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# Aircraft Accident Report - Rupp Automotive, Inc., Beechcraft Baron 58, N1553W, Chillicothe Municipal Airport, Chillicothe, Missouri, August 3, 1976

National Transportation Safety Board, Washington, D C

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16. Abstract


About 2116 c.d.t. on August 3, 1976, a Rupp Automotive, Inc., Beechcraft Baron 58 crashed after takeoff from the Chillicothe Municipal Airport, Chillicothe, Missouri. All occupants--the pilot and five passengers--died in the crash. The aircraft was destroyed.

At the airport, the night sky was dark, but clear, and the visibility was about 15 miles. After takeoff, the aircraft climbed to an altitude of between 50 and 100 feet above the runway where the left engine failed. The aircraft turned to the left, descended abruptly into a field, exploded, and burned.

The National Transportation Safety Board determines that the probable cause of this accident was the sudden failure of the airplane's left engine at a point on the takeoff flightpath where the airplane's single-engine performance in the takeoff configuration and its height above the ground combined to make the pilot's ability to sustain flight marginal. The pilot's failure to retract the landing gear and control the airplane to maintain a safe airspeed contributed to the accident and were factors in causing the high acceleration loads when the airplane struck the ground.


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TABLE OF CONTENTS


| | | Page |
|---|---|---|
| | Synopsis | 1 |
| 1. | Investigation | 2 |
| 1.1 | History of Flight | 2 |
| 1.2 | Injuries to Persons | 2 |
| 1.3 | Damage to Aircraft | 2 |
| 1.4 | Other Damage | 2 |
| 1.5 | Crew Information | 3 |
| 1.6 | Aircraft Information | 3 |
| 1.7 | Meteorological Information | 3 |
| 1.8 | Aids to Navigation | 4 |
| 1.9 | Communications | 4 |
| 1.10 | Aerodrome and Ground Facilities | 4 |
| 1.11 | Flight Recorders | 4 |
| 1.12 | Wreckage | 4 |
| 1.13 | Medical and Pathological Information | 7 |
| 1.14 | Fire | 8 |
| 1.15 | Survival Aspects | 8 |
| 1.16 | Tests and Research | 8 |
| 1.16.1 | Flight Tests | 8 |
| 1.16.2 | Crankshaft | 9 |
| 1.16.3 | Engine Manufacturer's Tests | 9 |
| 1.17 | Other Information | 10 |
| 1.17.1 | Single-Engine Operation Procedures | 10 |
| 1.17.2 | Aircraft Performance | 11 |
| 1.17.3 | Crankshaft Statistics | 13 |
| 1.18 | New Investigative Techniques | 13 |
| 2. | Analysis and Conclusions | 13 |
| 2.1 | Analysis | 13 |
| 2.2 | Conclusions | 17 |
| | (a) Findings | 19 |
| | (b) Probable Cause | |
| 3. | Recommendations | 19 |
| | Appendixes | |
| | Appenoix A - Investigation and Hearing | 21 |
| | Appendix B - Crew Information | 22 |

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

# AIRCRAFT ACCIDENT REPORT

Adopted: June 16, 1977

RUPP AUTOMOTIVE. INC.
BEECHCRAFT BARON 58, N1553W
LHILLICOTHE MUNICIPAL AIRPORT
CHILLICOTHE, MISSOURI
AUGUST 3, 1976

## SYNGPSIS


About 2116 c.d.t. on August 3, 1976, a Rupp Automotive, Tnc., Beechcraft Baron 58 crashed after takeoff from the Chillicothe Municipal Airport, Chillicothe, Missouri. All occupants--the pilot and five passengers--died in the crash. The aircraft was destroyed.

At the airport, the night sky was dark but clear and the visibility was about 15 miles. After takeoff, the aircraft climbed to an altitude of between 50 and 100 feet above the runway where the left engine failed. The aircraft turned to the left, descended abruptly into a field, exploded, and burned.

The National Transportation Safety Board determines that the probable cause of this accident was the sudden failure of the airplane's left engine at a point on the takeoff flightpath where the airplane's single-engine performance in the takeoff configuration and its height above the ground combined to make the pilot's ability to sustain flight marginal. The pilot's failure to retract the landing gear and control the airplane to maintain a safe airspeed contributed to the accident and were factors in causing the high acceleration loads when the airplane struck the ground.

# 1. INVESTIGATION

## 1.1 History of Flight

On August 3, 1976, the pilot of a Rupp Automotive, Inc., Beechcraft Baron 58, N1553W, was operating the aircraft on a noncommercial passenger flight from the Chillicothe Municipal Airport, Chillicothe, Missouri, to Kansas City, Missouri. In addition to the pilot, there were five passengers aboard the aircraft.

At 1658 1/, the pilot checked the weather and filed an instrument flight rules (IFR) flight plan with the Columbia. Missouri, flight service station. He estimated his time of departure from Chillicothe to be 2100 and his time en route to Kansas City as 20 minutes. The pilot intended to activate the flight plan after departing Chillicothe Airport because the airport had no air traffic control facilities.

About 2110, witnesses saw the pilot taxi the aircraft to the approach end of runway 14. One witless noted that the pilot stopped the aircraft on the approach taxiway and performed pretakeoff checks. About 2115, they saw the aircraft roll down runway 14 and take off with no apparent problems. According to one witness, he lact saw the aircraft climbing normally at an altitude of 100 to 150 feet above the runway. His attention was momentarily diverted by another witness, but after hearing a popping sound, he turned and looked for the aircraft. He did not see it, but instead saw a ball of fire east of the airport.

