Canadian Aviation Bureau canadien Safety Board de la sÈcuritÈ aÈrienne AVIATION OCCURRENCE AIR INDIA BOEING 747-237B VT-EFO CORK, IRELAND 110 MILES WEST 23 JUNE 1985 1.0 INTRODUCTION

Air India Flight 182, a Boeing 747-237B, registration VT-EFO, was on a flight from Mirabel to London when it disappeared from the radar scope at a position of latitude 51∞O'N and longitude 12∞50'W at 0714 Greenwich Mean Time (GMT), 23 June 1985, and crashed into the ocean about 110 miles west of Cork, Ireland. There were no survivors among the 329 passengers and crew members. The depth of the water at the crash site is about 6,700 feet.

At 0541 GMT, 23 June 1985, CP Air Flight 003 arrived at Narita Airport, Tokyo, Japan, from Vancouver. At 0619 GMT a bag from this flight exploded on a baggage cart in the transit area of the airport within an hour of the Air India occurence. Two persons were killed and four were injured. From the day of the occurrences, there have been questions about a possible linkage between the events.

This Submission examines the information available to the Canadian Aviation Safety Board (CASB) with respect to the circumstances surrounding the AI 182 accident. The sources of information include: information made public to the Indian Inquiry as a result of the RCMP investigation; the flight data recorder (FDR), cockpit voice recorder (CVR) and Shannon ATC tape recording analyses by Canadian, United Kingdom, and Indian authorities; the medical evidence obtained from Dr. Hill of the Accident Investigations Branch of the United Kingdom; and the evidence obtained by examination of the wreckage recovered, the wreckage distribution pattern, photographs, and videotapes of the wreckage on the ocean bottom.

2.0 EXAMINATION

2.1 Vancouver

On 19 June 1985, at approximately 1800 PDT (0100 GMT, 20 June), a CP Air reservations agent in Vancouver received a telephone call from a male with a slight East Indian accent.* He identified himself as Mr. Singh and informed the agent that he was making bookings for two different males also with the surname of Singh. One booking was made in the name of Jaswand Singh with CP 086 from Vancouver to Dorval on 22 June 1985 to link with AI 182 departing from Mirabel. The other booking was to Bangkok using CP 003 from Vancouver to Tokyo and AI 301 from Tokyo to Bangkok. This booking was made in the name of Mohinderbel Singh. A local telephone contact number was given and the call lasted about one-half hour.

On the same date at approximately 1920 PDT (0220 GMT), another reservations agent for CP Air was contacted and requested to change the booking for Jaswand Singh. The confirmed flight on CP 086 was cancelled and a reservation was made on CP 060 from Vancouver to Toronto, and a request to be wait-listed on AI 181/182 from Toronto to Delhi was made.

On 20 June 1985 at about 1210 PDT (1910 GMT), a male appearing to be of East Indian origin purchased the tickets with cash from a CP Air ticket office in Vancouver. The booking in the name of Mohinderbel Singh was changed to L. Singh and the booking using the name of Jaswand Singh changed to M. Singh. The telephone contact number was also changed. The final itinerary was as follows:

a) M. Singh - CP 060 Vancouver - Toronto Confirmed Scheduled to depart Vancouver at 0900 PDT, 22 June 1985

- AI 181 Toronto - Montreal Wait-listed Scheduled to depart Toronto at 1835 EDT, 22 June 1985

*See Appendix A for chronology of events.

- AI 182 Montreal - Delhi Wait-listed Scheduled to depart Montreal at 2020 EDT, 22 June 1985

b) L. Singh - CP 003 Vancouver - Tokyo Confirmed Scheduled to depart Vancouver at 1315 PDT, 22 June 1985

- Air India 301 Tokyo - Bangkok Confirmed Scheduled to depart Tokyo at 1705 (local time in Tokyo), 23 June 1985

On 22 June 1985 at about 0630 PDT (1330 GMT), a caller identifying himself as Mr. Manjit Singh called the CP Air reservations office. The caller spoke with a heavy East Indian accent and wanted to know if his booking on AI 181/182 was confirmed. The caller was informed by the agent that he was still wait-listed out of Toronto and offered to make alternate arrangements to Delhi. The caller stated that he would rather go to the airport and take his chances. The caller also asked if he could send his luggage from Vancouver to Delhi and was told he could not check his baggage past Toronto unless his flight was confirmed.

On Saturday morning, 22 June 1985, a CP Air passenger agent worked check-in position number 26 at the CP Air ticket counter, Vancouver International Airport, and recalls dealing with a passenger booked on CP 060 and then on to Delhi. The passenger stated that he wanted his bag tagged right to Delhi from Vancouver. After checking the computer, the agent explained that since he was not confirmed past Toronto he could not interline his baggage. The passenger insisted and, as the line-ups were long, the agent relented and interlined his suitcase. The flight manifest for CP 060 shows that M. Singh checked in through this passenger agent, was assigned seat 10B, and checked one piece of baggage. The flight manifest for CP 003 shows that on the same day the person using the name of L. Singh with a ticket to Bangkok also checked in through the same counter, was assigned seat 38H, and checked one piece of baggage.

A check of CP Air's records and interviews with passengers on flights CP 003 and CP 060 indicates that the persons identifying themselves as M. and L. Singh did not board these respective flights.

2.2 Toronto

Air India Flight 181 from Frankfurt arrived at Toronto on 22 June 1985 at 1430 EDT (1830 GMT) and was parked at gate 107 of Terminal 2. All passengers and baggage were removed from the aircraft and processed through Canada Customs. Passengers continuing on the flight to Montreal were given transit cards, and on this flight 68 cards were handed out. These transit passengers are required to claim their luggage and proceed through Canada Customs. Prior to entering the public area, there is a belt which is designated for interline or transit baggage. Transit passengers deposit their luggage on this belt which carries it to be reloaded on the aircraft. This baggage was not subjected to X-ray inspection as it was presumed to have been screened at the passengers' overseas departure point. When the transit passengers checked in to proceed to Montreal, their carry-on baggage was subjected to the normal security checks in place on this date. Passenger and baggage security checks were conducted by Burns International Security Services Ltd. and all passenger and baggage processing for both off-loading and on-loading was handled by Air Canada staff.

Air India Flight 181 was composed of the following:

- passengers continuing to Montreal (68)
- passengers from connecting flights

AC	102	(Saskatoon)	2	
AC	106	(Edmonton)	4	
AC	192	(Winnipeg)	1	
AC	170	(Winnipeg)	4	
AC	136	(Vancouver)	10	
CP	060	(Vancouver)	1	Standby (M. Singh)

- passengers originating at Toronto
- diplomatic bags from the Vancouver India Consul General via AC 508
- produce cargo from India
- cargo in the form of 5th pod engine components loaded in the aft cargo compartment.

It should be noted that some passengers from India book flights to Montreal with their intended destination being Toronto. The reason is that the fare to Montreal is cheaper and therefore some passengers get off the flight in Toronto, claim their luggage and leave without reporting a cancellation of the trip to Montreal. It has been established that 65 of the 68 transit passengers reboarded the flight to Montreal.

Air India personnel were in charge for the overall operation at Toronto regarding the unloading and loading of both passengers and cargo. Although the actual work was performed by various companies under contract, Air India personnel oversaw the operation. The Air India station manager was away on vacation on 22 June 1985. The evidence does not clearly establish who had been assigned to replace the station manager and assume his duties.

Air Canada had stored in a hangar an engine that had failed on a previous Air India flight from

Toronto on 8 June 1985. Air Canada received a message from Air India stating that the failed engine was to be mounted as a 5th pod on Flight 181/182 on 22 June 1985. The engine was prepared for loading and component parts were crated for loading into the aft cargo compartment. On 22 June, the component parts were taken from the hangar and placed outside to be delivered to the aircraft by MEGA International Air Cargo. The component parts were placed just inside the airport fence separating the restricted and unrestricted areas. The installation began immediately upon the arrival of Flight 181 and was completed at 1530 EDT (1930 GMT). The front engine cowling was crated but would not fit through the aft cargo door. The crating was rearranged, and the door stops on the cargo door were removed to permit the loading of the crate and the remaining engine parts were loaded on pallets. Due to problems with loading the 5th pod and component parts, the departure was delayed from 1835 EDT (2235 GMT) to 2015 EDT (0015 GMT, 23 June).

CP Air Flight 060 arrived in Toronto at 1610 EDT (2010 GMT) and docked at gate 44, Terminal 1. A number of passengers on this flight were interlined to other flights including passenger M. Singh wait-listed on Air India Flight 181/182. It has been established that this passenger did not board Flight CP 060 but did check baggage onto the flight. This baggage was to be interlined to the Air India flight departing from Terminal 2. In this case, CP Air employees would have off-loaded all baggage from CP 060 and deposited the baggage at Racetrack 6 on the ring road of Terminal 1 to be transported to the Air Canada sorting room at Terminal 2.

Consolidated Aviation Fuelling and Services (CAFAS) is a company which is contracted to pick up and deliver baggage from one terminal to the other. The CAFAS driver on duty at the time recalls picking up a bag from a CP Air flight originating in Vancouver and destined for Air India at Terminal 2. As this piece of luggage did not turn up as found luggage, it is deduced that normal practice was followed, and the luggage was interlined and loaded on AI 181/182.

MEGA International Air Cargo is a firm that handled air cargo and containers for Air India. Since the flight was carrying a 5th engine and component parts, no commercial cargo could be loaded at Toronto. MEGA delivered the engine component parts to be loaded in the cargo compartment by Air Canada employees. Later, MEGA received two diplomatic bags and delivered these to the aircraft. The bags were loaded into the valuable goods container (see Appendix B). These bags were not subjected to X-ray or any other security checks.

All checked-in baggage for AI 181/182 was to be screened by an X-ray machine which was located in Terminal 2 at the end of international belt number 4. This location would permit all baggage from the check-in counters and interline carts to be fed through the X-ray machine before being loaded. It has been established that this machine worked intermittently for a period of time and stopped working during the loading process at about 1700 EDT (2100 GMT). Rather than opening the bags and physically inspecting them, the Burns security personnel performing the X-ray screening were told by the Air India security officer to start using the hand-held PD-4 sniffer.

One Burns security officer checked the bags with the sniffer while another put stickers on the bags and forwarded them. The security officer forwarding the baggage recalls the sniffer making short beeping noises not long whistling ones. The security officer who used the sniffer claims it never went off, and the only time any sound was made was when it was turned on and off. At those times, it would emanate a short beep (refer to section 2.8 for further information regarding the PD-4 sniffer).

Burns International Security had a contract with Air India for the security of the aircraft while it was docked. The security arrangements contracted from Burns were as follows:

- security at the bridge door leading to the aircraft;
- security inside the aircraft from the time the passengers disembarked upon flight arrival until flight departure;
- security guards assigned the physical inspection of all carry-on baggage in the departure room; and
- security guards in the international baggage make-up room conducting screening of baggage using an X-ray machine and a hand-held PD-4 sniffer.

The statements taken from Burns security personnel in Toronto indicated that a significant number of personnel, including those handling passenger screening, had never had the Transport Canada passenger inspection training program or, if they had, had not undergone refresher training within

12 months of the previous training.

As a result of official requests made by Air India in early June 1985 for increased security for Air India flights, the RCMP provided additional security as follows:

- one member in a marked police motor vehicle patrolling the apron area;
- one member in a marked police motor vehicle parked under the right wing from time of arrival until push-back;
- one member on foot patrol at Air India check-in counter; and
- one member at the loading bridge during boarding.

In addition, all RCMP members working in that particular area of Terminal 2 were aware of the Air India flight and would check in with the assigned personnel during their patrols in the area of the aircraft and check-in/boarding lounges. Uniformed members are to patrol and monitor security within the airport premises as detailed in section 2.5 below.

Passenger check-in was handled for Air India by Air Canada under contract with Air India. The check-in included passengers originating in Toronto and interline passengers but did not include the transit passengers to Montreal. The check-in passengers were numbered using a security control sheet in accordance with instructions from Air India; however, the check-in and interline baggage was not numbered, and no attempt was made to correlate baggage with passengers. Hence, any unaccompanied interline baggage would not have been detected.

The flight and cabin crew had been in Toronto for the week prior to this flight and were to take the aircraft to London where they would be replaced by another crew. The crew members themselves and their carry-on baggage were not subjected to any security checks; however, their checked-in baggage was screened in the same manner as other baggage.

2.3 Montreal

Air India Flight 181 from Toronto arrived at Mirabel International Airport at about 2100 EDT (0100 GMT, 23 June) and parked in supply area number 14 at 2106 EDT (0106 GMT). The 65 passengers destined for Montreal along with three Air India personnel deplaned and were transported by bus to the terminal building. The remaining passengers remained on board as transit passengers and were not permitted to disembark at Montreal. Air Canada baggage handlers off-loaded four containers of cargo, three containers of baggage and a valuables container. Two diplomatic pouches from the Indian High Commission in Ottawa were delivered to the aircraft by MEGA International Cargo. One pouch weighing one kilogram was hand-delivered to the flight purser for storage in a valuables locker within the cabin and the other pouch was loaded into the valuables container.

During the check of the aircraft at Montreal, the second officer pointed out to an Air Canada mechanic that a rear latch on the fan cowl for the 5th engine did not appear to be properly secured. The mechanic examined the latch and found it well secured, but the handle was not flush and was hanging about five degrees. The mechanic applied high-speed tape to the latch handle for aerodynamic smoothness. This repair was examined by the second officer who was satisfied with the work. No records were completed by Air Canada in connection with this temporary repair.

At about 1730 EDT (2130 GMT), Air Canada, which is Air India's contracted agent, opened its check-in counter to passengers who would be flying on Air India Flight 182. Burns security personnel were also assigned at this time to screen the checked baggage. Passenger tickets were checked, issued a number, and copies of the tickets were removed and retained by Air Canada. Boarding passes were then issued and affixed to the numbered tickets. Also attached to the ticket booklets were numbered tickets which corresponded to each piece of checked baggage. The numbered checked baggage was sent to the baggage area by Air Canada personnel to be security-checked by Burns security personnel.

