount of overspeeding. Data obtained from overspeed tests on master rod bearings of this type of engine indicates that the oil film will remain intact for bearing loads imposed by an engine speed of at least 3000 rpm.

From test experience with other bearings which were damaged in a manner very similar to the damage incurred by these bearings it is estimated that the duration of the over-revving was from five to eight seconds and furthermore it appears that rotation of the engines was stopped very shortly after the over-revving occurred because certain marks on the crankpins which were caused by overspeeding would have been erased if the engines had again been operated at normal speed.

Witnesses near the scene of the accident also presented testimony which indicated over-revving. Several witnesses heard a loud roar of engines for varying periods of time. Mr. Garland Jacobs, who was 300 yards west of the scene of the accident, thought that the roar lasted for about 30 seconds. By retracing Mrs. Thompson's movements the estimated duration of the noise she heard was 19 seconds at 400 yards west of the scene of the

accident. Other witnesses made varying statements as to their estimate between the time of the lightning strike and the roar of the engines. Mrs. Jacobs estimated 10 seconds. The noise during descent sounded to her like a "siren" or "scream". Mr. Harry E. Everhart, who lives 1-3/4 miles southeast of the scene of the accident, estimated 15 seconds. Mrs. Everhart, who lives 2-3/4 miles east of the scene and who heard an "awful roar," reported 7 seconds. Mrs. Hickman, who lives about 2-1/2 miles southeast of the scene of the accident, estimated 16 seconds. Mr. McGaha, 4-1/4 miles southeast, also heard a "roar." Mrs. Ridgeway, 3-3/4 miles southeast, and Mrs. Hickman heard a noise that sounded like an old truck.

Information received from the N.A.C.A. indicates that a large increase in sound emission from a propeller would result only from overspeeding and that the engines must have been temporarily overspeeding to create the high pitch noise which could be referred to as a "shriek" or "siren" effect. This would explain the "siren" or "scream" which Mrs. Jacobs heard and would distinguish the high tip speed of the propeller from the "roar" of the engines. The testimony of the witnesses therefore corroborates the evidence on over-revving since the noise issuing from an airplane would not ordinarily be described as a "scream."

Over-revving might occur if the airplane were to accelerate faster than the propeller pitch could keep pace with it if in addition there had occurred a momentary interruption of the oil by which the pitch changing mechanism operates. This would create a tendency to rotate the propeller blades toward the low pitch position or at least retard them from moving to the high pitch position which they would normally tend to assume while the airplane was accelerating as in a dive.

Not only would the interruption of oil thus tend to invite overspeeding but the interruption itself could be caused by the same maneuver which created the acceleration. If the airplane went into a sudden dive a

momentary interruption of oil could be caused by the negative acceleration which would create a movement of oil away from the oil outlets in the tank, exposing the outlets to air. That such a condition is possible is borne out by the testimony of witnesses during the hearing.

This negative acceleration could be caused by a sudden dive or by having the airplane go over on its back or by a severe down gust. It is not likely that interruption to the oil supply during stable flight conditions could cause over-revving since if the oil interruption had occurred while these conditions obtained, the rate of rotation of the blades to low pitch would be at the slow rate of approximately one degree in eleven seconds.

Under normal conditions the propeller blades would have rotated toward the high pitch stop (about 45 degrees) while the airplane was accelerating and descending at high speed. From the fact that the pitch angle at time of impact appeared to be 24 degrees, which is a cruising angle, it may be inferred that the interruption in oil supply which might have taken place and which would tend to rotate the blades to low pitch, balanced the tendency of the blades to go into high pitch as a result of the high speed of the airplane. Under such conditions the propeller would have the characteristic of a fixed pitch propeller. If the propellers had been windmilling at a pitch setting of 24 degrees and at 3000 RPM, an airplane speed of 320 miles per hour would be indicated. If the propeller had been windmilling at 24 degrees and maximun engine RPM of 2350, it is estimated that the airplane speed would have been about 250 miles per hour.

It appears that the condition of the bearings and crank pins indicates over-revving immediately prior to impact and not mechanical failure within the engines themselves or their oil systems. An investigation was, nevertheless, made of the mechanical adjustment to the oil filter for the right engine which was required just prior to take-off of the airplane from Washington. As we have previously stated, the oil pressure as shown on the gauge for the right engine had fallen below normal and it was necessary to rotate the blades in the cuno oil filter to relieve it of any sediment which might be blocking the oil flow. It is not believed that the condition which required this mechanical adjustment had any bearing upon the accident or upon the condition of the engines prior to or after the crash. The accumulation of sediment on the oil filter discs to such an extent as to reduce oil pressure is not uncommon and the blades installed between each pair of discs are designed to remove this sediment. After the blades had been turned, the copilot stated that the oil pressure had returned to normal. Moreover, this adjustment was required only with respect to the right engine. Since each engine has an independent oil system, the low pressure on the right engine could not have had any effect upon the left engine. It is not unusual for sludge or sediment to appear in airplane engines making it necessary that filters be installed in the lubricating system to prevent sludge from being directed through the smaller passages throughout the engine which might cause lubrication failure with resultant serious damage or failure to the engine. The oil companies have made an extensive research in cooperation with the manufacturers of engines used in air carrier service, as well as the air carrier operations departments, resulting in only a high grade of oil being approved by engine manufacturers for use in their respective engines. The type and grade of oil used by Pennsylvania-Central Airlines is the same as that used in other of the larger air carrier services. The sludge or sediment

content which might be collected in an airplane engine would depend largely upon the usage of the engine, particularly the amount of power applied over extended periods. In other words, if the engine is operated at a high rate of horse power over an extended period of time, more sludge or sediment can be expected than if the engine is operated under lesser horse power conditions. If the cuno type filter which was installed in aircraft NC 21789 was free of sediment to an extent which would permit a normal oil pressure of 60 lbs. at the time of departure, it is not likely that sediment could collect in an amount that would be alarming prior to reaching the next scheduled stop. However, should the filter clog up with sludge or sediment so as to reduce the oil pressure below 40 lbs., the oil would be by-passed around the filter so that adequate lubrication would be provided to the engines and no stoppage of oil would result to the lubricating system. Thus, while the filter is not absolutely necessary to the operation of the engine, it contributes to its economical operation.

It is quite likely that if a material loss in oil pressure was indicated shortly after taking off, Captain Scroggins would have returned to the Washington-Hoover Airport. When this fact is considered with the evidence to the effect that the condition of both right and left engines after the accident was almost identical, the conclusion seems clear that the condition of the oil filter prior to departure from Washington could not have had any bearing upon the cause of the accident.

No reason has been found to suspect an engine failure while in flight. Not only does the direct physical evidence give no suggestion of such a failure, but the circumstances of the accident were such that engine failure, partial or complete, could hardly have initiated it. Had Captain Scroggins

encountered any malfunctioning of the engines or engine failure, he probably would have followed the usual procedure and returned to Washington. Had one engine failed, the flight could have been maintained over an extended period of time operating on the remaining engine, particularly since the engines were equipped with full-feathering propellers. Had both engines failed, there are numerous farms between Washington and the scene of the accident on which an emergency landing could have been effected. Weather conditions in the Washington area were favorable through the afternoon of August 31 and there is no evidence of a weather condition which would have prevented an emergency landing along the route up to within three miles of the scene of the accident at most. Had any mechanical difficulties arisen prior to the time Trip 19 got into serious difficulties, Captain Scroggins would undoubtedly have informed Pennsylvania-Central Airlines in Washington to that effect by radio. If he had experienced mechanical trouble on entering the storm, he would have turned back out of it.

The remains of the control system were examined to determine whether a mechanical jamming of the controls might have caused the accident. While all of thecontrol surfaces were located, it was impossible to discover, due to the condition of the wreckage, whether or not a mechanical jamming had occurred. However, no reason appears for concluding it had occurred.

Structural Failure

Consideration was also given to a possible structural failure during flight. In this respect the investigation was made difficult by the condition of the wreckage. However, all major component parts of the airplane were found forward of the point of impact. An examination of all pieces of the wreckage recovered revealed no evidence of any failure, displacement,

or distortion of the wings or tail surfaces during flight. All breaks and damage to the structure appeared to have been caused by impact or by the movement of the various parts over the ground following the initial impact. Therefore, it does not seem probable that structural failure during flight contributed to the accident.

Personnel Disability

By reason of the fact that the airplane plunged to the ground with power on, it is possible that for some reason the pilot and copilot were prevented from effectively operating the controls. The evidence shows that both Captain Scroggins and First Officer Moore were in good physical condition and in normal spirits at the time of departure from the Washington-Hoover Airport. There is no record or other indication that either of these pilots was subject to physical disabilities which would incapacitate him without warning. Moreover, it would be necessary to find that both pilots became incapacitated at just about the same time, for if only one pilot should be disabled and fall forward on the control column, the other pilot would not be called upon to exert extraordinary force in order to maintain control of the airplane.

It cannot be definitely said that both the Captain and the First Officer were in their respective seats in the pilot's compartment at the time of the accident. It is the usual practice for air carrier pilots to visit the passenger cabin sometime during the flight, but under ordinary circumstances such visits would not be made until after the airplane had reached its cruising altitude and then only under conditions of favorable weather. Since the accident occurred within about twenty minutes following take-off from Washington-Hoover Airport and the storm condition was being approached just prior to the accident, we find no reason to believe that both the Captain and the First Officer were not in their respective seats at the time of the accident.

It is, of course, possible to conceive of a variety of occurrences by which both pilots would have been disabled at the same time. However, the only possibilities that seem to justify discussion in the light of the present record are the effects of a lightning strike, fire, sabotage, or turbulent air. These four subject matters and their relationship to the flight crew will be discussed hereinafter.

Fire

Consideration was also given to the possibility that fire might have occurred prior to impact and contributed in some way to the accident because there were evidences of fire on many parts of the airplane, pieces of burnt paper were found behind the scene of the accident, and Mrs. Jacobs testified that she saw a blue looking flame in the air. From the evidence, it is clear that immediately following the impact the fuel tanks broke open and gasoline was sprayed over a wide area. Mrs. Jacobs and Mrs. Thompson testified that at the moment of impact there was a violent flash of fire. Mrs. Thompson stated that immediately after the impact, she saw fire rolling across the alfalfa and corn fields forward of the point at which the airplane struck. No witness, other than Mrs. Jacobs and Garland Jacobs, testified that he saw fire in the air. Carrol McGaha and his son, who testified that they saw the airplane go down, noticed neither fire nor smoke.

