CIVIL AERONAUTICS BOARD

ACCIDENT INVESTIGATION REPORT

Adopted: March 29, 1948 Released: March 30, 1948

PAN AMERICAN AIRWAYS—FLOYD BENNETT FIELD, BROOKLYN, NEW YORK—SEPTEMBER 20, 1947

The Accident

Pan American Airways' Flight 131, a C-54-DC airplane, NC-88911, executed an emergency landing at Floyd Bennett Field, Brooklyn, New York, at approximately 1823,[1] September 20, 1947 No injury was sustained by any of the 41 persons on board The aircraft, however, received major damage

History of the Flight

Pan American's Flight 131 departed from Bermuda at 1358, September 20, 1947, with 36 passengers and a crew of 5. The take-off and climb to the cruising altitude of 8,000 feet were normal, and the flight proceeded on course to LaGuardia Field, New York, for a period of 3 hours without incident Between 1650 and 1655, about 225 statute miles from destination, Warren Robinson, the first officer, noticed a fluctuation in fuel pressure for engines 1 and 2 Seconds later, the left auxiliary fuel tank quantity gauge dropped to zero, the fuel pressure warning light flashed on, and the No 1 engine faltered To insure a positive fuel supply for all engines Mr Robinson immediately turned the fuel selector valves for all engines to their respective main tanks,[2] following which all engines operated normally.

Mr Robinson then transferred fuel from the right auxiliary tank to the left auxiliary tank so that they would contain equal amounts, which was 40 gallons each according to the fuel quantity gauges after completion of the operation A few minutes later Mr Robinson noticed that the right auxiliary fuel gauge indicated not 40 gallons, but 100, and that it was visibly increasing even though no fuel was at that time being transferred The No. 3 main fuel tank gauge then dropped to zero, and the fuel pressure for the No 4 engine started to fluctuate. Alarmed by what now appeared to be a serious malfunction in the right side of the fuel system, Mr Robinson operated all engines from the left main tanks (1 and 2), turning on all the cross feed valves, and the booster pumps for main tanks 1 and 2

The flight had by this time reached position "Baker," a point on course and a distance of 212 statute miles from LaGuardia This check point was regularly used by Pan American on the route from Bermuda to LaGuardia, and was established by reference to precomputed radio bearings Flight Radio Officer Rea was instructed to call Captain Carl Gregg, who was eating lunch in the passengers cabin, to the cockpit. The captain, unable to account for what appeared to be a total loss of fuel in the right main tanks, tried to operate engines 3 and 4 from their respective mains. Shortly after, the fuel pressure for both these engines dropped, the fuel pressure warning lights came on, and engines 3 and 4 lost power. Other combinations of fuel valve settings were tried during the next few minutes, but power could not be restored to engines 3 and 4 The "fasten seat belt" sign was turned on, rated power was applied to engines 1 and 2, and a descent of 200 to 300 feet per minute started.

Two minutes later the fire warning light flashed on for engine 4 The flight radio officer was sent to the passengers cabin to see if any signs of fire from this engine were visible He saw none from engine 4, but he did see smoke trailing from engine 3. By the time Mr Rea

[1] All times referred to herein are Eastern Standard and based on the 24-hour clock.

[2] One main tank is installed in the C-54 for each engine and is numbered so as to correspond to the engine, i e , No 1 main tank is located in the wing panel next to and normally feeds the No 1 engine In addition to these 4 main tanks, there are 2 auxiliary tanks, one in the left and one in the right wing panel For further detail see the chart, Appendix I, attached to this report

returned to the cockpit, Captain Gregg noticed the smell of burning rubber, and furthermore, that the fire warning light for engine 3 was also on. No flames from either engine, however, were visible. Standard fire fighting methods were followed to control the fire in the No. 3 nacelle. The propeller was feathered, all fluids into the engine were closed at the emergency shutoff valves, and the CO_2 gas bottle was discharged. The fire warning light then went out. Since there was no visible indication of fire in engine 4, the CO_2 gas bottle was not discharged. As a precautionary measure, however, the shutoff valves for all fluids into the engine were closed, and an attempt made to feather the propeller But, the propeller would not feather, and continued to windmill.

At 1712, shortly after Mr. Rea transmitted to the company the flight's position as "Baker," a loud noise from the right side of the airplane was heard, and simultaneously the green right landing gear light came on. Through the drift sight the crew could see the right outboard tire burning, and a landing gear bungee cable hanging slack. All attempts to raise the right gear were unsuccessful, and it was found that with the right gear down, and with both right engines "out" that an air speed of 125 miles per hour was required to maintain directional control. At 1730, engine 4 stopped windmilling, having seized from lack of lubrication By 1745, altitude had been lost to about 1,000 feet, and over 100 statute miles remained to destination. Full take-off power was applied to engines 1 and 2 in an attempt to hold the remaining altitude.

A report had been transmitted to the company at 1729 that the fires in engines 3 and 4 were believed to be out, and at 1740, the company had been advised that the flight was at 2,000 feet still descending All radio contacts with Pan American at LaGuardia throughout the course of this emergency were accomplished through Eastern Air Lines' radio on the frequency 8565 kcs. Mr. Rea attempted to secure a fix on "CW"[3] from the U. S. Coast Guard, using the distress frequency of 8280 kcs. Because of an extreme amount of "CW" interference on this frequency only one station was actually contacted. This was NMR, the Coast Guard station in San Juan, Puerto Rico. Even this contact was not entirely satisfactory, and no radio bearing from it was ever received. The radio equipment was accordingly returned to the frequency of 8565 kcs , the established channel of communication, for further radiophone contact with New York. No call was ever made on the international distress frequency of 500 kcs., or over any of the "VHF" equipment on board.