The passengers for AI 182 after checking in were free to enter the departure area. At the entrance to the departure area, Burns security staff used X-ray units and metal detectors to screen passengers and carry-on baggage. At about 2100 EDT (0100 GMT), the passengers proceeded to gate 80 where they gave their boarding passes and numbered tickets to an Air Canada agent. The agent kept the numbered flight tickets and checked the numbers against the passenger list. Also, at gate 80, a secondary security check was done on passengers by a Burns security officer using a metal detector. Hand-carried baggage was subjected to further physical and visual checks. A total of 105

passengers boarded the flight at Mirabel Airport; there were no interline passengers.
Between 1900 (2300 GMT) and 1930 EDT (2330 GMT), Burns security personnel identified a suspect suitcase using the X-ray machine. The suitcase was placed on the floor next to the machine. The Burns security supervisor told Air India personnel that a suspect suitcase had been located and was advised within 15 to 20 minutes to wait for the Air India security officer who would be arriving on the flight from Toronto. Subsequently, a second suspect suitcase was identified and a little later a third. The three suitcases were placed next to the X-ray machine. Between 1930 (2330 GMT) and 1945 (2345 GMT), all the Burns security personnel at the X-ray machine were assigned to other duties and the three suspect suitcases remained in the baggage area without supervision. At about 2140 (0140 GMT), the Air India security officer went to the baggage room and inspected the three suitcases with the X-ray machine and a sniffer that was in the possession of the security officer. The Air India security officer decided to keep the three suitcases and, if further examination proved negative, send them on a later flight. At approximately 2155 (0155 GMT), the Air Canada Operations Centre supervisor contacted the airport RCMP detachment regarding the suspect suitcases. At about 2205 (0205 GMT), an RCMP member located the suitcases in the baggage room and requested that an Air India representative be sent to the baggage room. About five minutes later, the Air India security officer contacted the baggage room by telephone and advised that he could not come to the room immediately. The Air India security officer arrived in the baggage room at about 2235 (0235 GMT) and, when asked to determine the owners of the suitcases, informed the RCMP member that the flight had already departed [2218 (0218 GMT)]. The three suspect suitcases were later examined with negative results.
The remainder of the checked baggage which cleared the security check was identified by a green sticker. The baggage was then forwarded to Air Canada personnel who loaded the baggage in containers to be placed on board the aircraft. A later check with Canada Customs and Air Canada at Mirabel revealed no unclaimed baggage associated with AI 181/182. A similar check at Dorval Airport was conducted with negative results.
No record was kept as to the location and number of individual pieces of checked-in luggage. Records were kept as to the location of the containers according to destination, where loaded and the number of pieces of luggage in each container (see Appendix B).
The Mirabel Detachment of the RCMP provided the following security at the airport on 22 June 1985:

- one member in a police vehicle for airside security;
- one member on patrol in the arrival and departure areas;
- one member on general foot patrol throughout the terminal; and
- one member as a telecommunications operator in the detachment office.

In addition, due to the increased threat to Air India flights, the RCMP provided the following supplementary coverage to Air India Flight 181/182 on 22 June 1985:

- one member in a police vehicle escorted the aircraft to and from the runway and the terminal building and remained with the aircraft while it was stationary;
- one member in a police vehicle remained at the entrance to the ramp;
- two members patrolled the area of the ticket counter and access corridors, and one of these members also served in a liaison capacity with the airline representatives.

2.4 International Standards and Recommended Practices
International security standards and recommendations to safeguard international civil aviation against acts of unlawful interference are listed in ICAO Annex 17 to the Convention on International Civil Aviation. Suggested security measures and procedures are amplified in the ICAO Security Manual for Safeguarding Civil Aviation Against Acts of Unlawful Interference.
Annex 17 requires contracting States of which Canada is one to "take the necessary measures to prevent weapons or any other dangerous devices, the carriage or bearing of which is not authorized, from being introduced by any means whatsoever, on board an aircraft engaged in the carriage of passengers."
In addition to other recommendations, Annex 17 recommends that contracting States should establish the necessary procedures to prevent the unauthorized introduction of explosives or incendiary devices in baggage, cargo, mail and stores to be carried on board aircraft.

The Security Manual specifies that,
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Recently, ICAO has proposed amendments to Annex 17. These proposals arise from a decision taken by the Council in its 115th Session on 10 July 1985. The Council instructed its Committee on Unlawful Interference, as a matter of urgency, to review the entirety of Annex 17 and to report on those provisions which might be immediately introduced, upgraded to Standards, strengthened or improved. Among the proposed amendments is the following upgrading in the Standards:

- Each contracting State ensure the implementation of measures at airports to protect cargo, baggage, mail stores and operator's supplies being moved within an airport to safeguard such aircraft against an act of unlawful interference.

2.5 Canadian Law

In terms of Canadian statutory requirements, the Civil Aviation Security Measures Regulations and the Foreign Aircraft Security Measures Regulations made pursuant to the Aeronautics Act require specified owners or operators of aircraft registered in Canada or specified owners or operators who land foreign aircraft in Canada to establish, maintain, and carry out security measures at airports consisting of:

- systems of surveillance of persons, personal belongings, baggage, goods and cargo by persons or by mechanical or electronic devices;
- systems of searching persons, personal belongings, baggage, goods and cargo by persons or by mechanical or electronic devices;
- a system that provides, at airports where facilities are available, for locked, closed or restricted areas that are inaccessible to any person other than a person who has been searched and the personnel of the owner or operator;
- a system that provides, at airports where facilities are available, for check-points at which persons intending to board the aircraft of an owner or operator can be searched;
- a system that provides, at airports where facilities are available, for locked, closed or restricted areas in which cargo, goods and baggage that have been checked for loading on aircraft are inaccessible to persons other than those persons authorized by the owner or operator to have access to those areas;
- a system of identification that prevents baggage, goods and cargo from being placed on board the aircraft if it is not authorized to be placed on board by the owner or operator; and
- a system of identification of surveillance and search personnel and the personnel of the owner or operator.

Specified carriers including Air Canada, CP Air, and Air India were required to provide a description of their security measures to the Canadian Minister of Transport.

An Order-in-Council on 29 September 1960 established that the RCMP was responsible for the direction and administration of police functions at major airports operated by Transport Canada. The duties of the Police and Security Detail at these designated airports include the following:

- carry out policing and security duties to guard against unauthorized entry, sabotage, theft, fire or damage;
- enforce federal legislation;
- respond to violations of the Criminal Code of Canada, Federal, Provincial, and Territorial statutes, and perform a holding action pending arrival of the police department having primary criminal jurisdiction;
- man guard posts; and
- provide a police response in those areas of airports where pre-board screening takes place.

Section 5.1(9) of the Aeronautics Act states that "The Minister may designate as security officers for the purposes of this section any persons or classes of persons who, in his opinion, are qualified to be so designated." Pursuant to this section Transport Canada has established criteria for persons or classes of persons that are designated as security officers in a Schedule registered on 11 April 1984. The criteria also specify that a security guard company and its employees will meet Transport Canada requirements provided that the company:

- is under contract with a carrier to conduct passenger screening under the Aeronautics Act and Regulations;

- is licensed in the province or territory;
- complies with the security guard criteria as follows in that the guard must:
- be 18 years or older,
- be in good general health without physical defects or abnormalities which would interfere with the performance of duties,
- be licensed as a security guard and in possession of the licence while on duty, and
- meet the training standards of Transport Canada consisting of successfully completing the Transport Canada passenger inspection training program, attaining an average mark of 70 per cent, and undergoing refresher training within 12 months from previous training;
- uses a comprehensive training program which has been approved by Transport Canada and is capable of being monitored and evaluated;
- keeps records showing the date each employee received initial training and/or refresher training and the mark attained; and
- provides supervision to ensure that their employees maintain competency and act responsibly in the conduct of searching passengers and carry-on baggage being carried aboard aircraft.

2.6 Canadian Security Procedures

In accordance with the Canadian Aeronautics Act and pursuant regulations, air carriers are assigned the responsibility for security. Transport Canada provides the following security services for the air carriers using major Canadian airports, including the international airports in Vancouver, Toronto and Montreal:

- security and policing staff including RCMP airport detachments;
- specific airport security plans and procedures;
- secure facilities (e.g., secure areas, pass identification systems, etc.); and
- security equipment and facilities (e.g., X-ray detection units, walk-through metal detectors, hand-held metal detectors, explosive detection dogs).

As of 22 June 1985, the following general security measures were in place at Canadian airports:

- metal detection screening of passengers; and
- X-raying of carry-on baggage.

Checked baggage was not normally subject to any security screening. A few air carriers such as Air India had extra security measures in place because of an assessed higher threat level (see section 2.7 below).

On 23 June 1985, Transport Canada required additional security measures to be implemented by all Canadian and foreign air carriers for all international flights from Canada except those to the continental United States. These measures required:

- the physical inspection or X-ray inspection of all checked baggage;
- the full screening of all passengers and carry-on baggage; and
- a 24-hour hold on cargo except perishables received from a known shipper unless a physical search or X-ray inspection is completed.

Further, on 29 June 1985, Transport Canada directed that all baggage or cargo being interlined within Canada to an Air India flight was to be physically inspected or X-rayed at the point of first departure and that matching of passengers to tickets was to be verified prior to departure.

2.7 Air India Security Program in Canada

In accordance with the Foreign Aircraft Security Measures Regulations, Air India had provided the Minister of Transport with a copy of its security program. It included measures to:

- establish sterile areas;
- physically inspect all carry-on baggage by means of hand-held devices or X-ray equipment;
- control boarding passes;
- maintain aircraft security;
- ensure baggage and cargo security; and
- off-load baggage of passengers who fail to board flights.

Under these procedures established by Air India, passengers, carry-on baggage, and checked baggage destined for AI 181/182 on 22 June 1985 were subjected to extra security checks. A security officer from the Air India New York office arrived in Toronto on 22 June 1985 to oversee the security operation at Toronto and Montreal.

On 17 May 1985, the High Commission of India presented a diplomatic note to the Department of External Affairs regarding the threat to Indian diplomatic missions or Air India aircraft by extremist elements. Subsequently, in early June, Air India forwarded a request for "full and strict security coverage and any other appropriate security measures" to Transport Canada offices in Ottawa, Montreal and Toronto, and RCMP offices in Montreal and Toronto.

2.8 PD-4 Sniffer

On 18 January 1985, prior to the inaugural Air India flight out of Toronto on 19 January, a meeting on security for Air India flights (Toronto) was held with representatives from Transport Canada, RCMP and Air India. At this meeting, a PD-4 sniffer belonging to Air India was produced. It was explained that it would be used to screen checked baggage as the X-ray machine had not yet arrived. At that time, an RCMP member tested its effectiveness. The test revealed that it could not detect a small container of gunpowder until the head of the sniffer was moved to less than an inch from the gunpowder. Also, the next day the sniffer was tried on a piece of C4 plastic explosives and it did not function even when it came directly in contact with the explosive substance. It is not known if this was the same sniffer used on 22 June 1985.

2.9 Medical Evidence

Medical examination was conducted on the 131 bodies recovered after the accident. This comprises about 40 per cent of the 329 persons on board. It should be noted that assigned seating is based on preliminary information. Also, the exact position of passengers is not certain because it is not known if passengers changed their seats after lift-off. On the information available, the passengers were seated as follows:

Passengers:*

	Seats Available	Occupied	Bodies Identified
Zone A	16	1	0
Zone B	22	0	0
Upper Deck	18	7	0
Zone C	112	104 + 2	29
Zone D	86	84 + 1	38
Zone E	123	105 + 3	50
SUB-TOTAL	377	301 (+6 infants)	117
Crew:			
Flight Deck	3	3	0
Cabin	19	19	5
TOTAL	399	329	122

There were 30 children recovered and they showed less overall injury. The average severity of injury increases from Zone C to E and is significantly less in C than in Zones D and E.

Flail pattern injuries were exhibited by eight bodies. Five of these were in Zone E, one in Zone D, two in Zone C and one crew member. The significance of flail injuries is that it indicates that the victims came out of the aircraft at altitude before it hit the water.

There were 26 bodies that showed signs of hypoxia (lack of oxygen), including 12 children, 9 in Zones C, 6 in Zone D and 11 in Zone E. There were 25 bodies showing signs of decompression, including 7 children. They were evenly

*See Appendix C for interior seating arrangement.

distributed throughout the zones, but with a tendency to be seated at the sides, particularly the right side (12 bodies).

Twenty-three bodies showed evidence of receiving injuries from a vertical force. They tended to be older, seated to the rear of the aircraft (4 in Zone C, 5 in Zone D, 11 in Zone E, 2 crew and 1 unknown), and 16 had little or no clothing.

Twenty-one bodies were found with no clothing, including three children. They tended to be seated to the rear and to the right (3 in Zone C, 5 in Zone D, 11 in Zone E and 2 unknown).

There were 49 cases showing signs of impact-type injuries, including 19 children (15 in Zone C, 15

in Zone D, 15 in Zone E, 1 crew member and 3 unknown).
There is a general absence of signs indicating the wearing of lap belts.
Pathological examination failed to reveal any injuries indicative of a fire or explosion.

2.10 Flight Recorders and Shannon Air Traffic Control (ATC) Tape Analyses

VT-EFO was equipped with a Fairchild A100 Cockpit Voice Recorder (CVR) and a Lockheed 209E Digital Flight Data Recorder (DFDR). These were each equipped with Dukane Underwater Acoustic Beacons and were installed adjacent to each other in the cabin on the left side near the aft pressure bulkhead. The serial digital signal recorded by the DFDR was generated by a Teledyne Flight Data Acquisition Unit installed in the forward electronics bay below the cabin floor.
The Shannon Air Traffic Control Centre was in contact with VT-EFO and recorded radio communications with the aircraft. At the time of the accident, 5.4 seconds of noise was recorded, and the transponder signal seen on the radar scope was lost from the aircraft. This signal which displays aircraft altitude showed no deviation before disappearing from the radar scope.