It is conceivable that an explosion took place upon impact due to the large amount of gasoline which was being aarried and the fact that fire was seen. Such an explosion might have contributed to the disintegration of the fuselage and resulted in a blast of sufficient intensity to carry pieces of the airplane high into the air. The wide dispersion of the gasoline following impact and the intensity of the rain which was falling at that time woul

limit the duration of the fire. The blast would probably create quite a large volume of hot air which, because of the unstable conditions which exist in the neighborhood of storms, would tend to rise at a very rapid rate carrying particles, such as pieces of paper, with it. Fire and explosion at the time of impact could have been caused by gasoline coming in contact with hot parts of the engine, by breaking of electrical connections, and by metal striking rocks on the ground, creating sparks.

Examination of the wreckage disclosed that partially burned and scorched parts of the airplane were spread over a large area. These parts include the upholstery from the passenger compartment, one tire, various metal parts of the airplane's structure, and the fabric attached to the rudder and left elevator. It is necessary to determine whether these indications of fire resulted from the fire which occurred at the time of impact or a fire which had been burning prior to that time.

The evidence indicates that the marks of fire resulted from the fire at the time of impact. In many instances evidence of fire was found on one part of the airplane, while a part to which it had been attached showed no sign of fire. For example, the right tire was partially burned, but the landing gear parts to which it was attached and the wheel wells into which the landing gear wheels are retracted showed no evidence of fire. The right tire was more severely burned than any other part of the airplane. This tire was found in close proximity to the point of impact and probably collected a considerable amount of gasoline in the wheel depression as the gasoline was thrown from the fuel tanks. A short length of the upper forward part of the passenger compartment had broken in two. One of the pieces was found with the sound-proofing partially burned and the edges where the break occurred were smoked. The side upon which the sound-proofing was attached was down.

The other piece to which this one had been attached was found nearby with the sound-proofing side up. This piece showed no evidence of fire in the sound-proofing nor did the edges where the break occurred show any signs of smoke.

No parts of the engines, nacelles, or pilots' compartment showed any evidence of fire. Some parts of the fuel tanks which had apparently been broken at the time of impact showed evidence of fire. While this evidence consisted for the most part of marks of smoke, a large part of one tank had been melted, probably because it had carried a small quantity of gasoline with it following the impact, which burned on the ground. Ten pouches of mail which had been carried in the mail compartment which is formed by heavy wire mesh partitions in the companionway between the pilots' compartment and the passenger cabin were examined and no indications of fire on the pouches or the mail were found. All fire extinguishers on board the airplane were accounted for and none of them had been used.

There is nothing which could be considered as inflammable material either in the passenger or pilot compartment. The upholstery, carpets, seat cushions, etc., which are treated with a fire resistant chemical could be burned only by application of intense heat or after having been soaked with some inflammable fluid. There were three water flares in a closed compartment located about two feet behind the pilots' compartment. A one-gallon can of water to replenish the water supply in the boiler which provides steam heat to the airplane is normally carried in the same compartment about 18 inches below and 15 inches behind the water flares. Part of the flotation gear[15/] is carried between

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15/ The flotation gear carried by Pennsylvania-Central Airlines is to safeguard passengers in the event of a forced landing in crossing over Lake Erie and Lake Michigan. It consists of two rubber rafts which can be instantly inflated by releasing a valve in a carbon dioxide tank that is carried with each raft for that purpose. Life preservers to accommodate all passengers and crew are also carried on the airplane.

the water flares and the can of water. These water flares are composed of metal cans about six inches in length and two inches in diameter, containing a mixture of carbide which forms an inflammable gas when wet, and a substance which will produce a flame to ignite the gas upon contact with water. These cans are sealed and equipped with a pull ring in the top which, when pulled, opens a small hole. If the flare is then placed in water it will immediately ignite. These flares were, of course, inflammable, but under the conditions above described, it seems impossible that they could have ignited while the airplane was in flight in view of the care with which they are sealed and the unlikelihood of water entering the metal container during flight. The fact that the water carried for the boiler was located below the flares and was separated by a part of the flotation gear would preclude the danger of fire from that cause.

Under all of the circumstances, it seems highly unlikely that the airplane was on fire during the flight. It is possible that Mrs. Jacobs' and Garland Jacobs' impression of fire in the air actually resulted from the fire at the time of impact due to the rapidity with which events occurred. Furthermore, the space interval during which they could have seen the airplane was so short as to prevent an accurate observation of the condition of the airplane as it flashed by at a tremendous speed.

The discovery of a number of pieces of burned paper southeast of the scene of the accident appears at first glance to be inconsistent with this conclusion. One piece, a manila envelope, was found 1-1/4 miles southeast of the point of impact. One possible explanation of the presence of this burned envelope and other papers was that the airplane was on fire prior to impact and the papers blew or were thrown out. However, in view of the evidence which tends to show that there was no fire during flight, the most plausible explanation of the presence of the burned paper is that at the time of impact the terrific up-draft

which followed the blast carried the papers high in the air despite the heavy rain and they floated down to the places at which they were found.

It would not be unusual to find up currents moving at substantial speeds in a storm such as the one in process at time of the accident. Such a current further augmented by a blast of hot air from burning gasoline could conceivably carry papers, such as were found, to a considerable height. Even a comparatively mild breeze from the northwest could then have carried them to the points where they were found. It is noteworthy that material such as the flight calculator and manila envelope were carried the furthest and it is believed that this is due to the fact that such materials would be slower to absorb moisture than lighter papers which were found closer to the scene of the accident.

Tests were conducted by the National Advisory Committee for Aeronautics on a wet manila envelope such as that retrieved from the accident. The result, when considered in conjunction with the evidence of the gasoline explosion at the time of impact and the consequent vertical atmospheric currents, leads to the conclusion that the flight of the envelope from the scene of the crash to a point 1-1/4 miles distant is not only possible but highly probable.

This theory is supported not only by the evidence, which indicates that there was no fire in the air, but also by the fact that the scorch marks on the manila envelope and other papers found at various points southeast of the accident are similar in character to those on papers found at the scene of the accident.

Therefore, we conclude from the preponderance of the evidence disclosed by the investigation, that the only fire that occurred took place following the impact.

Turbulence

The Board has given consideration to the possibility that the accident may have resulted from turbulence so violent as to throw the airplane out of control.

Flying through turbulent air is not, of course, an unfamiliar experience for any transport pilot. It customarily involves nothing more than abrupt accelerations of the airplane, with resulting discomfort for the passengers, and an increased need for alertness on the pilot's part to keep the airplane on its course and to restore it to a normal attitude after any particularly violent disturbance. Instances are known, however, of airplanes having encountered turbulence of such extraordinary intensity as to momentarily throw them completely out of the pilot's control and into wholly abnormal attitudes. Cases have been reported of airplanes having encountered gusts so violent as to stall[16/] the wing completely, from a flight speed considerably above the normal stalling speed. Stalling due to turbulence, without there having been any ice on the wings to increase the susceptibility to such stalling, is extremely rare, but cannot be absolutely eliminated as a possibility.

When an airplane of the type involved in the Lovettsville accident is deliberately stalled with power on, the stall customarily develops first on one wing-tip and that wing drops sharply, the airplane simultaneously turning toward the low wing. Where the maneuver is deliberately executed by a pilot who is prepared to initiate immediately the required measures of recovery, evidence received in the present investigation indicates that only

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16/ Stall. A wing is said to be stalled when the angle at which it is moving through the air becomes so large (usually as a result of attempts to reduce the speed too far, or climb too steeply) that the air no longer flows smoothly along the upper surfaces of the wing, but eddies irregularly, resulting in sudden changes of lift and great instability.

from 400 to 600 feet of altitude is normally lost in restoring normal flight, the intentional stall, being initiated with the airplane's nose pointed up at a steep angle, does not strictly simulate the conditions of an inadvertent stall due to gusts encountered while in level or nearly level flight. It is impossible to produce that condition for test purposes. Any uncertainty arising on that score is added to uncertainty concerning the effect of intense turbulence during a recovery from a stall, and to uncertainty concerning the effect of bad visibility in making it difficult to estimate the amount of altitude that might have been lost during recovery if the airplane had stalled under the conditions existing at the time and place of the Lovettsville crash. It would seem most unlikely, in view of testimony that the training of Captain Scroggins and all other Pennsylvania Central Airline pilots flying the DC-3 had included many stalls and recoveries therefrom, including some under simulated instrument conditions with no dependence on outside visibility, that the airplane would have lost anything even approaching 5000 feet of altitude in the course of recovery from a stall uncomplicated by other factors than those of mere atmospheric turbulence and inability to see the ground.

It is conceivable that a stall might start a spin, although inadvertent spins with aircraft of this class have probably been even rarer than stalls due to turbulence while flying at normal speed. In view of the limited experience, it is impossible to speak with any certainty of how the aircraft would behave in a spin, although it is again true that recovery from a fully developed spin would normally be expected in much less altitude than is believed to have been available in this case between the height at which the airplane was cruising and the point at which it struck the ground. It is

possible, however, in view of the extreme unfamiliarity of the experience of spinning in a transport airplane and of the special difficulties presented by instrument conditions and rough air, that even a highly expert pilot might lose as much as 5,000 feet before being able to complete the maneuvers for checking the spin and recovering from the subsequent dive; but the need for speculation on that possibility is reduced by the mute denial of any likelihood of the airplane having spun that was provided by the position of the wreckage and by the reading (as previously referred to) of the directional gyro. At the time of impact the airplane was on its normal heading of 310 degrees magnetic, and it would have been most extraordinary if the pilot should have struck the ground during an unintentional spin, or in process of recovery from it, on the same compass heading at which the spin had begun. Tests of the directional gyro by its maker also indicate that if the airplane were spinning with its nose down as much as 40 degrees (as it probably would be in a fully-developed spin) the gyro element would have tumbled in the case and the instrument would have ceased to give any semblance of a true indication of heading. The uniform distribution of the wreckage ahead of the point of impact indicated that no rotation around the longitudinal or vertical axis of the airplane was occurring at the time of impact, which would in itself eliminate the possibility that the airplane was actually in a spin when it struck, although it would still leave the chance that the airplane might have been in a spin, which the pilot had checked, and that it had struck the ground before it had been possible for him to complete the flattening out of the flight path from the subsequent dive before striking the ground.

