No. 17

Panarctic Explorations, Lockheed L-188, CF-PAB, accident at Rea Point, Melville Island, Canada, on 30 October 1974. Report not dated, released by the Ministry of Transport, Canada.

ICAO Note: This report does not comply with Annex 13 Summary of Report format and therefore could not be abbreviated as other reports in this Digest. It has been included because of the unique circumstances of the accident and the findings of the investigation.

HISTORY OF THE FLIGHT

Lockheed L-188C Aircraft CF-PAB referred to as flight 416 departed Calgary International Airport at 1805 hours 29 October 1974. The aircraft was on a routine positioning flight to Edmonton with a pilot-in-command, co-pilot and flight engineer on board. The 30-minute flight was uneventful with no unserviceabilities reported by the crew. The aircraft was prepared for the continuing flight north with the loading of 20 000 lb of baggage and freight and 21 000 lb of jet B fuel. The aircraft pilot-in-command and flight engineer were replaced by those scheduled for the Edmonton to Rea Point leg.

The pilot-in-command received a weather briefing; an IFR flight plan was filed to Rea Point, via direct Fort Smith, direct Contwoyto Lake, direct Byron Bay, direct Rea Point at an initial cruising altitude of 18 000 ft with Pedder Point as the alternate. The estimated time en-route was 4 hours 12 minutes.

After loading 30 passengers and a fourth crew man, the loadmaster/flight attendant, the aircraft departed the Edmonton International Airport at 2004 hours. The flight proceeded uneventfully, cruising at 18 000 ft to Fort Smith where it was cleared to flight level 210. The aircraft reported over Byron Bay at 2304 hours with an estimated time of arrival at Rea Point of 0016. About 100 miles north of Byron Bay the aircraft was cleared to flight level 250.

Radio contact was established with Rea Point about 150 miles out and a descent was started for a straight-in VOR/DME approach to Runway 33. The descent was smooth except for some turbulence at 4 000 ft. The aircraft levelled at 17 miles DME from Rea Point at 2 000 ft for a period of 1 minute 45 seconds. The aircraft then slowly descended to about 875 ft ASL at 6 miles DME. A call was made to Rea Point advising them of the DME range on final. There was light turbulence. Fifteen hundred horsepower was selected on the engines; both the VHF navigation radios were selected to 111.2 MHz, the Rea Point VOR frequency; and both ADF's were selected to 396 KHz, the Rea Point OX nondirectional beacon frequency. Both cockpit barometric altimeters were set to 29.91 in of mercury, the latest Rea Point setting. The airspeed was indicating 150 kt which, with a 30 kt headwind component, resulted in a ground speed of 120 kt. The pre-landing check had been completed, 100 per cent flap selected and the landing gear was down. The landing lights were extended but were off; the wing leading edge lights as well as the alternate taxi lights were on. Glare had been experienced from external lights early in the descent from 10 000 ft, but not thereafter. There was no pre-landing briefing conducted by the pilot-in-command.

The flight engineer was able to see what appeared to be open water below with ice floes. The co-pilot set his radio altimeter warning to 450 ft and the pilot-in-command set his to 300 ft. When the warning light came on on the co-pilot's radio altimeter, he advised the pilot-in-command. As the descent continued through the minimum descent altitude of 450 ft, the co-pilot reset his radio altimeter to 300 ft and so advised the pilot-in-command. The aircraft was still in a shallow descent. At 300 ft radio altitude the co-pilot checked the DME reading as 3 miles, saw a dark area of open water and an ice line and reported to the pilot-in-command that they seemed to be approaching an ice ridge and that they had visual contact. The pilot-in-command reset his radio altimeter to about 150 ft. Also, close to this time the pilot-in-command said he believed they were on top of a layer of cloud, repeated the statement, following which he retarded the throttles and pushed forward on the control column with sufficient force to produce perceptable negative G.

Because of the small time frame, the sequence of events during the final descent could not be established with certainty. However, the rate of descent increased rapidly to between 1 700 and 2 000 ft a minute. The co-pilot recalled that he shouted at the pilot-in-command reporting their descent through 200 ft at 2 miles DME but there was no response. The flight engineer's recollection was that the co-pilot called through 100 ft and they both called through 50 ft without an observed reaction from the pilot-in-command. The co-pilot reached for the right side power levers and found the flight engineer's hands already on them. The co-pilot was observed to have his hands on the control wheel just prior to the impact.

On impact, the cockpit area broke away from the remainder of the fuselage and with the cargo continued along the ice surface for 900 ft. After the cockpit came to rest, the flight engineer, who did not remember the impact, undid his seat belt and saw both the pilot-in-command and co-pilot in their seats. The co-pilot although injured was able to undo his seat belt and the flight engineer pulled him on to the ice before the cockpit section sank completely. The flight engineer found a parka for the co-pilot and kept him awake until assistance arrived.

EVENTS ON THE GROUND AT REA POINT

At about 2330 hours the flight was in communication with Rea Point on 122.8 MHz concerning load and routing and confirming the arrival estimate of 0016 hours. The flight was provided traffic information and the 2400 hour weather observation which was: ceiling thin obscured, visibility 1 mile in blowing snow, temperature -11^{o}F, wind 312^{o} at 30 gusting to 38 mph, and the altimeter at 29.91 in of mercury. At 0015 hours the flight advised that it was 6 miles out on final approach and the radio operator gave the current wind and visibility. (It was later determined that the anemometer was in error and the actual wind speeds were 25 per cent lower than indicated.) One or two minutes later the radio operator's attention was attracted by sudden increases in wind velocity to over 50 mph. He observed the visibility to be less than one-eighth of a mile and occasionally less than 50 yards. This sudden reduction in visibility was transmitted but there was no response. Further contact with the aircraft was attempted on various frequencies but without success.

The senior company official at the site was advised by the radio operator that the aircraft was 11 minutes overdue and after consultation with the site foreman a decision was made to search for the aircraft. A Twin Otter pilot was alerted and briefed on the circumstances; he took off from Runway 33 at 0135 hours for a search of the approach area. The pilot reported that the visibility was about 1 mile in blowing snow during the take-off roll but was unlimited above the blowing snow. At 800 ft altitude during a left turn toward the approach area, he saw two small fires south of the airport. During a low pass with landing lights on, he saw a person standing in an area strewn with wreckage. After a brief aerial examination of the accident site 2 1/2 miles south on the extended centre line of Runway 33, he returned to the airstrip. A ground party departed the camp at about 0150 hours and guided by the Twin Otter circling over the accident site, arrived there in about 30 minutes. Three survivors, the co-pilot, flight engineer and a passenger were located and taken to the camp by about 0250 hours.

FINDINGS

The approach was continued below the company approved minimum descent altitude.

The pilot-in-command reacted inappropriately to a visual cue and suddenly initiated the final rapid descent.

Partial incapacitation of the pilot-in-command was a factor in the failure to recover from the high rate of descent.

Crew co-ordination in the cockpit in the final stages of the flight was inadequate.

No company Flight Operations Manual or similar document was available to adequately prescribe the aircraft crew's duties and responsibilities.

This operation was in the private category and was not operated or required to operate to the established commercial standards.

The established aerodrome emergency response procedures were inadequate.

CREW INFORMATION

Pilot-in-command

Flying history

The pilot-in-command, age 30, held a valid Airline Transport Pilot Licence endorsed for single and multi-engine land and sea up to a gross weight of 12 500 lb as well as Lockheed Electra aircraft. His class I instrument rating was valid to January 1975. He had accumulated a total of 8143 hours of which 3600 hours were flown on Twin Otters and 1792 on the Lockheed Electra including 907 hours as pilot-in-command.

