File No. 1-0134

CIVIL AERONAUTICS BOARD

AIRCRAFT ACCIDENT REPORT

ADOPTED: September 10, 1958 RELEASED: September 15, 1958

RIDDLE AIRLINES, INC., C-46R, N 3944C,
MIAMI, FLORIDA, AIRPORT, DECEMBER 20, 1957

The Accident

A Riddle Airlines C-46R, N 3944C, developed a powerplant fire during flight on December 20, 1957, about 1510.1/ It could not be extinguished and the aircraft returned to and landed at the Miami Airport from which it had taken off nine minutes earlier. Ground equipment smothered the fire as the two pilots deplaned uninjured. Damage to the aircraft was extensive.

History of the Flight

This was a scheduled cargo flight designated by Riddle as number 2 of the 20th, from Miami, Florida. It carried no cargo out of Miami; a stop was planned at Stuart, Florida, to load cargo for New York, New York.

A VFR flight plan was filed with Miami Air Traffic Control specifying direct flight from Miami to Stuart. Flight 2 left the Riddle ramp at 1500 after the usual predeparture check and runup.

Takeoff was normal from runway 9L at 1510 with a crew of Captain Otis E. McLendon and First Officer Sheldon Crocker. The aircraft's gross weight was less than the maximum allowable and the center of gravity was located within prescribed limits. Excellent weather prevailed.

At an altitude of 900-1,000 feet, an estimated two minutes after takeoff, the right engine's BMEP gauge suddenly dropped to zero. The aircraft did not yaw and the BMEP gauge returned to normal, except for fluctuations, after the right throttle was closed and opened. The right manifold pressure gauge dropped to about 30 inches (atmospheric) and subsequent throttle movement had no effect on that gauge. A few seconds later the right tachometer and right fuel flowmeter started fluctuating. Almost immediately the right engine fire warning lights came on for zones 1, 2, and 3. The captain closed the right throttle as the first officer reported fire in the right nacelle.

Captain McLendon actuated the firewall shutoff valve switch, feathered the right propeller, and actuated the No. 2 fire extinguisher switch. From the cockpit the fire seemed unaffected; the first officer so informed the captain and the latter told him to use the second charge of extinguisher. He actuated the No. 1 extinguisher switch; there was no apparent effect.

1/ All times herein are eastern standard based on the 24-hour clock.

Meanwhile, the tower observed smoke from the right engine. The flight was so informed and other traffic was advised to keep clear. A landing was authorized using any runway. Flight 2 landed on runway 17 with landing gear down and wing flaps extended, without further difficulty. It was met by tower-alerted airport fire apparatus which quickly had the fire under control.

Investigation

At about the time zones 1, 2, and 3 fire warning lights came on, the tower operator saw heavy black smoke trailing from the aircraft. Another qualified witness on the ground, nearly under the aircraft, also saw this heavy black smoke. The latter also saw a long heavy flame, possibly 8 or 10 feet long, coming from the engine's right side and lasting for about 20 seconds.

Both of these witnesses noticed that the heavy smoke soon disappeared although the tower operator saw continuing light white smoke. Heavy white smoke appeared while the aircraft was on the downwind leg for landing. But no more black heavy smoke or fire was observed until after the aircraft was on the runway when the right engine became enveloped in flame.

Examination, both external and internal, of the right engine's generator, starter, vacuum pump, hydraulic pump, fuel pump, fuel flowmeter, carburetor, and both the rear and blower sections revealed no evidence of malfunctioning, leakage, induction fire, or electrical arcing. The fire, in short, obviously did not originate in the engine proper which operated normally when subsequently tested.

Fire damage was general throughout zone 2. It was severe around the perimeter inside of the stainless steel cowling except for the bottom center portion, which was little damaged. Heavy fire concentration in the left upper area of zone 2 entered zone 3 by melting the dural support channel at the rear of the stainless steel firewall allowing the firewall to give way.

Heavy concentration of fire in the center and upper area of zone 2 penetrated zone 1 around the carburetor, through the fire diaphragm at the upper cowling slip joint. The lower surfaces of both wheelwell doors were soot-covered and the outer surface of the nacelle aft of zone 2 was slightly scoted but not fire-damaged on either side.