By 1800, altitude had been lost to 800 feet, and still over 50 statute miles remained to destination. Preparations were made for "ditching." The passengers were instructed in the use of life jackets, and in emergency water landing procedures. The life rafts were moved so as to be easily accessible from the main cabin door. Celluloid protective coverings were removed from all the emergency exit handles Clothing was loosened, and seat belts tightened. Flight Radio Officer Rea broadcasted "blind" on the frequency 8280 kcs., reporting the position of the flight to be 40-00 degrees north and 73-10 degrees west. From this point on only a small gradual loss of altitude was experienced. Captain Gregg decided to attempt to reach and land at Floyd Bennett Field, and was advised through Eastern Air Lines' radio that runway one would be available.

New York Air Traffic Control had been alerted through Eastern Air Lines' radio of the emergency, and they in turn had called Coast Guard search and rescue. Coast Guard, Army, and Navy rescue equipment was dispatched, and as Flight 131 approached the coast, the crew observed other aircraft and surface vessels proceeding out to meet them. At 1815, approximately 15 statute miles from Floyd Bennett Field, the flight had descended to an altitude of 400 feet. Full available power was now applied to engines 1 and 2, and the flight was able to not only hold, but even gain a slight amount of altitude. Four to five minutes later, 1820, throttles were retarded to take-off power and the aircraft maneuvered into a position for a straight-in landing approach on runway one.

The aircraft was set down 775 feet from the south end of runway one, wheels up. During the course of the crash landing the No. 1 propeller was torn from the engine, the propeller dome becoming embedded in the No. 2 main fuel tank.

[3] "CW"—Abbreviated for continuous wave transmission of code rather than voice

The spilled gasoline was ignited by sparks generated as the aircraft skidded 2,167 feet on the concrete runway to a stop U. S. Navy fire and crash equipment had been previously deployed along runway one which allowed the Navy's crash personnel to bring the fire quickly under control, and to assist the passengers and crew to deplane without injury.

Investigation

Considerable damage to the aircraft resulted from the crash landing and the fire which followed. The fabric on the rudder and elevators was burned off, and a portion of the left wing panel, including the No. 2 fuel tank, was also destroyed by fire. The underside of the fuselage, the engine cowlings and oil cooler scoops, the wing flaps, and the landing gear doors were torn and scraped from contact with the runway. All blades on propellers 1 and 2 were scuffed and bent. Two blades on 3 were scuffed, and the tip of one blade on 4 was slightly bent The nose section of engine 1 was torn completely from the rest of the engine. Damage which occurred prior to the crash landing was confined to the No. 3 engine nacelle, the right landing gear, and the No. 4 engine.

The C-54 has mounted forward of the front wing spar (zone 3) in engine nacelles 3 and 4 a battery "bus,"[4] a solid electrical line of 5/8" aluminum covered with fire resisting fabric insulation. Below this "bus," also mounted on the front wing spar in the No 3 engine nacelle is a magnesium engine control pulley bracket. In NC-88911 at a point directly above the pulley bracket, the battery "bus" had melted in two from electrical arcing. The bracket also had burned and melted from electrical arcing, and many of the engine control cables which it held had been fused together. From this particular area to all points within zone 3 of this nacelle, there was evidence of fire.[5] The aluminum conduit which carried the magneto ground leads for engines 3 and 4 was burned in two, part of the insulation was destroyed, and the magneto ground leads for engines 3 and 4 grounded. Many other electrical lines had been either burnt in two or grounded.

No irregularities were found in the fuel system, except those which had resulted from fire in the air in the No. 3 nacelle Otherwise, all lines, strainers, hose connections, pumps, and valves were found clean and in good condition. Fuel from all tanks was drained and measured The No. 1 main tank contained 150 gallons, No. 3 main 125, No. 4 main 335, the left auxiliary 28, and the right auxiliary 7 gallons No fuel was found in the No. 2 main tank for the reason that this tank had been broken open during the course of the crash landing by the dome of the No. 1 propeller

Engines 3 and 4 were sent from Floyd Bennett Field to the Pan American Latin-American base at Miami, Florida. No part of engine 3 was disturbed from the engine mount forward other than removing the generator for study at the National Bureau of Standards, and changing the damaged propeller for a test one, which was installed at Miami. This engine, when mounted on a test stand in Miami, was started and operated without difficulty. The No. 4 engine had been so damaged as a result of windmilling without lubrication that disassembly was necessary. Excessive damage was found to have resulted in the rear power section, but no indication of any malfunction or failure was found which occurred prior to the time that the flow of oil to the engine was stopped by Captain Gregg at the shutoff valves.

Electrical components including voltage regulators, reverse current relays, generators, and batteries were examined, and tests were also conducted by the National Bureau of Standards. All electrical components, with the exception of the No. 1 generator which was "out," appeared to be normal.

Because of the apparent origin of the fire—the electrical arcing between the battery "bus" and the engine control pulley bracket—tests with like materials were conducted in Miami by Pan American and CAA personnel. A 3-foot piece of 5/8" aluminum was energized with an electrical current of 400 amperes and 28 volts to simulate the "bus." It was then brought in contact with a section of magnesium alloy which was grounded and of a mass 1 5 times that of the pulley bracket found in NC-88911. The first contact was made intermittently, which resulted in a considerable amount of arcing. Melted particles of magnesium

[4] This "bus" connects all four generators to the batteries See Appendix II for diagrams of this installation.

