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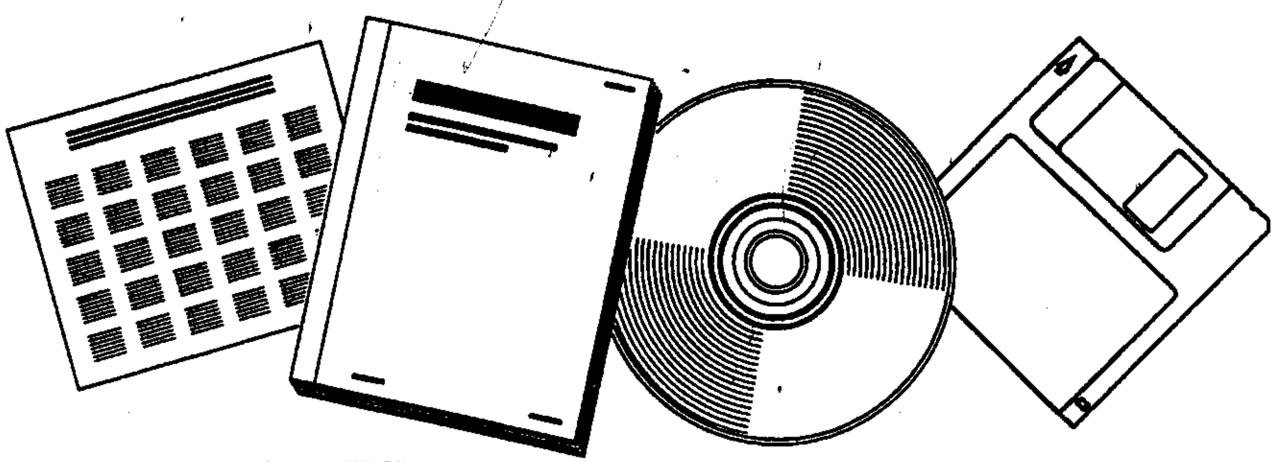
AIRCRAFT ACCIDENT REPORT. MOHAWK AIRLINES, INC. BAC 1-11, N1116J NEAR BLOSSBURG, PENNSYLVANIA JUNE 23, 1967

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, DC

1967



U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

SA-399 File 1-0004

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Adopted: April 18, 1968

MOHAWK AIRLINES, INC.

BAC 1-11, N1116J

NEAR BLOSSBURG, PENNSYLVANIA

JUNE 23, 1967

NATIONAL TRANSPORTATION SAFETY BOARD
DEPARTMENT OF TRANSPORTATION
WASHINGTON D.C. 20591

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TABLE OF CONTENTS

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SYNOPSIS

A Mohawk Airlines, Inc., BAC 1-11, N1116J, operating as Flight 40, crashed approximately one mile east of the town of Blossburg, Pennsylvania, on June 23, 1967, at approximately 1447 e.d.t. The aircraft was destroyed by impact and fire. The two flight crewmembers, two stewardesses, and 30 passengers aboard the aircraft all received fatal injuries.

Flight 40 was a regularly scheduled passenger flight which originated in Syracuse, New York, and was destined for Washington, D. C., with an en route stop at Elmira, New York. The flight from Syracuse to Elmira was routine, as were the ground handling and departure procedures at Elmira.

Following takeoff from Elmira at 1439 e.d.t., Flight 40 established radio contact with the New York Air Route Traffic Control Center at 1442 e.d.t., whereupon the flight was cleared direct to Harrisburg, Pennsylvania. Acknowledgement of this clearance was the last communication received from the aircraft. A subsequent clearance for Flight 40 to climb to 16,000 feet, transmitted by the New York Center at 1444 e.d.t., was received by the flight but their attempted acknowledgement was not received by the Center. At about

1447 e.d.t. the New York Center controller observed the radar target of the aircraft appear to slow down, move laterally, and then disappear from his radar scope.

The aircraft was observed in flight by a number of ground witnesses, who gave varying reports of smoke coming from the tail end of the aircraft as it proceeded south from Mansfield, Pennsylvania, which is about 9 miles north of Blossburg. Two witnesses, located about two miles north of Blossburg, observed large sections of the tail separate from the aircraft in flight, after which fire and smoke emitted from the tail as the aircraft dove into the ground.

The Safety Board determines that the probable cause of this accident was the loss of integrity of the empennage pitch control systems due to a destructive inflight fire which originated in the airframe plenum chamber and, fueled by hydraulic fluid, progressed up into the vertical fin. The fire resulted from engine bleed air flowing back through a malfunctioning nonreturn valve and an open air delivery valve, through the auxiliary power unit in a reverse direction, and exiting into the plenum chamber at temperatures sufficiently high to cause the acoustics linings to ignite.

1. INVESTIGATION

1.1 History of the Flight

Mohawk Airlines, Inc., Flight 40, operated on June 23, 1967, with British Aircraft Corporation BAC 1-11, N1116J, was a regularly scheduled passenger flight which originated in Syracuse, New York, and was destined for Washington, D. C., with an en route stop at Elmira, New York. A crew change with respect to N1116J was effected prior to the origination of Flight 40 and the aircraft departed from Syracuse at 1350, 1/ 15 minutes after scheduled departure time.

The flight from Syracuse to Elmira was routine in all respects, and the aircraft arrived at the Chemung County Airport at Elmira at 1407. One passenger was deplaned at Elmira, leaving the aircraft by means of the ventral stairway. Thirteen passengers were enplaned who, coupled with the 17 through passengers, brought the total number of passengers to 30. The passenger deplaning and enplaning, fuel servicing and ground handling at Elmira all were carried out in a routine manner.

Prior to takeoff, Flight 40 received an Instrument Flight Rules clearance to Washington National Airport in accordance with the filed flight plan, with the single exception that the flight was restricted in climb to maintain 6,000 feet, rather than the requested altitude of 16,000 feet. The climb restriction was imposed because of opposite direction traffic northbound on Victor Airway 31 at 7,000 feet between Williamsport and Elmira.

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

Flight 40 lifted off Runway 24 at Elmira at 1439:40. The tower controllers, who observed the progress of the aircraft visually following its takeoff until it started a left turn toward the south, noticed nothing unusual with respect to the aircraft or its maneuvering.

Following takeoff Flight 40 was instructed by Elmira Tower to contact the New York Air Route Traffic Control Center. This contact was established at 1442:28 on the assigned frequency of 134.6 MHz, whereupon the flight was cleared direct to Harrisburg. Flight 40 acknowledged this clearance and stated that they were climbing to 6,000 feet. This was the last communication from the aircraft that was heard either by the New York Center or by the other aircraft in the Elmira-Williamsport area which were known to be operating on a frequency of 134.6MHz.

At 1444:11 New York Center cleared Flight 40 to climb to and maintain 16,000 feet. Examination of the cockpit voice recorder tape indicates that this transmission was the last communication from New York Center which was received by the flight. The pilots' attempts to acknowledge this clearance, as well as subsequent transmissions from the aircraft of an emergency nature, were not received by the Center, nor were the Center's attempts to re-establish radio contact with Flight 40 received in the aircraft.

At 1447 the New York Center controller observed the radar target of Flight 40 appear to slow down for one sweep, 2/ then move laterally for one sweep, and finally to disappear from the scope. Thereafter, the Center controller vectored a Piper Aztec over the area of target disappearance. The

2/ The radar antenna utilized to track Flight 40 has a 5 r.p.m. scan rate, and thus completes one sweep every 12 seconds.

pilot of this aircraft reported observing the burning wreckage of an airplane, which was later identified as N1116J.

N1116J was observed in flight by a number of ground witnesses, most of whom were located in and near the town of Mansfield, Pennsylvania,[3/] and southward toward the crash site. They generally described the aircraft as flying in a straight and level attitude on a southerly course, the track of which was approximately one mile east of, and parallel to, U. S. Highway 15 which runs between Mansfield and Blossburg. The majority of the witnesses were also of the view that the aircraft was flying at an altitude substantially lower than aircraft of the same type which had previously been observed flying in that area.

Almost all of the witnesses reported that smoke was coming from the rear of the aircraft, although these reports varied as to whether the smoke was white, gray or black and whether it came from the engines rather than the fuselage or tail assembly. Two witnesses located in Mansfield, who were almost directly beneath the flightpath of the aircraft, observed a white, needle-like discharge of vapor extending from the very rear of the fuselage. One of these witnesses said that this trail of vapor looked like the airborne dumping of fuel he had once observed. Another witnesses, who was located on a hill about 1-1/2 miles west of Mansfield, observed a streak of heavy black smoke coming from the top of the tail assembly.

Two witnesses, located on Highway 15 about 2 miles north of Blossburg, observed a large section of the upper tail assembly separate from the aircraft,

3/ Mansfield is approximately 9 miles north of Blossburg.

after which some smaller pieces also came off the tail. The aircraft then nosed over and dove out of view. One of these witnesses also observed rust-colored fire and smoke emanate from the rear of the aircraft following the separation of the aforementioned sections of the tail.

The aircraft crashed approximately 1 mile east of the town of Blossburg, Pennsylvania, 4/ at an elevation of 1,813 feet m.s.l. The accident occurred during daylight hours.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	4	30	0
Nonfatal	0	0	0
None	0	0	

1.3 Damage to Aircraft

The aircraft was destroyed by inflight fire and disintegration, impact, and post-impact fire.

1.4 Other Damage

Apart from the aircraft, and property thereon, damage was confined to trees and ground cover, resulting from impact and fire.

1.5 Crew Information

The flight crew and stewardesses were properly qualified and certificated. For detailed information in this regard, see Appendix A.

1.6 Aircraft Information

N1116J was a British Aircraft Corporatión model BAC 1-11, S/N 098, with a date of manufacture of August 1, 1966. The aircraft had a total

4/ Latitude 41°40'57.5" north, Longitude 77°03'00.5" west.

flying time of 2,246:12 hours and was powered by two Rolls Royce Spey 506-14 engines. The total time on the engines, neither of which had been overhauled since new, was 1,575:31 hours for the No. 1 engine and 2,924:33 hours for the No. 2 engine.

An examination of the aircraft records revealed that all required inspections and service checks had been performed as prescribed by appropriate company requirements and Federal Aviation Regulations. A review of Airworthiness Directive notes applicable to BAC 1-11 aircraft indicated that the only notes which had not been complied with on N1116J were not due as of June 23, 1967.

