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REPORT OF THE CIVIL AERONAUTICS BOARD

Of the investigation of an accident involving civil aircraft of the United States NC 13359, which occurred near Charleston, West Virginia, on April 16, 1941.

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CONDUCT OF INVESTIGATION

An accident involving aircraft NC 13359 occurred in the vicinity of Charleston, West Virginia, on April 16, 1941, about 4:33 p.m. (EST), while the aircraft was operating in scheduled air carrier service between Knoxville, Tennessee, and Pittsburgh, Pennsylvania, as Trip 143 of Pennsylvania-Central Airlines Corporation.[1/] The accident resulted in the destruction of the airplane, serious injuries to one member of the crew and two passengers, and minor injuries to one member of the crew and the other four passengers. One member of the crew escaped injury.

The Washington office of the Civil Aeronautics Board[2/] was officially notified of the accident about 5:30 p.m. the same day, and was informed at this time that there had apparently been a failure of the right engine of the aircraft. 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. Investigators were sent to the scene of the accident and arrived there about noon on the day following the accident.

Inspection and Preservation of Wreckage

The wreckage was guarded by the captain and first officer until about 5:45 p.m. on April 16, at which time West Virginia State Police

1/ Hereinafter referred to as "PCA"
2/ Hereinafter referred to as the "Board".

assumed charge. The State Police continuously guarded the area in which the wreckage lay until the arrival of the investigators of the Board the next day. PCA personnel had visited the scene of the wreckage early on the morning of April 17 and one of them had entered the airplane. The officers who had been on duty at the time testified, however, that, to their knowledge, the PCA personnel had not examined the right engine other than to measure the amount of oil therein. Upon arrival, the investigators of the Board took custody of the wreckage.

After an examination of the wreckage at the scene of the accident the right engine and the right engine mount were removed from the aircraft under the supervision of investigators of the Board and were transported by them to the National Bureau of Standards, Department of Commerce, Washington, D.C., for a tear-down inspection. The airplane, the right engine, and the right engine mount were released to PCA upon conclusion of the investigation.

Public Hearing

In connection with the investigation of the accident a public hearing was held in Washington, D.C., on April 30, May 1, and May 2, 1941. Stuart G. Tipton, Assistant General Counsel for the Board, acted as Presiding Examiner, and was assisted by Gerald P. O'Grady, Attorney for the Board, who acted as Associate Examiner. The following personnel of the Safety Bureau participated in the hearing: Jerome Lederer, Director; Frank E. Caldwell, Chief,

Investigation Division; James H. Douglas, Assistant to the Chief, Investigation Division; Ralph A. Reed and E. N. Townsend, Air Safety Investigators.

All of the evidence available to the Board at the time was presented at the hearing. Eighteen witnesses testified and 34 exhibits were introduced. While the Examiners and the representatives of the Safety Bureau were the only ones designated to ask questions directly of the witnesses, 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 in writing to the Examiners. A number of written questions were so submitted during the hearing. Every question submitted was asked unless the subject matter of the question had previously been covered by the testimony.

After the close of the hearing, depositions were taken from the West Virginia State Police officers who had assisted in guarding the wreckage and were made a part of the record of the investigation.

Upon the basis of all the evidence accumulated in the investigation and at the hearing, the Board now makes its report in accordance with the provisions of the Civil Aeronautics Act of 1938, as amended.

SUMMARY AND ANALYSIS OF EVIDENCE

Air Carrier

PCA, 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 Pittsburgh, Pennsylvania; Wheeling, West Virginia; Clarksburg, West Virginia; Charleston, West Virginia; Bristol, Tennessee; Knoxville, Tennessee; Chattanooga, Tennessee; and Birmingham, Alabama. It had begun operations on this route on March 6, 1941.

Flight Personnel

On the flight in question the crew consisted of Captain Russell J. Wright, First Officer William H. Riley, and Flight Stewardess Irene Coates.

Captain Wright, age 25, had accumulated a total of approximately 2,327 hours of flight time and was the holder of an airline transport pilot certificate. He had originally been employed by PCA as a first officer on October 26, 1938. He was promoted to captain on March 4, 1941. Prior to the accident he had logged approximately 947 hours in Boeing Model 247D airplanes. His last physical examination required by the Civil Air Regulations, taken on November 22, 1940, showed that he was in a satisfactory physical condition. Prior to his promotion to captain, PCA had given

Captain Wright a period of flight training and a series of flight checks which included training and checks in single-engine operation. Company records indicated that he was a well qualified and proficient pilot.

First Officer William H. Riley, aged 28, had accumulated a total flying time of approximately 1474 hours and 40 minutes. He had been originally employed by PCA on February 1, 1940. At the time of the accident he held a commercial pilot certificate with an instrument rating, and had logged a total of 212 hours in Boeing Model 247D airplanes. His last physical examination required by the Civil Air Regulations, taken on April 10, 1941, showed him to be in satisfactory physical condition. He was regarded by PCA as well qualified for his duties.

Thus, it appears from the evidence that Captain Wright and First Officer Riley held the proper certificates of competency and were physically qualified for the flight and equipment involved.

Airplane and Equipment

Airplane NC 13359 had been manufactured by the Boeing Airplane Company in July, 1932. It was originally purchased by United Air Lines Transport Corporation which sold it to PCA in March, 1937. The airplane was a Model 247D powered with two Pratt & Whitney Wasp S1H1-G engines, and at the time of the accident had flown a total of about 14,866 hours, with replacements of engines and of parts from time to time. Subsequent to its purchase by PCA it was approved by the Civil Aeronautics Administration for air carrier operation

over the PCA route from Pittsburgh to Birmingham with three crew members and ten passengers. Its maximum gross weight was specified as 14,000 pounds without de-icer equipment. At the time of the departure of Trip 143 from Charleston the gross weight of the airplane was 12,913 pounds.

