NATIONAL TRANSPORTATION SAFETY BOARD

AIRCRAFT ACCIDENT REPORT

NORTH CENTRAL AIRLINES, INC.
CONVAIR 580, N2045
O'HARE INTERNATIONAL AIRPORT
CHICAGO, ILLINOIS
DECEMBER 27, 1968

NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D. C. 20591
REPORT NUMBER: NTSB-AAR-70-27

NATIONAL TRANSPORTATION SAFETY BOARD
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SA-409 File No. 1-0040

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E R R A T A

The following changes should be made to the subject report;

Page 1, paragraph 5, line 3, change "refraction" to "reflection"

Page 33, paragraph 6, line 5, change "refraction" to "reflection"

Page 34, line 2, change "refracted" to "reflected"

Page 34, paragraph 2, line 3, change "refracted" to "reflected"

Page 37, Probable Cause, line 3, change "refraction" to "reflection"

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SYNOPSIS

North Central Airlines, Flight 458, a Convair 580, crashed while it was on an instrument approach at O'Hare International Airport, Chicago, Illinois, at approximately 2022 c.s.t., on December 27, 1968.

The aircraft struck the side of a hangar, located adjacent to the approach end of the runway, in a near-inverted attitude, and was destroyed by impact and resultant ground fire. Twenty-seven of the 45 persons on board the aircraft, including the pilot, copilot, and an additional crewmember who was occupying the observer's seat, were fatally injured. One person in the hangar also received fatal injuries as a result of the accident.

At the time of the approach, the reported weather conditions were 200-foot ceiling, sky obscured in light rain and fog, with the recorded runway visibility (RVR) 2,800 feet variable to 4,500 feet.

According to information obtained from surviving passengers, and the flight data and cockpit voice recorders, the approach was normal until the aircraft had descended to approximately 210 feet above the elevation of the airport about 4,500 feet from the threshold of Runway 14R. At this point, the aircraft entered a sustained climb for approximately 11 seconds, at which point go-around procedures were initiated by the captain. However, the climb continued and the airspeed dropped off to the point where aerodynamic control of the aircraft was lost. Recovery was not effected and the aircraft impacted the hangar.

The National Transportation Safety Board determines that the probable cause of this accident was spacial disorientation of the captain precipitated by atmospheric refraction of either the approach lights or landing lights at a critical point in the approach wherein the crew was transitioning between flying by reference to flight instruments and by visual reference to the ground.

The Safety Board recommends that:

Section 121.652 of the Federal Aviation Regulations be amended to prohibit a captain from being removed from "high" minimums until he has accrued 100 hours as pilot-in-command in type and that 50 percent of this time may be reduced by 1 hour for one landing that is made by conducting a published instrument approach procedure. Actual or simulated IFR approaches accrued under the Part 121 Training Program would be accepted for such substitution cited.

1. INVESTIGATION

1.1 History of the Flight

North Central Airlines, Inc. (NCA) Flight 458, an Allison Prop-Jet Convair CV-580, N2045, was a regularly scheduled passenger flight originating in Minneapolis, Minnesota, and terminating at O'Hare International Airport, Chicago, Illinois, with en route stops at Wausau, Green Bay, Manitowoc, and Milwaukee, Wisconsin.

The flight departed Minneapolis on schedule at 1615 1/ on December 27, 1968. The flight operated routinely through Wausau, Green Bay, Manitowoc, and Milwaukee although it arrived in Milwaukee 1 hour and 2 minutes behind schedule. This was due to an accumulation of delays caused by en route weather and cargo handling.

Flight 458 departed the ramp at Milwaukee at 1948, 1 hour and 3 minutes behind schedule. Takeoff was at 1953 on an Instrument Flight Rules (IFR) flight plan to O'Hare Airport, to maintain 9,000 feet. The flight proceeded without incident to the Chicago area. At 2009, after having been cleared to descend to 6,000 feet by the Chicago Air Traffic Control Center, the aircraft was handed off to O'Hare Approach Control.

The approach controller advised the flight that he was in radar contact, and instructed it to turn left to a heading of 090° for a radar vector to the Instrument Landing System (ILS) for Runway 14R. He advised that runway visual range (RVR) was 4,500 feet for that runway. The flight was then cleared to descend to 3,500 feet, whereupon it reported leaving 6,000 feet. The controller concluded this exchange of communications by instructing Flight 458 to slow the aircraft to 180 knots.

At 2011, the flight was instructed to turn right to 180° for spacing and to reduce speed to 160 knots. Flight 458 acknowledged and reported reaching 3,500 feet. Subsequent to this, the flight was turned left to a heading of 050° and then to the right to a heading of 090° in order to effect spacing for other approaching traffic.

At 2014, the flight was instructed to turn right to a heading of 120° and to maintain this heading until it intercepted the ILS localizer for Runway 14R and then to fly the localizer inbound. The flight was then cleared for an approach, and was requested to maintain 160 knots until reaching the outer marker (Romeo). The flight was further advised that its present position was 14 miles from Romeo and that the RVR was 4,000 feet.

At 2015, a new RVR value of 2,600 feet was provided to the flight.

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

At 2017, Flight 458 was advised that it was 3-1/2 miles behind traffic which was 4 miles from Romeo, and was instructed to contact O'Hare Tower on 118.1 MHz at Romeo. At 2019, the flight reported at Romeo to the Tower, and was advised that it was No. 2 to land and that the RVR was 4,500 feet.

At 2020, Flight 458 was cleared to land. The acknowledgment of this clearance was the last communication from the aircraft.

The accident occurred at 2022:23, as determined from the cockpit voice recorder tape. The aircraft impacted the main door of a hangar located approximately 1,600 feet from the left edge of the runway and approximately 100 feet longitudinally southeast of the threshold.

There were only three ground witnesses who actually saw the aircraft just prior to its impact with the hangar. One of these witnesses was driving southbound on an airport road near the approach end of Runway 14R. His attention was drawn by the sound of an aircraft (loud engine noise) which appeared to be coming from the vicinity of the approach end of the runway. He continued to hear this noise for approximately 5 seconds and then saw the aircraft in flight proceeding in a northeast direction toward the hangar. When he first saw the aircraft, it was at an altitude of about 100 feet and in an approximate 50° bank to the left. The aircraft was in a nose-high attitude but appeared to be settling rather than climbing. The aircraft appeared to be unstable and not in a "normal" left turn. He observed the left wing contact the ramp approximately 100 feet in front of the hangar, sending up a shower of sparks. This was followed almost immediately by the aircraft's hitting the hangar door in a near-vertical bank and then continuing into the hangar in an inverted position.

Another witness was driving northbound on the same road when he heard the sound of an aircraft. He estimated that the aircraft passed over his automobile at a very low altitude at a point directly in front of the hangar. He described the engines as being very loud. Immediately after this, he glanced to his right and saw an explosion and flames as the aircraft struck the hangar. The only other witness was in a truck near the southwest corner of the hangar. He heard a "whoosh" sound and then saw the aircraft coming toward the hangar. He estimated that the aircraft was in a 30° to 45° left bank and in a nose-high attitude, as if it was "trying to get back in the air." He stated that the left wing of the aircraft was sheared off when it struck the hangar door and that the rest of the aircraft continued on into the hangar bay.

All of these witnesses stated that the visibility in the area of the accident site and the approach end of Runway 14R was very restricted due to fog and a light, misting rain.

The captain of a jet transport aircraft, which had landed on Runway 14R approximately 2 minutes before the accident, testified that the approach was normal for a low-visibility approach. He stated that the copilot reported the approach lights in sight when the aircraft was at an altitude of approximately 350 feet, and that he took over visually at an altitude of about 200 feet. At this point, he had the threshold and runway lights in view and landed the aircraft without difficulty.

Another airline captain who had landed on Runway 14R approximately 1-1/2 minutes after the accident, testified that his approach was completely normal and that he started seeing ground lights at an altitude of approximately 300 feet and that shortly thereafter, the strobe lights came into view. He further stated that at 250 feet, he observed the runway lights and landed with no problem. He estimated the RVR to be about 3,600 feet once beneath the fog layer.

Both of these pilots stated that no icing, turbulence, or wind shear was encountered during the approach.

The surviving stewardess testified regarding her recollections of the flight and the approach into O'Hare. She stated that the entire trip had been performed in a routine manner up until the final stages of the approach into Chicago. The first thing she noticed out of the ordinary was the "power being added" and that "it just appeared to be a normal go-around, as climbing out." She also stated that the pitch-up of the aircraft appeared to be normal for a go-around but that it felt as if the engine did not have quite the power to pull up. Following the application of power, the aircraft rolled from side to side two or three times. She related that when the airplane started to go from side to side, there was a feeling, ". . . I can't describe it, if it was shaking, or what. It was just -- the sound, and the feeling just wasn't normal, it was not right."

Another passenger stated that the approach seemed normal, that he had seen some lights on the ground, and that following this, the nose of the aircraft rose sharply and that the engines were "gunned" and sounded like they were going "full blast." He stated that the airplane began to shake violently and that the right wing dipped and then the left wing went down sharply at which point impact occurred. He also made the observation that the landing lights were on during the approach and, that at about the time the aircraft pulled up, they appeared to get brighter.

Most of the other surviving passengers stated that the approach into Chicago seemed to be normal until the sound of the engines suddenly increased and the nose of the aircraft came up. It was the consensus that the aircraft started to climb and that it rolled from side to side prior to the final impact sequence.

Others stated that their first indication of trouble was the rocking of the wings and the roar of the engines, which was followed by the crash.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	3	24	0
Nonfatal	1	17	7 2/
None	0	0	

Post-mortem examinations of the flight crewmembers revealed no evidence to indicate any preexisting disease that would have affected the performance of their duties. There was, however, a minute trace or spectra of an undetermined basic drug compatible with Pheniraminc or Chlorpheniraminc found in the tissues of the captain. This basic drug is commonly found in over-the-counter antihistamine compounds.

At the time of the accident, there were a number of airline employees, as well as a boys' drum and bugle corps group, in and around the main hangar bay area. Seven of these boys sustained varying degrees of injuries mainly consisting of burns and small lacerations. One of the boys succumbed to the injuries, or complications thereof, 9 days after the accident. 2/

1.3 Damage to Aircraft

The aircraft was destroyed by impact with the hangar and subsequent ground fire which resulted in a few areas because of spilled fuel.

1.4 Other Damage

Major damage to the hangar struck by the aircraft involved one of the main doors and surrounding door structure. Additional damage was incurred by some of the internal hangar partitions and several pieces of ground maintenance equipment.

1.5 Crew Information

The captain, copilot, and flight attendant were properly certificated and qualified for the operation involved. (For detailed information, see Appendix B.)

2/ In accordance with the definition as prescribed in the Investigation Rules of the NTSB, Part 430.2 "Rules Pertaining to Aircraft Accidents . . .", 'Fatal injury' means any injury which results in death within 7 days." Therefore, the fatality that occurred is reported herein as a "nonfatal" injury due to the technicality of classification.

1.6 Aircraft Information

The aircraft was properly certificated and had been maintained in accordance with all company and FAA requirements. (For detailed information, see Appendix C.)

The aircraft weight and center of gravity (c.g.) at the time of the approach, as computed by Board investigators following the accident, were determined to have been approximately 52,315 pounds and 26.42 percent mean aerodynamic chord (MAC), respectively. Maximum landing weight for the CV-580 is 53,000 pounds, and the acceptable c.g. range is between 22.1 percent and 34.0 percent MAC.

The aircraft was fueled with aviation jet type "A" kerosene.

1.7 Meteorological Information

At the time of the accident, the weather in the Chicago area was characterized by low cloudiness with the visibility considerably restricted by light rain and fog. Surface winds were light north-northeasterly, and the temperature was above freezing.

