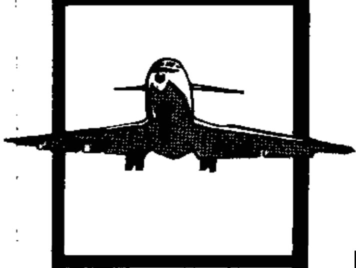

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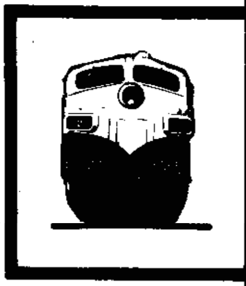
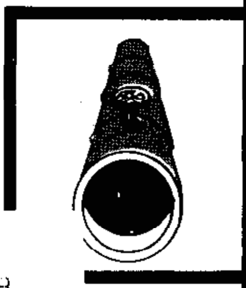


WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

CHAMPION HOME BUILDERS COMPANY
GATES LEARJET 25B, N999HG
SANFORD, NORTH CAROLINA
SEPTEMBER 8, 1977



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15. Supplementary Notes

16. Abstract

About 2020 e.s.t., on September 8, 1977, Champion Home Builders Company, Gates Learjet 25B, N999HG, crashed shortly after takeoff at Sanford, North Carolina. All five persons aboard were killed, and the aircraft was destroyed.

The aircraft departed Sanford Airport about 2018 e.s.t., for a flight to Flint, Michigan. In accordance with departure instructions from Payetteville departure control, the flight was about 3 mi west of the airport, climbing through *3,000* ft, on a heading of 270 , when it disappeared from radar. There were no distress calls, but several witnesses west of the airport saw the aircraft on fire below the 600-ft overcast ceiling. The flight completed a right turn to a northeasterly heading and suddenly dove to the ground. People in the immediate vicinity reported that the aircraft was on fire before it crashed.

The National Transportation Safety Board determines that the probable cause of this accident was one or more low-order explosions in the aircraft's aft fuselage which resulted in a fire and loss of control capability. The Safety Board could not determine conclusively the fuel and ignition sources of the initial explosion; however, gases from the aircraft's batteries or fuel leakage from fuel system components, or both, could have been present in the area of the initial explosion.

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

Adopted: September 20, 1979

CHAMPION HOME BUILDERS COMPANY
GATES LEARJET 25B, N999HG
SANFORD, NORTH CAROLINA
SEPTEMBER 8, 1977

SYNOPSIS

About 2020 e.s.t., on September 8, 1977, Champion Home Builders Company, Gates Learjet 25B, N999HG, crashed shortly after takeoff at Sanford, North Carolina. All five persons aboard were killed, and the aircraft was destroyed.

The aircraft departed Sanford Airport about 2018 e.s.t., for a flight to Flint, Michigan. In accordance with departure instructions from Fayetteville departure control, the flight was about 3 mi west of the airport, climbing through 3,000 ft, on a heading of 270°, when it disappeared from radar. There were no distress calls, but several witnesses west of the airport saw the aircraft on fire below the 600-ft overcast ceiling. The flight completed a right turn to a northeasterly heading and suddenly dove to the ground. People in the immediate vicinity reported that the aircraft was on fire before it crashed.

The National Transportation Safety Board determines that the probable cause of this accident was one or more low-order explosions in the aircraft's aft fuselage which resulted in a fire and loss of control capability. The Safety Board could not determine conclusively the fuel and ignition sources of the initial explosion; however, gases from the aircraft's batteries or fuel leakage from fuel system components, or both, could have been present in the area of the initial explosion.

1. FACTUAL INFORMATION

1.1 History of the Flight

On September 7, 1977, N999HG, a Gates Learjet Model 25B, operated by Champion Home Builders Company, departed Flint, Michigan, on a company business flight to Sanford, North Carolina. The president (the owner of the aircraft), his wife, a vice-president, and the two crewmembers arrived at Sanford Airport about 1745.1/ The crew parked the aircraft in front of the airport operations building. They did not report any problems or make any comments about the aircraft or the flight to Sanford. The crew did not request any servicing

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

and none was provided. The group of five persons departed the airport area and remained together throughout company plant inspections and business meetings on September 8.

About 1617 on September 8, the Raleigh-Durham Flight Service Station (FSS) received a call from a pilot who requested current and forecast weather at Flint, Michigan. Following the normal briefing, the pilot filed an instrument flight rules (IFR), flight plan for N999HG from Sanford direct to Flint, at flight level 410 (FL 410).2/ He estimated the time en route at 2 hours 30 minutes.

The local company vice-president drove the passengers and crew to the airport and arrived about 2000. He recalled that the pilot noticed that the aircraft's left wing was low and that he commented that he would "balance it out." The president's wife also commented, "It's listing again," and "It's that same thing."

The pilot unlocked the cabin door and entered the aircraft. The local vice-president heard a pump running while he helped load baggage, which took about 3 to 5 minutes. The pilot then sat down in his seat, and the copilot entered the aircraft and assisted the passengers in boarding. The local vice-president could not remember whether any radio communications took place or whether the pump was shut off. He did not know if any baggage, papers, or equipment was placed in the tail section of the aircraft, but he recalled that a roll of large drawings had been removed from the tail section on arrival and that some drawings could have been placed there for the return flight.

When the loading was completed and the cabin door was shut, the local vice-president drove his car from the ramp to the end of the operations building and parked facing the runway to watch the takeoff. He saw the pilot "doing his checks" and estimated that after 3 or 4 minutes, the engines were started. He remembered that the aircraft's lights were on and that the "blinkers" came on as he parked his car by the operations building. After the engines were running, he estimated that another 1 to 2 minutes elapsed before the aircraft was taxied to the takeoff end of runway 3. He also recalled that the aircraft's wings were level when it left the ramp. About 5 minutes later, he heard the engines roar and saw the aircraft lift off. He continued to watch the aircraft until it disappeared into the clouds over the highway area just north of the airport. He did not hear any abnormal noises. He recalled that it was not completely dark and that he was able to see the paint scheme on the aircraft as it took off.

Meanwhile, about 2008:45, the pilot of another aircraft called Fayetteville departure control and advised the controller that N999HG was attempting to get a clearance at Sanford. The controller used the other aircraft as a relay to clarify N999HG's destination airport, first en route navigational aid, and the pilot's proposed heading out of Sanford. He then cleared N999HG to Flint, Michigan, as filed, to depart Sanford heading 270°, climb to 2,000 feet, and expect FL 410 in 10 minutes. He assigned the flight a transponder code of 0600 and

2/ A level of constant atmospheric pressure related to a reference datum of 29.92 inches of mercury. Each level is stated in three digits that represents hundreds of feet.

advised that the clearance was void at 2020. The pilot received the clearance directly from the controller and relayed his acknowledgment through the other aircraft.

At 2019:15, the pilot advised, "Fayetteville, N999HG is off the ground." The controller cleared the flight to climb to 6,000 feet on a heading of 270° and requested that the flight change its transponder code to 0556. The controller noted that the code was not completely reset, and he repeated that instruction. After seeing the proper code, the controller cleared the flight to resume navigation and to maintain 6,000 ft. The flight did not acknowledge this clearance. The controller recalled that when he issued the clearance, the encoded altitude on the radar display was 3,000 ft and that the target was about 3 mi northwest of the airport on a westerly track. On the next radar sweep, the aircraft's transponder target disappeared. He did not see a primary or secondary target, and he was not able to establish any further communication with the flight.

Witnesses who were located northeast, north, northwest and west of the airport either saw or heard the aircraft after it took off from runway 3. From the information provided by these witnesses, the aircraft's ground track approximated a horizontal "S" with the top end at the departure end of runway 3 and the bottom end at the crash site.