The maintenance competency letter issued by the Civil Aeronautics Administration to PCA requires, with respect to Boeing Model 247D airplanes, that the engines be overhauled every 700 hours and that the airplane, including engines, be given a periodic inspection every 120 hours, a routine inspection every 20 hours, and a daily inspection. The right engine of airplane NC 13359, which had been operated a total of 6,076 hours 23 minutes, had been in service 668 hours 55 minutes since its last overhaul. The left engine, which had been operated a total of 6881 hours 19 minutes, had been in service 671 hours 58 minutes since its last overhaul. The airplane and its engines had been operated 29 hours and 33 minutes since the last periodic inspection. A daily inspection had been made at Pittsburgh on April 15, 1941. The condition of the airplane and the maintenance records produced by PCA indicated that the airplane was in an airworthy condition when it was dispatched from Charleston, West Virginia, on April 16, 1941, for the flight to Pittsburgh.

The engine maximums [3] authorized in the aircraft airworthiness certificate of NC 13359 at the time of the accident [4] were as follows:

	Press Alt.	In. Hg.	R.P.M.	H.P.
Take-off 1 Min.		35½	2200	550
Maximum except take-off	Sea level	35	2200	550
Maximum except take-off	3,000 feet	33	2200	550

When the manufacturer sought an Approved Type Certificate for Wasp S1H1-G engines in 1934, the usual tests were run. During these tests the engine was operated continuously for 50 hours at an average of 35.6 inches manifold pressure, at 2200 r.p.m., and at an average of 556 h.p., without in any way adversely affecting the engine.

The airplane was equipped with Hamilton Standard, constant speed, hydromatic, full-feathering propellers.

3/ Aircraft engines are designed to produce a given horsepower under continuous operation. This normal rated maximum horsepower can be exceeded for short periods without affecting the safety of operation or the service life of the engine. However, if an engine is operated at this higher horsepower for any continuous period of time, excessive temperatures will be developed in the cylinder head, valves, pistons, etc., which may result in a failure of any one of these parts or seriously reduce the service life of the engine. Accordingly, engine operation limitations are specified by the Civil Aeronautics Administration in the operation record attached to the aircraft airworthiness certificate of each airplane. These limitations are expressed in terms of maximum permissible (a) manifold pressure measured in inches of mercury, (b) revolutions per minute, and (c) horsepower.

When an engine is operated with a constant speed propeller, as were both engines on the airplane involved in the accident, the manifold pressure alone is used to gauge the horsepower output.

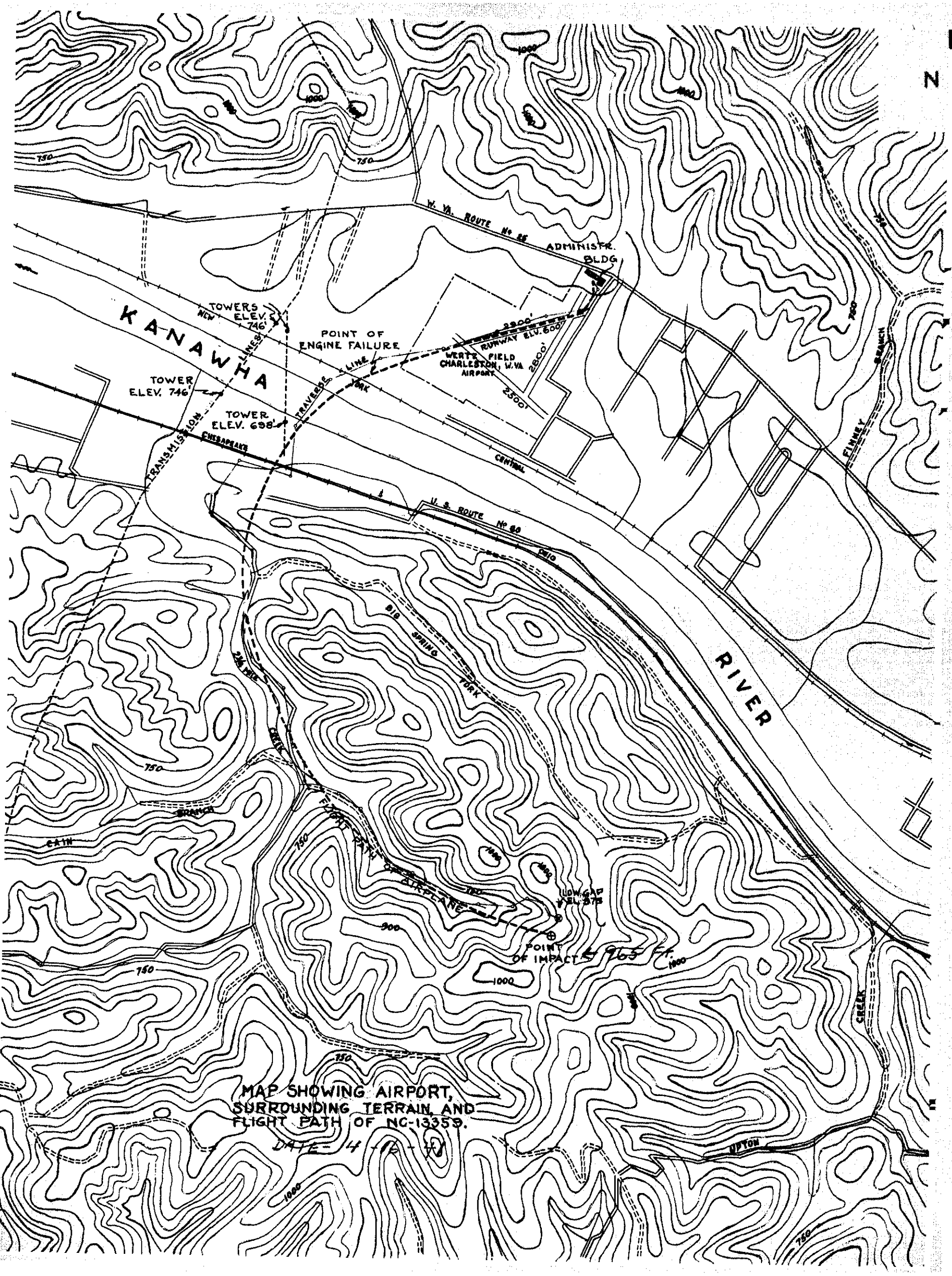
4/ See Appendix A for a history of the engine limitations for NC 13359.