2.10.1 Analysis by National Research Council, Canada

From the CVR and DFDR, AI 182 was proceeding normally en route from Montreal to London at an altitude of 31,000 feet and an indicated airspeed of 296 knots when the cockpit area microphone detected a sudden loud sound. The sound continued for about 0.6 seconds, and then almost immediately, the line from the cockpit area microphone to the cockpit voice recorder at the rear of the pressure cabin was most probably broken. This was followed by a loss of electrical power to the recorder. The initial waveform of the cockpit area microphone signal is not consistent with the sharp pressure rise expected with detonation of an explosive device close to the flight deck, but, with the multiplicity of paths by which sound may be conducted from other regions of the aircraft, the possibility that it originated from such a device elsewhere in the aircraft cannot be excluded.
By correlating the oscillograph records of the CVR and the Shannon ATC VHF recording, it was estimated that the unusual sounds recorded on the ATC tape started 1.4 ± 0.5 seconds after the start of the sudden sound detected by the cockpit area microphone and lasted intermittently for 5.4 seconds. It was felt the closeness in time of the two noises indicated the 5.4 seconds recorded on the ATC tapes originated from AI 182. The ATC recording that followed the cockpit area microphone sounds appeared at first to contain a series of short intermittent sounds. Listening to the sounds, it also appeared that a human cry occurred near the end of the recording. Spectral analysis of these sounds and comparison with voice imitations revealed that the recorded sounds do not contain all the pitch harmonic frequencies normally associated with voice sounds. The origin of these sounds has not been determined.
An examination of the DFDR showed no abnormal variations before the accident. With the spare engine, this aircraft was restricted to altitudes below 35,200 feet and indicated airspeeds less than 290 knots. During the last 27 minutes of the flight, the computed airspeed did gradually increase to nine knots above this limit in the first part of this period and the power was readjusted several times. The speed fell below the 290 knot limit at about 07h:09m GMT as recorded by the DFDR; power was increased again at about 07h:10m causing the aircraft to accelerate to six knots above the limit by the time the accident occurred at 07h:13m:59s. The observed excursions outside the specified limits are not considered significant.
The aircraft was flown with 1.5-degree left-wing-down with 4.2 degrees clockwise control wheel as compared to the aircraft without the 5th engine installation. Also, 9.4 per cent of right rudder pedal was applied giving a 1.1-degree right deflection of the upper and lower rudders. Considering the carriage of the 5th engine on the left side, these figures are not considered abnormal.
When synchronized with the other recordings, it was determined, within the accuracy that the procedure permitted, that the DFDR stopped recording simultaneously with the CVR.
Irregular signals were observed over the last 0.27 inches of the DFDR tape. Laboratory tests indicated that the irregular signals most likely occurred as a result of the recorder being subjected to sharp angular accelerations about the lateral axis of the recorder, causing rapid changes in tape speed over the record head. This equates to an angular acceleration on the recorder about the aircraft's longitudinal axis in a left-wing-down sense. Therefore, these tests indicate that the digital recorder was subjected to a sharp jolt separate from any violent motion of the aircraft.
The other possibility for the irregular signals is that the Flight Data Acquisition Unit which

generated the serial digital data signal and which is located in the electronics bay under the cabin floor forward of the cargo compartment could have suffered some damage or had an intermittent power supply that caused it to generate the irregular signals.

2.10.2 Analysis by Accidents Investigation Branch (AIB), United Kingdom

The AIB analysis was restricted to the CVR and the Shannon ATC tape. The correlation of the CVR and ATC tapes showed that the ATC recording started after the CVR had stopped recording and 1.1 ± 0.4 seconds from the start of the sudden sound. The total duration of the signal on the ATC tape was 5.4 seconds.

An analysis of the CVR audio found no significant very low frequency content which would be expected from the sound created by the detonation of a high explosive device. Evidence of the presence of audio warning signals buried amongst the noise was investigated with negative results. A comparison with CVRs recording an explosive decompression* on a DC-10, a bomb in the cargo hold of a B737, and a gun shot on the flight deck of a B737 was made. Considering the different acoustic characteristics between a DC-10 and a B747, the AIB analysis indicates that there were distinct similarities between the sound of the explosive decompression on the DC-10 and the sound recorded on the AI 182 CVR.

The analysis of the ATC tape audio determined three or four words could be heard at the beginning of the transmission, but extensive filtering did not allow the sounds to be transcribed. Two bursts of tone occurred during the first second. The spectrum of the tone does not coincide with any B747 audio warning. The transmission is chopped until at about 2.7 seconds into the transmission a loud noise lasting about 200 milliseconds is heard. This is followed about 0.5 seconds later by a sound which increases in volume. This sound is similar to that heard in other accidents where there has been a rapid increase in airspeed. Toward the end of the transmission a crying sound was heard; however, a study of the noise indicates a human cry would contain more harmonics. The origin of this sound was not determined. Knocking sounds were also heard during the transmission. These were initially thought to be due to hand-held microphone vibration, but this was discounted because of the frequency of the sounds. Almost identical sounds were heard on the DC-10 CVR after the explosive decompression had occurred. Their source was not identified. On the DC-10, the pressurization audio warning sounded 2.2 seconds after the decompression. No such warning was identified on the ATC tape.

*Explosive decompression is an aviation term used to mean a sudden and rapid loss of cabin pressurization. A loud noise is associated with this event but not necessarily an explosion.

Every aircraft provides a different signature when the press-to-transmit button is released. These signatures were compared with transients which occurred during the open microphone transmission. There is a close match with the previous AI 182 signatures. Therefore, it is almost certain that the ATC tape recording originated from AI 182.

The AIB report concluded that the analysis of the CVR and ATC recordings showed no evidence of a high-explosive device having been detonated on AI 182. It further states there is strong evidence to suggest a sudden explosive decompression of undetermined origin occurred. Although there is no evidence of a high-explosive device, the possibility cannot be ruled out that a detonation occurred in a location remote from the flight deck and was not detected on the microphone. However, the AIB report is of the opinion that the device would have to be small not to be detected as it is considered that a large high-explosive device could not fail to be detected on the CVR.

2.10.3 Analysis by Bhabha Atomic Research Centre (BARC), India

The BARC analysis was restricted to the CVR and the Shannon ATC tape.

Channel 3 of the recording which corresponded to the cockpit area microphone showed the first indication of a rising audio signal. The signal level rises from the ambient level in the cockpit by about 18.5 decibels in approximately 45 milliseconds. The signal starts falling and stabilizes at a level about 10 decibels higher than ambient for about 375 milliseconds. The total duration of the signal is about 460 milliseconds.

The timings of the CVR and the Shannon ATC tape were correlated, and it was determined that the explosive sound on the CVR coincided with the beginning of the series of audio bursts on the ATC tape. The report concluded that the sounds recorded on the ATC tape emanated from AI 182 at the time of the occurrence.

The noise on the CVR was compared with an explosion which caused the crash of an Indian Airlines B737. In this occurrence, the explosive sound recorded on the cockpit area microphone showed a rise time of about 8 milliseconds. It was also determined that the explosion occurred 8 feet from the microphone. The report concluded that the rise time is a measure of the distance from the cockpit area microphone to the source of an explosion. Hence, the exact location in the aircraft at which the explosion occurred is likely to be about 40 to 50 feet from the cockpit judging from the rise time of 45 milliseconds.

The report concluded that the series of audio bursts on the ATC tape were most probably generated by the break-up of AI 182 in mid-air.

2.11 Aircraft Structures Examination

The examination of aircraft structures consisted of the following areas: floating wreckage, wreckage mapping and surveying, wreckage distribution, photographic and video interpretation of wreckage, wreckage recovery and initial examination, and examination of recovered wreckage.

2.11.1 Floating Wreckage

During the search, aircraft wreckage was sited and recovered by several search vessels. The wreckage was transported to Cork, Ireland, where preliminary examination was conducted. This examination took place in June and July, 1985.

The wreckage consisted mainly of various leading edge skin panels of the left and right wings, left wing tip, spoilers, leading edge and trailing edge flaps, engine cowlings, flap track canoe fairing pieces, landing gear wheel well doors, pieces of elevator and aileron, cabin floor panels, cabin overhead and upper deck bins, passenger seats, life vests, slide rafts, hand baggage, suitcases, personal effects and a number of internal fittings. The floating wreckage constitutes about three to five percent of the aircraft structure.

The wreckage was then transported from Ireland to Bombay, India where it underwent further examination by the Floating Wreckage Structures Group which then produced a report which was submitted to the Indian Inquiry. The report concluded:

- There was no evidence of fire damage.
- There was no evidence of lightning strike damage.
- The cabin floor panels from the forward and rear sections of the aircraft separated from the support structure in an upward direction (floor to ceiling) pulling free from the attaching screws and, in some cases, breaking the vertical web of the seat track/floor beams.
- The position of the leading edge flap rotary actuator and the damage to the flap structure indicated that the leading edge flaps were in the retracted position.
- The six spoiler actuators found were in the retracted position. The lower surface of all the spoiler panels showed signs of spanwise skin splits with the edges curled into the core of the honeycomb. The report concluded that this was possibly due to the loading of the spoilers by being deployed in flight at high speed, resulting in compression on the lower surfaces. This, in turn, caused splitting of the lower skin into the honeycomb.
- The right wing root leading edge, number 3 engine inboard fan cowling, the right inboard midflap inboard leading edge, and the right stabilizer root leading edge all exhibited damage possibly due to objects striking the right wing and stabilizer before water impact.

In addition to the above conclusions, the following significant information regarding the floating wreckage is noted in the report:

- The aircraft was carrying a -7Q engine at the 5th pod and a -7J 5th pod kit in the aft cargo compartment. In all there were 14 engine fan cowls (four in the aft cargo compartment). Out of these 14 fan cowls, nine, including six from the working engines and three from the aft cargo compartment, and two additional pieces of fan cowls were found. Five of the fan cowls from the working engines showed folding damage lines at about the three and nine o'clock positions. The number 3 engine inboard fan cowl had severe impact damage on its leading edge and had small outward puncture holes but no penetration through the outer skin in the lower centre region. The two fan cowls of the -7J 5th pod kit stowed in the aft cargo compartment showed severe damage. One piece was cut at one corner in an arc of about 20 inches diameter and its external skin was peeled back.
- The cockpit entry door and the side bulkhead panel were found relatively intact but had

come out of their attachments.

- Twelve toilet doors out of 16 were found and were relatively intact but had come out of their attachments.
- Cabin interior panels and overhead bins of the main and upper decks which were recovered exhibited only minor damage.
- The wooden boxes which contained the fan blades of the 5th pod engine were loaded in container 24L in the forward cargo compartment and were found broken apart exhibiting no burn marks.
- One passenger oxygen bottle and one portable oxygen bottle were recovered and showed no sign of damage.

Mr. V.J. Clancy, an aviation explosives expert representing Boeing Aircraft Corporation, prepared a preliminary report based on his examinations of certain items of recovered and floating wreckage. Mr. Clancy's report notes the following with respect to floating wreckage:

- A foam-backed floor panel which showed a small number of perforations was recovered. Mr. Clancy recommended that it should be X-rayed and a detailed examination completed.
- One of the lavatory doors had, into its inner surface, a number of fragments of glass mirror - presumably from breakage of a mirror normally fitted into the lavatory. Most of the fragments, buried edgeways, were oriented parallel to each other. The remainder were approximately at right angles to the others. Mr. Clancy concluded that it would be improbable that any reliance could be placed on the penetration by mirror fragments as being indicative of an explosion.
- Three steel oxygen cylinders which were stowed in the forward cargo compartment were recovered. One had been dented apparently by the impact of an object measuring about one to two centimetres. The depression had a maximum depth of about four millimetres.
- A few suitcases recovered among the floating wreckage were examined. Mr. Clancy felt that one might provide useful information. It was of red plastic material with a blue lining. Mr. Clancy reported that plastic material has been found to retain identifiable traces of explosive after long immersion in the sea. Also, the lining which was severely tattered resembled that of one found after an explosion in an aircraft in Angola.
- A wooden spares box was found on the foreshore of Wales. It was of the kind used on the aircraft. It was charred on one side and partially on the bottom. The depth of charring suggested that the burn time was three to four minutes. This box was normally stowed in the aft cargo compartment; however, on this flight it may have been stowed in the forward compartment.
- Two pieces of the cover of an overhead locker originating above either door 2R or 4R were also found on the foreshore. They were partially damaged and blackened by fire. Mr. Clancy concluded that this indicated the presence of fire.
- Two pieces of U-section alloy channel partially filled with plastic foam were found on the foreshore. The alloy was of a kind not used in aircraft structure; however, it could have been from some fitting supplied by a sub-contractor. Also, since the pieces were found near an area where practice firings at targets are carried out off the west coast of the United Kingdom, it could have come from some other source. One piece of the alloy bore marks ("mooncraters") typical of an attack by very high velocity fragments such as produced by an explosion. X-rays showed the presence of a few small particles buried in the foam which Mr. Clancy recommended should be extracted and examined. He also felt that this provided the strongest single indication of an explosion and that it was essential to determine if these pieces came from the aircraft or any of the equipment or cargo aboard the aircraft.

The CASB in its examination of the floating wreckage noted the following:

- The fan cowls of the number 4 engine had a series of five marks in a vertical line across the centre of the Air India logo on the inboard facing side of the fan cowl. These marks had the characteristic airfoil shape of a turbine blade tip. It is possible that a portion of the turbine parted from the number 3 engine and struck the cowl of the number 4 engine.
- The upper deck storage cabinet which was located on the left side had unusual damage to its bottom. A large rounded dent in the bottom inboard edge of this stiff cabinet structure revealed smooth stretching without breakthrough. The damage did not seem to be achievable by inertia or impact forces as the cabinet except for the bottom was undamaged. The damage was considered by

a CASB investigator to be compatible with the spherical front of an explosive shock wave generated below the cabin floor and inboard from the cabinet; however, it is not known if this damage could be caused by some other means.