A witness, located about 1 3/4 mi northeast of the airport, saw the aircraft make a left turn toward a southerly heading. Although the landing gear was down, he saw or heard nothing unusual. A witness, located about 2 1/2 mi north-northwest of the airport, heard the airplane pass nearby and saw the reflection of a red light in a nearby pond. She said the airplane's engines sounded normal.

An airline pilot, located about 1 mi west of the airport, heard the aircraft pass north-northwest of his position, but he could not see it. He estimated the clouds at 500 ft above the ground with good visibility beneath the clouds. A witness, located about 2 mi west of the airport, heard the aircraft pass near her house. A witness, located about 3 mi west of the airport, saw the aircraft flying west and said that the airplane was on fire as it turned to the north. A witness, in the same vicinity, saw what he described as a "big light" in the sky.

A witness, located about 4 mi west-northwest of the airport and about 1 mi south-southwest of the accident site, saw fire "coming from below and near the tail. . . to the ground" and "flames at least 30 ft wide." As the aircraft flew northeast, he saw smoke behind the wings. Seconds after the aircraft disappeared, he heard an explosion and saw the sky light up with balls of fire spreading over the sky.

After hearing intermittent engine sounds, a witness, located about 1/2 mi southwest of the accident site, looked out the door and saw "an orange, red, white-hot looking ball of fire coming between my home and our neighbors." She then looked north, from a window, and saw that the object looked like a "huge white bird on fire," and realized it was an airplane.

Several witnesses who were near the accident site said that the aircraft hit the ground and exploded, bounced into the air, struck the ground again, and exploded a second time.

The aircraft crashed at night (about 2020) at latitude 35°27'19"N and longitude 79°14'54"W, about 4 mi west-northwest of the Sanford Airport, and at an elevation of about 400 ft.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Other
Fatal	2	3	0
Serious	0	0	0
Minor/None	0	0	0

1.3 Damage to Aircraft

The aircraft was destroyed.

1.4 Other Damage

The aircraft crashed in a field of soybeans. Some personal property and soybeans in the area were damaged by debris from the aircraft.

1.5 Personnel Information

The crewmembers were properly certificated for the flight. (See appendix B.)

1.6 Aircraft Information

The aircraft was certificated, equipped, and maintained in accordance with Federal Aviation Administration (FAA) requirements. The gross weight and center of gravity (c.g.) were within prescribed limits for takeoff. (See appendix C.)

1.7 Meteorological Information

The weather in the Sanford area was dominated by a weak, low pressure system centered near Myrtle Beach, South Carolina; a squall line extended northeastward from the low pressure system to Cape Hatteras. The pertinent area forecast called, in part, for ceilings of 1,500 to 3,000 ft broken, variable to overcast, visibility 3 to 6 miles, haze; ceiling and visibility frequently variable at or below 1,000 feet and 3 miles in light rain and fog, with a chance of a few embedded thunderstorms. Thunderstorm activity was to increase after 1200. The freezing level was variable from 12,000 to 15,000 ft.

AIRMET CHARLIE 4, issued at 1830 and valid from 1830 to 0030; warned of ceilings at or below 1,000 ft, 3 mi in stratus, fog, and occasional precipitation over most of North Carolina and the surrounding area.

SIGMET ALFA 8, issued at 1905 and valid from 1905 to 2305, for eastern North Carolina, northeastern South Carolina, and adjacent coastal waters warned of lines and clusters of thunderstorms, except scattered embedded thunderstorms over northeastern North Carolina. At 1900, numerous short lines of thunderstorms were forecast for southeastern North Carolina, south of a line from Cape Hatteras to Fayetteville and extreme northeastern South Carolina.

The pilot who relayed radio transmissions from N999HG to Fayetteville departure control while N999HG was on the ground at Sanford said that at the time he was about 25 mi south of Sanford at 6,000 ft. He was flying through light rain and intermittent clouds. He said that he listened to transmissions from N999HG after it was airborne and that he detected no sign of distress in the transmissions.

The surface weather observations in the area near the time of the accident were as follows:

Raleigh
2054 Record Special: Ceiling—measured 600 ft broken, 1,200 ft overcast; visibility—2 1/2 mi, light drizzle, fog; temperature—69° F; dewpoint-- 69° F; wind—040° at 8 kns; altimeter—30.00 in.; wind--360° variable to 060°.

Fayetteville
2000: Ceiling—estimated 700 ft broken, 4,000 ft overcast; Visibility-- 4 mi, light rain; temperature—77° F; dewpoint—76° F; wind--360° at 10 kns; altimeter—29.94 ins.

The 2000 winds aloft observation at Greensboro, North Carolina, was, in part, as follows:

Height (ft m.s.l.)	Direction (True)	Velocity (kns)
1,000	040	15
2,000	055	29
3,000	070	36
4,000	080	37
6,000	090	25

1.8 Aids to Navigation

Navigational aids were not a factor in the accident.

1.9 Communications

There were no communications problems after N999HG was airborne; however, communications were abruptly terminated without explanation or warning.

1.10 Aerodrome Information

Sanford Municipal Airport is located 3 mi south of Sanford, North Carolina, at an elevation of 430 ft. The only runway, 3/21, is 3,500 ft long and 75 ft wide; it is asphalt covered and is equipped with medium intensity runway lights. Fire and rescue services are provided by a local fire station, which is located about 1 mi away.

1.11 Flight Recorders

No flight recorders were required and none were installed in N999HG.

1.12 Wreckage and Crash Information

The aircraft crashed in a soybean field approximately 4 mi west-northwest of the departure end of runway 3. The aircraft fragmented and pieces scattered in a fan-shaped area about 700 ft long and 620 ft wide from north to east-northeast. The initial crash scar was oriented on a magnetic heading of about 040° and was about 55 ft long. The right wingtip tank fin assembly and other parts were scattered adjacent to and within the scar. The left main landing gear was recovered from a crater at a depth of approximately 6 ft. The initial crash site was excavated to a depth of approximately 7 ft; no other parts were recovered at that depth. There was no evidence of ground fire around or within the initial crash point.

Both engines separated from their attachment beams. The bulk of the right engine and the left engine were 130 ft and 244 ft, respectively, northeast of the initial crash point. Both engines had sustained foreign object damage throughout the internal structure, which indicated that they were rotating at crash.

The main wreckage which included the empennage fin and attached portion of the aft fuselage structure was about 205 ft northeast of the initial crash point. This structure was damaged severely by fire, but the surrounding vegetation was damaged only slightly by fire.

Two ground searches were conducted in the area beneath the derived flightpath in an effort to locate any aircraft parts that may have separated in flight. On the first search, several instrument approach charts, company papers, and part of a $20 bill were recovered within a distance of 2 mi south of the crash site. Most of this material was damaged by either heat or fire. A 1.5- by 2-in piece of fiberglass, containing two rivet holes was found about 0.8 mi southwest of the crash site. Although the piece was burned black, it was identified as part of the aircraft's ram air duct. An exhaustive search of a 3-square-mi area south of the crash site, resulted in the recovery of additional papers from the aircraft.

Flight instruments were recovered in a field and wooded area about 500 ft beyond the main wreckage. They had sustained heavy mechanical damage but were not damaged or sooted by fire. Two radio magnetic indicators (RMI) were recovered: one indicated approximately 060' and the other indicated between 060' and 085. The auxiliary attitude gyro was recovered with the word "DIVE" visible in two places on its face; the words were rotated in a counterclockwise direction approximately 50° from the horizontal. This corresponds to an aircraft attitude of approximately 25" nosedown and 50° right wing down.

All flight control surfaces were accounted for within the wreckage scatter. The spoilers, flaps, and landing gear were in the retracted position at impact. The horizontal stabilizer trim setting could not be determined.