The No. 2 fire extinguisher bottle had discharged but the No. 1 bottle had not although its actuating switch safety wire had been broken.

The CAA approved drawing did not, through oversight, show grounding of the bottles to complete the electrical circuits. The mechanic who installed the bottles did not connect ground wires, not surmising that the terminals on the bottle cartridges were for that purpose. However, tests indicated proper electrical continuity in the No. 2 bottle circuit. This electrical continuity existed only because of accidental grounding where the bottle's paint had chafed to bare metal against supports. A fresh No. 1 bottle had been recently installed about a week before this accident and its new paint was nonconductive, accounting for it not functioning.

Fuel, oil, and hydraulic shutoff valves and the zone 2 airblast tube shutoff doors were found open. The circuits from the actuating switch in the cockpit to

the firewall shutoff valves and to the generator air blast tube door motor were protected by the same circuit breaker. The wire to the latter was found burned from the motor and also from the cannon plug, located near the center of the firewall. Both the motor and the actuator were fire-damaged. Little insulation remained on the wire. Also, wires to the valves were fire-damaged in zone 3. An automatic reset circuit breaker was incorporated in this circuitry; under test it functioned normally.

The fire detector system could not be functionally tested because of damage to the aluminum cannon plugs on the firewall. This system was also protected by an automatic reset-type circuit breaker.

All fuel, oil, and hydraulic lines in zone 2 were fire-damaged. The aluminum vacuum pump pressure lines were consumed and the line relief valve so damaged that nothing could be learned from it. The tachometer transmitter and the BMEP transmitter were damaged by severe external heat. No evidence of failure, malfunctioning, or electrical arcing of any of these lines or units prior to the fire was found except as hereafter mentioned.

Three zone 2 lines were ruptured, failed, or melted off. One, the hydraulic flexible pressure line from pump to firewall appeared ruptured near its center lower side and also appeared burned through at an adjacent point. This line was fitted with an aluminum alloy socket and nipple at the pump end and an aluminum nipple at the firewall end. A functional check of the aircraft's hydraulic system revealed no evidence of malfunctioning of the regulator or relief valves. Approximately one foot to the left and one foot forward of this hydraulic hose rupture, the fabric shield around the exhaust tail pipe support bracket tube had torn away, exposing a hole of about 1-1/2 inches through the cowling. The shield on the engine's right tail pipe bracket and both shields of the left nacelle were in a similar condition. The aft edge of the zone 2 cowling, approximately one foot to the left of this area and approximately eight inches to the rear and four inches above the exhaust tail pipe tip, fitted poorly and was slightly open.

The second line, the main fuel inlet flexible hose between the fuel flowmeter and the carburetor, fitted with an aluminum alloy socket and insert at the flowmeter end and an aluminum alloy socket at the carburetor end, was disconnected but otherwise intact. Approximately one-third of the B-nut was recovered. The wire bundle containing the BMEP and the tachometer transmitter wires which was routed along the firewall approximately three inches from the B-nut was fire-damaged, but not as severely as it was under the hydraulic pressure line. Disassembly of the flowmeter revealed that its forward area had been subjected to heat to the extent that its gearing was blued, but the thin magnesium cover was intact except for incipient melting. The rear area of the flowmeter located to the rear of the firewall in a canister was severely damaged due to fire penetrating the canister through four holes in the firewall where the rubber shock mounts had burned away.

The third line, the fuel pressure gauge flexible hose of one-fourth inch diameter, was disconnected at the firewall fitting and appeared, by the condition of its flared wire mesh, to have blown off the B-nut insert. The steel B-nut and insert were still properly in place on the firewall fitting near the center of the firewall and the fire-damaged line was still properly connected

to the restrictor fitting on the right side of the firewall. A small area of recently molten nonferrous metal found at the dural ferrule position which partially followed the flare contour was either a part of the ferrule or part of a melted aluminum vacuum line located above that point. The hose had sagged at its disconnected inboard end and was directed toward the center of zone 2. The fuel pressure gauge, the fuel pressure warning light transmitter, and the fuel warning light tested satisfactorily, and disassembly of the gauge revealed no evidence of excessive pressures.