The accident occurred at night (about 2116), at an elevation of 780 feet m.s.l., and at latitude 39° 47' N. and longitude 90° 30' W.

## 1.2 Injuries to Persons

| Injuries | Crew | Passengers | Other |
|---|---|---|---|
| Fatal | 1 | 5 | 0 |
| Nonfatal | 0 | 0 | 0 |
| None | 0 | 0 | |

## 1.3 Damage to Aircraft

The aircraft was destroyed.

## 1.4 Other Damage

Portions of a soybean field and a wire fence were substantially damaged.

1/ All times are central daylight, based on the 24-hour clock.

## 1.5 Crew Information

The pilot was qualified and certificated for the flight in accordance with current regulations. (See Appendix B.)

On the day of the accident, the pilot and his wife left the Lake of the Ozarks, Missouri, in N1553W in the early afternoon and arrived at Chillicothe Airport about 1400. They had spent the previous night at their vacation cottage in the Lake of the Ozarks.

## 1.6 Aircraft Information

N1553W, a Beechcraft Baron 58, serial No. 240, was owned by Rupp Automotive, Inc. It had operated a total of 1,135.4 hours since its date of manufacture, June 9, 1971. The last annual inspection was completed on August 14, 1975, and additional maintenance was accomplished on March 3, 1976.

N1553W was equipped with two Teledyne Continental Motors model IO-520-C piston engines. Each engine was equipped with a Hartzell, model BHC-J2YF-2CF, two-blade propeller. Both engines and propellers had accumulated 1,135.4 hours in service.

The engine log books indicated that neither engine had been overhauled since manufacture. The suggested time-between-overhauls for the IO-520-C engine is 1,500 hours. According to the logs, because of a cracked crankcase, major repairs had been made to the left engine in August 1975. The repairs involved the installation of a new crankcase, new main bearings, and new piston rings. The engine had operated 237.4 hours since these repairs were made.

N1553W had been last serviced with 46 gallons of 100-octane aviation gasoline; it had 172 gallons of fuel in its tanks. Its certificated maximum gross weight for takeoff was 5,400 lbs. Using approximate passenger weights, known passenger seating locations, and approximate baggage weights and locations, the gross weight of the aircraft at takeoff was estimated to have been 5,496 lbs., and its center of gravity was near the center of prescribed limits.

## 1.7 Meteorological Information

The National Weather Service did not have a weather observation station a Chillicothe; therefore, no official observations were available. Nearby stations, including Kansas City, were reporting clear skies, visibilities of 10 to 15 miles, temperatures from 78° F. to 83° F., and light (6-to 7-kn) surface winds from the east, southeast, or southwest.

According to witnesses at Chillicothe Airport, the night sky was dark, but clear, and the winds were light from the south.

**1.8** Aids to Navigation

Not involved.

**1.9** Communications

Chillicothe Airport is an uncontrolled airport. There were no reported radio traasmissions from N1553W.

1.10 Aerodrome and Ground Facilities

The Chillicothe Municipal Airport has three runways, only one of which is hard-surfaced--runway ***14-32.*** This runway is 3,200 feet long and 100 feet wide, and is equipped with medium intensity runway edge lights. The lights were on at the time of the acciient. The airport elevation is **780** feet m.s.l.

1.11 Flight Recorders

Flight recorders were not installed in the aircraft, nor were they required.

1.12 Wreckage

N1553W struck the ground in a right wing-low and slightly nose-low attitude on a magnetic heading of about 110°. After first impact, the aircraft rotated left to a magnetic heading of about **060"** and came to rest in about **30** feet. The wreckage site was about 1/4 mile east-southeast **of** the departure end of runway *14.*

The aircraft remained essentially intact, but was severely damaged by impact forces and fire. The landing gears were extended and were broken from their mounting structure. The wing flaps were retracted. The flight control cables were intact from the cockpit to each control surface. The rudder was in the full right position, and the trim tab was positioned 3' to the left. The elevator trim tab was positioned 6° down.

The pilot's control column remained within the center instrument panel, and was selected for left seat operation. The control wheel was rotated fully right to the right aileron up position. Both fuel selectors were in the main tank position.

The throttles and propeller pitch control levers for both engines were in the cruise position. The mixture controls for the left and right engines were in the full rich position and the lean position. respectively.

The top and side structure of the fuselage from about fuselage station (FS) 58 aft to FS 179 was consumed by fire down to the floor structure. The skin of the upper left side of the fuselage down to the rear window sill was consumed by fire from FS 131 aft to FS 179 and the lower akin was severely burned from FS 131 to FS 207. The upper fuselage skin structure over the baggage compartment was almost completely consumed by fire.

The two front seats (crew seats) had separated from their track assemblies, and both seat backs had separated from their bottom structures. The seats were damaged extensively by impact forces and fire. The two center (aft facing) seats remained intact and attached to their support structures. They were damaged extensively by fire and heat. The two rear seats had separated from their support structures, and they were severely damaged by impact forces and fire--their backs had separated from their bottom structures.

The under surface of the fuselage was crushed severely and was discolored from exposure to heat.