[5] A detailed report of the damage found in zone 3 of engine nacelle 3 will be found in Appendix III of this report

dropped and burned until consumed. The "bus" bar was then held in firm contact with the magnesium It was found that, except for an initial small arc, no burning of the magnesium took place The parts welded together The third test consisted of adjusting the aluminum and magnesium pieces so as to maintain a continuous arc When so adjusted, the arcing resulted in rapid erosion of both the aluminum and the magnesium, however, the main body of the magnesium did not ignite except for small areas which were adjacent to the arc The last test consisted of dropping pieces of control cable over the energized "bus."

An inspection of nacelles 2 and 3 in other C-54 airplanes revealed in a few cases a chafed condition of the insulation on the "bus" in the vicinity of the engine control pulley bracket which had not been previously suspected. Such a chafed condition, where the clearance between the "bus" and the bracket was small, created an obvious hazard of arcing and fire Accordingly, the clearances between this bracket and "bus" were examined in C-54's, operated not only by Pan American but also by other carriers. It was found that the clearances varied from 1/16" to 2" A few carriers had protected the "bus" by a metal conduit or a rubber shield

Further examination of nacelle 3 in NC-88911 revealed that the support for the "bus" inboard of the engine control pulley bracket was a piece of fabricated dural not standard with the Douglas manufactured product, and of thinner material than that found in the No 2 nacelle of the same airplane It is not known when or by whom this "bus" support in nacelle 3 was installed. Furthermore, this support, and similar supports in this particular model of C-54's, held the "bus" closer to the face of the spar and the engine control pulley bracket than was true in later models. Notice through the Air Transport Association was sent to operators of C-54's describing the condition found in NC-88911, which provided the operators with an opportunity to inspect their aircraft and perform the necessary preventive maintenance. On October 31, 1947, the Administrator notified all field offices that an inspection of the bus installation in the C-54 was mandatory. This action was followed by the issuance of a CAA Airworthiness Directive which required further inspection and corrective action to eliminate the possibility of "bus" bar trouble in the C-54's.

Maintenance and historical records of NC-88911 were carefully examined. All entries including pilot complaints appeared routine, however, several entries had been made in the aircraft log to the effect that the aircraft vibrated excessively during climb There is a possibility that excessive vibration may have contributed to the electrical arcing between the "bus" and the engine control pulley bracket in this case.

It was found that all members of the crew were qualified to make the flight from Bermuda to New York. Captain Carl Gregg, age 36, had a total of 9,758 flying hours, 1,800 of which were in C-54 equipment. He had accomplished a ground school course in the operation of the C-54, and had, during his period of employment with Pan American, successfully completed training as a navigator. Training in navigation consisted of a ground school course averaging approximately 200 hours, and covered celestial and dead reckoning navigation, cruise control, star identification, and other related subjects. After completing several flights, the principal duty being navigation, Captain Gregg was qualified by the company as a navigator as well as a pilot. He satisfied the company requirements that the captain of any flight over water be a qualified navigator as well as pilot.

Warren R Robinson, age 27, the copilot, had a total of 3,456 hours in the air, of which 200 hours were in C-54 equipment. Mr. Robinson had also accomplished a ground school course in the operation of the C-54 as well as flight training in the airplane. Though he had not completed the course in celestial navigation, Mr. Robinson had accomplished the training offered in dead reckoning navigation.

All members of the crew, including the radio officer, purser, and steward, had been given training in emergency procedures and "ditching." Each crew member knew and performed his duties in a calm and efficient manner.

Radio direction finding stations, operated by the Coast Guard prior to the close of the war, are now maintained only in a caretaker status. Their function has been assumed by the Federal Communications Commission. Since the FCC, however, is primarily a law enforcement

agency, it is not able to give as complete a service to aircraft in distress as that which was previously rendered by the Coast Guard

A representative of the United States Coast Guard was asked for his recommendation as to how best alert search and rescue facilities. He stated that under present conditions the most efficient means was to use any channel of radio communication established at the time of the emergency. The international emergency frequency 500 kcs., though guarded by all surface vessels, is of limited use since its range is relatively short Furthermore, to utilize fully that frequency it is necessary to use a trailing antenna. The carrier in this case believed the difficulty of handling in flight a trailing antenna offset any benefit which might be received from its use. Much greater range is possible on 8280 kcs. than on 500 kcs., and it is sometimes used by aircraft of United States registry for distress calls However, no international agreement exists setting this particular channel aside for distress. Though limitations have been set as to the use of 8280 kcs by the Federal Communications Commission, and notice of the limitations given to foreign governments by the State Department, surface vessels and aircraft, particularly those of foreign registry, use 8280 kcs. as a calling frequency. In the present case the radio operator was confronted with so much interference on 8280 kcs. from other operators attempting to use the same frequency for other than distress purposes that he found it impossible to establish any satisfactory contact

Actually, Radio Officer Rea's distress call on 8280 kcs. was heard by the Coast Guard, but they could not reply before he had changed back to 8565 kcs. Investigation disclosed, however, that one operator in a Coast Guard listening station, because of lack of personnel, is at times required to guard as many as 9 frequencies simultaneously, one being 8280 kcs. It is, of course, virtually impossible for any one operator to listen to and receive all calls on 9 frequencies at one time, especially when considering the noise and static which necessarily accompanies reception on a frequency when the volume is adjusted high.

