

Doc
NTSB
AAR
73/19
c.2

File No.3-0520

AIRCRAFT ACCIDENT REPORT

Continental Airlines
Saberliner Model NA-265-60, N743R

Montrose, Colorado

April 13, 1973

Adopted: November 7, 1973

NATIONAL TRANSPORTATION SAFETY BOARD

Washington, D.C. 20591

Report Number: NTSB-AAR-73-19

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No. NTSB-AAR-73-19		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle Aircraft Accident Report - Continental Airlines, Sabreliner Model NA-265-60, N743R, Montrose, Colorado, April 13, 1973		5. Report Date November 7, 1973		6. Performing organization Code	
7. Author(s)		8. Performing Organization Report No.		10. Work Unit No. 1184	
9. Performing Organization Name and Address National Transportation Safety Board Bureau of Aviation Safety Washington, D. C. 20591		11. Contract or Grant No.		13. Type of Report and Period Covered Aircraft Accident Report April 13, 1973	
2. Sponsoring Agency Name and Address NATIONAL TRANSPORTATION SAFETY BOARD Washington, D. C. 20591		14. Sponsoring Agency Code			
5. Supplementary Notes This report contains Aviation Safety Recommendations A-73-107 & 108.					
16. Abstract A Continental Airlines Sabreliner, Model NA-265-60, N743R, crashed shortly after takeoff from Montrose Airport, Montrose, Colorado, at 1635 m.s.t., on April 13 1973. The two pilots were killed, and the aircraft was destroyed by impact and fire Witnesses saw the aircraft climb straight off the runway to about 1,000 feet above the ground, make a shallow right turn, and then begin a left turn which steepened as the nose dropped. After the crash, an examination of the left engine revealed that the left engine thrust reverser was in the deployed position. The National Transportation Safety Board determines that the probable cause of this accident was the continued operation of the left engine at climb power after an unwanted in-flight deployment of the left engine thrust reverser, which resulted in a deterioration of aircraft performance. Two recommendations were made to the Federal Aviation Administration.					
17. Key Words Thrust Reverser System, Full Climb Power			18. Distribution Statement This document is available to the public through the National Technical Information Service, Springfield, Virginia 22151		
19. Security Classification (of this report) UNCLASSIFIED	20. Security Classification (of this page) UNCLASSIFIED	21. No. of Pages 23	22. Price		

No.
tion
tion
No.
port
Code
ly April 13, and fire.
feet
engine
use of after sulted
ement lable n the nforma- field,
Price

TABLE OF CONTENTS

	Synopsis	1
1.	Investigation	1
1.1	History of Flight	1
1.2	Injuries to Persons	2
1.3	Damage to Aircraft	2
1.4	Other Damage	2
1.5	Crew Information	2
1.6	Aircraft Information	3
1.7	Meteorological Information	3
1.8	Aids to Navigation	3
1.9	Communications	3
1.10	Aerodrome and Ground Facilities	3
1.11	Flight Recorders	4
1.12	Aircraft Wreckage	4
1.13	Fire	5
1.14	Survival Aspects	5
1.15	Tests and Research	5
1.15.1	Operational Tests of Thrust Reverser	6
1.16	Other Pertinent Information	7
1.16.1	Thrust Reverser Operation	7
1.16.2	Thrust Reverser Advisory Lights	8
1.16.3	Thrust Reverser Control Switch	8
1.16.4	Thrust Reverser Lever Stop Assembly	9
1.16.5	Previous Incidents of Unwanted Thrust Reverser Deployment in Flight	9
1.16.6	Operational Information	11
1.16.7	Thrust Reverser Emergency Stow Procedure	12
2.	Analysis and Conclusions	12
2.1	Analysis	12
2.2	Conclusions	15
	(a) Findings	15
	(b) Probable Cause	16
3.	Recommendations and Corrective Action	16
	Appendix A - Investigation and Hearing	19
	Appendix B - Crew Information	20
	Appendix C - Aircraft Information	21

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D. C. 20591

AIRCRAFT ACCIDENT REPORT

Adopted: November 7, 1973

CONTINENTAL AIRLINES SABRELINER MODEL NA-265-60, N743R
MONTROSE, COLORADO
APRIL 13, 1973

SYNOPSIS

A Sabreliner, Model NA-265-60, N743R, owned and operated by Continental Airlines, crashed shortly after takeoff from Montrose Airport, Montrose, Colorado, at 1635 mountain standard time on April 13, 1973. The two pilots, the only persons on board, were killed and the aircraft was destroyed by impact and fire.

The aircraft was on a routine flight from Montrose to Denver, Colorado. Witnesses reported seeing the aircraft climb straight ahead after takeoff to about 1,000 feet above ground level, where it started first a shallow right turn and then a left turn, which steepened as the nose dropped. The aircraft crashed in a 55° left-bank and 10° nosedown attitude. Examination of the wreckage disclosed that the left engine thrust reverser was in the deployed position.

The National Transportation Safety Board determines that the probable cause of this accident was the continued operation of the left engine at climb power after an unwanted in-flight deployment of the left engine thrust reverser, which resulted in a deterioration of aircraft performance. As a result of the investigation of this accident, the Safety Board has made recommendations to the Administrator of the Federal Aviation Administration.