- The right wing root fillet which faired the leading edge of the wing to the fuselage ahead of the front spar had a vertical dent similar to that which would have resulted had the fillet run into a soft cylindrical object with significant relative velocity. The paint on the inboard chord appeared to be scorched brown in the centre areas of three honeycomb panels. It has been determined that sudden heat can turn these panels brown, but it is not known if other reasons for the discolouration exist. The fillet abutted the fuselage side at the aft end of the forward cargo compartment.
- There was blackened erosion damage to the bottoms of some seat cushions. The damage had an appearance similar to that which would have been caused by an explosive device. It is not known if marine life feeding on the cushions or some other cause could have produced the same effect.
- The charred wooden spares box contained some sand and small shellfish. The flesh from the shellfish appeared to be charred, indicating that the box was subjected to fire after the occurrence.

An electronic device was found among some floating wreckage and was forwarded to the Bhabha Atomic Research Centre for analysis. There was some concern that it could have been used to detonate an explosive device. The device was forwarded to the RCMP who in conjunction with the CASB determined it to be an item manufactured for use in radiosondes (weather balloons) and was not modified as a detonating device.

2.11.2 Wreckage Mapping and Surveying

The Canadian Coast Guard Ship (CCGS) John Cabot was given the task of mapping the wreckage on the ocean floor. On 19 July 1985, the Cabot with a SCARAB deep submersible on board departed Cork. On arrival at the site, and based on surface wreckage distribution and bottom side scan sonar plots, four transmitters were placed on the sea bed. These transmitters provided signals for the ALLNAV navigation system used to accurately plot the sea bed wreckage.

Based on all the data available, the SCARAB was launched on 24 July 1985 to begin the bottom search in position 51∞01.9'N 12∞41.0'W. During the mapping, stage areas were designated for search and each progressive area was determined based on the information gained during the search. The search was conducted using sonar and video. Wreckage found was recorded on video tape and on 35mm positive film.

The first object plotted on the sea bed was a torn suitcase located at lat 51∞02.63'N, long 12∞53.15'W and was the most westerly object located. This suitcase has not been recovered, nor has it been positively identified as having come from the accident aircraft.

As the search progressed eastward, the first positive identification of aircraft wreckage was made at lat 51∞02.9'N, long 12∞49.93'W. Slowly, over a period of about 90 days, a detailed bottom wreckage plot was developed.

While mapping was in progress, some of the wreckage was revisited to obtain additional data. During the transit through areas already searched, wreckage not previously plotted was found, and, in some areas, the density of wreckage physically precluded 100 per cent coverage. Components and major structural items were identified from all sections of the aircraft and when the mapping of the sea bed ended, most of the aircraft had been found and photographed. Although positive identification of each piece of wreckage could not be made, it was decided in late October 1985 that the search phase was essentially completed and wreckage recovery could begin. A bottom wreckage distribution plot is contained separately in an envelope as Appendix F.

2.11.3 Wreckage Distribution

The wreckage distribution as determined by the mapping of the sea bed provided some distinct distribution patterns. The depth of the wreckage varies between about 6000 and 7000 feet, and the effect of the ocean current, tides and the way objects may have descended to the sea bed was not determined, thus some distortion of an object's relationship from time of water entry to its location on the bottom cannot be discounted. In general, the items found east of long 12∞43.00'W are small, lightweight and often made of a structure which traps air. These items may have taken considerable time to sink and may have moved horizontally in sea currents before settling on the bottom. Marks left on the sea bed beside some wreckage does indicate horizontal movement of the wreckage as it settled.

Although badly damaged, sections 41, 42 and 44*, and the wing structure were located in a relatively localized area centred about lat 51∞03.30'N and long 12∞47.80'W, and the wreckage scatter was oriented north/south. The wreckage scatter in this area was so dense that it is probable that some of the wreckage may not have been plotted or photographed.

Sections 46 and 48, including the vertical fin and horizontal stabilizer, extended in a west to east pattern with the westernmost identified aircraft component located at lat 51∞02.90'N and long 12∞50.1'W. The wreckage extended in a line about 110 degrees True to an eastern position of lat 51∞02.04'N and long 12∞41.26'W, a distance of approximately 6.5 nautical miles. The aircraft structure had a random scatter pattern. That is, items such as the aft pressure bulkhead were broken into several pieces, and these pieces were located throughout the pattern.

A?? third area which had some distinctive pattern was that of the engines, engine struts and components and was localized about lat 51∞03.25'N and long 12∞47.4'W in a northwest/southeast orientation. One of the operating engines was displaced 0.5 nautical miles to the north of this area, and it was also geographically separated from the wing structure. The number 3 engine nacelle strut was also separated from the rest of the engine components and was located about one nautical mile to the west-southwest at lat 51∞02.87'N, long 12∞48.05'W. The reasons for the displacement of the number 3 engine nacelle strut and one of the operating engines from the other engines are not known.

*See Appendix D for location of aircraft sections and aircraft body stations (BS).

2.11.4 Photographic and Video Interpretation of Wreckage

2.11.4.1 Photographic Interpretation

All wreckage sighted was recorded on video tape and all major items were recorded on 35mm positive film. During the course of the investigation, several members of the investigation team had the opportunity to view the tapes and photographs. Subsequently, when some items were recovered, it became apparent that the optical image presented on video and still film had some limitation with respect to identification of damage or damage patterns. For example, the sine wave bending of target 7* appeared in the video and photographs as a sine wave fracture, and some of the buckling on target 35 was not evident in either the video or photographs. The interpretation of damage through photographic/video evidence without the physical evidence might be misleading, and any interpretation should take this into account.

2.11.4.2 Engines

The four operating engines were all extensively damaged. A view of the fan blades did not show signs of any rotational damage, and it could not be determined whether any pre-impact failures had occurred. The external damage to the engines varied, and at least one engine appeared to be attached to part of the nacelle strut. Except for the non-operational fifth engine, the engines could not be matched with their original positions on the aircraft.

2.11.4.3 Landing Gear

The nose, wing, and body landing gear were all located. Photographic examination indicated that all the gear were in the 'up' position at the time of impact.

2.11.4.4 Flaps and Spoilers

Positive identification of all the flap and spoiler surfaces was not made. All the flap jackscrews indicated that the flaps were retracted at impact. Of the spoilers identified, six had actuators attached. The actuators were in the fully retracted position.

*See Appendix E for location of targets on aircraft.

2.11.4.5 Section 41

Section 41, consisting of the cockpit, first-class section, and electronics bay and identified as target 192, was found in a near-inverted attitude. This section was severely damaged. The electronics bay and cockpit areas could not be located within the wreckage. The first officer's seat was found on the sea bed near section 41 wreckage.

2.11.4.6 Section 42

Portions of section 42, consisting of the forward cargo hold, main deck passenger area, and the upper deck passenger area, were located near section 41. This area was severely damaged and some of section 42 was attached to section 44. Some of the structure identified from section 42 was the crown skin, the upper passenger compartment deck, the belly skin, and some of the cargo floor including roller tracks. The right-hand, number two passenger door including some of the upper and aft frame and outer skin was located beside section 44. Scattered on the sea bed near this area were a large number of suitcases and baggage as well as several badly damaged containers.

All cargo doors were found intact and attached to the fuselage structure except for the forward cargo door which had some fuselage and cargo floor attached. This door, located on the forward right side of the aircraft, was broken horizontally about one-quarter of the distance above the lower frame. The damage to the door and the fuselage skin near the door appeared to have been caused by an outward force. The fractured surface of the cargo door appeared to have been badly frayed. Because the damage appeared to be different than that seen on other wreckage pieces, an attempt to recover the door was made by CCGS John Cabot. Shortly after the wreckage broke clear of the water, the area of the door to which the lift cable was attached broke free from the cargo door, and the wreckage settled back onto the sea bed. An attempt to relocate the door was unsuccessful.

2.11.4.7 Section 44

Section 44, containing the aircraft structure between body station (BS) 1000 and BS 1480 including that area where the fuselage and wings were mated was located in the same general area as the forward sections of the aircraft. This section was severely damaged but maintained its overall shape and was lying on its right side. Part of the left wing upper skin was attached to the fuselage and a large portion, about one-third of the upper wing skin, separated and was lying against the fuselage crown skin. Some of the body and wing landing gear were found beside this section of the aircraft. The gear was detached from the main structure. The interior of the fuselage was extensively damaged.

2.11.4.8 Wing Structure

The wing structure was located near the forward area of the aircraft structure and towards the northernmost area of the wreckage pattern. The wings showed extreme damage patterns with the top and bottom surfaces separated and the wing surfaces broken into segments.

2.11.4.9 Sections 46 and 48

Sections 46 and 48 contain that part of the aircraft structure aft of BS 1480 and, for purposes of this Submission, will include the horizontal stabilizer and vertical fin. This section of the aircraft was scattered in a west to east pattern about 6.5 nautical miles in length and exhibited severe break-up characteristics.

The aft cargo and bulk cargo doors were found in place and intact, and 5L, 5R and 4R entry doors were identified. Four segments of the aft pressure bulkhead were identified (targets 35, 37, 73 and 296), and one portion of the bulkhead was never located. Much of the fuselage which was forward of the number five door and above the passenger floor area was not located, or if located was not recognizable as having come from a specific area of the aircraft.

Sections of the outer skin below the cargo area were located as was some of the cargo floor structure. Generally, the stringers and stiffeners are attached to the skin; however, the lower frames, which provided the cargo floor support, were detached from the skin. The rear cargo floor from BS 1600 to BS 1760 was located and was found to have little or no distortion; however, the lower skin and stringers were missing. A second portion of the aft cargo compartment floor containing cargo drive wheels and cargo roller trays was located. This structure was severely damaged and mangled.

The tail cone and the auxiliary power unit (APU) housing were located and had received relatively minor damage; however, the APU had broken free and was never located.

A large portion of the outer skin panels showed signs of a force being applied from the inside out. On several pieces of wreckage, the skin was curled outwards away from the stringers and formers. This could have been the result of an overpressure of air or water.

The vertical tail was found in good condition, in a single piece with both rudders attached. The top cap was partially separated and a small dent was noticed in the middle of the leading edge at the bottom. A curved broken portion of fuselage was observed with a portion of the "Y" ring and pressure bulkhead attached. Another small segment of the pressure bulkhead was leaning on the lower section of the tail.

The horizontal stabilizer tail section was located and was one unit with the elevators attached. The actuator jackscrew was attached to the assembly. The stabilizer jackscrew ballnut was observed to be located at the upper jackscrew stop. This equates to a full deflection of elevator trim. Since there is nothing on the DFDR or CVR to indicate a malfunction of the trim, it is deduced that this was not the lead event. It is not known if the position of the ballnut resulted from a pilot trim selection, a result of the initial event or if it rotated to the observed position under the influence of gravity. Two-thirds of the leading edge of the right horizontal stabilizer was missing and the auxiliary spar was exposed. There was localized damage to the right-hand root of the leading edge through about a span of five ribs. The leading edge skin and part of the leading edge ribs were torn downwards. Some localized damage to the root of the left leading edge was visible with the remainder of the leading edge undamaged. There was minor damage to the trailing edge of the outboard left elevator, and a major portion of the inboard left elevator was missing.

2.11.4.10 Passenger Seats

Many of the passenger seats located among the wreckage pattern and identified as having come from sections 46 and 48 appeared to have the aft support legs buckled with little or no damage to the forward support legs. Seats located in the wreckage containing sections 41, 42, and 44 appeared to have varying types of damage, that is, aft support legs only buckled, and all legs buckled. One consistent feature noted was that in the majority of seats located it was possible to ascertain that the seat-belts were not fastened.

2.11.5 Wreckage Recovery and Initial Examination

During the wreckage mapping, some small items were recovered, and an unsuccessful attempt was made to recover a portion of the forward cargo door. On completion of the sea bed survey, an offshore supply ship, Kreuztrum, chartered by the National Transportation Safety Board (NTSB), joined John Cabot for a wreckage recovery operation. Prior to the commencement of the wreckage recovery, the structures group met at the Boeing facility in Seattle, USA and reviewed the video tapes and photographs of the wreckage. Based on their findings, a list of items was identified as being most desirable for recovery. The priority list was prepared by a group in Cork, Ireland, headed by Dr. V. Ramachandran. On 8 October 1985, the John Cabot sailed, and on 9 October 1985, the Kreuztrum sailed for the accident site. The following target numbers and items were recovered during the mapping and wreckage recovery stages of the investigation: 7, 8, 35, 47, 117, 193, 223, 245, 287, 296, 299, 362/396, and 399 (as the location on the aircraft of some of the targets was not known when Appendix E was created, some are not shown in the appendix). The first officer's seat, some suitcases and small debris were also recovered using a metal frame basket. Initial examination of the wreckage was carried out in Cork and then it was transported to Bombay for detailed examination.

2.11.6 Examination of Recovered Wreckage

Although all the recovered wreckage was examined, only those items exhibiting characteristics which provided some evidence as to what may have happened to the aircraft during its final moments of flight are discussed. CASB engineering personnel and other participants examined the recovered wreckage at Cork and Bombay. The observations made during their examinations are discussed below.

2.11.6.1 Target 7 - Lower Fuselage Skin Panel

This skin panel was located below the aft cargo area and contained the keel beam. Target 7 extended from BS 1480 to 1860 and was about eight feet in width and 32 feet in length. The left edge had a full length rivet line tear, and the torn edge was buckled in waves, like the trace of a sine wave. On the right side, between the one-quarter and midway segment, a large flap of skin was attached. The skin was folded aft, diagonally underneath, from right to left and the paint was scoured off the leading edge. The forward break was at the joint at BS 1480. The skin tear located at about BS 1860 was irregular in nature. The forward keel joint splice plate was bent, and the keel joint bolt holes were distorted and elongated.

The left and right trunnion vertical support fittings located at BS 1480 were examined optically using the stereomicroscope. Both trunnions were fractured through the three bolt holes. The right fracture characteristics were consistent with an overload mode of failure. Although most of the left fracture surface was also characterized by overload features, there were heavily corroded areas where the fracture mode could not be confirmed through optical examination. One lug fracture was sectioned from the left trunnion and prepared for scanning electron microscope (SEM) examination. After the corroded area was cleaned, the examination revealed some ductile characteristics on the fracture surface. There was no evidence of intergranular fracture observed to suggest a stress corrosion cracking mode of failure, nor was there any evidence of progressive failure observed. The corrosion appeared to have developed after the accident.