History of the Flight

PCA Trip 143 was scheduled to depart Knoxville, Tennessee, on April 16, 1941, at 1:25 p.m. (CST) and was scheduled to make intermediate stops at Bristol, Tennessee; Charleston, West Virginia; and Clarksburg, West Virginia; and the terminal stop at Pittsburgh, Pennsylvania. Prior to departure from Knoxville, Captain Wright prepared a flight plan for the route to be flown.

The 12:35 p.m. (CST) weather sequence reports issued by the United States Weather Bureau indicated that the weather along the entire route from Knoxville to Pittsburgh was well above the minimums prescribed by the Civil Aeronautics Administration and set forth in the PCA operation manual.

The flight, which had been previously cleared by the PCA dispatcher at Pittsburgh, departed from the Knoxville loading ramp on schedule at 1:25 p.m. (CST) and proceeded in a routine manner to Bristol, Tennessee, approximately 100 miles from Knoxville, and then to Charleston, West Virginia, approximately 150 miles from Bristol. Just prior to arriving at Charleston, Captain Wright switched the fuel tank selector valve to the right main tank, which was then full. The flight landed at Charleston at 4:17 p.m. (EST). Upon arrival at the loading ramp the aircraft was serviced with 35 gallons of gasoline. The right main tank was refilled with 5 gallons and the other 30 gallons were placed in the left main tank. This brought the fuel on board to an estimated 203 gallons. Captain Wright and First Officer Riley testified that while Trip 143



MAP SHOWING AIRPORT, SURROUNDING TERRAIN AND FLIGHT PATH OF NC-13359.

DATE- 4-16-40

was on the ground at Charleston no one approached the aircraft except the passengers and the refueling crew.

The Charleston Municipal Airport is situated approximately nine miles west of the City of Charleston in the Kanawha River Valley at a mean elevation of 600 feet above sea level. 5/ It is equipped with three runways, extending approximately north-northeast -- south-southwest, east-northeast -- west-southwest, and southeast-northwest. The Kanawha River channel lies immediately to the south of the airport and is bordered on the south by a range of hills which extend to approximately 1000 feet above sea level. On the north, the airport is bordered by another range of hills which also extend to approximately 1000 feet above sea level. To the west of the airport a primary high-tension line extends across the valley in a north-south direction on towers which are 146 feet above the mean level of the airport. This high-tension line crosses the flight path from the east-northeast -- west-southwest runway at a point 2750 feet from the west end of the runway. At a point west of the airport a secondary high-tension line branches off from the primary one and extends across the valley toward the southeast on towers 98 feet above the level of the airport. This secondary line crosses the flight path from the east-northeast -- west-southwest runway at a point 2500 feet from the west end of the runway. The secondary power line constitutes an obstruction which requires, to clear it, a minimum climb angle of about 25 to 1 from the end of this runway, while the primary power line constitutes an obstruction which requires a minimum climb angle as steep as 19 to 1 from the end of this runway.

5/ See map facing this page.

Trip 143 departed from the Charleston loading ramp at 4:28 p.m. (EST). The 4:35 p.m. weather report from Charleston indicated that there was a ceiling at an estimated height of 4000 feet, with high broken and lower broken clouds, visibility five miles, light smoke, temperature 81, dew point 49. There was a west-southwest wind of 12 m.p.h.

In describing the flight,[6] Captain Wright stated that he taxied to the east end of the east-northeast -- west-southwest runway, the usable length of which is 2900 feet, and that he then ran up both engines at 28 inches indicated[7] manifold pressure. The right engine turned 2150 r.p.m. and the left turned 2125 r.p.m. At approximately 4:30 p.m. Captain Wright started the take-off toward the southwest on the runway. For the take-off Captain Wright used 34 inches of manifold pressure at 2200 r.p.m. Subsequent calculations showed that this represented 502 h.p. from each engine under existing conditions of temperature, relative humidity and altitude. The aircraft left the ground at an air speed of approximately 80 m.p.h. and retraction of the landing gear was started immediately.

According to Captain Wright's testimony, about five seconds after the airplane had left the ground the right engine lost power in much the same manner as if the throttle had been closed.

6/ For the probable flight path, see map facing page 9.

7/ All manifold pressure readings and air speed readings are those indicated.

Captain Wright immediately pumped the throttle in an effort to start the engine and, when unsuccessful, placed the propeller control in the full-feathering position in order to stop the propeller from windmilling and to obtain the best possible single engine performance. He also cut the right engine ignition switch. First Officer Riley stated that the fuel pressure warning light for the right engine did not indicate a loss of fuel pressure until after the right engine had stopped turning. First Officer Riley immediately advised the PCA radio station at Charleston that the engine had stopped.