I. INVESTIGATION

1.1 History of Flight

On April 13, 1973, N743R, A Rockwell International Sabreliner, Model NA-265-60, departed from Los Angeles International Airport, California, for Montrose, Colorado, about 1345, ^{1/} with three passengers and two crewmembers aboard. The flight to Montrose was routine; however, according to the passengers, who had ridden in N743R many times, the landing at Montrose was made farther down the runway and with heavier

^{1/} All times shown herein are mountain standard, based on the 24-hour clock, unless otherwise noted.

reversing than usual. The aircraft then taxied off the runway to the right, onto a taxiway located about 1,900 feet from the end of the runway; it then taxied to a position in front of the terminal building. The aircraft landed at 1609 and was parked at 1611.

No servicing was required while the aircraft was at Montrose. About 20 minutes after they deplaned, the crew again boarded the aircraft, started the engines, and taxied to Runway 30 for a flight to Denver, Colorado. The takeoff was made about 1633, opposite to the direction of the preceding landing. The fuel load was estimated, after the accident, to have been 4,000 pounds of Jet 1-A fuel, and the aircraft gross takeoff weight was 15,500 pounds.

Five witnesses who had observed the takeoff and initial climb described the takeoff as normal. In the opinion of two other witnesses, the takeoff roll was longer and the climb angle more shallow. According to the witnesses, the aircraft after takeoff continued on the runway heading for about one-half mile and then started a shallow bank to the right. After turning right approximately 30° and reaching a height of approximately 800 to 1,000 feet above the runway, the aircraft started to bank left. At that point it began to lose altitude, and continued to do so until it struck the ground. Some witnesses reported that the bank angle and nosedown attitude continued to steepen as altitude was lost. Other witnesses reported that the left wing suddenly dropped when the aircraft was about 200 feet above the ground.

The accident occurred in daylight. The sun was 25° above the horizon on an azimuth of 275°. The airport elevation is 5,759 feet.

1.2 Injuries to Persons

<u>Injuries</u>	<u>Crew</u>	<u>Passengers</u>	<u>Others</u>
Fatal	2	0	0
Nonfatal	0	0	0
None	0	0	

1.3 Damage to Aircraft

The aircraft was destroyed by impact with the ground and postcrash fire. The wreckage covered an area 400 feet long on a heading of 078° magnetic.

1.4 Other Damage

None.

1.5 Crew Information

The pilots were certificated in accordance with existing regulations. Both pilots received ground school instruction and flight training in the Sabreliner at the company pilot training facilities. (See Appendix B for details.)

1.6 Aircraft Information

N743R, a Rockwell International Sabreliner, Model NA-265-60, was owned and operated by Continental Airlines. It was certificated and maintained in accordance with existing regulations. At takeoff, the gross weight and center of gravity were within prescribed limits.

The engine reversers were manufactured by Rohr Industries, Inc. The left engine reverser was overhauled and installed on January 25, 1971, and operated 732 hours thereafter. The right reverser was installed after overhaul on March 19, 1971, and operated 703 hours thereafter. The last annual inspection on the reversers was accomplished on September 20, 1972. The last thrust reverser rigging inspection was performed on December 12, 1969, as a result of Rockwell Service Bulletin 69-29 (AD 70-209). No thrust reverser rigging inspection was performed thereafter. (See Appendix C for additional aircraft information.)

1.7 Meteorological Information

The official surface weather observations taken at the Montrose Airport for the times indicated were:

1540 - estimated 5,000 feet broken clouds, visibility 40 miles, temperature 68° F., dew point 24°, wind from 240° at 14 knots, altimeter setting 29.90.

1650 - estimated 5,500 feet broken clouds, visibility 40 miles, temperature 68° F., dew point 20°, wind from 240 at 10 knots, altimeter setting 29.88.

1.8 Aids to Navigation

No aids to navigation were involved.

1.9 Communications

There were no known difficulties with communications.

1.10 Aerodrome and Ground Facilities

Runway 12/30 is 7,000 feet long by 100 feet wide and is constructed of bituminous material. The runway threshold is displaced 1,000 feet at

the southeast end. During the landing and subsequent takeoff, work on a 1,500-foot extension at the northwest end of the runway was in progress. To allow for the construction activity, the threshold of the runway was displaced 889 feet from the northwest end. Movement of dump trucks over the dry, dusty soil adjacent to the construction caused large clouds of dust to be blown by a westerly wind across the runway.

Approximately 3,000 feet from the southeast end of Runway 30, a 100-foot wide dirt strip crossed the runway at a nearly 90° angle. This strip extends about 1,000 feet to the west side of the runway and about 1,500 feet to the east side.

At the time N743R took off from Runway 30, large chunks of hardened mud were lying across the runway in line with the dirt strip. The investigation disclosed that the airport manager had scraped the strip, using a road grader with dual tire wheels which picked up large amounts of dirt between the tires. As the grader crossed the hard runway surface, clumps of hardened dirt fell from the tires onto the runway.

A set of four high-tension electrical wires, oriented north and south, was located approximately 6,500 feet from the end of Runway 30. Large florescent orange painted balls were attached to the wires to alert pilots to their presence, since the wires lay across the approach path to Runway 12. The wreckage area was located about 1,200 feet to the northwest of the wires.