2.11.6.2 Target 8 - Lower Fuselage Skin Panel

This skin panel was located below the aft cargo area and extended from BS 1860 to 1960 and from stringer 46L to 46R. A small section from the aft end along the belly skin splice at stringer 46L was removed for examination. SEM examination revealed that the fracture was characterized by slightly elongated ductile dimples along its length, including areas adjacent to the edges of the rivet holes. On the aft edge of each rivet hole examined, a distinctive shear lip was observed. These features are consistent with an overload mode of failure along the skin splice with an apparent direction of failure from aft to forward.

2.11.6.3 Target 35 - Portion of Rear Pressure Bulkhead

Looking forward from behind the aircraft, this segment of pressure bulkhead occupied the 9 to 1 o'clock position. The piece from 12 to 1 o'clock had the flange from the outer ring attached. The web below the outer ring flange had areas of buckling. From the 11 to 12 o'clock position, the outer edge showed sinusoidal buckling, and the edge sector at 9 o'clock was partially collapsed and its edge was turned under. Samples taken for optical stereomicroscope and SEM examination revealed that the fracture characteristics were consistent with an overload mode of failure. The examination suggested a general direction of failure from the aft to the forward edge of the rear pressure bulkhead panel.

2.11.6.4 Target 296 - Portion of Rear Pressure Bulkhead

Looking forward from the rear of the aircraft, this segment of the bulkhead occupied the 7 to 9 o'clock position. Optical and SEM examination were undertaken on this item.

The fracture along the left-hand edge of target 296 (viewed from the rear) was examined optically prior to removing any representative samples. The fracture was at the rivet line at a skin splice, except for a length of fracture about 15 inches long near the forward end, which was through the skin away from the rivet line. Most of the rivet holes along the fracture path showed some slight elongation and skin deformation.

Representative fracture samples were cut from the left-hand and right-hand edges of the fracture surfaces. Optical and SEM examination revealed that the fracture characteristics are consistent with an overload mode of failure.

2.11.6.5 Target 47 - Aft Cargo Compartment

This portion of the aft cargo compartment roller floor was located between BS 1600 and BS 1760. Based on the direction of cleat rotation on the skin panel (target 7) and the crossbeam displacement on this structure, target 47 moved aft in relation to the lower skin panel when it was detached from the lower skin. No other significant observation was noted. There was no evidence to indicate characteristics of an explosion emanating from the aft cargo compartment.

2.11.6.6 Target 117 - Floor with Seats Attached

These seats were right-section doubles, located between BS 1880 and 1980 and were from rows 46, 47 and 48, F and G (Zone E). The seats were displaced to the left with the rear legs buckled to the left. The front leg supports exhibited only minor damage. The middle and rear doubles had aisle-side seat arms bent to the right. There was no impact damage to the seat backs or seat pans, and all life vests except one were gone from the underseat container bags.

2.11.6.7 Target 399 - Left-Hand Side Triple Seat with Tray Arms

It would appear that this section was from row 18, seats A, B and C, the first set of triple seats aft of door 2L. The notable damage to this unit was as follows: front leg aisle side buckled and crushed in place; front leg window side buckled and crushed in place; forward edge tube to seat broken and bent downwards at joint with fore and aft tube between window and centre seats; and fore and aft tube between centre and aisle seat broken at start of T-connection to rear edge of seat tube. The damage suggests that the failures resulted from vertical loading. All the life-jackets were in place.

2.11.6.8 Target 399 - Fuselage Side and 2R Entry Door

The fuselage segment was located between BS 780 and 940. This piece was badly damaged and buckled inwards along a line through the lower door hinge. There were 12 holes or damaged areas on the skin generally with petals bending outwards. The curl on a flap around a hole had one full turn. This curl was in the outward direction. Cracks were also noticed around some of the holes. Part of the metal was missing in some of the holes. The edges of some of the petals showed reverse slant fracture. In one of the holes, spikes were noticed at the edge of a petal.

When this target was recovered from the sea, along with it came a few hundred tiny fragments and medium-sized pieces. One of the medium-sized pieces recovered with this target was a floor stantion about 35 inches long. It was confirmed that this stantion belonged to the right side of the forward cargo hold. The inner face of the stantion had a fracture with a curl at the lower end, the curl being in the outboard direction and up into the centre of the stantion.

Scientists from the Bhabha Atomic Research Centre, the National Aeronautical Laboratory and the Explosives Research and Development Laboratory in India conducted a metallurgical examination of certain items of wreckage. Their report on target 399 concluded that:

- the curling of the metal on the floor channel was indicative of a shock wave effect;
- the large number of tiny fragments from the disintegration of nonbrittle aluminum was a characteristic indication of explosive forces; and
- the indications of punctures, outward petalling around holes, curling of metal lips, reverse slant fracture, formation of spikes at fracture edges and certain microstructural changes all were indicative of an explosion.

2.11.6.9 Target 193 - Fuselage Side and 2L Entry Door

The fuselage segment was located between BS 720 and 840. The door and fuselage skin were buckled outwards, approximately in line with the buckling on the fuselage and 2R entry door directly opposite.

2.11.6.10 Target 362/396 - Lower Skin Panel - Forward Cargo Area

This section of skin panel was located between BS 720 and 860 and is just below target 399. The skin was badly crumpled and torn and had several punctures. It was pulled free from a large mass of debris which included some mangled cargo floor beams and roller trays. Some of the punctures had a feathered or spiked profile, with spikes angled at approximately 45 degrees to the edge. Other puncture holes gave clear indication of being formed by underlying stiffeners at impact. Two of these holes contained pieces of web stiffener. Most of the punctures were the result of penetrations from inside.

In the preliminary report of Mr. V.J. Clancy, representing Boeing, the following observations regarding target 362/396 were made:

- There were about 20 holes in the lower skin panel clearly resulting from penetration from inside.
- In addition to the fact that perforation was from inside, there were certain features which suggested that they were made by high velocity fragments such as those produced by an explosion.

Mr. Clancy's report describes these features as follows:

- the presence of toothed or spiked edges at some parts of the metal which has petalled out from the perforations;

(Tardif and Sterling, Canadian Aeronautics and Space Journal, 1969, 15, 1, 19-27, obtained spiked fractures in fragments from sheet alloy subjected closely to an explosion. They stated that they had not obtained this effect in fractures otherwise produced.)

- the presence of marked curling (in some cases of more than 360 degrees) of some of the petals;

(Tardif and Sterling stated that such curling was a feature of explosively produced fragments.)

- the virtual absence of scratches or score marks on the petals such as might be expected if something were slowly forced through the metal;
- the virtual absence of other impact marks on the inside surface such as might have been produced by a massive impact with a substantial object, thereby suggesting that the production of at least many of the perforations were separate independent events; and
- the presence of one perforation (identified as number 14) resembling a "bullet hole" that was clearly punched out - a type of hole usually associated with a high velocity missile.
- There was evidence that the forward part of the skin panel had been folded back inward

along the line of station 760 and then bent back again along a line slightly forward of this station.

- Such folding, perhaps violently produced on impact with the water, could have brought broken metal of stringers or stiffeners into forceful contact with the internal surfaces, thus producing perforations outwards. The overlap of such folding would conceivably have covered the area up to station 800 and thus included most of the perforations.
- One hole (identified as number 13) was almost certainly caused by a slipping wire rope used as a sling.
- Part of the inner surface, aft of station 780 was superficially blackened as if by soot from a fire. Swabs were taken of this area for further examination for evidence of fire or explosives.
- A large number (several hundred) of small fragments were recovered. These varied in size from an inch or less to a few inches. They included fragments broken out of sheet metal, and these were reported to be from the same area as T362.
- The production of a large number of small fragments is generally regarded as an indication of an explosion.
- One piece, which was isolated, was about an inch square of sheet alloy with characteristic spikes on one edge similar to those described by Tardif and Sterling.

The following is an excerpt from the report by Mr. V.J. Clancy wherein he gives his opinion and conclusions regarding target 362.

"Opinion

The features discernible to a careful close visual examination point towards the possibility of an explosion but taken alone do not justify a firm conclusion.

Curling of petals and spiked or toothed fractures may be observed in other events than explosions despite the failure by Tardif and Sterling to obtain them in their limited number of attempts. It is probable that these features indicate a rapid rate of failure but not necessarily of a rapidity which could only be produced by an explosion.

A more detailed study, metallurgical and fractographic, is required.

The studies by Tardif and Sterling were done on fragments produced from aluminium alloy in contact with the explosive. Very little information is available on the behaviour of aluminium alloy some distance from the explosive and subjected to attack by secondary fragments. To determine this some trials will be necessary, to obtain reference samples for comparison.

The single "bullet hole," No. 14, strongly supports an explosion hypothesis but, being the sole example of its kind, is not, by itself determinative.

If the forward part of this item was forcefully and rapidly folded back to impact on the other part, it might explain the other features apparent to visual examination. It would require detailed laboratory examination and tests to eliminate this possibility.

The production of a large number of small fragments is generally regarded as a pointer towards an explosive cause but cannot be relied upon unless it is clear that they could not have been produced by some other means. It is known that the break-up of an aircraft at high speed may produce great fragmentation.

The single spiked fragment must be regarded as important but a single specimen is not, by itself, determinative."

Mr. Clancy concluded that:

"there is strong circumstantial evidence that an explosion occurred but neither individually nor collectively do the several pointers give the degree of confidence necessary for a firm and final conclusion, at this time."

With respect to target 362/396, in his report Mr. Clancy recommended:

"that firing trials be carried out projecting various size missiles at targets similar to the material of T362 to obtain reference samples for laboratory comparison with the perforations in T362."

The Indian report, in addition to the observations made by Mr. Clancy, noted the following with respect to the metallurgical examination:

- The microstructure in the various areas examined on target 362/396 confirmed explosive loading in this part of the aircraft.
- The holes and other features observed in targets 362/396 and 399 must have been due to shock waves and penetration by fragments resulting from an explosion inside the forward cargo

hold.

- The chemical nature of the explosive material was not identified. No part of an explosive device, its detonator or timing mechanism was recovered.

2.11.6.11 Examination of Wreckage in India with CASB Participation

The examination of the targets recovered did not reveal any pre-existing defect, premature cracking or pre-impact corrosion damage associated with any of the failures.

3.0 DISCUSSION

From the correlation of the recordings of the DFDR, CVR and Shannon ATC tape, the unusual sounds heard on the ATC tape started shortly after the flight recorders stopped recording. The conversations in the cockpit were normal, and there was no indication of an emergency situation prior to the loud noise heard on the CVR a fraction of a second before it stopped recording. The DFDR showed no abnormal variations in parameters recorded before it stopped functioning. The only unusual observation was the irregular signals recorded over the last 0.27 inches of the DFDR tape. Laboratory tests indicated the possibility that these signals resulted from the recorder being subjected to a sharp disturbance at the time it stopped recording. The other possibility for the irregular signals on the DFDR is that they were caused by a disturbance to the Flight Data Acquisition Unit in the main electronics bay. Since there was an almost simultaneous loss of the transponder signal, this indicates the possibility of an abrupt aircraft electrical failure. The medical evidence showed a general absence of signs indicating that seat-belts were fastened. From the video and photographic examination of the wreckage on the bottom, it was ascertained that the majority of seats located did not have the seat-belts fastened. The above evidence indicates that the initial occurrence was sudden and without warning. The abrupt cessation of the data recorder could be caused by airframe structural failure or the detonation of an explosive device as the initial event. The millisecond noise on a CVR as observed in this case is usually, as described in the available literature, the result of the shock wave from detonation of an explosive device. However, in this case, certain characteristics of the noise indicate the possibility that the noise was the result of an explosive decompression. There is some disagreement regarding the cause and location of the source of the noise heard on the CVR, that is, whether the noise resulted from an explosive device or an explosive decompression and whether the noise originated from the rear or closer to the front of the aircraft.

3.2 Passenger/Flight Deck Area

From the examination of the wreckage recovered and wreckage on the bottom, there is no indication that a fire or explosion emanated from the cabin or flight deck areas. The medical examination of the bodies also showed no fire or explosion type injuries. However, pieces of an overhead locker coming from above door 2R or 4R had been blackened by fire. There was blackened erosion damage to the bottoms of some seat cushions, showing damage possibly from an explosive device, and the upper deck storage cabinet had a large rounded dent in the bottom inboard edge which might have been caused by an explosive shock wave generated below the cabin floor and inboard from the cabinet. It should be noted that the pieces of the overhead locker were found on the Welsh shore some time after the accident, and it is not known if the pieces were subjected to a fire after the accident. Also, it is not known if the damage to the seat cushions and the upper deck storage cabinet could have been caused by other means. Nevertheless, the above evidence suggests that some areas of the passenger cabin may have been subjected to minor fire and explosive damage possibly emanating from below the cabin floor.

3.3 Aircraft Break-up Sequence

The medical evidence showed a proportion of the passengers with indications of hypoxia, decompression, flail injuries and loss of clothing. The incidence of hypoxia and decompression indicates that the aircraft experienced a decompression at a high altitude. The flail injuries and loss of clothing indicate a proportion of the passengers were ejected from the aircraft before water impact. The severity of injuries increased from Zones C to E and was significantly less in Zone C than in Zones D and E.

The wreckage of the forward portion of the aircraft up to and including the aircraft body wheel well area and the wings was lying about 0.8 miles north of the vertical and horizontal stabilizers. Hence, it is likely that the aft portion of the aircraft separated from the forward portion before striking the water. In addition, the wreckage found west of longitude 12∞48' consisted of suitcases and aft cargo compartment lower skin panels. There was also a wide scatter of sections 46 and 48 in an east-west direction, whereas the wreckage of the forward portion was mainly localized within a relatively small area.