Immediately after he had placed the right propeller control switch in the full-feathering position and cut the right engine ignition switch, Captain Wright started a gradual left turn and increased the manifold pressure on the left engine to 36½ inches in order to clear the secondary high tension line. Later calculations indicate that the left engine was developing approximately 575 h.p. at this time. While the airplane was climbing over the secondary power line the airspeed dropped from just above 100 miles per hour to approximately 85 miles per hour. After clearing this line Captain Wright reduced the manifold pressure to 34 inches and continued his left turn into a small valley which extends into the range of hills south of the airport. As he proceeded up the valley, he continued to use 34 inches of manifold pressure, approximately 502 h.p. He was able to maintain 85 to 95 miles per hour airspeed but was unable, with the amount of power applied, to increase the airspeed above 95 miles per hour because the rising terrain of the

valley made it necessary to keep the aircraft in a climbing attitude. After the airplane had climbed over the secondary high tension line and during the flight up the valley the rate of climb indicator showed an average rate of climb of about 100 feet per minute.

After making several slight turns and while traveling in approximately an eastward direction, Captain Wright found the upper end of the valley blocked by a wooded ridge rising to an elevation of about 1000 feet above sea level. Realizing that he could neither turn back nor execute a successful landing, he decided to make a stall landing into the trees near the top of the ridge at a spot where the timber seemed to be small and not very dense. He increased the left engine manifold pressure for about 15 seconds to 42-1/2 inches, subsequently calculated to represent approximately 695 h.p., so as to gain enough altitude to reach the spot selected. Captain Wright stated that he then pulled the nose of the aircraft up, reducing the air speed to 60 m.p.h., and cut the master electrical switch and the left engine throttle.

As the aircraft settled through the trees the right wing tip and the right wing panel were sheared off. The wing tip was later found about 80 feet to the rear and to the right of the nose of the fuselage, and the wing panel was found 49 feet in the same direction. The left wing, which was sheared off just outboard of the left engine, reversed ends and fell back over the top of the fuselage. A tree 9 inches in diameter, broken off by the left wing, also fell across the top of the fuselage. When it struck the ground the fuselage broke in two near the rear seat of the cabin. The forward portion of it came to rest flat on the ground and right side up. The tail cone, the tail group, and the rear portion of the fuselage came to rest just to the rear of the forward portion of the fuselage. Both

engine nacelles were damaged considerably. The blades of both propellers were damaged to some extent and those of the right propeller were found to be in the full-feathered position.

The forward part of the fuselage lay headed in an easterly direction on the west side of the wooded ridge at an elevation of 965 feet above sea level, approximately 110 feet below the tops of the trees which covered the top of the ridge directly in front of it. There is a gap in the wooded ridge about 250 feet north of where the wreckage lay. The lowest point of this gap is 973 feet above sea level and is covered by trees between 50 and 60 feet high. The airplane had flown approximately 2.4 miles from the point at which the right engine lost power to the point of the crash.

Immediately after the main portion of the fuselage came to rest on the ground Captain Wright cut the left engine switch. He then attempted to turn the fuel valve to the "off" position, but he found that it was jammed and could not be turned to this position. Since the cabin door could not be opened the passengers were removed through the emergency exit hatch in the roof of the cockpit. One of the passengers left the scene of the wreckage in an effort to locate a telephone and report the crash while the crew remained to guard the wreckage. As noted before, Captain Wright and First Officer Riley remained with the wreckage until the State Police arrived at approximately 5:45 p.m.

Examination of the Right Engine

A detailed examination of the wreckage at the scene of the accident failed to indicate any structural, control, or mechanical failure in flight.

After the right engine and the right engine mount were transported to the National Bureau of Standards, Department of Commerce, Washington, D.C., a tear-down inspection of them was made. This inspection was supervised by representatives of the Safety Bureau and was witnessed by representatives of the National Bureau of Standards. The inspection revealed that there had not been any structural or mechanical failure of such a nature as to cause the engine to lose power. In fact, the engine was found to be in good mechanical condition. The ignition and lubrication systems were also found to be in satisfactory operating condition. The National Bureau of Standards, therefore, concluded that the engine had probably lost power because of either insufficient fuel or insufficient air, but was unable to determine positively which condition was responsible. 8/

As noted previously, the airplane, after it was serviced at Charleston, had approximately 203 gallons of gasoline in its three tanks. Representatives of the Safety Bureau of the Board inspected the fuel system at the scene of the accident. They disconnected the gasoline supply line to the right engine at the carburetor and applied pressure to the fuel system by use of the hand-operated wobble pump. Under these circumstances a full normal flow of gasoline was obtained from each of the gasoline tanks. After the whole fuel system was checked, the gasoline was removed from the tanks and tests were run separately on samples taken from each tank. These tests showed that the gasoline in each of the tanks met the

8/ For full Report of National Bureau of Standards see Appendix B.

established standards of purity and octane rating. The carburetor was removed and was flow-tested at the Naval Aircraft Factory, Philadelphia, Pennsylvania. It was found to be in normal operating condition. The possibility of an air or vapor lock was considered, but, due to the design of the fuel system and the type of fuel being used, such an occurrence is extremely improbable.

The possibility that the loss of power in the right engine could have been caused by the action of the pilot in inadvertently shutting off the fuel supply to that engine was also investigated. Two tests were conducted on a Boeing Model 247D airplane by an investigator of the Safety Bureau to determine the length of time which would elapse between the act of placing the engine fuel selector valve 9/ in the "on" position for one engine only and (a) the lighting up of the fuel pressure warning light for the other engine, and (b) the loss of power in the other engine. In the first test the engines were operated at 27 inches manifold pressure and 2150 r.p.m. and the engine fuel selector valve was then turned to the one engine "on" position. The fuel pressure warning light for the engine from which the fuel was cut off lighted up approximately 10 seconds after the fuel supply had been cut off. By this time the fuel pressure had fallen off from the normal 5 lbs. per square inch to about 2-1/2 lbs. per square inch. In the second test, which was also begun while the engines were operating at 27 inches manifold pressure and 2150 r.p.m., the engine from which the fuel

9/ This valve may be set in either of four positions. Reading clockwise on the dial they are: Both engines off; both engines on; left engine on; and right engine on.

supply was cut off stopped 30 seconds after the fuel was cut off. It stopped without any back-firing or other abnormal indications. During a normal take-off the manifold pressure is increased with acceleration up to the maximum permissible, which, according to PCA instructions, is 34 inches. If a normal take-off were started immediately after the fuel supply to one engine had been inadvertently cut off, the length of time required to exhaust the fuel in the carburetor and fuel lines to this engine would be about 20 seconds, the approximate length of time in the take-off at Charleston before the right engine stopped.