Official surface weather observations at O'Hare Airport taken before and after the accident were as follows:

> 1935 - local observation, indefinite ceiling 200 feet, sky obscured, visibility one-quarter mile, light drizzle, light rain, fog, temperature 40° F., dew point 38° F., wind 040° at 5 knots, altimeter setting 29.36 inches, RVR Runway 14R 1,400 feet variable to 2,000 feet.
>
> 2020 - ceiling 200 indefinite, sky obscured, visibility one-quarter mile, light rain, fog, temperature 39° F., dew point 37° F., wind 010° at 6 knots, altimeter setting 29.35 inches, RVR Runway 14R 2,800 feet variable to 4,500 feet.
>
> 2050 - ceiling 200 feet indefinite, sky obscured, visibility one-quarter mile, light rain, fog, temperature 39° F., dew point 37° F., wind 010° at 6 knots, altimeter 29.34 inches, RVR for Runway 14R not obtainable.
>
> The Peoria 1800 radiosonde observation at lower levels (below 5,000 feet m.s.l.) showed a ground-based, approximately 2° C. inversion, top near 2,500 feet and stable air above. The air was saturated. Temperatures were above freezing.

Flight 458 established radio communication with the center at 1958, at which time the area altimeter setting of 29.39 inches was provided. RVR values for Runway 14R were also provided to the flight during the approach. The last value was given when the flight reported over Romeo (OM) at 2019:30, at which time the RVR was reported to be 4,500 feet.

During the hour prior to the accident, the RVR values for Runway 14R being measured and reported to arriving aircraft evidenced variations over a considerable range, including, but not necessarily limited to, 2,200 feet to 4,500 feet. These fluctuations were noted by the weather observer on duty who, about 2000, notified the FAA systems maintenance technician of this observation.

Tests were performed on the RVR but the system was not taken out of service until after Runway 14R was no longer being used for landing and departing aircraft.

The tests showed that the RVR was functioning properly although there was an error in display equipment, the effect of which would indicate an RVR value 200 to 400 feet below that which actually existed in the atmosphere being measured.

Although a NOTAM 3/ had advised that RVR was out of service at 2130, the investigation revealed that it had not been taken out of operation until after Runway 14R was no longer in use.

A later NOTAM advised that the RVR was back in service at 2315.

1.8 Aids to Navigation

During the hour preceding the accident and for a quarter-hour thereafter, approaches were being conducted to both Runways 14L and 14R. Arriving aircraft were being advised by O'Hare Approach Control to expect an ILS approach to either runway. This was being done because of the variability in the RVR values being reported for each runway and the proximity of these values to the minimums prescribed for the approach.

Parallel ILS approaches were not in progress for these runways; rather, the two final approach courses were being treated as a single course with regard to aircraft separations.

All departing aircraft were using Runway 14L for takeoff. There was no aircraft or vehicular traffic known to be or detected on radar in the immediate area of the approach end of Runway 14R during the time Flight 458 was on the approach.

3/ Notice to Airmen.

The last aircraft movement on Runway 14R prior to the accident was the arrival of Northwest Airlines Flight 231 (NW 231), a Boeing 727. According to the recording of Air Traffic Control Communication between this aircraft and the O'Hare Tower and Approach Control, NW 231 was 2-1/2 miles ahead of NCA 458 when the latter was 7 miles outboard of Romeo. NW 231 reported over Romeo at 2017:50, or about 1 minute 36 seconds prior to NCA 458's report over the same point. It is estimated (with accuracy deemed to be within plus or minus 5 seconds) that NW 231 touched down at 2020:25, or about 1 minute 58 seconds prior to the time of NCA 458's impact with the hangar door.

All components of the ILS serving Runway 14R were in operation at the time of the accident. These NAVAID's were flight checked by the FAA the following morning and were found to be operating within prescribed tolerances.

There were no reported outages of any of the ILS components by any of the flights utilizing this system prior to or following the accident.

The ILS approach procedure for Runway 14R provides that the minimum crossing altitude over the outer marker is 2,140 feet m.s.l. Glide slope interception altitude is 2,200 feet m.s.l. Glidepath angle is 2.5°. Localizer (and runway) magnetic heading is 138°. Missed-approach procedure prescribes, initially, a right turn to a heading of 155°, a climb to 1,500 feet, thence a right climbing turn to 3,500 feet, and return to the DuPage VOR via its 085° radial.

Distance from Romeo to the runway threshold is 5.3 nautical miles. The glidepath transmitter is located 1,250 feet southeast of the runway threshold.

1.9 Communications

All communications with NCA 458 were routine and in accordance with established procedures. The last communication from NCA 458 was with O'Hare Approach Control when the flight reported over the outer marker (Romeo).

1.10 Aerodrome and Ground Facilities

Runway 14R is 11,600 feet long and 200 feet wide. The elevation at the runway threshold is 661 feet m.s.l.; published field elevation is 667 feet. The runway is served by an ILS with an associated standard configuration "A" approach lighting system with sequenced flashing lights. The runway is equipped with high-intensity edge lighting, centerline lights, and touchdown zone lights. According to the local controllers on duty in the tower during the time that NCA 458 was executing its approach, all the lights were being operated at maximum intensity.

1.11 Flight Recorder

N2045 was equipped with a United Control Data Division, Model FA-542 flight data recorder (FDR).

The recorder was recovered completely intact and with no evidence of mechanical damage. The foil medium was minutely examined from the point of takeoff at Milwaukee to the accident for evidence of mechanical damage, parameter malfunction, abnormality in the traces, and styli alignment, all with negative results. The recording medium was readable and all parameters were functioning throughout the flight.

A data graph was plotted for the period 8:55 minutes prior to, until, and including the time of accident. It shows that the final descent commenced about 3 minutes and 32 seconds prior to the accident from an altitude of 2,350 feet m.s.l. A fairly constant descent rate, averaging 485 feet per minute, was maintained for a period of 2 minutes and 58 seconds, bottoming at an altitude of 875 feet m.s.l. During this period, airspeed reduced from 142 knots indicated airspeed (KIAS) to a fairly constant 122 knots during the latter stages of the descent. Heading changes varied from a maximum of 10° near the midpoint of the descent to less than 3° near the end, with the average heading during this time being about 134°. Only minor fluctuation in the vertical acceleration trace was noted.

At this point, 34 seconds before impact, the descent stops and a climb begins. The readout shows that the climb was maintained for approximately 24 seconds, peaking at an altitude of about 1,620 feet m.s.l. During this climb, the airspeed depreciates from 122 KIAS to 80 KIAS and the heading changed from 138° to 100°. The altitude trace then drops almost vertically while the heading trace shows a rapid movement (turn) to the left culminating at 314°.

A United Control Corporation Model V-557, Serial No. 1973, cockpit voice recorder (CVR) was installed in N2045.

The CVR evidenced no signs of damage from impact or fire except for some sooting on the exterior surfaces of the dust cover and the front and rear faces. The tape magazine was removed and was found to be in good condition.

A transcription of the last 9 minutes of the cockpit area microphone (CAM) recording was made. (See Attachment No. 1.) Interspersed therein are air/ground communications relative to this flight and/or its environment which were transcribed from the captain's and copilot's radio channels of the CVR.

Voices of the crewmembers were identified by several flightcrew personnel of NCA who were familiar with the voices of both the captain and copilot.

An estimated flightpath was constructed, using the flight data recorder information in conjunction with the projected ILS glidepath and localizer course. The flightpath was plotted from the point of impact back to the outer marker, using an approximate groundspeed determined from the IAS and the estimated winds during this period. Correlation of the CVR information was accomplished by using the real times established for the CVR communications in conjunction with the predetermined time base of the estimated flightpath plot. (See Attachment No. 2.)

Inasmuch as the flightpath plot is primarily dependent on FDR information and the applied wind, any undeterminable factors affecting the various recorded parameters will, similarly, affect the accuracy of the layout. Therefore, in this context, the presentation represents only a reasonable facsimile of the final approach maneuver and is not used for finite measurements or values.

1.12 <u>Aircraft Wreckage</u>

The aircraft impact marks left on the hangar door and surrounding area showed that the aircraft was in an inverted or near-inverted position at the point of initial contact. The aircraft impacted the west side of the hangar at an angle of 29°, or on an approximate heading of 345° magnetic.

The hangar door separated from the structure, with the lower part of the door rotating inward and upward while simultaneously rotating in a horizontal plane approximately 90° in a clockwise direction. The torn and distorted door came to rest on the hangar floor with the inside of the door facing upward. Portions of the aircraft structure were found under the door.

All of the aircraft wreckage was found in, or in the immediate vicinity of, the hangar. The main fuselage section was found inside and to the rear of the hangar in an inverted position. Both wings and powerplants separated from the aircraft at impact. The right wing and its engine were found outside of the hangar door in the vicinity of the hangar center support beam. The left wing was fragmented with pieces strewn from the ramp area at the hangar door and across the hangar floor and covered by the fallen hangar door. The separated left engine was found at the rear of the hangar near the main fuselage section. Fragmented and burned pieces of the cockpit area and forward cabin section were found in the vicinity of the hangar door. The empennage, except for the flight control cables, was separated from the rest of the aircraft and came to rest inverted, several feet aft and in line with the main fuselage section at the rear of the hangar.

Because of the extensive breakup of the left wing and the flight compartment areas and because of the ground fire damage, the preimpact integrity of the flight control cable systems could not be determined. However, no evidence of a preimpact failure or malfunction of the flight control systems was observed, and all of the cable breaks showed general characteristics consistent with overload failure.

The left and right wing flap drive motor and gearbox assemblies were examined and showed a corresponding flap extension of 13° for all wing flap assemblies. The flap position indicator in the cockpit was recovered and showed a flap setting of 15°.

Trim jack measurements showed settings of 1-1/2° aircraft noseup trim and 3/4° aircraft nose right trim at impact. The nose gear and two main landing gears had separated from the aircraft at impact, and based on the examination of the actuator pistons, all three landing gears were in the retracted position at impact. The landing gear selector valve was recovered in the gear up position.

The right wing landing light was recovered in the extended position; its lens was broken. The position of the left wing landing light at impact could not be determined because of impact and fire damage.

There was no evidence of preimpact failure or malfunction of the hydraulic and electrical systems. The standby electrical inverter was relatively free of impact damage and had no fire damage. There was no indication of rotation at impact.

Various components of the autopilot and flight director systems which were recovered included the following: autopilot amplifier units, aileron and elevator servo units, Nos. 1 and 2 vertical gyros, Nos. 1 and 2 altitude controllers, instrument amplifiers, Nos. 1 and 2 flight director computers and indicators, Nos. 1 and 2 course indicators, and the yaw rate gyro. Testing of these components at the manufacturer's facility revealed no evidence of any malfunction prior to impact.

There were no identifiable pieces of the autopilot pedestal controller recovered from the wreckage.

Heat for deicing is provided by 14th-stage bleed air from each engine. The air supply is controlled by a firewall bleed shutoff valve. Both the left and right bleed shutoff valves were recovered in the closed position. The five pneumatic anti-icing valves were recovered in the open position.

Both altimeters (Kollsman three-pointer) sustained extensive damage due to impact and fire. The barometric scales were found with settings of 29.38 and 29.37, respectively. Because of the damage, functional testing was not possible.

