REPORT OF

COMMISSION OF INQUIRY

INTO CRASH OF TRANS-CANADA AIR LINES

DC-8F AIRCRAFT CF-TJN

AT STE. THERESE DE BLAINVILLE, P.Q.

ON 29th NOVEMBER, 1963

ORDER IN COUNCIL DATED 8 OCTOBER, 1964, P.C. 1964-1544

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TO HIS EXCELLENCY THE GOVERNOR GENERAL IN COUNCIL

MAY IT PLEASE YOUR EXCELLENCY,

As the Commissioner appointed by Order in Council dated 8 October, 1964, P.C. 1964-1544, to inquire into and report upon the circumstances surrounding the crash of a Douglas DC 8F Aircraft, Registration CF-TJN, at Ste-Therese, Quebec, on the 29th day of November, 1963, when on a flight from Montreal to Toronto and more particularly, and without restricting the generality of the foregoing, upon:

(a) the cause or causes that occasioned or may have occasioned the crash; and

(b) whether the crash was occasioned by any breach or breaches of the Aeronautics Act or the Air Regulations or any order or direction made pursuant thereto.

BEG TO SUBMIT TO YOUR EXCELLENCY
THE FOLLOWING REPORT

IN THE MATTER OF:

THE PUBLIC INQUIRY INTO THE CIRCUMSTANCES SURROUNDING THE CRASH OF A TRANS-CANADA AIR LINES DC-8F AIRCRAFT, REGISTRATION CF-TJN AT STE. THERESE DE BLAINVILLE, QUEBEC, ON 29th NOVEMBER, 1963, WHEN ON A FLIGHT FROM MONTREAL TO TORONTO.

REPORT OF:

HON. GEORGE S. CHALLIES, COMMISSIONER

CAPT. WILLIAM S. ROXBOROUGH
AIR COMMODORE RAYMOND H. BRAY, RCAF (retired)
Technical Advisers

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Counsel for Canadian Air Lines Pilots Association

OBSERVER:

DONALD W. MADOLE,
Civil Aeronautics Board of United States

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ORGANIZATION OF INQUIRY

By Order in Council P.C. 1964-1544 of the 8th October, 1964, the undersigned was appointed a Commissioner under the Inquiries Act, chapter 154 of the Revised Statutes of Canada, 1952, to inquire into and to report upon the circumstances surrounding the crash of a Douglas DC-8F aircraft, Registration CF-TJN, operated by Trans-Canada Air Lines, which occurred near Ste. Therese, Québec, on the 29th November, 1963, about 6:30 p.m., when on a flight from Montreal to Toronto, with loss of life of all the occupants, i.e., the crew of 7 and 111 passengers, and more particularly, and without restricting the generality of the foregoing, upon:-

a) the cause or causes that occasioned or may have occasioned the crash; and

b) whether the crash was occasioned by any breach or breaches of the Aeronautics Act or the Air Regulations or any order or direction made pursuant thereto.

Capt. William Sydney Roxborough, of West Vancouver, B.C., and Air Commodore Raymond Harris Bray, RCAF (retired) of Ottawa, were appointed technical advisers and Batonnier Leon Lalande, Q.C., of Montreal, was appointed counsel to the inquiry.

Public notice was given that the inquiry would open in Room 24 of the Old Court House, Montreal, on 9th November, 1964. A pre-hearing conference was held in the Old Court House, Montreal, on 3rd November, at which were present a representative of the parties to the investigation who were Trans-Canada Air Lines and Douglas Aircraft Company, Inc. In addition, Canadian Air Line Pilots Association were invited as observers. Hearings were held on 9th, 10th, 12th November and 2nd, 3rd, 7th and 8th December, 1964. Forty-five witnesses were heard and 78 exhibits were filed.

The evidence of 13 of these witnesses was given in French and later translated into English.

The parties to the investigation and the Canadian Air Line Pilots Association who were observers, were invited to submit written argument. Trans-Canada Air Lines and Canadian Airline Pilots Association did so.

Early in 1965, it was learned that the Civil Aeronautics Board of the United States was shortly to re-open their inquiry into the crash of a DC-8F aircraft into Lake Pontchartrain, Louisiana, under circumstances quite similar to the circumstances surrounding the crash at Ste.

Therese. In case the additional evidence put before the U.S. Inquiry could be of assistance in the study of the Ste. Therese disaster it was decided to delay the preparation of this report until such evidence became available.

Late in April 1965 the Civil Aeronautics Board of the United States re-opened their inquiry into the New Orleans accident for the purpose of receiving and placing on record this additional data and information that had by then become available. Sessions were held in Washington, D.C., and Los Angeles at which were present Captain W.S. Roxborough, one of the technical advisers to the present inquiry, and representatives of the Department of Transport, Douglas Aircraft Company and Trans-Canada Air Lines.

After further public notice the present inquiry reconvened at the Exchequer Court, Supreme Court Building, Ottawa, on the 9th June 1965 and the evidence at the C.A.B. inquiry in April 1965 was formally submitted. This evidence had been made available to the parties in advance. Brief additional evidence was made of other pitch incidents involving DC-8 aircraft to supplement evidence already in the record. Counsel was given an opportunity of presenting further oral argument immediately and the inquiry then terminated.

We would like to express appreciation to Mr. Donald W. Madole of the C.A.B. for the full co-operation which has

been extended by him and his organization and to counsel for the interested parties for their assistance, to express special thanks to Batonnier Lalande, counsel for the Commissioner, Messrs. C.S. Booth and R.L. Bolduc, and to commend the Department of Transport on the thoroughness of the investigation into the disaster.

While the name of Trans-Canada Air Lines was changed to Air Canada which became effective from 1st January 1965, the name Trans-Canada Air Lines is used throughout this report as that was the official name at the time of the crash, at the time of the passage of the Order in Council setting up the inquiry, and at the time of the hearings in 1964.

HISTORY OF THE FLIGHT

The aircraft was on a regular scheduled flight from Montreal to Toronto, scheduled to leave Dorval International Airport at 6:10 p.m. EST. On the evening in question, at 6:25 p.m., the weather was reported as overcast, light rain and fog, visibility 4 miles, surface wind NE at 12 m.p.h. Because of delays to ground transportation of passengers coming from Montreal, the flight was delayed about 10 minutes.