No difficulty was experienced in establishing communication on 8565 kcs. All messages concerning the distress were promptly relayed through Eastern Air Lines' radio to Pan American and CAA Air Traffic Control. All information received by Air Traffic Control was relayed to Coast Guard search and rescue, and available facilities for rescue were promptly and efficiently dispatched.

The weather which existed during the time of the flight is not considered a factor in this accident. A large high pressure area was centered over New England, and a cold front crossed the flight route at approximately 34 degrees north In the frontal zone were scattered thunderstorms and towering cumulonimbus clouds. The flight had progressed beyond this frontal area at the time that trouble was experienced, and only scattered clouds were encountered from that time until the crash landing at Floyd Bennett Field.

Discussion

As stated above, no irregularities were found in the fuel system other than those caused by fire in the No 3 nacelle. It was impossible to make an accurate determination of the quantity of fuel contained in the left auxiliary tank prior to take-off from Bermuda, but the testimony of the co-pilot indicated it to be sufficient for about 10 minutes of flight. The only possible cause of fuel pressure fluctuation in engines 1 and 2 was exhaustion of fuel in the left auxiliary tank. This conclusion is supported by the fact that no difficulty was experienced when the engines were switched to their respective main tanks, and engines 1 and 2 continued to operate normally after gasoline had been transferred into the left auxiliary tank, and the engines were again operated from it.

Erratic operation of the quantity gauges for the right fuel tanks resulted from the insulation being burnt on the electric leads running from the tank transmitters to the instruments, and the wires being shorted. Engines 3 and 4 failed not from lack of fuel, but because the leads from the master switch to the primary coils of the magnetos were grounded after the aluminum conduit and insulation on the wires had been destroyed by fire,[6] therefore, the changing of the fuel selector valves had no effect in restoring power to engines 3 and 4.

[6] See Appendix III These leads were found grounded at the time the airplane was examined

The false fire warning from the No. 4 engine resulted when the insulation on the electric lead had burned away, and the lead from the detector unit became energized by other wires and control cables in the nacelle Since the fire warning detectors are located in zone 2 of the nacelles, and the fire in nacelle 3, was in zone 3 in which there was no fire detector unit, no indication of the fire in the No 3 nacelle was given until the fire had progressed to the extent of causing hot gasses to pass forward into zone 2. By that time the conduit carrying the magneto ground wire, had been destroyed, and both engines had stopped The discharge of the CO_2 gas bottle in zone 2 chilled the detector, and by normal action the fire warning light for engine No 3 went out

The No. 4 propeller could not be feathered for the reason that the propeller feathering motor electric lead was shorted as a result of the insulation being burnt by the fire in nacelle No. 3.

The loud noise heard by the crew was the outboard tire on the right landing gear blowing out This tire had been burning in the nacelle, and the bungee cable had been so weakened by fire that it broke when the gear extended. The extension of the gear resulted from the up-gear latch, located at the top of the nacelle, being destroyed by fire Even had the gear been retracted there would have been no latch to hold it in position. Failure of the retracting mechanism was also a result of the fire in the No. 3 nacelle.

More confusing circumstances surrounding an emergency than those encountered in this case would be difficult to imagine. There were several indications of trouble in the fuel system, though no real trouble existed, there was no warning of the fire in the No. 3 nacelle until most of the wiring, plumbing, and engine control cables were destroyed, and then there was the false warning of fire in engine 4. The two right engines "out" right gear down combination resulted in such an unsymmetrical flight condition that 125 miles per hour air speed was required to maintain directional control of the airplane, and that air speed could be held only by losing altitude.

No other case of fire in the C-54 originating as this one did from arcing between "bus" and engine control pulley bracket is known to the Civil Aeronautics Board. However, as pointed out above, an inspection of several C-54's disclosed in a few cases that a chafed condition of the insulation on the "bus" bar existed in the vicinity of the engine control pulley bracket The hazard of electrical arcing and resulting fire was apparent The "bus" needed only to be pushed a little closer to the pulley bracket, or allowed to vibrate a little longer so as to wear more insulation away before the same condition would have occurred as that which confronted Captain Gregg in this case.

Compliance with the intent of Section 04 53 of the Civil Air Regulations which provides in part "...electrical systems and equipment shall...be free from hazards in themselves...be installed in such a manner that they are suitably protected from.. mechanical damage...," should have prevented the type of bus bar installation found in this particular aircraft. Adequate clearance should have been provided between the bus and the engine control pulley bracket. Further, the bus should have been securely anchored to the aircraft structure so that chafing with adjacent parts of the aircraft would not have been possible.

Had a fire warning device been available in zone 3 of the engine nacelles in NC-88911, Captain Gregg might not have closed the shutoff valves into engine 4 which created the additional hazard of engine 4 seizing from lack of lubrication The immediate warning of fire in zone 3, and the existence of an extinguishing agent in that zone, should have enabled the crew to put the fire out before it had progressed to the extent of burring the conduit carrying the magneto ground wires which resulted in the stoppage of both engines 3 and 4.

Finally, this investigation disclosed a need for a high frequency international distress channel Notice of the emergency in this case was possible largely because of the previously established radio contact on company frequency. Aircraft flying without the benefit of company radio would not have had this alternative available. Little use can be made of search and rescue facilities if aircraft in distress at sea are unable to call for help immediately after an emergency develops. It should also be noted that safety in overseas flights requires not only a satisfactory channel for communication of distress calls but also a dependable

listening watch of the channel. Only after these general requirements have been satisfied may the facilities of search and rescue be fully utilized.