The two flight directors and both course indicators were recovered in the wreckage. The instruments, as found, disclosed the following information:

Captain's flight director indicator, Collins Model 329B-7A, S/N 1182

Left bank of 105°-110°
Nosedown pitch - 17°
Glide slope and localizer flags - out of view
Gyro and computer flags - in view

First Officer's flight director indicator, Collins Model 329B-7A, S/N 1368

Left bank of 110° - 115°
Nosedown pitch
Glide slope and localizer flags - out of view
Gyro and computer flags - in view

Captain's course indicator, Collins Model 331A-6A, S/N 2446

Course setting - 138°
DME window - 003 miles
Compass card - 330°
Compass flag - in view
Glide slope flag - in view
VOR-LOC flag - in view
LOC deviation bar - right of aircraft symbol 2-1/2 dots

First Officer's course indicator, Collins Model 331A-6A, S/N 2258

Course setting - 139°
DME window - 002 miles
Compass card - 334°
Course flag - 138°
Compass flag - in view
Glide slope flag - in view
VOR-LOC flag - in view
LOC deviation bar - right of aircraft symbol 2-1/2 dots

The two vertical gyro assemblies were recovered. The No. 1 gyro received extensive impact damage. Damage to the outer gimbal (roll) and inner gimbal (pitch) exhibited positions at impact equivalent to approximately 70° left bank and pitch down of 40°. The No. 2 gyro had impact damage to the main cover only. No altitude information was obtained. Testing of this gyro with electrical power showed normal operation.

The DME was recovered with a channel digital reading of 86, which is the O'Hare TACAN Station.

Both engines and propellers were recovered in the wreckage area and were removed to the NCA hangar at O'Hare Airport for detailed examination and documentation of the specific engine components and accessories.

A second-phase examination was conducted at the engine manufacturer's facility wherein specific components of both propellers, engine torquemeters, and safety couplings were disassembled and examined. The turbine inlet temperature and horsepower indicator gauges for both engines were also examined. Subsequently, the left engine was completely disassembled and examined at the same facility.

Inspection of the compressor and turbine sections of both engines at the NCA hangar revealed compressor blade bending in a direction opposite to engine rotation along with rotational damage to the early stages of compressor blades and stators. Extensive foreign debris damage was visible throughout the first two compressor stages. All blades of the compressor and turbine assemblies were fully intact and attached to their respective wheels. The turbine assemblies were inspected. No localized overtemperature, or indications of operation at an overtemperature condition was found. Deposits of light, bright, metallic material were noted on the turbine inlet thermocouple of the left engine and on the first-stage turbine vanes of the right engine. A full disassembly of the left engine and functional testing and/or disassembly of the left engine accessories at the manufacturer's facility revealed no physical evidence of any transient engine power interruption, engine malfunctions and/or mechanical failures until impact.

Examination and disassembly and/or functional testing of the various components related to the left engine fuel system and to propeller scheduling indicated no preimpact failure or malfunction.

The engine/propeller safety couplings of both engines were inspected and the coupling for the left engine was completely disassembled. Both engines were found fully coupled, with no evidence of ratcheting or previous decoupling.

The horsepower indicator potentiometers for both engines were examined in detail by the engine manufacturer.

The right engine indicator case was badly crushed and the pointers were smashed against the dial at a horsepower indication of 3,550 h.p. The end of the potentiometer was pulled from the outer casing. The manufacturer's evaluation of the horsepower indication as found in the potentiometer was 3,457.73 h.p.

The left engine potentiometer was only slightly damaged. The indicator pointer for the large scale was detached and the pointer for the small scale was set at 700 h.p. The manufacturer's evaluation of the horsepower indication as determined by testing of the potentiometer was 3,726.60 h.p.

The turbine inlet temperature (TIT) gauges were recovered from the wreckage and examined. The left TIT gauge read 976° C., and the right TIT gauge read 960° C.

All components of the left propeller were found inside the hangar except for blade No. 4 which was located outside of the hangar approximately 280 feet northwest of the impact point. All four propeller blades had broken at the hub due to impact.

The No. 1 blade socket was flattened to the extent that the blade retainer nut could not be removed. The propeller blades, fixed splines, torque pistons, and other related parts were removed from the remaining blade assemblies. Distinct impact marks were noted on each fixed spline. By relating these marks to torque piston position at impact, the following approximate blade angles were established:

Blade No. 2 - 42.6°
Blade No. 3 - 42.8°
Blade No. 4 - 43.4°

The master gear for the left propeller was pitch locked in a position which corresponded to blade angles of 42.3°

The right propeller assembly was found just outside of the main hangar door with the four blades still attached. All blades were extensively bent and damaged. Measurements taken of the distance between wear marks observed on each of the fixed splines, which corresponded to the full reverse position, and impact marks on each of the fixed splines were related to the following approximate blade angles at impact:

Blade No. 1 - 45.1°
Blade No. 2 - 45.2°
Blade No. 3 - 46.1°
Blade No. 4 - 45.3°

The master gear for the right propeller was pitch locked in a position corresponding to a blade angle of 39.4°

1.13 Fire

Examination of the wreckage revealed no evidence of in-flight fire or explosion prior to impact.

Following impact, several fires erupted in the main hangar area as a result of ignited fuel from the ruptured fuel tanks. However, the hangar deluge (water sprinkler) system was activated by these fires and minimized the fire damage within the hangar.

Most of the forward fuselage and cockpit area (outside of the hangar) was destroyed in the postcrash ground fire. The rear fuselage area received extensive-to-moderate fire damage.

The main cabin area, from fuselage Station 435 to 760, was extensively damaged from impact but was virtually free of fire damage. Only light sooting was noted on the bottom skin.

1.14 Survival Aspects

This accident is classified as partially survivable. The cockpit area and the forward fuselage, encompassing seat rows 1 through 5, were nonsurvivable. The fuselage area at rows 6 and 7 was considered a questionable area of survivability. The rear fuselage section from seating rows 8 through 12 was considered to be a survivable area.

SEAT/SURVIVABILITY STUDY

The Human Factors Group made a study concerning the damage sustained by the aircraft interior and seats on impact as related to the aspects of survivability.

Twenty-four double passenger seats were installed in this aircraft. Five double seats were found intact in the aircraft (8A and 8B, 9A and 9B, 10A and 10B, 12A and 12B, 12C and 12D). All other seats separated from their fastenings in various failure modes. The seatbelts of the five double seats remaining in place were intact and unbuckled except for 12D. The buckle of 12D was fastened; the outboard segment of the seatbelt separated from the seat rear frame. There were no visible signs of leg or head impact dents on the backs or bottoms of these seats. The center armrests of these five double seats were bent to the left in varying degrees from 80° on 12C and 12D armrest to 6° to 8° on other seat armrests. All seat cushions on these seats were intact.

All passenger seats forward of row 8 separated, or partially separated from their fastenings. The arm/leg structures of 21 seats were intact at the wall attachment points. Nineteen arm/leg structures were still attached at the floor fastening points. The floor bolts were screwed directly into the fuselage structure rather than to seat tracks. The center structures, backs and bottoms separated from the arm/leg structures. Documentation on all seat structures from row 7 aft through row 12 showed that separation of seats was in an upward, sideward (left), and forward direction. An exception was noted on the mount bolts of one seat leg/arm structure. This seat part, found on the hangar floor, which showed the breakaway to be in a right direction. This was a B seat arm/leg structure at the aisle end. Parts of seats found outside the aircraft were thrown clear during breakup of the aircraft. Other loose seat parts were removed from the aircraft by rescue workers. Seatbelts were intact on most of these seat parts.

The window exit at seat Row 9 on the right side of the aircraft was used during evacuation. It was 8 feet from the lowest point of the exit to the hangar floor. The passenger loading door, window exits at rows 3 and 4 on the left and right sides, and the window exit between rows 5 and 6 on the right side were torn away in the crash sequence. The window exit between rows 5 and 6 on the left side was damaged, and blocked by outside wreckage. The galley access door was blocked by outside wreckage. The handle on the galley access door was turned three-fourths of the way toward the open position.

An opening in the forward section of the fuselage was large enough to pass through, in a crouched or crawl position, in the area of seat rows 3, 4 and 5. The area from seat row 6 aft including the lavatory and buffet compartment was intact with buckling and twisting of the fuselage from rows 4 through 6.

The left side of the fuselage, at window level, was pushed inward approximately 18 inches from row 7 through row 11. This was an area of the fuselage that came to rest against a conveyor truck and other ground service equipment that was located inside the hangar at the time of the accident.

The tail section of the fuselage separated aft of the bulkhead of the buffet and lavatory compartment. The lavatory and baggage compartment had flame damage. The plastic wall covering on the lavatory side had melted. The access door between the lavatory and baggage area was missing from the bulkhead. This door apparently was removed after the fire, because there was no direct flame damage or heavy sooting inside the lavatory area. The luggage side of the buffet and luggage compartment bulkhead had fire damage.

The cockpit area was heavily damaged by impact and postcrash fire and little information could be obtained from the recovered cockpit seats.

This accident shows that a direct relationship existed between the severity of injury sustained by passengers and cabin crewmembers and the restraint system (seatbelt, seat attachment) failures. In this partially survivable accident, occupants whose seats and restraint systems remained intact sustained the least overall degree of injury. Conversely, fatalities and most severe injuries were generally associated with failures of the occupant restraint system.

1.15 Tests and Research

VORTEX STUDIES

At the request of the NTSB, studies were made by the FAA and the National Aeronautics and Space Administration (NASA), Langley Research Center, to determine whether Flight 458 could have encountered airplane wing trailing vortices generated by other preceding aircraft operating on Runways 14L and 14R.

In the FAA study, simple calculations of Vortex movement, as affected by wind, were made for all landing and departing aircraft operating on these runways during the 10-minute period immediately preceding the accident. The only VORTEX selected for more precise calculations was that of Northwest Airlines Flight 231 (NW 231), a Boeing 727, which immediately preceded NCA 458 on the approach to Runway 14R. Vortices from the other aircraft were considered unable to reach the flightpath of NCA 458 or would have required transit time of sufficient duration to dissipate below vortex hazard conditions.

Flightpath information for NW 231 and NCA 458 were derived from flight data recorder plots obtained for both aircraft. Equations used for the calculations were standard form, based on state of the art data.

Calculations of the vertical and lateral movement of the vortices generated by NW 231 indicate that they would have been significantly below the flightpath of NCA 458. Because the flight profile of NCA 458 was well above the vortices of NW 231, neither precise computations of vortex persistence, nor the effects of the vortices on NCA 458 after they were 1-1/2 minutes old was made in this study.

The study conducted by NASA used the following information supplied by the NTSB 1. The flightpath of NCA 458; 2. the flightpath of NW 231; 3. Weight of NW 231, 137,000 pounds; and, 4. Airspeed of NW 231, 140 knots, wind 010° at 6 knots.

The movement of the vortices shed by the B-727 was computed by using standard procedures and equations. 4/ According to these computations, the vortices shed by the B-727 were well below, and to the right of, the flightpath of the CV-580. The proximity of the CV-580 to the vortices at the time (0221:52) at which the final climb commenced was calculated to be about 190 feet above and 170 feet to the left of the

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4/ "State of the Art Survey for Minimum Approach, Landing and Takeoff Intervals as Dictated by Wakes, Vortices, and Weather Phenomena." W. J. Bennett.

left vortex of the B-727. The right vortex would have been approximately 920 feet away. Simplified computations of the effect of the vortices on the aerodynamic response of the CV-580, at this point, indicated that the induced roll rate on the CV-580 would have been less than 0.03° per second and the induced vertical acceleration, less than 0.01 g.

A check was also made in this study to determine whether the CV-580 could have encountered vortices shed by aircraft taking off and landing on the parallel Runway 14L. It appeared that for extreme conditions of aircraft assumed to be using 14L (large aircraft, low speeds, maximum weight), it would take the vortices shed during approach or takeoff about 8 minutes to reach the vicinity of Runway 14R during which time the maximum vortex velocity would have decayed to the order of 4 feet per second and the center of the core would be at a height of about 50 feet.