Captain Wright and First Officer Riley both testified, however, that the engine fuel selector valve was "on" for both engines at the time the take-off was started and that they did not notice the fuel pressure warning light for the right engine of NC 13359 until after the propeller was feathered and that engine had stopped completely. Since this light is approximately 1-1/2 inches in diameter and makes a brilliant green light, Captain Wright and First Officer Riley probably noticed it as soon as it came on. Moreover, First Officer Riley stated that the fuel pressure did not drop from the normal five pounds until after the engine had stopped. If the pilot had inadvertently shut off the gasoline to the right engine or if there had been some other stoppage of the flow, the fuel pressure would have dropped and the fuel pressure warning light would have come on before the engine stopped. Based on the testimony of Captain Wright and First Officer Riley, it appears improbable that the right engine could have been cut off from the fuel supply by a maladjustment of the engine fuel selector valve.

A flight test was also conducted on a Boeing Model 247D airplane to determine whether sudden opening of the throttle from the closed position or actuating of the throttle control would adversely affect the automatic mixture control and result in malfunctioning or loss of power in the engine. The engine responded normally throughout this test.

The testimony with respect to the fuel system of the right engine of NC 13359 and the tests subsequently run furnished no evidence that the fuel system was not operating properly at the time the right engine lost power or that the loss of power in the engine resulted from insufficient fuel. Therefore, while the possibility remains, it seems improbable that the loss of power resulted from improper operation of the fuel system or insufficient fuel.

During the tear-down inspection of the right engine two small pieces of cloth were found in the carburetor grid. 10/ These two pieces of cloth were found wadded together in such a way that they covered most of two openings of the carburetor grid, or approximately 2% of the total grid area. When they were removed from the grid and unwadded it was found that one of them was about 1-1/2 inches long and 1 inch wide and that the other was about 3 inches long and 1/4 inch wide. The National Bureau of Standards concluded in its report:

> "The presence of cloth and threads in the induction system and charred cotton on one of the pistons indicates that cloth portions, threads, or fibers had passed through the induction system and at a time which evidently coincides closely with the time of the engine failure.

10/ See photograph attached to National Bureau of Standards Report, Appendix B.

> "It is possible that enough cloth or cloths somewhere in or at the entrance of the carburetor air system could have been present during take-off to restrict the carburetor air flow sufficiently to cause the engine to lose power."

Careful consideration was given by the Board to the possibility suggested by this report, i.e., that enough cloth or cloths could have been present in or at the entrance to the air induction system during take-off to restrict the carburetor airflow and cause the engine to lose power.

The air induction system to the carburetor of NC 13359 consisted of two air ducts, one for cold air and one for hot air. The opening to the air stream of the cold air duct was located between the No. 7 and No. 8 cylinders on the upper side of the engine, and faced forward. It was about 7 inches x 3 inches and was covered with a wire screen of 1/2 inch mesh to prevent foreign materials from being drawn into the duct and carburetor. The cold air duct extended backwards from this opening. The opening of the hot air duct was located inside the nacelle near the exhaust manifold and was covered with a wire screen of 1/8 inch mesh to prevent foreign materials from entering the duct and carburetor. These two ducts converged in a common tube a short distance below the carburetor at a point where a mixing valve was installed. This mixing valve was adjustable from the cockpit so that hot or cold air might be used to provide the proper temperature of the mixture and to safeguard against possible carburetor icing. The common tube extended upwards from the mixing valve to a grid directly beneath the carburetor. This carburetor grid was made of steel with apertures 1/2 inch x 1/2 inch.

Its purpose was to diminish the turbulence in the air flow into the carburetor so as to obtain the best possible fuel-air ratio for fuel distribution throughout the engine. At the time of the take-off at Charleston, Captain Wright was using only cold air and consequently any stoppage of the hot air duct would have had no effect on the functioning of the engine.

Subsequent to the issuance of the Report of the National Bureau of Standards, in order to further explore the possibility suggested in that report that the right engine of NC 13359 had stopped because the air flow had been obstructed by small rags of the type which were found in the carburetor grid of that engine, a test was conducted by representatives of the Safety Bureau with the cooperation of representatives of PCA. This test was witnessed by representatives of the National Bureau of Standards and of the Aircraft Airworthiness Section of the Civil Aeronautics Administration. The engine employed in this test was identical with the one involved in the accident at Charleston. The test consisted of introducing rags approximately 1 inch wide and from 7 inches to 12 inches long into the cold air intake scoop. The engines were run up to 28 inches manifold pressure [11/] at 2150 r.p.m. and 61 rags were introduced by hand, one at a time, from behind the propeller before any effect upon the engine was noticed. The engine r.p.m. then dropped to 2000 and the manifold pressure fell to 27 inches but the engine continued to operate normally with no perceptible variation.

11/ Between the time Captain Wright began his take-off and the time the right engine lost power, the engines of NC 13359 were being operated at 34 inches manifold pressure. To this extent the test conditions differed from the conditions in actual flight. However, it appears that this difference is not sufficient to affect substantially the validity or usefulness of the results of this test.

After the engine was stopped it was found that a number of the rags had become draped over the mixing valve and had closed off about 80 per cent of the air intake area at this point. This valve and the tube leading from it to the carburetor grid, were then removed. A number of rags fell from the bottom of the carburetor grid. Thirty rags were found still attached to the grid itself and were covering approximately 50 per cent of the grid area.