The pilot-in-command obtained a commercial pilot's licence in 1964 and for the next 10 years progressed through various flying positions to that of pilot-in-command on a large 4-engine turbine aircraft. His first instrument rating, a Class II, was obtained in 1968. In January 1970 he began his employment with the Company as a pilot-in-command on Twin Otter aircraft. During 1971 he took his initial ground school and simulator training on Lockheed Electra aircraft at a commercial school. This was part of the upgrading process from a Twin Otter pilot-in-command to an Electra co-pilot. The training was completed in December 1971. Training reports indicate he experienced problems with IFR approaches and in adapting to the flight director system. After flying as co-pilot for about 7 months, he was given an instrument flight rating recheck by an MOT inspector who reported problems with cockpit management as well as the use of the ADF (Automatic Direction Finder). His next instrument check about 6 months later revealed only a problem in altitude control. In June of 1973, he took simulator and flight training for upgrading from co-pilot to pilot-in-command. During an MOT instrument flight rating check in the same month, his procedures were considered to be "somewhat unorthodox". In July 1973 he was upgraded to pilot-in-command on Lockheed Electra aircraft. In December 1973, he successfully passed a MOT instrument flight rating recheck, the report of which contained a comment of "some confusion" relating to the assigned runway for approach. Approximately 6 months later, an instrument flight rating recheck by an MOT approved Company check pilot reported that the pilot-in-command should give more attention to the detail of clearances and approach charts, but the test was successfully completed. His last proficiency check of any kind prior to the accident was on 24 August 1974, in a Lockheed Electra simulator. Comments included by the company check pilot were: preparation for ILS poor, not holding altitude to glide path intercept; slow initiating descent on ADF approach; speed high on missed approach. The pilot-in-command had not flown in the eleven days before the accident flight. During this period he worked as duty-pilot on normal working days.

Physiological aspects

Pathological evidence indicates possible extension of the left leg at impact. There was a fracture of the left hand of the type commonly associated with the hand being positioned on a control wheel at impact. There was a 50 per cent compression fracture of the L1 vertebrae indicating vertical acceleration in the area of 25 g with an onset rate of at least 300 g per second, and a duration of about 0.1 seconds.

The liver was found to be considerably enlarged with a very severe degree of fatty change. This condition is associated with metabolic disturbances such as a lowered amount of potassium in the blood as well as other blood chemistry changes including lowered blood sugar, changes in heart rhythm that could result in incapacitation and/or sudden death. The degree of fatty change noted in the liver, in an otherwise healthy individual, was considered by consulting pathologists to be almost certainly associated with the excessive intake of alcohol. Patients with fatty liver diseases but without clinical evidence of heart disease can exhibit an abnormal heart rhythm in response to stress and consequent incapacitation to any degree, including death. No evidence of recent alcohol or drug ingestion was found in the tissues. In addition, on 19 June 1974 a cardiological assessment was requested due to flattening of the T waves in the pilot-in-command's electrocardiogram. The cardiovascular report was negative although in retrospect it can be seen the T wave flattening may have been due to a lowered serum potassium.

A heterophoria (eye convergence or divergence) of between 6 to 8 diopters was noted on the pilot-in-command's medical records. While this condition would not normally be a problem it can result in an increase in the time of transition from instrument to visual reference under conditions of fatigue.

Psychological aspects

This pilot had spent most of his flying career on light aircraft up to and including Twin Otters. During all of this time he would have been the only pilot on board with no requirement for co-ordinated crew procedures. While he had held an instrument rating during the four years up to and including 1971, flight deck procedures during the approach phase would be markedly different from those employed in a high performance well-equipped, large, two-pilot aircraft. His total experience on two-pilot aircraft was in the Lockheed Electra starting in about January 1972 for 12 months as a co-pilot and the following 14 months to the time of the accident as a pilot-in-command. Many of the problems associated with proficiency checks on this pilot relate to flight deck management and instrument procedures.

The pilot-in-command had been initially well motivated towards flying but had been increasingly dissatisfied and frustrated during the year prior to the accident with this type of flying which he considered to be hazardous. The manifestation of his dissatisfaction included a desire to change jobs or to leave flying completely. There is evidence of chronic fatigue in the few months prior to the accident which may have been partially caused by his liver condition and amplified by the frustration and anxiety which was developing.

Co-pilot

Flying history

The co-pilot, age 32, held a valid Airline Transport Pilot licence endorsed for single and multi-engine aircraft up to a gross weight of 12 500 lb as well as helicopter and Lockheed Electra. His Class I instrument rating was valid to 1 March 1975. He had accumulated about 5100 hours of flying of which 1583 hours were on Twin Otters and 160 hours on the Lockheed Electra. Of the 1583 hours on the Twin Otter, 665 hours were experienced on Arctic operations out of Rea Point.

He commenced flying in 1966 and in 1970 obtained a Class II instrument flight rating. About 1 year later he had an instrument flight rating recheck by an MOT inspector which renewed the Class II rating with problems showing up in instrument procedures but one month later he was upgraded to a Class I. He continued to successfully pass instrument proficiency flying rechecks to a Class I standard with no outstanding problems. In July and August 1974 he successfully completed classroom, simulator training and a flying proficiency check on the Lockheed Electra aircraft and began flying in the capacity of a co-pilot. He had not flown during the six days preceding the accident and had not previously flown with this pilot-in-command.

Flight Engineer

The flight engineer, age 26, obtained a Private Pilot Licence in 1969. After serving an apprenticeship he received his Aircraft Maintenance Engineers Licence in 1972. In June 1973 he successfully completed flight engineer Lockheed Electra ground training and a service training course on Allison Turbine Engines in August of the same year. During the same month he successfully completed Lockheed Electra simulator and flight training and obtained a Flight Engineer's Licence.

Loadmaster/Flight attendent

The loadmaster, age 22, had been flying in this capacity with the company for about 1 year. During flight time he was to fill the role of a flight attendant combined with his pre- and post-flight loadmaster duties.

AIRCRAFT

The aircraft was a Lockheed Electra model L-188C, powered by four Allison 501-D13 engines driving constant speed Aeroproducts A6441 FN 606 hydromechanical propellers. The Federal Aviation Agency Type Certificate Data Sheet was issued 22 August 1958. The aircraft came to Canada in 1969 under an FAA Certificate of Airworthiness for Export issued 29 December 1969 when the airframe had accumulated 19133.4 hours. The Ministry of Transport issued a Certificate of Airworthiness for CF-PAB on 30 December 1969 and on 2 January 1972 reregistered for the company involved.

The form used to calculate the weight and balance position of each flight had been in use for only a few weeks prior to the accident. This form included aircraft compartments that were not in the basic weight and balance document.

The weight and balance form made up prior to the flight to show the load and C of G position at a maximum take-off weight of 114 580 lb was calculated on the basis of 20 009 lb of cargo and 5 270 lb for 31 male passengers. There were in fact 30 male passengers with a corresponding passenger load of 5 100 lb. The burn off or en-route fuel was calculated to be 18 930 lb to provide a maximum landing weight at Rea Point of 95 650 lb. The total fuel for take-off was indicated to be 26 530 lb and the C of G was shown as 26.7 per cent MAC. The flight engineer's fuel log from the aircraft showed the fuel at take-off to be 27 860 lb or 1 330 lb more than indicated on the weight and balance form which would have resulted in an overweight landing. Other discrepancies existed on the weight and balance sheet and despatch documentation; however none would have had a direct bearing on the accident circumstances.

Two significant points in the cockpit instrument presentation were noted. The altimeter, while of an approved type, was of the three-pointer type known to induce perception errors. The only DME read-out was on the pilot-in-command's panel even though it was used as a primary approach aid. The co-pilot would be hindered in his cross checking of this and other instruments with the DME read-out in this position.