FLIGHT DATA RECORDER EXAMINATION

At the request of NTSB, NASA conducted a detailed examination of the flight recorder record for the purpose of determining if the CV-580 encountered atmospheric turbulence during the landing approach and whether or not the recording showed any evidence of abnormal flight characteristics.

Under microscopic examination, it was shown that the acceleration trace oscillated sinuously during the approach and that it does not contain rapid high frequency oscillations that would be expected if turbulence were present. Also, up until the final seconds of the approach (28.10 on the flight recorder record), the acceleration trace appears to be normal and does not suggest the presence of any unusual flight disturbance. The study indicated that subsequent to this time, the increased levels of acceleration are associated with the increase and subsequent loss of altitude which preceded the crash.

Moreover, the acceleration trace was examined for approximately 40 previous landing approaches for this aircraft and these traces were compared with the trace of the subject landing approach. It was shown that the accelerations experienced during the landing approach of Flight 458 are not uncommon since accelerations of somewhat similar nature existed on other flights as depicted by the trace. The comparison further suggests that of the 40 landing approaches examined, the approach of Flight 458 appears to have been made in the smoothest air.

The examination of the airspeed and altitude traces for the landing approach of Flight 458 did not reveal anything unusual prior to the climb before the crash.

Additionally, a detailed examination was made of the flight recorder record from the NW B-727 which landed just ahead of NCA 458. The characteristics of the acceleration trace are similar to those found on other landings of this aircraft, in smooth air, and do not appear to be unusual.

CVR SOUND SPECTOGRAPHIC EXAMINATION

The Board requested that the General Electric Company conduct a study of the frequencies and waveforms of sounds recorded on a copy of the CVR tape of NCA 458 to determine whether both engines were operating at their normal governed speed, and whether required engine power response was rapid and sustained from the initial application of power until impact.

Since engine sound pressure level data were not available, the approach used for the initial examination of the copied tape was to establish the detectable engine sounds on the basis of frequency separation and expected pressure level. Those to be monitored were:

(1) Stage 1 and 2 Compressor Blade Passing Frequency (7602 Hz);

(2) Main Reduction Gear Tooth Passing Frequency (7371 Hz);

(3) Engine Revolution Frequency (230 Hz) (1/rev.);

(4) Propeller Blade Passing Frequency (68 Hz).

This tape was void of frequencies above 4,000 Hz; however, frequencies corresponding to 1/rev. and the propeller blade passing frequency were detectable.

The two detectable engine frequencies were analyzed with both a 10 Hz and 2.4 Hz bandwidth filter, which substantially improved the signal to noise ratio. It was not possible to separate the signals to distinguish individual engine operation. The tape contained substantial flutter and a high noise level, which could potentially conceal or obscure transient changes in frequency.

The original CVR tape was then examined. The signal to noise ratio was substantially better than that of the copy. Improved frequency resolution was obtained by use of a 1 Hz bandwidth filter. Tape flutter was also present on the original tape. Neither the 1/rev. signal nor the blade passing frequency could be separated to indicate the presence of two unique signal sources that could be associated with engine operation.

No apparent changes in either frequency signal could be detected which would be indicative of a substantial change in power level. The tape flutter was sufficiently pronounced so that transient changes could potentially be obscured, hence, engine operation could not be positively demonstrated by use of this technique only.

The determination was then centered about an analysis of the propeller blade passing frequency waveform and pressure amplitude.

The waveform demonstrated clear evidence that the two propellers were generating the signal, resulting in an amplitude "beat" with a period of about 15 seconds. This represents a near perfect synchronization, and a valid explanation of why the signal source frequencies could not be separated in earlier attempts.

Allison Division of General Motors Corporation offered data that, as the propellers shift phase angle or break synchronization, a substantial increase in sound pressure level occurs as a strong "beat" for a few seconds.

The signal waveform demonstrated no evidence of strong "beats," that would be indicative of a phase angle shift or break of propeller synchronization, throughout the examined regime. (See Attachment No. 3.)

A large change in relative sound pressure level, associated with a rapid power increase, was detected approximately 21 seconds prior to impact. During this power level increase, no evidence of any strong "beat" changes was apparent.

It was also noted that at approximately 28 seconds prior to impact, a smaller increase in the sound pressure level had occurred and remained at this value until the rapid power increase commenced.

This observation is indicative that the blades did not break synchronization and even more finitely did not exhibit a significant change in blade phase relationship even with the increase in power level and during the unusual change in aircraft attitude just prior to impact.

CONVAIR 580 QUALITATIVE FLIGHT TEST

A qualitative flight test was conducted on September 18, 1969, in a North Central Airlines Convair 580, N7743U, to determine whether the flight characteristics of the Convair 580 in the approach and go-around configurations substantiated the assemblage of information from the flight data recorder and the cockpit voice recorder, and also to demonstrate the basic aircraft stability and control in the go-around configuration. The flight test indicated the following:

a. The Convair 580 will follow the profile derived from the flight data cockpit voice recorders with no pressures applied to the control yoke if an increase of approximately 800 h.p./eng. is utilized to effect the level off and initiate the climb phase prior to application of maximum available power.

b. The nose of the Convair 580 tends to pitch up with the application of maximum available power. The test indicates the indicated airspeed at application of maximum available power can be maintained by exerting a force in the order of 47 pounds on the control yoke when the aircraft is at its fore or aft c.g. limit and a force in the order of 25 pounds in the mid-c.g. range.

c. The Convair 580 will maintain a heading when the aircraft is flown stick-free and the application of maximum available power occurs with the wings level. If the application of maximum available power occurs with the aircraft in a 10° bank angle, the bank angle will continue to increase in that direction during the ensuing maneuver.

d. The Convair 580 exhibited heavy prestall buffet and the recovery characteristics were positive. Elevator, rudder, and aileron controls were effective in the deep buffet region of flight.

ILS TEST CIRCUITRY

During the investigation, consideration was given to the possibility of inadvertent operation of the ILS test circuitry, actuated by test buttons, located in the front of the VOR accessory unit in the radio rack. The inadvertent actuation of this circuitry could possibly cause an erroneous indication of the flight director command bars for the pilot to fly "up" and to the "left."

A flight test was performed to evaluate the reaction of the aircraft while in a coupled mode on autopilot and actuating the test circuitry. The installation was the same as that in the aircraft involved in the accident.

The test revealed that with the autopilot coupled and the test circuitry actuated, the aircraft would follow the command bars up and to the left or down and to the right. It was also noted during the actuations of the test circuitry that there was no warning flag indicator on the captain's side utilizing the 51 RV-1. The 51 RV-2, mounted on the first officer's side, did give a flag warning.

It was noted that in the fly-up mode, the command bars would assume a position calling for an aircraft attitude of 4° noseup and 10° left bank.

AUTOPILOT STUDY

As part of the investigation the Board considered the possibility of an autopilot malfunction during the approach that could have resulted in an extreme noseup trim condition unknown to the flightcrew. Specifically, it was of interest to know: (1) what type of failure would be necessitated within the autopilot system to cause an unscheduled and extreme noseup elevator trim condition; and, (2) if such a condition could occur, what effect would the resultant forces have upon the controllability of the aircraft.

At the request of the Board, Collins Radio Company, the manufacturers of the autopilot installed in N2045, prepared a report on the functioning of the AP-103F autopilot system with respect to the operation of the primary and trim-tab servo units.

It was shown that the primary (elevator) servo provides the means for the autopilot to move the elevator control surfaces, and that electronic circuitry within the autopilot amplifier determines the commands that cause this servo motor to run. The elevator command will be either up or down, as determined in the amplifier unit, at which point a current flow will be directed to one of the two servo motor circuits causing the motor to run in the direction of desired elevator movement. The force output of the motor is increased by servo gearing to obtain the necessary torque to move the elevator. The maximum torque that the servo may put out is limited by the torque limit clutch. In accordance with flight test certification requirements, the power output of the torque limit clutch is restricted so that it cannot produce a force in excess of one additional g based on the most adverse anticipated flight conditions.

The trim servo receives its commands directly from the circuits that control the primary servo motor. Whenever the voltages at these two points are different (indicating operation of the primary servo) a current will also flow through the trim motor causing it to operate. The servo then drives the trim tab by means of a chain and sprocket through an engage clutch and a slip clutch arrangement.

The speed at which the trim motor runs is directly related to the torque output of the primary servo 5/ and is similarly governed by the voltage differential in the primary servo circuits.

Typical operation of the combined action of the autopilot elevator servo and automatic trim is as follows:

(1) Elevator command calls for noseup attitude.

(2) Current flows through the noseup circuit of the servo motor causing deflection of the elevator in the called-for direction. The servo holds the surface in the proper position to maintain the commanded attitude.

(3) At the same time, the trim servo begins to run and deflect the trim tab in the indicated direction.

(4) As the trim tab moves, stick force is removed from the main servo.

(5) Eventually, the tab will be positioned so that all stick force is relieved and the elevator command is satisfied.

(6) At this time, current flow to the primary servo up circuit ceases, equalizing the voltage at both points of the servo. The trim motor stops running and the tab maintains the proper aircraft attitude.

It can be seen that independent operation of the trim tab motor apart from the primary servo would require that the voltage leads to the trim tab motor separate from the circuitry leading to the motor windings of the primary servo. It would then require that these same two leads to the trim tab motor make contact with separate and dissimilar voltage sources elsewhere in the system. These different voltage levels would have to be sufficient to run the motor, yet not too great or the motor would be damaged and not operate. The speed of trim tab movement would be dependent upon the voltage difference measured across the trim tab motor. Polarity in the proper direction would also be required to run the motor in a specific direction.

The autopilot would then sense the effect of trim tab movement due to the malfunction and command the elevator to move in a direction to

5/ In the CV-580, the torque limit is 170 inch pounds. When this limit is reached, the maximum trim tab speed (7° per minute) occurs. A high gear ratio between the trim motor and the trim tab prevents the variance of trim speed with airspeed.

maintain the proper pitch attitude. The elevator should continue to act in this manner until the torque output of the primary servo reaches that set in the torque limit clutch. At this point, the primary servo would not be able to compensate for additional movement of the trim tab. The amount of trim tab deflection at this point would be dependent upon the flight condition of the aircraft. The trim tab will continue to move, so long as the motor is running, until it reaches its mechanical limits (12° noseup tab, -9° nosedown tab). Thereafter, the trim tab motor will continue to run and the servo slip clutch will begin to slip. The slip clutch design is such that it will continue to slip, with the tab at its limit stop, for a period of several hours.

It should also be noted that the two pitch trim manual control wheels, located on the pilot center pedestal in the cockpit, move any time the trim tab is moving. There is no audible signal associated with the movement of the pitch trim tab.

In addition, a flight test was conducted in a North Central Airlines CV-580 to determine the stick forces required to overpower the autopilot while in the "coupled" ILS approach mode of operation and also various stick force pressures in the noseup trim regime.

With the aircraft "coupled" on the ILS in the landing configuration (landing gear down, flaps set at 28°, airspeed 118 KIAS, and a descent rate of approximately 500 feet per minute), increasing amounts of pressure were applied to the control yoke to the point where the autopilot could no longer retain the aircraft on the ILS course. Measurements of these forces showed that it required 32 pounds of pressure in the roll axis, and 70 pounds of pressure in the pitch axis, to overpower the autopilot and cause the aircraft to deviate from the respective localizer or glidepath course.