From this test two conclusions may be reached. First, a substantial quantity of small rags must enter the cold air duct to cause a loss of power in the engine; and second, if such a quantity of rags actually enters the cold air duct, most of them will remain in the induction system. It appears, therefore, that small rags of the type found in the induction system of the right engine of NC 13359 could not have caused the loss of power in that engine. While it would have been possible for a few small rags to have been passed through the propeller, thence through the screen at the opening of the cold air duct, and thence through the induction system to the carburetor grid, it is extremely unlikely that a number of such rags sufficient to have stopped the engine could have taken this course. Moreover, if a quantity of small rags sufficient to have stopped the engine had entered the cold air duct, they would have been found in the induction system after the accident. The only way for them to get out would have been through the carburetor into the engine where they would have been burned.

Consideration was also given to the possibility of the presence in the air induction system of a single rag or other foreign material large enough to cause the engine to lose power. It is improbable that such a rag or other foreign material would have passed through the propeller to the screen at the outer entrance to the cold air duct. If such a large rag or other foreign material did pass intact through the propeller to the screen, and such an occurrence has never come to the attention of the Board, it would be held tightly against the screen by force of the airflow. If this were to happen, it would probably occur during the take-off run, and the engine would stop instantly before the airplane left the ground. As we have seen, the right engine of NC 13359 was not adversely affected until after the airplane had been in the air about five seconds and even then the engine ceased to deliver power not abruptly, but as if throttled back. To test the effect of the presence of a large rag in this position a representative of the Safety Bureau placed a piece of fine-weave doubled burlap entirely across the cold air duct of a similar engine. Enough air filtered through this cloth to permit the engine to operate normally.

It is conceivable that someone might have left a large rag or other foreign material in the induction system behind the screens. If this had happened, however, the rag or other material would have been caught by the carburetor grid and would not have passed through the engine. There was no large rag or other material found against the carburetor grid of the right engine of NC 13359. Nevertheless,

a test was conducted to determine the effect of a single large obstruction in the cold air duct. A similar engine was run up at 28 inches of manifold pressure and 2150 r.p.m. with the propeller in the full-low pitch position, which were the power and the propeller setting used by Captain Wright when he ran up his engine at Charleston. In the test a board was placed across the cold air duct so that it blocked off approximately half of the air intake area. The area blocked off was then increased in stages of 10 per cent. No abnormal functioning of the engine was noticed until 95 per cent of the total air intake area had been blocked off, at which time the manifold pressure and engine r.p.m. dropped to 25 inches and 1800, respectively, but the engine then continued to operate normally at this manifold pressure and r.p.m.

The possibility of carburetor icing was also considered. The engine lost power in a comparatively short time without the gradual loss of power which characterizes the presence of carburetor ice. Since the temperature was 81 and the dew point 49, and since the other engine functioned normally under the same conditions, the presence of carburetor ice is quite improbable.

On the basis of all of the evidence, the tear-down inspection of the engine, and the inspections and tests with respect to the fuel and air intake systems, the Board is unable to determine the reason for the stopping of the right engine of NC 13359. 12/

12/ After consideration of pages 14 to 22, inclusive, of this report, the National Bureau of Standards in a memorandum dated September 5, 1941, agreed to the correctness of this decision of the Board.

Conduct of the Flight

While there appears to be no question that the right engine of aircraft NC 13359 failed and that this failure was the only mechanical or structural failure in the aircraft, it does not necessarily follow from this that the accident could not have been avoided despite such failure. It is, therefore, necessary to inquire into the activities of all those who were concerned with the flight before any decision may be reached upon that issue.

It is apparent that Trip 143 was dispatched from Knoxville in accordance with proper procedure. The United States Weather Bureau and PCA forecasts proved to be accurate within reasonable limits and weather conditions along the route remained above the minimums prescribed for contact flight.

PCA maintenance records indicated that the engines of NC 13359 had been maintained in an airworthy condition. In addition, the National Bureau of Standards in its report of the tear-down inspection of the right engine concluded that the engine had been properly maintained and that it was in good mechanical condition.

It is necessary to inquire whether Captain Wright took all steps that he might reasonably be expected to take in order to avert an accident after the right engine of the aircraft had failed. When the failure occurred, Captain Wright was faced with the necessity of making an immediate emergency decision. His decision was to feather the right propeller, apply additional power to the left engine, pass over the secondary high tension line, and

make a gradual left turn into the small valley which extends into the range of hills south of the airport. This was, of course, not the flight path which would normally be followed after such a take-off toward the southwest.

It appears that there were four other possible courses of action open to him. He might have attempted to land straight ahead, but this would have necessitated passing under both high tension lines. It is doubtful that a safe landing could have been effected in this manner, inasmuch as a New York Central Railroad roadbed and the Kanawha River were directly in his flight path. He might have attempted to make a left turn over the river before reaching either high tension line so as to proceed eastward up the Kanawha Valley. This would have involved a steep bank at a dangerously low altitude and air speed and it is doubtful whether there was sufficient room for the turn between the point at which the right engine failed and the hills to the south of the Kanawha River. Also, he might have climbed straight ahead over both high tension lines, attempting to follow the normal flight path after such a take-off. This would have been a hazardous undertaking under the circumstances and might have resulted in striking the primary high tension line. Lastly, he might have attempted a right turn, but this would also have involved great danger of striking the primary high tension line.
In view of the above, it seems that the decision made by Captain Wright was a wise one.