The direction in which the airplane was headed at the time of impact

even argues against the possibility of a stall having taken place after the airplane had for some reason descended to a low altitude, since the dropping of a wing in the stall is attended by a considerable turning of the airplane and recovery from the stall is not normally on the same heading on which the maneuver was started. The same reasoning applies, with even more force, to any theory that the airplane might have stalled in conditions of such violent and continuous air turbulence that the pilots were never able to regain control during the 20 seconds or more that would have ensued before the machine would have struck the ground. The presumption of turbulence of that order, and continued over so long a period, seems in any event a virtually incredible one in the light of all that is known of atmospheric structure. It would, in any event, have been impossible for violent turbulence to extend to a very low altitude without having shown itself as a surface wind.

A possibility that may be considered in connection with the discussion of turbulence, though it is not strictly in that category, is the action of a simple down-draft or descending current of air. Thunderstorms are characterized by violent vertical motions of the air, and especially by rising currents, often of very high velocity. Such rising currents have been known to attain a velocity of several thousand feet a minute. In undisturbed air, at 6000 feet, the maximum rate of climb of a fully loaded aircraft of the type involved in this accident is approximately 800 feet per minute at take-off power. Even with one engine dead, the maximum rate of climb would be over 100 feet per minute. If the airplane had flown out of a rising current in front of the storm and directly into rapidly descending air, approximately as it entered the rain, it is conceivable that it might have been impossible,

of altitude. Aside from the improbability in the light of existing meteorological knowledge of so strong a descending current, and aside from the fact that vertical currents lose their violence near the ground so that the pilot would have in any case been able to check a descent induced in that fashion before the ground had been reached, the time element seems to eliminate a steady vertical current as a possible primary cause of the accident. The earliest point at which the pilot could by any possibility have entered a strong descending current to the point of contact with the ground was only about two miles. It could not possibly have taken over one minute to cover that distance, and to have descended from cruising altitude to ground level within that time would have required a mean rate of descent of over 5000 feet per minute, and a descending current of even more velocity than that. It seems impossible to credit the existence of any such condition.

The Board has also given consideration to the possibility that in the event of severe turbulence, the occupant of the jump seat in the pilots' compartment might have inadvertently disturbed the pilot's control of the airplane. The jump seat installation in NC 21789 consisted of a 12 x 18 inch flat board about 1/2 inch thick. It is supported by two steel pins about 1/2 inch in diameter on one side, one of which is spring loaded to hold it in place. These pins are placed in holes in the secondary structure provided for that purpose. The other side is supported, when in a down position, by resting on a channel which supports a part of the mail pit. There were no back or side arms attached. The seat was designed so that it might be raised upward from one side to permit pilots to pass to or from the cockpit.

The seat, when in place, is located in the companionway directly behind the archway leading to the pilots' cockpit. It was approximately 15 inches from the forward edge of the jump seat to the back of the pilot's seat. The jump seat safety belt is of a material similar to that used in the safety belts in the passenger cabin. It was fastened on each end to the airplane structure, on the righthand side by a standard end type eye bolt and on the lefthand side by a special fitting designed by the manufacturer of the aircraft.

The landing gear, flap and engine selector valve controls are located forward of the jump seat on the righthand side. The wobble pump control is located forward of and on the lefthand side of the jump seat and all are easily accessible as a support to one sitting in the jump seat if he finds it necessary to hold on to something. Since the occupant of the jump seat was not a pilot and had not ridden frequently in airplanes, consideration was given to the possibility that he might have grasped the flap control in order to steady himself if the airplane had been passing through turbulent air conditions and the possible effect such action could have had upon the flaps or the controllability of the airplane. The possibility of such action having contributed to the accident is eliminated because of the fact that the flap control mechanism is so designed that the flaps could not be actuated at a speed in excess of 112 miles per hour. If the flaps had been lowered at a speed of 112 miles per hour or less, the airplane would have assumed a settling attitude in a horizontal position and would have had no tendency to assume a diving attitude. There are also a number of other fixtures such as the channels of the archway and the back of the pilots' seats which an occupant of the jump seat could grasp.

A question was also raised as to whether the occupant of the jump seat had his safety belt fastened. If he had not, there is a possibility that he might have been thrown forward so as to interfere in some way with the handling of the airplane controls. The jump seat was found in a badly damaged condition. A part of each side of the safety belt was found and the webbing of both had been broken or cut. Close examination of these parts does not indicate whether either was broken under heavy strain such as might be expected at the time of impact had the belt been fastened and therefore it is impossible to determine whether the belt was fastened at the time of impact.

It is unlikely that the person sitting in the jump seat would have been thrown forward because of up or down drafts such as might be expected in turbulent air conditions. The usual tendency is for one to be thrown straight upwards when the airplane strikes a severe downward gust of air. However, if the seat belt had not been fastened, the occupant of the jump seat might be thrown forward involuntarily into the pilots' compartment if the airplane were suddenly nosed down steeply so as to cause a pitching movement. Therefore, if the airplane suddenly went into a steep dive, the observer might have been thrown forward into the pilots' compartment and might have thereby interfered with any attempts the pilots could make to regain control.

Effect of Heavy Rainfall on Performance

The witnesses testified that the rainfall, which was occurring at the time and place of the accident, was the heaviest experienced in a great many years. These statements were substantiated by the fact that small streams in that area were filled to overflowing, bridges were washed out, and highways were flooded. In view of this evidence the Board sought and received a report from the National Advisory Committee for Aeronautics as to the effect of heavy rainfall on airplane performance.

Calculations were based on an estimated rain density of 50 grams per cubic meter. This rain density is equivalent to a rainfall of 1.4 inches per minute if the falling velocity is taken as 12 meters per second. According to a recent report prepared by the United States Weather Bureau this is maximum rain density likely to be experienced anywhere in the eastern part of the United States and represents extreme conditions of actual rainfall in a cloud burst.

According to the National Advisory Committee for Aeronautics report, the increase in weight due to the accumulation of rain, as well as the impact of rain, assuming a mean rain drop velocity of 20 feet per second, is negligible.

Using a rainfall of the same intensity, calculations were also made to determine the effect of the drag which might result from rain impinging on the frontal area of the airplane. The results show that this effect, while not negligible, is not likely to force an airplane down. The drag effect varies with the size of the rain drops, but, assuming that the rain consisted entirely of large drops, the power absorbed by the rain, while substantial, would be less than the power reserve available. Even if the reserve power were not drawn upon, the path angle and rate of descent

would have to be maintained for several minutes and over a distance of several miles to force an airplane down from 5500 feet above the ground.

The roughening effect of rain due to fixed or splashing rain drops on the airfoil is unknown, but the percentage increase in drag from that cause is believed to be small in airplanes such as the DC-3 with overlapped skin construction, exposed rivet heads, and other departures from an absolutely smooth wing surface.

While the conclusions of the National Advisory Committee for Aeronautics indicate that heavy rainfall will not disturb the performance or behavior of an airplane such as a DC-3 to any marked degree, the Committee believes that heavy rainfall would have a substantial effect on the performance of the airspeed indicator. Beyond a certain critical combination of airspeed and rain density, the airspeed head will flood and the water will accumulate in the pressure line. If such be the case the airspeed would no longer serve as a guide to the true flight condition.

However, in the case of NC 21789, a hand pressure pump was incorporated in the airspeed indicator system so that any accumulation of water could be manually discharged. It was impossible to determine whether this pump had been used, but had the airspeed indicator been affected due to water in the pressure line, it should not have caused serious complications for one of Captain Scroggins' experience because he had undoubtedly encountered a similar condition resulting from the pitot head freezing under icing conditions. Moreover, any inaccuracy of the airspeed indicator would be revealed by the attitude of the airplane, as shown by the artifical horizon, the altimeter, the power output of the engines, and the feel of the controls.

Based upon all the available evidence, it appears that the effect of the rainfall could not alone have caused the accident.

Sabotage

Examination of the wreckage did not reveal any evidence of the aircraft or its controls having been tampered with prior to the accident. An alarm clock was found in the wreckage in a damaged condition. This clock was turned over to the Federal Bureau of Investigation for inspection to determine whether it could have been associated with a detonating mechanism. The inspection of this clock revealed that the alarm had been set for 9:15. There was no connection on the clock which could have been used for wiring connections necessary to have used it as a detonating mechanism.

Since the door between the pilots' compartment and the cabin was not locked, there is a possibility that a passenger might have entered the pilots' compartment and interfered in some way with the control of the airplane. However, there is no evidence whatsoever in support of such a presumption and the jump seat upon which the observer was seated in the aisle running between the pilots' compartment and the passenger cabin would have made it especially difficult for a passenger to enter the pilots' compartment.

Robert Williams, an airplane cleaner for Pennsylvania-Central Airlines, employed at Washington-Hoover Airport testified that he saw a man enter the passenger cabin of the airplane two or three minutes before the other passengers and that he did not see this man leave the airplane before the passengers boarded. He could not

state positively that the Stewardess or the rest of the crew were on board at the time this man entered. Since it was about time for the passengers to board the airplane he assumed that the man whom he had observed go on board was a passenger and he paid no further attention to his movements. No evidence was found which would indicate that this person entered the airplane for the purpose of committing sabotage.

Two employees of the Federal Bureau of Investigation, one a special agent, were on board at the time the airplane crashed. An investigator from the Federal Bureau of Investigation testified that the special agent was making a routine trip and that the special agents of the Federal Bureau of Investigation who came to the scene of the accident did so only for the purpose of identifying the bodies of their colleagues.

No evidence was found during the course of inspection or investigation to justify a conclusion that sabotage caused or contributed to the accident.

Lightning

The testimony of witnesses who were in the Lovettsville area at the time of the accident clearly indicates that a flash of lightning occurred in the vicinity of the aircraft while it still was

proceeding in a normal flight attitude and at a time less than thirty seconds before the plane's impact with the ground.