The vacuum pump showed no evidence of malfunctioning or excessive internal heat. The blades were blued where in contact with the rotor but were not blued where in contact with the pumped air. The fusible plug was melted away and no overboard drainline had been provided, but the pump inlet hose was not routed near any normal source of heat. The remaining pressure lines were tested up to the de-icer distributor valve without revealing a restriction.

The manifold pressure gauge flexible line was fire-damaged but intact except for severe burning of the rubber. This line was airtested and leaked at numerous points to the extent that it was open to the atmosphere.

Approximately 1-1/2 gallons of hydraulic fluid were missing from the hydraulic system; the aircraft's supply of de-icer alcohol was up to normal.

Oil was seeping from the damaged flexible hose between engine pump and firewall. Approximately 33 gallons of engine oil were missing from the right oil tank. (This measurement was made 72 hours after the accident and considerable oil had been lost during this period.)

There were 15 holes through the firewall. Two were caused by stainless steel patches falling off when their dural rivets melted and the others were where nonfireproof phenolic bushings around cables had burned away.

The aircraft, engine, and propeller times had been zeroed (logged times restarted) on September 22, 1955, during modification to specification 3A-2. The operational time since overhaul on September 22, 1955, was 996:35 hours; total time and manufacturing date are unknown. The engines were overhauled by American Airmotive Corporation and the aircraft by Conner Airlines, both in Miami, Florida. The aircraft had been certificated in the transport category on July 1, 1957, in accordance with Special Civil Air Regulation No. SR-406A.

At the time of the accident the aircraft had 996:35 hours since overhaul and 1:04 hours since the last major check which was a No. 1 inspection.

This aircraft had been test flown a few hours prior to the accident by Riddle's engineering test pilot. He found the aircraft to be satisfactory and airworthy and so logged the flight. Testimony of the company check pilot indicated that both Captain McLendon and First Officer Crocker were thoroughly competent in flying the C-46R.

A review of the maintenance history of this aircraft brought to light no item pertinent to the accident.

Fuel "boost pumps off" was the third item on the "after takeoff" cockpit checklist aboard the aircraft. The fuel boost pump, according to the crew, was

on for takeoff but turned off immediately thereafter and previous to the difficulty.

Analysis

Under Investigation was mentioned the temporary abatement of the fire, and its resumption, as seen by ground witnesses. It seems most likely that the abatement followed the application of fire extinguisher which was not completely effective, allowing the fire to resume strength. It is impossible to correlate the precise times of these events.

In attempting to determine the origin of the fire, numerous possibilities were considered. Three of these remain suspect. These are failure of and/or leakage from the one-fourth-inch fuel pressure line, or the approximately three-fourths-inch main fuel line to the carburetor, or the hydraulic pump pressure line. Because fire damage was severe, far-reaching, and somewhat obliterative, a number of imponderables were created which prevent positive determination.

However, a most logical chain of events is as follows. The hydraulic pump pressure hose ruptured and sprayed fluid under 1,500 pounds system pressure into the left side of zone 2. This fluid vaporized and became ignited. The source of the ignition may have been the left exhaust tail pipe flame which the vapor possibly could have reached, or the tail pipe which it could readily have contacted through a hole, approximately 1-1/2 inches across, in the cowling at the exhaust tail pipe brace tubing located approximately one foot forward, one foot below, and one foot to the left of the hose rupture point.

Flame burned away insulation on the BMEP transmitter wiring just under the hose rupture point resulting in shorting and malfunctioning of the gauge. Flame was reversed by and carried upward with the air-blast from the air-blast upward directed elbow due to fire-damage malfunctioning of its shutoff door to impinge upon the manifold pressure gauge hose just above the ruptured hose. The manifold pressure gauge hose burned through, leaked, and a 30-inch atmospheric pressure was then indicated on the manifold pressure gauge. Flames were also enveloping the tachometer transmitter wiring, in the same bundle with the BMEP wiring, and they began shorting causing fluctuating tachometer readings.

About this time flames against the main fuel line and the left side B-nut on the flowmeter, approximately one foot to the right, eight inches above, and one foot to the rear of the hydraulic hose rupture point, melted the dural B-nut and released fuel causing severe fluctuation of the fuel flow gauge.