Engines - Both engines were intact, but were extensively damaged by fire. The cylinders were externally intact and remained attached to their crankcases. The spark plugs were intact and in normal condition, and the ignition harnesses were intact but damaged by heat. The oil tank filler caps were securely fastened. The fuel injector lines. oil lines, and fuel flow dividers were all intact and securely fastened.

Samples of oil sludge from each engine's propeller oil passageway were sent to the Federal Bureau of Investigation for analysis, and fuel samples were analyzed by a commercial laboratory. There was no evidence that any of the samples contained contaminants.

The engine accessories were intact, but damaged by fire and heat. There was no evidence of failure or malfunction in any of these components.

The induction tubes for each cylinder, the manifold assemblies, elbow tube assemblies. and lower portions of the air throttle assemblies were compressed toward the top of the engines. Also, the oil sump cases were crushed and flattened and the crankcase assemblies were broken and compressed inward.

The crankshaft on the left engine was broken at the No. 7 crankcheek. The four crankshaft counterweights moved freely and were not worn. The camshaft was broken at two locations. One break was at the No. 5 intake valve cam lobe radius; the other was at the center of the No. 3 cam bearing journal.

The connecting rods were intact and undamaged, except the No. 5 rod was twisted to a longitudinal position and the No. 6 rod was damaged at the fillet edge. The rod bearings were in normal condition except the No. 5 bearing was scored and the No. 6 bearing was severely polished at its front and rear edges. The running surfaces of the main bearings were in normal condition.

The pistons and connecting rods were removed and weighed. All were within specified tolerances. The cylinder bores, the intake valves, and the exhaust valves were in normal condition.

The crankshaft on the right engine was intact except for a forward portion that was broken off with the propeller and its mounting flange. A magnaflux examination disclosed minor cracks in the shaft behind the oil slinger flange which was adjacent to the propeller mounting flange fracture. There were no other cracks or abnormalities in the crankshaft assembly, including the connecting rod and crank journals.

The cylinder bores were in normal condition. except the Nos. 1 and 3 bores had significantly greater degrees of scoring on their piston thrust faces. The Nos. 1 and 3 piston skirts were heavily scored and their oil scraper rings were abnormally worn. All six pistons had considerable amounts of carbon deposits on their domes and they were discolored. The discoloration was typical of that associated with high engine operating temperatures, which might have occurred anytime during the engine's operating history.

The main bearings, connecting rod bearings, connecting rods, camshaft, intake valves, and exhaust valves were in normal condition.

Propellers - The left propeller was broken from the engine crankshaft about 1/2 inch rearward of the aft face of the propeller mounting flange, and it was lying about 3 1/2 feet forward of the left horizontal stabilizer. The break was almost perpendicular to the flange and it displayed no torsional failure characteristics. The camber and flat faces of the blades were not scratched. Both blades were intact and were attached to the propeller hub, but the outer 12 inches of one blade was buried almost perpendicularly in the ground.

The chord line of the buried blade, at the surface of the ground, was aligned approximately with the aircraft's heading at initial inpact, and the ground surrounding the blade was not disturbed in a manner that would suggest the blade had twisted in the ground after impact. Between the propeller hub and midspan of the blade, the blade was bent at a 90" angle to the plane formed by the chord line and the axis of the blade.

The spinner was attached to the propeller hub, but it was damaged to the extent that the outline of the propeller cylinder and blade counterweights were visible. The propeller cylinder contained an air charge of 80° psi. The location of the blade. counterweight outlines related to nominal blade angles of 21°. The automatic high pitch stop (centrifugal responsive) pins 2/ were not damaged **or** deformed. The pitch change mechanism functioned normally.

The propeller gsvernor was functionally tested. Relief valve, underspeed, on speed, overspeed, and feathering operations were satisfactory.

The right propeller was broken from its crankshaft mounting flange about 2 1/2 inches aft of the rear face of its mounting flange. The break was shaped irregularly and it exhibited some torsional failure characteristics. The propeller was lying about *6* feet aft and *4* **1/2** feet to the right of the right horizontal stabilizer.

The spinner was attached to the propeller hub, but it was crushed inward to the extent that a portion of the outline of the propeller cylinder and the blade counterweights were visible. The counterweights were imbedded in the cylinder. Contact marks on the cylinder corresponded to nominal blade angles of ***14*** **1/2°.** The cylinder was charged with air to a pressure of ***80*** psi.

The propeller blades were intact. One blade was bent rearward, and the other was twisted from midspan to tip. The camber and flat surfaces of the tips of both blades were scratched superficially in a direction parallel to the chord of the blades. The propeller governor was damaged and could not be functionally tested. It was disassembled and examined; there was **no** evidence of preexisting discrepancies.

## **1.13** Medical and Pathological Information

There was **no** evidence of any medical **or** physiological problems that. might have affected the pilot's performance. Although the pathologist who conducted the autopsy and heart examination was not **a** qualified aviation specialist, he was provided with standard instructions from Civil Aeromedical Institute (CAMI). Additionally, t'ne heart and heart tissues were examined at CAMI. Neither heart examination disclosed any problems. However, the toxicological tests **on** the heart tissues conducted by CAMI disclosed chat the specimens were unsuitable **for** analysis. **All** occupants were severely burned, and they died from either impact injuries or severe burns.

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*2/* According to the Hartzell Propeller Owner's Manual Logbook, "...the propeller **is** prevented from feathering, when it **is** stationary, by, centrifugal responsive pins, which engage a shoulder on the piston rod. These pins move out by centrifugal force against springs, when the propeller turns at over **700** rpm.