As previously mentioned, Mr. McGaha and his son both saw lightning in line with the plane's flight and they testified that immediately thereafter they saw the plane dive toward the ground. Mrs. Everhart likewise saw a blinding flash of lightning on the path of the flight which caused her to lose sight of the plane. The young boy, George Pendley, in the house of Miss Virgie Mentzer testified he felt shocks at the moment of the lightning flash and roar of thunder preceding the roaring noise of the plane's motors.

The testimony of a great many witnesses agreed on a sequence of a flash of lightning, or at least the thunder which accompanied it, immediately followed by the roaring sound of the plane's motors apparently ending upon impact with the ground.

Several experts who testified and many data made available to the Board indicate that conditions in the Lovettsville area at the time of the accident were of a nature which could produce very strong discharges of lightning between the cloud which was over Short Hill and the ground. Descriptions of the unusual darkness and other characteristics of the cloud indicate that it could have generated large charges of electricity. Furthermore, it had been raining for some time in the vicinity and the dampness of the earth would have increased its conductivity so that electrical charges from a considerable area of the earth might collect at one point for a strong lightning discharge. Although there is no record of a great number

of lightning flashes over any considerable period of time, there was at least one flash and possibly two flashes a very short time before the crash of the airplane and one of the results was the well-established splintering of the wooden butt of a rifle which was in Mr. Baker's barn some distance from the scene of the accident.

A flash of lightning close to an airplane in flight, and less than thirty seconds later, the crash of the same airplane into the ground, are two events of so much importance taken together that they cannot be dismissed as a mere coincidence and their relationship must be analyzed to the fullest possible extent.

The experts who testified and the data collected reveal the extent of the knowledge thus far accumulated concerning the causes, character, and the various results of lightning discharges, together with their effects on aircraft in flight and their crews. As relating to the accident under investigation, our analysis appropriately may be divided into four general effects of lightning:- thermal, electrical, optical, and mechanical.

The thermal or heat effect of lightning is the one typically found on the many aircraft which have been struck in flight. Generally, lightning enters and leaves airplanes at two different and often widely separated structural extremities, such as the nose, the tips of the wings, the units of the tail assembly, propeller blades, radio antenna masts, pitot tubes, etc. The point where the lightning enters or leaves the plane usually can be discovered by a hole or indentation "as small as a pin prick" or "as large as two silver dollars." Occasionally, the external fabric of an airplane may be burnt at the point of entrance or exit of the lightning. Experience has revealed that the speed of the airplane through the air quickly extinguishes these fires leaving indications of burns in straight lines rather than in curves.

The thermal effect of lightning is recognized in the electrical and radio systems of airplanes through burnt fuses, melted or destroyed wires, and other damage of a like nature, and there may be similar effects upon other parts of the airplane's structure, controls, or equipment.

Past experience has failed to reveal any case where lightning has caused the fuel of an airplane to catch fire while in flight, nor is there any record of any other serious form of fire in flight from this cause.

In this case, although all the parts of the plane were not found, those parts which usually are struck by lightning were examined, together with the remains of the electrical and radio systems. All the technicians and experts who examined the wreckage agreed that there were none of the recognized indications that lightning had struck the airplane before its crash near Lovettsville. There is no reason to believe that any usual form of lightning struc the plane or that there were any thermal effects of lightning upon the plane.

The electrical effect is not known to have caused any injury to persons on all-metal airplanes of structure similar to the one involved in the present accident, which have been struck by lightning while in flight, nor any serious damage to the airplane itself. Mr. L. P. Harrison, United States Weather Bureau,[17/] summarized reports on a great many cases of lightning strikes on aircraft including one instance of a pilot being incapacitated because of electrical shock which was conducted to him through the mechanism of his radio headgear, but that incident involved an airplane of a very different type and it was agreed by all the experts who testified that the protection provided by the all-metal fuselage and wings and the characteristics of the electrical, radio, and other equipment would make any significant electrical shock to

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17/ Mr. Harrison is employed by the United States Weather Bureau as an Assistant Meteorologist and has participated in the work of the Sub-Committee on Lightning Hazards to Aircraft of the N.A.C.A.

persons virtually impossible on the airplane under consideration. While the electrical effect of lightning frequently produces a magnetic field which may temporarily or permanently influence metal parts, compasses, or other instruments, there is no record of serious results therefrom on aircraft in flight.

The electrical effect of lightning has been known to produce a sudden and tremendously increased noise or vibration in the receiving unit of telephones or radios of such intensity as to produce acoustical shock, especially under circumstances where earphones are held closely to both ears. In such an event, characteristic marks are usually left upon the diaphram of the receiving unit. Although the earphones of the plane were not recovered for examination, the testimony of experts indicated that an electrical charge sufficient to produce acoustical shock upon the pilot probably would not reach the earphones due to the design and installation of the radio system in the airplane involved in the accident.

There is no reason to believe that any electrical effect of lightning other than accoustical shock may have been even a contributing cause of the accident.

The optical effect of lightning, or of any sudden and bright light, is well known. Mrs. Everhart testified that the lightning flash which occurred in the vicinity of the airplane while she was watching from a distance of about 1-1/2 miles was so brilliant that she was blinded for a brief time during which she lost sight of the airplane. Experts testified that the nature of lightning illumination was especially injurious to human eyesight and a considerable number of pilots have reported temporary impairment to their eyesight from lightning flashes near their aircraft while in flight for varying lengths of time depending upon such conditions as the brilliance of the flash, whether the pilot was looking directly at the lightning, the

degree of darkness in the cockpit and outside the plane. Some persons have reported that the blinding effect of a lightning flash in their vicinity has lasted for a good many minutes or even hours with a recurring after image and other forms of interference with normal eyesight which have been noticeable for several days after.

It is evident that the cloud toward which the airplane was flying was very dark and that the airplane was quite close to it at the time of the lightning flash. If the pilots had been looking forward through the windshield at the time the flash occurred in front of the plane, the result could have been so severe as to produce virtual blindness throughout the dive of the airplane to the point of impact.

It is obvious that the sudden blinding of a pilot might seriously interfere with his efficient control of an airplane in flight. While the blinding of the pilots in the present case might have been an added and grave complication in attempting to regain control once the dive had started, it is not believed likely that the optical effect of lightning of itself represents a basic cause for the airplane to change its normal flight attitude and dive toward the ground.

The mechanical or pressure wave effect of lightning was described at some length by one of the expert witnesses, Dr. Karl B. McEachron, an electrical engineer of the General Electric Company, who has been in charge of lightning research for the past several years and is generally recognized as an authority of great eminence on the subject.[18/] In one type of lightning stroke, there is a relatively long time, slow discharge of small value current which produces a burning or thermal effect. However, there is a very different

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18/ Dr. McEachron is Director of High Voltage Research Laboratory, General Electric Company; Member of Sub-Committee on Lightning Hazards to Aircraft of the National Advisory Committee for Aeronautics.

type of lightning stroke which lasts an extremely short space of time but involves a very high value of current and results in a mechanical effect. The first type of lightning may set a tree on fire, whereas the latter type may splinter a tree and toss heavy pieces of wood a considerable distance away. Brief, powerful discharges set up pressure waves with characteristically steep fronts which are capable of a damaging effect at a short distance away from the path of the lightning itself. It should be noted that a single lightning discharge may involve not only mechanical but also thermal and electrical effects. Thus a severe lightning stroke involving a high value of electrical current may disintegrate a tree while also setting it on fire.

If the particular discharge of lightning with which we are concerned in this investigation were of a nature to produce a strong pressure wave, the pilots might have suffered from acoustical shock or concussion of a severity depending upon the proximity of the lightning to the cockpit and whether or not the cockpit windows were open. Experience has revealed that such pressure waves have produced severe concussion upon human beings which might result in unconsciousness. The possibility of acoustical shock or concussion as one of the basic elements in this case cannot be dismissed.

Pilots quite frequently have reported that when a flash of lightning has passed near their planes they have felt a slight "bump." This would be a result of the pressure wave, but all available data indicate that there never have been any serious effects upon the stability and flight path of an airplane from this cause. We do not believe that lightning itself produced such severe turbulence as to have caused or contributed to this accident.

The mechanical effect of lightning has been known to smash in the windows of buildings even though the discharge itself may have passed some little distance away. Although the cockpit windows were designed, installed, and

approved to withstand any reasonable impact or pressure load, it appears entirely possible that a lightning flash near the nose of the plane might result in their being smashed in. The plane must have entered a torrential downpour of rain at the time of, or immediately following, the flash of lightning in its vicinity, and if the cockpit windows had been smashed in, the pilots might have been subjected not only to the violent impact of flying pieces of glass but also to a withering stream of water striking them with all the force of the airplane's speed through the air of 150 miles an hour and upwards. The smashing of the cockpit windows as a result of an unusually powerful lightning discharge near the nose of the plane with a consequent serious interference with the pilot's control of the airplane remains a possibility.

No airplane has been reported to have suffered structural damage resulting from the mechanical effect of lightning while in flight. Furthermore, Dr. McEachron testified that the available data indicate that the destructive force of lightning decreases in proportion to the altitude above the ground and, as already mentioned, it appears that the airplane in the present case was flying at an altitude of 6,000 feet at the time of the lightning flash. However, as Dr. McEachron said during his testimony, "We are looking here for the unusual thing, not the ordinary thing," and the rare chance of serious damage to the airplane or its controls caused by lightning should not be overlooked. If the mechanical effect of lightning may have been a factor causing the accident, the smashing impact with some part of the plane's structure typically would have left none of the usual indications of a lightning strike of a thermal nature. A violent pressure wave conceivably could damage the tail of an airplane to such an extent as to cause the loss of all normal

flight control, but the testimony of eye witnesses as to the relative position of the airplane and the flash of lightning would lead to a conclusion that the lightning discharge occurred in front of the plane rather than to one side or in back.

According to Dr. McEachron's testimony, the greatest damage by lightning occurs at or near the earth terminal of a brief, high current value discharge. It is natural to consider the destructive force of such a discharge at or near its cloud terminal. There is some reason to believe that the airplane in this case must have been just about to enter the cloud and its rainstorm at the exact moment of the flash of lightning. It is useless to speculate as to whether or not this airplane may have been in the cloud terminal of the lightning discharge or what may have been the effect of its being there since Dr. McEachron pointed out the limited knowledge on the subject and the obvious difficulty of research.