OPERATIONAL CONTROL

When the Company proposed its L-188 operation it was ruled by the Canadian Transport Commission as non-commercial. The effect of this decision was to render the issuance of an Operating Certificate by MOT inapplicable, and consequently the Company became responsible for selecting and applying its own safety standards to some of its aviation operations. Although the MOT standards applicable to Companies holding Operating Certificates were available for guidance, the Company was under no obligation to apply them. Similarly, the application of some standard of safety to its air routes, navigation and communications facilities, aerodromes etc., is a Company responsibility.

The Company in response to these safety responsibilities created an Air Transportation Department embracing flight operations, aircraft maintenance and airlift co-ordination. The remaining aviation functions were not given department or section status in the Company's organization structure.

Thus this flight was conducted in accordance with a mixed set of standards: MOT standards for crew qualifications, aircraft certification, flight procedures (i.e. all those aspects covered by Air Regulations and Air Navigation Orders applicable to private operations), Company applied standards for flight despatch, flight following, crew procedures, passenger safety, facilities, aerodromes, air routes, etc. The items in the former group are subject to MOT routine surveillance for compliance but those in the latter group would not be, under the particular circumstances of this operation.

METEOROLOGICAL INFORMATION

Synoptic situation

The meteorological conditions over the Arctic Islands north of 70° latitude from 1700 hours on 29 October to 0500 hours on 30 October were influenced by a 978 millibar low that existed in Baffin Bay at 1700 hours on the 29 October and a ridge of high pressure extending from Gladman Point to Northern Banks Island with a surface low that moved to the vicinity of Thule by 2300 hours and began to fill. A new low pressure centre developed northeast of Alert by 0500 on 30 October. The ridge of high pressure remained stationary through the period. A broad cyclonic flow of continental arctic air prevailed over the arctic islands with the maximum northwesterly surface gradient occurring in a northwest/southeast band over eastern Melville Island.

There was a trough embedded in the northwesterly flow which moved southeastward at an estimated speed of 30 kt; passed Rea Point at 2000 hours on 29 October and Resolute Bay 3 hours later. Weather reports at Resolute and Rea Point indicate that overcast layer cloud prevailed ahead of the trough and decreased to scattered cloud one hour after the passage of the trough. The Resolute Bay radiosonde at 1700 hours on 29 October showed a saturated layer between 2 000 and 9 000 ft ASL. This indicates that sufficient moisture existed to create overcast merged layers ahead of the trough. However, the surface weather reports at Resolute Bay near 1700 hours indicated only scattered to thin broken layers. Rea Point reported overcast clouds ahead of the trough with an estimated base of 1 000 ft above ground level. One hour after the passage of the trough (at 2100 hours on 29 October) Rea Point reported 1/10 of altocumulus.

Maximum surface winds and the lowest visibility occurred ahead of the trough. Winds abated slightly and the visibility improved to 1 mile, behind the trough. However, the wind reached a second peak with gusts to 28 mph at 2400 hours on 29 October.

Forecast

The terminal forecast for Rea Point issued by the Arctic Weather Central forecast office in Edmonton at 1530 on 29 October valid for 12 hours from 1600 to 0400 hours on 30 October was included with the general weather information provided to the pilot-in-command prior to his departure from Edmonton. This forecast indicated: scattered clouds at 1 500 ft with a broken ceiling at 8 000 ft, conditions variable to partially obscured and a broken ceiling at 1 200 ft; a visibility of 3 miles obstructed in ice crystals and ice fog variable to 3/4 mile in light snow and ice fog; the surface wind 300° True at 25 mph with gusts. The surface weather observation at Rea Point taken at 2400 hours on the 29 October, about 16 minutes prior to the accident, was: a partially obscured condition of blowing snow with an opacity of 2/10; the visibility 1 mile in blowing snow and occasionally higher; the surface wind 312° True at 22 gusting to 28 mph.

Alternate

Pedder Point had been filed as the alternate although contrary to the requirement for filing alternate airports no terminal forecast was available. The only weather available for Pedder Point would have been the last hourly sequence which at 1800 hours was: sky clear, visibility 10 miles in ice crystals. Hourly weather observations continued to be taken with the 2400 and the 0100 observations missing. The 2300 hours observation was: "sky partly obscured in blowing snow with an opacity of 2/10 with scattered altostratus clouds at 10 000 ft; visibility 3 miles in blowing snow; wind 320° True at 17 mph".

Observations

The weather observed by the surviving crew members included moderate turbulence at 4 000 ft and turbulence again at 300 ft; some surface detail was visible vertically up to and during the early stage of the approach and just prior to the sudden descent; no lights on the ground were observed at any time. When the Twin Otter took off from Rea Point at 0135 to search for the aircraft the pilot observed the weather to be: visibility of about 1 mile in blowing snow up to about 100 ft above ground and unlimited conditions above. Very low fog of perhaps 10 ft in height appeared to be streaming out over the open water caused by the wind blowing off the ice.

Facilities

The observing stations at Rea Point and Pedder Point as well as other arctic sites that are primarily used by private oil drilling operations are manned by radio operators employed by the drilling company involved but under contract to the Department of the Environment on a no cost mutual benefit basis. As well as taking weather observations these operators have other duties including communication with aircraft and ground stations. They are not required to take special weather observations. Six days after the accident the weather observing equipment and capability were examined by an inspector of the Department of the Environment. The inspection revealed that the observations were satisfactory with one exception, the wind speed detector was found in error and consequently all measured wind speeds required a correction factor of -25 per cent.

Micro-meteorological considerations

There was a strip of open water of at least several miles width over which the aircraft flew immediately prior to the accident. An atmospheric structure analysis based on physical modelling and numerical computation indicates:

1) the extreme contrast in temperature as the airflow from the land and sea ice moved over the open water creates an internal boundary layer;

2) within the internal layer the flow would have an increased turbulence due to the convection originating from the "hot" open lead;

3) development of sea smoke mixed with ice crystals from blowing snow originating several hundreds of metres from the edge of the shore-fast ice and the open water, thickening with distance to dimensions suggested on the diagram; and

4) the position of the aircraft at the point where an abrupt descent was initiated corresponds closely to a position where optical shifting of surface images (mirage effect, foreshortening) would have been at a maximum.

AIDS TO NAVIGATION

A non-directional beacon, OX (Rea Point) on 396 KHz is located 0.79 nautical miles from the threshold on the extended centre line of Runway 33. A VOR/DME located on the same extended centre line 0.19 nautical miles from the end of the runway. There was no indication of an unserviceability at the time of the accident.

COMMUNICATIONS

The radio operator at Rea Point did not hold a licence as required by the Radio Regulations of the Department of Communications. He was communicating with the flight on 122.8 MHz. There were no indications that any problems existed in the ground or aircraft installations. However, due to the multiplicity of communication duties he could not give full attention to the inbound flight. Apparently, priorities had not been well established.

AERODROME AND GROUND FACILITIES

The airstrip at Rea Point oriented 333° True is located on Melville Island (75° 22'N, 105° 42'W) about 1 mile from the shoreline of Byam Channel. It is a firm level sand surface 200 ft wide and 6 300 ft long. There were 2 standard red obstruction lights on top of the NDB and VOR towers with a "T" pattern approach lighting system. This comprised nine 50 Watt amber lights across the runway direction followed by 4 similar amber lights leading into the runway threshold spaced about 200 ft apart. The threshold was marked with 10 green lights of 50 Watts with white runway lights of 50 Watts spaced at 200 ft intervals. If this lighting system met MOT or ICAO standards it would have extended at least 400 ft further from the threshold.