Seven of the eight fuselage/wing attachment fittings were recovered. All major components of the wing assemblies, including both tip tanks, spoilers, and flaps, had separated and the wings were fragmented. There was no evidence of in-flight fire in the wing tanks or the right tip tank. The aft bulkhead of the left tip tank was sooted and was discolored from heat. Similarly, the outer tank skin and underside of the bulkhead attachment flange, which had separated, were sooted. The rivet holes in this area were not sooted but some were discolored from heat. The tank's tailcone was sooted and discolored from heat.

After removal from the crash site, wreckage parts were separated, and two-dimensional layouts were made of various major components, including fuselage, wings, cabin, engines, and tip tanks. After a preliminary evaluation of this evidence, a three-dimensional mockup of the fuselage structure, including the aft portion of the occupiable area forward of the aft pressure bulkhead rearward to the empennage, was constructed. (See figure 1.) The fuselage structure forward of that included in the mockup was fragmented except for a 4-ft piece of top skin, a few small window structure pieces, the upper and lower sections of the main entry door, and the emergency window exit assembly. The main entry door was recovered in several pieces; the lower locking pin for the upper section of the door was in place through the mating fuselage frame. The emergency window exit frame had a double fold bend in its forward portion, and its upper support latches were attached to the frame.

Approximately one-half of the top fuselage skin, in the portion encompassed by the mockup, was identified and placed on the mockup. About one-third of the left side fuselage skin and relatively little of the right side fuselage skin were identified for placement on the mockup.

The forward interior portion of the mockup contained the divan seat and baggage compartment floor. All of these pieces were damaged mechanically and by fire, except for two pieces of support angle for the baggage compartment floor. One of the pieces was sooted, but its fracture surfaces were clean; the other piece was not damaged or sooted by fire. The two folddown divan seat backs were separated from their attachment structure. The right seat back was damaged by fire, and the baggage placard was sooted. The left divan seat back was sooted. The inboard half of the right divan seatbelt had melted away from its anchor attachment ring.

The blower evaporator assembly, which was located in the cabin ceiling and over the baggage area, separated from its attachment structure and was recovered in several pieces. Other than the fire-damaged recovered pieces of freon line between the blower evaporator and the compressor, there was no fire damage or soot on any of the parts.

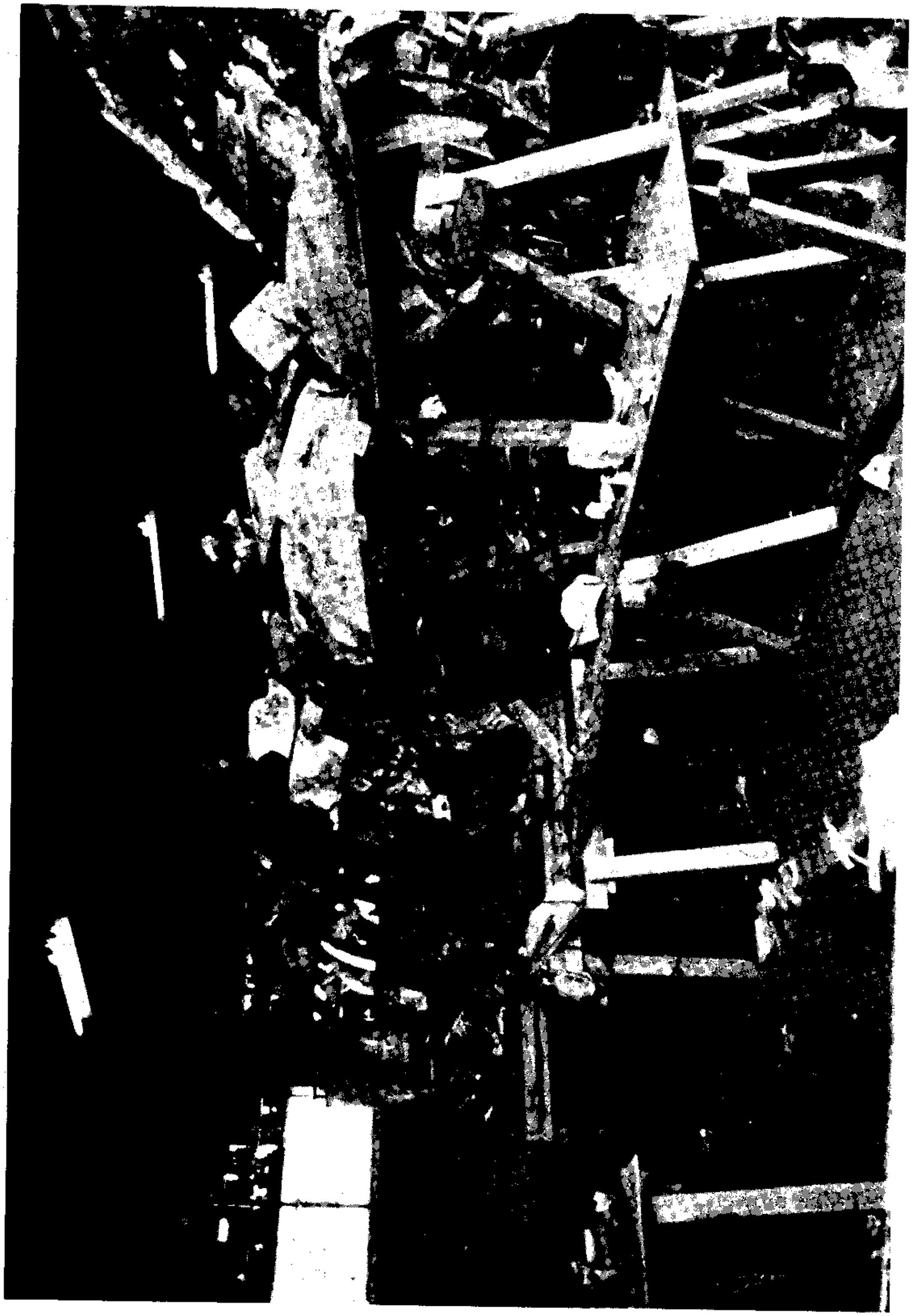


Figure 1. Three-dimensional mockup of the fuselage structure.

The aft section of the fuselage from fuselage frame (FF) 22, the aft pressure bulkhead, to and including the empennage was damaged extensively by fire and impact. Except for their fracture surfaces and torn rivet holes, various pieces of fuselage skin were sooted and burned.

The aft pressure bulkhead had separated into three major pieces. The bulkhead was split vertically along its centerline, and the right half was split horizontally near its midpoint. Both sides of the left half of the bulkhead were burned severely along its lower portion, and the left edge was torn and buckled near its midpoint. The fracture surfaces and torn rivet holes in this area were clean. The upper right quarter of the bulkhead was burned and sooted along its outer edge; the torn rivet holes in this area were sooted. The inboard fracture surfaces were clean. The lower right quarter was burned and sooted; compression wrinkles in the metal contained soot. The cracks and fracture surfaces on the top portion of this piece were clean. Except where attached to extrusions, individual panels on the aft surface of the bulkhead were depressed forward. Carpet and insulation material which covered the forward face of the bulkhead had separated. The carpet and its backing were not burned or sooted. The insulation material attached to the backing was discolored from yellow to a brownish-gray by heat.

The fuselage fuel tank compartment was located between FF 22 and FF 25. (See appendix E.) The compartment contained two bladder-type fuel cells which were interconnected. The compartment was fragmented extensively. Some pieces of fuselage skin and stringers surrounding the compartment were damaged and sooted by heat and fire; other pieces were clean. A piece of the top left portion of the tank compartment just forward of FF 25 was torn in a sawtooth pattern. It was not damaged by fire or sooted. Another piece which mated with the sawtooth tear was burned. Also, a 12-in piece of stringer from the top right portion of the fuselage between FF 22 and FF 23, with attached pieces of fuselage skin, intercostal, and compartment liner was burned and sooted except for the forward 5 in of the stringer; this stringer mated with another piece of burned fuselage skin.