Upon the evidence of record, we cannot conclude that the airplane was struck by the usual type of lightning which produces a thermal effect; that the airplane or its crew were injured by any electrical effects of lightning other than acoustical shock; or that lightning itself produced any turbulence which changed the flight attitude of the plane. We, therefore, conclude that none of these phenomena of lightning were related to any cause of the accident.

We do think it possible that lightning may have temporarily blinded the pilots or that the pressure wave resulting from the lightning may have subjected the pilots to acoustical shock or concussion; may have smashed the cockpit windows, or may have caused other damage to the structure and controls of the airplane through mechanical effect.

Recommendations

(1) The possible effects of lightning upon aircraft should be the subject of continued research. The difficulties of direct research upon a natural phenomenon occurring unpredictably as to time and location, and only at considerable intervals in any particular area, are obvious. Nevertheless, much has been accomplished in the last twenty years in a number of laboratories. The National Advisory Committee for Aeronautics has for some time had a special subcommittee on Lightning Hazards to Aircraft, on which interested Government departments and airlines and industrial laboratories having given special attention to lightning are represented, and some specialized researches have already been conducted. We recommend that further attention be given to such research, and that there be included among other matters the study of the optical quality of lightning flashes, the nature of their blinding effect, and the extent to which protection can be given against blinding by the use of windshield materials of various light-transmission characteristics; the possibility of acoustic shock through radio earphones, and the extent to which the liability of such shock would vary with the particular characteristics of the earphones used and of other parts of the radio installation; and the possible mechanical effects of lightning on aircraft in flights.

(2) A continuation and accentuation of research on atmospheric turbulence. Here again, as in the case of lightning, direct research is difficult, but a substantial amount has already been accomplished. We believe it important that the existing store of knowledge of the nature of atmospheric turbulence, of its structure when its severity is at a maximum, and of its effect on the flight performance and the control of the aircraft should be extended as

rapidly as possible. It is of particular importance that further knowledge should be sought on the probabilities of association of extreme turbulence with predictable meteorological conditions, so that the likelihood of such turbulence can itself be predicted. The development of a generally acceptable scale of measurement of the severity of turbulence, and of a standard nomenclature for the various types of turbulence, would also be valuable as a possible product of further study. It is hoped that research in this field may receive a high priority with the Weather Bureau, the National Advisory Committee for Aeronautics, and such other governmental and private agencies as may have special interest in the problem or special qualifications to deal with it.

(3) Methods should be developed for collecting and correlating the experiences that airplane pilots may have with exceptional turbulence, or other unusual atmospheric conditions. It happens from time to time that a pilot, military, airline, or private, observes some exceptional atmospheric condition, or some exceptional effect upon the flight of the aircraft. The ability of pilots to benefit from one another's experiences in such matters is quite largely limited to the results of informal report. It would be of great value in connection with continued research on atmospheric structure and its effect on aircraft if records of all such exceptional experiences could be brought into the hands of a single agency, for comparison and the development of such generalized conclusions as the collected mass of data may allow. The National Advisory Committee for Aeronautics has already made progress along this line, with specific reference to the magnitude of the accelerations of aircraft in turbulent air and to the conditions noted by pilots

at the time of lightning strikes, but it would appear that a much more extended program of collection and correlation of data would be possible. It is recommended that this matter receive the consideration of all organizations operating substantial fleets of aircraft, and of the National Advisory Committee for Aeronautics, which already has in existence a sub-committee on meteorological problems on which the Administrator of Civil Aeronautics, the Weather Bureau, and the Army and Navy as the major aircraft-operating departments of the Government are all represented.

(4) Where pilots encounter conditions not shown in the latest weather report for the area or in any forecast, including those cases in which they encounter turbulence of what appears to them very exceptional intensity, their observations should be transmitted to the nearest available Weather Bureau office at the earliest possible moment. Not only would a better-established practice in this particular be of assistance in correcting and amplifying current reports for the benefit of other pilots and for the improvement of forecasts currently being made, but information received on current turbulence conditions should be of assistance in research on the forecasting of turbulence by making it possible to establish immediate correlations between turbulence data and other weather information which can be currently secured for the regions of reported exceptional turbulence.

THE CIVIL AERONAUTICS BOARD:

Harllee Branch, Chairman

Oswald Ryan, Member

Edward P. Warner, Vice-Chairman

G. Grant Mason, Jr., Member

George P. Baker, Member

APPENDIX A

The following passengers were on board the airplane at the time of the accident:

Miss Dorothy Boer, 106 Maple Avenue, Abingdon, Illinois

Mr. E. G. Bowler, 245 Ashland Avenue, Mt. Lebanon, Pittsburgh, Pa.

Mr. W. M. Burleson, 57 Look Lane Road, Richmond, Virginia

Mr. W. B. Chambers, 17 Craighoad Road, Pittsburgh, Pa.

Miss Mildred Chesser, Mineral, Ohio

Dr. Charles D. C. Cole 5305 41st Street, N. W., Washington, D. C.

Miss Naomi Colpo, 3621 Newark Street, N.W., Washington, D. C.

Mr. A. H. Elliott, 3757 McKinley Street, N.W., Washington, D. C.

Mr. William Garbose, U.S. Department of Justice, Washington, D. C.

Miss Evelyn Goldsmith, 5847 Douglas Street, Pittsburgh, Pa.

Mrs. Rose Z. Hale, Pennsylvania Apartments, 4403 Center Ave., Pittsburgh, Pa.

Mr. Arthur Hollaway, 838 N.E. 24th Street, Oklahoma City, Oklahoma

Mr. H. J. Hofferth, 5531 N. Spalding, Chicago, Illinois

Mr. D. P. James, 1212 Lee Street, Jefferson City, Missouri

Senator Ernest E. Lundeen, 6221 29th Street, N.W., Washington, D.C.

Mr. M. P. Mahan, 1610 Grandville Avenue, Chicago, Illinois

Mr. Adolph Mook, 1788 Lanier Place, Washington, D. C.

Mr. Joseph J. Pesci, 213 West Market Street, Blairsville, Pa.

Miss Chloe Post, Minerva, Ohio

Mr. E. J. Tarr, 1722 19th Street, N.W., Washington, D. C.

Miss Margaret Turner, Huddleston, Virginia

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APPENDIX B

Weather Analysis

The weather analysis for August 31, 1940, prepared by meteorologists is as follows: A weak occluded low pressure area was located over the Lake Superior region, with its principal front occluded at the center of the system, becoming a cold front of weak intensity extending from the central portion of Lake Erie south-southwestward across Ohio, where it became too diffuse to remain of any importance. There were indications of a cold front of more active nature running from the center of the depression south and southwestward across Lake Michigan to the Missouri-Iowa State line, where it also became too diffuse to be carried any further. East of Illinois the pressure gradient was comparatively flat. An anticyclonic circulation prevailed along the Coast north of the Virginia Capes produced by a high pressure area situated some distance off shore in the Cape Cod area. The very sluggish circulation resulting from this pressure distribution and the saturated state of the lower layer was such that a widespread low cloud deck, with considerable fog, was reported in all sections of the area extending from the northern Smoky Mountains northeastward to the central St. Lawrence Valley.

The meteorologists stated that while the fronts did not exert a dominating influence over weather conditions in any section southeast of the Lakes, the approach of any front, no matter how weak, would contribute to the vertical lifting of an air mass which was already being acted upon by other forces such as convergence, aerographic lift, etc. There was no temperature differential in the horizontal between Pittsburgh and Washington.

The tropical hurricane which was reported moving slowly northeastward over the South Atlantic was considered by the weather experts as being too far removed at any time during the period under consideration to be an influencing factor. The above analysis was based entirely upon a synoptic weather map with upper air directions and velocities and available radiosonde data superimposed.

Weather Forecast

The following is the airway forecast issued by the Cleveland station of the U.S. Weather Bureau for the period 11:30 A.M. to 7:30 P.M. (EST), for the route Detroit to Washington:

"Weak low pressure central over eastern Lake Superior and northern Lake Michigan with poorly defined and weak cold front near Indianapolis, Grand Rapids, and north westward at 7:30 A.M. Pressure gradient is very flat throughout this district. Cloudiness will increase to broken or overcast to westward of mountains with ceiling 4 to 7000 and lower clouds 2 to 4000 variable scattered to broken first quarter and broken to overcast thereafter. Scattered showers in afternoon and some mild thunderstorms probable central Michigan, eastern Indiana and western Ohio second half period. Overcast to occasionally broken clouds mountains eastward with fog diminishing and ceiling lifting to 6 or 800 over higher terrain and 1 to 2000 ground scattered showers through mountains and some mild thunderstorms likely in afternoon. Local areas of very low to low visibility with fog slowly dissipating over middle and eastern ridges

first quarter but improving to between 1 and 3 in afternoon hours and to between 6 and 3 other sections. Visibility between 5 and 10 westward of mountains. Winds aloft 250 to 270 degrees 20 to 30 mph."

The trip forecast issued to the captain by the Company's meteorologist was as follows:

"Trip 19 forecast:

"Washington to Pittsburgh - cruising altitude 6000 feet, wind 260°, 10 mph, temp. 66.

"Pittsburgh to Cleveland - cruising altitude 2500 feet, wind 280°, 10 mph, temp. 76.

"Cleveland to Detroit - cruising altitude 4000 feet, wind 220°, 30 mph, temp. 72.

"Overcast to broken, Washington to Pittsburgh, base 1500, Washington area top 5500 over ridges stop broken to scattered Pittsburgh to Detroit, base 5000 lowering to 3000 in scattered mild to moderate thunderstorms stop

"All terminals scattered to broken at 5000 lowering to 2000 in thunderstorms, visibility unlimited, lowering to 3 in storms signed Coons Pittsburgh 12:30 p.m."

The sequence weather reports and forecasts available to Captain Scroggins at the time of scheduled departure, 1:50 P.M. (EST) and which appeared on the clearance, were as follows:

12:35 p.m., EST - Washington, D.C. C (satisfactory for flight under contact flight rules) Ceiling estimated 1400 feet overcast lower broken clouds, visibility 7 miles, light rain shower, pressure 1017.3 millibars, temp. 78, dewpoint 74, wind SW 5, altimeter setting 30.03.

Frederick, Maryland. Special observation.[1] Ceiling estimated 900 feet, overcast lower broken clouds, visibility 6 miles, light rain, temp. 78, dewpoint 74, wind WSW 7.