The 111 passengers were finally all loaded by the front door because of water on the ramp area at the rear of the plane and the flight was cleared by air traffic control to Toronto Airport via the St. Eustache omni range station and Ottawa direct to Kleinburg and Toronto at a flight level of 29,000 feet, with instructions to report at 3,000 and 7,000 feet on the climb-out from the airport. Flight 831 started its take-off roll on runway 06 right at approximately 6:28 p.m. which is believed to be accurate within 30 seconds. The evidence shows that the aircraft took off normally, reported in at 3,000 feet and acknowledged a clearance for a left turn to St. Eustache. This was the last radio contact with the flight. The flight was monitored on air traffic control radar at the airport to about 8 nautical miles from the airport when the aircraft was in a left turn and surrounded by rain clutter on the radar and was not again observed.

The flight did not report through 7,000 feet as instructed. Repeated efforts to re-establish radio contact with the flight were unsuccessful and Dorval International Airport learned of the crash about 7:00 p.m. The scene of the crash was about four miles roughly north of Ste. Therese de Blainville, P.Q., and a few hundred yards to the west of Highway 11 at a point Latitude 45°40'53"N; Longitude 73°53'55"W, approximately 16.9 statute miles from Dorval International Airport, as the crow flies. The time of the crash was about 6:33 p.m., established from the seismograph at College Brebeuf, Montreal.

THE INVESTIGATION BY DEPARTMENT OF TRANSPORT

Dorval International Airport was alerted by St. Hubert Airport, about 15 minutes after the crash, St. Hubert having been informed by telephone by an eye witness. The Regional Superintendent of Accident Investigation of the Department of Transport, with Headquarters at Montreal, advised the Ottawa Headquarters of the crash and proceeded to the scene, arriving within 2½ hours of the crash, where he was shortly joined by the Chief of the Accident Investigation Division who came down from Ottawa. After a preliminary appraisal of conditions at the crash site, heavy construction equipment and earth movers were procured to commence salvage operations. Organized salvage operations began on 30th November, 1963.

After appropriate consultations, an investigation team was developed to cover six major areas of interest, namely, Records and Documents, under the chairmanship of Mr. A.J. McDonell of the Department of Transport, Ottawa; Operations, under the chairmanship of Mr. S.T. Grant of the Department of Transport, Ottawa; Power Plants, under the chairmanship of Dr. E.P. Cockshutt of National Research Council, Ottawa; Human Factors, under the chairmanship of S/L A.C. Bryan, RCAF; Structures, under the chairmanship of Mr. A.H. Hall of National Research Council, Ottawa; and Systems, under the chairmanship of Mr. J.W. Noonan of National Research Council, Ottawa.

A team of 14 people were assigned the task of locating and interrogating witnesses. The search for witnesses was conducted by a door-to-door survey in the immediate vicinity of the crash and southward towards Ste. Therese and Ste. Rose. A total of 110 statements were taken by members of the Operations Group from witnesses located, for the most part, in the immediate vicinity of Highway No. 11 between Ste. Rose and St. Janvier, Quebec, a distance of approximately 8½ miles. Due to the nature of the accident and soil conditions at the scene of the crash, protracted and costly salvage operations commenced on 30th November, 1963, and extended until 27th April, 1964. At the height of the operations

early in December, 1963, over 1500 personnel were involved, drawn from Department of Transport, National Research Council, Department of National Defence, RCAF and Army, Air Canada, Red Cross and Montreal Civil Defence.

Excavation in the crater area involved the moving and screening of 26,000 cubic yards of soil under very difficult conditions. It was found that wreckage was distributed in two major areas: the crater area of about 17,000 square feet and an area ahead of the crater area which will be referred to as a scatter area involving another 700,000 square feet. During the first two weeks of December, the crater area was surveyed by engineers and a grid system established, in order that the identity and location of salvage could be recorded. The recovery of human remains and aircraft salvage was extremely difficult during the early stages, due to the weather and the nature of the soil. A limited recovery was achieved during this stage by the labour force using picks and shovels but early in December, heavy equipment was introduced comprising four cranes with clam shells, pay loaders and end loaders which excavated around the edge, cutting gradually towards the center of the crater. Pumps were employed to dispose of the water.

All salvage was removed, transported to a sorting area where it was separated from the clay type soil, washed, and then trucked to an empty hangar at Montreal Airport for subsequent identification and investigation. Within a few days, the operation proceeded on a 24-hour basis by means of floodlights.

As the heavy equipment progressed toward the center of the crater, serious engineering problems were encountered because the sub-soil could not support heavy equipment and on 12th December, 1963, it was decided that it was not possible to continue the excavation because of increasing landslides as the excavation reached the 20 to 30 foot depth. As a result of an engineering investigation carried out on the 14th December, 1963, it was determined that further excavation would require the construction of a coffer dam. Commencing on the 14th January, 1964, metal piles were driven down to bedrock and the coffer dam was completed on 13th February, enclosing an area of 140 x 120 feet. As excavation progressed, a network of steel bracing was installed every 10 feet in order to support the walls.

The total weight of the aircraft, including life jackets, was 135,030 pounds. Of this, 105,442 pounds were recovered, leaving 29,588 pounds unaccounted for. It was considered that the bulk of this missing 29,588 pounds would exist in very small pieces and that the recovery of the missing material would not assist in determining the cause of the crash.

RECORDS AND DOCUMENTS GROUP

The Records and Documents Group made the following findings:

Flight Personnel

The flight personnel consisted of:

Capt. John Douglas Snider
First Officer Harry Jacob Dyck
Second Officer Edward Desmond Baxter

The flight attendants were Imants E. Zirnis, purser, and Kathleen P. Creighton, Linda J. Slaught and Lorna J. Wallington, stewardesses.

a) Capt. John Douglas Snider

Capt. John Douglas Snider was 47½ years old and held an airline pilot licence No. AT-666, valid until the 21st March, 1964. He served with the RCAF from 1940 to 1944 and flew 1,045 hours, mostly as a bomber pilot. He commenced his employment as a pilot with Trans-Canada Air Lines on 27th October, 1944, and up to the time of his death, he had flown a total of 17,206 hours, of which 458 were flown on a Douglas DC-8 and 103 hours were flown on a DC-8F. He possessed a D.O.T. Class I instrument flight rating, valid until 1st April, 1964, and, except for a five week period early in 1963, he had maintained this rating or its earlier equivalent continuously during 17½ years.