A review of the flight log sheets of N1116J revealed that there were numerous discrepancies concerning its pneumatic system, including the APU (Auxiliary Power Unit). More specifically, it was noted that during the period from April 1 to June 22, 1967, 55 of the 289 log writeups pertained to this system. 5/ Such writeups included, inter alia, the following items:

1. Low main duct air pressure when air was being supplied from the APU.
2. APU would not hold both air conditioning packages.
3. Excessive APU tailpipe gas temperature when both systems were on APU.
4. APU generator disconnects with both MAC valves on APU.
5. Excessive reading on main duct air pressure gauge (attributed to defective gauge).

5/ Seventeen of the writeups on the pneumatic system were recorded during a 15-day period in June.

6. When MAC valve is switched from APU position to open position, or from closed to APU, there is a loud fluttering or chattering noise and air pulsation is felt (this item appeared 5 times during the 10 days preceding the accident).
7. Overtemperature on No. 1 system but no system fail and shutdown.
8. Repeated failure of No. 1 system.

All of the foregoing discrepancies received corrective action, and the components involved were checked out on the ground to the satisfaction of the maintenance personnel.

The crewmembers who operated N1116J during the flights immediately prior to Flight 40 related that they noticed nothing unusual about the aircraft with the single exception of an odor and mist observed during the approach and landing at Newark on the morning of the accident. During the cruise portion of this flight the two MAC (master air conditioning control) valve switches were in the open position 6/ and the APU air delivery valve was closed. 7/ During the descent, at a point about 30 or 40 miles from the airport, the air delivery valve was opened and the No. 1 MAC valve selector was switched to the APU position, while the No. 2 MAC valve selector was left in the open position. The captain explained that he did not switch the No. 2 system from engine air to APU air in order to avoid the cabin pressure

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6/ The two MAC valve switches are located in the cockpit and allow the pilot to select either engine bleed air (open position) or APU bleed air (APU position) as the air source for either or both air conditioning systems. These switches also have an off position which isolates the system from all bleed air sources.

7/ The APU air delivery valve (also known as the load control valve) controls the flow of bleed air from the APU and may be selected open or closed from the cockpit.

fluctuation normally associated with such a change. [8] When the aircraft was about 4 miles out on final approach, a strong odor became evident throughout both the cabin and the cockpit. The first officer, who was operating the aircraft controls, then turned both MAC valve selectors to the off position, in order to prevent outside air from entering the air conditioning system. However, the odor persisted.

After landing and applying reverse thrust to the main engines, the captain observed that the No. 2 air conditioning system fail light was illuminated. He attributed this to an overpressure condition associated with reverse thrust. The captain then reset the No. 2 system and left the No. 2 MAC valve in the off position. As the aircraft slowed to taxi speed, both MAC valves were switched to the APU position, thus allowing APU bleed air to flow into both systems, and within 5 to 10 seconds the odor disappeared. After the aircraft was parked, the junior flight attendant opened the aft bulkhead door, at which point she saw that the rear stairwell area behind the door was filled with a foggy mist which produced the same odor she had previously noticed in the cabin. The mist and odor dissipated quickly when the stairs were lowered. A walkaround inspection of the aircraft was performed immediately thereafter but nothing abnormal was observed nor did the crew notice a similar odor or mist at any time later in the day. The flight crewmembers stated that they attributed the source of the odor and mist to the industrial area of Newark over which the aircraft was flown during the letdown and final approach. Although the captain on this flight did not write up

8/ During this period, and until after landing, the crossfeed valve remained closed. This valve, when selected open from the cockpit, allows bleed air from a single engine or the APU to supply both air conditioning systems.

this occurrence in the logbook, he did mention it to the captain of Flight 40 when the crew change was effected at Syracuse. 9/

During the investigation, the foregoing crew was subjected to a number of odors, including those from burning matches, hairspray, lighter fluid, hydraulic fluid and aluminum. In addition, the crew was asked to smell various sections of the wreckage. It was their consensus that none of these odors was similar to the odor noticed in the aircraft at Newark.

The actual gross weight of N1116J at the time of takeoff from Elmira was recomputed to be 65,612 pounds. Maximum allowable gross weight for a takeoff from Runway 24 under the conditions which then existed was 69,300 pounds. The center of gravity of the aircraft was calculated to have been within the prescribed limits both at the time of takeoff and at the time of the crash.

The aircraft was loaded with 13,000 pounds of Avjet A kerosene fuel at the time of takeoff.

1.7 Meteorological Information

The Elmira/Williamsport area was in a post-cold frontal zone characterized generally by broken or scattered cumulus clouds, with bases at about 4,500 feet, and associated light turbulence. Both ground and airborne witnesses reported that the weather conditions along the track of Flight 40, and in the area of the crash, were generally good with no restriction to visibility. The accident occurred in sunlight conditions.

For more detailed information regarding meteorological conditions, see Appendix B.

9/ There were no actual pilot discrepancies noted in the flight log on the day of the accident. The only entry stated that the radar was operating normally.

1.8 Aids to Navigation

There were no reported discrepancies of ground or airborne navigation equipment during the flight. The aircraft came under the radar observation and control of the New York Air Route Traffic Control Center at 1442. Both primary and secondary radar targets 10/ were observed until they disappeared from the radar screen at 1447. The radar system (primary and secondary), the low altitude video map, the mapping equipment and the beacon decoder were ground or flight checked, as applicable, subsequent to the accident. All functions were operating within accepted tolerances.

A flight check of the Elmira, Williamsport and Stony Fork VORTACs, and the Grover, Pennsylvania, intersection, was conducted immediately after the accident and completed at 2013 on June 23, 1967. All were found to be operating within prescribed limits. In addition, a ground check was conducted on the above three VORTACs, and they were certified as operating normally.

1.9 Communications

Prior to the events described below, there were no apparent discrepancies in the air to ground communications between Flight 40 and the New York Center, which were being conducted on a frequency of 134.6 MHz. 11/ In a transmission

10/ Primary radar targets are reflections from the aircraft surfaces, while secondary targets are electronic returns from a radar transponder aboard the aircraft.

11/ Examination of the radio frequency selector panel as found in the wreckage indicated that the No. 1 VHF communication transceiver was set on a frequency of 134.6 MHz. The antenna for the No. 1 VHF system is located on the top surface of the horizontal tailplane while the wiring leading to this antenna runs up the interior of the vertical fin along the aft side of the rear spar.

which ended at 1444:14, the New York Center controller issued a clearance to Flight 40 to climb to 16,000 feet, which was the last Center communication received in the aircraft. An attempt was made by the flight to acknowledge this clearance, beginning at 1444:24. Additional attempts were made by the flight to transmit to New York Center at approximately 1444:50 and again at 1445:14. None of these messages were received at the Center. The controller repeated the climb clearance since no acknowledgement thereof had been received. Thereafter, a number of unsuccessful attempts were made by the controller to re-establish radio contact with the flight, both directly and through the medium of northbound aircraft on Victor 31. 12/

Federal Aviation Administration (FAA) flight check data, as well as successful communications with other aircraft at various altitudes, indicated that satisfactory coverage of the New York Center remote communications on 134.6 MHz existed along Victor 31 between Williamsport and Elmira down to the minimum en route altitude of 4,000 feet.

1.10 Aerodrome and Ground Facilities

Not involved in this accident.

1.11 Flight Recorders

(a) Flight Data Recorder

The aircraft was equipped with a United Data Control Flight Data Recorder, model F542, S/N 1756, which was installed in the radio rack at the rear of the flight deck on the right hand side of the aircraft.

12/ Information concerning the transmission and receipt or non-receipt of the above messages was derived from the cockpit voice recorder and the recording of communications transmitted by and received at the New York Center.

Although the flight recorder sustained substantial impact damage the recording medium itself received only minor damage which did not impair the readout of the flight record. However, a malfunction of the take-up mechanism spool within the recorder resulted in intermittent parameter traces and skip or gap areas between styli markings.

Examination of the data graph prepared from the recorder readout indicates that, during the first 4 minutes of flight, the aircraft climbed out to an altitude of 6,000 feet m.s.l., while maintaining a steady rate of climb of approximately 1,200 feet per minute. The airspeed rapidly increased to 156 knots after takeoff where it remained steady for 30 seconds before commencing a buildup to 240 knots during the remainder of the climb to 6,000 feet. After maintaining a heading slightly to the right of the runway heading of 240 degrees magnetic for the first minute of flight, the aircraft swung to the left, reaching a heading of 206 degrees at 2-1/2 minutes after takeoff. Thereafter, the aircraft turned back to the right, reaching a heading of 220 degrees at the 3-1/2 minute mark. Throughout the remaining 4 minutes of flight, the aircraft maintained a gradual, steady turn to the left, culminating in a final heading trace indication of 180 degrees.

After reaching 6,000 feet 4 minutes after takeoff, the aircraft levelled off and remained at that altitude for 50 seconds while its speed increased from 240 knots to 266 knots. Thereafter, the aircraft climbed to 7,500 feet in a 32-second period as the airspeed dropped back to 243 knots. This rapid climb was reflected in the vertical acceleration trace, which showed several sharp positive "G" excursions before climbing to the positive .5 "G" increment level, where it remained constant for a period of 8 seconds.

After the sharp climb to 7,500 feet, the aircraft abruptly levelled off and remained level for a period of 20 seconds, during which time the airspeed stopped decreasing and started to increase while the vertical acceleration trace indicated negative "G" values. Thereafter, the aircraft descended 3,700 feet in 46 seconds while the airspeed increased to 320 knots and the vertical acceleration trace continued to reflect negative "G" values.

The aircraft then shifted rapidly from a descent to a climb, which was reflected by positive "G" excursions in the vertical acceleration trace. The resulting climb took the aircraft from 3,800 feet to 5,100 feet in 26 seconds, while the airspeed decreased rapidly from 320 knots to 224 knots.

After the aforedescribed climb, the aircraft immediately went into a descent, which commenced at approximately 37 seconds prior to the time when the parameter traces became aberrant. During this descent, which culminated in a final altitude indication on the graph of 2,700 feet, the airspeed rose from 224 knots to a final value of 315 knots.