The forward engine beam was damaged extensively by crash forces and fire. The aft face of the beam shroud was compressed forward against FF 24. Although portions of the shroud were burned, a number of rivets in the left end of it were not damaged by heat or fire.

About 80 percent of the vertical and longitudinal divider, including FF 24, in the fuel compartment was destroyed by fire. The remaining 20 percent was bent and flattened to about 25 percent of its original thickness; it also was burned.

FF 25 was a sealed bulkhead; the aft engine beam was attached to its rear face. FF 25 was separated from the adjoining fuselage structure and was damaged by fire and impact. The lower portion of the bulkhead frame was bent aft about 15 in from its normal position. Where not burned away, the forward face of the aft engine beam shroud was depressed rearward between the caps.

FF's 26A through 30 were missing or were damaged too severely to identify. A large piece of fuselage skin which covered the upper middle to lower left side of the fuselage from FF 26 to FF 30 was bowed outward at its midpoint and was blistered along its inner surface forward of the attachment position of the aft face of the plenum chamber. The rivet holes along the top portion of this piece of fuselage skin were elongated upward, and the rivet holes along the bottom portion of the skin were elongated downward. This skin normally covers, and is a part of, the plenum chamber which is located between FF 27 and FF 28. A bulge in this area conformed to the outline of the plenum chamber, and the holes for rivets that attached the chamber to the skin were not distorted. The rivets and the plenum chamber were missing.

The ram air inlet and duct, which extended between FF 26A and the vertical stabilizer, was fragmented extensively. The inlet end was burned, but those pieces of the duct located aft of FF 27 were not burned. The duct was made of fiberglass. a piece of which was found about 0.8 mi southwest of the accident site; however, its previous location on the duct could not be established.

The vertical stabilizer was damaged severely by impact and fire. Skin from the lower left side of the stabilizer was smeared with mud; beneath the mud, the skin was burned in places, and the paint covering was blistered in other places. Torn rivet holes in the skin were free of soot. The entire right side of the vertical stabilizer was burned and sooted to various degrees except for a small portion beneath a fold near the leading edge. The right VOR antenna was detached and was located away from the empennage section. It was burned and sooted. The left VOK antenna was partially detached and its base was heavily charred,

Many components of the fuselage fuel tank system were recovered, including the transfer pump, quantity probe, vacuum relief check valve, and fuel transfer valve. These components were damaged mechanically and by fire to various degrees. The transfer valve was in the closed position. The tank float switch was not located

The fuselage tank transfer pump was separated from its left bladder cell attachment. The pump mounting flange was broken from the fuel inlet housing. The flange was broken partially and was displaced downward into the area' of the seal drain and fuel outlet bosses. The broken surfaces of the pump flange were sooted, and the external side of the flange and attached fuselage structure were sooted. The internal side of the pump flange was charred. The housing of the pump's electric drive motor was dented, scored, and punctured. The motor was not burned or sooted

The fuselage tank quantity probe was separated and broken into four pieces. The pieces were bent and flattened but were not burned or sooted. The electrical wires on top of the probe were burned away. The interiors of the pieces showed no evidence of arcing.

The fuselage tank transfer valve was in the closed position. The vacuum relief valve was operational. The left and right fuel shutoff valves were in the open position; both valves were damaged extensively by fire. The left fuel filter head was burned extensively; the right filter head was sooted. The bowls of neither filter were located.

The left and right motive flow control valves remained partially attached to the aft face of the FF 25 bulkhead. Both valves were in the open position. On the left valve, the inlet line was disconnected from the inlet port and the O-ring seal was not located. The threads of the attachment fitting were not stripped or scored; they were discolored from heat and were sooted slightly. The right valve was broken into two pieces; both pieces were damaged by fire.

Each starter/generator had separated from its engine. Both were damaged mechanically; there was no evidence of electrical distress on the brushes and commutators. Neither unit was damaged by heat or fire.

Various electrical components including the aircraft's batteries and the generator control box were normally located between FF 25 and FF 26. Two 19-cell, 24-volt, 40-ampere-hour, nickel-cadmium (NiCad) batteries, and stainless steel cases for each, were recovered in the wreckage scatter area. The battery cases had broken open, and the plastic jars, enclosed plates, and electrolyte were scattered. The jars were shattered, but there was no evidence of operating distress on the plates, plate liners, plastic jar pieces, or connectors.

Both battery lids had separated from the battery cases. The heat and mechanical damage to the lids did not match the heat and mechanical damage to the cases. One battery case, recovered approximately midway between the initial impact area and the main wreckage area, was broken open at a side seam; the bottom was detached on three sides. A short length of vent hose remained attached to one of the two vent nozzles; the free end of the vent hose. was scorched. The other vent nozzle had no hose or hose connector attached.

The second battery case was found adjacent to the main wreckage. This case separated along a side seam. The bottom was detached, bent; and dimpled in both directions. The paint was in good condition. The right side of the case was damaged by fire and heat, and the damage was covered by mud splatter. The heat damage stopped at and did not extend across the side seam separation. A small piece of vent hose was still attached to one vent nozzle by the hose clamp. There was no vent hose or connector on the other nozzle.

The generator control box was recovered in the tail wreckage area. The box was damaged both mechanically and by severe fire. Droplets of slag were attached to the box, and insulation was burned from the attached large copper wire. A section of nonmetallic mounting board, found beneath the box, was burned except for a corner which was buried in the mud A shadow like pattern of heat damage to the mounting board outlined bus bars and interconnecting devices in their normal position.

Most of the components of the hydraulic system were found in the wreckage and placed in the aircraft mockup. There was no pattern of fire damage among adjacent units. The hydraulic reservoir was recovered in three pieces. The dome ends separated from the cylindrical center section at the connecting welds. Both the top and bottom domes were heat damaged and sooting was interrupted by folds or creases in the metal. Portions of the center section were sooted and heat damaged; other areas of the same piece were not damaged by heat. The heat damage on the center section was continuous throughout folds created by mechanical damage.

The hydraulic accumulator was recovered from the tail section. One end was sooted, but the separated mating fitting was not. The opposite end of the accumulator was wet with hydraulic fluid, a paper label was charred, and a separated fitting at this end was damaged by heat. The auxiliary hydraulic pump and its electric motor were recovered from beneath the tail wreckage; neither was damaged by heat nor soot.

The environmental system of the aircraft consisted primarily of cabin pressurization and **air** conditioning air supplied from engine bleeds. The bleed air was cooled by routing ram air through a duct, heat exchanger, and other components attached to the plenum chamber. Cabin air was further cooled by circulation through the evaporator located in the cabin ceiling.

Air from the ram air inlet passed through the heat exchanger, to the upper chamber of the plenum and aft into the tailcone area. The ambient air from the tailcone was then directed through the condenser, on the front of the plenum chamber, into the lower chamber and overboard. The compressor motor and condenser cooling fan were located in the front opening of the plenum chamber, with the fan mounted in the intake shroud which partially surrounded the condenser.

The plenum chamber and the fiberglass intake shroud were not recovered. The compressor motor and fan assembly were relatively free of fire damage, but the assembly was sooted, and mud was splattered over the soot. The fan blades were folded forward against the motor axle; the condenser was gouged by the axle and was fractured, but it was free of fire damage. The housing surrounding the motor brushes, at the forward end of the motor/fan assembly, was distorted in an outward direction. The motor brush leads were damaged by fire, but there was no evidence of heat damage on either the commutator **or** a wire mesh in the **air** inlet section of the housing. The compressor had a hole in the side of the case and some soot on its lower end

The heat exchanger was recovered beneath the main wreckage. The aft face was concave and exhibited marks corresponding to the engine pressure ratio (EPR) sensors. One corner of the heat exchanger was sooted. There was no evidence of soot on the inside of any ducts associated with these systems.