His latest medical examination was on 26th September, 1963, and nothing abnormal was recorded. During the 19 years preceding the accident, he had successfully passed 40 medical examinations, all of which were assessed as physically fit.

b) First Officer Harry Jacob Dyck

First Officer Dyck, aged 35½, had been employed with Trans-Canada Air Lines as a pilot from the 9th February, 1953, until his death. During this period, his grand total flying time as a pilot was 8,302 hours and 58 minutes, of which 336 hours were in a Douglas DC-8 and 61 hours and 54 minutes on a DC-8F. He possessed a D.O.T. airline transport pilot licence, No. YZA-818, valid until 25th March, 1964 and had maintained this licence continuously during the five years preceding the accident. This licence was endorsed for Douglas DC-8 type aircraft on 17th May, 1963, and the latest renewal date was 23rd September, 1963. He possessed a D.O.T. Class I instrument rating, valid until 1st June, 1964. This Class I rating was first issued on 6th May, 1954, but during the four years preceding the accident he had allowed it to lapse to a Class 2 rating on four occasions. The latest renewal date of the Class I rating was 7th November, 1963.

His latest medical examination was on 23rd September, 1963, and nothing abnormal was recorded. During the 11½ years preceding the accident he had successfully passed 26 medical examinations, all of which assessed him as physically fit.

c) Second Officer Edward Desmond Baxter

Second Officer Baxter, aged 29½, had several periods of employment as a young man with TCA as a labourer, truck driver, clerk, cashier and as an RCAF student pilot. He was employed as a pilot with Trans-Canada Air Lines on 8th July, 1957, trained in Viscount aircraft after flying North Stars, and in June, 1963, he completed training in Douglas DC-8 aircraft. His grand total flying time as a pilot up to his death was 3,603 hours, of which 133 hours had been flown on a Douglas DC-8 and 144 hours in a DC-8F. He was issued commercial pilot licence YCZ-7668, valid until 11th September, 1964. The latest renewal date of this licence was 11th September, 1963. He possessed a Department of Transport Class I instrument flight rating, valid until 31st December, 1963, which he had allowed to lapse to a Class 2 rating on five occasions. The latest renewal date of this Class I rating was 15th June, 1963.

His latest medical examination on 11th September, 1963, recorded nothing abnormal. He had experienced chest

pain during a flight in December, 1961, and was grounded for two weeks, but this was assessed as muscle spasm and no evidence was found of any heart trouble.

d) The records of the purser and the three stewardesses revealed nothing pertinent to this inquiry.

The Records and Documents Group concluded that the three pilots had all received at least two TCA enroute flight checks during the year prior to the accident; they had accumulated sufficient experience in DC-8 aircraft to be qualified for their respective duties at the time of the accident; and that nothing in any of the known crew histories suggested any causes for the accident. We concur with these conclusions.

2. The Aircraft

The aircraft, CF-TJN, a DC-8F-54, was manufactured by Douglas Aircraft Company at Long Beach, California, in 1963, and bore manufacturer's serial number 45654. It was powered by four Pratt & Whitney JT3D-3 jet engines. The first flight, a test flight, took place on 5th February, 1963. About that time, Trans-Canada Air Lines purchased and accepted this aircraft at Long Beach and assigned company serial number 814. On 8th February, 1963, a TCA crew ferried this aircraft from Long Beach, California to Montreal, Quebec. The Department of

Transport on 12th February, 1963, issued a certificate of registration No. 28887, allocated registration marks CF-TJN and issued a certificate bearing No. 9183 authorizing this aircraft to fly as a normal category land plane, subject to the conditions of being operated by a crew of two qualified pilots and a qualified flight engineer or with a crew of three qualified pilots.

Up to the date of the crash, the aircraft's total time in the air was slightly more than 2,174 hours.

The history of the power plants is reported by the Records and Documents Group as follows:

No. 1 engine - Serial No. 72-00-102-222, installed in the aircraft 29th August, 1963, in position for 686 flying hours until accident. Total power plant time 1,590 hours.

No. 2 engine - Serial No. 72-00-102-212, installed in the aircraft 22nd August, 1963, in position 753 hours until accident. Total power plant time 1,660 hours.

No. 3 engine - Serial No. 72-00-102-218, installed in the aircraft 22nd August, 1963, in position 753 hours until accident. Total power plant time 2,174 hours.

No. 4 engine - Serial No. 72-00-102-209, installed in the aircraft 27th November, 1963, in position 21 hours until accident. Total power plant time 1,697 hours.

The Records and Documents Group concluded that there is nothing in the maintenance history of the aircraft which would suggest a cause of the accident.

In the light of the evidence made at the hearing, we concur in that conclusion.

OPERATIONS GROUP

1. Witnesses

After the accident, at the request of the Operations Group, representatives of the Department of Transport or Trans-Canada Air Lines visited a large number of dwellings between Ste. Rose and the site of the crash and found 110 witnesses from whom statements were taken. The most relevant of these statements were studied and the people who made them testified at the hearing. As may be expected, the evidence of some of the witnesses was quite contradictory. The most useful witness, Thomas Watt, who lives at 333 Ste. Rose Boulevard, Ste. Rose, some seven miles from the site of the crash, testified on the basis of years of experience as a bush pilot. He was outside near his house about 6:30 p.m., and he heard a jet airplane near the autoroute west of his position and stated "that this jet was climbing because the engine noise was strong and then there was abrupt cessation of power or this noise, the jet noise, and then a whistling noise that you could attribute to empennage or flying wires. It is kind of a whistling noise in an aeroplane that is coming down. Any aeroplane with power cut is going to do some screaming". Mr. Watt said to himself that the pilot was doing an expedited letdown, a real expedited letdown; in his

opinion the whistling noise was from the passage of the aircraft through the air and not from the engines as he said at page 165 of the transcript "It was so unusual because he was, to me, climbing and that is the kind of power he had on and all of a sudden just stopped".

The main facts that could be determined from the evidence of the various other witnesses were that the aircraft was not on fire prior to impact and that electric power was available to the lighting system.