(b) Cockpit Voice Recorder

Installed aboard the aircraft at the time of the accident was a Collins Cockpit Voice Recorder, model 642C-1, S/N 65. 13/ Examination of the unit following its removal from the wreckage revealed that the recorder was operating normally until ground impact occurred. Voice reproduction

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13/ The voice recorder was installed forward of the aft pressure bulkhead on the right hand side of the aircraft.

was adequate for transcribing the recorded conversation and the recording was considered satisfactory.

The recorded conversation indicates that, prior to starting engines, the pilots noted an excessive reading on one of the two gauges which reflect the air pressure in the crossfeed supply duct of the pneumatic system. After starting one of the engines and opening the crossfeed valve, the pilots noted that the other main duct pressure gauge was indicating a normal value. The pilots then made comments indicating that they attributed the excessive reading to a defective gauge. Just prior to the start of the second engine the captain mentioned that the "last time we had a real hot start."

After starting the engines, the pilots went through the after-start checklist, during which specific reference was made to the air delivery and crossfeed valves being open and the isolation valves being closed. 14/ Throughout the ground operation and initial portion of the flight, the captain was reading the challenge portion of the checklists and making the radio transmissions while the first officer was apparently operating the controls. 15/

The first apparent indication of any difficulty during the flight was an exclamation uttered by the captain during the transmission from the New York Center controller at 1444:11 clearing the flight to 16,000 feet.

14/ The isolation valves, which can be positioned open or closed from the cockpit, control the flow of high pressure bleed air from the engines into the pneumatic system.

15/ This conclusion was based on identification of the voices which are heard on the recording.

At 1444:33 the first officer remarked that "it's hard to tell just what it is." At 1444:41 the captain directed the first officer to "pull back on your speed", to which the latter replied "I'm doing it." Immediately thereafter, one of the pilots commented that "there's something screwy here" and the captain referred to "having a little control problem."

The recording then indicates that the captain took over the controls of the aircraft and decided to return to Elmira, which intention both pilots attempted to transmit on the assigned radio frequency. These messages were recorded on the radio channels of the cockpit voice recorder but were not received at the New York Center. At 1445:18 the captain exclaimed "we lost all control /pause/ we don't have anything." The first officer then remarked "we're in manual now," to which the captain responded "yeah, but I can't do anything." Shortly after 1445:29 the sound of the landing gear warning horn is heard, ceases, and then commences again. One of the pilots then stated "put it back in the second system."

At 1445:42 the captain declared his intention to "go up for a minute", which was followed by a series of statements over the next 30-35 seconds regarding attempts to control the aircraft (e.g., "Pull back! Pull back! . . . keep working, we're making it . . . straight now . . . climb now . . . easy now"). Thereafter, one of the pilots stated "now cut the gun . . . we're in now," following which the sound of the horn ceased.

At 1446:31 the captain stated "we better turn back towards Elmira", but then apparently changed his mind and said "let's go straight ahead." At 1446:37 the captain remarked "what have we done to that . . . tail surface, ya have any idea?" The first officer replied "I don't know . . . I just can't figure it out", following which he stated "we've lost both systems." Thereafter, the captain stated "I can't keep this [apparent reference to aircraft] from . . . all right I'm gonna use both hands now." This was followed by a series of statements which referred to using "both hands" and to "pulling back." At 1447:11 the captain stated "I've gone out of control", and at 1447:17 the recording ended. 16/

1.12 Wreckage

The aircraft impacted in a heavily wooded area near the crest of a hill where the terrain was basically level. Based on damage to trees, the average descending angle of the aircraft at the main wreckage site was approximately 40 degrees. The wreckage distribution was oriented along a true bearing of 142 degrees and was located within an area 1,300 feet long and 420 feet wide. All major aircraft structural components and all flight control surfaces were accounted for.

The fuselage, both wings and both engines were located within the main impact area, in which were two large craters. The inboard section of the right wing and fuselage parts were located in the left crater, relative to the apparent direction of flight at impact, while the engine components and aft fuselage structure were found in the right crater. The right wing from rib No. 11 outboard had separated from the remainder of the wing. There was no evidence to show that this separation occurred at impact. The damage at the zone of separation indicated that the wing failed downward by compression

16/ Attached hereto is a chart correlating pertinent pilot conversation, derived from the cockpit voice recorder, and the altitude profile of the flight, taken from the flight recorder data graph.

failures of the lower stringers and tension failures of the top stringers. The left wing was fairly intact. The remainder of the wreckage in the main impact area was broken into small pieces.

A large section of the tail assembly, which included the tailplane, elevators and the top two feet of the vertical fin structure, was found approximately 510 feet back from the main impact area along the apparent direction of flight. The rudder was located approximately another 430 feet beyond this tail section. Vertical fin skin sections were found between the main impact area and the rudder. There was no evidence to indicate that the aforedescribed tail components had been thrown back from the main impact area at impact. The direction of tree damage and furrows made in the ground indicated that these components were separated from the aircraft prior to striking the trees and were moving in the same general flight direction as the main part of the aircraft.

Extensive heat and fire damage was visible on sections of the vertical fin and rudder. Molten metal splatter was visible on the vertical fin skin sections, on the vertical fin and at the lower hinge point of the rudder. Soot and dark colored stains on the external surfaces of these units were aligned with inflight air flow patterns. There was no ground fire associated with any of the above items. 17/

Evidence in the wreckage indicated that both main engines were rotating at impact, and that the APU was running at or near governed speed. There was

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17/ However, there was evidence of heat damage to ground cover in this area which appeared to have resulted from contact with the hot aircraft components.

no evidence of inflight or ground fire on or about any of these units. The APU air delivery valve was found in the open position. Examination of appropriate valves in the fuel system indicated that the engines were being supplied with fuel at impact. There was no evidence of fuel leaks in the fuel lines running from the wheelwell area to the engines, or in the fuel line to the APU.

Evidence in the wreckage also indicated that the landing gear and flaps were fully retracted at impact. Three of the four spoiler/speed-brake power control units were found fully retracted while the fourth one from the left side was extended one inch. Evidence further indicated that the tailplane trim at impact was 0 degrees 54 minutes nose up, which is within its normal setting based on the aircraft center of gravity, weight, and speed.

With respect to the hydraulic systems, both engine-driven pump fluid suction shutoff valves were found to be fully open. In addition, the elevator emergency toggle switch was found in the emergency position, and there was no evidence that the toggle had been struck by some object or otherwise forced into this position.

The majority of the pneumatic system ducting was recovered. There was no evidence of pre-existing cracks or loose joints in this ducting, nor was there any external or internal evidence of exposure to smoke, heat or fire, with the exception of some small portions recovered from ground fire areas. The various pneumatic system flow control valves were also recovered and all were found to be in the open position. These include (1) the isolation valves, located in the engine bleed air high pressure ducting in the left and right stub wings; (2) the pressure reducing valves, located in the stub wings immediately downstream of the isolation valves in the high pressure ducts; (3) the crossfeed valve, located in the crossfeed supply duct; and (4) the nonreturn valve, located in the APU bleed air duct just aft of the crossfeed supply duct.

The purpose of the nonreturn valve is to prevent the main engine bleed air from flowing back to the APU. As found in the wreckage, one of the two valve flaps was forced down inside the intake ring while the other flap was partially open with some of the buckled ducting folded underneath it in a manner suggesting that the flap was partially open at impact. 18/

Examination of the valve disclosed that both of the valve flaps were severely deformed, being cupped inward toward the intake ring so that the seat sides of the flaps were convex. The pattern of distortion was similar in both flaps, with the maximum bend being about 45°. There was also some deformation of the seat areas on the flaps and on the intake ring. In addition, galling was present on the surfaces of the valve hinge ears of both flaps.

1.13 Fire

On the basis of witness statements and observations of the wreckage, it was apparent that an inflight fire had occurred in the rear part of the fuselage and in the tail assembly. In order to isolate the inflight fire area within the airframe, a modified three-dimensional type mockup was constructed. Inasmuch as the fire-damaged rudder and tail sections were found

18/ Deposits were found on the upstream or APU side of the valve flap which was jammed shut and on the same side of the intake ring center web. These deposits were subsequently indentified as nylon residue.

upstream of the main impact area along the apparent flightpath, the mockup was constructed starting first with the rearmost components of the aircraft, and proceeding forward until the inflight fire damage limits were ascertained.

Based on the above process, the inflight fire area was isolated in the rear section of the fuselage between Fuselage Station (FS) 936 and 958 and above the APU bay. The fire damaged the airframe plenum chamber and the hydraulics bay compartment, which are located in the top part of the fuselage between the foregoing fuselage stations, [19] burned through the top fuselage skin in the area of FS 936, and damaged the rudder and vertical fin. No evidence of inflight fire was found anywhere else in the aircraft.

Based on known melting points and observations of molecular structure, metal temperatures in the airframe plenum chamber were calculated to be in the 648°C. to 882°C. range, which constituted the highest such temperatures within the designated inflight fire area. The fire damage was more intense in the forward inboard section than in any other part of this chamber. The plenum chamber acoustic linings, whose primary purpose is sound suppression, were essentially destroyed in the fire, as was the aluminum wall separating the hydraulics bay from the plenum chamber. The fire damage and metal discoloration in the hydraulics bay was the most severe in the forward inboard corner of that compartment.

19/ Facing forward, the plenum chamber is on the right hand side of the fuselage, while the hydraulics bay is on the left side. The plenum chamber was designed primarily to facilitate the smooth flow of outside air to the APU compressor inlet. The hydraulics bay houses the hydraulic compensator units in the return lines from the power control units.

The existing 8 inch by 4 inch hydraulic hose exit hole in the top of the fuselage skin near the centerline of the aircraft, just aft of FS 936, was enlarged to a hole 10 inches by 6 inches by fire damage. The flexible hoses which pass through this hole, and which carry the hydraulic fluid which operates the rudder controls located in the tail assembly, were to a large extent never recovered. However, sections of hydraulic tubing and flexible hoses and the two rudder power control units, all of which were blackened and spattered with metal, were recovered back along the probable flightpath upstream from the main impact site.

The elevator control rods, located on the rear side of the aft spar in the lower section of the vertical fin, were destroyed by fire.

The rudder and vertical fin assembly sustained extensive fire damage. With respect to the rudder, the most intense fire damage was centered in the forward, lower section of that component, particularly in the area of the lower rudder hinge box. There was also evidence of fire damage, intense heat, metal splattering or sooting throughout the length of the vertical fin, with the most severe indications located in the lower, interior section of the fin.