1.14 Fire

According to witnesses, there was no in-flight fire. After impact, fire erupted and major portions of the aircraft were consumed by fire. According to witnesses who arrived at the crash sire about 4 to 5 minutes after the impact, the fire was too intense to attempt rescue efforts.

1.15 Survival Aspects

The accident was not survivable because of high impact forces and the immediate, intense fire which was fed by 100-octane aviation gasoline.

Firefighting equipment was not located at the airport and none was required. The Chillicothe Fire Department was notified of the accident about 5 minutes after the crash, and its personnel arrived at the crash site about 10 minutes later. They extinguished the fire shortly thereafter.

1.16 Tests and Research

1.16.1 Flight Tests

Flight tests were conducted in a Beechcraft Baron 58 to verify the data in the airplane flight manual. The test aircraft weighed 5,379 lbs.and its c.g. was slightly aft of the center of prescribed limits at 82.56 inches aft of the datum. The tests were conducted at a pressure altitude of about 3,200 feet where the ambient air temperature was 58°F.

With the aircraft in the normal takeoff configuration (landing gear down and flaps up) and engines at full throttle (26 inHg and 2,700 rpm), the pitch attitude on the attitude indicator was about 15° to maintain an indicated airspeed of 102 mph--normal takeoff speed. The left engine was shutdown (mixture control off) and the propeller was not feathered. With a constant pitch attitude of 15°, the airspeed decayed from 102 mph to 90 mph 5.2 seconds after the engine shutdown. Stall indications occurred, but directional control was maintained at 90 mph.

With the same initial configuration, a descent rate of 100 to 200 fpm was needed to maintain a constant airspeed of 102 mph after the left engine was shutdown.

With the same initial configuration, the time was recorded to complete the "Engine Failure After Lift-off" procedure in the flight manual. The elapsed time from mixture off on the left engine to complete feathering of the propeller was 12.9 seconds. The aircraft's pitch attitude was changed from about 15" to 9° to maintain an indicated airspeed at 102 mph. The aircraft climbed about 20 feet during this test.

With the same initial configuration, the flight manual's "Engine Failure After Lift-off" procedure was repeated but the best single engine rate of climb airspeed (117 mph) was maintained throughcut the test. The elapsed time from mixture off to complete feathering of the propeller was 12.4 seconds. The aircraft's pitch attitude was changed from about 13° to 8° to maintain 117 mph. The aircraft climbed about 50 feet during this test. During these tests, the landing gear retracted in about 4 seconds.

1.16.2 Crankshaft

The crankshaft from the left engine of N1553W was examined in the Safety Board's metallurgical labrratory. The shaft contained a fracture through the No. 7 crankcheek. which is located between the No. 3 main bearing journal and the No. 5 connecting rod crankpin. The surfaces of the fracture exhibited characteristics of a fatigue crack that had originated below the forward radius of the No. 3 main bearing journal. This crack extended forward through the crankcheek. The two fracture surfaces of the broken crankcheek were mechanically damaged as if they had recontacted each other during postfracture rotation of the two portions of the crankshaft. Although this damage obliterated most of the fracture features near the terminus of the fatigue area, the fracture surfaces contained markings which indicated that the fatigue crack had propagated nearly through the crankcheek before the crankcheek finally separated.

Examination of the origin of the cracks with a scanning electron microscope disclosed that the fracture began from a small area 0.06 inch below the surface of the radius. An X-ray energy dispersive analysis of the origin of the crack disclosed no foreign elements or large inclusions which could be associated with a stress raiser. The spectrums generated were consistent with the prescribed crankshaft material--4340 modified steel. A metallographic microsection through the origin of the crack disclosed a normal microstructure for nitrided case hardened material and its underlying core.

Core hardness tests, nitrided case depth measurements, and all measurable dimensions of the crankshaft were within specified tolerances.

1.16.3 Engine Manufacturer's Tests

After the accident, the engine manufacturer employed consultants to review its processes for crankshaft material selection, forging, manufacturing, and heat treatment. No deficiencies were reported.

Static operating stress tests were conducted on an instrumented IO-520-C crankshaft. These tests included normal operating cylinder pressures and abnormal operating pressures approximately twice the normal pressures. None of the stresses measured approached stresses that would initiate a fatigue crack in the crankshaft.

A test was conducted to determine whether an abnormally hot alternator, which is attached to the crankcase forward of the No. 5 cylinder, could distort the crankcase and bend the crankshaft. The base casting of a 100-amp alternator was heated from 70°F to 500°F in 2.8 minutes. The hot base casting produced no binding between the crankshaft and its bearings, and there were no measurable stresses on the instrumented crankshaft.

Dynamic tests were conducted on an instrumented TSIO-520-L engine which uses the same crankshaft, crankcase, and cylinders as the IO-520-C engine. These tests included the measurement of stresses produced by improper ignition timing, turbocharging (higher manifold pressures), crossed spark plug leads (to simulate the effect of internal arcing in a magneto). throttle bursts and chops, "kickbacks" during starting, and engine overspeed (to 2,900 rpm). None of the stresses measured approached stresses that would initiate a fatigue crack in the crankshaft.

Tests were conducted to determine whether propeller shaft bending induced by vibrations or aircraft maneuvering loads might significantly affect crankshaft stresses. The tests produced no significant increase in crankshaft stresses in the area where the crankshait broke.