The fire fighting equipment consisted of four 350 lb dry chemical reel type extinguishers; two positioned on the aircraft ramp, one in the main garage and one in a heated area. There are also numerous small fire extinguishers located throughout the camp. The reel type extinguishers are mounted on elevated platforms to provide for mobility by use of a pickup truck.

The planning for a disastrous aircraft accident was inadequate and there was no off-airport vehicle on stand by for emergency use.

FLIGHT RECORDERS

The aircraft was equipped with a Fairchild A-100 cockpit voice recorder serial #1698 and a Fairchild 5424-221 flight data recorder serial #1301 although carriage of Flight Recorders is not required of a private operator. The rear section of the aircraft containing both recorders sank to the bottom of Byam Channel in about 100 ft of water. The recorders were subsequently recovered without any damage from the accident or the immersion in sea water. However, the cockpit voice recorder was found to be unserviceable due to a failure of an incorrect tape splice and the data recorder was found to have an inoperative heading stylus and reversed Pitot and static pressure connexions. The company had been advised of the reversed connexions subsequent to a previous accident. Time histories of altitudes and airspeeds were derived but with a reduced accuracy that resulted from the reversed connexions. The accuracy of the acceleration data was poor in the final stages of the approach due to vibration from turbulence. The data derived for the last 10 minutes of flight as well as an expanded version of the last 100 seconds is included.

The fluctuations in the derived pressure altitude over the last 40 seconds of the accident flight were studied in order to try and explain their presence and resolve why the final recorded altitude was at least 110 ft above sea level. It was obvious that the fluctuations were too rapid to represent genuine flight variations. However, there is no obvious explanation for the variations and no satisfactory corrections could be found to reduce them to a more realistic value. Since the altitude had to be derived from a combination of the altitude and air speed stylus positions, there is a combination of measurement errors that degrades the accuracy.

WRECKAGE

All major surface wreckage was located and identified. The major portions of the wreckage underwater were located and identified with the use of underwater video and divers. Without exception the fracture characteristics of the identified items were typical of instantaneous overload failure. Some 200 other unidentifiable fragments also showed instantaneous overload characteristics.

The aircraft struck the 8-in thick sea ice on a heading of about 321° True with about a 2° crab angle to port. The wings were level or slightly left wing low with a nose-down attitude in the order of 7°. The break-up sequence is shown on the following page.

The burnt part of the upper rear portion of the fuselage indicates that it was partially immersed in water for some time prior to sinking. The rear main passenger door was in the open position during the time the surface fire was burning. Underwater examination showed that the emergency recessed T-handle used to operate the door manually had been pulled and the door was moved to a nearly fully open position. No satisfactory explanation was found for the position of the door and emergency handle as all passenger seats had been ejected through the front of the passenger compartment at the time of the aircraft break-up. This resulted from the passenger compartments being exposed to decelerations in the order of 16 to 20 g.

The examination of pressure sensitive instruments did not reveal any significant witness marks or indications; however, both altimeters were set at the latest altimeter setting provided by the ground station of 29.91 in of mercury. Significant electrical instrument indications included the single DME indicator on the pilot-in-command's side showing 2.3 nautical miles and the radio altimeter also on the pilot-in-command's side indicating 27 ft with the altitude warning set at 160 ft (it is believed the intended selection was 150 ft). The co-pilot's radio altimeter was indicating 35 ft and the altitude warning was set at 290 ft (intended selection 300 ft).

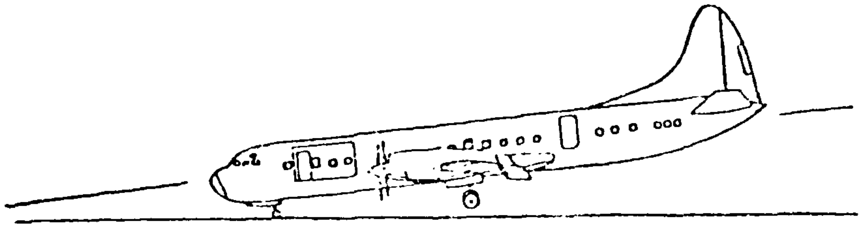
The engine power indications showed turbine inlet temperatures of 742, 755, 748 and 718 degrees centigrade, and horsepowers of 2 835, 2 725, 2 720 and 2 445 for engines 1 to 4 respectively. The oil pressures and fuel flows showed appropriately similar indications. The fuel quantity gauges read 3 210, 3 680, 1 790 and 1 930 pounds at impact.

The warning light bulb indications of the aircraft's major systems of hydraulics, electrical and fuel as well as control boost were examined. With the exception of the landing gear down indicator bulbs which were on at impact, all warning indicator bulbs were found to be off.

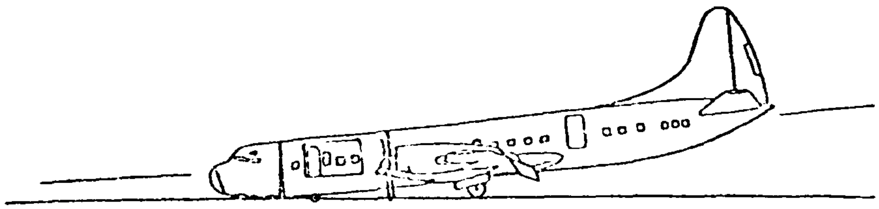
The number 1 engine was found on the ice surface and examination showed it to have been functioning normally at the time of impact. The fuel co-ordinator was found to have been set at 70 degrees at impact and the test of another engine with a similar setting, revealed a turbine inlet temperature of 756 and a horsepower of 2 300. The remaining 3 engines sank to the bottom and although observed on an underwater video camera, were not recovered for more detailed examination. However, all propellers indicated substantial power was being developed at impact. Fuel samples taken from No. 1 engine showed that the fuel met the specific gravity and distillation range requirements for jet B type fuel. Neither the previous history nor the Flight Engineer's operating log recovered from the wreckage showed any major problems associated with engine operation.

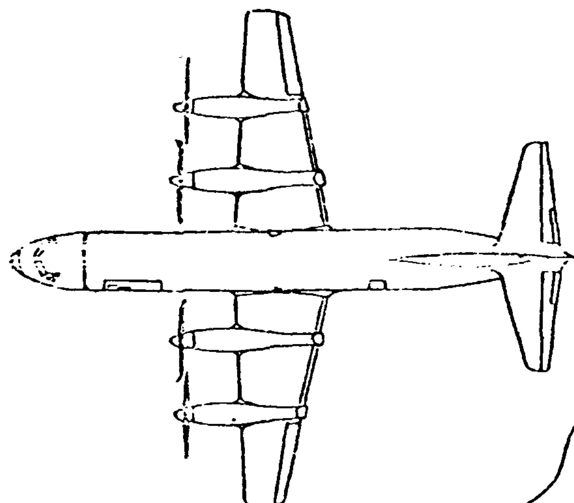
TEST AND RESEARCH

A test flight was conducted on a similar aircraft with similar loading and centre of gravity positions. The purpose was twofold: a) to determine what effect if any, changes in power had on the static system as a result of changing airflows over the static port caused by the number 2 and 3 propellers, b) to determine trim, power and pilot control input to achieve conditions similar to those in the accident.