In another test, the aircraft was manually flown on the ILS, landing gear down, flaps set at 28°, airspeed 118 KIAS, and a descent rate of approximately 500 feet per minute. In this configuration, and while maintaining the established glide slope descent, five units of noseup trim 6/ were required to maintain the descent with zero stick force pressure. Increasing amounts of noseup trim were applied and the resultant stick forces (pilot input) necessary to maintain the previously established glide path and performance were measured. They were as follows:

Noseup Trim	Measured Stick Forces
5 Units	Zero
6 "	20 Pounds
7 "	28 "
8 "	35 "
9 "	45 "
10 "	55 "
11 "	64 "
12 " (full noseup trim)	70 "

6/ The pitch trim tab is actually a servo trim tab and its angular relationship to the elevator is, in part, determined by the position of the elevator. For this reason, an accurate correlation between the angular tab position and the pitch trim unit indicator in the cockpit, in flight, is not possible.

In accordance with NCA maintenance procedures the pitch trim tab on all of their CV-580 aircraft is adjusted to zero degrees deflection under static conditions with the cockpit pitch trim indicator reading zero and the elevator in a neutral position. Sample comparisons of the cockpit pitch trim indicator, from zero to full noseup (12 units), and the position of the trim tab were made on two NCA CV-580 aircraft with the elevator locked in a neutral position. In general, for the lower settings (0-6 units noseup), it was found that the tab deflection in degrees corresponded, approximately, with the numbered units on the cockpit trim tab indicator. For trim settings of 6 to 12 units noseup, the trim tab deflection ranged from 1/4° to 1° less than shown on the indicator.

2. ANALYSIS AND CONCLUSIONS

2.1 Analysis

All of the evidence obtained during the investigation, including the statements of the surviving stewardess and passengers, indicate that the flight was routine and that the approach was normal until approximately 35 seconds prior to the crash. At this time, the airplane was approximately 4,500 feet from the approach end of the Runway 14R, slightly right of the centerline approaching the middle marker, and about 210 feet above the runway elevation. The landing check was completed, the flight had been cleared to land, and the first officer had the approach lights in sight at the 12 o'clock position. At this point, the flight recorder shows that the aircraft commenced a sustained climb straight ahead. The aircraft gained approximately 230 feet of altitude in 11 seconds (1,244 feet per minute), at which point the captain issued the commands associated with a go-around, i.e., maximum power and flap retraction to 15°. The aircraft continued to climb an additional 500 feet in approximately 13 more seconds (2,308 feet per minute) with an attendant decrease in airspeed to 80 knots. At this point, the aircraft was well within the stall buffet regime and the FDR altitude trace shows an abrupt and rapid loss of altitude and a sharp turn to the left, culminating with ground impact.

Slightly more than 2 seconds before the peak altitude had been reached, the captain called for the landing gear to be retracted. Subsequent examination of the aircraft wreckage confirmed that the landing gear was retracted and that the flaps were positioned at 13° at impact.

Investigation of the ILS facility serving Runway 14R showed that all components of this system were functioning normally during the time of the approach. This was further verified by flightcrews who had utilized the ILS before and after the accident and reported normal operation of the facility.

The possibility of airplane icing which could have affected aerodynamic characteristics of the aircraft was also explored. Although the existing weather conditions could have been conducive to airframe icing, there were no comments by the crew found on the CVR that would indicate any problem of this nature. Further, flightcrews who had conducted approaches during this period reported that no airframe icing was observed during their respective approaches to the airport.

Examination of the aircraft structure, systems, and components revealed no evidence of any failure or malfunction prior to impact. There were no comments by the crew recorded on the CVR that would indicate any malfunction of the aircraft or components. Moreover, both the captain's and first officer's flight directors and course indicators were recovered with readings compatible with the impact attitude and heading, which indicate that these primary flight instruments were functioning normally throughout the approach and final accident maneuvers.

Extensive examination of both engines revealed no evidence of failure or malfunction prior to impact, and further indicated that considerable power was being developed at the time the aircraft struck the hangar. The propeller blade angles at impact of approximately 42° correlate the readings on the TIT gauges and both horsepower indicator potentiometers, all of which indicates that the engines were producing horsepower at or near the full power regime at impact.

Additionally, a sound spectral study of the CVR tape was conducted by the General Electric Company in order to determine, to the extent possible, the amount and continuity of the engine power for an inclusive period of time before and including impact. (See Attachment No. 3.)

The beginning sound of impact, as recorded on the cockpit area microphone (0222:23.8), was designated as zero time on the signal waveform. The previously determined real time base of 28 minutes 48 seconds after lift-off was used as zero time for the integration of the pertinent flight data recorder parameters with the signal waveform analysis.

Using the zero times cited above and the signal waveform chart, an analysis of engine power management versus aircraft operation was made by the Allison Division, General Motors Corporation.

This analysis indicates that during the time period -189 to -27 seconds prior to impact, when the engines are known to be functioning normally in phase synchronization, short-term sound level changes in the order of 2 to 4 decibels (db) are observed. This agrees well with the expected variation in noise produced by engines operating in phase synchronization. The trend toward slightly higher average noise levels as time (hence altitude) decreases is also to be expected.

At some time during the period commencing 97.5 seconds to 59.4 seconds prior to the sound of initial impact, the captain stated "About nine hundred on 'er Gerr?" to which the copilot replied, "Okay, nine hundred." It was during this time period that the flightcrew apparently stabilized both engines at 900 h.p., the power setting normally commensurate with a final descent configuration.

Approximately 28 seconds before impact, an increase in relative sound pressure commensurate with a small power increase was noted.

This increase in sound pressure level remained essentially constant until 21.4 seconds to impact. At this point (21.4 seconds before impact), a rapid increase in the waveform trace height commenced, which was equivalent to approximately 6.7 db increase in about 1.8 seconds. This increase coincided with the CAM-1 recorder request for "Nine Seventy One, Four Thousand."

While it is not possible to judge absolute horsepower levels from cabin sound data, the changes in power indicated by short-term sound level changes should be reasonably accurate. A 6.7 -db level change is equivalent to a change of approximately 4.67 which is within the full power regime of the engine.

Further examination of the waveform trace indicates, by virtue of the consistent trace height, that this power increase was sustained without interruption from time -19 seconds to -9 seconds. The further increase in noise level from 6.7 to 8.7 db may be accounted for either by changes in phace angle or by a small increase in power with time.

During the time period which commenced with the rapid increase in engine power, and through approximately the -9 second mark, the airplane had apparently entered the stall buffet regime. Thus the study indicates that throughout this time period both propellers continued to operate in phase synchronization producing a constant power of the magnitude previously cited.

During the last 9 seconds, the sound trace height became less consistent, but maintained a relatively high level. While the trace height is less consistent, there is no evidence of an overall degradation of engine sound level that would be indicative of a transient engine stall occurring during this time period.

The findings indicated in this study as well as the physical evidence revealed during the engine examination all lead to the conclusion that both engines were capable of normal and continuous operation throughout the approach and would not have been a causal factor in any phase of the accident maneuver.

The possibilities of atmospheric turbulence or aircraft trailing vortices initiating and/or sustaining the final climb maneuver were also given extensive consideration during the investigation.

Vortex studies conducted by NASA and the FAA both indicate that there were no aircraft trailing vortices in the approach area utilized by NCA 458 that could have been a factor in the pitchup and climb. Both studies were in agreement that the primary aircraft of concern was the

NW B-727. It was found that the vortices generated by the B-727 would have been sufficiently removed from the flightpath of NCA 458 so as not to present a problem.

In this respect, the Board acknowledges that information regarding the generation, movement, and dissipation of aircraft trailing vortices is still subject to further research. The computations utilized to obtain these findings, while in accordance with present day state-of-the-art data, possibly do not consider some heretofore unknown factors that may or may not be relevant in accurately determining this information. However, in this case and based on the calculations at hand, it is believed that the flightpath of NCA 458 was removed from all vortices to the extent that any minor variations that might be applied by refinement of the analysis would still not place any vortex in a position to be considered a factor in the accident.

In addition, a study of the flight data recorder readout shows that the approach was made in relatively smooth air with no appreciable amount of turbulence indicated. This is corroborated by the surviving stewardess and passengers who also indicate that the approach was relatively smooth until after the pullup was commenced.

The probability of inadvertent actuation of the ILS test circuitry, resulting in or contributing to the accident, seems negligible. This is partially true because this test circuit affects only the command bar of the flight director and not the accuracy of the attitude portrayed. Further, if an erroneous "fly up" signal is delivered to the command bar through the ILS test circuit, a simultaneous "turn left" signal would also be received. The magnitude of these two signals would be only 4° noseup and 10° left bank. At this point in time, the flight recorder readout does not reflect this type of a maneuver. Actuation of the "go-around" button could drive the command bar to only an 8° noseup pitch attitude, whereas it was shown during the flight test that approximately 20° pitch-up nose attitude would be required to duplicate the final climb performance of NCA 458.

In addition to the foregoing, it is difficult to actuate these buttons by accident within the sphere of normal cockpit activity.

The possibility of some unknown aircraft characteristic, such as undesirable control force lightening or reversal, or excessive pitch forces, was explored in qualitative flight tests performed in the CV-580. None of these characteristics was evidenced in the tests and it was found that aileron, rudder, and elevator controls were effective throughout all phases of the simulated accident maneuver including the stall buffet regime. The aircraft did exhibit a noseup pitching tendency with high power applications, but the nose attitude could be easily controlled by moderate pilot forces on the yoke. However, pilots should be aware of this characteristic to avoid the possibility of an over-rotation during a go-around or missed approach.

In the flight test, it was noted that an application of power to 1,600 h.p. duplicated the initial climb performance depicted on the FDR readout of NCA 458. Following this, full available power was added, flaps were retracted to 15°, and, at 85 KIAS, the landing gear was retracted. The entire maneuver was performed with no pilot pressures applied to the control yoke, and it was shown that the resulting aircraft performance very closely duplicated the final flight performance of NCA 458 up to stall buffet entry.

A comparison of the results of the test flight maneuver, therefore, with the recorded performance of NCA 458, indicates that little or no pilot control forces were applied from the moment NCA 458 initially commenced a climbing departure from the ILS approach path until the stall occurred.

In fact, a similar small initial power application at the beginning of the roundout and climb was shown on the waveform analysis for NCA 458. This occurs as the flight was approaching "minimums" and is probably indicative of the pilot's anticipated procedure to arrest or reduce the descent rate at this point. As in the flight test, this approximate power level remained until the final full power application is made.

From the above and in conjunction with the lack of any evidence that would indicate any problem with the aircraft, approach aid systems, or aircraft controllability, it appears that both the captain and the first officer failed to recognize the aircraft's nose-high attitude (in excess of 20° during the final stages of the climb) and took no positive action to lower the nose. Similarly there are no remarks on the CVR that would indicate that the crew was alarmed at the aircraft's attitude prior to the loss of control.

Considerable emphasis was placed on the readout and evaluation of the CVR conversations in an attempt to reconstruct the operational sequence of events that occurred during the approach.

Based on conversation recorded on the CVR just subsequent to the time that the flight passed the outer marker (0220:03), it is believed that an autopilot "coupled" ILS approach had been planned by the crew and was commenced at this time. The comment "captured," followed by "She'll fly the glide path," indicates that the autopilot was coupled to the glide slope and was following signals from the ILS. There were no further remarks by the crew specifically concerning the autopilot or the "coupled" aspects of the approach. It is impossible, therefore, to determine the point at which the autopilot was disengaged; however, in the absence of any evidence to the contrary, such as crew conversation or apparent excursions from the glide slope or localizer to indicate this event, it is assumed that a fully coupled approach was continued to the point where the descent stops and the climb commences. This position also coincides with the approximate point where the flight was approaching minimums and, similarly, a logical point for the captain to decouple the autopilot and either continue the approach by visual reference or execute a missed approach.

Autopilot decoupling can be accomplished by the captain by depressing either the autopilot disengage button or the "go-around" button, both located on the control yoke, or by using the ON-OFF switch at the control box located on the center pilot pedestal.