2. Report of Operations Group

The Operations Group came to the following conclusions:

a) The Air Carrier was properly certificated,

b) The flight crew were qualified on the type and properly certificated,

c) The aircraft was properly loaded,

d) The aircraft and flight crew were properly despatched,

e) The aircraft was observed to take off normally and thereafter carried out the noise abatement procedure prescribed for runway 06 right at the Montreal International Airport,

f) No difficulty with the operation of the flight was indicated or reported by the flight crew,

g) The aircraft commenced a left turn in accordance with the clearance approximately 8 nautical miles from the point where power was applied for take-off,

h) In the vicinity of Ste. Rose, a jet aircraft was heard by a witness to reduce power abruptly at the approximate time that Flight 831 would have been in the immediate area. There is no record of any other jet aircraft, civil or military, in the vicinity at that time,

i) In the vicinity of Ste. Rose, the aircraft deviated from its normal flight path approximately 55° to the right,

j) The aircraft descended quickly from the altitude attained during climb after passing Ste. Rose,

k) The aircraft maintained a relatively straight course on a heading of approximately 330° M. between Ste. Rose and the crash site,

l) The aircraft impacted the ground at a steep angle,

m) The total time involved in this flight from the commencement of the take-off roll and the impact with the ground was 5 minutes (± 15 seconds),

n) A ground and air search of the probable flight path and adjacent areas revealed no evidence of wreckage or parts having fallen from the aircraft while in flight,

o) Weather conditions, as reported, were suitable for the flight.

We concur in these findings and wish to add that the evidence showed that the flight crew were in their proper positions as the aircraft left the ramp and that the First Officer made all the radio transmissions. It is therefore assumed that the Captain was flying the aircraft. The Operations Group also produced as Appendices C and D, probable horizontal and vertical flight profiles. These flight profiles were computed by the

National Aeronautical Establishment, Ottawa, in an effort to find flight paths within the performance capabilities of the aircraft which would satisfy a number of conditions which had arisen from other aspects of the investigation. We concur in general with the horizontal flight profile but consider that the slightly curving profile found in figure 14 of Appendix 20 to the report of the Structures Group (Exhibit No. 62) is more probable. While the vertical flight profile is open to question as based upon assumptions which are not necessarily correct, this is not material in the determination of the possible causes of the accident as it throws no light upon the cause of the initial upset.

POWER PLANT GROUP

The purpose of the power plant group was to determine whether a major malfunction of one or more engines occurred as a prime cause of the crash, whether a lesser malfunction of one or more engines occurred which could have contributed to the crash, and to determine the operating conditions of the engines at the moment of the impact as to speed and thrust.

The Power Plant Group concluded as follows:

a) Approximately 75% in weight of all four power plants was recovered. No anomalous deficiencies were found in the material recovered,

b) There was no catastrophic failure of a single engine and no simultaneous interconnected failures of several engines,

c) There was no evidence of in-flight fire, contaminated fuel, contaminated oil, bird ingestion, icing, engine flame-out or water ingestion and no evidence of inadvertent or accidental application of reverse thrust,

d) The physical evidence available indicated that all four engines were at or near a forward flight idle condition at the time of impact and that the flight idle power setting was selected at least ten seconds prior to impact. This figure may be considerably greater but cannot be less than ten seconds.

We concur in these findings.

HUMAN FACTORS GROUP

The Human Factors Group concluded as follows:

a) The analyses of tissue samples show no evidence of unusual carbon monoxide concentrations or the presence of toxic volatile components,

b) Company personal and health records of the flight crew as well as interviews with their private physicians, revealed no significant information. As far as can be told from these records and interviews with friends, the flight crew were physically and mentally competent,

c) No evidence could be found that any toxic or potentially toxic substances which could have contributed to crew failure during the period involved, were on board the aircraft.

During the hearing, corroborative evidence was given, which indicated the thoroughness of the investigation and leads the commission to concur in the conclusions of the Human Factors Group.

STRUCTURES GROUP

Following examination of all available evidence, the following conclusions were reached by the Structures Group:

a) The material recovered was sufficient to assure reasonably firm conclusions in respect of all aspects of structural performance and integrity,

b) Un-recovered material does not appear to be essential to the conclusions,

c) The flight path heading as deduced from throw of dense pieces of wreckage is estimated to be 296 ± 15 degrees Magnetic,

d) The direction and angle of descent as deduced from a group of trees which were cut by the aircraft suggests a heading of 295 ± 12 degrees Magnetic and an angle of descent of 55 ± 7 degrees. The fuselage datum may be something less than this angle,

e) The estimated right wing down attitude of the aircraft at impact is 35 ± 8 degrees which angle reconciles tolerances in flight path headings, angle of descent and lie of the power plants within the crater,

f) Confirmation of nose first impact includes, compression wrinkles in the fuselage shell, progressive aftwards decrease in degree of fragmentation and the forces which disrupted the retracted nose gear,

g) At time of impact the aircraft main structure was intact and functional. All power plants were attached to their pylons. The main and nose gears were retracted. There is no indication of prior tire or wheel explosion. The cockpit windshield was not shattered by penetration or an airborne object and the windows were closed and locked,

h) All control surfaces were in place and structurally functional,

i) The horizontal stabilizer exhibits witness marks which indicate the left hand side to be set at aircraft nose down trim of between 1.6 and 1.7 degrees and the right hand side approximately 1.9 degrees,

j) The right hand aileron was indicating a trailing edge down position of 8 to 10 degrees while the left aileron shows approximately 8 degrees trailing edge up. The latter was influenced by some wing twisting. Both right and left aileron tabs were effectively in their neutral positions,

k) The flight and ground spoilers were retracted,

l) The flaps were retracted and the exhaust gates were faired,

m) The rudder was initially damaged at an instant when it was near its neutral position,

n) Crew harness recovered showed evidence of being fastened, while passenger harness recovery indicates the possibility of only one-third being fastened,

o) There is no clear evidence as to the position of the elevators at impact,

p) There was no evidence of internal or external fire damage prior to impact, or contamination by noxious fumes. Also ruled out by lack of evidence is any explosive fracture of high pressure systems components,

q) The presence of deleterious conditions such as bracket distortion, cable fretting or corrosion was not detected. No evidence of fouling or prior damage was detected on the elevator tab push pull rods.

The commission accepts these findings.