Findings

Upon due consideration of all available evidence, the Board finds that

1. The carrier, aircraft, and crew were properly certificated.

2. No irregularities were found in the maintenance of the aircraft, nor were any mechanical deficiencies found in any part of the aircraft, except as described below.

3. A "bus" bar support was installed in the number 3 nacelle of NC-88911, made of fabricated dural not standard with the Douglas Aircraft Company's part, at a time and place not known. This support held the "bus" closer to the face of the wing spar than the standard support found in other C-54's

4 Electrical arcing occurred bétween the "bus" and an engine control pulley bracket mounted on the face of the front wing spar and immediately below the "bus" in the No. 3 engine nacelle. A fire fed by combustible fluids in the No. 3 nacelle started from the electrical arcing.

5. The fire in the No. 3 nacelle burned and destroyed the insulation and conduits which protected much of the electrical wiring routed through the nacelle, in particular, the magneto ground wires for engines 3 and 4.

6 The magneto ground wires, for engines 3 and 4, became grounded on adjacent metal parts which resulted in power failure of engines 3 and 4.

7. No fire warning unit or extinguishing agent was installed in zone 3 of the engine nacelles in the aircraft

8 The operator in a few of the Coast Guard listening stations is required to guard as many as 9 frequencies at one time, one frequency being 8280 kcs.

9 Notification of the emergency was transmitted on company frequency, 8565 kcs., and proper relay of the information was sent through CAA Air Traffic Control, to Coast Guard search and rescue

10. Search and rescue equipment was promptly dispatched, and intercepted the flight as it approached the eastern coast of the United States

11. The aircraft with the 2 right engines "out" was successfully crash-landed at Floyd Bennett Field. Fire and major damage resulted to the aircraft, but no injury was sustained by the passengers or crew.

Probable Cause

The Board determines that the probable cause of this accident was electrical arcing between the battery "bus" and an engine control pulley bracket in the No 3 engine nacelle. This arcing resulted from the lack of adequate protection for the "bus."