1.11 Flight Recorders

Flight recorders were not installed in this aircraft, nor were they required.

1.12 Aircraft Wreckage

There was no evidence of in-flight fire. All major structural components and all control surfaces were accounted for in the wreckage. All systems were examined, and there was no evidence of malfunction. The landing gear and speed brake were found in the retracted position. The wing flaps were found in the "full down" position.

The No. 1 engine thrust reverser was found deployed in the reverse thrust position. The No. 2 engine thrust reverser was stowed in the forward thrust position. Powdery dust was found in both engines. A piece of aluminum foil was found wrapped around the leading edge of an inlet guide vane on the No. 1 engine. Aluminum splatter was found on the aft side of the rearmost turbine blades of the No. 2 engine.

The engines were completely disassembled and examined at the Continental Airlines facilities in Los Angeles. The compressor sections of

both engines sustained minor impact and rotational contact damage. The combustion sections sustained local impact damage on the combustion chamber outer cases and the adjacent area of the combustion chambers. Aluminum deposits were fused to the domes of the combustion chamber in the No. 2 engine.

The turbine case of the No. 1 engine sustained a complete circumferential fracture. The second-stage turbine vanes were free of their retaining pins and had sustained minor rotational damage. Four blades were buckled. The turbine section of the No. 2 engine sustained minor rotational contact damage. The turbine blades were splattered with fused aluminum deposits. The turbine shafts of both engines were undamaged but were coated with oil.

The Nos. 1, 2, and 3 bearings of both engines were intact and free to rotate. No metallic deposits were found in the main oil screen of either engine. Fuel was found throughout the fuel systems of both engines. Both fuel controls were internally intact and relatively undamaged.

The No. 1 engine thrust reverser and its electrical and hydraulic components were bench tested. No malfunction was found.

1.13 Fire

A fuel-fed fire broke out after impact and consumed most of the aircraft cockpit and cabin area. The Montrose Fire Department equipment arrived at the scene shortly after the crash and extinguished the fire with foam and water.

1.14 Survival Aspects

This was a nonsurvivable accident.

1.15 Tests and Research

Rockwell International furnished the following information regarding the possibility of foreign object ingestion by the engines in forward or reverse-thrust modes:

"The engine inlet location above the wing trailing edge shields it from any object liquid or solid thrown up by the main gear. The use of chine nose wheel tires (mandatory on the Series 60, optional on Series 40) flattens the nose gear spray pattern to pass beneath the wing and thus avoid the engine inlet. There is no history of any problem with solid objects thrown up by the nose gear. In the reverse thrust mode, the lower exhaust gas plume directed downward and forward will sweep the runway and kick up loose objects or water spray. With correct usage of the reverser

in which reverse thrust is terminated at approximately 60 knots, the rearward relative wind created by the aircraft's forward speed keeps the engine inlet ahead of any material tossed up by the reverser gases. Reverser use into lower than recommended speeds results in exhaust gas ingestion and presumably could lead to foreign object ingestion."

1.15.1 Operational Tests of Thrust Reverser

After the accident, two flight tests were conducted with a Rockwell International Model 60 Sabreliner. The first test was flown by a Rockwell International engineering flight test crew to determine the effect of reverse thrust when the aircraft was in a climb configuration and attitude. After the flight, the chief test pilot reported that with full reverse thrust on the left engine and full forward thrust on the right engine, there was sufficient lateral control, with the use of ailerons and rudder, to bank the aircraft as much as 30° in either direction; however, altitude and airspeed could not be maintained. Reverse thrust produced very noticeable buffeting which resulted in control wheel movement, but not in movement of the instrument panel to the extent that the instruments could not be read. The reverser could not be stowed while the engine was at full power; however, when the power was retarded to approximately 85 percent, or less, the reverser did stow.

The second flight test, made with a Safety Board investigator on board, essentially duplicated the first test, with similar results. The second tests were conducted with the aircraft in a climbing attitude, landing gear and flaps up, and at an airspeed of approximately 160 knots. Instantaneous reverser deployment was simulated by placing the left engine power lever in idle, deploying the reverser, and immediately thereafter increasing the engine thrust to match the right engine (approximately 90 percent r/min). Balanced flight was maintained by manual input to the flight controls. From this stabilized configuration, the flight controls were released and the aircraft was allowed to deviate from level flight.

The first attitude change was a slow pitchup, approximately 2°, followed by an increased bank and heading change to the left. It was noted that while the aircraft was maintaining an indicated airspeed of 160 knots with the left engine reverser deployed and 90 percent r/min on each engine, its rate of descent was 600 feet per minute. Also, no control problems were noted in any configuration of reverse (flaps up or down) at indicated airspeeds ranging from 210 knots down to stickshaker activation speed.

After these tests, the left reverser was alternately deployed and stowed while the aircraft was taxiing. Before the reverser reached the fully stowed position, however, the thrust reverser control switch (located in the cockpit on the engine switch panel) was placed in the

OFF pc
short
advise
shield
depl
three

not 1
slow
the r
power

peak,
enou
chec
retu

1.16

1.16

whi
the
sec
by
loc
dr:
ea
th
Se
th
vi
th

ca
l
t'
t
r
d
t

1

OFF position, which shut down the system, placed the reverser doors just short of the locked position, and illuminated the left reverser unlock advisory red light (located in the cockpit in the center of the eyebrow shield). Power was then applied to the left engine, and the reverser deployed when the power was at 75 percent. The procedure was repeated three times with the same result.