The right propeller was feathered, shutting off the flow of hydraulic fluid by stopping the pump, but fuel was still flowing from the main fual line because the firewall shutoff valves did not close when the switch was actuated by the crew.

The No. 2 bottle was actuated which almost put the fire out, but it soon redeveloped to its original intensity. The ungrounded No. 1 fire bottle did not discharge when its switch was actuated.

Flame by this time had penetrated the firewall into zone 3. Not until after the aircraft had landed and was rolling on the runway did the fuel boost pump wiring in zone 3 short due to fire damage, opening the circuit breaker and

shutting off the fuel. The crew then turned off the master switch and evacuated the aircraft.

Because external and internal examination of the generator, starter, vacuum pump, hydraulic pump, fuel pump, fuel flowmeter, carburetor, and engine rear and blower sections revealed no evidence of malfunctioning, leakage, induction fire, or electrical arcing, none of these units can be considered as a possible source of the fire.

Because all fluid lines except the main fuel line, the one-fourth-inch fuel pressure gauge line, the hydraulic pressure line, and vacuum pressure lines were intact, although fire-damaged, it may be concluded that one of these four was the source of the fire.

The aluminum vacuum pressure line was consumed by fire with its pressure relief valve nearly so, and, as mentioned, no overboard drain line was provided for the fusible plug, but it is likely that spontaneous combustion of lubricating oil in the pressurized vacuum lines, due either to line restriction or radiated heating of the pump inlet air would have been indicated by heat bluing of the blades in contact with the pumped air and the inlet line was not routed near a heated unit. This appears to eliminate the vacuum pump system as the initial source of the fire and indicates that the fusible plug and lines melted from external heat.

The disconnected main fuel hose was installed and secured to another hose by seizing with a rubber lanyard in such a way that vibration could loosen the nut. If this had occurred, the leaking fuel under 25 pounds of pressure could have been carried to an ignition point through the cowling hole to the exhaust tailpipe, or possibly to the exhaust flame through the ill-fitting cowling by the blast tube air flow. This air theoretically goes upward from the upward directed elbow in the lower forward area of zone 2, then downward along the firewall, exiting below the firewall through louvres for that purpose in an area of negative pressure just ahead of the closed wheelwell doors. The air passes over horizontally mounted units in the area and no doubt becomes turbulent to the extent that some exits through openings in the cowling.

If the B-nut became loose or split open, resulting in a leak, however, an erratic fuel flow should have been the first indication rather than complete loss of BMEP. Since BMEP loss indication (engine power loss) was not accompanied by aircraft yaw, it appears evident that no right engine power loss occurred. The indication, therefore, obviously resulted from fire damage to the BMEP transmitter wiring at that point located over the leaking hydraulic hose, with the second indication from fire damage to the manifold pressure gauge hose located over the same area, and finally the tachometer and fuel flow fluctuations after the tachometer transmitter wiring located in the same area burned and the B-nut located above and to the right of the area had melted.

The one-fourth-inch fuel pressure gauge flexible hose appeared blown out at its inboard end under pressure, as indicated by the symetrically flared appearance of its wire braid, and was directed toward a concentrated fire area at the center of zone 2. It cannot be definitely determined whether this line blew out before the fire or as the result of it.

However, it is most probable that the line blew off after melting of the

sleeve over its end for the following reasons: The hose could have slipped out of the sleeve and off the steel insert (as indicated by the missing internal rubber in the most highly pinched area at the end of the hose) leaving the sleeve secured to the threads of the insert with the dural sleeve subsequently consumed by fire. But the wire braid should not have flared in that event due to lack of a restriction against which the outward forces could act.

The escaping fuel could have been carried to a hot exhaust pipe or exhaust flame ignition point by air from the air-blast tube as suggested in the discussion of the possible leak in the main fuel line. However, this would not account for the BMEP, tachometer, and manifold pressure indications since the wires, transmitters, and hose are on the opposite side of the nacelle.

Although this line extends laterally across the right side of the firewall and its open end was directed leftward, the restrictor fitting (one-sixteenth inch bleed hole) was on the closed right end. This should have reduced any spraying effect under the 25 pounds of pressure to a small, low pressure stream by the time it passed through the approximately foot-long hose. Such a stream would not, in all probability, have squirted approximately three feet to the left area.