There was extensive fire damage between the forward and aft vertical fin spars in the area of vertical fin separation. The aft spar webbing, just below the second rib from the top, was burned through, as was the second rib itself. The vertical fin forward spar was exposed to temperatures of a magnitude sufficient to destroy the integrity of the spar, as evidenced by the foliation of the spar material in the fracture. Evidence indicated that the vertical fin forward spar failed in tension while the aft spar failed in compression.

Electrical wiring in the horizontal tailplane extended approximately five feet below the tailplane and was severely burned throughout its exposed length. This wiring included the coaxial lead for the No. 1 VHF communications antenna and the lead for the electrical elevator trim.

The fire extinguisher bottles for each of the engines and the APU were recovered in the empty condition. However, there was no evidence in the wreckage indicating that any of these extinguishers had been discharged by activating controls located in the cockpit.

1.14 Survival Aspects

This was a nonsurvivable accident.

1.15 Tests and Research

Due to the presence within the designated inflight fire area of a wide variety of deposits whose identity could not immediately be established, a representative sampling of these deposits was submitted to laboratory examination. In addition, where the identity of certain fabricating materials found within the inflight fire area was considered desirable, samples thereof were also taken for laboratory analysis. The results of the laboratory analyses of these samples disclosed no evidence of materials not indigenous to the aircraft. Moreover, the selected fabrication samples were found to be composed of the materials called for in the manufacturer's drawings.

A series of flight tests were conducted, utilizing a 400 series BAC 1-11 aircraft, in order to determine whether leaking aircraft fuel could possibly be transmitted to the intake of the airframe plenum chamber. By means of releasing dyed water from the various simulated leak areas, these tests established the external flow pattern of fuel leaking from the wing root area, the single point refueling cap, the main landing gear wheelwell area, and the stub wing area. These tests duplicated typical flight conditions from takeoff through the reverse thrust phase of landing roll. In none of these tests did the discharged fluid ever reach the plenum chamber intake.

Additional tests disclosed that exhaust gases from the right engine entered the airframe plenum chamber through the intake screen, as evidenced by a rise in temperature at the screen of up to 8°C. during application of reverse thrust. [20/] However, the test aircraft was not instrumented to detect the ingestion of glowing carbon particles or unburned fuel into the plenum chamber during reverse thrust.

Dyed water was also released in the area of the rudder power control units in order to determine the path of Skydrol [21/] leaking from this area during flight. The bulk of the fluid so released drained into the hydraulic compensator bay, where some of it was trapped in the inboard section of the

20/ It should be noted that the exhaust gas flow during reverse thrust is slightly different on the test aircraft, a 400 series BAC 1-11, as opposed to the 200 series BAC 1-11 aircraft involved in the accident, although not in a sense that would alter the test results.

21/ Skydrol is the trade name of the fluid utilized in the hydraulics system of the BAC 1-11.

bay due to an inadequate drainage system. A check of all nine aircraft on the BAC 1-11 production line showed that the sealing between the hydraulic compensator bay and the airframe plenum chamber was imperfect, with the consequence that the trapped fluid, under ambient conditions, seeped into the airframe plenum chamber. The flight tests were conducted with the plenum chamber acoustic lining installed, and some of the fluid became coated on, or was absorbed by, these linings.

Flight tests to determine airflow patterns within the airframe were also conducted, in order to determine the extent to which normal internal airflows contributed to the propagation of the inflight fire. The flow patterns were deduced from static pressure measurements taken in the APU bay, the plenum chamber, the hydraulics bay, the rudder control unit bay and the vertical fin. The data derived from these tests verified the potential for a draft from the hydraulics bay up through the vertical fin. These tests also disclosed that the pressure in the hydraulics compensator bay was greater than the plenum chamber pressure, a differential which no doubt contributed to the aforementioned seepage of leaked Skydrol fluid from the former compartment into the latter.

In addition to pressure measurements, flight tests were also performed to ascertain and record normal operating temperatures within the aircraft in the designated inflight fire area and adjacent compartments. The highest temperature recorded was in the APU bay in the proximity of the air delivery duct. Although heat from this duct warmed the underside of the hydraulic compensator bay, the maximum temperature recorded in this bay was 70°C., which is only slightly above the normal operating temperature of the Skydrol in the hydraulic lines within the compensator bay.

Other tests were conducted to determine the possibility of combustion arising from sonic vibration within the airframe plenum chamber acoustic linings. The acoustic energy developed during these tests was three times that normally found in the plenum chamber but still was not sufficient to ignite the linings, although a temperature rise of 150°C. was recorded. These tests were conducted both with dry acoustic linings and with linings wetted with kerosene and Skydrol.

Tests were also performed to ascertain the extent to which lining material could be heated by frictional rubbing, such as might occur if the linings should come in contact with the rotating APU compressor disc. These tests were conducted by placing dry, kerosene wetted and Skydrol wetted acoustic linings in a fixed position against smooth and serrated discs of aluminum alloy, steel and titanium, and then rotating the discs at speeds up to 36,000 feet/minute. Combustion of kerosene and Skydrol wetted linings was achieved with the serrated aluminum alloy discs, but not with the steel or titanium discs. The APU compressor disc material is titanium.

To determine whether a fire could be started in a Skydrol-wetted electrical cable energized at the potential found in the tail of the BAC 1-11, a "wet wire" test was performed. The results of this test were negative.

An extensive series of tests were conducted to determine the effect of ingesting raw fuel, Skydrol, and acoustic linings (both dry and soaked with kerosene and Skydrol) into the compressor inlet of the APU during various induced surge and operating conditions of that unit. None of these tests produced ignition or flame propagation in the compressor inlet. 22/

During the course of the above APU tests, it was noted that it was possible to achieve a reverse airflow through the APU. It was further observed that such reverse flow was accompanied by a temperature rise at the intake to the APU, or in what would be the airframe plenum chamber. On the basis of this information, an extension of these tests was carried out, under still air conditions, utilizing the static mounted rear fuselage section of a BAC 1-11 in which an APU was installed. A hot air supply, simulating main engine bleed air, was connected to the APU air supply ducting. 23/ The airframe plenum chamber in the fuselage was fitted with a full set of acoustic linings. Prior to each of three tests which were conducted, these linings were injected with controlled amounts of aviation turbine fuel, Skydrol and white spirit. In addition, a small quantity of Skydrol was applied to the walls and floor of the hydraulic compensator bay.

With the APU running in the no load condition and the air delivery valve selected closed, the pressure of the simulated engine bleed air in the delivery duct was raised to equal the pressure in the APU turbine plenum. The APU air delivery valve was then selected open 24/ and the simulated engine

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22/ Even with a massive simulated fuel leak into the intake plenum, there was no fire until the APU was shut down and coasting to a stop.

23/ This ducting did not contain a nonreturn valve, although the flow of air was approximately equivalent to that which would be allowed by a half-open valve.

24/ The air delivery valve on the test APU had its rate control head blanked off, as did the APU on N1116J.

air pressure gradually increased until surge of the APU compressor occurred. The compressor surge took place at a turbine plenum static pressure of between 44 and 45 p.s.i.g. At this pressure, the simulated main engine air flow into the APU turbine plenum increased rapidly from less than 1 lb. per second to approximately 4 lbs. per second, due to a reduction in back pressure, and hot air was discharged into the airframe plenum chamber. When the surge point was reached, the APU appeared to flame out and drop to 95 percent speed, allowing automatic re-ignition to occur. The APU then recovered to a speed only slightly above normal, and continued to run with reverse flow conditions prevailing. Apparently, a portion of the simulated engine air was utilized to sustain combustion, while the remainder passed through the compressor section and into the airframe plenum chamber.

After several minutes of operation in this condition, a considerable amount of smoke was emitted from the plenum chamber. In addition, Skydrol vapor could be seen issuing from the aperture in the top of the hydraulics bay. Apart from the smoke and vapor, the only indication that the unit was not operating normally was a change in noise emission from the installation.

After respective test periods of 3-1/2, 6-1/2 and 16-3/4 minutes, termination of the reverse flow condition and reversion to normal APU operation was accomplished, either by closing the air delivery valve or by an unintentional drop in the simulated engine bleed air pressure. In each instance, the transition to normal APU operation was smooth.

During the reverse flow tests, temperatures in the airframe plenum chamber and the hydraulics bay were sensed by 8 thermocouples. In addition, temperature sensitive paint and control samples of various metals whose melting points were known were distributed throughout the plenum chamber. The pertinent temperatures indicated were as follows: 25/

1. The maximum recorded air temperature within the plenum chamber was 375°C. In the third and longest test this temperature reached 360°C. after 6 minutes, where it remained stable for the next 5 minutes.

2. Temperatures inside most of the acoustic linings continued to rise after the intake air temperature had stabilized, reaching a maximum of 515°C. after 11 minutes in the third test. 26/

3. The maximum air temperature in the hydraulics compensator bay was 297°C., reached after about 10 minutes in Test 3.

4. The maximum temperature recorded by the thermocouple attached to the hydraulics bay wall adjacent to the plenum chamber was 340°C., a level which was reached after 13 minutes in Test 3.

An examination of the plenum chamber following the completion of each test indicated that the nylon cords which held the acoustic linings in place had melted 27/ and the linings covering the wall adjacent to the hydraulics bay had fallen away, presumably at an early stage in each test. In addition, there was evidence that internal combustion had occurred within some of the linings, primarily in localized areas.

25/ It should be noted that the temperature of the simulated engine supply air, which was initially measured at 250°C., decreased to 160°C. - 170°C. toward the end of the two longest tests.

26/ This temperature occurred in the lining which was located against the wall separating the plenum chamber from the hydraulics bay.

27/ The melting point of these cords is 215°C.

Using infrared and gas chromatographic analyses, it was determined that both the No. 1 and No. 2 hydraulic systems of N1116J contained uncontaminated Skydrol at the time of the accident. Skydrol and/or its thermal decomposition products were found on the hydraulic compensator bay floor, on both sides of the FS 936 bulkhead, and on the internal and external surfaces of the vertical fin and horizontal tailplane.