From his testimony it appears that Captain Wright thought, on the basis of PCA instructions, that he could not safely operate the engines after take-off at a manifold pressure in excess of 34 inches and that, if he exceeded this amount of power for an appreciable length of time,

a structural failure might result. Captain Wright increased the manifold pressure to 36-1/2 inches for a few seconds in order to clear the secondary high tension line. Thirty-four inches of manifold pressure were used in the left engine after the airplane had cleared this line. The aircraft airworthiness certificate of the airplane authorized operation of the engines at maximums of 35-1/2 inches of manifold pressure for one minute during take-off and 35 inches for cruising at sea level. The manifold pressure maximum varied lineally from 35 inches for cruising at sea level to 33 inches for cruising at 8,000 feet. These limitations did not apply to emergency situations and the certificate did not specify what amount, if any, of additional power might be used in an emergency. Only when Captain Wright saw that a crash was imminent because of the steep rise of the terrain at the top of the valley did he again exercise his emergency powers under Section 61.7811 of the Civil Air Regulations[13/] and increase the manifold pressure above 34 inches. He increased it to 42-1/2 inches at this time and placed the airplane in a steep, climbing attitude so as to make a stall landing into the trees on the side of the ridge. This, he believed, was the course involving the least possible danger.

The PCA Superintendent of Maintenance testified that "34 inches /of manifold pressure/ at 2200 r.p.m. is normal take-off power. However, instructions are also set up that for maximum power 35-1/2 inches at 2200 r.p.m. is permissible." He further stated that he believed "the engine could be operated at short intervals up to 40 inches" manifold pressure and that the engine "could be used in

13/ This section provides:

"The first pilot is authorized, in emergency situations which require immediate decision and action, to resolve upon a course of action which is required by the factors and information available to him. He may, in such situations, deviate from prescribed methods, procedures or minimums to the extent required by considerations of safety. ....."

extreme emergency up to that /40 inches/, as a last resort, without giving any further thought than to avoid an accident."

Captain Wright had made three round-trip qualification flights as required by the Civil Air Regulations over the route from Knoxville to Pittsburgh on March 20-21, 22-23, and 25-26, 1941, and had made at least seven round-trip scheduled flights over the route during April. It appeared from his testimony, however, that he was not sufficiently familiar with the terrain in the vicinity of the Charleston Municipal Airport and had not previously acquainted himself with the narrow valley as a possible outlet in case of a power plant failure such as occurred. In fact he stated: "...We do not generally fly in that valley, so I was not familiar with the terrain and the sudden rise, of course, that we encountered." He testified, in effect, that he thought that the character of the terrain into which he was proceeding would require him to fly 15 or 20 miles before reaching the Kanawha River Valley on his return to the airport. As a matter of fact, the small valley extended for less than three miles before it ended in the ridges which were the highest obstructions in Captain Wright's path. If Captain Wright had cleared the ridge on which the accident occurred he would have had to fly only two miles over descending terrain to reach the Kanawha Valley.

The Civil Aeronautics Act of 1938 recognizes "the duty resting upon air carriers to perform their services with the highest possible degree of safety in the public interest."[14/] The operations and pilot manuals issued by PCA and in effect at the time of the accident did not contain any instructions to flight personnel as to the amount of

14/ Section 601(b).

power which might be obtained under emergency conditions from the type of engine involved. Nor did they contain any instructions requiring that pilots be familiar with the terrain and elevations in the vicinity of airports. It is the opinion of the Board that PCA should have issued such instructions to its pilots in an effort to achieve that "highest possible degree of safety" referred to in the Act.15/

It is probable that, if Captain Wright had been instructed as to the amount of power which could be used for short intervals in an emergency and had known the terrain over which he was forced to fly, he would have cleared the ridge on which the accident occurred.

The Charleston Municipal Airport presents conditions of great hazard to a pilot in case of an engine failure in take-off towards the west or southwest. The primary and secondary high tension lines form very prominent obstructions, and the ridges to the south and southwest are so close to the airport that any attempt during single-engine operation to make a left turn and proceed eastward up the Kanawha Valley would be attended by serious risks. Although the municipal officers of the City of Charleston have recognized the hazards incident to operation into and out of the present airport and have considered various sites for a new airport, no new site has been finally selected.

15/ The Board is considering an amendment to Part 40 of the Civil Air Regulations to clarify the obligation of air carriers to require their pilots to have knowledge of the terrain over which they fly.

It was revealed during the course of the investigation that, while PCA required in the use of Douglas DC-3 airplanes a definite established cockpit procedure by which the captain and first officer checked with each other the setting of various navigation instruments and the operation of the cockpit controls, no such procedure was required by the company in the use of its Boeing Model 247D airplanes. A "check list" was not used by Captain Wright and First Officer Riley prior to and during the take-off at Charleston. Although the record does not indicate that this failure to use a "check list" had any bearing on the accident, such failure might well contribute to accidents of a similar nature in the future.

CONCLUSIONS

We find upon all the evidence available to the Board at this time that the facts relating to the accident involving aircraft of United States registry NC 13359 which occurred near Charleston, West Virginia, on April 16, 1941, were as follows:

1. The accident, which occurred at approximately 4:33 p.m. (EST) on April 16, 1941, to PCA Trip 143 of that date, resulted in the destruction of the aircraft, serious injuries to one member of the crew and two passengers, and minor injuries to one member of the crew and the other four passengers.

2. At the time of the accident PCA held a certificate of public convenience and necessity and an air carrier operating certificate, authorizing it to conduct the flight.

3. Captain Wright and First Officer Riley were physically qualified and held proper certificates of competency to operate as air carrier pilots over the route between Birmingham, Alabama, and Pittsburgh, Pennsylvania, via intermediate points.

4. Aircraft NC 13359 was currently certificated as airworthy at the time of the accident.

5. Trip 143 was cleared in accordance with proper procedure from Knoxville, Tennessee, to Pittsburgh, Pennsylvania.

6. At the time of the departure from Knoxville, Tennessee, and at the time of the accident, the gross weight of the aircraft did not exceed the permissible gross weight.