Subsequent testing revealed that when the reverser was stowed, but not locked, the reverser doors would deploy if full power was applied slowly. Rapid application of power, on the other hand, had no effect on the reverser position. The effect of prolonged operation at the high-power setting was not determined during the test.

Further tests conducted with the Model 60 Sabreliner indicated that peak-pressure values in the hydraulic system return lines were not high enough to release the primary thrust reverser locking mechanism should the check valve malfunction in the thrust reverser hydraulic control valve return line.

1.16 Other Pertinent Information

1.16.1 Thrust Reverser Operation

The reverser assembly consists of two vertically oriented doors which, when deployed, direct engine exhaust gases forward over and under the engine nacelle. In the stowed position, these doors form the aft section of the engine nacelle fairing. They are either deployed or stowed by a hydraulic actuator through a single pivot system. The actuator, located on the outboard side of each reverser, is connected to two main drive links which, in turn, are attached to separate drive fittings on each door. The actuator incorporates an internal lock which provides the primary means for retaining the reverser in the stowed position. Secondary locks, actuated by a latch lock solenoid, are provided for the doors if the actuator lock should fail. Appropriate electrical advisory indicating switches are incorporated to denote the condition of the reverser doors.

Selection of reverser door deployment, reverse thrust power application, and reverser door stowing is made by a thrust reverser control lever in the cockpit. This control lever, which is mounted on the engine thrust control lever (throttle), is normally positioned forward and below the throttle lever knob. When the throttle lever is at IDLE, and the reverse thrust control lever is pulled up and aft, the reverser doors deploy. Once deployment of the doors is initiated, application of reverse thrust (engine thrust increase) is restricted by a solenoid interlock in the reverser control lever system until the doors reach the fully deployed position. The reverser control lever can then be moved aft to increase engine thrust for maximum reverse thrust. Reverse thrust operation is

terminated by moving the control lever forward and down, thereby reducing engine thrust and staving the reverser doors. 2/

1.16.2 Thrust Reverser Advisory Lights

Six thrust reverser advisory lights are located in front and to the right of the pilot, slightly below eye level. These lights are attached to the underside of the radio control heads which are mounted in the center of the instrument panel shroud visor. When they are illuminated, the lights read, from left to right: LH T/R ARM LH T/R UNLOCK; LH T/R DEPLOY; RH T/R ARM; RH T/R UNLOCK; RH T/R DEPLOY. 3/

The amber LH and RH T/R ARM lights, which illuminate and stay on as long as the thrust reverser control switch is in the ON position and the engine power levers are at IDLE, indicate that electrical power is available for thrust reverser deployment. If either ARM light comes on in flight, the master caution light will also illuminate.

The red LH and RH T/R UNLOCK lights will come on when the respective thrust reverser doors are not completely stowed or the secondary lock is not in the engaged (locked) position. If either UNLOCK light comes on in flight, the master caution light will also illuminate.

The blue LH and RH T/R DEPLOY lights come on when the thrust reverser doors are fully deployed.

The thrust reverser indicator light circuit is protected by a circuit breaker. Deactivation of the circuit breaker removes the electrical power needed to illuminate the indicator lights and the master caution light protected by the breaker.

After the accident, Rockwell International issued Sabreliner Service Bulletin 73-6. Compliance with this bulletin is mandatory and requires removal of the UNLOCK and DEPLOY lights from the dimming circuit so that they will be bright at all times.

The T/R advisory lights and circuit breakers were not recovered from the wreckage, since the area in which they were located was demolished by impact and fire.

1.16.3 Thrust Reverser Control Switch

A three-position thrust reverser control switch is located on the left side of the engine switch panel. The engine switch panel is located on the center pedestal, just aft of the thrust levers. When the switch

2/ Excerpted from Rockwell International Report NA-67-374.

3/ LH - left-hand, RH - right-hand, T/R - thrust reverser.

is in the ON position (forward), electrical power is available for normal operation of the thrust reverser system. When the switch is in the OFF position, all electrical power is removed from the thrust reverser system. When the switch is in the EMERG STOW position, the gear and thrust lever safety switches are bypassed, the stow solenoids of both left and right thrust reverser hydraulic control valves are energized, and hydraulic pressure is directed to the actuator stow ports.

A red plastic safety cover is installed over the switch, which must be lifted to actuate the switch to either the ON or EMERG STOW positions. (Placing the safety cover in the down position moves the toggle to the OFF position). The switch was not recovered from the wreckage, since the area in which it was located was demolished by impact and fire.

1.16.4 Thrust Reverser Lever Stop Assembly

The purpose of the vernier stop is to limit the amount of reverse thrust lever travel so that maximum allowable thrust is not exceeded. The stop assembly is used when a landing is made at any field elevation up to 2,500 feet. Before the landing, the applicable field elevation and temperature index markings should be aligned by turning the knurled adjustment knob, as necessary. Above 2,500 feet in elevation, the thrust lever should be actuated only to the precomputed EPR setting. The vernier stops for the left- and right-hand reverser piggyback lever were found set in a position corresponding to 1,000 feet altitude and 60° F. This setting limited the reverse thrust 15 percent to 20 percent from what should have been available at Montrose.