BY THE CIVIL AERONAUTICS BOARD

/s/ OSWALD RYAN
/s/ HARLLEE BRANCH
/s/ JOSH LEE

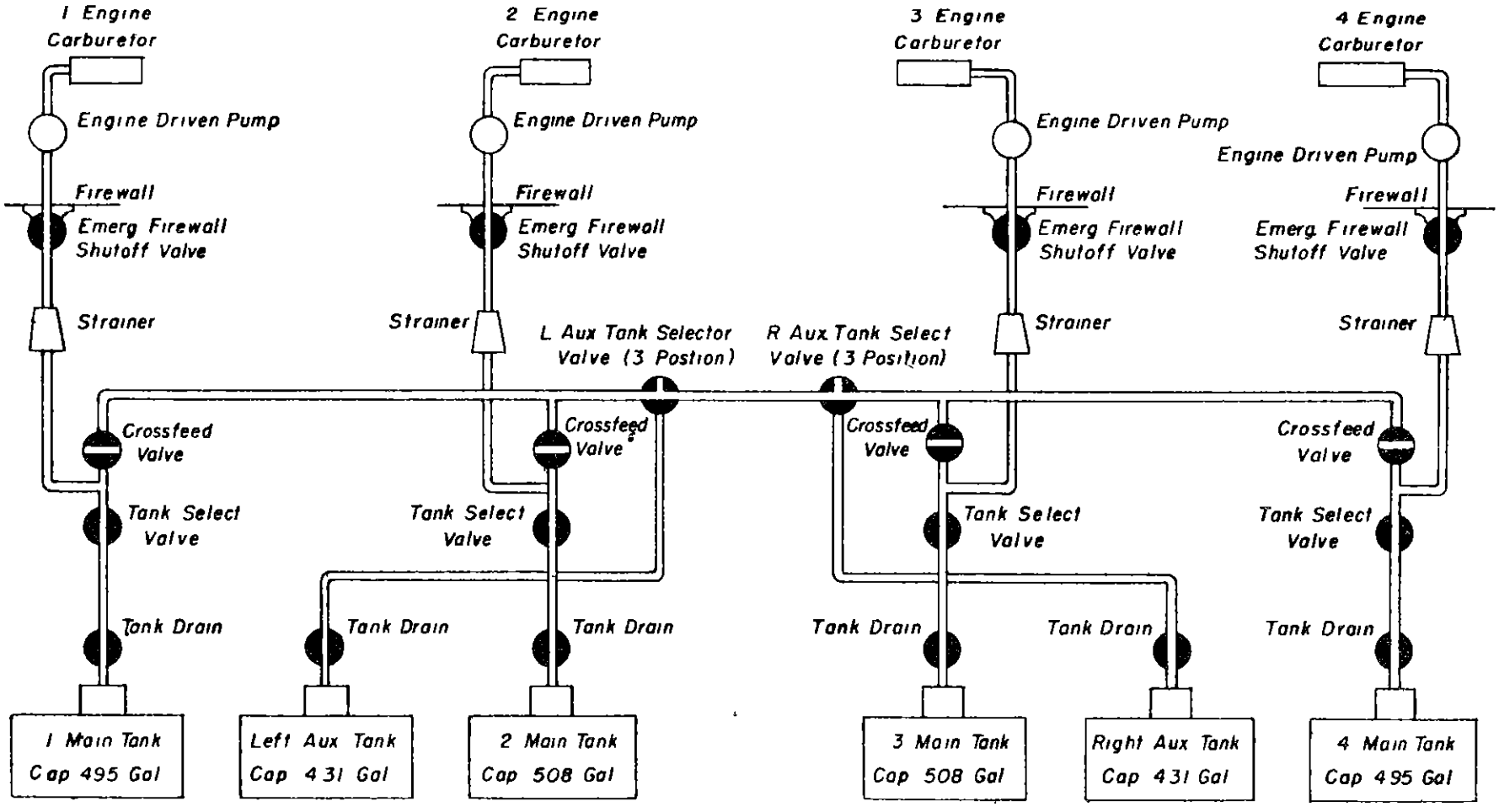
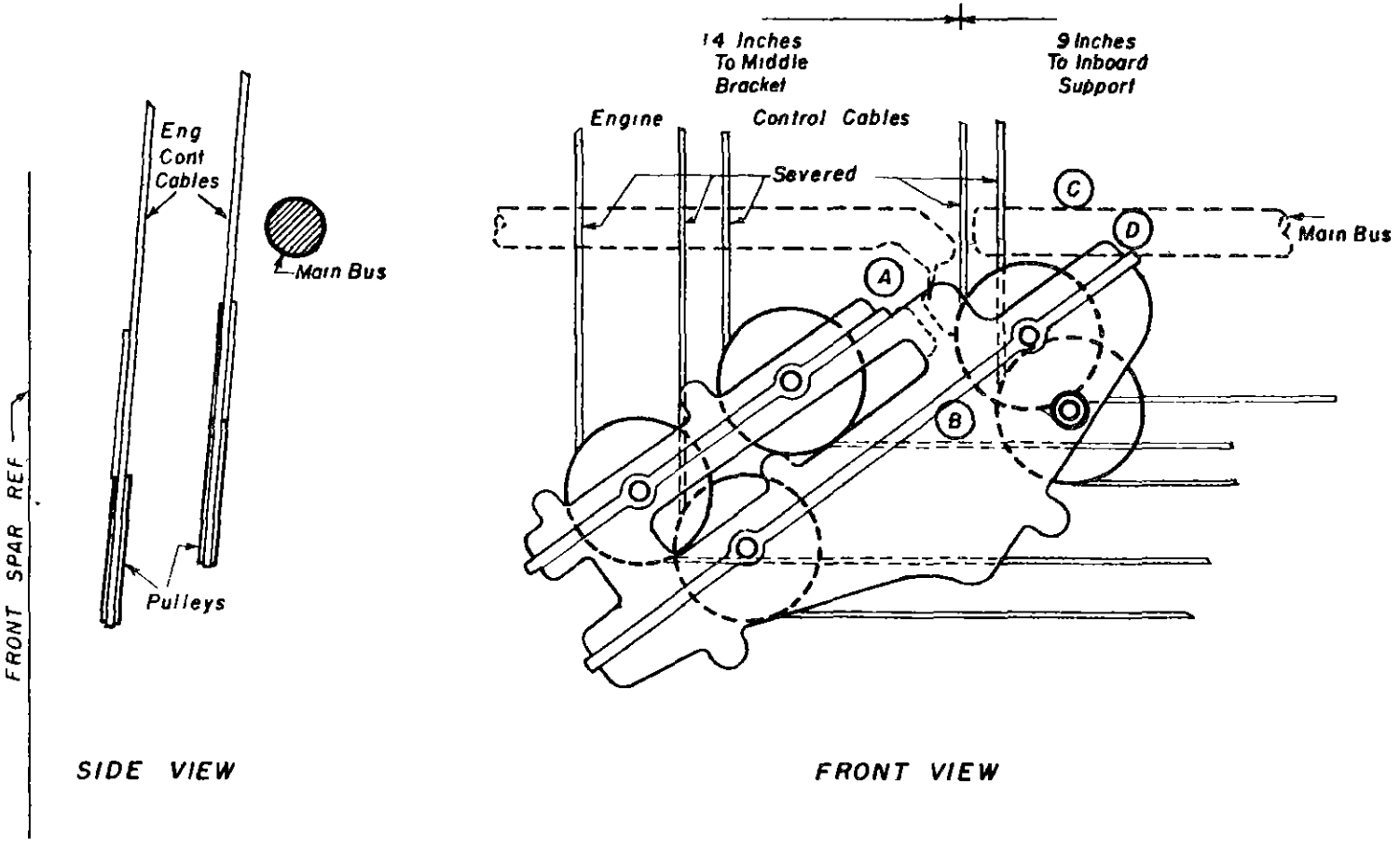


FIG 2 FUEL SYSTEM DIAGRAM - SCHEMATIC
C54B-DC 4 TANK SYSTEM
PREPARED BY PAA

Appendix I


Eng
Cont
Cables
Main Bus
FRONT SPAR REF
Pulleys
SIDE VIEW
14 Inches
To Middle
Bracket
9 Inches
To Inboard
Support
Engine
Control Cables
Severed
C
D
Main Bus
A
B
FRONT VIEW

Appendix III

The damage which occurred in the No. 3 nacelle, Zone 3, has been divided into the following areas

1. The region immediately behind the firewall.
2. The sides and top of the nacelle region.
3. The front face of the spar region.
4. The under wing wheel well fairing region.

The material which follows has been further subdivided into the following sections

(a) Damage which occurred to the fluid system and plumbing.
(b) Damage to the structure.
(c) Damage to the electrical system and electrical components.