Front Royal, Va. Ceiling estimated 3500 feet, high broken lower broken clouds, visibility unlimited, pressure 1016.9 millibars, temp. 80, dewpoint 73, wind N 3, altimeter setting 30.03, scattered clouds at 2000 feet, thunderheads all quadrants.

Martinsburg, W. Va. Special observation. Ceiling estimated 3800 feet, overcast lower broken clouds, visibility 7 miles, pressure 1017.3, temp. 74, dewpoint 71, wind NW 8, altimeter setting 30.04.

Elkins, W. Va. Ceiling estimated 4000 feet, overcast lower scattered clouds at 800 feet, visibility 5 miles, light ground fog, prewsure 1018.3 millibars, temp. 69, dewpoint 66, wind SE 4, altimeter setting 30.11, west ridge obscured.

Middletown, Pa. Special observation. Ceiling estimated 1200 feet, overcast, visibility 5 miles, light fog, pressure 1016.9 millibars, temp. 75, dewpoint 71, wind WNW 10, altimeter setting 30.02, lower scattered clouds at 800 feet.

1/ A "special observation" is one taken between regular reporting times. Its purpose is to report abrupt and extensive changes in the weather.

Harrisburg, Pa. C (satisfactory for flight according to contact flight rules) Ceiling estimated 1000 feet, overcast lower scattered clouds at 800 feet, visibility 4 miles, moderate rain showers pressure 1016.6 millibars, temp. 72, dewpoint 72, wind NW 3, altimeter setting 30.02.

Cove Valley, Pa. Special observation. Ceiling 3000 feet, overcast lower broken clouds, visibility 7 miles, pressure 1017.6 millibars, temp. 72, dewpoint 68, wind missing, altimeter setting 30.07, overcast at 6500 feet.

Buckstown, Pa. Special observation. Ceiling estimated 7000 feet, overcast lower scattered clouds at 2000 feet, visibility 7 miles, pressure 1017.3 millibars, temp. 70, dewpoint 64, wind S 3, altimeter setting 30.12, breaks in overcast.

Pittsburgh, Pa. C (satisfactory for flight according to contact flight rules) Special observation. Ceiling estimated 2500 feet, overcast thin lower broken clouds, visibility 4 miles, light rain shower, light smoke, pressure 1017.6 millibars, temp. 69, dewpoint 65, wind NNW 2, altimeter setting 30.07.

East Liverpool, Ohio. Ceiling estimated 3500 feet, high and lower broken clouds, visibility 4 miles, hazy, pressure 1017.3 millibars, temp. 74, dewpoint 68, wind S 4, altimeter setting 30.05.

Cambridge, Ohio. Ceiling estimated 2500 feet, broken lower broken clouds visibility 8 miles, pressure 1017.3 millibars, temp. 81, dewpoint 66, wind W 7, altimeter setting 30.05.

Akron, Ohio. C (satisfactory for flight according to contact flight rules) Ceiling unlimited high broken clouds lower scattered clouds at 3500 feet visibility unlimited, pressure 1018.0 millibars, temp. 79, dewpoint 50, wind SE 4, altimeter setting 30.08.

Cleveland, Ohio. C(satisfactory for flight according to contact flight rules) Ceiling unlimited scattered clouds at 8000 feet, visibility unlimited, pressure 1017.6 millibars, temperature 79, dew point 52, wind SSW 2, altimeter setting 30.05.

The 1:35 p.m. weather sequence may have been available to Captain Scroggins prior to departure from Washington, since the departure of the trip was delayed, or he may have obtained the weather data from this sequence by listening in on the Washington radio range frequency.

Washington, D. C. C (satisfactory for flight according to contact flight rules) Ceiling estimated 1500 feet, overcast lower broken clouds, visibility 5 miles, light rain shower, pressure 1016.3 millibars, temp. 76, dewpoint 72, wind SW 10, altimeter setting 30.00.

Frederick, Md. Ceiling estimated 1000 feet, overcast lower broken clouds, visibility 1-1/2 miles, light thunderstorms, moderate rain, light fog, temp. 77, dewpoint 75, wind SW 12.

Front Royal, Va. Ceiling estimated 2500 feet, broken clouds lower broken clouds, visibility unlimited, light rain showers, pressure 1015.6 millibars, temp. 76, dewpoint 74, wind calm, altimeter setting 29.99

Martinsburg, W. Va. Ceiling estimated 6000 feet, broken clouds, lower scattered clouds at 4000 feet, visibility 7 miles, pressure 1016.3 millibars, temp. 78, dewpoint 70, wind NNW 4, altimeter setting 30.01.

Elkins, W. Va. Ceiling estimated 6000 feet, overcast lower scattered clouds at 800 feet, visibility 7 miles, pressure 1017.6 millibars, temp. 72, dewpoint 63, wind SE 4, altimeter setting 30.10.

Middletown, Pa. Special observation. Ceiling estimated 1200

feet, overcast lower broken clouds, visibility 2 miles, light rain shower, light fog, pressure 1016.9 millibars, temp. 72, dewpoint 70, wind WNW 12, altimeter setting 30.02, conditions extremely variable.

Harrisburg, Pa. N (satisfactory for flight under instrument flight rules) Special observation taken at 1:37 p.m., EST. Ceiling estimated 800 feet, variable overcast, visibility 1-1/4 miles, variable light thunderstorm, heavy rain shower, pressure 1016.3 millibars, temp. 72, dewpoint 71, wind SE 5, altimeter setting 30.01

Cove Valley, Pa. Ceiling estimated 3000 feet, overcast lower broken clouds, visibility 8 miles, pressure 1017.3 millibars, temp. 74, dewpoint. 68, wind calm, altimeter setting 30.06, overcast at 6500 feet.

Buckstown, Pa. Ceiling estimated 7000 feet, high overcast lower broken clouds, visibility 8 miles, pressure 1015.9 millibars, temp. 74, dewpoint 64, wind SW 3, altimeter setting 30.09, lower overcast to the east.

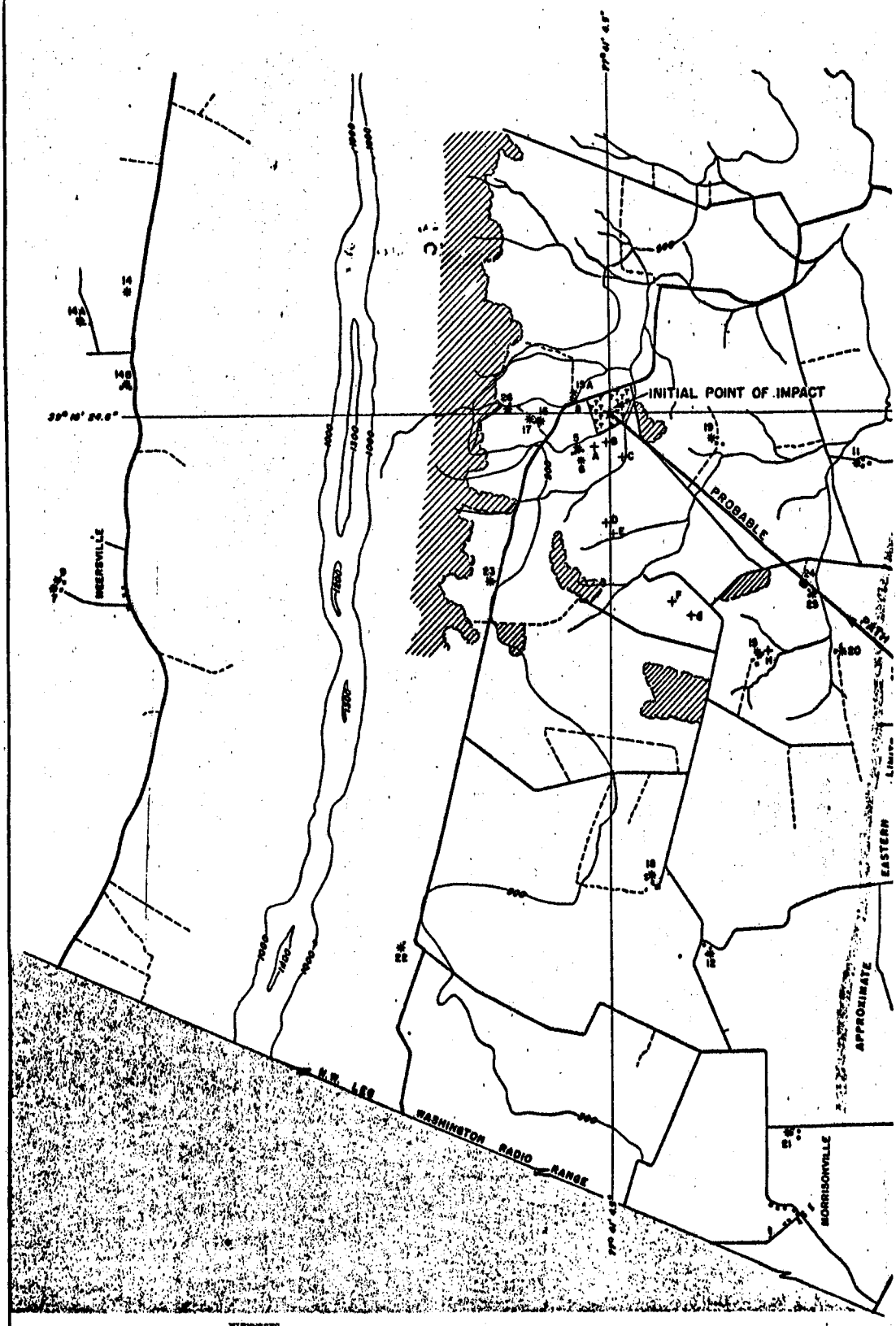
Pittsburgh, Pa. C (satisfactory for flight according to contact flight rules) Ceiling estimated 2500 feet, overcast thind lower broken visibility 4 miles, light thunderstorm light rain shower, light smoke, pressure 1016.9, temp. 68, dewpoint 66, wind NW 9, altimeter setting 30.05, overcast at 5000 feet.

East Liverpool, Ohio. Special observation. Ceiling estimated 4000 feet, high and lower broken clouds, visibility 4 miles, hazy, pressure 1016.9 millibars, temp. 77, dewpoint 68, wind NW 4, altimeter setting 30.04, wind shifted from the south at 1:35 p.m.