1.13 Medical and Pathological Information

There was no evidence of any preexisting disease **or** physical condition that would have affected the pilots in the performance of their duties.

1.14 Fire

Witnesses stated that the aircraft was on fire before it crashed. Parts of the aircraft burned on the ground for about **15** minutes after the crash. Units from the Tramway Volunteer Fire Department responded to the scene of the accident.

1.15 Survival Aspects

The accident was not survivable.

1.16 Tests and Research

1.16.1 Temperature and Airflow Survey

Tests were conducted by the Gates Learjet Corporation to determine the temperature and airflow patterns in the aft fuselage section of the Learjet Model 25B during representative flight conditions. The tailcone area of the aircraft was ventilated in flight by the airflow which entered the ram air inlet and exhausted through an outlet on the left side of the tailcone. Flight tests showed the air temperatures were as high as 97° F in the left side of the tailcone and as high as 108° F on the right side of the tailcone at airspeeds of 150 to 300 kn and at an outside air temperature of about 60° F. The volumetric airflow through the tailcone area at an airspeed of 180 kn and a density altitude of 3,000 ft was sufficient to totally displace the contained air approximately 11 times per minute.

The fuselage fuel cell compartment area was totally enclosed without forced airflow through the area. Additional tests were conducted to determine the maximum temperature of the generator control box under conditions of maximum battery discharge and the environment which existed at the time of the accident; The tests indicated the maximum temperature on the buses and terminals was less than 190° F, and on the current limiters, the maximum temperature was less than 290° F.

1.16.2 Fuel System Motive Flow Control Valve Leakage and Effect Tests

Tests were conducted to determine the amount of external fuel leakage which would occur at the fuel system motive flow control valve-to-line fitting if an O-ring were omitted during installation or if the fitting connection jamnut was torqued improperly. The results indicated (1) a leakage rate of 0.067 gal/hr with the O-ring missing but with a properly torqued jamnut, (2) a leakage rate of 0,057 gal/hr with an O-ring installed but with a loose jamnut; and (3) a leakage rate of 0.150 gal/hr with the O-ring missing and the jamnut backed off.

An additional test was conducted to determine the effect that an open fuel line at the motive flow control valve would have on engine operation. It was found that the engine could not be started if the line was opened to permit unrestricted leakage at the motive flow control valve. When the line was open while the engine was running, the engine continued to operate at higher power settings with noticeable fluctuations in the indicated engine pressure ratio; when power was retarded the engine ceased operation.

1.16.3 Motive Flow Control Valve and Fitting Assembly: Heat Discoloration and Residue Tests

Tests were conducted to determine the effect of externally applied heat on the control valve and fitting assembly with particular attention to the residue remaining after the O-ring burned.

The AN union with an appropriate O-ring and a 45° elbow fitting with an O-ring and jamnut were threaded into the motive flow valve. The union was torch-heated to a slight bronze color, and the valve body in the area of the 45° elbow and jamnut was heated to the melting point of the aluminum body. In both areas, the O-rings burned, and the interface between the union and the valve and the interface between the jamnut and the valve exhibited a black discoloration that was not easily removed.

The jamnut from N999DH's left motive flow control valve fitting was examined by the National Bureau of Standards to determine the principal elements of the dark residue on the nut. The examination disclosed that the jamnut surface contained a major amount of carbon and a minor amount of sulfur.

1.16.4 Aircraft's Flight Track

The flight track derived from the composite of witnesses' statements was flown by a Gates Learjet during the investigation. The test flight confirmed that the track was within the performance capability of the aircraft.

1.17 Additional Information

1.17.1 Independent Expert Examination of Wreckage

Three independent experts, who were retained by the Board examined the structural mockup of the recovered parts of the aircraft's aft fuselage for the purpose of analyzing evidence of in-flight explosion and fire. One expert, employed by the FAA, specialized in high-order explosions. He examined the wreckage for striation marks, stretch marks, minute missile penetrations, and impact marks, any of which would be evidence of a high order explosion. He found no such evidence or other indications of incendiary material.

The second expert, employed by the Batelle Columbus Laboratories, Columbus, Ohio, specialized in fracture analysis. He examined the wreckage for indications of overpressure. He found that the failures and deformations of the structure between the aft pressure bulkhead and the solid bulkhead at FF 25 were compatible with an overpressure in that enclosed area. He also found that the deformations were not compatible with an overpressure aft of FF 25.

The third expert was an independent aeronautical engineer whose past experience included extensive investigation of aircraft accidents involving fire in flight. He found that there was no evidence of a high-order explosion before impact but that the forward deformation of the aft pressure bulkhead, in the forward direction, the sawtooth tear in the fuel tank compartment near FF 25, the mode of failure of the fuel transfer pump, and the type of damage to the upper fuselage skin forward of FF 25 were indicative of a low-order explosion.

He also found that the fire patterns on the wreckage were not characteristic of those which would be produced by a forced-draft in-flight fire. Nor did he find evidence of temperatures in excess of 2,000° F which could be associated with the combustion of petroleum products when subjected to the forced draft of slipstream air. He qualified his findings, however, by stating that:

"In the case of N999HG, I do not believe we can readily assume because the indicated fire temperatures were at, or below, 2,000° F that an inflight fire did not occur. Firstly, much of the aircraft structure aft of Frame 22 was not recovered and was assumed destroyed by fire. Perhaps the inflight fire indications were destroyed in the ground fire. Secondly, the fuselage area aft of Frame 22 is not pressurized but considered a confined or 'sealed' area. It is possible that the necessary forced draft to produce the hotter inflight fire characteristics were not present."

1.17.2 Generation of Gas During Battery Charging Process

When the charging process of the NiCad batteries nears completion, and during overcharge, the battery cells generate hydrogen and oxygen gas. This is the result of electrolysis of the water in the electrolyte, which is potassium hydroxide (KOH). These gases are vented to the battery case which in turn is vented to the atmosphere. The battery manufacturer supplied an empirical formula for determining the amount of hydrogen gas produced by a NiCad battery during charging. This formula states that 8 cm^3 of hydrogen is generated each minute in each cell per ampere of charging current. The aircraft manufacturer calculated that the batteries in the accident aircraft discharged 8 ampere-hours during engine start, fuel transfer, and radio operation. Additionally, the manufacturer's calculations showed that the batteries would reach a state of full charge 4 minutes after an engine was started.

Authorities on NiCad batteries stated that a 4 percent concentration of hydrogen forms a flammable atmosphere and that a 7 percent concentration 'is explosive. The authorities were in agreement that a fire or an explosion of gases outside a battery case would probably propagate to the battery and appear to be a battery explosion. Also, they agreed that NiCad batteries should not be vented to a confined area. In this case the design of the battery system provided appropriate venting of the hydrogen gas overboard. An expert from a U.S. Army laboratory stated that a hydrogen explosion within a steel case would be similar to the explosion of a handgrenade and that cell jars would shatter. One industry expert suggested that the blister pattern about the plenum chamber area may have been caused by the electrolyte from the batteries. The Safety Boards laboratory analysis disclosed that potassium was present to a significant degree in the blistered material. Potassium is a major ingredient of the NiCad battery electrolyte.

1.17.3 Fuel System Description

The aircraft fuel tank system is comprised of a tank on each wingtip, integral tanks in each wing, and a fuselage tank. An electrically operated boost pump and a jet pump are installed at the most inboard position of each wing tank, and a jet pump is installed in each tip tank. The jet pumps operate on the venturi principle by high pressure fuel (motive flow) from their applicable engine-driven fuel pumps. The jet pumps in the tip tanks transfer fuel to the wing tanks and the jet pumps in the wing tanks transfer fuel to each engine. The motive flow control valves control operation of the jet pumps.