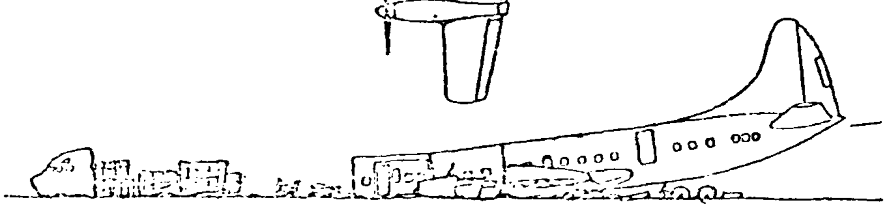


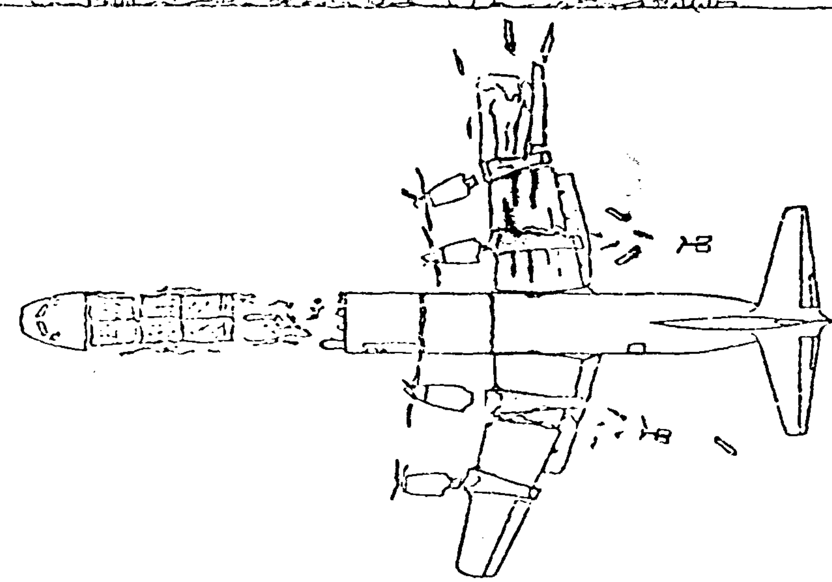
The Electra at impact with nose oleo fully compressed and about to punch through the ice.





The main gear penetrates the ice, the outboard propellers begin to slash the ice and the nose gear truss girders and shock tube tear out with the fuselage rupturing at FS 200.





The nacelles and wing centre box contact the ice, the propellers, gearbox and engines separate from the wings, the fuselage ruptured at FS 570, the right wing exploded outboard of WS 170, the left wing separated intact outboard of WS 170 and the centre wing box disintegrated. The cockpit and bulk cargo slid ahead of the decelerating structure, and the passengers, seats and emergency gear cabinet broke free within the aft fuselage.

Flight profiles similar to those provided by the information from the flight data recorder and witnesses' testimony were flown with the following results: no significant effect of changing thrust on the aircraft could be associated with responses on any pressure instrument during flight. From a normal power setting to maintain level flight a reduction to 200 horsepower on all engines and a control input to achieve about a 7 degree nose-down attitude resulted in a "hands off" stabilized descent without changes of trim with a vertical velocity of about 2 000 ft a minute.

FIRE

There was no indication of any in-flight pre-impact fire. Post-impact fire from burning fuel was evident. The post-crash fire did not spread on a large scale until about 15 minutes after impact.

SURVIVAL ASPECTS

The injury to the pilot-in-command and co-pilot of compression factors of L1 vertebrae indicate the greatest impact of the decelerative force was directed upwards. The high peak G loading appeared to be the result of the use of thick elastic non-energy - absorbing type seat cushions as well as the dynamic failure of the vertical adjustment seat friction clamp mechanisms. The fact that the flight engineer did not have a compression fracture can be explained by the hunched forward posture that would be required to operate the throttle from the flight engineer's seat.

The occupants in the passenger compartment in the rear of the aircraft were exposed to substantial horizontal deceleration forces; however, 50 per cent had potentially survivable injuries. As the passenger restraint systems were not designed to withstand the deceleration forces, the passengers were subjected to secondary impact. In all cases the seat mountings came loose from the floor track. A number of these were broken indicating they had pulled through the floor tracks and a number showed no witness marks, indicating that the floor tracks separated releasing the seats. The seat pans of the canvas type were intact except in cases where burning occurred. Some of the seat belts were of the fabric pull-through lift-latch type where the evidence confirmed previous experience of inadvertent release. Chafing on the fabric showed that the belt pulled through the latch and allowed the passenger to fly free.

The three crew seats were equipped with 5 point harnesses with a single release and the shoulder harnesses with an inertia reel of the rate of extension type. None of the crew had elected to wear shoulder harnesses nor was this a practice with Panarctic crews nor a requirement of the company. As it was established that the pilot-in-command died from drowning, probably while unconscious, utilization of the shoulder harnesses could have contributed to his survival.

Of the four crew and thirty passengers on board, only the co-pilot and flight engineer survived. One passenger survived initially but succumbed to haemorrhagic shock while en route to Edmonton on an air medical evacuation flight. Of the remaining 31 occupants of the aircraft, 16 had potentially survivable injuries. Of these with survivable injuries, it is estimated that five survived for longer than 15 minutes, four survived for ten to 15 minutes and seven survived for less than 10 minutes. Of those who survived for less than ten minutes, six were found on the ocean floor and probably succumbed to drowning.

ANALYSIS

The flight from Edmonton to Rea Point was routine for the type of operation involved until the aircraft had descended to about 875 ft above sea level and 6 miles from the DME. The pilot-in-command made the decision to descend to 300 ft before reaching the minimum descent altitude of 450 ft; the co-pilot accepted the pilot-in-command's action. While the co-pilot reset his radio altimeter warning to the minimum descent altitude of 450 ft, the pilot-in-command set his to 300 ft. Considering the runway elevation of 50 ft the radio altimeter selection of 300 ft would provide for a warning light when the barometric altimeter indicated an altitude of 350 ft above sea level over the runway or 100 ft below the minimum authorized altitude. When they descended through 450 ft, the co-pilot reset his radio altimeter warning to 300 ft and advised the pilot-in-command.

The statements of the pilot-in-command that he believed they were on top of a layer of cloud at 300 ft just prior to the sudden steep descent is significant. This signifies that the pilot-in-command may have been using outside visual reference. Normally, the pilot flying maintains instrument reference until the other pilot indicates he has sight of the runway or approach lights. The pilot-in-command's selection of 150 ft on the radio altimeter would be consistent with an intent to try to descend below cloud.

The co-pilot observed an ice/water line and advised the pilot-in-command he had visual contact. With this observation being made through the forward windshield, the pilot-in-command should have been able to see the same ice/water line. However, the reaction of the pilot-in-command would be based on what he perceived. A rapid descent was initiated very quickly with a large control input causing a marked feeling of negative "G". The interpretation of sensory stimuli is dependent upon many complex variables including both psychological and physiological, factors. Identical stimuli may be perceived by different people in different ways or interpreted differently by the same person at different times. In this case there were a number of factors that could possibly have degraded the pilot-in-command's perceptual state including:

a) fatty liver disease possibly causing low blood sugar and deteriorating performance,

b) a degree of fatigue,

c) the movement of the ice/water line seaward from the position observed by the pilot-in-command on previous flights,

d) stress from flying with a new co-pilot under marginal weather conditions,

e) the stress of continuing to fly in an operation of which he was apprehensive.

In his perceptual state the pilot-in-command interpreted the visual information as requiring an immediate steep descent. Misinterpretations could include: the ice/water line location; pitch-up from the dark/light difference; the ice being a cloud layer; or variations in light intensity and/or image shifting.

After the steep descent was established the pilot-in-command did not respond to the warnings of the co-pilot and flight engineer. He also failed to respond to the instrumentation that showed a hazardous rate of descent at low level three miles from the airstrip. This failure to respond indicates a degree of incapacitation.