SYSTEMS GROUP

Following examination of recovered components, the conclusions reached by the Systems Group are as follows:

a) The overall average of systems' component recovery was approximately 65 per cent, ranging from 90 per cent of the flight control system to 33 per cent of the ice and rain protection system,

b) Hydraulic, electrical and pneumatic power was available up to the time of impact,

c) The aircraft was supplied with the proper fuel,

d) The aircraft was in a clean configuration, i.e., landing gear, wing flaps and spoilers were retracted and the wing slots were closed,

e) The ailerons were in the power operated mode and in an attitude calling for right wing up,

f) The pitch trim compensator actuator was in the extended position,

g) The horizontal stabilizer was at an angle between 1.65° and 2° nose down trim and had been operated to that position by hydraulic power,

h) The radio equipment and weather radar were operating normally,

i) Engine tachometer indications were all consistent with a flight idle power setting,

j) The indicated airspeed at impact, as determined by the position of the MACH corrector cams of the two independent Kollsman Integrated Flight Instrument System units, corrected to 225 feet above sea level at 38°F. ambient air temperature, was 470 knots to a conversion accuracy of plus or minus 1 per cent. On this basis, the velocity of the aircraft at impact was calculated as being between 470 and 485 knots,

k) No evidence was discovered to indicate that any defect existed or that any malfunction occurred during the flight which would cause a loss of flight control of the aircraft,

l) No traces of smoke or toxic substances were discovered in the air conditioning system,

m) No evidence of in-flight fire was found,

n) With the exception of the cockpit area, approximately 90 per cent of the flight systems components were recovered and no evidence of in-flight fire was found,

o) No evidence of in-flight explosion of tires, wheels or brakes was discovered,

p) There was no evidence of any malfunction of the drive motors or controls which actuate the horizontal stabilizer,

q) It was not possible to establish the position of the elevators at impact. However, examination of the cable runs from fuselage station 1500 to the elevator servo tab torque arms indicate this to be in good order,

r) It was not possible to determine the power status or attitude of the rudder at impact.

Again, the commission concurs in these conclusions.

ANALYSIS OF EVIDENCE

The evidence indicates that there was no mid-air disintegration due to turbulence, collision with birds or other objects, explosion or fire and that the aircraft was structurally intact at the time of impact. The evidence also indicates that the major systems, electric, hydraulic and pneumatic, were functioning throughout the flight. Therefore, it appears that all controls and all control surfaces were serviceable, functioning and available to the flight crew.

Since the Human Factors Group reported that they were unable to analyse any human tissue which could be positively identified as belonging to the flight crew, it cannot be said that toxic environment, sudden illness or malice are not possible causes of the accident. However, the possibility is considered to be very remote because none of the many samples of tissue which were analysed showed any evidence of unusual toxic substances or in-flight fire. Furthermore, the throttles were manually moved to the flight idle position and the ailerons were moved to correct an angle of bank. These facts indicate that one or more persons on the flight deck were conscious and capable of co-ordinated movement up to the moment of impact.

At the time that Flight 831 took off, the evidence indicates that the weather conditions were such that only light icing could be expected. It is considered that the aircraft did not encounter icing of a severity to cause air flow disturbance on the flight surfaces and thereby render the aircraft uncontrollable. The engine anti-icing system was found to have been operating, as would be expected, and therefore, the possibility of engine failure through icing is ruled out.

The position of the horizontal stabilizer appears to be very significant. On aircraft CF-TJN, this

stabilizer had a range of motion from approximately 10 degrees Aircraft Nose Up (ANU) to approximately 2 degrees Aircraft Nose Down (AND). The motion of the horizontal stabilizer is obtained from two screw jacks which are driven by a hydraulic motor. Normal control of the motor and therefore control of the angle of the horizontal stabilizer is exercised by the pilot in two separate ways: One method is by movement of two handles (called suitcase handles) on the central pedestal. These handles control the hydraulic motor directly and through these handles the pilot can obtain the full range of stabilizer travel. The second method is by means of a pair of two-way switches on the control column itself. These switches control an electric motor which in turn controls the movement of the suitcase handles and the full range of stabilizer movement is available. The actual position of the stabilizer at any time cannot be determined from the position of either the suitcase handles or the control column switch. A sliding pointer moving along a scale on the central pedestal provides the indication of the horizontal stabilizer position. It is worth noting that this sliding pointer is so placed that it is not in plain view of the pilot when he is in his normal flying position.

The auto pilot, when engaged, will also control the movement of the horizontal stabilizer through

a secondary electrical system. In the event of a hydraulic failure, or if the pilot so elects, he can control the horizontal stabilizer movement by electrical switches which energize the secondary electrical system.

However, if the secondary electrical system is used, horizontal stabilizer movement is restricted to 1.5 degrees AND. Since the stabilizer jacks were found after the crash in a position representing more than 1.6 degrees AND, it is evident that this position was reached by the use of the hydraulic power system and not through the auto pilot and the electrical system.

According to the evidence, it is not possible for the hydraulic system to malfunction in such a way as to cause the stabilizer to move to a position which had not been pre-selected by the pilot. It is therefore concluded that the pilot intentionally or unintentionally moved the stabilizer into the more than 1.6 degrees AND position by means of the suitcase handles or the trim switches.

There have been cases of unintentional trimming of the stabilizer but these have generally occurred with relatively inexperienced pilots. In the case of aircraft CF-TJN, unintentional trimming is considered highly unlikely.

With the application of more than 1.6 degrees of AND trim, the aircraft would assume a nose down attitude and would build up airspeed at a very rapid rate. If the pilot did not attempt swift recovery action, the speed would build up to a point where actual recovery would become difficult, if not impossible. In the earlier stages of the airspeed buildup, recovery could have been effected by re-trimming the horizontal stabilizer to a neutral or ANU position, or by pulling back on the control column to deflect the elevators. However, as speed increases, the force required to pull back the control also increases until it becomes a physical impossibility to apply sufficient force. Recovery can still be effected by re-trimming the horizontal stabilizer, provided that the trimming mechanism can function. The evidence showed that at high rates of speed with a pull force exerted on the control column, the hydraulic motor which actuates the screw jacks in the horizontal stabilizer is effectively stalled and cannot overcome the aerodynamic forces. Under such circumstances, it appears that the only possibility of recovery is to release the pressure on the control column, thereby relieving the aerodynamic forces on the empennage and unstalling the hydraulic motor which would then be able to move the horizontal stabilizer from its extreme AND

position. Release of the pull on the control column would, of course, momentarily aggravate the situation and permit the aircraft to assume a steeper glide angle and increase its velocity.