The higher severity of injuries in the aft end of the passenger cabin appears to coincide with the break-up of the aft end, sections 46 and 48 of the aircraft. The fact that items from the aft cargo compartment were found further west than the tail section indicates that the aft cargo compartment ruptured first during the break-up sequence of the aft end. The forward portion of the aircraft was highly localized, which indicates that it struck the water in one large mass.

3.4 Aircraft Structural Integrity

As described earlier, the sudden nature of the occurrence indicates the possibility of a massive airframe structural failure or the detonation of an explosive device.

3.4.1 Aircraft Break-up

The examination of the floating wreckage indicates that the right wing root leading edge, the number 3 engine inboard fan cowling, the right inboard midflap leading edge, and the right horizontal stabilizer root leading edge all exhibit damage consistent with objects striking the right wing and stabilizer before water impact. In addition, the right wing root interior area appears to have been scorched briefly by a heat source. The fan cowls of the number 4 engine show evidence of being struck by a portion of the turbine from number 3 engine.

The number 3 engine nacelle strut was separated from the rest of the engine components and was located about one nautical mile to the west indicating that there was some break-up of the number 3 engine before water impact.

The forward cargo door which had some fuselage and cargo floor attached was located on the sea bed. The door was broken horizontally about one-quarter of the distance above the lower frame. The damage to the door and the fuselage skin near the door appeared to have been caused by an outward force and the fracture surfaces of the door appeared to be badly frayed. This damage was different from that seen on other wreckage pieces. A failure of this door in flight would explain the impact damage to the right wing areas. The door failing as an initial event would cause an explosive decompression leading to a downward force on the cabin floor as a result of the difference in pressure between the upper and lower portions of the aircraft. However, examination showed that the cabin floor panels separated from the support structure in an upward direction. Also, passenger seats viewed and recovered exhibited that they had been subjected to an upward force from below. They showed that the seats to the rear in sections 46 and 48 had their back legs buckled, and the seats toward the front had both front and back legs buckled. This indicates the vertical force was greater at the front than the rear of the aircraft. It is possible that this vertical force on the floor was caused by the force of the water during impact, but the rear of the aircraft broke up before impact and therefore any vertical loading on the floor in this area is unlikely to have occurred at impact. Twenty-three passengers also showed evidence of vertical impact injuries. These could have been caused from a force from below during flight or at water impact. Sixteen of these passengers had little or no clothing indicating that some may have been ejected before water impact. Therefore, there is some indication that the upward force on the floor may have occurred in flight and was more severe toward the front.

3.4.2 Aft Pressure Bulkhead

The localized impact mark found on the leading edge of the right horizontal root leading edge is indicative of an object striking the stabilizer in flight before water impact. This suggests that the loss of the tail plane was not the first event. The horizontal and vertical stabilizers were found separated and each was intact and in good condition. Items from the aft cargo compartment were found further to the west of the tail plane. The absence of the type of damage to the tail plane as was found in the Japan Airlines (JAL) Boeing 747 accident where the aft pressure bulkhead failed and which took place shortly after this occurrence, and the rupture of the aft cargo compartment before the loss of the tail indicate that there was not an in-flight failure of the aft pressure bulkhead. In addition, examination of the recovered portions of the bulkhead shows evidence of overload failures from the rear to front only and no evidence of any pre-existing defect, premature cracking or pre-impact corrosion damage.

3.4.3 Target 7 - Lower Fuselage Skin Panel

Target 7 which extends from BS 1480 to 1860 shows a break at the joint at BS 1480. The forward keel joint splice plate is bent and the keel joint holes are distorted and elongated. Some of the fracture surface was heavily corroded. An in-flight failure in this area would cause a massive failure of the aircraft's structural integrity. Further examination showed the fractures to be overload, and there was no evidence of an intergranular type fracture to suggest a stress corrosion cracking mode of failure. The corrosion was concluded to be post-impact and, therefore, there is no evidence to suggest an in-flight failure in this area as the initial event.

3.4.4 Structural Failure

The examination of the floating and recovered wreckage and the analysis of the photos and videos of the wreckage on the bottom failed to indicate any evidence of a failure of the primary or secondary structure as a result of a pre-existing defect. The initial event has been established as sudden and without warning. The abrupt cessation of the flight recorders indicates the possibility of a massive and sudden failure of primary structure; however, there is evidence to suggest that there were ruptures in the forward and aft cargo compartments prior to any failure of the primary structure in flight. Therefore, available evidence tends to rule out a massive structural failure as the initial event.

3.4.5 Explosive Device

A violent explosion occurring within an aircraft in flight usually leads to a complicated break-up mode and sequence of failure. Fractures of metal caused by an explosion are normally different in character to those caused by overstressing or crash impact forces. Shattering of metal into very small and numerous fragments and minute deep penetration of a metal surface are not usually found in aircraft accident wreckage. The size and characteristics of these particles often accompanied by rolled edges, surface spalling, pitting or evidence of heat are indicative of an explosion.

Of the floating wreckage, there is little to indicate the possibility of an explosion:

- the lining in one suitcase was severely tattered;
- although the wooden spares box was burned, this could have happened after the occurrence;
- although pieces of an overhead locker were damaged by fire, it is not known if the burning happened at the time of the occurrence;
- although the pieces of U-section alloy clearly indicated evidence of an explosion, it is quite possible that these pieces were not associated with the aircraft;
- the bottoms of some seat cushions show indications of a possible explosion;
- the inside of the right wing root fillet appears to have been scorched; and
- the deformation of the floor of the upper deck storage cabinet might have been caused by an explosive shock wave generated below the cabin floor and inboard from the cabinet.

It is not known if the suitcase came from the aft or forward cargo compartment, and the location of the seats from which the cushions came is also unknown.

The scorching of the right wing root fillet and the damage to the upper deck cabinet suggest, if there was an explosion, it emanated from the forward cargo compartment.

From the examination of the recovered wreckage, the following deductions can be made:

- Target 47, which is a portion of the aft cargo compartment roller floor, shows no indications characteristic of an explosion emanating from the aft cargo compartment.
- Target 362/396, which is a lower skin panel from the forward cargo compartment is badly crumpled and torn and has about 20 punctures resulting from penetration from inside. It appears that some folding occurred on water impact which brought stringers or stiffeners from the aircraft structure into forceful contact with the internal surface of the panel producing most of the penetrations. However, there are certain punctures which indicate no evidence of impact marks on the inside surface and show evidence of being produced by high velocity fragments. Part of the inner surface of the skin panel appeared to have been blackened by soot from a fire.
- Target 399, consisting of a piece of the skin and stringers on the right side in the area of the forward cargo compartment contained holes and several hundred metal fragments. The damage to the floor stantion and the presence of the fragments are consistent with an explosion.

The examination of the recovered wreckage contains no evidence of an explosion except for targets

362/396 and 399 which contain some evidence that an explosion emanated from the forward cargo compartment.

An explosion in the forward cargo compartment would explain the loss of the DFDR, CVR and transponder signal as the electronics bay is immediately ahead of the cargo compartment.

3.5 Security Aspects

There is a considerable amount of circumstantial and other evidence that an explosive device caused the occurrence. Therefore, it is reasonable to examine the security measures in place on 22 June 1985. The evidence indicates that if there was an explosion, it most likely occurred in the forward cargo hold, not the passenger and flight deck areas or exterior to the fuselage. Although an explosive device could have been placed in a cargo hold in a number of ways, the available evidence points to the events involving the checked baggage of M. and L. Singh in Vancouver. The investigation determined that a suitcase was interlined unaccompanied from Vancouver via CP Air Flight 060 to Toronto. In Toronto, there is nothing to suggest that the suitcase was not transferred to Terminal 2 and placed on board Air India Flight 181/182 in accordance with normal practice. The aircraft departed Toronto for Mirabel and London with the suitcase unaccompanied. Similarly, a suitcase was interlined unaccompanied on CP Air Flight 003 from Vancouver to Tokyo to be placed on Air India Flight 301 to Bangkok. The explosion of a bag from CP 003 at Narita Airport, Tokyo, took place 55 minutes before the AI 182 accident. Therefore, the nature of the link between the two occurrences raises the possibility that the suitcase which was unaccompanied on AI 182 contained an explosive device.

3.5.1 Canadian Security Situation

Canadian security arrangements in place prior to 23 June 1985 met or exceeded the international requirements for civil air transportation. However, before this date, the emphasis was on preventing the boarding of weapons including explosive devices in hand luggage. Hence, the screening of checked baggage was only undertaken in conditions of a heightened threat as was the case with respect to Air India flights.

In Canada, the Department of Transport (Transport Canada) is responsible for establishing overall security standards for airports and airlines, and for the provision of certain security equipment and facilities at airports. By regulation, air carriers are responsible for applying security standards for passengers, for baggage and cargo and for ensuring security within individual aircraft. The RCMP provides airport physical security and responds to criminal incidents.

Air carriers contract for or otherwise provide the personnel who operate the security check-points through which passengers and their carry-on baggage enter the secure area of the airport terminal. These personnel also operate security equipment for the screening of cargo, passengers and checked baggage. Usually, air carriers use the service of private security firms. Transport Canada has established certain standards required for licensed security guards, such as the successful completion of the Transport Canada passenger inspection training program and annual refresher training. As stated earlier, a significant number of the security guards did not meet the criteria with respect to the completion of the training program and refresher training. In addition, the criteria do not require training for the screening of cargo and checked baggage.

ICAO Annex 17 recommends that contracting States establish the necessary procedures to prevent the unauthorized introduction of explosives or incendiary devices in baggage or cargo intended to be carried on board aircraft. For all Canadian airlines, Canadian regulations before 23 June 1985 required a system of identification that prevented baggage, goods and cargo from being placed on board an aircraft if it was not authorized to be placed on board by the airline operator. However, if someone were to purchase a ticket, check in baggage and not board the aircraft, the baggage would in all likelihood have been authorized by the airline to be placed on board the aircraft. Therefore, it was possible to interline baggage unaccompanied and this explains how a suitcase was interlined to AI 181/182 from CP 060. It is not the normal practice of airlines to interline baggage if there is not a confirmed reservation to the destination. In this case, the ticket agent allowed the suitcase to proceed; however, if there had been a confirmed reservation, the suitcase would have been interlined unaccompanied without question.

3.5.2 Air India Security

Air India, as required by Canadian regulation, had a security program. Because of the threat level assessed against the airline, Air India had more extensive security measures than almost any other Canadian or international airline. These measures were generally in accordance with the recommended procedures of the ICAO Security Manual for special risk flights. Air India had also requested and received extra security from Transport Canada and the RCMP for the month of June 1985. For Air India Flight 181/182, Air India provided a security officer from its New York office to oversee the security arrangements at Toronto and Mirabel. The security program at each airport was under the overall supervision of the respective Air India station managers. In Toronto, it was not clear who, if anyone, was undertaking this function.

It is not known if the suitcase interlined from CP 060 was screened before or after the X-ray machine broke down in Toronto. Although baggage not examined by X-ray was screened by a PD-4 sniffer, there are indications that the sniffer could have been ineffective in detecting explosives, especially plastics. Rather than using the sniffer, it would have been more effective to open all bags and physically inspect them. Even though a number of security personnel were not adequately trained in the screening of passengers and baggage, it is not known whether more training would have prevented an explosive device from being placed on board.

Although airline procedures required baggage to be accompanied, the agents checking in passengers in Toronto used a passenger security numbering system but did not number checked-in baggage, and baggage was not correlated with passengers. Therefore, the interlined unaccompanied suitcase from CP 060 was not detected. At Mirabel, checked-in passengers and baggage were numbered so that the number of passengers checking in baggage could be correlated with the number of passengers boarding the aircraft. Had a passenger-baggage correlation been carried out in Toronto, the suitcase from CP 060 would have been detected. The airline procedures would have prevented the placement of the suitcase on the aircraft.

Once loaded on the aircraft, the suitcase would have been placed in container 11L and 12L (see Appendix B) if in the forward cargo compartment, in container 44L or 44R if in the aft cargo compartment, or in position 52 if in the bulk cargo compartment. It could not be determined in which cargo compartment the suitcase was loaded.

Therefore, although the procedures were in place to prevent an explosive device from being placed on board the aircraft in checked-in baggage, there was a breakdown in the X-ray machine used to screen baggage, and there are indications that the PD-4 sniffer was inadequate. Also, the security numbering system used in Toronto was ineffective in preventing unaccompanied interlined baggage from being placed on board the aircraft.

4.0 CONCLUSIONS

The Canadian Aviation Safety Board respectfully submits as follows:

4.1 Cause-Related Findings

1. At 0714 GMT, 23 June 1985, and without warning, Air India Flight 182 was subjected to a sudden event at an altitude of 31,000 feet resulting in its crash into the sea and the death of all on board.
2. The forward and aft cargo compartments ruptured before water impact.
3. The section aft of the wings of the aircraft separated from the forward portion before water impact.
4. There is no evidence to indicate that structural failure of the aircraft was the lead event in this occurrence.
5. There is considerable circumstantial and other evidence to indicate that the initial event was an explosion occurring in the forward cargo compartment. This evidence is not conclusive. However, the evidence does not support any other conclusion.

4.2 Other Findings

Even though they may not be causal or related to the accident, the following additional conclusions can be drawn from the investigation with respect to certain security arrangements and their application pertaining to this flight:

1. In compliance with the International Civil Aviation Organization Annex 17 to the Convention on International Civil Aviation, the Department of Transport of Canada has made regulations requiring foreign aircraft operators who land in Canada to establish, maintain, and carry out certain security measures at airports.

2. In accordance with these regulations, Air India submitted a security program to the Minister of Transport which included security measures with respect to aircraft, cargo, baggage, and passengers.
3. On 22 June 1985, an unaccompanied suitcase was interlined from Vancouver to Toronto on CAP Flight 060 for transfer in Toronto to Air India Flight 181/182.
4. The baggage loaded in Toronto was screened through an X-ray machine process but, during the course of this procedure, the X-ray machine broke down.
5. After the X-ray machine breakdown, an explosives detector was used to screen the baggage; the baggage was not opened and physically examined.
6. The effectiveness of the explosives detector is in doubt.
7. It is not known whether the unaccompanied suitcase interlined from Vancouver was screened before or after the X-ray machine broke down.
8. The security numbering system used in Toronto did not prevent unaccompanied interlined baggage from being placed on board the aircraft.
9. The normal procedures for interlining baggage in Toronto indicate that the unaccompanied suitcase was loaded on Air India Flight 181/182.