1.16.5 Previous Incidents of Unwanted Thrust Reverser Deployment in Flight

There are two known cases of unwanted in-flight thrust reverser deployment involving Sabreliners. The first occurred on December 17, 1969, and involved a Model 60, N3600X. Shortly after that flight, the pilot prepared a written statement, a portion of which is presented below:

"After liftoff the gear was retracted, and light in the handle went out, thrust reversers were placed to off, and the acceleration was started to 200 kts. As we passed 800 ft. MSL, I started a left turn to intercept the radial. At this time the Master caution light came on. I checked the panel and no lights were visible on it. I immediately saw the left thrust reverse unlock light was on and seconds later the left thrust reverser deployed. At climb power the aircraft became almost uncontrollable [sic]. My first reaction was to control the aircraft. Seconds later I raised the guard and placed the thrust reverser switch to emergency stow; waited a few seconds for something to happen. The reverser didn't stow. I then snapped the left throttle to idle. The aircraft became more controllable [sic] but speed and altitude were

deteriorating. The tower had noted that we were in difficulty and called us asking if we needed assistance. I instructed Mr. Woodard to ask for landing. My speed at this time was 138 kts and slowly losing altitude. With full power on the right engine I placed the reverser switch in arm, backed to off, and then to emergency stow. The reverser stowed, I left the engine in idle and landed—on—runway 34 at White Plains without further incident. On taxing /sic/ in, I armed the reverser and ran them through and they operated normally."

In the investigation subsequently conducted by Rockwell International, no clear reason for the unwanted reverser deployment was found, although thrust reverser rigging and the thrust reverser control switch were suspect. As a result of its investigation, Rockwell International issued two mandatory Field Service Bulletins, which were implemented on N743R:

1. 69-29 " Engine " Thrust Reverser Rigging Inspection.
2. 70-6 " Thrust Reverser Control Switch Part Number 4TL11-1.

The second incident of unwanted reverser deployment occurred on December 19, 1972, and involved a Sabreliner Model 40, N360N. The incident came to the attention of Board investigators during the present investigation and the pilot of N360N was requested to prepare a written statement. He stated, in part:

"While taxiing out I went through the prescribed North American checklist, actuated the reversers and stowed them with the stow switch. All lights were normal during deployment and all lights were out after using the stow switch. The stow switch was off and switch guarded.

"We received take off clearance with a normal take off until we reached 140 knots and the gear had been retracted. At this point there was a lot of noise and vibration and I first thought that we had lost the right engine. . . . I checked the engine instrument group. These instruments showed normal. Out of the corner of my eye, I caught the unlock and deploy light on the right thrust reverser. I immediately went to the stow position with the reverser switch and reduced power to idle on the right engine. The thrust reverser stowed. During this time I monitored airspeed to maintain 140 knots or below 160. The maximum time of emergency was approximately 30 to 45 seconds.

"After the thrust reverser stowed, I maintained idle power on the right engine and had the co-pilot pull all circuit breakers on the thrust reversers. These circuit breakers are the rear row on the co-pilot's sub-panel. Upon completion, I returned to climb power on both engines and accelerated air speed to indicated 350

knots. The thrust reversers remained stowed with the switch in the stowed position and circuit breakers pulled.

"continued flight to Calgary, Canada and landed with no thrust reversers. On the ground taxiing in, I reactivated all systems and checked the thrust reversers which activated normally."

Likewise, no definite reason could be given for the unwanted thrust reverser deployment in this case.

1.16.6 Operational Information

The following operational data were calculated, based on aircraft weight of 15,500 pounds, field elevation of 5,700 feet, temperature 68° F., (20° C.), runway slope zero, wind velocity zero, takeoff thrust on both engines, and aircraft rotation held to the recommended 13° takeoff attitude during climbout:

FAA required runway length	5,500 feet
V ₁	104 Knots Indicated Airspeed (KIAS)
V _R	111 KIAS
V ₂	118 KIAS
Ground roll	2,900 feet
Distance to 35-foot obstacle	4,000 feet
Speed at 35-foot obstacle	125 KWS
Height at 3,500 feet (distance traveled)	16 feet (approximately)
Height at 7,000 feet (distance traveled)	470 feet (approximately)

The Board asked Rockwell International to comment on the control and climb capabilities of the Model 60 Sabreliner when one reverser is deployed and the respective engine throttle is retarded to idle. The assumptions were: the airplane had reached 150 KWS (estimated average speed between obstacle height and end of runway); one engine was at takeoff power; the other engine was at idle with reverser deployed; the landing gear was retracted; and the flaps were up. Under these conditions, Rockwell International calculated that the airplane could climb out on a 5.7 percent gradient. The heading could be held, using a 8.7° rudder deflection (25° was available) and 7° aileron angle (31° was available). Both the 7° and 31° figures are the sum of the deflection angles of the two ailerons. If no control correction was applied, the yaw angle resulting from the thrust and drag asymmetry would be 5.4°. Moreover, if the aircraft was in a coordinated, 60°-banked left turn, with left reverser deployed and the power levers of both engines advanced, the aircraft would be in a 2g turn, and would lose speed at a rate of approximately two knots per second. At 2g, the aircraft stall speed would be increased by about 40 percent. If the flaps were lowered, drag would have increased, and any power reduction would have caused a stall almost immediately.