If an aircraft has sufficient altitude, recovery can be effected by the procedure outlined above, as has been demonstrated in other documented cases where jet aircraft have upset. However, in the other cases of which we have cognizance, losses in height of upwards of 13,000 feet were required before pull-out from the dive could be effected. While the exact altitude of aircraft CF-TJN at the time of the upset is not known, it is most unlikely that it was above 8,000 feet, and more probably between 5,000 and 7,000 feet.

During the climb to cruising altitude, it would have been normal procedure to have the aircraft trimmed in a nose up attitude, and this attitude should have been maintained far beyond Ste. Rose or Ste. Therese. Therefore, if the trimming was intentional, it must be assumed that some event or events occurred which indicated to the pilot that he must trim the aircraft nose down.

The reasons why the pilot would intentionally apply a large amount of nose down trim have been explored. The only obvious conclusion which was reached was that

the pilot, by instrument indications or physical sensations, felt that a nose down attitude was required.

In an attempt to determine how the pilot could have been misled by physical sensations, the possibility of turbulence has been considered. The weather information which was given in evidence and the testimony from other pilots who flew in the area shortly before and after the accident, precluded the possibility of turbulence existing which in itself would be severe enough to cause the pilot any difficulty.

The possibility of an instrument or instrument system failure which would give the pilot the impression that a nose down attitude was required has been explored. These possibilities are:

1. Failure of an airspeed indicator,
2. Icing or blockage of the static system,
3. Leakage in the static system,
4. Unwitting engagement of auto pilot,
5. Failure or icing of the pitot system,
6. Erroneous Indication of Aircraft Attitude,
7. Unprogrammed extension of pitch trim compensator.

1. Failure of an Airspeed Indicator

Airspeed indicator failures are considered to be rare. In any event, such a failure should be detected before the aircraft would be put into a dangerous attitude.

2. Icing or Blockage of the Static System

It is unlikely that this could occur to an extent that both the Captain and First Officer's instruments would be seriously affected. Indications of this sort of fault should have been apparent to the pilots prior to or immediately after take-off.

3. Leakage in the Static System

The most serious type of leak would be the one which would allow pressurized cabin air to enter the static system. It is highly unlikely that this could occur in both the Captain's and First Officer's systems simultaneously. It is unlikely that a fault of this nature would not be detected by the contradictory instrument indications which would be evident, in time to avoid a serious upset.

4. Unwitting Engagement of Auto Pilot

If the auto pilot was unwittingly engaged during climb and the pilot trimmed the aircraft nose down to achieve a less steep climb angle, the auto pilot would tend to automatically re-trim the stabilizer towards the nose up condition. However, if the pilot trimmed the stabilizer full nose down and disengaged the auto pilot as the stabilizer reached the full aircraft nose down position, this could account for the mis-trimmed condition. It is unreasonable to expect that at this time the aircraft was in such an attitude and speed condition that recovery could not be accomplished.

5. Failure or Icing of the Pitot System

A mechanical failure of this system is unlikely.

A failure of a pitot heater can occur and would likely result in freezing of the pitot head. If the pitot head became blocked with ice a fairly rapid drop in airspeed would be indicated on the airspeed indicator associated with the blocked pitot system. There are two completely separated pitot systems on the aircraft; one which supplies pitot pressure to the Captain's instruments and one which supplies pitot pressure to the First Officer's instruments. If freezing of a pitot head occurred it is reasonable to assume that the pilot would push the nose of the aircraft down in order to maintain airspeed and in doing so could put the aircraft into a diving attitude. If only one pitot head was frozen however, correct airspeed would be indicated on the airspeed indicator associated with the unfrozen pitot system. This should alert the pilots to the fact that a fault had occurred in a pitot system and corrective action should have been taken in time to avoid a serious upset.

If the pitot heat had not been switched on it is possible that both pitot heads could become frozen simultaneously and both the Captain's and First Officer's airspeed indicators would indicate a decreasing airspeed.

In this event the pilot could be misled by airspeed indications to the extent that a dive could result from which recovery could not be made in the altitude available.

6. Erroneous Indication of Aircraft Attitude

If an attitude instrument, for example, artificial horizon, fails without warning during a time when a pilot is concentrating intently on flying the aircraft, such as he would be doing during initial climb-out and manoeuvering, it is likely that the pilot would follow the instrument until he becomes aware of the false information by reference to other instruments. By this time, the aircraft may be at or approaching extreme attitudes.

If an artificial horizon indicator fails through lack of electrical power or fails to truly follow the vertical gyro associated with it, a warning flag should appear and the pilot should be alerted to the failure.

If its associated vertical gyro fails and the artificial horizon follows the failed gyro, a warning flag will not appear. Evidence was given which indicated that the roll resolvers in the auto pilot system showed a position which was consistent with the calculated bank angle of the aircraft on impact.

Although the roll resolver reading was consistent with a correctly operating vertical gyro, it does not prove that the Captain's vertical gyro was in fact operating properly.

There is also the possibility, although it is remote, that the Captain's artificial horizon instrument itself failed and the warning flag did not appear.

7. Unprogrammed Extension of Pitch Trim Compensator

The Pitch Trim Compensator is described on page 13 of chapter 21 in vol. 55 of the DC-8 Operating Manual of TCA in force on 29th November 1963 (produced as Exhibit 82) as follows:-

"Pitch Trim Compensator

General Description:

1. The pitch trim compensator system applies up elevator force to the First Officer's control column to prevent "tuck under" when operating in the speed range between Mach.700 and .950.

2. At the high subsonic Mach numbers, the airflow pattern over the wing results in the formation of local shock waves which cause the centre of lift on the wing to be shifted rearward. The effect is to cause

the airplane to nose down or "tuck" as speed increases. An up elevator movement is required to counteract the tuck, requiring greater force as airspeed increases. The pitch trim compensator provides this up elevator movement automatically by sensing Mach number and reacting accordingly.

3. The system consists basically of a Mach computer and a jack-screw-type actuator, powered by a 28 volt DC motor. The First Officer's pitot system supplies pitot pressure to the computer. Static pressure is obtained from the auto pilot static line. The force applied to the control column is a function of the Mach number which is computed from the pitot static pressures. The computer controls the actuator motor. The actuator is mechanically linked to the bottom of the First Officer's control column. A mechanical indicator on the left side of the First Officer's control column indicates the relative amount of force being applied to the control column by the pitch trim compensator.