Cambridge, Ohio. Ceiling estimated 3000 feet, broken clouds, visibility 9 miles, pressure 1016.6 millibars, temp. 80, dewpoint 63, wind WNW 10, altimeter setting 30.03.

Akron, Ohio. C (satisfactory for flight according to contact flight rules) Ceiling unlimited, high scattered clouds lower scattered clouds at 4000 feet, visibility unlimited, pressure 1016.3 millibars, temp. 81, dewpoint 49, wind S 4, altimeter setting 30.02.

Cleveland, Ohio. C (satisfactory for flight according to contact flight rules) Ceiling unlimited, clear visibility unlimited, pressure 1016.3 millibars, temp. 83, dewpoint 56, wind SSW 7, altimeter setting 30.01.



WITNESSES

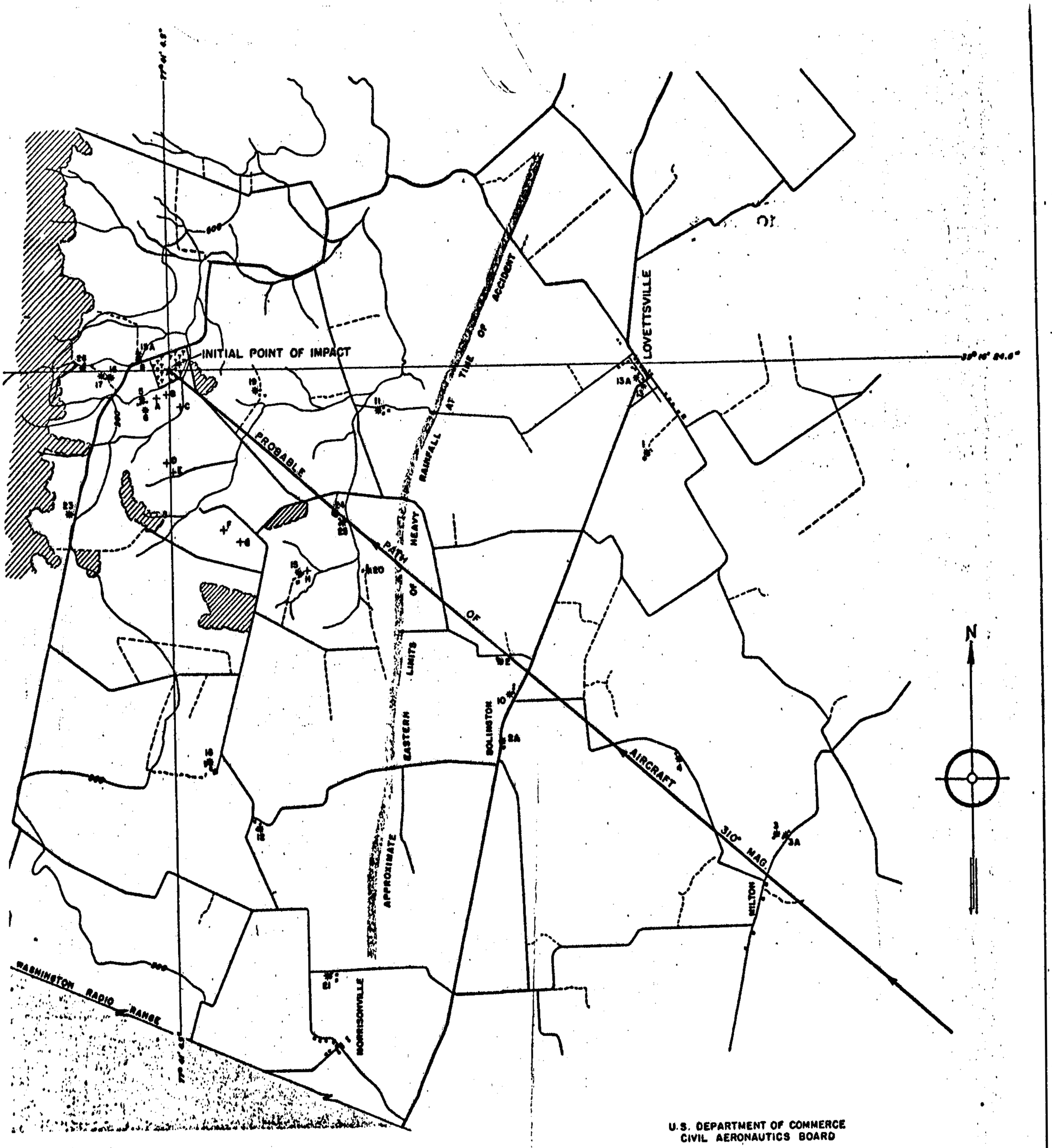
1. Mrs. Dorothy Everhart
2. H. O. Vincell
2a. Mrs. Mattie R. Hickman
3. Carroll Warren McCuba
3a. Warren McCuba
4. Fanny Ridgeway
5. Lydia Jacobs
6. James Garland Jacobs
7. Charles William Bailey
8. Clarence William Bishop
9. Annie M. Glatterbuck
10. Chester Beatty
11. Charles Miller
12. Ernest Everhart
13. Bryce Weaver
13a. Lester R. Mason
14. J. T. Dagnet
14a. W. P. Fleming
14b. George W. Stone
15. Ernest Graham
15a. Henry Thompson
16. Richard Thompson
17. Mrs. Viola Thompson
18. Mrs. Robert English
19. George Compher
20. H. E. Everhart
21. I. V. Baker
22. Thomas R. White
23. Martin Young
24. Virgie Mantier (Miss)
25. George D. Pooley
26. Lelia Shoemaker

EXHIBITS

A. Pieces of Paper
B. Pieces of Paper
C. F. C. A. Form 278
D. F. C. A. Passenger Manifests
E. F. C. A. Passenger Manifests
F. F. C. A. Passenger Flight Indicator
G. Piece of Paper
H. F. C. A. Manilla Envelope

LEGEN

FIRST GLAS
SECOND GLA
TRAILS
WITNESSES
EXHIBITS
CORN FIELD
WOODS



U.S. DEPARTMENT OF COMMERCE
CIVIL AERONAUTICS BOARD

MAP OF LOVETTSVILLE AREA

"SCALE"
IN FEET
1000 0 1000 3000 5000 7000

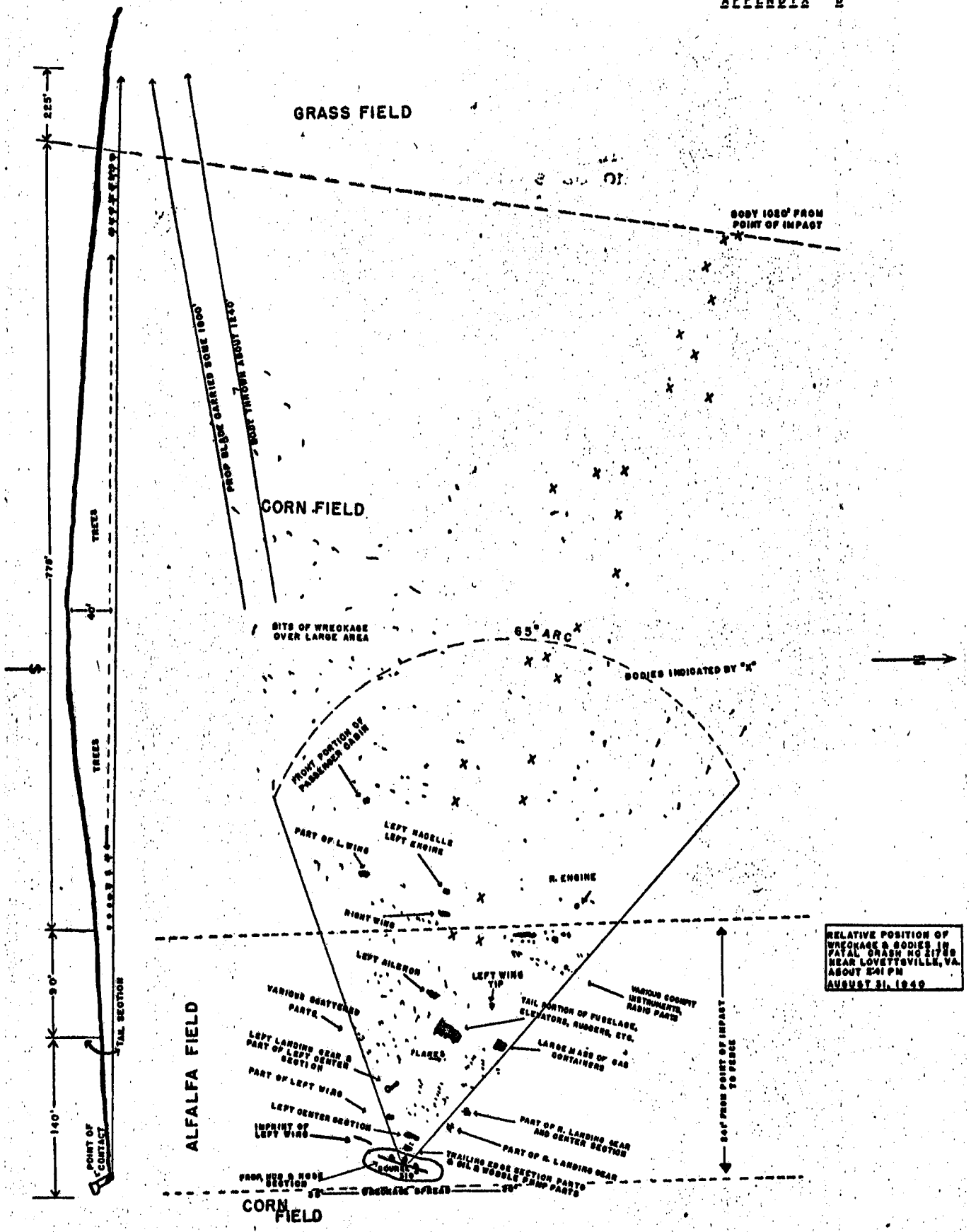
IN MILES
0 ¼ ½ 1 2 3

APPENDIX "C"

WITNESSES	EXHIBITS	LEGEND	
Thompson	A. Pieces of Paper	▬	FIRST CLASS ROAD
...la Thompson	B. Pieces of Paper	—	SECOND CLASS ROAD
...ert English	C. P. C. A. Form 278	---	TRAILS
...asher	D. P. C. A. Passenger Manifests	✱	WITNESSES
...erhart	E. P. C. A. Passenger Manifests	+	EXHIBITS
...ber	F. P. C. A. Passenger Flight Indicator	,Y,	CORN FIELD
... White	G. Piece of Paper	▨	WOODS
Young	H. P. C. A. Manilla Envelope		
...ontier (Miss)			
... Penley			
...omaker			

COMPILED BY P.H.