## 1.17 Other Information

### 1.17.1 Single-Engine Operation Procedures

The flight manual contained considerable information on single-engine operation, including the symptoms of the loss of an engine and techniques for coping with the loss. The manual emphasized the need to maintain airspeed at or above the minimum control airspeed ($V_{mc}$) of 94 mph, and it specified the best rate-of-climb and best angle-of-climb airspeeds as 117 mph and 111 mph, respectively.

The flight manual contained, among others, the following engine failure procedure:

> "ENGINE FAILURE AFTER LIFT-OFF--The most important aspect of engine failure is the necessity to maintain lateral and directional control, and to achieve and maintain normal take-off speed or above. The following procedures provide for minimum diversion of attention while flying the airplane."

NOTE

"If airspeed **is** below *94* mph/82 kts. reduce power on operative engine as required to maintain lateral and directional contrcl.

1. Landing Gear and Flaps - *UP*
2. Throttle (inoperative engine) - CLOSED
3. Propeller (inoperative engine) - FEATHERED
4. Power (operative engine) - AS REQUIRED
5. Airspeed - AT OR ABOVE NORMAL TAKE-OFF SPEED"

The flight manual contained a warning note to the effect that a single-engine go-around from a landing approach might not be possible for certain combinations of gross weight and density altitude, but it did not contain a similar warning note that level flight might not be possible in the takeoff conitguration with one engine inoperative and its propeller windmilling. Civil Air Regulations *(CAR)* Part 3 did not require any of this information and *14* CFR 23 requires information only on the single-engine go-around performance capability.

1.17.2 Aircraft Performance

With several exceptions, the Baron 58 was certificated in accordance with the standards of Part 3 of the CAR's as amended to May *15, 1956.* Under these regulations (and their successors in Par: 23 of the Federal Aviation Regulations), there was no requirement that airplanes of the normal or utility category be capable of climbing in the takeoff configuration with a critical engine inoperative and its propeller windmilling. In this respect, airplanes in the normal **or** utility category differ from transport category aircraft, except when the former (those that are capable of carrying more than 10 passengers) are used in air taxi or commercial operations. 3/ **In** such cases, if the airplane does not have the capability to climb in the takeoff configuration with a critical engine inoperative, its takeoff gross weight must be reduced until the airplane does have the capability.

Under certain conditions **of** gross weight, airspeed, and density altitude, the Baron 58 **is** capable of climbing in the takeoff configuration with one engine inoperative and its propeller windmilling. For instance, according to aircraft performance charts in the flight manual, on a standard day at a pressure altitude of 2,000 feet and. at a gross weight of **4,500** lbs., the Baron 58 can climb about 200 fpm at an indicated airspeed of 117 mph with one engine inoperative, its propeller windmilling, the power on the other engine at maximum continuous power, and the landing gear extended. However, under other conditions of gross weight, density altitude, or airspeed, the airplane **is** not capable of maintaining

3/ *14* CFR 135, Special Federal Aviation Regulation 23.

level flight in the same configuration, and the pilot must cause the airplane to descend to maintain airspeed at or above minimum control airspeed or he must comply with the "Engine Failure After Lift-off" procedure in the flight manual to maintain level flight or to climb.

According to Part 3 of the CAR's, minimum control airspeed ($V_{mc}$) is that minimum speed at which it is possible to recover control of the airplane after one of the engines suddenly has become inoperative at that speed. and it is the minimum speed at which control can be maintained in straight flight, with one engine still inoperative, either with zero yaw or with a bank angle of not more than 5°. $V_{mc}$ shall not exceed 1.3 times the aircraft's stall speed 4/ with: Takeoff or maximum available power on all engines, rearmost center of gravity, flaps in the takeoff position, and landing gear retracted. During recovery from the sudden loss of one engine. the airplane shall not assume any dangerous attitudes, nor shall it require exceptional skill, strength, or alertness on the part of the pilot to prevent a change of heading in excess of 20" before recovery is complete.

According to the flight manual's performance charts, and based on N1553W's gross weight and the atmospheric conditions that existed on the night of the accident, N1553W's takeoff ground roll was about 1,560 feet and its takeoff distance to clear a 50-foot obstacle was about 1,900 feet. Normal takeoff speed was 102 mph and normal climb speed was 121 mph. N1553W's single-engine climb performance should have been about 300 fpm at an airspeed of 117 mph with the landing gear retracted and the propeller feathered on the inoperative engine. If the landing gear was extended, climb performance was degraded 200 fpm; if the propeller was windmilling. climb performance was degraded another 200 fpm.

N1553W's power-on stall speed at a gross weight of 5.400 lbs, and with landing gear and flaps up was 76 mph; its power-off stall speed in the same Configuration was 96 mph. For a normal stall recovery, the maximum altitude loss was 300 feet.

Considering N1553W's takeoff distance to a point 50 feet above the runway to have been about 1,900 feet. from that point, and at an average groundspeed of 95 mph, the aircraft would have been airborne about 19 seconds before it struck the ground about 1.320 feet from the departure end of the runway. If the aircraft had climbed another 50 feet above the runway at an average rate of climb of 800 fpm, from that point to impact, it would have been airborne about 15 seconds. Similarly, if the aircraft had climbed to 150 feet above the runway at an average rate of climb of 800 fpm from that point, it would have been airborne about 11 seconds before impact.