1.16.7 Thrust Reverser Emergency Stow Procedure

The emergency procedure section of the Sabreliner Airplane Flight Manual (dated 12-29-69) contains the following instruction:

"If a thrust reverser malfunction is indicated in flight, proceed as follows:

1. Power level (affected engine) Retard to IDLE.
2. THRUST REVERSER toggle switch " EMERG STOW.
3. Check respective LH or RH T/R lights " Out.

"If either amber T/R ARM light only comes on in flight, proceed as follows:

1. THRUST REVERSER toggle switch " EMERG STOW. Thrust reverser operation will not be available until the toggle switch is placed back at Normal (ON)."

2. ANALYSIS AND CONCLUSIONS

2.1 Analysis

The crew was properly certificated, and there was no evidence of crew incapacitation. The aircraft weight and center of gravity were within prescribed limits. There was no evidence of any malfunction or failure of the airframe or systems. Although there was concern that the dirt and rocks from the runway construction activity might have caused foreign object damage, disassembly of the engines after the accident revealed that both were capable of normal operation. Similarly, there was no evidence that any engine thrust reverser components had distorted before ground impact.

The takeoff and initial portion of the climb were normal. Witnesses noted what appeared to be a 30° change of heading to the right, which was toward the shortest route to Denver. However, the direction of the turn reversed to the left, and the left bank angle increased as the aircraft descended to the ground. Although the reversal undoubtedly marked the onset of difficulties, it is not known why the turn and descent continued unchecked.

The flight tests revealed that even though the asymmetrical thrust condition resulting from an unwanted thrust reverser development tended to make the aircraft turn in that manner, the aircraft was controllable laterally, and the pilot should have had no difficulty in establishing or maintaining any bank he desired. The pilot could have elected to continue the turn back to the airport while he was troubleshooting the

difficulty, but, because of his inability to maintain altitude, he would have been more prudent to have kept a wings-level attitude and to have landed straight ahead if the difficulty could not have been corrected. Not only was there open and level terrain to the north and to the west, but also there were the high-tension lines and construction equipment between his position and the airport, which would have seriously compromised the safety of an emergency approach. Furthermore, the pilot would have had slightly more time to troubleshoot because of the decrease in descent rate, due to a wings-level attitude.

The reason for the apparent inability of the crew to resolve the problem confronting them is difficult to understand, particularly in view of the apparent ease with which the pilots involved in the two previous incidents identified the problem and employed the correct emergency procedure to eliminate the difficulty.

Three explanations for the catastrophic results of the unwanted thrust reverser deployment in this accident may be considered:

- a The crew was unable to identify the problem;
- the crew identified the problem, but could not get emergency stow system to work; or
- the crew identified the problem, but used improper emergency procedures in an attempt to correct the situation.

It is very unlikely that the crew failed to notice the vibration and turning of the aircraft that would have indicated some difficulty, either with the flight controls or with the engines. A quick scan of the instrument panel should have eliminated any concern about an impending engine failure. Thus, if there were no indications to the contrary, the crew might have assumed that there was some problem with the flight controls, which would have prompted them to continue the turn back to the airport, and to lower the flaps in an effort to alter the configuration and improve controllability. There are two difficulties, however, in the way of this assumption. First, a control problem should not have had a serious effect on the aircraft acceleration and climb performance. Second, there is only one way the actual emergency situation would not have been indicated on the instrument panel. If the circuit breaker protecting the thrust reverser indicator circuit were inoperative, the various reverser indicator lights and the master caution light, in turn, would fail to illuminate. There was no evidence to suggest that this circuit breaker was inoperative. In fact, the pilots had used the reverser system during the preceding landing, apparently without difficulty. Moreover, all appropriate switches were tested after the accident, and they operated normally. The Board concludes that the LH unlock, LH T/R deploy lights, and, in turn, the master caution light did illuminate during the emergency.

The pilots might have had difficulty detecting, or might have failed momentarily to have seen, the lights (located slightly below the glare shield) because of the sun. The flight was turning toward the sun, which was fairly low on the horizon. The lighting conditions might have been such that the LH unlock and the LH T/R deploy lights were not readily discernible; however, the considerably larger master caution light should have been easier to see, and should have alerted the crew to the problem with the other warning lights. Accordingly, the position of the sun relative to the cockpit should have delayed evaluation of the problem only momentarily, if at all.

Once the crew identified the problem and followed the emergency procedure, it is possible that a malfunction in the thrust reverser system prevented the reverser doors from stowing. However, all mechanical reverser components were functionally tested and were found capable of normal operation. Even if the emergency stow switch had malfunctioned, a reduction in thrust on the engine in the reverse thrust configuration would have enabled the crew to climb, if necessary, and to return for a safe landing. The Board concludes that neither electrical nor mechanical malfunction of the thrust reverser system prevented the crew from controlling the aircraft safely.