Region Behind Firewall

Fluid Systems and Plumbing

1. Oil out line hose connection burned on aft side. Not leaking.
2. Feathering supply line hose connection charred at oil tank on aft side only. Not leaking.
3. Line lashings burned off at R.H. side of firewall.

Structure

1. Inboard oil tank strap broken with strap pad burned out. Outboard strap pad burned and blistered.
2. Upper landing gear door fitting bent upward (probably in landing).
3. Landing gear door mechanism spring stretched permanently and overheated. (Due loss of spring tension when heated.)

Electrical

1. Upper inboard fire warning wiring insulation burned off to where it touches oil tank overflow line and 3" each way from this point as it branches out. Wire insulation charred about 12" beyond bare wire.
2. Wiring from oil pressure and fuel pressure warning switches on firewall blistered and charred to nacelle junction box.
3. Generator field and volt-ammeter circuit breakers on nacelle junction box had not opened.
4. Wire bundle right side of firewall blistered to firewall junction box.
5. Upper outboard fire detector wiring insulation burned off from Adel clamp to wire bundle (6").
6. Magneto plug and receptacle on firewall showed moderate blackening of female receptacle insulation and male pins.
7. Lugs and wiring associated with reverse current relay in firewall junction box show discoloration. Wire from equalizing resistor to ground shows scorched insulation.
8. Feathering motor power wiring inside the firewall junction box showed evidence of heavy currents at the solenoid.

Sides and Top of Nacelle Region

Fluid Systems and Plumbing

1. Carburetor vapor return line burned in half at a point 36" aft of firewall (outboard rear side of nacelle) for a distance of 12". Then at a point 2" aft of the break it is deformed by heat for a distance of 3 1/2" pressing on aft outboard nacelle gusset.
2. Rubber in gang line clamps blistered, 12" from spar, outboard rear side of nacelle.
3. Carburetor alcohol supply line broken 10" from tee between No. 3 and No. 4 solenoids, outboard rear side of nacelle. A 5" section is burned out from this point as it passes over to face of spar.
4. Propeller alcohol line has 3" section burned out, starting 1 1/2" from union in line. This is in same location as carburetor alcohol line in the previous item.
5. Three deicer air pressure lines burned across top of nacelle over tires. Severe burning from entrance at nacelle side walls to area over top of tires. Inboard of nacelle centerline burning starts 12" inboard of nacelle centerline and lines completely burned from 18" from centerline to inboard side of nacelle (10"). Outboard of nacelle two lines burned off at side of nacelle completely for 9" and one from side of nacelle up to top of nacelle to hose joint.
6. Capped oil transfer line for No. 3 engine (not in use, but containing engine oil blocked off) burned or broken top end off including cap and shows heavy black carbon deposit on line from upper end as overflowing oil flowed out without pressure. This line is in inboard rear corner of nacelle Oil still in open end of line.
7. Oil transfer line for No. 4 engine following same routing as deicer air pressure lines has 9" section burned out over outboard tire This was an unused

line and little if any oil was released from it. No oil in line.

Structure

1. Nacelle longitudinal just outboard of top centerline of nacelle burned out from 37" to 41" aft of firewall. Same area as burned out deicer lines.

2. Rearmost nacelle frame (transverse ring) burned away for 10" over outboard tire. Cracked at top at nacelle centerline and 10" outboard of centerline. Mashed forward 13" outboard of centerline (by heat).

3. 6" section of nacelle frame burned out in area of burned out deicer lines over inboard tire.

4. Upper inboard pulley bracket mounted to top rear of nacelle entirely burned out except for stubs attaching to nacelle hat sections. Stub ends of bracket casting show one melted stub and four broken stubs. Bracket is magnesium.

5. Upper outboard pulley bracket mounted to top rear of nacelle entirely burned away except for stubs attaching to nacelle hat sections. Stub ends of bracket casting show six melted and one broken stubs. Bracket is magnesium.

6. Hat section top rear of nacelle for attachment of outboard pulley bracket broken. Also four other hat sections at top of nacelle same area were broken. These also show severe burning. Probably weakened sections cracked in landing.

7. Molten metal from pulley brackets found lying on lower spar cap, on aft end of landing gear doors (proving they were closed during magnesium fire) and on retracting strut cylinder lower end. Locations are—on spar rail, 12" from inboard side of nacelle. On doors both sides, 16" from centerline of nacelle.

8. Nacelle skin area which was over burned inboard deicer air pressure lines had soot smudged as if by some contact—possibly piece of tire.

9. Nacelle hat section stringer 26" aft of firewall and 22" inboard of nacelle centerline is dented locally.

10. Top inboard nacelle longitudinal at a point 33" aft of firewall was dented toward center of nacelle.

11. Landing gear uplatch had one link broken and shear pin sheared downward about one-half way through.

12. Cable fair leads at top of nacelle burned out.

Electrical

1. Oil quantity gauge wiring from top of oil tank along top inboard side of nacelle burned and charred 2/3 back from firewall. From this point to terminal strip at spar, wire was bare. Wire loose from terminal strip which is burned out.

2. Wiring along right aft side of nacelle up to carburetor deicing solenoids was raw and burned through 16" from solenoids.

3. The flexible lead from the main bus to the firewall junction box had insulation burned off 33 1/2" forward toward the firewall. Copper appeared subject to high overheat condition but not enough to melt. Clamps for this lead burned leaving lead hanging loosely in nacelle.