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4/ Not necessarily the aircraft's stall speed at its maximum certificated takeoff gross weight.

1.17.3 Crankshaft Statistics

The basic 10-520 engine was certified in 1963 with the part' No. 633620 crankshaft. Since then, various models of the engine have used the same crankshaft, and 15,018 crankshafts had been put into operation by August 31, 1976. The manufacturer estimated that the engines using these crankshafts have a unit life 5/ of 225,270 years, that 89,637 years of engine experience had been realized by August 31, 1976, and that 135.633 engine years remain.

From entry into service in 1963 to August 31, 1976, the manufacturer recorded a total of 86 failures of the part No. 633620 crankshaft. Of these crankshaft failures, 13, including N1553W's, failed at the No. 7 crankcheek because of the propagation by fatigue of a crack with a subsurface origin. According to the manufacturer, it discovered **no** reasons for the origination of the crocks.

Available records indicate that only 2 of the other 12 crankshafts had been involved in engine overhauls, and that engine operating times varied from a low of 183 hours to a high of 1,697 hours. The majority of the fractures to the No. 7 crankcheek occurred in engines with relatively low operating times--less than 600 hours. The other 73 crankshafts failed for a wide variety **of** reasons at widely varying hours of engine operation.

According to the Safety Board's records and the engine manufacturer's records, this accident was the only fatal accident related to an 19-520 engine failure because of a fracture in the No. 7 crankcheek of the part **No**. 633620 crankshaft.

**1.18** New Investigative Techniques

None

2. ANALYSIS AND CONCLUSIONS

2.1 Analysis

The pilot was certificated properly and was qualified for the flight. There was no evidence that medical or physiological problems might have affected his performance.

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5/ Unit life is based **on** 15 years of engine operation at about *200* hours operation per year. The manufacturer estimates that the crankshaft will be replaced during the second engine overhaul, **or** after about 3,000 hours of operation.

The aircraft was certificated, equipped. and maintained in accordance with regulations and approved procedures. Although the aircraft might have been slightly overweight when it departed Chillicothe Airport, this condition would not have significantly affected the aircraft's performance. A 100-pound overweight condition would have degraded the aircraft's single-engine climb performance about 30 fpm. There was no evidence of sabotage or in-flight fire, nor was there any evidence of flight control malfunction or structural failure before impact. The elevator and rudder trim settings were normal for the takeoff configuration.

The evidence indicates that the left engine failed shortly after the aircraft took off because the crankshaft broke at the No. 7 crankcheek. This is substantiated by the fatigue fracture characteristics of the break, the mechanical damage to the two portions of the No. 7 crankcheek, which continued to rotate after the crankshaft broke, and the damage to the No. 5 connecting rod. Also, the damage to, and the condition of, the left propeller indicates that it was rotating slowly or was not rotating at all when it struck the ground.

The crankcheek broke because a pre-existing fatigue crack propagated through the crankcheek and the cheek could no longer withstand the operating stresses imposed by the takeoff power demand on the engine. The Safety Board's metallurgical tests disclosed no material defects in the crankshaft, nor did the manufacturer's testing produce a probable operating stress that could have contributed to the initiation of the fatigue crack. Therefore, the cause of the crack's initiation was not determined. However, because no metallurgical defects existed, we believe that the crack probably was initiated by stresses inherent and applied; that is. by a combination of residual stresses (which probably were introduced sometime during the manufacturing process) and normal or abnormal operating stresses.

Although major repairs had been made to the left engine about a year before the accident, there is no evidence that these repairs affected the condition of the crankshaft. This is because the fatigue crack originated from a subsurface area rather than an area that might have been exposed and damaged during the course of the repair work.

The right engine continued to function properly after the left engine failed. The condition of the right propeller indicates that it was turning at a relatively high rpm at inpact but was not under full power from the engine. This condition is consistent with the pilot's apparent retention of lateral and directional control of the aircraft, which struck slightly right-wing low, because he probably reduced power on the right engine sometime shortly before impact in an effort to control the aircraft laterally and directionally.

The exact time at which the crankshaft broke was not determined. However, since the landing gear apparently remained extended until the aircraft struck the ground, the crankshaft probably broke before the pilot normally would have retracted the gear, or when the aircraft was somewhere between *50* and **100** feet above the runway. Consequently, the pilot probably was distracted fros initially retracting the gear by the failure of the left engine.

After the engine failed, the pilot apparently did not perform the first item **in** the "Engine Failure After Lift-off" procedure because the landing gears were extended in the wreckage. It is not known why he did not retract the gears, but under the circumstances, and where insufficient runway remains **on** which to land the aircraft, an almost instinctive reaction might have occurred: An immediate attempt to seek and correct the cause of the perceived engine malfunction and, in the process, to increase the aircraft's altitude by increasing the rate of climb at the expense of any excess airspeed. It is possible that this pilot reacted in such a manner.

**On** the other hand, considering (1) the possible elapsed time between engine failure and impact, (2) the rapid degradation in airspeed that occurs after **loss** of an engine if the landing gear are not retracted, the propeller feathered, or the pitch attitude decreased, and (3) the single-engine stall speed of **near 90** mph, the pilot had little time or altitude in which to recognize the problem and reepond with the appropriate corrective action. Additionally, the nighttime conditions probably would have made both recognition and response more difficult. If the aircraft entered the stall regime at 150 feet abcve the runway, **an** accident would have been unavoidable.