The Board considered the possibility of an autopilot malfunction during the approach which could have resulted in an unscheduled and undetected extreme noseup trim condition. It was postulated that such a condition would have produced a pitch transient when the autopilot was disengaged, thereby causing the initial departure from the glidepath.

The studies indicated, however, that the possibility of a malfunction of this type occurring within the autopilot system was extremely remote, and that if such a malfunction should occur, the resultant forces on the control surface would only require approximately 70 pounds of stick force pressure to overcome the full noseup trim condition and continue the preestablished descent.

Additional factors which further refute this premise are: (1) there was no evidence found in the recovered components of the autopilot to indicate any failure or malfunction prior to impact; (2) trim-jack measurements showed only a 1-1/2° noseup trim setting at impact as opposed to a full (12°), or near full, setting that would be expected if this situation had occurred; (3) the FDR acceleration and altitude traces showed no abnormal excursions (spikes) such as would be expected in the event of a sudden pitch transient; and, (4) there were no comments by the crew found on the CVR pointing to, or even suggestive of, this type of occurrence.

The only clues found that point to the possible reason for the unexplained climb and loss of control were the two comments recorded on the CVR. The first (0221:41.4), just prior to the climb, was a remark by the captain, "Sure wish /you'd, he'd, or they'd_7 turn those # off," and the second (0222:22.7), just prior to impact, was a remark made by the crewmember in the observer seat, "The lights (fouled) it up."

There is no way of positively determining whether the crew was referring to the runway approach lights or to the aircraft's landing lights, but it is reasonably certain that either or both initiated the chain of events that led to the accident.

Although it was established that the landing lights had been extended and turned on during the approach, no determination could be made as to the exact point at which this occurred. However, according to passenger testimony, it is relatively certain that the lights were on prior to the initiation of final maneuver. Whether or not the lights were turned off, and if so, when, could not be determined.

At 0221:54.6, approximately 3 seconds after the climb commenced, there was an expletive uttered by the captain which is indicative of some concern or irritation on his part, but for about 8 additional seconds the aircraft continued to climb until the sound of the full power application (increased ambient cockpit noise) is heard. Only then (0222:03.0) did the pilot call for "go-around" power.

It is believed that during these 8 seconds the pilot suffered severe spatial disorientation which precluded his effecting a successful recovery.

Based on the conversation between the pilot and copilot just preceding the climb, ". . . [pilot] 'See the runway yet?' . . . [copilot] 'No, not yet' . . . [copilot] 'There, you're high' . . .," it is presumed that the captain at this point looked out of the cockpit in an attempt to observe the runway and continue the landing. There is nothing to indicate that he did see the runway or associated lights, and it is interesting to note that during this period of time, the autopilot was apparently decoupled and initial climb commenced. This is followed by the pilot's remark indicative of concern.

Considering the crew's remarks concerning the "lights," it is noted that one of the surviving passengers stated that the landing lights were on," . . . then they came real bright as he started -- I don't know if he hit a cloud bank, or what it was, a fog bank -- but they got real bright as he tried to make this -- take the plane back up in the air again to get away from the landing."

The bases of the clouds were estimated by other pilots to have been approximately 300 feet, with fog restricting visibility below. It is, therefore, most probable that NCA 458 reentered the cloud base within seconds after the pilot went "visual." It would have been at this most critical point that the landing light refraction in the atmosphere and from the cloud base would have had its most brilliant and damaging effect within the cockpit. The level or duration of this illumination or the level of the cockpit ambient lighting cannot be determined and, therefore, no reasonable estimate of the effect of the refracted illumination on the pilots visual acuity (ability to see the flight instruments) can be made.

Further, there is no way of determining the possible effects, if any, from the approach and strobe lights if, in fact, they played any part at all.

However, based on the remarks by the crew, the observations of a surviving passenger, and the events that occurred, it appears that there is a direct tie in between some degree of intensity of refracted light and the apparent disorientation suffered by the pilot.

It is known that pilots have experienced spatial disorientation in rapid transition from visual to instrument flight conditions, from sudden encounters with marginal visibility, and in entry to rotational maneuvers. In such cases, it has not been unusual for pilot confusion concerning attitude and altitude to result.

The various comments recorded on the CVR between 0222:02.3 and 0222:18.6 clearly identify go-around activity and a rapidly growing sense of alarm possibly caused by the diminishing airspeed and vibration as the aircraft entered stall buffet.

The final comment by the observer (0222:20.7) explains his version of how they got into this fatal maneuver. His comment about the lights could have been with reference to either the approach lights or landing lights. In either case, the comment would be compatible with, and in support of, conditions leading to spatial disorientation and possibly to the primary reason for the pitchup and sustained climb.

Despite the difficulties associated with spatial disorientation, it is difficult to believe that both pilots could sit through this maneuver, particularly in the area of stall buffet, without somehow realizing the nature of the problem. It can be seen that the copilot, during the later stages of the climb, was occupied with setting the go-around power and monitoring the flap indicator until the flaps were positioned at 15° as ordered by the captain. These duties conceivably would have prevented him from monitoring the flight instruments and thus detecting the nose-high attitude and precariously low airspeed.

Why the captain did not overcome his initial disorientation and, at least, lower the nose of the aircraft, unless he was temporarily blinded by the aforementioned illumination, is more difficult to rationalize.

Although the captain is considered to have been an experienced pilot with a total company time of 10,973 hours, his total time in CV-580 model aircraft was only 123:00 hours, all of which was accrued since April 17, 1968. He had accrued a total time of 54 hours in this type aircraft as captain, of which 46:19 hours were flown in the previous 90 days.

He had been released from high landing minima 7/ just 3 days before the accident. As previously stated, the captain had accrued 54 hours as captain in the CV-580 which necessitated a substitution of 46 landings to qualify him for low minimums and, thus, make him "legal" to conduct this flight. His accrued instrument time in the last 90 days was 14:20 hours, an average of less than 5 hours per month.

It is, therefore, reasonable to conclude that the captain had relatively minimum experience in the CV-580 aircraft, particularly under instrument conditions. It cannot be determined if this aspect was a factor in the accident, although the progress of the aircraft into an imminently dangerous condition may have been recognized sooner by a captain more familiar with the flight handling characteristics ("feel") and flight director instrument display of this type aircraft.

2.2 Conclusions

(a) Findings

1. The crew was properly certificated and qualified.

2. The flight was properly dispatched.

7/ Federal Aviation Regulations, 121.652 Landing weather minimums: IFR: all certificate holders. (a) If the pilot in command of an airplane has not served 100 hours as pilot in command in operations under this part in the type of airplane he is operating, the MDA or DH and visibility landing minimums in the certificate holder's operations specification for regular, provisional, or refueling airports are increased by 100 feet and one-half mile (or the RVR equivalent). The MDA or DH and visibility minimums need not be increased above those applicable to the airport when used as an alternate airport, but in no event may the landing minimums be less than 300 and 1.

(b) The 100 hours of pilot in command experience required by paragraph (a) of this section may be reduced (not to exceed 50 percent) by substituting one landing in operations under this part in the type of airplane for 1 required hour of pilot in command experience, if the pilot has at least 100 hours as pilot in command of another type airplane in operations under this part.

3. Weather conditions were above minima for the selected approach procedure.

4. Longitudinal separation between this flight and others was maintained above minimum standards.

5. Navigation aids, approach aids, and communications facilities were operating within prescribed tolerances.

6. RVR equipment for Runway 14R was functioning normally within established limits.

7. The approach was normal until 35 seconds prior to the crash, or when the flight was in the vicinity of the middle marker. At this point, the flightcrew had the approach lights in sight at their 12 o'clock position, the aircraft had been cleared to land, and the final landing checklist had been completed in preparation for a landing.

8. In the vicinity of the middle marker, the aircraft commenced a rate of climb of about 1,244 feet per minute, straight ahead. Some 11 seconds later, after gaining about 230 feet of altitude and with the airspeed down to about 105 KIAS, the captain called for the application of full available power (971° or 4,000 h.p.). Thereafter the aircraft gained an additional 500 feet of altitude and the airspeed decreased to the point where control of the aircraft was lost.

9. The aircraft impacted a hangar located approximately 100 feet southeast of the threshold and approximately 1,600 feet from the edge of Runway 14R.

10. There was no evidence of any failure or malfunction to the aircraft structure, powerplants, or components prior to impact.

11. Sound spectrographic analysis of the CVR showed that no power interruption to either engine occurred during the approach up until time of impact.

12. There was no atmospheric turbulence or wingtip vortex encountered by Flight 458 during the later portion of the approach which could have resulted in, or contributed to, the final climbing departure from the ILS approach path.

13. Qualitative flight test of the CV-580 revealed no adverse flight characteristics during the duplicated climb maneuver including the stall buffet regime. Positive aileron, rudder, and elevator control were available throughout the maneuver.

14. Comments made by the flightcrew during the latter stage of the approach, as found on the CVR, indicate that "lights," either on the ground or from the aircraft, were a factor which resulted in spatial disorientation of the pilot and the subsequent loss of control of the aircraft.

(b) Probable Cause

The Safety Board determines that the probable cause of this accident was spatial disorientation of the captain precipitated by atmospheric refraction of either the approach lights or landing lights at a critical point in the approach wherein the crew was transitioning between flying by reference to flight instruments and by visual reference to the ground.

3. RECOMMENDATIONS

In connection with this accident, the Safety Board recommends to the Administrator of the Federal Aviation Administration that:

Section 121.652 of the Federal Aviation Regulations be amended to prohibit a captain from being removed from "high" minimums until he has accrued 100 hours as pilot-in-command in type and that 50 percent of this time may be reduced by 1 hour for one landing that is made by conducting a published approach procedure. Actual or simulated IFR approaches accrued under Part 121 Training Program would be accepted for such substitution cited.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD:

/s/ JOHN H. REED Chairman

/s/ OSCAR M. LAUREL Member

/s/ FRANCIS H. McADAMS Member

/s/ LOUIS M. THAYER Member

/s/ ISABEL A. BURGESS Member

November 12, 1970

INVESTIGATION AND HEARING

1. Investigation

The Board received notification of the accident at approximately 2045 c.s.t., on December 27, 1968, from the Federal Aviation Administration. An investigating team was immediately dispatched to the scene of the accident. Working groups were established for Operations, Air Traffic Control, Witnesses, Weather, Human Factors, Structures, Powerplants, Systems, Maintenance Records, and Flight Recorders. Parties to the Investigation included: North Central Airlines, Inc., the Federal Aviation Administration, Air Line Pilots Association, and the Allison Division, General Motors Corporation.

2. Hearing

A public hearing was held by the Safety Board at Chicago, Illinois, on April 15, 1969.

FLIGHTCREW INFORMATION

Captain Marvin A. Payne, aged 39, was employed by North Central Airlines on July 24, 1957, and was upgraded to captain on the Allison-Convair (CV-580) in September 1968. He possessed airline transport pilot certificate No. 1281390, with type ratings for the Douglas DC-3, Convair 340/440, and Allison-Convair 340/440. His last first-class medical certificate was dated August 21, 1968, and was issued with no waivers.

Captain Payne had accrued a total of 10,972:50 hours pilot time at the time of the accident. He had accrued 123:00 hours since April 17, 1968, in the model aircraft involved. At the time of the accident, he had accrued 53:59 hours as captain, of which 46:19 hours were in the last 90 days. Captain Payne had been released from high minimums on December 24, 1968, 3 days prior to the accident. In accordance with FAR 121.652, a captain must have 100 hours as pilot-in-command in type prior to release to low minimums or this total may be reduced (not to exceed 50 percent) by substituting one landing in operations in the type of airplane for 1 required hour of pilot-in-command experience, if the pilot had at least 100 hours as pilot-in-command of another type airplane in operation under this part. Captain Payne's total time of pilot-in-command of 53:59 hours required substitution of 46 landings to qualify for low minimum approaches. He had accrued 14:20 hours instrument flying time in the last 90 days.