While the pilot-in-command's actions may have been influenced by perceptual problems the factors that predisposed him to be affected by these problems are significant. The descent to 300 ft on the radio altimeter put the aircraft 150 ft below the minimum authorized altitude. It was done in an apparently routine manner without discussion with the co-pilot. This disregard of approach criteria was accepted by the co-pilot as it had happened before on at least one previous flight with another pilot-in-command. It can be concluded that this procedure was either acceptable to those in control of the company flying operation or that they did not have an effective system for detecting operational deficiencies.

The omission of a pre-landing briefing of the flight crew denied the pilot-in-command the safety factor inherent in cross monitoring by the crew. Both the co-pilot and flight engineer were restricted in their capacity to monitor the approach due to a lack of information. Standardized procedures were not followed nor were procedures promulgated in a Flight Operations Manual or similar document. The pilot-in-command's past experience flying single pilot aircraft was probably a factor in his actions.

After the abrupt descent was initiated the pilot-in-command failed to respond to shouted warnings and instrument indications. The ice impact at about seven degrees indicates that there was little or no rotation of the aircraft in an attempt to arrest the descent. Despite concern and shouted warnings from the co-pilot and flight engineer the co-pilot did not take over the control of the aircraft. There was no company procedure established whereby the pilot not flying would detect subtle incapacitation and take over control in the case of any incapacitation. However, when the high descent rate in the order of 2 000 ft per minute was established below 300 ft the possibility of a safe recovery was remote.

Undoubtedly the pilot-in-command was incapacitated to some degree. The evidence of his left leg being extended with the slight yaw to the left and being slightly right of the centre line indicates a remaining ability to recognize and react. However, the possibility of a serious debilitating condition brought about by metabolic change cannot be discounted.

From the time of the crash until rescue crews reached the scene about 2 hours had elapsed even though the crash site was 2 1/2 miles from the end of the runway. The delay occurred due to an inadequately defined response procedure. There was no off-airport vehicle on a stand-by basis and indecisive action followed the loss of communication with the aircraft. It is unlikely that a more rapid response in this instance would have affected the outcome.

ICAO Ref.: AIG/372/74

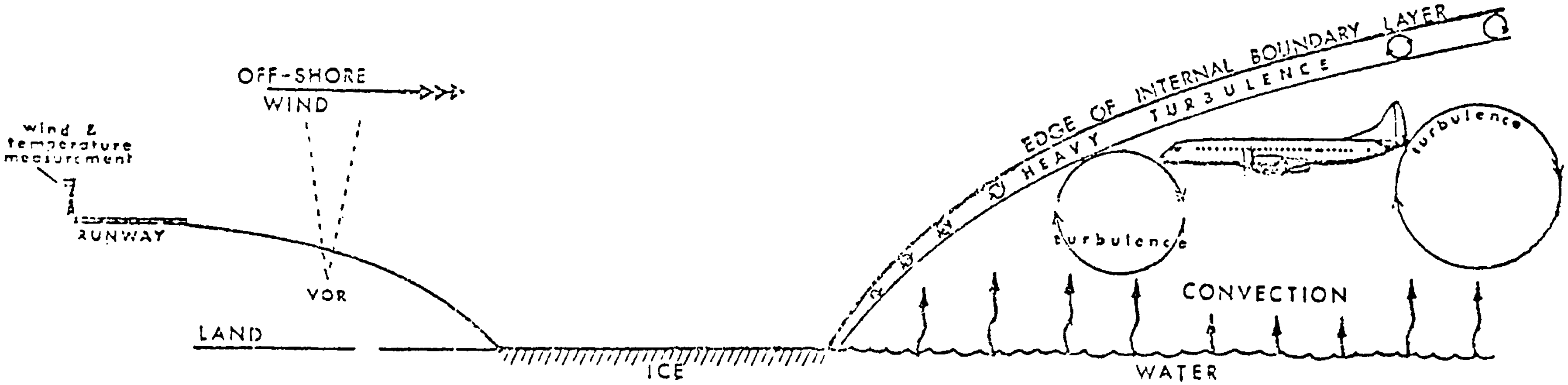


Figure 17-1.- Cross-section of local meteorological situation (or internal boundary layer) associated with cold flow from land over "warm" open lead offshore

(Prepared by Dept. of Environment)

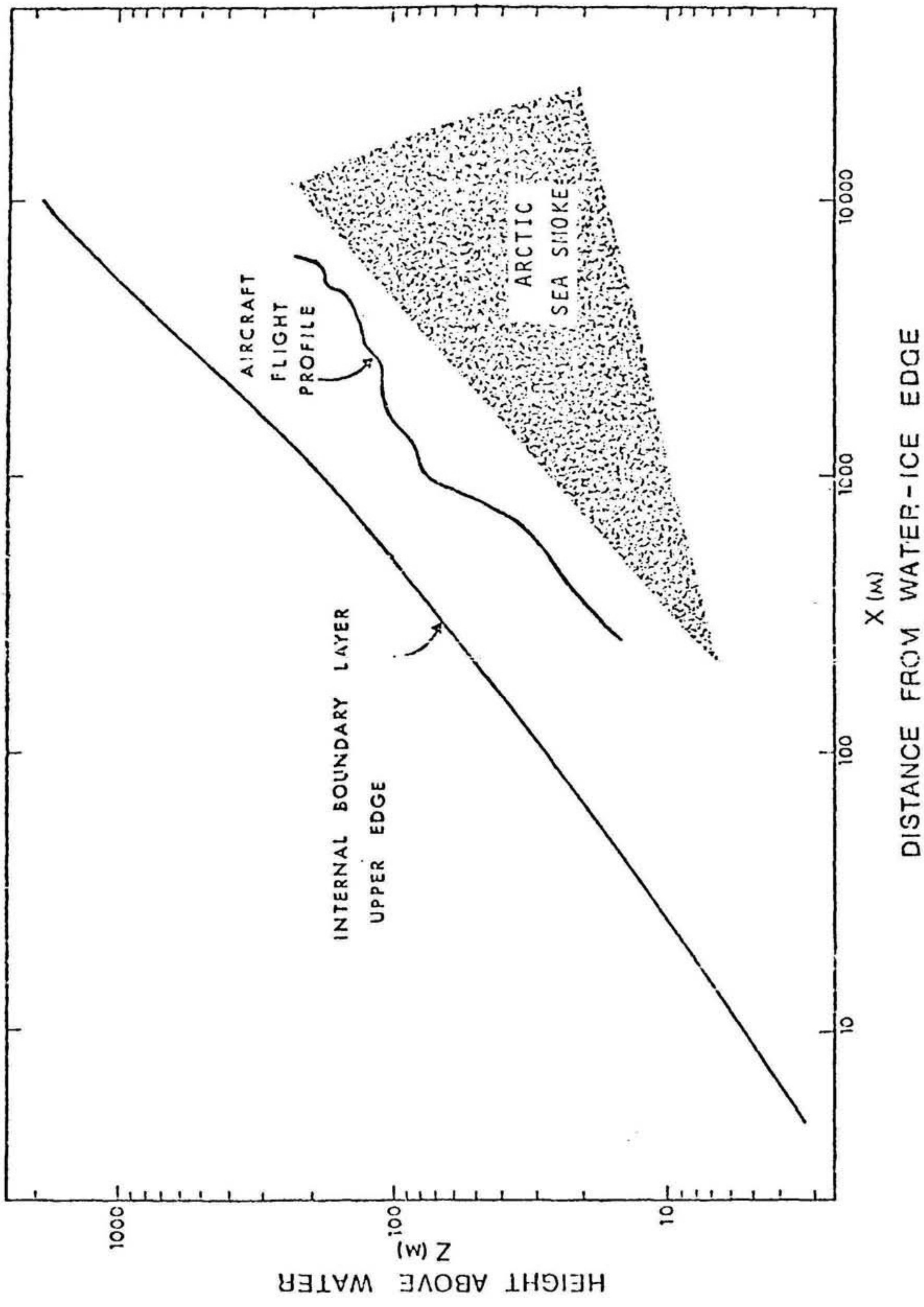


Figure 17-2.- Position of aircraft and of upper edge of internal boundary layer

(Prepared by Dept. of Environment)