The left propeller apparently was at **or** near the feathered position when the aircraft struck the ground because: (1) The propeller was rotating slowly or was not rotating at all. (2) the chord line, near ground level, **of** the partially buried propeller blade was approximately aligned with the aircraft's impact heading, and (3) there was **no** apparent twisting of the blade in the ground after it had been buried into the ground. Although the left propeller blades were found at a pitch angle of **about 21°,** the Safety Board believes that the aircraft's left rotation after impact probably rotated the blades from a near feather angle (about 80°) to contact with the centrifugal responsive pins before the propeller broke from its shaft. **In** fact, the partially buried blade probably acted as an anchor which, coupled with the aircraft's forward momentum, produced the left turning moment **on** the aircraft after impact,

Considering the critical conditions with which the pilot was faced following failure of the crankshaft, and since he did not perfcrm the first item in the engine failure procedure, the Safety Board believes that the left propeller probably feathered automatically after the camshaft broke and disrupted the oil supply to the propeller governor. This disruption probably occurred several seconds after the crankshaft failed, and, during this time period, the propeller would have windmilled and would have produced a significant amount of drag. When combined with the extended landing gear, the aircraft's climb capability would have been reduced sustantially--possibly to as little as a negative 100 fpm at 117 mph. If the airspeed was less than 117 mph, the rate of descent could have been greater.

As the propeller moved toward the feather position, it would have produced less drag, which eventually should have enabled the pilot to establish a climb even with the landing gear extended if he had maintained the appropriate airspeed. However, since the aircraft struck the ground with considerably more force than would have been generated by a 100 fpm rate of descent, the Safety Board concludes that the pilot stalled the aircraft in an attempt to maintain altitude and avoid the ground. This conclusion is confirmed by the short distance the aircraft traveled after impact, the crushed and flattened underside of the fuselage and engines, and the impact damage to the pilots' and passengers' seats.

The Safety Board is concerned that such an engine failure can be catastrophic. We believe that 13 fractures in the same area of the No. 7 crankcheek for undetermined reasons are sufficient to indicate that a problem exists with this particular crankshaft. Because the reason for the initiation of the fatigue crack probatly involved a combination of residual stresses and operating stresses, we believe it important that the manufacturer continue its efforts to identify and eliminate the cause of the crack initiation. These efforts should include a complete analysis of residual stresses introduced during the manufacturing process. Furthermore, the Federal Aviation Administration should initiate a program: (1) For inspecting the. crankshafts from IO-520 series engines for cracks whenever the crankshafts are available for inspection, and (2) for reviewing the results of these inspections to determine whether any deficiencies exist in these engines.

However, because engines fail for many reasons, including a substantial number involving operator errcr, and to further reduce the possibility that catastrophic accidents of this kind will be repeated, we believe that improvements are needed in the information and training on single-engine performance that is provided to pilots of light twin-engine airplanes. Most pilots of these airplanes are probably aware that, under some combinations of gross weight, density altitude, and airspeed, the airplanes can maintain level flight or climb in the takeoff configuration with one engine inoperative and the propeller windmilling. These generally are the conditions which pilots are exposed to in training, initial checkouts, and flight checks. However, they may or may not know that under other conditions, the airplane will be unable. to climb or. maintain level flight in the takeoff configuration with one engine inoperative and its propeller windmilling. This is particularly true for high gross weights and high density altitudes--conditions that the average pilot is nut exposed to in training. Consequently, a careful study and analysis of the airplane's performance charts, if available 6/, is required to determine the airplane's single-engine capabilities for a given set of conditions.

Many pilots might not fully appreciate the its significance of $V_{mc}$ as related to aircraft stall speeds with takeoff power on one engine. As shown in the Baron 58 flight tests. the single-engine stall speed in the takeoff configuration was near 90 mph, or quite close to the certificated $V_{mc}$ of 94 mph. Also, although the test aircraft was controllable at 90 mph, it is likely that lateral and directional control below $V_{mc}$ would be difficult to maintain with full power on one engine the lower density altitude existing at the time of the accident.

Therefore, to adequately cope with loss-of-engine emergencies, pilots of light. twin-engine airplanes must know the performance capability of their airplanes for each set of conditions. They must be mentally prepared on every takeoff and approach for the possibility of engine failure, and they must be capable of making appropriate go/no go decisions without prolonged thought. They must know the symptoms of the loss of an engine and they must know the appropriate corrective action. Above all, to maintain lateral and directional control, they must maintain airspeed above $V_{mc}$ by reducing the aircraft's pitch attitude, or they must reduce power on the operative engine. If they are unable to complete the emergency procedure, or otherwise maintain controlled level or climbing flight, they must be prepared to accept a controlled descent to the ground.

To aid pilots of light twin-engine aircraft in acquiring this knowledge and information. we believe that the flight manuals for these aircraft should contain single-engine performance data, and that it should contain performance charts for takeoff gross weights versus critical engine failure speed and runway lengths for various atmospheric conditions. Also, the flight manual should contain a warning, when applicable, that, under certain combinations of gross weight. density altitude, and airspeed, the aircraft will not be able to maintain level flight in the takeoff configuration with one engine inoperative and its propeller windmilling. Finally. pilots of these aircraft should be required to demonstrate their knowledge of single-engine performance during biannual flight reviews.