Captain Payne had satisfactorily completed his last proficiency check in type equipment involved on September 20, 1968, and passed his last line check on September 24, 1968.

He had a rest period of 24:00 hours within the 24-hour period preceding the flight.

First Officer Gerald R. LeValley, aged 24, was employed by North Central Airlines on April 11, 1966. He held commercial pilot certificate No. 1611210, with airplane single-engine land and instrument ratings. His last first-class medical certificate was dated November 21, 1968, and was issued with no waivers. First Officer LeValley had a total of 2,421:00 pilot hours, of which 526:00 hours were in the Allison-Convair (CV-580) as first officer. First Officer LeValley had flown 218:53 hours 90 days preceding the accident. His last proficiency check was satisfactorily completed on March 11, 1968.

First Officer LeValley had a rest period of 24 hours within the 24-hour period preceding the flight.

AIRCRAFT HISTORY

The aircraft was originally manufactured as a Convair 440 on October 8, 1956. The aircraft was subsequently converted to the Allison-Convair on July 10, 1968, and was placed in service by North Central on August 9, 1968. At the time of the accident, the aircraft had accumulated a total time of 27,180:40 hours, of which 1,079:52 hours were accumulated since date of conversion.

N2045 was powered by two Allison 501-D13D engines which were equipped with Aeroproducts A6441FN-606A propellers.

The aircraft records indicate that N2045 had been maintained in accordance with all company procedures and FAA directives. There were no aircraft discrepancies reported prior to departure from the flight's origination point at Minneapolis, Minnesota.

Attachment 1

NATIONAL TRANSPORTATION SAFETY BOARD
Bureau of Aviation Safety
Washington, D. C.

TRANSCRIPTION OF PERTINENT COMMUNICATIONS FROM COCKPIT VOICE RECORDER,
NORTH CENTRAL AIRLINES CONVAIR 580, N2045
CHICAGO, ILLINOIS, DECEMBER 27, 1968

LEGEND

CAM	-	Cockpit area microphone source of conversation or sound
RDO	-	Radio transmission from B2045, or source of sound
-1	-	Voice identified as Captain
-2	-	Voice identified as First Officer
-3	-	Voice identified as Additional Crewmember
-?	-	Voice unidentified
ORD AR W	-	O'Hare West Arrival Radar
ORD LC	-	O'Hare Tower Local Control
NW231	-	Northwest Airlines Flight 231
AA254	-	American Airlines Flight 254
NW716	-	Northwest Airlines Flight 716
TW28	-	Trans World Airlines Flight 28
EA229	-	Eastern Air Lines Flight 229
#	-	Nonpertinent word
*	-	Unintelligible word
( )	-	Words enclosed in parentheses are subject to further interpretation

Time (GMT) & Source	Content
CAM-2	Both needles are on the, uh
CAM-1	Both on Romeo now
CAM-2	Romeo
CAM-2	Markers set up
CAM-1	On mine?
0214:06 ORD AR W	North Central four fifty eight turn right heading one twenty, intercept the fourteen right ILS, fly it inbound, cleared for the approach, one sixty till Romeo, RVR four thousand, position from Romeo is fourteen miles
RDO-2	Roger, North Central Four fifty eight, that heading one two zero, take over on the approach, one sixty to Romeo
0214:26.5 ORD AR W	Roger

CAM-2	Down to twenty-five hundred
CAM-2	Fourteen miles out
CAM-?	* * *
CAM	Sound of landing gear warning horn
CAM-2	Comin' in on the localizer
0215:30.0 ORD AR W	RVR fourteen right North Central four five eight two thousand six hundred
RDO-2	Okay
CAM-1	# # #
ORD AR W	What do you need, twenty four?
CAM-1	Yeah
CAM-2	Now wait a minute now
CAM-1	Yeah
RDO-2	Ah, yes sir
0215:41.5 ORD AR W	Okay
CAM-2	No, we can go to eighteen
CAM-1	Eighteen?
CAM-2	(We can)
CAM-1	Shows twenty-four in my book
CAM-2	I got eighteen in my book
CAM-1	Have you
CAM-2	Yes, sir
CAM-2	Right here
CAM-2	Full ILS
CAM-1	Okay

CAM-2	As long as they got all components working
CAM-2	Twenty-five hundred feet we are
CAM-2	All components are working. We're good for eighteen hundred, Marv
CAM-1	How about the glide path?
CAM-2	Gotta have center line and touchdown
CAM-1	Both of them
CAM-1	What date on that, Jerr?
CAM-2	Huh?
CAM-1	What date you got on your - -?
CAM-2	- -on the approach plate, December twenty, sixty- eight
CAM-1	'der what mine is
CAM-2	We're about five out from Romeo
CAM-1	Yeah
0217:26.5 ORD AR W	North Central four fifty-eight is three and a half behind traffic that's four from the marker, and the tower is one eighteen one at Romeo, RVR is three thousand eight hundred
RDO-2	Four fifty-eight, one eighteen one at the marker
0217:37.6 ORD AR W	Roger
CAM-2	Four for the lockon
CAM-3	One fifty-five's the missed approach, uh, thirty-five hundred
CAM-2	Down to twenty-two hundred
CAM-1	Fifteen degrees
CAM-2	Okay, you got it, two two hundred
ORD AR W	We got RVR two thousand eight hundred now
CAM-2	We got twenty-eight hundred RVR - - -
RDO	Sound of outer marker commences, softly, then gradually increasing

CAM-2	- - - coming up on the outer marker
CAM	Sound of landing gear warning horn
CAM-1	Twenty-four
CAM-1	Gear and landing check
CAM-2	They're both on now
CAM-2	Smoker's on
CAM-2	T D temp trim is three caps
CAM-2	Three green, brakes?
CAM-1	Off
CAM-2	Yaw damper
CAM-1	Off. What are *?
CAM-2	Landing check's complete
CAM-1	One twenty?
CAM-2	Ah, one fifteen
CAM-1	Twenty-eight
CAM	Sound of outer marker ceases abruptly
CAM-2	Twenty-eight coming
0219:22.8 ORD LC	Northeast two three one report the lights
0219:26.6 RDO-2	North Central four fifty eight's at Romeo
0219:28.8 ORD LC	North Central four fifty eight number two fourteen right, the RVR forty-five hundred
RDO-2	Okay
CAM-2	Pretty good
CAM-1	Yeah
CAM-1	One fifteen, huh?
CAM-2	One fifteen
ORD LC	American two five four are you here?

0219:39.2 NW231	I got the lights two thirty-one
ORD LC	Thank you, two thirty-one, clear to land
0219:41.1 CAM-2	Below the glide path - - -
CAM-1	- - - yeah - - -
CAM-2	- - - a little bit
CAM-3	Never captured the son of a buck
CAM	Sound of click
CAM	Two clicking sounds, close together
0220:02.6 ORD LC	North Central four fifty-eight cleared to land fourteen right
RDO-2	Four fifty-eight
CAM-?	Captured
CAM	Sound of click
0220:05.0 CAM-2	She'll fly the glide path
AA254	Chicago, American two fifty-four approaching, ah, fourteen left ready for takeoff?
ORD LC	American two fifty-four, okay, let me know when you're right up at the runway
AA254	Wilco
0220:38.2 ORD LC	Northwest two thirty-one a left turn off, you're approaching the taxiway now, left turn there, call ground one twenty one nine as you clear
NW231	Try it
0220:45.5 CAM-2	You're on it now
0220:46.3 ORD LC	'kay, and tell them you're off fourteen right
NW231	All right
ORD LC	Northwest seven sixteen right to one eight zero, contact departure

NW716	Oh, that's seven sixteen roger change over
ORD LC	American two fifty four taxi into position fourteen left and hold
AA254	Position and hold, American, uh, two five four, we're just coming up to make the, uh, first right turn right now
CAM-1	About nine hundred on 'er, Gerr?
ORD LC	Okay, after departure it'll be a left turn to zero nine zero
CAM-2	Okay, nine hundred
AA254	Understand zero nine zero after takeoff
CAM-?	*
CAM	Sound of click
0221:24.4 TW28	TWA twenty-eight's Romeo inbound
ORD LC	TWA twenty-eight, O'Hare, number two, continue approach
CAM-1	Least they're running us in pretty tight
TW28	TWA twenty-eight
0221:30.9 CAM-2	Ah, you're coming up on five hundred feet, a hundred and eighteen, sinking five, occasional ground contact
CAM	Three closely spaced clicks
CAM-3	Pretty good
CAM-2	Four hundred feet, one eighteen, sinking five, approach lights twelve o'clock in sight
CAM-?	(Beginning to rain)
CAM-1	Sure wish * turn those # off 1/
0221:46.4 CAM	Sound of windshield wiper operation commences
CAM-1	See the runway yet?
CAM-2	No, not yet
0221:51.7 CAM-2	There, you're high

1/ Unintelligible word believed to be one of the following: "you'd", "he'd", or "they'd."

0221:53.9 CAM	Sound of click
0221:54.6 CAM-1	#
EA229	O'Hare Tower, Eastern two twenty-nine's ready
0221:57.7 CAM-2	On a hundred
ORD LC	Eastern two twenty nine up to the runway but hold short
0222:02.3 CAM	Sound of ambient cockpit noise increases
0222:03.0 CAM-1	NINE SEVENTY-ONE, FOUR THOUSAND, FLAPS FIFTEEN!
EA229	Two twenty-nine
AA254	American two fifty-four is, uh, on the runway an-nd about to hold in position
0222:11.5 CAM	Sound of clicking commences
0222:11.7 CAM	GEAR UP! ! !
ORD LC	Okay, I'll have a release for you just shortly
AA254	Okay
0222:17.2 CAM-1	YOU GOT NINE SEVENTY-ONE ON 'ER? ? ?
0222:18.6	YOU GOT IT ALL, DAD ! ! !
0222:20.7 CAM(3)	The light # it up!
0222:22.5 CAM-2	WE'RE GONNA HIT! ! !
0222:23.8 CAM	Sound of impact begins
0222:24.4	End of recording