Skydrol is a fire resistant hydraulic fluid in accordance with the standards set forth in Aeronautical Material Specifications (AMS) 3150c. These specifications prescribe that the autogenuous ignition temperature of such a fluid must be higher than 750°F. (399°C.), determined in accordance with certain testing procedures. Testing conducted by the manufacturer of Skydrol indicates that the flash point of that fluid is 180°C., the fire point is 215°C., and the autoignition point is 496°C. However, Skydrol exposed to air at elevated temperatures will undergo thermal decomposition and the flash, fire and autoignition temperatures will decrease by as much as 9°C. 28/

Tests conducted during the investigation demonstrated that a jet spray of Skydrol, flowing at a rate associated with a characteristic leak in a flexible hydraulic hose, could be ignited by a propane flame, a high energy spark, or a hot wire source. Furthermore, when the ignition source was removed, the ignited Skydrol, with an air/fluid ratio of 300:1, would sustain a flame 6 to 8 feet long.

28/ Independent laboratory tests indicated that, when Skydrol is heated, the flame retardants associated with that fluid are among the first of its basic components to vaporize.

Acoustic linings of the type utilized on N1116J were composed of two layers of a glass fiber batting material enclosed within an envelope of borosilicate glass fabric impregnated with silicone rubber. In tests designed to determine the susceptibility of the linings to ignition and flame spread, it was noted that the flame spread was confined primarily to the silicon rubber coating material. When impregnated with Skydrol and kerosene, the blanket acted primarily as a wick, and the contaminants flamed vigorously until their volatile components had been consumed.

Other tests indicated that the glass fiber batting insulation might self-heat to ignition if a one-inch thick slab were exposed on one side to 405°F. (207°C.), with the other side perfectly insulated, under still air conditions. 29/ The measured self-ignition temperature in a hot air furnace of the rubber coated fabric, and of the acoustic lining assembly, was 890°F. (477°C.).

Visual inspection was made of approximately 34 sets of acoustic lining assemblies following their removal from operational aircraft. Approximately one-third of these sets contained areas of deterioration, some of which appeared to be caused by mechanical means, such as rubbing or sonic vibration while other damaged areas appeared to have resulted from exposure to heat. 30/ A small portion of these damaged specimens was subsequently subjected to

29/ The addition of contaminants such as Skydrol and kerosene appeared to decrease the self-heating tendency of the linings.

30/ Approximately one-third of the 34 sets also contained areas which were wetted or soaked with Skydrol. However, only 3 or 4 of the total number of sets exhibited both deterioration and Skydrol contamination.

laboratory examination. It was concluded therefrom that the majority of damaged areas on the specimens submitted were caused by mechanical means, although in regard to two of the failures studied it could not be determined whether the damage was caused mechanically or by heat.

A metallurgical examination of the nonreturn valve taken from the wreckage of N1116J indicated that the chemical composition of that valve was essentially similar to the standards called for in its design drawing. The mechanical property requirements, such as hardness and tensile and yield strengths, also appeared to meet these specifications. Observations of microstructure made through metallographic examination of the flaps and intake ring did not disclose evidence of any properties which would adversely affect the functioning of the valve. Numerous cracks were noted on the convex side of the valve flaps, which were a logical consequence of the warpage which occurred in those flaps. However, all of the cracks observed were primarily surface cracks, and none of them penetrated through the thickness of the flaps.

When the possibility of reverse air flow through the APU became evident on the basis of the aforementioned tests, an inspection campaign was conducted in order to determine the condition of nonreturn valves on all BAC 1-11 aircraft in service throughout the world. 31/ This campaign disclosed that approximately 20 percent of the valves checked were totally serviceable and conformed to specifications, 60 percent had deformed flaps which would cause leakage, although not to an extent that would render the valves unserviceable, and 20 percent were deficient in a manner making them totally unserviceable.

31/ The worldwide BAC 1-11 fleet consists of approximately 80 aircraft.

The results of the reverse air flow tests also led to a further examination of the APU taken from the wreckage of N1116J in order to determine if that unit contained any internal indications of having been subjected to the type of heat associated with reverse flow. This examination disclosed that some of the elastometer sealing material in the APU compressor had an appearance consistent with exposure to a temperature of approximately 600°F. (316°C.) for an unknown period of time. In addition, some of the metal sections of the compressor itself had an appearance similar to samples of the same type of metal which had been subjected to a temperature of 550°F. (288°C.) for 5 to 10 minutes.

2. ANALYSIS AND CONCLUSIONS

2.1 Analysis

The investigation disclosed that the only causal factors involved in the accident were those directly associated with the inflight fire which occurred in the rear fuselage and tail section of the aircraft. The crew was properly qualified and certificated for the flight. The weight and c.g. of the aircraft were within limits at takeoff and were calculated to have remained so until the tail began to disintegrate in flight. Both engines were developing a high level of power at impact, and the APU was rotating at or near governed speed. The landing gear, flaps, and spoiler/speed brakes were retracted. There was no evidence of structural or system failures other than those directly resulting from the fire. The air traffic control handling of the aircraft was routine until air to ground communications were lost. There were no indications that weather contributed in any way to the accident.

From a study of the mockup of the inflight fire area, it was determined that the inflight fire originated in the airframe plenum chamber, spread to the hydraulics compensator bay and simultaneously therewith burned through the hydraulic hose exit hole in the top fuselage skin, which was enlarged by the fire, and up into the vertical fin. After the origin and path of the inflight fire were so established, the investigation focused primarily on determining (1) the combustibles which fueled the fire, (2) the manner in which ignition occurred, (3) the propagation of the fire, and (4) the consequences of the fire.

With respect to combustibles, laboratory tests of numerous deposits taken from the inflight fire area ruled out the possibility that any material foreign to the aircraft was involved in the fire, therefore negating sabotage as a causal factor. In addition, external air flow tests showed that fuel leaks from potential leak sources could not reach the intake of the plenum chamber, and thus discounted kerosene as a combustible. By the process of elimination, therefore, the only remaining materials within the inflight fire area which could be considered combustibles were Skydrol hydraulic fluid, which flows through tubing and flexible hoses from the hydraulic bay up into the vertical fin, 32/ and the acoustic blankets which line the airframe plenum chamber. The conclusion that these two materials fueled the fire was further established by the fact that Skydrol deposits in various stages of thermal decomposition were found throughout the inflight fire area while the acoustic linings, except for a small fragment, were totally consumed in the fire.

32/ In addition, it is probable that some Skydrol was present on the floor of the hydraulic bay due to leakage and an inadequate drainage system.

Extensive testing negated the possibility of a number of potential ignition sources, such as acoustical energy within the plenum chamber linings, electrical energy, frictional rubbing of the linings against the rotating APU compressor disc, and ingestion of lining material, Skydrol and/or kerosene into the APU with a resultant flashback into the plenum chamber. There also was no evidence to suggest that a glowing carbon particle exhausted from the engines somehow passed through the intake screen and into the plenum chamber. Testing further established that the normal operating temperatures within the tail section of the aircraft, including heat produced by hot engine exhaust gases flowing into the plenum chamber through its intake during application of reverse thrust, were far below temperatures required to ignite the combustibles located within the inflight fire area.

On the other hand, there is substantial evidence in the record to support the conclusion that main engine bleed air flowed through a normally operating APU in the reverse direction and exited into the airframe plenum chamber at temperatures sufficiently elevated to cause the acoustic linings located therein to self-heat to the point of ignition. The main engines are capable of supplying air to the pneumatic system at a pressure greater than that of the air delivered from the APU. When main engine bleed air is selected as the supply source, such air flows into the main system duct through the isolation and pressure reducing valves. This air is prevented from flowing from the main system duct back to the APU by the self-operating nonreturn valve, which is spring loaded to the closed position, and by the air delivery valve, if that valve has been selected closed from the cockpit. 33/ Both isolation valves, both pressure reducing valves, the crossover valve and the air delivery valve were all found in the wreckage to be in the open position. Accordingly, the nonreturn valve was the only valve separating engine bleed air from the APU.

On the basis of visual inspection of the nonreturn valve as found in the wreckage, it appeared that one of the valve flaps was partially open at impact. A further sign that the flaps may have been in an asymmetrical position at some time prior to impact is the fact that nylon deposits, which presumably came from the nylon cords in the plenum chamber, were found on the upstream or APU side of only that flap which was found closed in the wreckage. Further examination disclosed that both flaps were severely warped, such that they could not fully seat in the closed position, and galling was present on the surface of both flap hinge ears. These conditions indicated not only that leakage could occur through a closed valve, but also that the valve flaps were binding to an extent sufficient to cause a flap to stick in the open or partially open position. Accordingly, there is persuasive evidence that the nonreturn valve on N1116J was not operating properly and thus, by failing to fulfill its function of preventing engine bleed air from flowing back toward the APU, was the mechanism which initiated the chain of events leading to the fire.

It appears that the aforedescribed damage to the valve was caused primarily by repeated rapid closing and opening of the flaps, which resulted

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33/ In addition, the crossover valve, if closed, will prevent engine bleed air from the No. 2 engine from flowing either into the No. 1 pneumatic system or into the APU air delivery duct.

in repeated hammering of the flaps against the intake ring and repeated hammering together of the opening stops. This repeated and rapid movement of the valve flaps resulted no doubt from pressure fluctuations within the pneumatic system which occur when the air source for the pneumatic system is being switched or when pressure from a given source varies rapidly. Such fluctuations could be expected to occur with particular frequency on short flight segments. There was no evidence that defects in the valve material contributed to the damage, or that the valve was damaged by abnormally high temperatures or pressures. It should be emphasized that the damage to the nonreturn valve on N1116J was not an isolated instance, but rather was representative of the condition of a substantial number of these valves when examined during the fleet inspection campaign conducted subsequent to the accident. It should also be noted that the nonreturn valve was considered an "on condition" item, and thus was not subjected to periodic inspections.

Extensive testing established that simulated main engine bleed air, at temperatures as low as 160°C., would flow through a failed or half-open nonreturn valve and an open air delivery valve, pass through a normally operating APU in the reverse direction, and exit at a temperature of 360°C. into the airframe plenum chamber. The increase in air temperature probably resulted from the heat absorbed from the torus housing as the air passed through the APU turbine plenum chamber and from the work done on the air by the impeller blades as it passed in a reverse direction through the APU compressor. The probability that reverse air flow through the APU on N1116J did in fact occur is substantiated by the internal indications that the APU compressor section had been subjected to temperatures of approximately 300°C. The tests also indicated that reverse air flow would cause the air temperature in the hydraulic bay to rise to 297°C. and the metal temperature on the wall adjacent to the plenum chamber to reach 340°C.