It is the conclusion of the Board that the crew did not know the proper corrective procedures for an unwanted deployment of the thrust reverser in flight, despite their years of piloting experience and their specific qualification in the Sabreliner. The crewmembers were primarily flight instructors in the Boeing 727, and, like several other flight instructors, they flew the Sabreliner only at random, as company needs required. The total accumulated flight time for the captain in the Sabreliner was relatively low, averaging approximately 9 hours a month. The first officer averaged fewer than 7 hours a month. Although the procedure for in-flight stowage of the thrust reverser was discussed in ground training, the fact that the reverser will not stow in flight at a high-power setting was not stressed. The procedure was also described in the flight manual; however, it was considered a Phase 2 emergency, which meant that immediate action was not necessary; as a result, the procedure usually was not memorized.

In this instance, the crew was faced with a loss of altitude and airspeed approximately 1,000 feet above the ground which, according to the aircraft performance data, would have continued as long as the left engine remained at a high-power setting. As might be expected, the crew would not consider a reduction of power to correct for a loss of altitude and airspeed unless they were aware of the emergency procedure which called for an appropriate reduction in power.

The landing flaps were found in the extended position. The pilot apparently had lowered the flaps during the turning descent, possibly in an effort to lower the stall speed. However, the flaps (which on this

model aircraft primarily increase drag) only aggravated the control problem. As indicated by the Rockwell International performance calculations, extension of the flaps under these circumstances very likely induced, rather than prevented, a stall condition during the final seconds of flight.

Examination of the engines after the accident produced sufficient evidence to indicate that they were at idle thrust at impact. It is logical to conclude that the pilot, reacting normally to the critical circumstances, retarded the thrust levers just before the aircraft crashed. Undoubtedly, the reverser control switch was not in the emergency stow position at this time.

2.2 Conclusions

(a) Findings

- (1) The crewmembers were certificated to conduct this flight.
- (2) The aircraft was certificated, and the gross weight and center of gravity were within prescribed limits.
- (3) There was no evidence of any failure or malfunction of the airframe or aircraft systems, nor was there any fire in flight.
- (4) The left engine reverser was deployed, the flaps were down, and the engines were at idle when the aircraft crashed.
- (5) In-flight reverser deployment caused buffeting, but the aircraft was controllable.
- (6) When the thrust reverser doors were deployed in flight and the reversed engine developed high power, the doors would not stow, and the aircraft did not maintain altitude and airspeed.
- (7) Performance data based on this takeoff indicate that N743R could have climbed with the right engine at climb power, provided the left engine was at IDLE.
- (8) There was no evidence of warning light malfunction.
- (9) The crew should have been aware of the unwanted thrust reverser deployment.
- (10) The crew did not know the proper corrective procedure for the emergency.

(b) Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the continued operation of the left engine at climb power after an unwanted in-flight deployment of the left engine thrust reverser, which resulted in a deterioration of aircraft performance.

3. RECOMMENDATIONS AND CORRECTIVE ACTION

(a) Corrective Actions

Soon after the accident, the Federal Aviation Administration (FAA) issued a telegraphic Airworthiness Directive (AD) to all owners of North American Rockwell Model NA-265-40, - 60, and -70 airplanes. The AD required the thrust reversers to be stowed and locked in the forward thrust position. The telegram stated that this was an interim measure and that final disposition of the restriction would depend on the results of tests and investigations then in process.

Rockwell International issued a "Sabre Gram" dated May 2, 1973, to all Sabreliner operators bringing to their attention the results of the flight tests in relation to the controllability of the aircraft with unwanted thrust reverser deployment in flight. The Sabre Gram stated, in part :

"The flight test evaluation . . . has been completed using a Series 60 Sabreliner in Type Design configuration except for rewiring to permit thrust reverser deployment with gear up for the tests. This airplane was chosen as representative of all three models. Test [sic] were flown in a representative series of conditions: gear extended, gear retracted, wing flaps up, and wing flaps fully extended. Test speeds covered the range of 110 to 200 knots, with test points at 20 knot intervals between 140 and 200 knots. Tests were conducted in the altitude range of 10,000 to 6,000 feet. The tests resulted in Sabreliner Flight Test Pilot, Russ Scott, terming controllability EXCELLENT at any speed from 140 knots upward. A selected heading could be held, or could be trimmed hands off, and 30° bank turns into and away from the reverse thrust engine could be made at will, with ample control movement in reserve. Below 140 knots, control requirements progressively increase, full rudder deflection being required to hold a heading at 110 knots."

The FAA issued AD 73-12-9, Amendment 39-1664, which became effective June 16, 1973. This AD required accomplishment of one of three alternatives prior to further flight of Model NA-265 thrust reverser equipped airplanes:

1. The aircraft can be operated if the reversers are stowed and locked as required by the telegraphic AD.

2. The aircraft can be operated if:

- (a) Revisions dated May 16, 1973, are incorporated in the NA-265 series Sabreliner Airplane Flight Manuals approved by the FAA. These revisions require: a visual inspection of each thrust reverser "S" hook for proper engagement before each flight; the thrust reverser control switch be in the EMERG STOW position before takeoff, and remain in that position until the aircraft reached 1,500 feet above ground level; the thrust reverser control switch be placed in the EMERG STOW position before placing the landing gear handle at DOWN for landing; and operational check of the thrust reverser system should be made after each flight. The emergency procedures section (Section 11, page 19) contains these notes: "An inadvertent thrust reverser deployment in flight will result in heavy buffet which decreases as the respective engine thrust is decreased. The aircraft is readily controllable, however, altitude cannot be maintained until thrust is reduced on the engine with the deployed thrust reverser. If the thrust reverser fails to stow after placing the thrust reverser control switch in the EMERG STOW position, shut down the respective engine and land as soon as practicable."
- (b) Certain preflight inspections are performed.
- (c) Certain inspections of the thrust reverser system are performed at 100- and 300-hour intervals.
- (d) The dimming circuit is modified so that the T/R advisory lights cannot be dimmed,

3. The aircraft can be operated if equivalent inspections, maintenance procedures, and installations are approved by the Chief, Aircraft Engineering Division, FAA Western Region.