SEQUENTIAL

FRAMES

OF

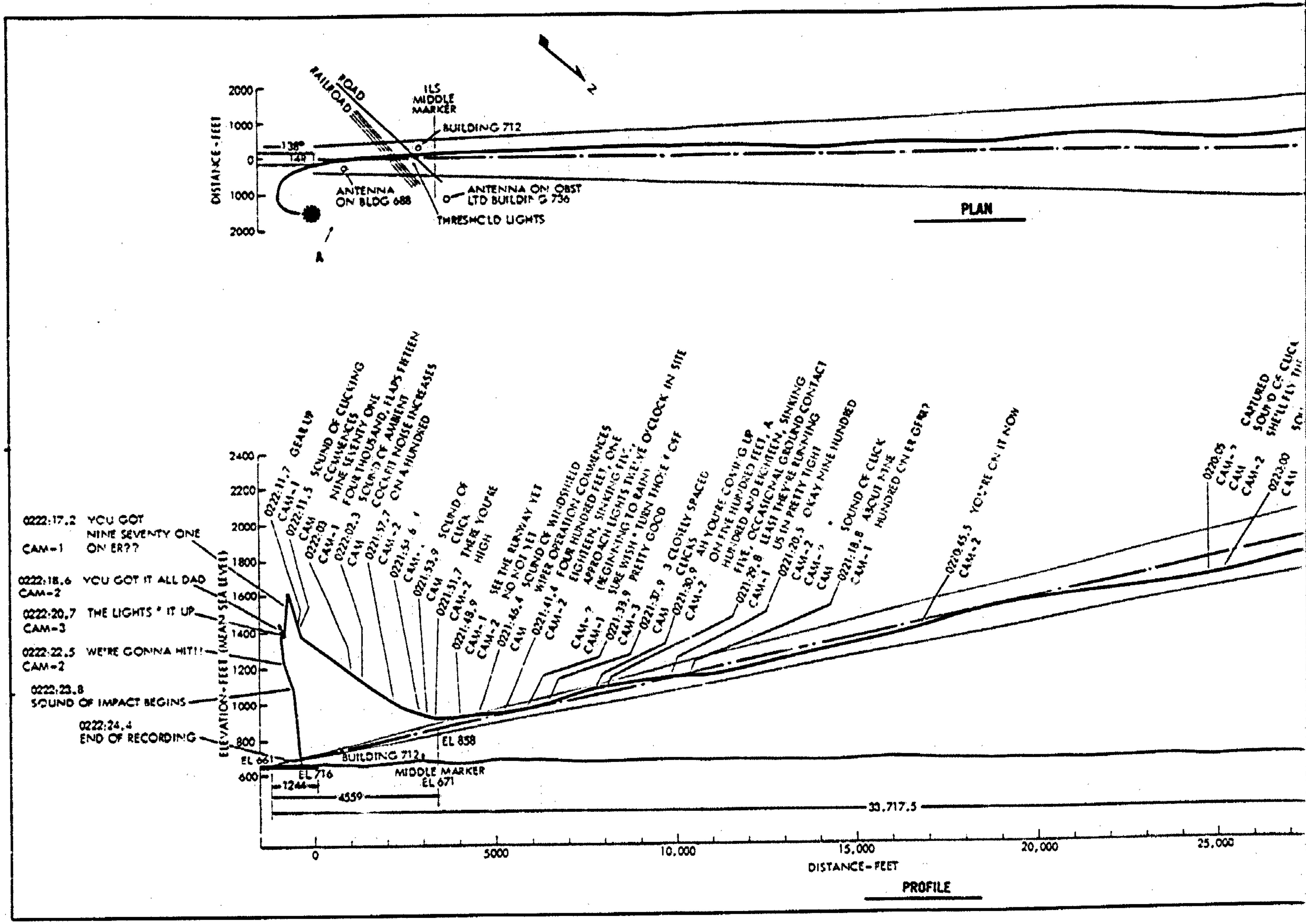
OVERSIZED

DOCUMENT

REQUIRES 2 FRAMES

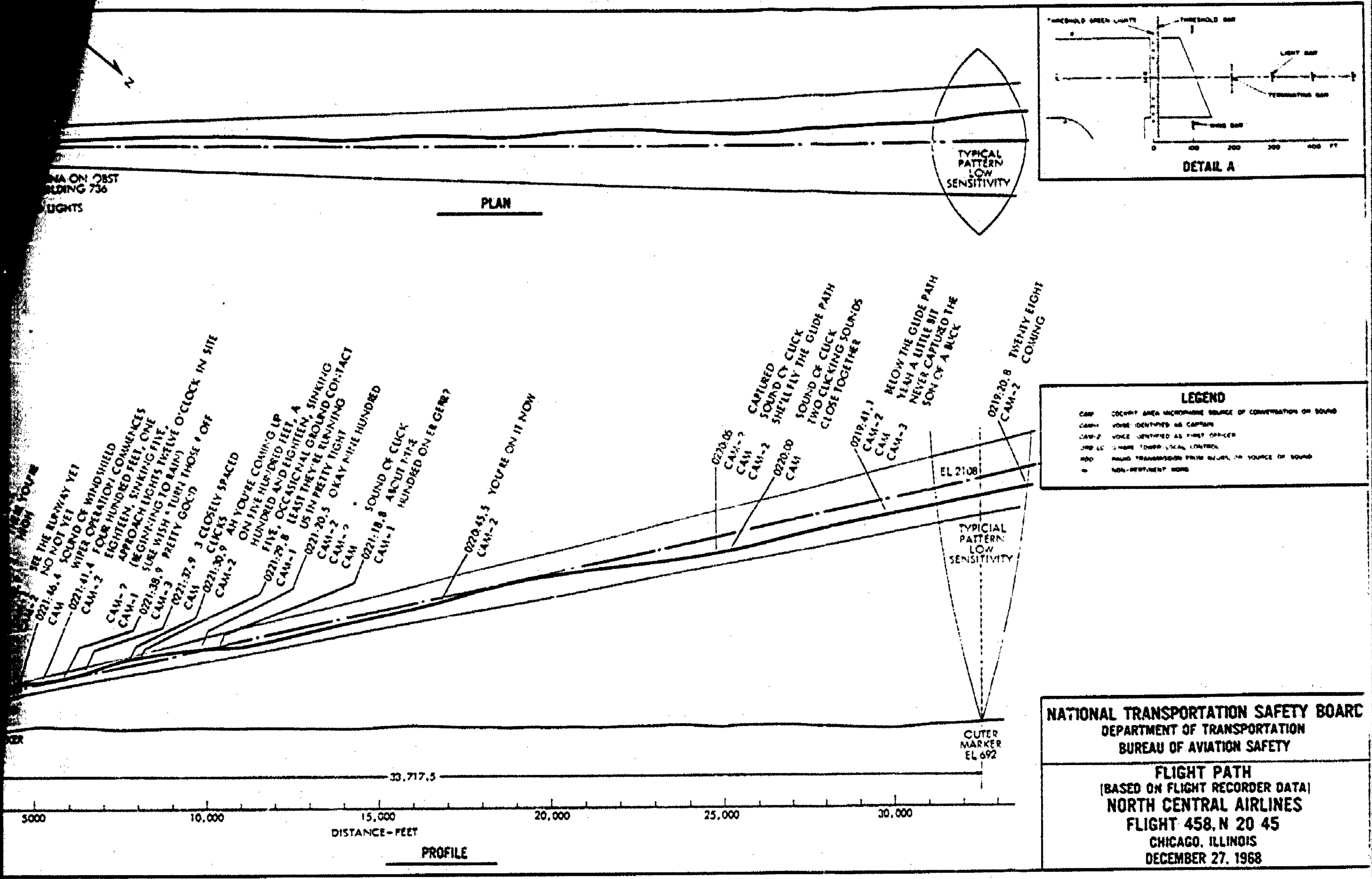
PAGE # 52

A Thru B


PLAN
PROFILE
DISTANCE - FEET
ELEVATION - FEET (MEAN SEA LEVEL)
ILS MIDDLE MARKER
BUILDING 712
ROAD
RAILROAD
ANTENNA ON BLDG 688
ANTENNA ON OBST LTD BUILDING 736
THRESHOLD LIGHTS
0222:17.2 YOU GOT NINE SEVENTY ONE ON ER??
CAM-1
0222:18.6 YOU GOT IT ALL DAD
CAM-2
0222:20.7 THE LIGHTS * IT UP
CAM-3
0222:22.5 WE'RE GONNA HIT!!
CAM-2
0222:23.8 SOUND OF IMPACT BEGINS
0222:24.4 END OF RECORDING
0222:11.7 GEAR UP
EL 858
EL 661
EL 716
MIDDLE MARKER EL 671
1244
4559
33,717.5
0
5000
10,000
15,000
20,000
25,000

52-A

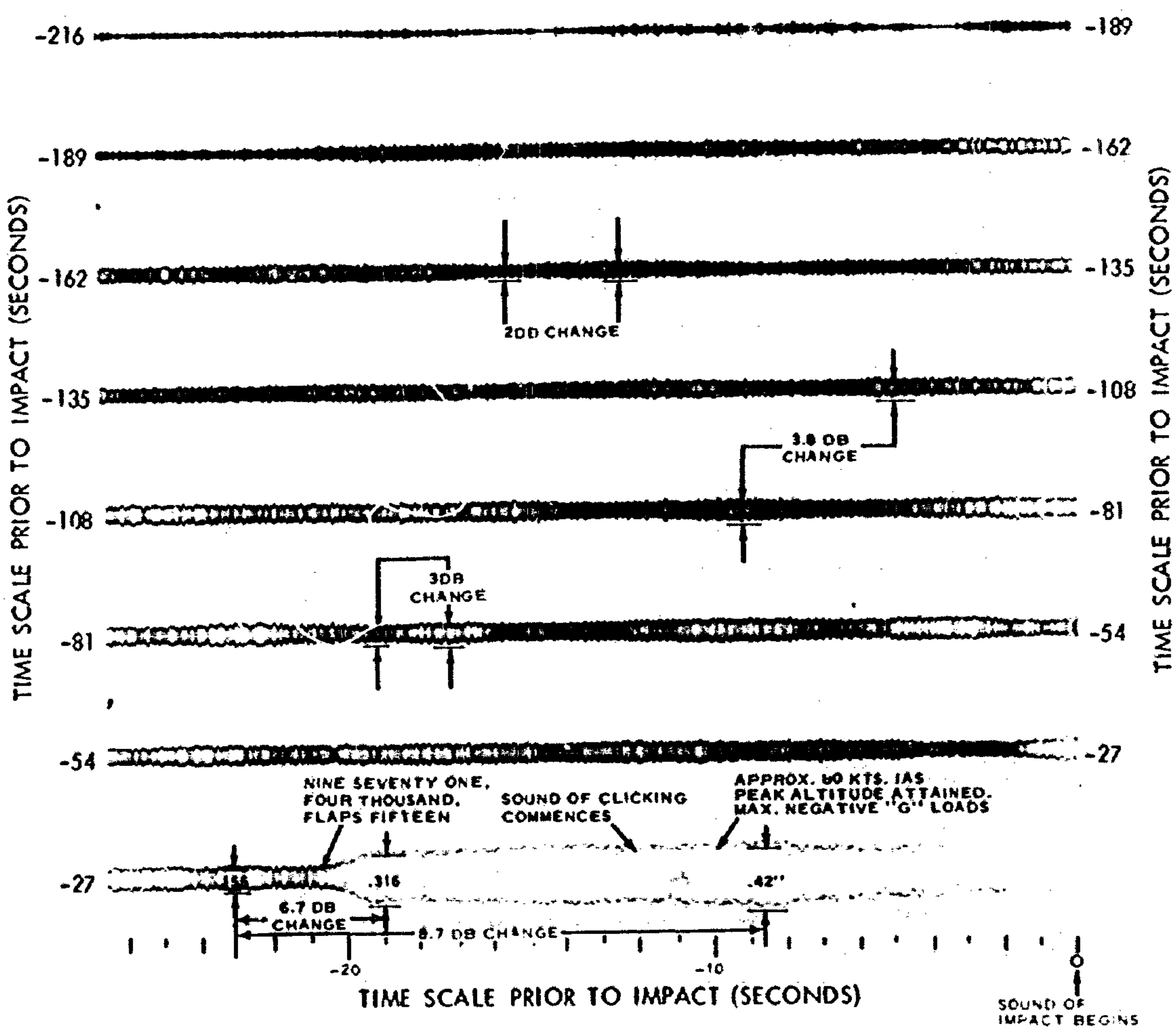
ATTACHMENT NO. 2



52-B

NORTH CENTRAL AIRLINES, FLIGHT NO. 458, CONVAIR CV-580,
N2045, O'HARE INTERNATIONAL AIRPORT, CHICAGO, ILLINOIS,
DECEMBER 27, 1968

PROPELLER BLADE PASSING FREQUENCY WAVE FORM INTEGRATED WITH SPECIFIC
EXCERPTS FROM AIRCRAFT COCKPIT VOICE AND FLIGHT DATA RECORDERS



Signal Waveform - Propeller Blade Passing Frequency
G.E. Research & Development Center

GPO 907.212