The elevated temperatures in the plenum chamber and the hydraulic bay created an environment in which the acoustic lining located on the wall separating these two compartments could self-heat to the point of ignition.[34] These temperatures in effect acted not only as a heat source, but as an insulant on each side of the lining, thus causing it to gain more heat than it lost to its surroundings. Tests indicated that the lining material will self-heat to ignition at a temperature well below that which exists on both sides of the blanket during reverse flow conditions. Combustion resulting from ignition due to self-heating starts in the center of the material and progresses outward. Visual evidence of this combustion pattern was found in the blankets used in the reverse flow tests. Further confirmation of the self-heating phenomenon is the fact that when the air temperature in the plenum chamber stabilized at 360°C., the temperature in the acoustic lining on the inboard wall continued to rise to 515°C. It should also be noted that a number of acoustic blankets removed from operational aircraft after the accident contained indications of heat damage, which could have been caused by reverse air flow.

34/ It is significant that examination of the metal walls of the plenum chamber of N1186J indicated that the fire started in this particular section of the chamber.

Based on tests and operational experience, it is probable that the acoustic linings on N1116J were contaminated with Skydrol fluid which had leaked into the plenum chamber due to inadequate drainage and imperfect sealing. Moreover, such Skydrol would have been in a partially decomposed state due to having been subjected to heat over an extended period of time, and thus would have been more rapidly ignited than fresh Skydrol. Accordingly, once the blanket material itself ignited, the Skydrol with which it was wetted or soaked would in turn have ignited, and thus acted as an additional fuel for the fire within the plenum chamber.

Once the fire started in the plenum chamber, its path and manner of propagation, as well as the consequences thereof, can be pieced together on the basis of the available evidence. 35/ As the fire spread upwards along the inboard plenum chamber wall, heat would have become concentrated in the uppermost levels of the chamber until a hole was burned through the top fuselage skin, adjacent to the hydraulic hose exit hole. At about this same time, the vertical aluminum wall between the plenum chamber and the hydraulics bay would have melted due to the extreme heat. Once this wall was destroyed, the flexible hydraulic lines attached hereto were exposed to the fire and would also have failed quickly due to the heat. Consequently, substantial amounts of Skydrol would have been fed under pressure to the fire. In addition, the chimney effect, resulting from the updraft from the

35/ It should be noted that the plenum chamber was not within a designated fire area, which accounts for the fact that the chamber was not constructed completely of fireproof material and did not contain a fire warning device or a fire extinguishing system.

hydraulics bay through the hose exit hole in the top fuselage skin, would have caused the Skydrol-fed fire to burn intensely up into the vertical fin. 36/

The fire would then have progressed across the rudder power control unit box and through the rear spar web of the vertical fin, destroying the elevator control rods, which are located just aft of the rear spar, and the coaxial cable containing the No. 1 VHF transceiver antenna lead, which also runs along the aft side of the rear spar. As the fire spread upwards through the vertical fin, the extremely high temperatures generated thereby would have destroyed the structural integrity of the lower rudder attach fitting and both vertical fin spars.

From the physical appearance of the rudder, as well as its position in the wreckage distribution, it is probable that this component separated in flight prior to the horizontal tailplane. Once the integrity of the vertical fin spars was destroyed, the normal aerodynamic loading on the horizontal tailplane in level flight, which is in the downward direction with the center of pressure aft of the rear spar, caused the top two feet of the vertical fin and the horizontal tailplane to separate in one piece, with the tailplane going aft and rotating in a trailing edge downward direction. This mode of separation, which was confirmed by ground witnesses, is further evidenced by the fact that the forward spar of the vertical fin

36/ The thin, needle-like discharge observed by the two ground witnesses located at Mansfield was probably unburned vaporized Skydrol leaking from failed flexible hoses, while the black smoke observed by another witnesses at this same time probably came from burning Skydrol.

failed in tension while the aft spar failed in compression. With the loss of the horizontal tailplane, the airplane pitched over sharply and the right wing failed negatively at rib No. 11 from aerodynamic loads. After the separation of the right wing, aerodynamic forces positioned the aircraft in a left yaw as well as initiating a right roll. Consequently, the aircraft contacted the trees in a descending nose left yaw and left wing high attitude, with ground impact being essentially on the right side of the aircraft.

The maintenance history of N1116J, as well as the events which occurred prior to and during the accident flight, are in no manner inconsistent with, and in some ways corroborate, the foregoing conclusions concerning the circumstances which caused the inflight fire. The flight log sheets covering the several month period prior to the accident contain a substantial number of discrepancies pertaining to the pneumatic system and APU of N1116J. It does not appear, however, that the number of writeups on these components was disproportionate when compared with other operational BAC 1-11 aircraft. Furthermore, the frequency of these writeups probably stems in large part from the fact that they involved a complex system which had been in operation only a short time.

From the vantage point of hindsight, however, several of these discrepancies can reasonably be construed as evidencing symptoms of a malfunctioning nonreturn valve. Thus, the loud fluttering or chattering noise noted on several occasions when the MAC valve selector was switched from APU to open, or from closed to APU, may have been the erratic movement of an improperly operating nonreturn valve responding to pressure fluctuations. In addition, the repeated citations of the APU failing to supply adequate air pressure may have been caused by the failure of a sticking nonreturn valve to open fully, thus restricting the flow of air from the APU into the pneumatic system.

Due consideration has been given to the possibility that the odor and mist observed at Newark on the morning of the accident constituted evidence of a burning or smoldering condition in the plenum chamber. Reverse flow from the No. 1 engine could have taken place when the pilots opened the air delivery valve during descent when the No. 1 system was still being supplied with engine bleed air. 37/ On the other hand, the captain indicated that after opening the air delivery valve, he switched the No. 1 system to APU, thus closing the No. 1 system pressure reducing valve. Accordingly, unless there was a lapse of several or more minutes between these two actions, reverse flow of No. 1 engine bleed air to an extent necessary to start a fire could not have taken place. Moreover, since the crossfeed valve was closed throughout this flight, reverse flow of bleed air from the No. 2 engine could not have occurred.

The presence in the ventral stairway area of a mist, of which there was no trace in either the cabin or the cockpit, cannot be explained. It is improbable that this mist was an indication of a fire in the plenum chamber in view of the physical separation of that compartment from the ventral stairwell.

37/ The No. 1 system supplies air to the cabin and the cockpit. Assuming reverse flow occurred and started a fire in the plenum chamber, the odor resulting therefrom would have been drawn into both the cabin and the cockpit when the No. 1 pneumatic system was switched to APU.

On balance, there is insufficient evidence upon which to conclude that the odor and mist resulted from a fire in the plenum chamber. Rather, it is more probable that such indications stemmed from the industrial area of Newark over which the aircraft was being flown at that time. In any event, it appears that the pilot's conclusion that the odor and mist came from the latter source was reasonable under the circumstances. Nor does it appear that there are any valid grounds upon which to connect the failure of the No. 2 system on landing at Newark with the circumstances which led to the fire. Pneumatic system failures due to an over pressure condition following the application of reverse thrust are a common occurrence.

Prior to starting the engines at Elmira, the pilots noted an excessive reading on one of the main air duct pressure gauges. However, after trouble-shooting this problem, they reached the conclusion that it represented nothing more than a defective gauge. Such reasoning was logical and there is no reason to connect this occurrence with the subsequent fire. However, the captain's reference to a "hot start," which occurred "the last time" or presumably at Syracuse, may be significant. Such a start usually results from an inadequate air supply and thus may be symptomatic of a malfunctioning nonreturn valve which failed to open fully, thus restricting the flow of air from the APU to the engine being started. 38/

After starting the engines the pilots specifically referred to closing the isolation valves and, in accordance with standard procedures, these valves

38/ If the engine was being started by air supplied from the other engine, rather than air from the APU, the "hot start" may have resulted from some of the supply air leaking back through the nonreturn valve which failed to close completely.

would have remained closed until after takeoff. Consequently, reverse air flow could not have occurred during this period. Moreover, there was no indication either within or outside the aircraft of a fire in the plenum chamber while the aircraft was on the ground.

The entire departure operation from Elmira, including ground procedures, takeoff, and initial climb, appeared to be routine. Assuming the crew operated the aircraft in accordance with standard procedures, they would have executed the after takeoff check list after raising the landing gear and reducing power to the climb setting, or about one minute after takeoff at an approximate altitude of 1,500 feet above the field. This checklist is not executed by the challenge and response method, but rather can be carried out by a single pilot with no oral reference being made to any of the items thereon. This accounts for the absence on the cockpit voice recording of any conversation concerning this checklist. In the process of completing the checklist, the pilots would have opened the isolation valves and switched the MAC valve switches from APU to open, thus allowing main engine bleed air to flow into the pneumatic system. The conclusion that the pilots took these actions is corroborated by the open position of the isolation valves and pressure reducing valves as found in the wreckage. It was at this point that reverse air flow would have commenced with engine bleed air flowing back to the APU through the malfunctioning nonreturn valve and the open air delivery valve.

The BAC Flight Manual and the Mohawk Operations Manual both provide that the air delivery valve should be closed when the pneumatic systems are switched from APU to engine bleed air after takeoff. However, these manuals also provide that the pneumatic systems may be left on APU air if the flight will remain below 10,000 feet, thus requiring that the air delivery valve also be left open. The Mohawk pilots apparently construed these provisions, as reflected by their description of company policy, to allow the air delivery valve to remain open until a flight exceeded 10,000 feet, even on those flights on which it was intended to ultimately climb to an altitude above 10,000 feet and on which the pneumatic systems were therefore switched to engine air shortly after takeoff. That the pilots on the accident flight were in the process of utilizing such a procedure is borne out by the fact that the air delivery valve was found in the wreckage to be in the open position.

It should be emphasized at this point that initiation and continuance of reverse flow would not have been evident in the cockpit. The reverse flow tests demonstrated that the only indication of the commencement of this process, apart from the discharge of smoke, was a change in noise emission from the APU, which obviously could not be heard in the cockpit, and a slight drop in APU r.p.m. prior to reignition, which likewise is not recorded in the cockpit.