(b) Recommendations

A review of the Rockwell International Sabreliner Model 60 thrust reverser system and regulations governing thrust reverser systems was initiated as a result of this accident. Since certain proposals which resulted from this review exceeded the scope of the measures required by AD 73-12-9, Amendment 39-1664, the National Transportation Safety Board recommends that the Federal Aviation Administration amend Airworthiness Directive 73-12-9 to:

1. Require modification of the thrust reverser system for the Rockwell International Sabreliner Model 60 which would minimize

reverser system dependence upon rigging tolerances to insure proper indicator light operation. In any modification, serious consideration should be given to:

- (a) Incorporation of a microswitch in the thrust reverser actuator to control the unlock light.
 - (b) Relocation of the present unlock light microswitch from the secondary latch solenoid to a position which results in unlock light deactivation only upon positive physical engagement of secondary latch and reverser door strikes. (A-73-107)
2. Incorporate a stowing function in the Sabreliner reverser system which would automatically stow a deployed thrust reverser when the throttle is not in the idle position. (A-73-108)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD:

/s/ JOHN H. REED
Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ LOUIS M. THAYER
Member

/s/ ISABEL A. BURGESS
Member

/s/ WILLIAM R. HALEY
Member

November 7, 1973

APPENDIX A

INVESTIGATION AND HEARING

1. Investigation

The National Transportation Safety Board received notification of the accident at approximately 1800 on April 13, 1973. Two investigators were dispatched immediately from the Denver Field Office. They were joined the following day by two investigators from the Washington Office. A fifth investigator was dispatched from the Los Angeles Field office to conduct an examination of maintenance records at Continental Airlines headquarters in Los Angeles.

Investigative groups were established for Operations, Witnesses, Structures, Systems, Powerplants and Maintenance Records.

2. Hearing

There was no public hearing held in connection with this investigation.

APPENDIX B

CREW INFORMATION

Captain Robert Morah Walsh, aged 37, was employed by Continental Airlines as an instructor pilot. He was hired by the company on January 9, 1967, and served as a line pilot until January 1, 1972. He held Airline Transport Pilot Certificate No. 1638576 with ratings for airplane multi-engine land, with type ratings in the Boeing 727 and the NA-265 (Sabreliner), and commercial privileges for airplane multiengine land, Boeing 707/720. His latest FAA first-class medical certificate was issued on March 23, 1973, with no limitations. Company records indicate that Captain Walsh received 24 hours of Sabreliner initial training (ground) from June 27 through June 30, 1972. From July 18 through July 25, 1972, Captain Walsh received 6 hours 12 minutes of flight instruction, of which 1 hour 15 minutes were used for a rating ride given by an FAA inspector. He had a total of 10,000 hours' pilot time, of which 83 hours 43 minutes were in the Sabreliner, and 28 hours 25 minutes were in the Sabreliner during the 90-day period preceding the accident.

Captain James Louis Ford, aged 33, was employed by Continental Airlines as an instructor pilot. He was hired on March 8, 1965, and served as a line pilot until November 1, 1972. He held Airline Transport Certificate No. 1524586, with ratings for airplane single- and multiengine land with type ratings in Boeing 707, 720, 727, and the NA-265, and commercial privileges for airplane single-engine land. His latest FAA first-class medical certificate was issued on October 4, 1972, with no limitations. Company records indicate that Captain Ford received 24 hours of Sabreliner initial training (ground) from September 12 through September 15, 1972. From September 20 through October 3, 1972, Captain Ford received 4 hours 45 minutes of flight instruction, and a rating ride of 1 hour 28 minutes, given by an FAA inspector. Captain Walsh accompanied Captain Ford as a check pilot on this flight. He had a total pilot time of 7,317 hours 27 minutes of which 26 hours 18 minutes were in the Sabreliner. Fourteen hours 23 minutes were in the Sabreliner during the 90-day period preceding the accident.

AIRCRAFT INFORMATION

Aircraft Data

The airplane, a Sabreliner Model NA-265-60, was manufactured by North American Aviation, Inc. (**now** doing business as Rockwell International), under serial No. 306-11. It was assigned U, S. Registry No. 743R. Manufacture was completed on March 26, 1968. The total flying time was 2,372 hours 5 minutes.

N743R was equipped with two Pratt & Whitney JT12A-8 engines. Engine serial numbers and times were as **follows**:

	<u>Date of Mfg.</u>	<u>S/N</u>	<u>Total Time</u>	T.S.O.
Left	2-1-68	P673095NB	2,241:50	732:11
Right	1-27-68	P673096NB	2,213:03	703:24

All pertinent Airworthiness Directives issued by the **FAA**, as well as pertinent Service Bulletins issued by the manufacturer, had been complied with.