This failure was subsequent to the left-side fire and caused the concentrated center and upper area fire damage. This does not account for the 8-10-foot heavy flame seen coming from the right exhaust or under it. Since there was no other open line or other fire source on the right side, the fire must have been coming through the air-blast exit louvres just forward of the wheelwell doors. This belief seems warranted by the sooted condition of the doors and lack of soot or heat damage on the nacelle aft of the exhaust area.

Although the ruptured hydraulic pressure line had been in service only 996:35 hours and there was no indication of fatigue in the wire braid adjacent to the rupture point, it is believed that this line ruptured and caused the fire. No other possibility fits the overall picture as well as this one.

Fuel was the only means of feeding the fire after the engine was stopped. Engine oil was only seeping, no alcohol was missing, and a check valve downstream of the accumulator would prevent gravity feeding of hydraulic oil except for slight seepage.

The hydraulic fluid in use flashes readily when vaporized upon contact with hot metal. This has been demonstrated by numerous brake fires. Since the exhaust flame left the tailpipe upstream of the ill-fitting cowling, it is most probable that fire started when vaporized hydraulic fluid was carried into the exhaust flow.

The continuous strip fire-detector sensing tube follows the firewall face near its perimeter, then follows the engine mounts on each side to and through the forward fire diaphragm, one also looping the carburetor. The fire, if originating at any of the three suspect points, would be only about one foot from the sensing tube. It, therefore, seems most likely that the sensing tube was triggered but that its cockpit indications went temporarily unnoticed. However, the condition of the fire-damaged system precluded adequate tests to determine whether or not it was slow to actuate.

The firewall shutoff valves and the generator air-blast tube door actuator motor had a common auto-reset type of circuit breaker. The actuator motor's

wiring was severely fire-damaged in zone 2. Thus, it seems likely that the circuit breaker continued to go on and off without sufficient current reaching the valves to close them. Under test the circuit breaker opened immediately when a short was created and required 8 to 16 seconds to reset.

No. 1 fire bottle did not discharge because it was not grounded. No. 2 fire bottle was not properly grounded either but it fired nevertheless. This is probably due to the existence of an accidental ground as No. 2 bottle had been installed for some time and its paint would normally have worn through to base metal in a number of places from vibration. The very recently installed No. 1 bottle would not normally have this type of accidental ground and its malfunction contributed, in all probability, to the widespread fire damage.

The Civil Air Regulations require that the registered owner or operator maintain a record of the total time in service on the airframe, engines, and propellers. In the case of engines and propellers for which complete records are not available it is permissible to use such components with new (zeroed) records, providing those components are rebuilt by the manufacturer or by the manufacturer's agent designated by him to re-manufacture with the approval of the Civil Aeronautics Administration.

Thus, it appears that there was an irregularity, possibly a violation, of the Civil Air Regulation in connection with the restarting or zeroing of the aircraft's maintenance records. However, this irregularity is not a contributing factor to this accident.

As a result of this investigation the air carrier has made a number of modifications to its C-46R airplanes and is preparing service bulletins for the modifications of those airplanes owned by other operators which comply with Riddle's type certificate. The more important of these modifications deal with the separation electrically of the flammable fluid shutoff valves and the air blast tube actuator motor, the provision of an electrical ground for each fire extinguisher bottle, the replacement of the aluminum channel supporting the firewall with a stainless steel channel, the covering of the nonfireproof fairleads with steel, the installation of a steel enclosure for the air blast tube actuator motor, the covering of the end fittings of the flammable fluid carrying lines in zone 2 and the exhaust collector ring support rod with asbestos boots, and the replacement of aluminum rivets in the stainless steel nacelle skin with steel rivets.

Findings

On the basis of all available evidence the Board finds that:

1. The air carrier and the crew were properly certificated.

2. The aircraft was currently certificated and its weight and center of gravity were within prescribed limits.

3. Immediately after takeoff, a hydraulic line in zone 2 of the right engine ruptured or leaked for reasons undetermined.