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6/ Under CAR, Part 3, as amended to May 15, 1956. a flight manual is not required for airplanes with a maximum certificated weight of 6,000 lbs. or less, nor is single-engine performance data required.

The Safety Board has issued recommendations (A-76-97 through 100) concerning revision of approved flight manuals and pilot handbooks to reflect specific single-engine performance data and procedures, revision of certain advisory circulars concerning simulated and actual engine-out emergencies, and issuance of others in these areas. We are also aware of FAA's current proposed rule changes which. if adopted, would result in improved and updated airworthiness standards applicable to aircraft performance. flight characteristics, flight manuals, and operating limitations and information. The Safety Board believes this accident illustrates further the need for early accomplishment of these measures to insure that this critical information is available to all pilots.

## 2.2 Conclusions

### (a) Findings

1. Neither weather nor air traffic control were factors in this accident.

2. When the aircraft was between 50 and 100 feet above the runway, its left engine failed because the crankshaft broke at the No. 7 crankcheek.

3. The crankshaft broke because a pre-existing fatigue crack had propagated through the crankcheek and the cheek could no longer withstand normal operating stresses.

4. No material defects were found in the crankshaft that could have contributed to the initiation of the crack. The reason for the initiation of the crack was not determined, but it probably was initiated by a combination of residual stresses and operating stresses.

5. The right engine continued to function normally after the left engine failed.

6. According to performance charts and flight tests, the aircraft was capable of climbing about 300 fpm at 117 mph with one engine Inoperative, its propeller feathered, and the landing gear retracted.

7. According to performance charts and flight tests, the aircraft could not maintain level or climbing flight in the takeoff configuration with one engine inoperative and its propeller windmilling, and a descent of 100 to 200 fpm was required to maintain takeoff airspeed.

8. Following failure of the left engine, the pilot lost control of the aircraft because he permitted the airspeed to decrease below $V_{mc}$, and he permitted the aircraft to stall.

9. The pilot did not retract the landing gear either before or after the engine failed.

10. The left propeller probably feathered automatically after the camshaft broke; however, until the propeller blade angles had increased substantially, the propeller would have windmilled and would have produced significant drag.

11. The pilot's ability to maintain flight after the engine failed was marginal because of nighttime conditions, the aircraft's low altitude, and the aircraft's inability to climb or maintain level flight in the takeoff configuration with one engine inoperative and its propeller initially windmilling.

12. The accident was not survivable because of the high Impact forces generated by the high rate of descent and the fire that erupted after impact.

(b) Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the sudden failure of the airplane's left engine at a point on the takeoff flightpath where the airplane's single-engine performance in the takeoff configuration and its height above the ground combined to make the pilot's ability to sustain flight marginal. The pilot's failure to retract the landing gear and control the airplane to maintain a safe airspeed contributed to the accident and were factors in causing the high acceleration loads when the airplane struck the ground.

## RECOMMENDATIONS

As a result of this accident. the National Transportation Safety Board has recommended that the Federal Aviation Administration:

"Issue a maintenance alert bulletin to advise engine overhaul and repair facilities to inspect the 10–520 series crankshafts for incipient or developed cracks. preferably using an inspection means capable of detecting subsurface cracks, in the vicinity of the short crankcheeks any time that the crankshafts are available for inspection. (Class 11–Priority Followup) (A-77-43)

"Conduct a directed safety investigation consisting of a review of overhaul and repair facility inspection results to determine if the frequency and distribution of detected fatigue cracks indicates a deficiency in the 10–520 engine. (Class 11–Priority Followup) (A–77–44)"

BY THE NATIONAL TRANSPORTATION SAFETY BOARD.

/s/ WEBSTER B. TODD, JR.
Chairman

/s/ KAY BAILEY
Vice Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PHILIP A. HOGUE
Member

/s/ WILLIAM R. HALEY
Member

June 16, 1977

## APPENDIX A

## INVESTIGATION AND HEARING

### 1. Investigation

The National Transportation Safety Board was notified of the accident about 2145 on August 3, 1976. Investigators from the Kansas City Field Office proceeded immediately to the scene. Additional investigators from Washington, D.C., were sent later.

Investigative groups were established for structures/systems and powerplants. The Investigator-in-Charge was responsible for operations, air traffic control, witnesses, human factors, and maintenance records.

Parties to the investigation were: The Federal Aviation Administration, Teledyne Continental Motors, Beech Aircraft Corporation, and Hartzell Industries, Inc.

### 2. Public Hearing

No public hearing was held and no depositions were taken.

APPENDIX B

CREW INFORMATION

Paul L. Rupp, Jr.

Mr. Rupp, 44, held commercial certificate No. 1822179 with airplane single-engine land, multiengine land, and instrument ratings. He held a third-class medical certificate with no limitations which was issued October 2i. 1975.

Mr. Rupp passed his last biannual review on May 12, 1976. On that day, he also completed a refresher course in instrument flying which included 1 hour of ground school, 3 hours of simulator training, and 2.2 hours of flying in N1553W. During his flying career, Mr. Rupp had flown 2,288 hours, of which 2,012 hours were in multi-engine aircraft. He had flown 1,136 hours as pilot in command in the Beechcraft Baron 58, and he had flown 245 hours in instrument conditions and 202 hours at night.

During the 24-hour period preceding the accident, Mr. Rupp had flown 4 hours of which 0.6 hours were at night. In the 90-day period before the accident. he had flown 40 hours, including 4 hours at night and 2 hours in instrument conditions.