4. Wire bundle inboard side of nacelle charred.

Front Face of Spar Region

Fluid Systems and Plumbing

1. Manifold pressure line (1/4" tubing) broken in two at a point 8" from outboard side of nacelle.

2. Vacuum line hose from No. 4 nacelle blistered on forward side, outboard side of nacelle.

3. No Adel clamp rubber burned below 12" above bottom spar cap.

4. Note Carb. vapor return line, carb. alcohol and prop. alcohol lines burned through in outboard rear corner of wheel well were listed under the "Sides and Top of Nacelle Region" could also be listed in this section as they are close to face of spar also.

Structure

1. No. 3 engine R.P M., carb. air temp, throttle, mixture and supercharger, two each control cables (3/32 steel) burned through at pulley bracket.

2. No. 4 dump valve cable burned through at pulley bracket.

3. Three cables (2 mixture and 1 short piece unattached 6 1/2" long) welded together at point where they burned through.

4. Two cables (supercharger) welded together at burned end.

5. Wire bundle (40 wires) sagging down 18" due to support brackets burned off.

6. All micarta pulleys in pulley brackets on face of spar burned out leaving only center bearings. Exception 2 pulleys only half burned—located most aft, next to spar web.

7. Bus support brackets. Outboard bracket bent up and burned away partially. Center bracket burned away to 4 1/4" of spar. Inboard bracket burned off to 4 1/8" of spar. Diagonal leg

support for this bracket hanging loose and burned off to 4 5/8" of spar

8. Outboard spar face pulley bracket had all pulleys burned out, but bracket was not melted.

9. Main spar face pulley bracket (nearest bus) had upper forward section burned away directly below bus separation. All pulleys, except as noted in item 6 burned out leaving pulley bearings on bolts which still remained.

10. Uplatch cable bellcrank located about 8" aft of spar on top wing surface was pulled out of its support bracket which was partially burned away.

11 Top wing skin aft of spar warped from heat.

Electrical

1. No. 4 engine wire bundle mounted just forward of bus had insulation burned off all but two wires (38 wires) for 56" across back of wheel well and extending beyond side of nacelle 6" on outboard side (this was not protected by nacelle sidewall). Wire bundle blistered 5" beyond burning on inboard side and 7" beyond on outboard side.

2. In same wire bundle, 18 out of the 40 wires were burned until broken, and 2 wires (thermocouple head temperature gauge) which had asbestos covering still had asbestos covering although it was beginning to fall off and was not insulating wire in region near pulley bracket.

3. 45" of No. 4 engine magneto ground wire conduit which ran across nacelle near main bus was burned out, wire insulation burned off and wires broken. One wire burned in half 42" from outboard side of nacelle (4" from inboard side) and the other wire 7" from outboard side of nacelle (41" from inboard side).

4. Main bus (from No. 3 and 4 engines) burned through 15" from inboard wall of nacelle (from bottom edge of main gusset) and 32 5/8" from outboard wall of nacelle (from bottom edge of main gusset). Insulation burned off of bus from Adel clamp at outboard gusset for 51" across face of spar. Bus completely bare for 47" of this distance.

5. Extra white condition of burned bus 7" outboard to 3" inboard of bus separation. (Due to magnesium pulley bracket fire.)

6. Inboard segment of bus touched upper corner of pulley bracket. This corner had about 1/4" burned off. Dimension of bus to spar is 4 7/8" as found, both segments.

7. Little pieces of engine control cable wire welded to bus where cables laid on the bus after burning in two. One piece outboard of break and three inboard of break.

8 Terminal strip at inboard aft end of nacelle close to upper magnesium pulley bracket which burned had disappeared in fire and wires attaching to it were burned and hanging loose.

Under Wing Wheel Well Fairing Region

Fluid System and Plumbing

1. No. 3 main tank outlet hose at booster pump blistered and found leaking a small amount a day after the accident.

2. Fuel line from strainer to bottom wing skin fitting (thence leading to inboard side of nacelle and forward to No. 3 engine firewall shutoff valve) had piece about 3/4 x 1 1/2" broken out. At upper end of line below wing skin fitting, line was severely burned and cracked, but no part of the tube was missing.

3. Dural drain line from No. 3 main tank drain valve burned off from exit grommet in fairing back 16" toward valve. Hose attachment burned through on bottom side.

4. Air brake line burned off at bottom wing skin fitting.

Structure

1. Fairing frame 14" aft broken fuel line was severely burned with top edge of dural sheet burned away.

2. Bottom wing skin warped and cracked in one place. Most intense on outboard side.

Electrical

1. Wire bundle from inboard side of nacelle down and back to junction box on outboard side of under wing fairing region had raw wires from junction to rear side of landing gear retract strut (outboard side of region), semi-raw for another 6" and charred from there to the forward edge of the nacelle fairing, gradually tapering off to O.K. at entrance into wing at inboard side of nacelle.

2. Wire bundle from under wing junction box aft to rear main strut attach fitting (region aft of broken fuel line) bare.

3. Wire from bundle in item 2 which led to landing gear strut extension safety switch was blistered in nacelle region.

4. Inside of junction box all wiring was burned, some bare, but terminal strip

had not disintegrated. Junction box front cover blackened smoothly on inside but only spotted from burned rubber (tires) on outside.

5. Heater solenoid near front of fairing, on outboard side overheated and wire bare from solenoid to junction box.

6. Landing gear up microswitch at center of nacelle mounted under wing aft of spar (near region of broken fuel line) burned, particularly on outboard side nearest broken fuel line.

7. Wires to No. 3 main boost pump, outboard side of this region, burned off at pump connection. This connection was well cooked inside.

—18824