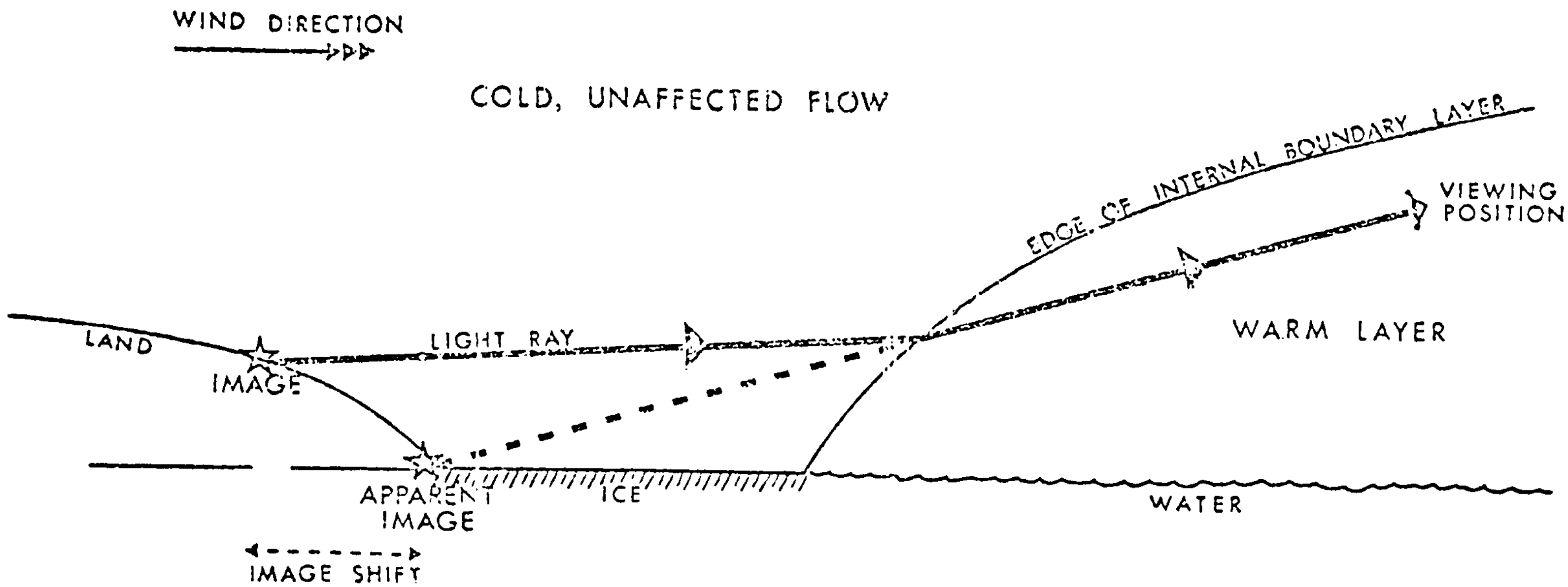


Figure 17-3.- Pictorial demonstration of image shifting due to internal boundary layer

(Prepared by Dept. of Environment)

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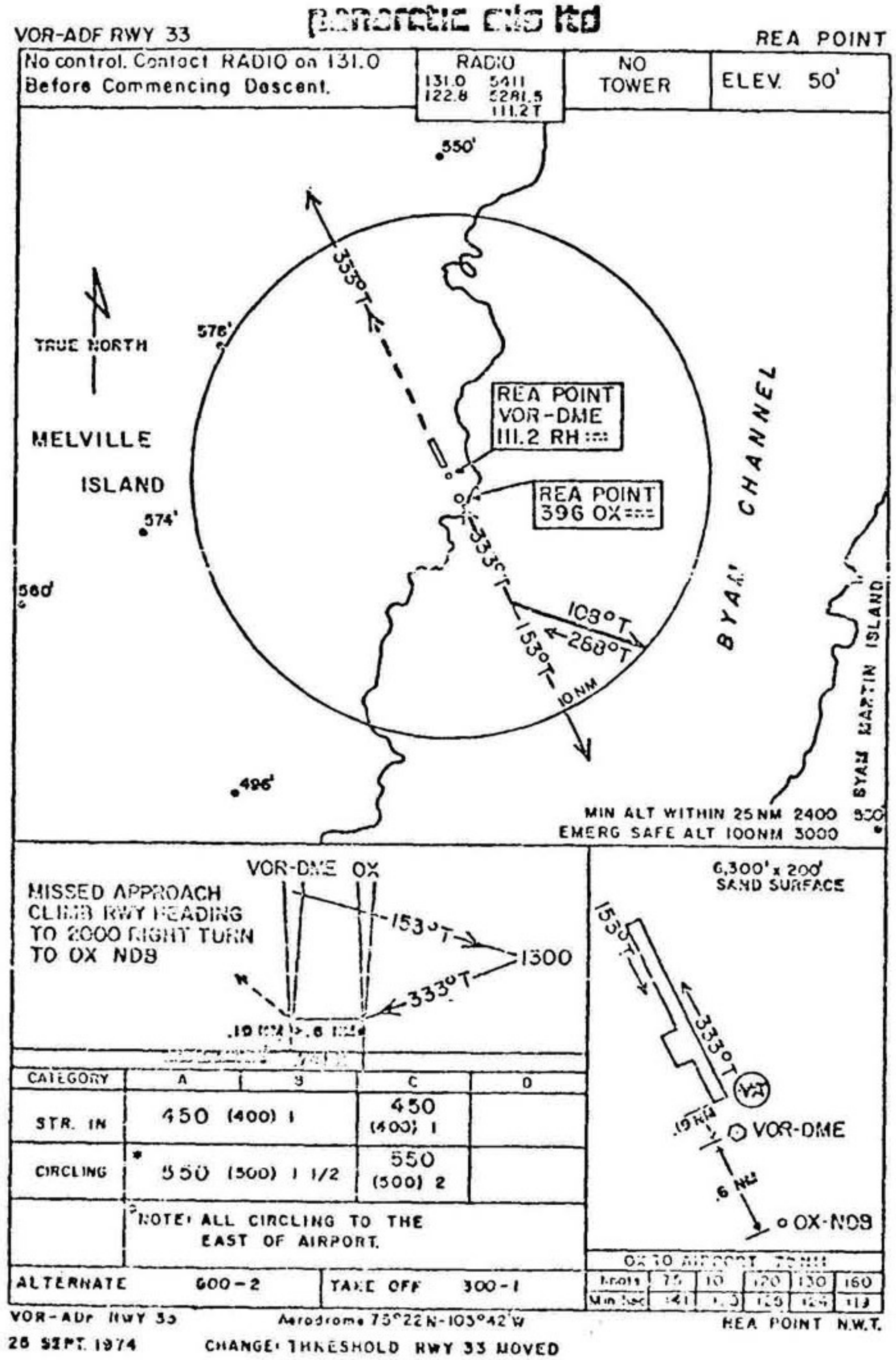