4. There is little or no force applied to the control column at computed Mach numbers below .800. Minimum force starts to be applied at

Mach .800 and the force increases as Mach increases. The equivalent control column "nose up" force is approximately three pounds at Mach .825 increasing to 34 lbs. at Mach .880".

The pitch trim compensator has been known to extend fully, due to a fault in the system. If this occurs, it usually is detected immediately by the rearward pressure on the control column and by the clicking sound which accompanies the extension. If the pilot did not become aware of the unprogrammed extension, he would tend to apply nose down trim to counteract the effect. If the pitch trim compensator subsequently retracted or was retracted by pilot action with counteracting nose down trim applied, there would be a tendency for the aircraft to pitch nose down. This should immediately be apparent to the pilot and no difficulty should be encountered in effecting recovery at the speeds estimated for this flight during climb.

If the pitch trim compensator extended fully and remained extended with the horizontal stabilizer trimmed to counteract the effect of "up" elevator the aircraft's manoeuvering stability would be adversely affected.

Tests were conducted by the Douglas Aircraft Company and the FAA using a fully instrumented DC-8.

The results of these tests were submitted in evidence. The purpose of the tests was to determine the stability characteristics of the DC-8 with a fully extended pitch trim compensator and with the stabilizer trimmed to .5° AND.

These tests indicated that, in this configuration the stability of the aircraft was such that a pilot could experience difficulty in maintaining proper aircraft attitudes particularly in turbulence. This problem would be accentuated when flying in cloud without visual reference to the ground or the horizon.

Although fully instrumented flight tests have not been conducted using more than .5°AND stabilizer trim with the pitch trim compensator fully extended we are satisfied that larger amounts of AND stabilizer trim would have a more adverse effect on aircraft stability.

This has been confirmed by the report of Richard S. Sliff produced as exhibit 13-L in docket SA-379 of C.A.B. at Los Angeles on April 22, 1965, which docket and exhibits were produced as exhibit 79 at this inquiry.

Mr. Sliff is Assistant Division Chief for the Engineering and Manufacturing Division of the F.A.A., has been a rated pilot for 30 years, has had 1500 hours

of experience testing jet aircraft in the United States, and was supervising project test pilot for F.A.A. for the Boeing 707,720 and 727.

The following is quoted from Mr. Sliff's report:-

"Because of the problems with airplane N6571C another airplane was substituted to not only check the validity of the findings on airplane N6561C but to also continue with the testing. The problem with this second airplane was that it was a modified DC-8 called the 4% leading edge model powered by P & W JT3D engines. This airplane to be equivalent to the standard wing airplane would have to be loaded to a center of gravity 2% further aft. For maximum rear C.G. this would require that the airplane be at 34% MAC.

In the interim while awaiting loading, a flight was made on this airplane at a nominal C.G. of 26% MAC. The purpose of this flight was to check PTC malfunctions against those experienced in the other airplanes. The result was that there was not an appreciable difference, however, a very interesting side benefit came out of this flight. This area was during manoeuvering with a fully extended PTC at a velocity of approximately 220 knots and the airplane trimmed

to its previous extreme of full nose down (2.0° AND). It was observed that any attempt at manoeuvering the airplane with the elevator system resulted in sharp reversals in the airplane's manoeuvering stability. This would be another strong reason for limiting the airplane nose down stabilizer travel. These findings were conveyed to the Western Region for their further testing with the Douglas Company. They responded at a later date that they had confirmed my findings and felt that with the restricted stabilizer, it was not a serious control problem."

It should be noted here that aircraft CF-TJN had a trim capability of 2.0° AND. However, the Douglas Aircraft Company issued Service Bulletin No. 27-161 on 9th September, 1964, which calls for a relocation of the stabilizer trim stop. The relocation of this stop reduces the amount of aircraft nose down trim available from 2 degrees to approximately .5 degrees. The reason for this modification was to minimize the possibility of mis-trimming. (See Exhibit No. 76, and evidence of Mr. Bates on 9 June 1965.)

CONCLUSIONS

1. It is concluded that the investigation of the crash as organized and directed by the Department of Transport was complete and thorough in every respect and that every detail which could have been relevant or pertinent to the cause of the accident was carefully explored by experts in their particular field.

2. It is concluded that the actual cause of the accident cannot be determined with certainty.

3. It is concluded that many of the possible causes can be considered unlikely beyond any reasonable doubt. It is concluded that there was no engine failure, in-flight structural failure or severe icing sufficient to cause air flow disturbance on the flight surfaces and thereby render the aircraft uncontrollable. Additionally, it is concluded that aircrew incapacitation total or partial due to toxic environment, sudden illness or malice did not occur. It is therefore concluded that the above factors may be effectively ruled out as having occasioned the crash. It is also concluded that although turbulence existed along the flight path and was probably contributory to the cause of the accident, the extent of the turbulence was by itself not sufficient to have rendered the aircraft uncontrollable and turbulence is therefore ruled out as the primary cause of the accident.

4. It is concluded that the most probable chain of events which occasioned the crash can be identified as follows. For one of the reasons which are set forth below, the pilot applied the near maximum available Aircraft Nose Down Trim to the horizontal stabilizer. The aircraft then commenced a diving descent building up speed at such a rate that any attempted recovery was ineffective because the stabilizer hydraulic motor had stalled, thus making it impossible within the altitude available to trim the aircraft out of the extreme AND position.

(a) The first reason which might have indicated to the pilot the necessity for applying nose down trim could have been icing of the Pitot system as discussed in the Analysis of Evidence. While the experience and competency of the crew would likely have led them to recognize the fault in time to take corrective action, the possibility that this condition caused the application of AND trim cannot be dismissed.

(b) The second reason could have been a failure of a vertical gyro. The evidence indicated that it was possible to have a failure of a vertical gyro without an associated warning flag. If such a failure occurred

and the aircraft was being flown with reference to the associated artificial horizon instrument it is likely that the pilot would be misled by the erroneous indication and could have applied nosedown trim. Aircraft CF-TJN was equipped with a standby artificial horizon located on the Captain's instrument panel and this cross reference together with the experience and competency of the crew would likely have led them to recognize the fault in time to take corrective action. Again, the possibility that this condition caused the application of AND trim cannot be dismissed.