The first indication on the part of the pilots of any difficulty occurred approximately 4-1/2 minutes from takeoff, after the flight had leveled off at 6,000 feet, when the captain uttered an exclamation during the transmission from the New York Center clearing the flight to 16,000 feet. It was sometime during the next 10 seconds that communication with the Center was lost, due to the fire burning through the No. 1 VHF transceiver antenna lead. In view of the proximity of the elevator control rods to the antenna lead in relation to the path of the fire, as well as the fact that the control rods are made of aluminum, it is probable that the control rods were destroyed by the fire within a matter of seconds of the time when the antenna lead was burned through and communications were lost. The destruction of these rods, and the electric elevator trim lead which runs within the same bundle of wiring containing the No. 1 VHF transceiver antenna lead, resulted in a complete loss of control of the elevators.

In light of the progress of the fire at the time communications were lost, it is also probable that the No. 1 and No. 2 hydraulic systems were lost during this same period, due to the loss of hydraulic pressure when the fire destroyed the flexible hoses connected to the rudder power control units. It is possible that some hydraulic pressure was available after the elevator control rods were destroyed, which may account for the fact that a climb was initiated at about the same time that communications were lost. Even though elevator control had been lost at this point, the climb could have been initiated by the pilots, in response to the clearance, by utilizing tailplane incidence trim, which would have been available as long as at least one of the hydraulic systems was still operating. On the other hand, if both hydraulic systems had been lost prior to the initiation of the climb, it is obvious that this maneuver was not initiated by the pilots but rather was caused by aerodynamic forces beyond their control.

Following the aforementioned climb, which became increasingly steep as the aircraft gained 1,500 feet in 30 seconds, the aircraft abruptly leveled off at 7,500 feet. If tailplane incidence trim was still available, the leveling off may have been effected by the pilots. However, if both hydraulic systems had been lost, the maneuver again could not have been pilot induced. In any event, it appears that the latest point in time at which both hydraulic systems were lost came at the end of this 20-second period of level flight, when the captain exclaimed "we lost all control . . . we don't have anything" and then, when the first officer stated that "we're in manual now," replied "yeah but I can't do anything." These statements indicated that both hydraulic system fail warning lights were illuminated and that the pilots had lost artificial elevator feel. 39/

Immediately thereafter, the aircraft commenced a steep descent, during which the landing gear warning horn sounded intermittently, due to power reductions which were effected, no doubt, in an effort to reduce speed. During this descent, one of the pilots stated "put it back in the second system," which may have been a reference to the emergency elevator system. This interpretation is supported by the fact that the elevator emergency toggle switch was found in the on position in the wreckage. Turning this switch on would have reactivated the artificial feel system which in turn would have caused the pilots to believe they were receiving a response from their cockpit flight control movements, although they in fact were not.

39/ In view of the fact that hydraulic and aerodynamic forces operate the rudder and elevators, artificial means have been incorporated into the flight control system in order to provide a representative "feel" at the pilot's controls.

The fact that the feel system was in effect is further evidenced by the cockpit conversation in the period subsequent to the switch to the "second system," during which the pilots' comments indicated that they believed the aircraft was responding to their efforts to bring it out of the steep descent.

The aircraft did in fact pull out of this descent at 3,800 feet, following which it climbed to 5,100 feet, and then commenced a second and final descent during which the tail separated and the aircraft dove to the surface. None of these maneuvers, however, was caused by the pilots' manipulation of the flight controls. Once the elevator control rods were destroyed and both hydraulic systems were lost, the pitch of the aircraft could not be influenced by the pilots. The transitions between climbing and descending which occurred subsequent to loss of pitch control were the result of a phenomenon known as phugoid oscillation. Phugoid or long period oscillation involves noticeable variations in pitch, altitude, and airspeed, but a nearly constant angle of attack. Such oscillations of the aircraft can be considered as a gradual interchange of potential and kinetic energy about some equilibrium airspeed and altitude. With normal elevator control, a pilot readily damps out these oscillations in pitch and is often unaware of their existence. When pitch control is lost, however, there is nothing to act as a damper, except the flopping of the elevators and manipulation of the power. Accordingly, the roller coaster type phugoid motion becomes exaggerated into a series of descents and climbs, as clearly depicted on the altitude profile of the flight. (See attached chart.)

It should therefore be emphasized that the structural failure of the empennage a few seconds prior to impact merely affected the exact time and location of impact. Once control of pitch was lost, it was inevitable that the aircraft would crash, following a series of phugoid oscillations.

On the basis of the recorded cockpit conversation, it is obvious that the pilots were totally unaware of the existence of the inflight fire. This is readily understandable in view of the fact that the fire occurred within an area in which there were no fire sensing devices and thus no means by which a fire warning signal could be transmitted to the cockpit. The only result of the fire which manifested itself to the pilots was the loss of the hydraulic systems and the pitch control systems located in the empennage, a condition which, from the pilots' viewpoint, could have caused by a number of means other than a fire and which the pilots were therefore desperately attempting to troubleshoot. Even if the pilots had somehow deduced the cause of the control problem within the short time available, there was no remedial action which could have been taken, since the inflight fire area was devoid of any system for extinguishing a fire in flight.

2.2 Conclusions

(a) Findings

1. The crew was properly qualified and certificated.
2. Weather was not a causal factor in the accident.
3. The weight and c.g. of the aircraft were within limits at takeoff from Elmira and, on the basis of available evidence, were computed to have remained within limits until the empennage disintegrated in flight.

4. The engines were developing a high level of power at impact and the APU was rotating at near governed speed.

5. There were no structural or systems failures other than those associated with the inflight fire.

6. There was an inflight fire which originated in the airframe plenum chamber, burned through to the hydraulics compensator bay, and thence up into the vertical fin.

7. The mechanism which initiated the sequence of events leading to the fire was a malfunctioning nonreturn valve which allowed engine bleed air to flow back through an open air delivery valve, through the APU, and exit into the airframe plenum chamber at elevated temperatures.

8. The temperatures introduced into the plenum chamber by reverse air flow were sufficiently elevated to cause the acoustic blankets lining the chamberwalls to self-heat to ignition.

9. The primary combustible fueling the fire was hydraulic fluid, which was fed to the fire under pressure when the flexible hoses in the hydraulics bay failed due to excessive heat.

10. The fire burned intensely from the fuselage up into the vertical fin due to the updraft and the built-in chimney which existed in that area.

11. The fire destroyed the elevator control rods, the electric elevator trim lead, and both hydraulic systems, thus causing the pilots to lose all control of the pitch of the aircraft.

12. The fire ultimately weakened the lower rudder attach fitting and the vertical fin spars to the point where those components failed under normal aerodynamic loading and the rudder, top two feet of the vertical fin, and horizontal tailplane separated in flight.

(b) Probable Cause

The Safety Board determines that the probable cause of this accident was the loss of integrity of the empennage pitch control systems due to a destructive inflight fire which originated in the airframe plenum chamber and, fueled by hydraulic fluid, progressed up into the vertical fin. The fire resulted from engine bleed air flowing back through a malfunctioning nonreturn valve and an open air delivery valve, through the auxiliary power unit in a reverse direction, and exiting into the plenum chamber at temperatures sufficiently high to cause the acoustic linings to ignite.

3. RECOMMENDATIONS AND CORRECTIVE ACTION

In a letter to the Administrator of the FAA dated July 25, 1967, the Board made the following recommendations:

(1) That a fireproof barrier of appropriate width be provided at the top fuselage skin between Fuselage Stations 936 and 958 in order to provide effective isolation of the vertical fin, particularly the area aft of the rear spar wherein is located electrical circuits, hydraulic lines and mechanical devices for directional and longitudinal control.

(2) That the aluminum alloy wall separating the hydraulics bay and the airframe plenum chamber be replaced with a suitable fire-proof material.

(3) That inflight use of the APU be restricted as a precautionary measure until such time as the suitable barriers recommended above are provided.

The Administrator, in his written response of August 15, 1967, to the Board's recommendations, noted that the FAA was working with the manufacturer and the Air Registration Board (ARB) concerning the leakage and drainage of hydraulic fluid in the BAC 1-11. The Administrator's letter then continued as follows:

"We have confirmed that U. S. operators of BAC 1-11 aircraft have complied with the campaign alerts issued by the British Aircraft Corporation, including the removal of the sound proofing material from the auxiliary power unit air inlet plenum chamber, thus eliminating material from that area which might support combustion.

In addition, we have agreement of the U. S. operators to voluntarily prohibit in-flight use of the APU until such time as suitable installation modifications are completed. They have agreed that the APU will be shutdown prior to takeoff and will not be restarted until after landing. It is intended that this restriction on the APU would be lifted at such time as approved modifications are developed to provide a fire proof barrier isolating the APU plenum chamber." 40/

By Airworthiness Directive (AD) No. 68-1-1, effective January 3, 1968, 41/ the FAA prescribed a number of measures designed to prevent heat damage or possible fire in the airframe plenum chamber of the APU. The AD required that, if use of the APU on the ground was to be continued, the following steps are to be taken:

(1) Visually check the fiberglass surround on the plenum chamber intake for evidence of heat discoloration and, if such evidence is present, replace the nonreturn valve with a serviceable valve or a modified valve. 42/

(2) Install a placard in the cockpit specifying (a) that the APU air delivery valve shall be closed when starting an engine

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40/ Mohawk Airlines had accomplished these measures (i.e., removal of blankets and inflight shutdown of APU) in early July on its own initiative.

41/ This directive was published in the Federal Register (33 F.R. 10) as Amendment 39-538.

42/ The modification to the nonreturn valve includes the addition of a flange to the backface of each valve flap (i.e., the side opposite to the setting face), which substantially increases the resistance of the flap to distortion. The depth of each flange is varied so that when the flaps are opened, contact is made along the entire length of the two flanges, thus reducing the distortion caused by forces produced by the rapid opening of the valve. In addition, the valve spring has been strengthened and a sleeve fitted to keep the spring from contacting the main spindle, thus avoiding wear between those two parts. Finally, the valve has been fitted with a stop device to insure that the two flaps cannot fall over or close on one side.

from external supply or by cross-feeding air from an operating engine, and (b) that the air delivery valve be closed and the APU shutdown for takeoff and flight operations.

(3) Remove all airframe plenum chamber acoustic linings. 43/

The AD further required, as a condition precedent to the operational use of the APU in flight, that the following items be accomplished: 44/

(1) Replace the nonreturn valve with a modified valve.