Figure 17-4

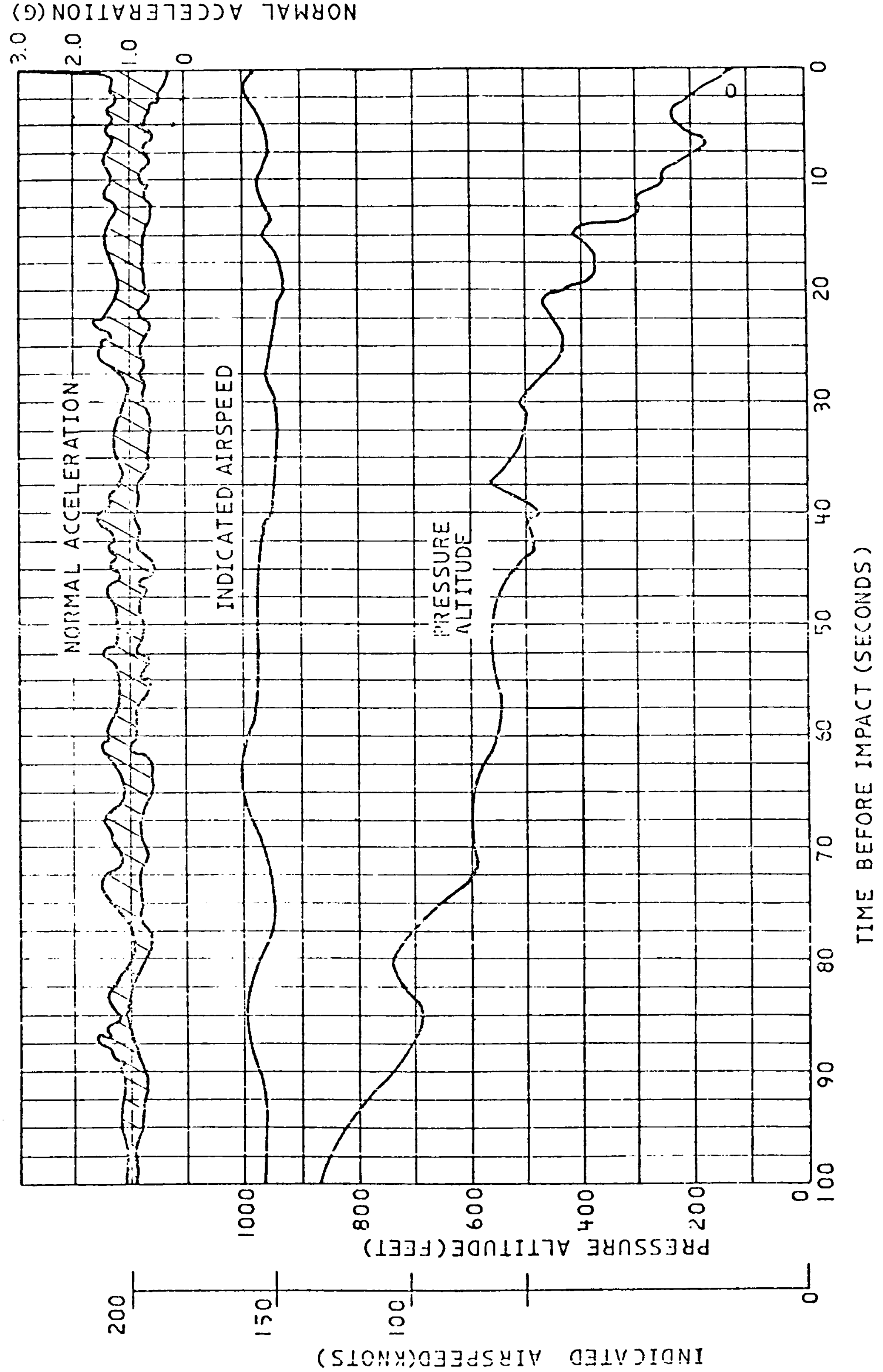

Figure 17-5.- Time histories of flight recorder data over last 100 seconds

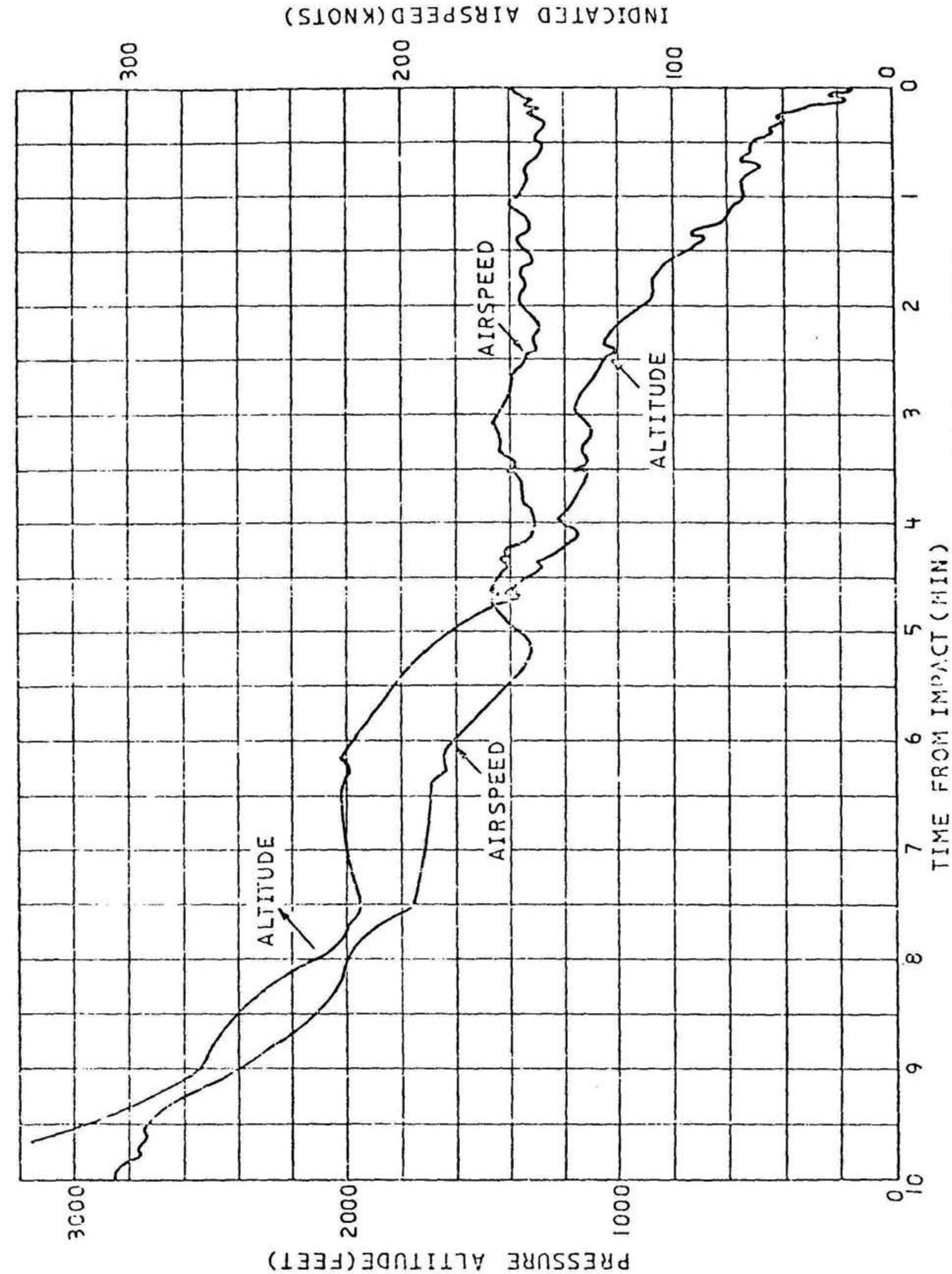

Figure 17-6.- Altitude and airspeed data over last 10 minutes of flight