DR. BY MOE SPECIFICATION & MATERIAL SECTION CAA M-42


GRASS FIELD
BODY 1050' FROM POINT OF IMPACT
PROP BLADE CARRIED SOME 1000'
ENGINE THROWN ABOUT 1240'
CORN FIELD
TREES
TREES
225'
775'
40'
90'
140'
TAIL SECTION
POINT OF CONTACT
SITS OF WRECKAGE OVER LARGE AREA
65° ARC
BODIES INDICATED BY "X"
FRONT PORTION OF PASSENGER CABIN
PART OF L. WING
LEFT NACELLE LEFT ENGINE
R. ENGINE
RIGHT WING
LEFT AILERON
LEFT WING TIP
VARIOUS SCATTERED PARTS
TAIL PORTION OF FUSELAGE, ELEVATORS, RUDDERS, ETC.
VARIOUS COCKPIT INSTRUMENTS RADIO PARTS
LEFT LANDING GEAR & PART OF LEFT CENTER SECTION
FLARES
LARGE MASS OF GAS CONTAINERS
PART OF LEFT WING
LEFT CENTER SECTION
IMPRINT OF LEFT WING
PART OF R. LANDING GEAR AND CENTER SECTION
PART OF R. LANDING GEAR
TRAILING EDGE SECTION PARTS & OIL & HYDRAULIC PUMP PARTS
FROM NOSE & HOOD SECTION
ALFALFA FIELD
CORN FIELD
RELATIVE POSITION OF WRECKAGE & BODIES IN FATAL CRASH NC 21788 NEAR LOVETTSVILLE, VA. ABOUT 2:41 PM AUGUST 21, 1949

APPENDIX E

Radio logs for Pennsylvania-Central Airlines reveal the following information in connection with the operation of Trip 19 of August 31:

2:02 p.m. - Pittsburgh ground station called Trip 19. No acknowledgment. Pittsburgh repeated the flight plan which had been approved for this trip.

2:08 p.m. - Captain Scroggins to Pennsylvania-Central Airlines ground station, Washington: "Have a mechanic come out and turn our oil filter." Reply: "OK will do."

2:23 p.m. - Aircraft to ground station, Washington: "Trip 19 left the ramp 2:18 off the ground 2:21." Acknowledged by ground station 2:24 p.m.

2:31 p.m. - Trip 19 to ground station: "Trip 19 Herndon fan marker 2:31 4000 feet climbing contact." He gave his first departure from ramp at Washington: "Trip 19 first time leaving ramp 2:02 returned at 2:07." Acknowledged.

3:03 p.m. - Ground stations at Pittsburgh and Washington called Trip 19. No acknowledgment. Pittsburgh broadcast to Trip 19: "Cleared Washington boundary to Scottsdale cruise 6000 Scottsdale at 4000 no delay expected traffic Trip 42 departed Pittsburgh 2:59 cruise 5000."

3:10 p.m. - Pittsburgh ground station to Trip 42: "If you see Trip 19 on the way give us a call."

3:14 p.m. - Pittsburgh called Trip 19: "Trip 19 advise your passengers you will change ships at Pittsburgh." Not acknowledged.

3:24 p.m. - Pittsburgh ground station to Trip 19: "Trip 19 cleared Frostburg to Pittsburgh tower circle field at 2500 feet before landing and look for light and will broadcast it on range. AW23PXW broadcast it. Also change to night frequency and give me a call." Not acknowledged.

3:39 p.m. - Pittsburgh ground station to Trip 19: "Trip 19 switch over on battery also change transmitter and try western day frequency and night frequency." Not acknowledged. Pittsburgh to Detroit: "Stand by on western day and night frequencies." Pittsburgh repeated the above instructions to Trip 19. Not acknowledged.

3:39 p.m. - Pittsburgh to Trip 19: "Trip 19 change over to batteries and try changing your transmitter to western day and night frequencies." Not acknowledged.

3:41 p.m. - Pittsburgh to Trip 19: "Trip 19 Pittsburgh weather 3:35 p.m. estimated high broken lower broken visibility 4 miles smoke SE 10 ALTM 3000 scattered 2500". Not acknowledged. The above message was repeated to Trip 19. Not acknowledged.

3:44 p.m. - Pittsburgh to all ground stations: "Suspend traffic and operations for time being."

3:48 p.m. - Pittsburgh to Airways Radio Range Station: "Airways broadcast clearance on BLV." Reply: "OK will do."

4:04 p.m. - Washington to Trip 19: Repeated 3:35 weather sequence. Not acknowledged.

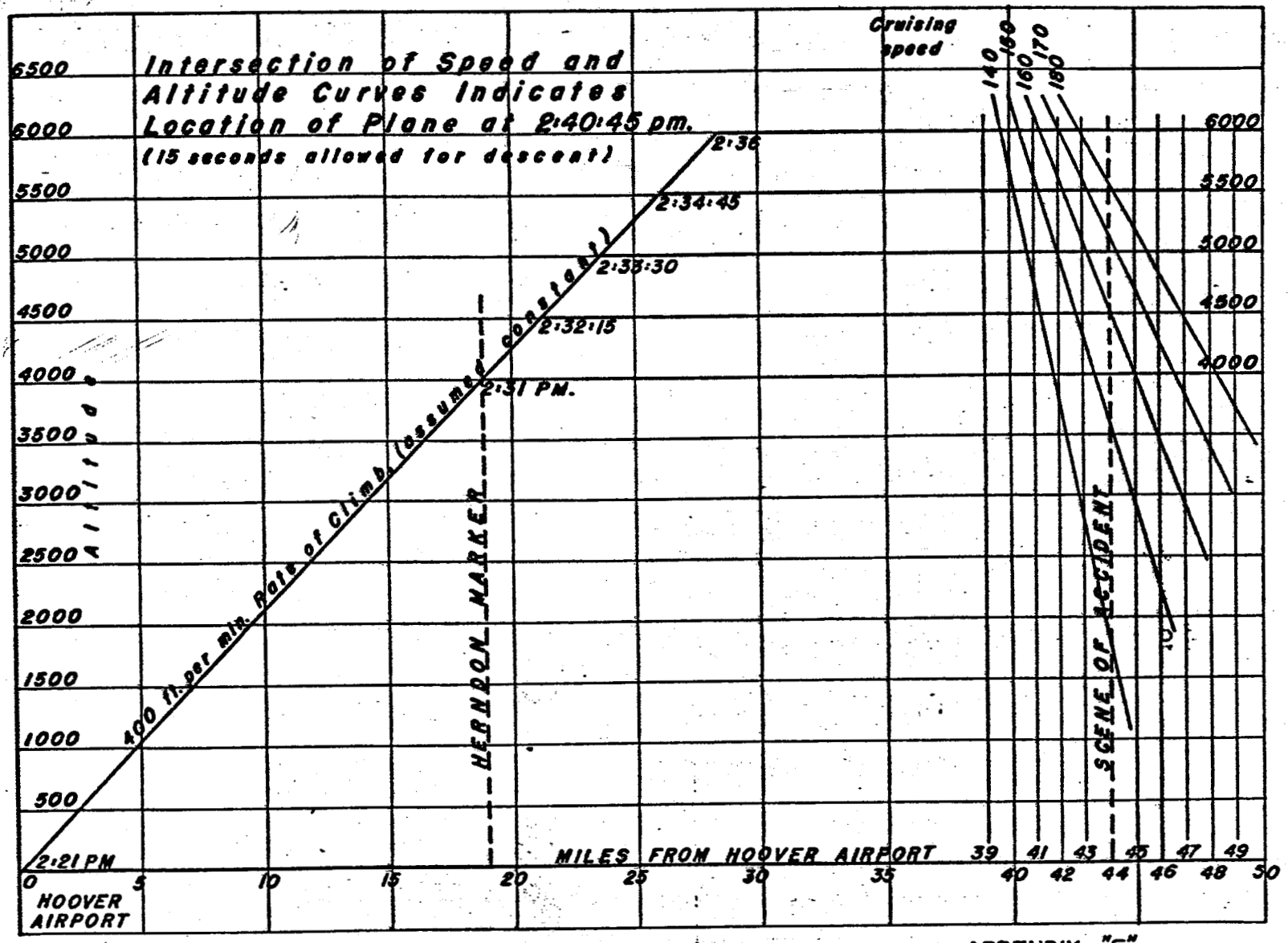
4:04 p.m. - Pittsburgh broadcast complete weather sequence to Trip 19. Not acknowledged.

4:07 p.m. - Pittsburgh to Trip 19: "A ship south of the field about 4:02 at about 3000 circled then turned south into the overcast."

4:17 p.m. - Pittsburgh to Airways at Pittsburgh: "Airways advise all ships coming into Pittsburgh at the pilot's discretion until we hear from PCA Trip 19."

4:22 p.m. - Pittsburgh called Trip 19. Not acknowledged. Pittsburgh to Harrisburg: "Did you hear Trip 19 call you?" Harrisburg: "No." Harrisburg called Trip 19. Not acknowledged.

5:23 p.m. - Pittsburgh to all stations: "Resume normal operations and traffic."


Intersection of Speed and Altitude Curves Indicates Location of Plane at 2:40:45 pm.
(15 seconds allowed for descent)
Cruising speed
140
150
160
170
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
Altitude
2:36
2:34:45
2:33:30
2:32:15
2:31 PM.
400 ft. per min. Rate of Climb (assumed constant)
HERNDON MARKER
SCENE OF ACCIDENT
2:21 PM
MILES FROM HOOVER AIRPORT
0
5
10
15
20
25
30
35
39
40
41
42
43
44
45
46
47
48
49
50
HOOVER AIRPORT

APPENDIX "F"