During a normal mode of operation, the jet pump switches are on, the crossflow valve is closed, and the fuselage transfer valve is closed. When the starter-generator switch is moved to the start position, the motive flow control valve for that engine closes, and the wing tank boost pump is energized. After the engine is running, and the starter-generator switch is moved to the generator position, the boost pump is deengerized, and the motive flow control valve opens, providing high pressure fuel to operate the jet pumps.

1.18 New Investigative Techniques

None.

2. ANALYSIS

The flightcrew was properly certificated and qualified for this flight operation. There was no indication of any medical or physiological problem that would have affected them in the performance of their duties.

The aircraft was maintained in accordance with applicable regulations. The gross weight and c.g. were within prescribed limits.

There were only two apparent problems experienced by the crew before takeoff. The aircraft was left wing low because fuel was seeping past the flapper valves in the tanks. The condition apparently occurred frequently, based on comments made, and was remedied before taxi out. The second problem was an inability to contact Fayetteville departure control while on the ground. Since the other aircraft in the area received all transmissions from N999HG and since the crew received the clearance from Fayetteville directly without any difficulty, the Safety Board presumed that the aircraft was in a "blind spot" initially.

The evidence indicates that the flightcrew had difficulties with the aircraft shortly after takeoff. Furthermore, these difficulties apparently began after the departure controller asked the flight to change its transponder code and about the time the controller issued a change to the flight's clearance because immediately thereafter, the aircraft's transponder target disappeared from the controller's display, the flightcrew failed to respond to the controller's transmissions, and the departure route was abandoned without notice or warning to the controller.

The Safety Board believes that this evidence indicates that the flightcrew was having difficulties that possibly included an interruption of electrical power, at least to the aircraft's radios and transponder. Also, about the same time, the aircraft descended rapidly from 3,000 ft to an altitude beneath the 600-ft overcast and witnesses about 3 mi west of the airport saw the aircraft to the west of their positions in a right turn to north. According to those witnesses, the aircraft was on fire at that time.

Other witnesses who saw the aircraft during its last mile of flight also stated that the aircraft was on fire. One witness described the fire as coming from below and to the rear of the aircraft with the flames extending toward the ground. This witness' account suggests that fuel was escaping from the aircraft and was burning as it fell to the ground.

Based on the above evidence, the Safety Board concludes that the aircraft caught fire soon after takeoff. Based on evaluations of the wreckage and the three-dimensional mockup, the Safety Board further concludes that the in-flight fire was confined to the fuselage aft of FF 22, the aft pressure bulkhead.

Although the typical evidence of inflight fire -- streaks of soot and burns extending from fore to aft, soot deposits on forward portions of rivets and other projections, and melted parts -- did not exist or was destroyed by postcrash explosions and fire, the burns and soot on the left side of the vertical stabilizer, which were covered by mud, and the clean fracture surfaces of pieces of metal that were otherwise extensively burned and sooted clearly indicate a fire in the aft section of the aircraft before the crash. Additionally, soot on the air conditioner motor and plenum chamber fan assembly, which was covered with mud, and the scorched piece of fiberglass from the ram air inlet, which was found about 0.8 mi southwest of the crash site, verifies the existence and location of the in-flight fire.

Evidence of overpressure in two areas of the aircraft's aft section suggested the possibility that a low-order explosion in one of these areas was the initiating mechanism for the fire.

The evidence of explosive overpressure in the fuselage fuel tank included the forward bending and tearing of FF 22 along its left edge, the forward deformation of the panels on the rear face of FF 22, the depression of the tank compartment liner around the transfer pump mounting flange, the sawtooth tear in the top of the compartment liner, the aft bending of the lower portion of FF 25, and the deformation of the engine beam shrouds. This evidence, in addition to the absence of soot on various fracture surfaces, indicates that at least one explosion, followed by burning occurred in the area of the crash. However, although potential ignition sources existed within the fuel tank and included the pump motor, the quantity probe, and the tank shutoff float switch, there was no evidence that any of these components provided ignition to the contents of the tank.

The second area of explosive overpressure was the plenum chamber area. The large piece of fuselage skin, part of which covered the exterior face of the chamber, was bowed outward and clearly showed the outline of the surfaces of the chamber that were riveted to the skin. Also, the rivet holes in this piece of skin were deformed in a manner which indicates that an explosion within the chamber bent the piece outward. Further, the housing of the air conditioning motor was distorted outward circumferentially, indicating that an explosive mixture was ignited within the housing.

The Safety Board was not able to determine conclusively the initial source of the combustible material. However, two possible sources were identified. The first possible source involves a disconnected fuel inlet line on the left motive flow control valve. Tests established that the line could not have been disconnected when the left engine was started and that it was not likely that the line was disconnected before takeoff. However, it is possible that the jamnut was loose, that it backed off after takeoff, and that fuel escaped from the loosened connection into the compartment aft of FF 25. Fuel escaping into this section would have vaporized in the comparatively warm air there, and although tests showed that during flight, the airflow in the tailcone area was sufficient to totally displace the volume of air in the area about 11 times per minute, the Safety Board believes that a progressively larger fuel leak into the area could have formed an explosive mixture. Furthermore, the mixture would have been in close proximity to many electrical components in the area, such as the air conditioner motor, which could have provided ignition.

The second possible source was hydrogen from the two NiCad batteries. Physical evidence indicated that two of the four vent lines on the battery cases were not installed prior to the crash. This would have allowed hydrogen to escape from the battery cases into the tailcone area. The batteries were discharged partially before the engines were started when the pilot corrected the fuel imbalance condition which caused the aircraft to list. He probably corrected this condition by transferring fuel from the low wing's integral tank to the high wing's integral tank or from the low wing's tank to the fuselage tank, which would have required operation of a wing tank boost pump. The batteries were further depleted by prestarting checks and engine starting. According to the aircraft's manufacturer, the partially discharged batteries should have been recharged about 4 minutes after the engines were started and the generators turned on. Consequently, hydrogen production would have begun while the pretaxi checks were performed and while the aircraft was taxied to the runway.

Calculations show that about 1.14 ft^3 of hydrogen would have been vented into the tailcone area in the approximate 10-minute interval between engine starting and takeoff. Since the air volume of the tailcone area is about 75 ft^3, this amount of hydrogen would not have been sufficient to form a flammable atmosphere, assuming that the hydrogen mixed uniformly with the air in the tailcone. However, based on the structure of the tailcone area, the Safety Board believes that the hydrogen could have collected within a specific area of the tailcone, such as the plenum chambers, rather than mixing uniformly with the air throughout the tailcone. Furthermore, although during flight the volume of air within the tailcone is changed every 5 to 6 seconds, it is possible that the hydrogen collected in the plenum area was not subject to a significant flow of air (particularly during ground operation and at low airspeeds in flight) and could have built up to a flammable or explosive mixture. However, the Safety Board is unable to conclude that this condition in fact developed.

There is evidence that the batteries exploded before the crash. The heat and mechanical damage to the battery case lids could not be matched to the heat and mechanical damage that occurred to the cases, indicating that the lids probably were not in place when the aircraft crashed. Also, the blisters on the piece of fuselage skin which forms a part of the plenum chamber contained potassium, one of the elements of the battery electrolyte. However, the blister pattern on the skin indicates that the plenum chamber was not intact when the electrolyte contacted the skin. Therefore, the batteries exploded after the plenum chamber was disrupted.