4. Escaping hydraulic fluid vaporized under the existing high system pressure.

5. This vapor ignited from either the exhaust pipe or exhaust flame.

6. The fire destroyed wiring and other lines, including one carrying fuel.

7. The emergency shutoff valve malfunctioned and fuel continued to flow from that line.

8. The first application of fire extinguisher checked but did not stop the fire.

9. The attempt to use a second application of extinguisher was futile because of a faulty installation of that fire bottle as a result of an omissive error in a CAA approved drawing.

10. The fire became uncontrollable because of inability to close the firewall shutoff valves due to fire damage.

Probable Cause

The Board determines that the probable cause of the accident was the failure of a hydraulic fluid hose and the subsequent ignition of its vaporized fluid. Contributing to the seriousness and the uncontrollability of the fire was an inadequate emergency fuel shutoff system, an inadequate fire barrier between zone 2 and zone 3, and an inoperable fire bottle.

BY THE CIVIL AERONAUTICS BOARD:

/s/ JAMES R. DURFEE

/s/ CHAN GURNEY

/s/ HARMAR D. DENNY

/s/ G. JOSEPH MINETTI

/s/ LOUIS J. HECTOR

SUPPLEMENTAL DATA

Investigation

The Civil Aeronautics Board was notified of the accident shortly after occurrence. Investigation was started immediately in accordance with the provisions of Section 702 (a) (2) of the Civil Aeronautics Act of 1938, as amended. Depositions, ordered by the Board, were taken in Miami, Florida, January 22, 23, and 24, 1958.

Air Carrier

Riddle Airlines, Inc., is a Florida corporation with its general offices and principal operating base at the Miami International Airport. It operates as a cargo air carrier under a currently effective temporary certificate of convenience and necessity issued by the Civil Aeronautics Board and a cargo carrier operating certificate issued by the Civil Aeronautics Administration. These certificates authorize the company to transport cargo over the route being flown in this instance.

Flight Personnel

Captain Otis E. McLendon, Jr., age 36, was properly certificated for the subject flight. He had been employed by Riddle Airlines since December 1949. His flying time was in excess of 10,000 hours, of which 5,000 had been in C-46 aircraft. His rest period prior to this flight had been adequate and his last physical examination was current. Captain McLendon had completed familiarization with the C-46R aircraft to the satisfaction of the company, and had also satisfactorily completed an examination on its powerplants.

First Officer Sheldon A. Crocker, age 33, was likewise properly certificated for this flight. He had been employed by Riddle since February 1956. His total piloting time was about 2,900 hours, of this, some 2,400 hours had been in C-46's and of the 2,400 hours about 900 had been as pilot in command. All of his various checks, line, instrument, and physical, were current and his previous rest period was adequate.

The Aircraft

This Curtiss C-46R was built for the United States Air Force during World War II and bore the military serial number 30466. It was sold by the Air Force, and registered in Colombia, South America, then was returned to this country and registered in December 1951 in the name of the Carmas Supply Company, Washington, D. C.

The aircraft was then leased to Continental Charters, Inc., a nonscheduled air carrier then based in Miami after it had been modified for air carrier operations as a C-46A. It was involved in an accident near Little Valley, New York, on December 29, 1951.

Conner Airlines, another nonscheduled air carrier also based at Miami, purchased the wreckage and rebuilt the aircraft. An overhaul and modification was then started. Riddle Airlines purchased the aircraft from Conner while this work was in process. Conner, however, continued the work for Riddle and completed it in September 1955. At that time the total aircraft time was zeroed.

On March 9, 1956, the aircraft was delivered to Riddle and modified by them to Riddle Airlines C-46/CWT Report RA-43 Transport Category Specifications. It was certificated by the CAA as a C-46R5 on July 1, 1957, under Special Civil Air Regulation No. SR-406A.

While this modification was in process the engines were overhauled by the American Airmotive Company at Miami, modified from R2800-22's to R2800-34's and their total times zeroed. The propellers also were overhauled by Propeller Services, Inc., at Miami and modified to Model 33E60 with 6801a-b blades. The total propeller time was zeroed.

At the time of the accident the aircraft had a total operational time of 996:35 hours since overhaul, and 1:04 hours since the last major check, which was a No. 1 inspection. Total operating times of airframe, engines, and of propellers are not known.