REPORT OF THE COURT INVESTIGATING ACCIDENT TO AIR INDIA BOEING 747 AIRCRAFT VT-EFO, "KANISHKA" ON 23RD JUNE 1985

HON'BLE MR. JUSTICE B. N. KIRPAL JUDGE, HIGH COURT OF DELHI

ASSESSORS

DR. V. RAMACHANDRAN MR. J. S. GHARIA
CAPT. J. S. DHILLON MR. J. K. MEHRA
CAPT. B. K. BHASIN

SECRETARY

MR. S. N. SHARMA

FEBRUARY 26, 1986

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INTRODUCTION

1.1.1 On the morning of 23rd June, 1985 Air India's Boeing 747 aircraft VT-EFO (Kanishka) was on a scheduled passager flight (AI-182) from Montreal and was proceeding to London enroute to Delhi and Bombay. It was being monitored at Shannon on the Radar Scope. At about 0714 GMT it suddenly disappeared from the Radar Scope and the aircraft, which has been flying at an altitude of approximately 31,000 feet, plunged into the Atlantic Ocean off the south-west coast of Ireland at position latitude 51∞ 3.6'N and Longitude 12∞ 49'W. This was one of the worst air disasters wherein all the 307 passengers plus 22 crew members perished.

1.1.2 The fact that emergency had arisen was first noticed by Shannon Upper Area Control (UAC) after the aircraft had disappeared from the Radar Scope. The control gave a number of calls to the aircraft but there was obviously no response. Thereafter various messages were transmitted and that is how the rest of the world came to know of the accident.

1.1.3 Shannon Control at 0730 hours advised the Marine Rescue Coordination Centre (MRCC) about the situation which appeared to have arisen. MRCC, in turn, explained the situation to Valencia Coast Station and requested for a Pan Broadcast. Thereafter ships started converging on the scene of the accident and they commenced search and rescue operations.

1.1.4 The aircraft in question - Kanishka, was named after the most powerful and famous king of the Kushanas who perhaps ruled in India from AD 78 to AD 103. Besides being a great conqueror, he was an ardent supporter and follower of Budhism - a religion which preaches non-violence. Emperor Kanishka, however, met a violent end. After 25 years of reign he was killed by some of his own subjects. His life was thus brought to an abrupt end.

1.1.5 It is indeed ironical that the Jumbo Jet which bore the name 'Kanishka' also met with a violent and a sudden end on that fateful morning of 23rd June, 1985.

INITIAL ACTION TAKEN BY THE GOVERNMENT OF INDIA

1.2.1 Initial intimation of the accident was received by Air India who, in turn, communicated the same to Mr. H.S. Khola, Director of Air Safety, Civil Aviation Department, New Delhi. The Accident Investigation Branch of United Kingdom also sent information to the Director General of Civil Aviation, New Delhi to the effect that the accident had taken place on international waters and as such it was India which was the authority to investigate the accident in accordance with the provisions of ICAO Annex 13.

1.2.2 Thereupon Order No. AV.15013/8/85-AS dated 23rd June, 1985 was issued by the Director General of Civil Aviation whereby Mr. H.S.Khola was appointed Inspector of Accidents for the purpose of carrying out the investigation into the aforesaid air accident. This appointment was made under Rule 71 of the Aircraft Rules, 1937.

1.2.3 While search and rescue operations were underway at the site of the accident, a team of officials headed by Dr.S.S. Sidhu, Secretary, Ministry of Tourism & Civil Aviation rushed from India to Cork. The said team was joined by Mr. Kiran Doshi, the Indian Ambassador to Ireland, and also by two officers of the Indian Navy who were attached to the Indian High Commission at London. Subsequently two Medical Experts from India also joined the said Team.

1.2.4 The Indian Team arrived at Cork, Ireland on 24th June, 1985. Representatives of the Governments of United States of America, Canada and United Kingdom also reached there that day. They were met by the representatives of the Government of Ireland.

1.2.5 The members of the Team saw the rescue and salvage operations being conducted. They also visited the Cork Regional Hospital and had discussions with Irish and other Authorities with a view to release the bodies of the victims which were being brought to Cork.

1.2.6 For facilitating the process of investigation the Inspector of Accidents after consulting the representatives of the aforesaid Governments formed the following groups:

a. Structures, Power Plant and Systems Group.
b. Operations Weather & ATS Group.
c. Medical and Human Factor Group.
d. Search & Rescue Group.

The aforesaid groups were required to collect evidence and to submit their respective reports to the Inspector of Accidents.

1.2.7 The bodies which were being recovered were brought to the Cork Regional Hospital for identification and post-mortem. At that time it was considered proper that apart from the two medical experts from India, Wing Commandor Dr.I.R. Hill, who is an expert in aviation pathology should also be called from United Kingdom.

1.2.8 It was also being speculated that the accident may have occurred due to an explosion on board the aircraft. In order to see whether there was any evidence of an explosion which could be gathered from the floating wreckage which was being salvaged, the Government of India requisitioned the services of Mr. Eric Newton, a Specialist in the detection of explosives sabotage in aircraft wreckage.

1.2.9 In order to coordinate and guide the operations of the various ships working at the crash site, a control centre was set up at Cork Airport on 30th June, 1985.

1.2.10 The control centre was manned by representatives of the Governments of Ireland, Canada and United States. The Indian Naval Officers from the High Commission at London were overall in-charge of this centre. After the flight recorders had been recovered the centre continued to function, but the representatives of the United States departed.

1.2.11 For retrieving the Cockpit Voice Recorder (CVR) and Digital Flight Data Recorder (DFDR), a cable ship named Leon Thevenin was engaged which had on board Submersible Robot (Scarab) which was fitted with a Sonar receiver and TV Cameras. The aforesaid ship was engaged and after an intensive search CVR and the DFDR (more popularly known as 'the black boxes') were located and retrieved on 10th July and 11th July, 1985 respectively.

1.2.12 The Government of India, in exercise of the powers conferred by Rule 75 of the Aircraft Rules, 1937 vide Notification No. AV.15013/10/85-A, dated 13th July, 1985, directed that a formal investigation of the accident be carried out. Mr Justice B.N. Kirpal, Judge of the Delhi High Court, was appointed as the Court to hold the said investiation. The Central Government also appointed Dr. V. Ramachandran of National Aeronautical Laboratory, Bangalore; Mr. J.S. Gharia of Explosive Research and Development Laboratory, Pune; Captian J.S. Dhillon, retired Director of Operations, Air India, Bombay; Mr. J.K. Mehra, retired Manager (Technical Training), Indian Airlines, Hyderabad and Captain B.K. Bhasin, Deputy Managing Director of Indian Airlines, New Delhi to act as Assessors of the said Investigation. The Court was required to make its report to the Central Government by 31st December, 1985, which date was later extended to 28th February, 1986.

1.2.13 Mr. S.N. Sharma, Director of Airworthiness, Civil Aviation Department, was appointed as Secretary to the Court vide Ministry of Tourism & Civil Aviation letter No. AV/15013/10/85-A, dated 22nd August, 1985. The appointment was to take effect from 13th July, 1985.

ACTION TAKEN BY IRELAND, INCLUDING THE CORK REGIONAL HOSPITAL

1.3.1 The accident had occurred on the Atlantic Ocean approximately 100 miles south-west of the coast of Ireland. It is the Air Traffic Control at Shannon, Ireland who first became aware of the tragic event.

1.3.2 On coming to know of the accident, various authorities in Ireland took immediate action. The Shannon ATC asked the Marine and Rescue Coordinating Centre there to take emergency action. Thereupon MRCC, Shannon asked Valantia Coast Radio Station (CRS) for a PAN broadcast requiring all the vessels in areas 51N/1250W to keep a look out for the wreckage of an aircraft. The PAN broadcast was repeated and all ships were directed to proceed to the site of accident which was determined as 5101.9N/1242.5 W.

1.3.3 Irish authorities also took great pains in rendering every possible assistance to the Indian and other authorities. Some of the wreckage which had floated in to the west coast of ireland was transported to Cork where a boat house had been hired by the Government of India. The wreckage which was placed in the said boat house was protected from any outside interference by the local Gardai (police).

1.3.4 Irish ships proceeded to the scene of accident and helped in search and rescue operations. The ATC at Shannon gave details about the accident, in so far as they were aware of it, and copies of the ATC tapes were supplied. Aer Lingus, national airline of Ireland, provided assistance by making available its local engineering facilities to the coordinating centre at Cork and also to the other authorities.

1.3.5 Cork is a city having a population of approximately 1,34,000. One of the hospitals which was opened in 1978 is the Cork Regional Hospital which had been set up to meet the needs of the people. This 600-bed hospital was designated for the purposes of the Major Accident Plan of the Southern Health Board and thus became the appropriate centre for the reception of the casualities of the Air India disaster. Since the hospital first opened, it had dealt with a number of major accidents involving road, rail and marine incidents. The Major Accident Plan of the Southern Health Board sets out formally, the strategy and procedure which the hopital is required to follow while deailing with major accidents.

1.3.6 On the morning of 23rd June, 1985 at approximately 11.20 A.M. the hospital was put on alert following the disappearance of the Air India Flight 182 off the south-west coast of Ireland. The first message which was communicated to the hospital indicated that it was unlikely that there would be any survivors. The key hospital personnel were alerted and a meeting was arranged in the hospital for the purposes of discussing and making arrangements for the receipt of the bodies on the basis of the information which was available at that time.

1.3.7 On being informed that there were no survivors in the accident and that the hospital should be prepared to receive a large number of bodies, then, in accordance with the Major Accident Plan, mortuary facilities were improvised by appropriating the gymnasium attached to the Deparatment of Rheumatology. Subsequently it became evident that additional mortuary and postmortem facilities would be needed. In order to decide where the second mortuary was to be located, the hospital had to take into cosideration the following factors:-

(a) The number and the condition of the bodies;

(b) The period during which the bodies would be retained;

(c) The hospital would be required to provide an on-going service for in-patients, out-patients and serious accident and emergency cases;

(d) To avoid unnecessary internal transport problems, the bodies should be near the Post-Mortem and Pathology Departments; and

(e) To facilitate traffic flow in the hospital curtilage and to to aviod unduc public access.

The hospital authorities accordingly located the second mortuary in a recreational room adjoining the gymnasium.

1.3.8 Two rooms were put at the disposal of the Garda (Police) authorities for use as Garda Control Rooms in the hospital. Telecommunications lines were set up immediately for their assistance as the Gardai was responsible for the forensic and identification procedures in regard to the bodies brought to the hospital.

1.3.9 A small Co-ordinating Group was set up consisting of the Chief Executive Officer of the Southern Health Board, Medical Co-ordinating Officer, Press Liaison Officer, a Senior Registrar who knew about Indian customs and traditions and a Hospital Administrator. This small Co-ordinating Group, whose membership never changed, worked together and were capable of assessing situations, making decisions, liaising with other agencies and services and undertaking with other agencies and services and undertaking responsibility for hospital press releases. Apart from individual contact between members, the Group had a standing arrangement to meet every morning and afternoon. In the late evening, the Group, met the Garda, Hospital Pathologists and key staff members for a general review of progress and to decide the tasks and objectives for the following day.

1.3.10 Within a few hours, the Co-ordinating Group realised that the hospital was a world focal point of the international media, and was required to:

a. Accommodate 131 bodies;

b. Provide pathological and Radiological services for each body;

c. Co-operate with the Garda in their forensic work;

d. Cater for relatives of the victims;

e. eet representatives of foreign Governments; and

f. Keep press agencies informed.

Thus began an operation which demanded a quick and dedicated response from all staff working in close cooperation with the Gardai. At the same time, the hospital was required to continue functioning in the delivery of normal in-patient and out-patient services. The Major Accident Plan, apart from alerting staff, provided the framework and basis for many decisions taken as events evolved. An additional advantage in the practical implementation of the

Plan was the fact that the hospital had staff experienced in dealing with previous emergency situations and could marshal the extensive manpower resources available.

1.3.11 The hospital authorities also made the following arrangements:-

a. They briefed Government Ministers and Officials and other dignitaries who visited the hospital. They were taken round the hospital and were explained the arrangements which had been made.

b. Some of the services which were being provided at the hospital were either discontinued or postponed.

c. Bodies were received at the hospital and arrangements were made on their arrival to numerically label and certify as dead all the 131 bodies which were initially received. All the bodies, at that stage, had been individually placed in special purpose body bags. Initially, bodies were placed on tables, but, it was subsequently decided that it would be much easier for all concerned to place the wrapped bodies on polythene covered floors.

d. Arrangements were made for carrying out of the post-mortem examinations. Three Pathologists from other city Hospitals were recruited to augment the existing staff. Dr. Harbison, State Pathologist, was in charge of this aspect of the operation. All the post mortem were completed by 27th June, 1985.

e. For the preservation of the bodies five refrigerated containers with a capacity to hold 140 bodies were hired. These containers were fitted with timber shelving.

f. Government Information Service was located in the Matron's Office.

g. The Army provided troops for the unloading of the bodies from the helicoplers at Cork Airport. They also supplied and erected two large tents for storing bodies after post mortem and embalming. Under Garda escort transport of all the bodies which were recovered was undertaken by the Army and these arrangements were co-ordinated by Chief Ambulance Officer.

h. Embalming was carried out in the hospital and bodies were then coffined and the coffins with appropriate number plaques were subsequently laid out in the numerical order on the floor when all the post mortems had been completed.