Since the flames from the ignition of hydrogen gas frequently travel to the source of the gas, it is possible that the hydrogen was ignited within the air conditioner motor housing, which exploded hydrogen collected in the plenum chamber, and that the flames also traveled forward to the battery cases and ignited the gases within the cases. On the other hand, fire from any source within the aft section probably would have caused the batteries to explode. Consequently, the Safety Board concludes that the batteries exploded before the crash; however, we were not able to determine conclusively the source of the fire that caused the batteries to explode.

Based on all the evidence, the Safety Board believes that the most likely sequence of events was a low-order explosion in the aircraft's tailcone area, aft of FF 25, followed by inflight fire. The explosion or fire penetrated the fuselage fuel tank and permitted fuel within the tank to escape and burn. Shortly before the crash, the fuselage fuel tank probably exploded and disrupted elevator and rudder controls which made further control of the aircraft impossible.

This accident and several other accidents 3/ involving complex general aviation type aircraft illustrate the difficulty of clearly establishing causal factors and possible preventive measures without the aid of a cockpit voice recorder and a flight data recorder. The Safety Board continues to believe that these recorders are invaluable tools in accident investigation and, therefore, in accident prevention.

3. CONCLUSIONS

3.1 Findings

1. The aircraft was certificated and maintained in accordance with approved procedures.
2. Crewmembers were certificated and qualified for the flight.
3. The flight was operating in accordance with an IFR flight plan, under radar control.
4. No radio transmissions from the aircraft were heard regarding an emergency condition or requesting to deviate from the departure clearance.

3/ Aircraft Accident Report: Southern Company Services, Inc., Beech–Hawker 125–601A, N40PC, McLean, Virginia, April 28, 1977. (NTSB–AAR–78–11.)
Aircraft Accident Report: Jet Avia, Ltd, Learjet LR24B, N12NK, Palm Springs, California, January 6, 1977. (NTSB–AAR–77–8.)
Aircraft Accident Report: Johnson and Johnson, Inc., Gruman Gulfiltrion II, N500J, Hot Springs, Virginia, September 25, 1976. (NTSB-AAR-78-4.)

5. The flight was in instrument meteorological conditions when it diverted from its departure route.

6. Based on witness observations and damage to the aircraft, a fire started in the aircraft's aft section shortly after takeoff.

7. The fire probably was preceded by at least one low-order explosion.

a. There was evidence of explosions in two areas of the aircraft's aft section before the aircraft crashed: the plenum chamber and the fuselage fuel tank.

9. The inflight fire grew progressively worse and probably was fed by fuel which escaped from the fuselage fuel tank.

10. Elevator and rudder controls in the aircraft's aft section were disrupted shortly before the crash which made further control of the aircraft impossible.

11. The source of combustible material for initial ignition could not be determined conclusively; however, possible sources included fuel leakage from the left motive flow control valve inlet line and hydrogen from the aircraft's batteries.

12. The accident was not survivable because of high crash forces, explosion, and fire.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this 'accident was one or more low-order explosions in the aircraft's aft fuselage which resulted in a fire and loss of control capability. The Safety Board could not determine conclusively the fuel and ignition sources of the initial explosion; however, gases from the aircraft's batteries or fuel leakage from fuel system components, or both, could have been present in the area of the initial explosion.

4. RECOMMENDATIONS

As a result of this accident and several others involving corporate jet aircraft, the National Transportation Safety Board reiterates the following recommendations to the Federal Aviation Administration:

> "Develop, in cooperation with industry, flight recorder standards (FDR/CVR) for complex aircraft which are predicated upon intended aircraft usage. (Class II, Priority Action) (A-78-27)
>
> "Draft specifications and fund research and development **for** a low cost FDR, CVR, and composite recorder which can be used on complex general aviation aircraft. Establish guidelines for these recorders, such as maximum cost, compatible with the cost of the airplane on which they will be installed and with the use for which the airplane is intended. (Class II, Priority Action) (A-78-28)
>
> "In the interim, amend **14** CFR to require that no operation (except for maintenance ferry flights) may be conducted with turbine-powered aircraft certificated to carry six passengers or more, which require two pilots by their certificate, without an operable CVR capable of retaining at least 10 minutes **of** intracockpit conversation when power is interrupted. Such requirements can be met with available equipment to facilitate rapid implementation of this requirement. (Class II, Priority Action) (A-78-29)"

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JAMES B. KING
Chairman

/s/ ELWOOD T. DRIVER
Vice Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PATRICIA A. GOLDMAN
Member

/s/ G. H. PATRICK BURSLEY
Member

September 20, 1979

5. APPENDIXES

APPENDIX A
INVESTIGATION AND HEARING

1. Investigation

The Safety Board was notified of the accident about 2130 on September 8, 1977. Investigators from the Safety Board's Dulles Field Office and Washington, D.C., headquarters went directly to the scene. Working groups were established for operations/air traffic control, structures, systems, powerplants, maintenance records, witnesses, and weather.

Participants in the investigation were the Federal Aviation Administration, Champion Home Builders Company, Gates Learjet, and General Electric Company.

2. Public Hearing

A public hearing was not held.

APPENDIX B

PERSONNEL INFORMATION

Pilot James D. Taylor

Mr. Taylor, 40, the pilot–in–command, held airline transport pilot certificate No. 1443087 with ratings for airplane multiengine land and Learjet aircraft. He also held airframe and powerplant mechanic certificate No. 1471200. His second–class medical certificate was issued with no limitations on May 2, 1977. He previously had held a flight instructor's certificate. At the time of the accident, he had accumulated a total of 9,364 flying hours. His flight time in the Learjet could not be determined.

Copilot Leroy J. Sutherland

Mr. Sutherland, 58, the copilot, held commercial pilot license No. 248272 with ratings for airplane single and multiengine land, helicopters, and instruments. He had type ratings in the Learjet, Aero Commander 1121, and Jet Commander 1123. His second class medical certificate was issued on July 22, 1977, with the limitation that, "The holder shall wear glasses which correct distant vision while exercising the privileges of his airman Certificate." He previously had held a flight instructor's certificate. At the time of his Learjet type rating check ride on May 19, 1976, he had accumulated a total of 17,033 flying hours. His total flight time in the Learjet was about 1,500 hours.

APPENDIX C

AIRCRAFT INFORMATION

N999HG, a Gates Learjet Model 25B, serial No. 25B-178, was operated and leased by several corporations after delivery from the factory on September 11, 1974, until it was purchased by Mr. Henry George, Chairman of the Board and Chief Executive of Champion Home Builders Company, on May 6, 1976. The 300-hour and 6-month inspections were completed at that time (447.5 hours total time) by Duncan Aviation, Inc., Lincoln, Nebraska. Duncan Aviation provided maintenance support for the aircraft until the crash. Pertinent aircraft maintenance included:

Date	Inspection	Total Time
July 7, 1976	75-hour	522.5
November 17,1976	300, 600-hour and 6-Month	596.9
May 18, 1977	75-hour	669.9