(c) The third reason could have been an unprogrammed and unnoticed extension of the Pitch Trim Compensator. This would have had the effect of moving the control column back, the elevators up and the aircraft to a nose up condition. The pilot would likely have counteracted the pitch up force of the elevators by trimming the horizontal stabilizer to or near to the limit of the Aircraft Nose Down setting. The evidence shows that the simultaneous application of up elevator from the PTC and the application of as little as 0.5 degrees of Aircraft Nose Down trim on the horizontal stabilizer has an adverse effect on aircraft stability and can create a difficult control problem. The problems of instability and control are more serious as further

AND trim is applied. In aircraft CF-TJN 2.0 degrees of AND trim was available and it appears that the pilot applied at least 1.6 degrees of the available trim. It is unlikely that the flight crew were aware of the serious stability and control problems that we now know can result from the combination of extended PTC and AND trim, even if they had been aware that the PTC had extended. The aircraft would then be in a condition where a slight displacement from its trim point would lead to divergent oscillations. In other words, a minor change of attitude, easily caused by the existing turbulence, would build up into large displacements. The inadequate control available to the pilot and the lack of an external horizon reference would likely result in the aircraft eventually assuming a dive attitude.

It is concluded that an unprogrammed extension of the Pitch Trim Compensator is the most probable cause for the pilot having applied Aircraft Nose Down Trim, which initiated the chain of events that culminated in the crash.

5. It is concluded that the crash was not occasioned by any breach or breaches of the Aeronautics Act or the Air Regulations or any order or direction made pursuant thereto.

RECOMMENDATIONS

We make the following recommendations:

1. To provide a positive aircraft flight history, a flight data recorder should be installed as soon as possible at least in all transport category turbine-powered aircraft engaged in Commercial operations in Canada.

2. DC-8 pilots should be made fully aware of the stability characteristics of the DC-8 with the full extension of the pitch trim compensator and with the stabilizer trimmed to counteract this effect.

3. An improved vertical gyro warning system should be installed in DC-8s which would give the pilot immediate warning of any type of failure which would affect aircraft attitude indications.

4. The pitot heat circuit in the DC-8 should be modified so that a positive warning is provided to the pilot if the pitot heat is either not switched on or has failed.

5. An improved means of indicating horizontal stabilizer position to the pilots of DC-8s should be provided.

6. We have noted from the evidence that it was not normal practice to use a check list after take-off. We question the advisability of checking without

the aid of a check list and recommend that the Department of Transport study and report on the advisability of making the use of check lists mandatory.

7. It appears from Exhibit No. 54 that Federal Aviation Agency (FAA) Airworthiness Directive 63-8-2, required that the elevator control tab push rod assembly be removed and visually inspected within 300 hours service time after 18th April, 1963. Notwithstanding this directive, this inspection on aircraft CF-TJN was not made until 708 hours service time after 18th April, 1963. Moreover, the assembly was not removed, but merely inspected in place.

It also appears that FAA Airworthiness Directive 61-24-1 requires that if any JT-3D3 engine was disassembled since last overhaul to the extent of exposing any bearing compartment, the main oil screen be inspected at periods of not more than 12 hours service time until the screen was free of contamination for two successive inspections. TCA inspected the main oil screens after ground running the engines and found them free of contamination but did not inspect them after time in service.

While the evidence does not indicate that either of these servicing shortcomings had any influence

upon the crash, it is recommended that, in the future, airworthiness directives be followed and that appropriate procedures be instituted to ensure that this be done.

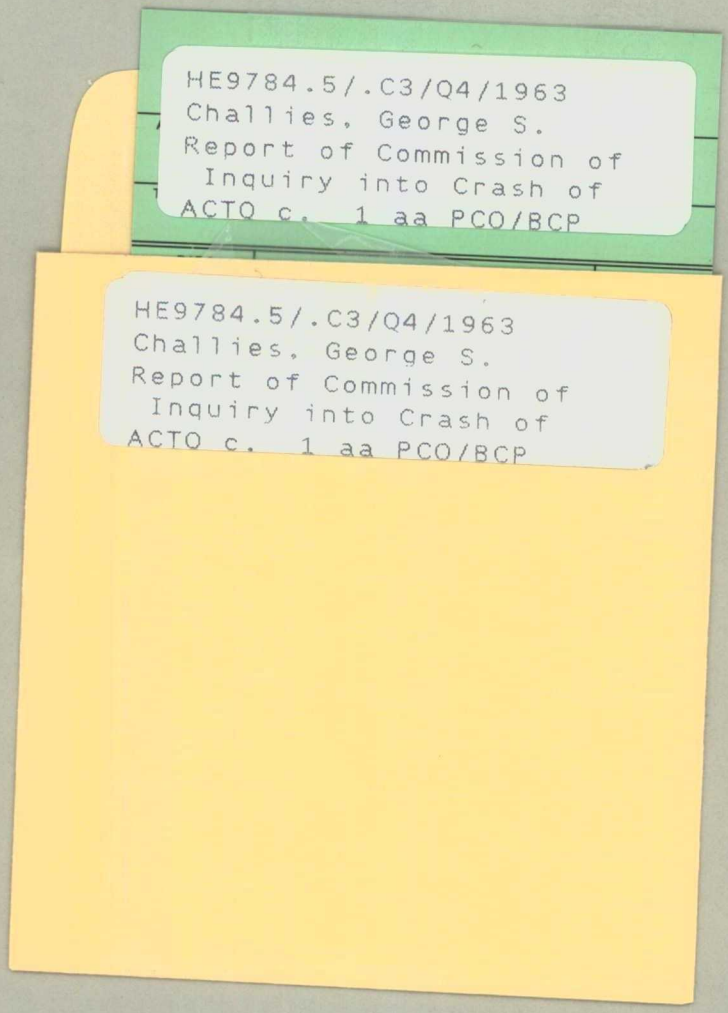
It should be noted that the above recommendations are based upon the evidence as submitted to the inquiry.

In conclusion I should like to express sincere appreciation to Captain W.S. Roxborough and Air Commodore R.H. Bray, RCAF (retired) my two Technical Advisers for their invaluable assistance and co-operation during the inquiry and in the preparation of this report.

Serge S. Claudius

COMMISSIONER.

Montreal, P.Q.,
June, 1965.


HE9784.5/.C3/Q4/1963
Challies, George S.
Report of Commission of
Inquiry into Crash of
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