7. Trip 143 operated normally from Knoxville, Tennessee, to Charleston, West Virginia.

8. The weather along the route from Knoxville, Tennessee, to Pittsburgh, Pennsylvania, was above the minimums specified for contact flight operations and had no bearing on the accident.

9. At the time of departure from Charleston, West Virginia, the aircraft carried sufficient fuel to permit flight at normal cruising power for slightly more than three hours.

10. Captain Wright was flying the aircraft during the take-off and at the time of the accident at Charleston, West Virginia.

11. Aircraft NC 13359 and all of its equipment were functioning normally until the take-off was started at Charleston.

12. About five seconds after the airplane left the ground at the Municipal Airport at Charleston, the right engine failed.

13. Following the failure of the right engine Captain Wright turned the airplane to the left and flew up a narrow valley for a distance of about two miles before the valley ended abruptly in a ridge covered with timber. Being unable to clear the ridge, Captain Wright stalled the airplane and pancaked it into the trees on the side of the ridge.

14. PCA had not established adequate procedures to require its pilots to be familiar with the terrain surrounding airports, and Captain Wright was not sufficiently familiar with the terrain surrounding the Charleston Municipal Airport to deal adequately with the emergency with which he was faced.

15. PCA had not informed its pilots of the maximum power which could be taken under emergency conditions from Pratt & Whitney Wasp S1H1-G engines, and Captain Wright was not familiar with the amount of power which could be obtained from the engine in the emergency.

16. A tear-down inspection of the engine, together with a complete examination of the fuel system, failed to disclose any reason for the engine failure. Although two small pieces of rag, one 1-1/2 inches long and 1 inch wide and the other 3 inches long and 1/4 inch wide, were found in the carburetor grid, subsequent tests revealed that the presence of such rags in the grid would not cause any malfunctioning of the engines.

17. The high tension lines and hills which surround the Charleston Municipal Airport are definite hazards 16/ in case of a complete or partial power plant failure during a take-off toward the west or southwest in an air carrier airplane.

PROBABLE CAUSE:

Loss of power in the right engine due to causes unknown.

CONTRIBUTING FACTORS:

1. Failure of PCA to establish adequate procedures to require its pilots to be familiar with the terrain surrounding airports, and failure of Captain Wright to familiarize himself adequately with the terrain surrounding the Charleston Municipal Airport.

2. Failure of PCA to inform its pilots of the amount of power which could reasonably be taken from Pratt and Whitney Wasp S1H1-G engines under emergency conditions, and the consequent hesitancy of Captain Wright to exercise his emergency authority and use additional power soon enough to clear the ridge.

RECOMMENDATIONS:

As a result of the investigation of this accident the Civil Aeronautics Board recommends to the Administrator of Civil Aeronautics, unless appropriate action has already been taken:

16/ Where state public utility regulatory commissions are empowered to require public utilities to maintain safe facilities and to remove such as are unsafe, the elimination of hazardous power, telegraph or telephone lines obstructing airport approaches is made possible by action of these state agencies. The expense is borne by the public utility involved which is permitted to recover the cost through consumers' rates. The Pennsylvania Public Utility Commission, pursuant to such a policy, recently accomplished the removal of telephone and telegraph lines from the airport approaches at four different airports of that state.

1. That the Administrator give consideration to the question whether restrictions on the basis of the gross weight of the airplanes, wind direction, and wind velocity, should be imposed upon take-offs by air carrier aircraft from the Charleston Municipal Airport.

2. That the Administrator make certain that air carriers discharge their responsibility to provide adequate operating instructions for their pilots by

(a) Requiring air carriers to include in operations or pilot manuals a sketch of each regular and alternate airport indicating heights of obstructions and elevation of terrain within a radius of ten miles of the airport;

(b) Requiring air carriers to include in operations or pilot manuals instructions setting forth the amount of power which can reasonably be taken from engines under emergency conditions; and

(c) Requiring air carriers to provide and require the use of a cockpit "check list" for each type of aircraft operated by them, and to provide appropriate instructions governing the use of such "check list" by pilots.

3. That the Administrator indicate in the aircraft operation record for air carrier aircraft that the engine limitations therein prescribed are not applicable in the event of an emergency.

/s/ Harllee Branch

Harllee Branch

/s/ Edward Warner

Edward Warner

/s/ Oswald Ryan

Oswald Ryan

/s/ G. Grant Mason, Jr.

G. Grant Mason, Jr.

/s/ George P. Baker

George P. Baker

APPENDIX A

Engine Operation Limitations for NC 13359

On April 5, 1939, the Civil Aeronautics Authority specified in the operation limitations, which were made a part of the aircraft airworthiness certificate of NC 13359, that the engine maximums should be as follows:

	In. Hg.	R.P.M.	H.P.
Maximum, except take-off	33	2200	550
Take-off (1 min.)	35½	2200	550

By Aircraft Specification No. 558, issued by the Civil Aeronautics Administration on September 6, 1940, the following limitations on the use of Pratt & Whitney Wasp S1H1-G engines in Boeing Model 247D airplanes were specified:

Placard limits

Maximum, except take-off
8000 ft., 33.0 in. Hg., 2200 r.p.m. (550 h.p.)
Sea level, 35.0 in. Hg., 2200 r.p.m. (550 h.p.)

Take-off (one minute)
35.5 in. Hg., 2200 r.p.m. (550 h.p.)
34.0 in. Hg., 2100 r.p.m. (510 h.p.)

On October 22, 1940, the engine maximums specified in the aircraft airworthiness certificate of NC 13359 were revised to be as follows:

	Press Alt.	In. Hg.	R.P.M.	H.P.
Take-off 1 min.		35½	2200	550
Maximum except take-off	Sea level	35	2200	550
Maximum except take-off	8,000 feet	33	2200	550