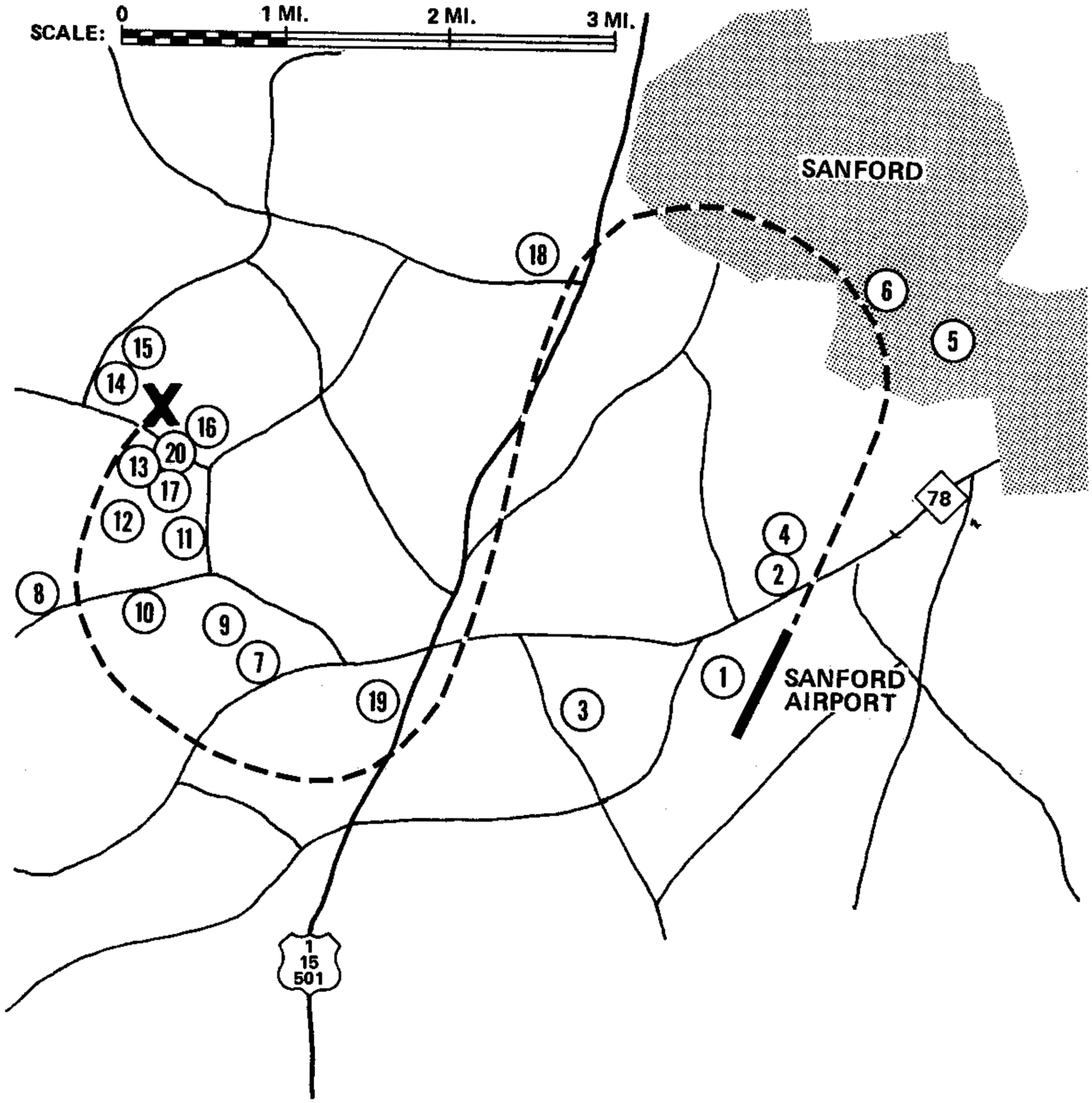
At the time of the accident, the aircraft had about 700 hours since new.

On April 28, 1976, the aircraft was modified with the installation of the Howard-Raisbeck performance improvement package. Modifications included 1) a recontoured wing leading edge with anti-ice capability; 2) a recontoured flap leading edge and removal of the vortex generators; 3) installation of a flap-actuated pitch compensator in the elevator system; and 4) revised flap position indicating and stall warning systems.

The computed takeoff weight for N999HG was 12,373 lbs; its allowable takeoff gross weight was 15,000 lbs. The c.g. was calculated at 27.9 percent mean aerodynamic chord which was within the limits of 12.2 and 30 percent.

APPENDIX D

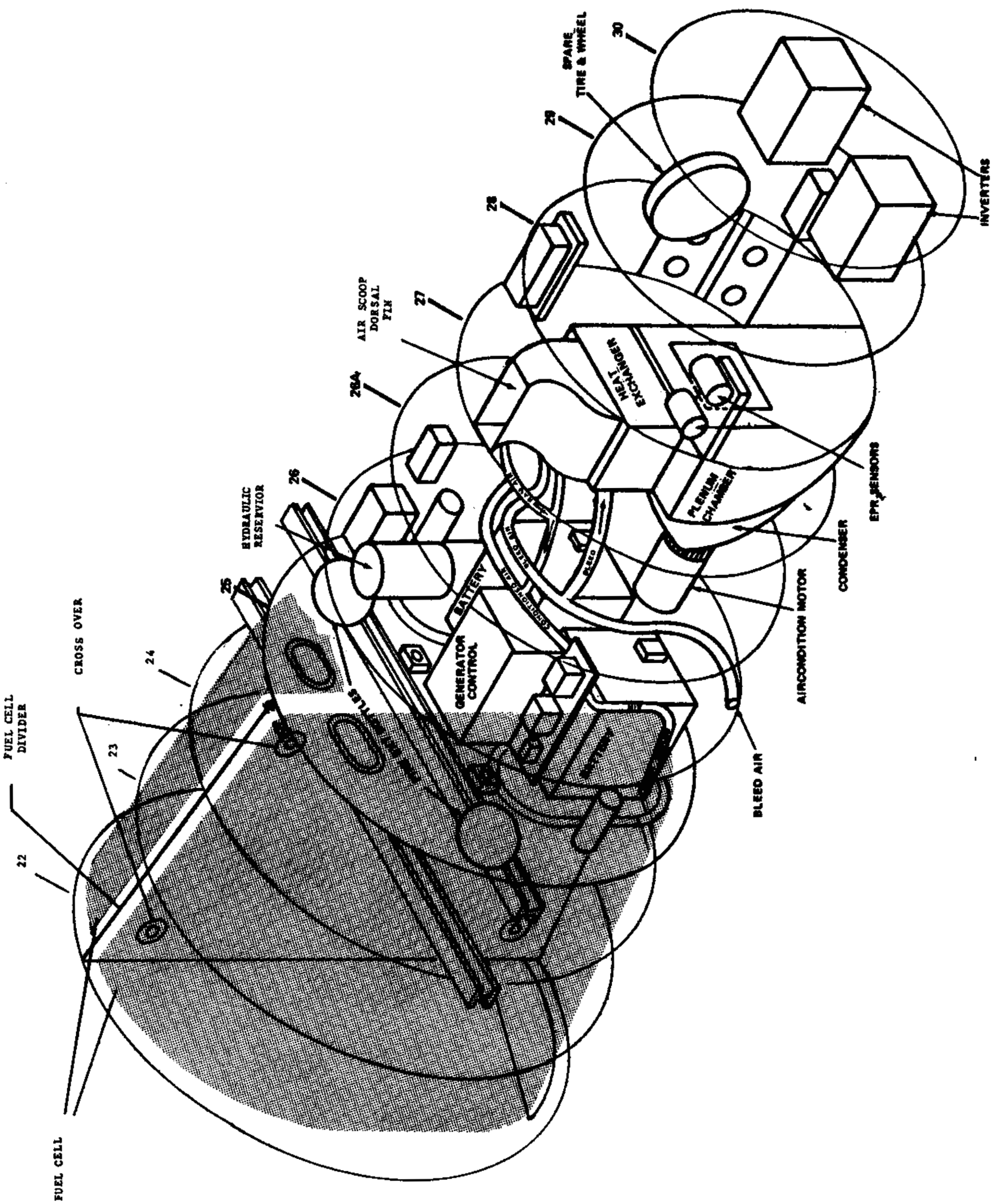
WITNESS LOCATION CHART AND PROBABLE FLIGHTPATH



① – WITNESS LOCATIONS
X – CRASHSITE

APPENDIX E

DIAGRAM OF FUSELAGE AFT SECTION



APPENDIX F

PHOTOGRAPH OF MOTIVE FLOW CONTROL VALVE