(2) Perform the following structural modifications:

(a) Install additional fireproof, stainless steel skin over the existing light alloy outer skin on top of the fuselage, between Fuselage Stations 936 and 958, in order to isolate the airframe plenum chamber from the vertical fin.

(b) Replace the light alloy wall separating the airframe plenum chamber from the hydraulic compensator bay with a stainless steel wall, enlarging the hydraulics bay in the process.

43/ The AD also provided that, as an alternative to the above three items, use of the APU on the ground could be continued if the items prerequisite to inflight APU operation were accomplished within 50 hours time in service after the effective date of the AD.

44/ One of the items listed in the AD, which has no apparent connection to the circumstances pertaining to the subject accident, has been omitted from the list set forth below.

(c) Modify the hydraulic compensator drain box and the drain outlet.

(d) Install a revised spring loaded door in the bulkhead at FS 936 (forward wall of plenum chamber).

(3) Install sealing plates around the control guard, located above the rudder power control units, and over the hole in the vertical fin rear spar, in order to restrict airflow into the vertical fin.

(4) Install an additional bimetallic temperature sensor in parallel with the existing mercury sensor in the circuitry which controls the electrically actuated primary temperature valve located in the low pressure bleed flow duct to the heat exchanger. 45/

(5) Revise the airplane flight manual to assure that at no time is air from either engine and from the APU being delivered simultaneously into a common duct. 46/

45/ The AD further provided that items (1) through (4) listed above should be accomplished in accordance with the appropriate BAC Service Bulletins, later ARB approved issues, or FAA approved equivalents.

46/ The AD noted that item (5) was covered by BAC Flight Manual Advance Amendment Bulletins.

The Safety Board believes that the corrective measures heretofore taken, as described above, should prevent similar accidents in the future in this type aircraft from this cause.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD:

/s/ JOSEPH J. O'CONNELL, Jr.
Chairman

/s/ OSCAR M. LAUREL
Member

/s/ JOHN H. REED
Member

/s/ LOUIS M. THAYER
Member

/s/ FRANCIS H. McADAMS
Member

APPENDIX A

Crew Information

Captain Charles E. Bullock, age 43, held airline transport pilot certificate No. 411052 with ratings in the DC-3, CV-240/340/440, M-202/404, and BAC 1-11. His last line check was dated September 15-16, 1966. He had a total flying time of 13,875:32 hours, including 58:44 hours during the 30 days preceding the accident. His total time in the BAC 1-11 amounted to 603:25 hours. His first-class physical examination was dated December 1966. He had been on duty for 3:47 hours at the time of the accident.

First Officer Troy E. Rudesill, age 33, held commercial license No. 1400974, with single and multiengine land and instrument ratings. His last line check was dated May 30, 1966. He had a total flying time of 4,814:49 hours, including 62:07 hours in the 30 days preceding the accident. His total time in the BAC 1-11 amounted to 677:29 hours. His first-class physical examination was dated May 29, 1967. He had been on duty for 3:47 hours at the time of the accident.

Stewardess Gale Sardelle, age 21, was employed by Mohawk Airlines on February 13, 1966. She had a total of 59:43 hours flying time during the 30 days preceding the accident, including 4:42 hours in the last 24-hour period.

Stewardess Virginia Bungert, age 21, was employed by Mohawk Airlines on May 21, 1965. She had 57:23 hours flying time during the 30 days preceding the accident, including 4:42 hours in the last 24-hour period.

would develop rapidly between 1300-1500, possibly forming a northeast-southwest line. Tops were expected to build rapidly to near 55,000 feet with the thunderstorms becoming more numerous and continuing beyond 1500.

The Williamsport terminal forecast issued at 1245 and valid for a 12 hour period beginning at 1300 called for ceiling 4,000 feet broken, broken clouds variable to scattered, widely scattered thunderstorms with heavy rain showers in the vicinity. The Elmira terminal forecast for the same period predicted a ceiling of 4,000 feet in broken clouds.

Official weather observations made at Elmira at 1458 indicated an estimated ceiling 3,500 feet overcast, visibility 15 miles, towering cumulus in all quadrants and breaks in the overcast. Similar observations at Williamsport at 1457 noted scattered clouds at 4,000 feet, estimated ceiling 7,000 feet broken, and visibility 12 miles.

The 1445 observations from WSR-57 weather radars at both Pittsburgh and New York showed no echoes over the Elmira-Williamsport area. Persons operating the weather radar at Pennsylvania State University in State College, Pennsylvania, recalled seeing no echoes on their equipment during the period in question.

Ground and airborne witnesses reported that the weather along the flight track and in the accident area generally was clear with some scattered clouds but no restriction to visibility.

Weather information, both actual and forecast, was included among the flight documents which were furnished the crew prior to commencing Flight 40 at Syracuse. The meteorologist in charge of the Weather Bureau

APPENDIX B

Meteorological Information

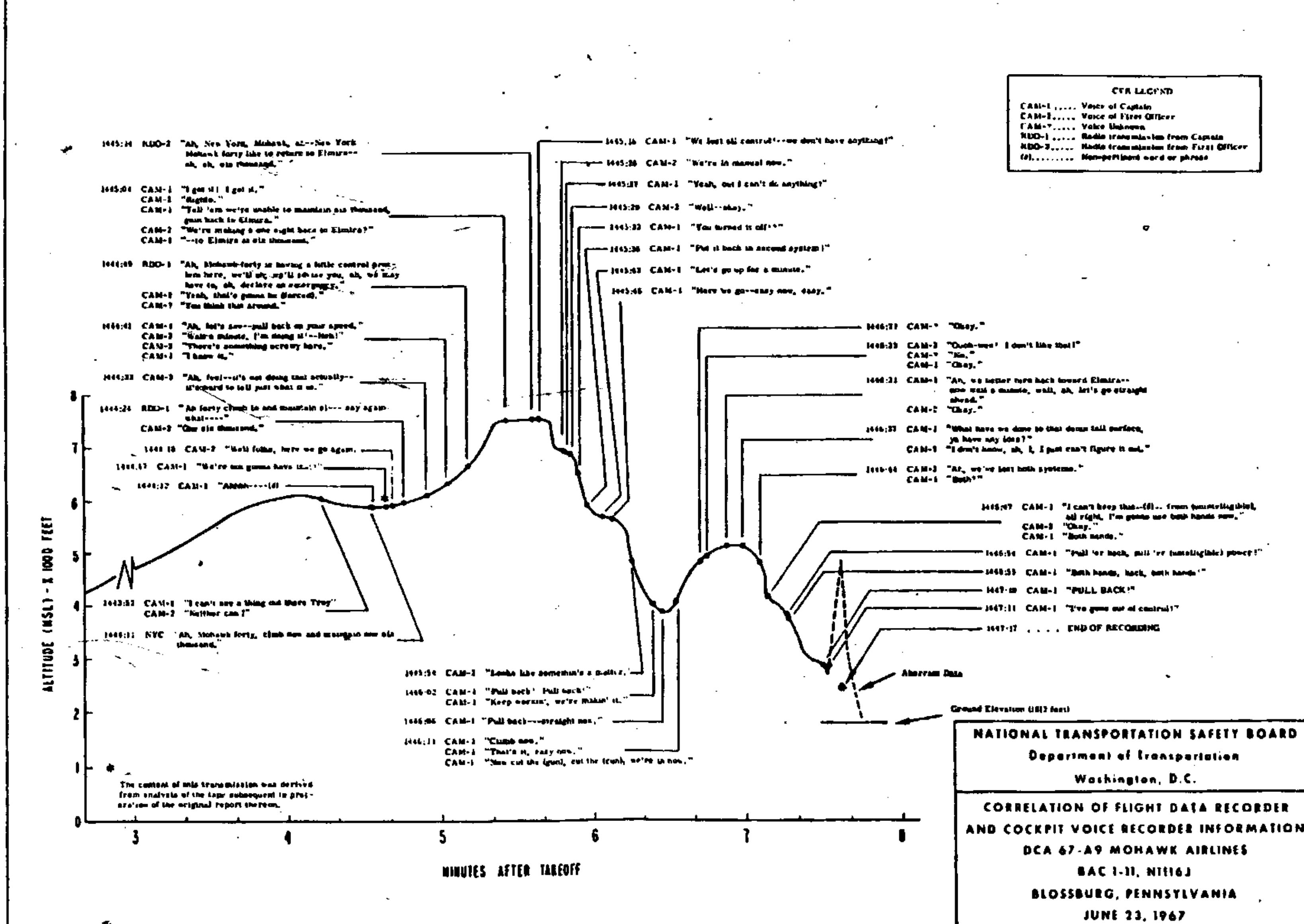
The routine aviation area forecast issued by the Weather Bureau at the John F. Kennedy International Airport (JFK) at 0845 on the day of the accident, valid for 12 hours beginning at 0900, described a low pressure trough extending from western Massachussetts to Harrisburg, Pennsylvania, and moving in a southeasterly direction. West of the trough through eastern Pennsylvania and southeastern New York clouds were forecast at 1,000-1,500 feet scattered variable to broken, 2,500-3,000 feet broken, and 10,000 feet broken; visibility 1-3 miles in fog and haze; and scattered light rain showers and a few small thunderstorms. Forecast local conditions called for ceiling 400-800 feet broken variable to overcast with visibility 1 mile in fog and haze. Conditions were forecast to improve slowly to 3,000-4,000 feet broken variable to scattered, 10,000-12,000 feet broken, visibility 3-5 miles in haze by late forenoon; and 4,000 feet scattered, 12,000 feet scattered, with visibility more than 6 miles by late afternoon. The freezing level was forecast to be 13,500 to 14,500 feet with moderate rime icing in clouds and showers, and moderate to heavy mixed rime and clear icing in cumulonimbus clouds. Moderate turbulence was forecast at all levels in showers, with moderate to frequently severe turbulence in thunderstorms.

There was an In-Flight Advisory (Airmet ALFA 2) issued by JFK at 1300, covering interior southeast New York, eastern Pennsylvania, and northwestern New Jersey, which forecast that scattered thunderstorms

Airport Station at Syracuse reported that no weather briefing was furnished to the crew. The captain did discuss with the Mohawk Airlines dispatcher in Utica possible thunderstorms over the proposed route.

63

ATTACHMENT



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