I. All the embalmed bodies were x-rayed (whole body). The examination was completed on 28th June, 1985.

j. A provision was made for a 24 hour extended catering service to meet the needs of staff, Gardai, Army and other personnel involved including visiting relatives.

k. A simple plan was devised for dealing with the relatives. This was a sensitive task bearing in mind the varying religious beliefs, customs and cultures generally of the visiting relatives. Their main function was to provide moral and emotional support to the relatives.

l. As identification progressed, special arrangements were made to assist the relatives. They were met by teams of councellors from the Hospital as soon as they disembarked at Cork Airport and subsequently at the Hospital. The relatives had the same Counsellor and Garda Officer throughout the identification procedure. An interesting development noted was that each family group of relatives, their Counsellor and Garda officers formed a single family unit transcending cultural barriers. On subsequent visits, families appeared lost if their own Counsellor was not immediately available to them. Usually, the Counsellor and the Garda officers accompanied the relatives, at their own request, for visual identification.

m. When plans were being formulated to receive the relatives, it had been hoped to discourage them from coming to the Hospital until such time as progress had been reported on the identification process. Practical experience subsequently proved this strategy to be inappropriate for a number of reasons. Apart from facilitating the collection from relatives of salient information on the victims, the most fundamental reason was the underestimation of the abiding wish of the relatives to be physically and psychologically as close as possible to their deceased dear ones. Moreover, it was the express wish of almost all relatives on arriving at Cork Airport to proceed directly to Cork Regional Hospital; there, they were given an informal talk by Air India and Garda representatives on the progress of the investigation and the methods of identification. Many of the relatives visited the hospital daily and remained there throughout each day.

n. Coach trips were arranged to Bantry Bay for the relatives; Bantry Bay is the nearest landmark from the site of the crash. Relatives visited the seaside to pay their last respects to the departed souls. These were solemn occasions when each relative prayed in his/her own way. Rose petals and wreaths were immersed in the sea in keeping with Indian traditions. The visit gave them mental satisfaction and in the early days following the crash, helped in diverting their attention while the investigative procedures were being completed.

o. A small number of visiting relatives had personal medical problems and they were treated at out-patient and in-patient levels at the Hospital.

p. Cork/Kerry Tourism Organisation helped to co-ordinate the accommodation of relatives between a number of hotels. Approximately seven hotels were used within a radius of twenty miles of the city for this purpose.

g. A number of press conferences were held. The Chief Executive Officer, directed that press photography and television filming be not allowed within the hospital in deference to the privacy of patients and in respect for the relatives wishes.

r. Responsibility for the identification of bodies rested with the Garda Authorities and the conditions under which bodies were released are summarised as follows :-

(I) Satisfactory identification
(ii) Consent of the Coroner
(iii) Proper authentification of the person claiming each body

All bodies arriving at Cork Regional Hospital had already been numerically labelled by the Garda Authorities. To prevent confusion, the bodies were then given identical numbers under the hospital major accident labelling system and this proved to be very helpful later during identification, investigations and recordings. A routine was established for examining and recording information about each body. Teams consisting of a doctor, nurse, clerical officer and Garda made the necessary examination, labelling and recording each body and such details as :-

a. Sex
b. Adult or child
c. Clothing
d. Jewellery and personal effects
e. Injuries
f. Obvious scars

Death was confimed in all cases. Each body was fingerprinted and photographed by Garda Technical Bureau Staff. Each body was subjected to autopsy, forensic and dental examination. All bodies were embalmed and following embalming, were photographed and x-rayed. This procedure was completed in respect of all the bodies by the evening of the fifth day of the crash. The data from these investigations was collated on an Interpol form (pink) for each body. Similar ante-mortem information was obtained from the relatives about each victim on a separate Interpol form (yellow). When the information on the pink and yellow forms matched beyond doubt, a positive identification was made. It might be noted that the photographs originally taken by the Garda Technical Bureau Officers of each body were matched with photographs of the 131 embalmed bodies. When a positive identification was made, the relatives were shown photographs of the deceased. These photographs were available for inspection by Saturday, 29th June. As positive identification progressed,

personal effects were added to the identification process and finally, visual identification took place. For obvious forensic reasons, positive identification was necessarily slow and meticulous and, in fact, was made more difficult by reason of the fact that only 131 bodies out of the 329 passengers and crew were recovered. All 131 bodies were identified, the first positive identification was made on 27th June and the last on the 6th August. Each coffin had affixed to it a metal plaque clearly indicating the number assigned in the first instance to the body it contained. The bodies when identified were released by the Garda Authorities through the undertaker. The Coroner directed that a reasonable time would have to elapse before unidentified bodies could be disposed off an this was to be by way of burial. The final date for this purpose was fixed for 3rd August, 1985, but, this date was subsequently extended to 6th August, 1985, to coincide with the date of the Civic Commemoration Ceremony.

(s) Bodies of victims for identification were brought individually to separate viewing rooms, suitably decordated with flowers and with incense burning. Visual identification was performed in private by the relatives and moreover, it allowed them to pay their last respects in their own religious beliefs. An adjoining room was also made available where they could grieve in private. Subsequently, it was learnt that these arrangements were much appreciated by the relatives who articulated this appreciation by commenting that the arrangements provided were as near as possible to the funeral rites observed in their domestic communities. The relatives were of the opinion that the special arrangements made conveyed a deep personal and individual response to the dignity of each victim which might otherwise be lost with such a large number of bodies.

(t) Procedures were laid down which were required to be followed and observed for the purposes of preventing infection.

(u) On 6th August, 1985 an interdenominational service was held in the morning. In the evening on that day a Civic Commemoration Ceremony was held which was attended by a large number of persons.

(v) A formal inquest was held by the Coroner in the Courthouse, Cork, which commenced on 17th September, 1985 and ended on 23rd September, 1985. The Coroner's Jury returned a verdict in accordance withmedical and pathological evidence.

ACTION TAKEN BY THE COURT

1.4.1 Despite the fact that Mr. H.S. Khola had been appointed as the Inspector of Accidents under Rule 71 of the Aircraft Rules, the Government thought it proper to appoint Mr.Justice B.N. Kirpal as the Court to investigate into the circumstances of the accident.

1.4.2 The appointment of the Court was made under Rule 75 of the Aircraft Rules, which is as follows :-

"75. Formal Investigation - Where it appears to the Central Government that it is expedient to hold a formal investigation of an accident it may, whether or not an investigation or an inquiry has been made under rule 71 or 74, by order direct a formal investigation to be held and with respect to any such formal investigation the following provisions shall apply namely

(1) The Central Government shall appoint a competent person (hereinafter referred to as "the Court"), to hold the investigation, and may appoint one or more persons possessing legel, aeronautical, engineering, or other special knowledge to act as assessors, it may also direct that the Court and the assessors shall receive such remuneration as it may determine.

(2) The Court shall hold the investigation in open court in such manner and under such conditions as the Court may think fit most effectual for ascertining the causes and circumstances of the accident and for enabling the Court to make the report hereinafter mentioned.

(3) (i) The Court shall have, for the purpose of the investigation, all the powers of a Civil Court under the Code of Civil Procedure, 1908 and without prejudice to those powers the Court may :-

(a) enter and inspect, or authorise any person to enter and inspect, any place or building, the entry or inspection whereof appears to the court reguisite for the purpose of the investigation; and

(b) enforce the attendance of witness and compel the production of documents and material objects; and every person required by the Court to furnish any information shall be deemed to be legally bound to do so within the meaning of section 176 of the Indian Penal Code.

(ii) The assessors shall have the same powers of entry and inspection as the Court.

(4) The investigation shall be conducted in such manner that, if a charge is made or likely to be made against any person, that person shall have an opportunity of being present and of making any statement or giving any evidence and producing witness on his behalf.

(5)Every person attending as a witness before the Court shall be allowed such expenses as the Court may consider reasonable: Provided that, in the case of the owner or hirer of any aircraft concerned in the accident and of any person in his employment or of any other person concerned in the accident, any such expenses may be disallowed if the Court, in its discretion, so directs.

(6)The court shall make a report to the Central Government stating its findings as to the causes of the accident and the circumstances thereof and adding any observations and recommendations which the Court thinks fit to make with a view to the preservation of life and avoidance of similar accidents in future, including, a recommendation for the cancellation, suspension or endorsement of

any licence or certificate issued under the rules.
(7)The assessors (if any) shall either sign the report, with or without reservations, or state in writing their dissent therefrom and their reasons for such dissent, and such reservations or dissent and reasons (if any) shall be forwarded to the Central Government with the report. The Central Government may cause any such report and reservation or dissent and reason (if any) to be made public, wholly or in part, in such manner as it thinks fit."

1.4.3 The Court, which is appointed under Rule 75, does not act as a 'Commission of Inquiry' which is usually appointed under the Commissions of Inquiry Act to inquire into any definite matters of public importance. The role of the Court, on its appointment under Rule 75 of the Aircraft Rules, is essentially that of an Investigator. It is for this reason that no procedure has been prescribed in the Rules which the Court is required to follow. While carrying out its functions, the Court is not only required to comply with the provisions of the Aircraft Act, and the Rules framed thereunder, but it must necessarily also keep in view the provisions of ICAO Annex. 13.

1.4.4. As an Investigator, investigating into an accident, the Court had to perform multi-farious duties and functions. Before referring to them, it would be pertinent to point out that whereas an Inspector of Accidents, who is appointed under Rule 71, would normally be belonging to the Civil Aviation Department and would have all the machinery available to him for conducting the investigation, the Court, when it is appointed to hold an investigation under Rule 75, lacks the basic infrastructure to conduct the investigation of such a magnitude. Assessors are appointed to assist the Court but the actual investigation work cannot be carried out by them. Despite these handicaps, the investigation continued smoothly primarily due to the fact that whenever directions were issued by the Court to any of the participants before it or to the Civil Aviation Department or any other Organisations, the directions of the Court were readily complied with. On a few occasions it also became necessary to require the Assessors to conduct the investigation, which they did with the help of other organisations.

1.4.5 As an Investigator, the first task which was undertaken was to see that the tapes from the Cockpit Voice Recorder, which had been salvaged, were recoverd from the recorders and subsequently analysed. Requisite directions were issued and the tapes were removed from their respective recorders on 16th July, 1985. This operation was carried out at the Air India workshop at Santacruz in the presence of the accredited representatives of Lockheed (manufactures of DFDR), Fairchild (manufacturers of CVR), Boeing Airplane Co., Canadian Air Safety Board (CASB), National Transportation Safety Board, USA (N.T.S.B), Air India and Government of India. The tapes so recovered were subsequently played and analysed.

1.4.6 On an appointment being made under Rule 75 the Court would become incharge of overall investigation of the accident. In that capacity, and in order to effectively discharge its functions, it became necessary for the Court to undertake the following tasks :-

(a) For getting first hand information, the Court had to personally inspect the wreckage which had been recovered and was housed in a boat yard in Cork. While in Cork opportunity was also taken to go to the Cork Regional Hospital and to have discussions with and be briefed by the hospital staff. A trip was also made to Shannon with a view to see and understand the working of the Secondary Radar System which was in use there. On this visit the original ATC tape, which contained communication betwen Kanishka and the ATC, was also heard.

As it was suspected that there may be a link between the blast which had taken place at Narita Airport on 23rd June, 1985 and the accident to Air India's flight 182, it was felt necessary to inspect the site of the bomb blast at Narita Airport.

On the aforesaid visit to Tokyo, the site where the blast had taken place was inspected which gave some, though very vague, idea of the detonating power of the blast. While in Tokyo meetings and discussions were also held with the police and Aviation Authorities. The Court also had the advantage of being able to meet members of the team investigating into the Japan Airlines Flight JL 123 accident which had occurred near Tokyo on 12th August, 1985. Similarities and dissimilarities between the two accidents were, to some extent, noticed and some information was exchanged.

Information was received, that some floating wreckage had been picked on the coast of England and it was possible that some of the places, which were so received, should be subjected to further detailed chemical and metallurgical examination. In order to decide this, it became necessary to visit RADRE, Kent, U.K. As a result of the inspection and the discussions there, it was decided by the Court that the pieces so recovered should be sent to BARC at Bombay for further analysis.

(b) Directions had to be given, from time to time, with regard to the mapping and salvaging of the wreckage which was being effected. It had to be decided as to how, and in what areas, the Scarab should continue to map the wreckage and take video films and still photographs. Based on the information received therefrom and after discussions with the experts, both Indian and foreign, a list was drawn up indicating the items which had to be salvaged. As the weather was likely to be unpredictable, with a possibility of its deteriorating rapidly, a priority list of items to be salvaged had also to be prepared, and this was done. In view of the fact that the Canadian ship John Cabot and the Scarab had a limited capacity, with regard to the size and weight of pieces which could be lifted from the bottom of the ocean, decision had also to be taken with regard to the deployment of another ship. As a consequence thereof a ship 'Kreuzturm' was also engaged in salvage operations.

(c) Directions had also to be given assigning work and duties to different teams of persons. As an Investigator, the Court was incharge of the entire work of investigation which was being carried out in different parts of the world. It not being possible for the Court itself to undertake all the tasks, decisions had to be taken as to how the investigating work was to progress and who would carry out the directions issued from time to time. For example, immediately after reaching Cork on 25th July, 1985 it was felt necessary that a team should be immediately sent to Canada in an effort to get relevant information from there in connection with the flight AI 182. Accordingly, a team of 3 persons headed by Mr. H.S. Khola was directed to proceed to Canada immediately. As a result of the efforts put in by this team, and with the considerable amount of cooperation, help and assistance rendered by the Canadian Authorities valuable information was received by the Court having direct bearing on the investigation. Yet another example in this regard was of requiring Dr. V. Ramachandran, one of the Assessors and an expert in Metallurgy, to be stationed on board the salvage ships during the recovery operations. The procedure which had to be followed by him was also determined. Information about the progress of the salvage operations was communicated on telephone to the Court at all times of day and night. On receipt of such information further instructions, when ever necessary, used to be issued.

(d) Discussions were held with the Indian experts in order to understand some of the complicated questions which had arisen during the investigation.

In an effort to be able to fully appreciate the effect of decompression, the Court visited the Institute of Aviation Medicine at Bangalore where explsoive decompression was simulated for the Court's benefit. Discussions were also held with other experts of aviation medicine who were also given copies of the post-mortem reports for their opinion. National Aeronautics Laboratory was also visited in Bangalore where meeting was held with experts in aerodynamics, structure and metallurgy. Visits to Bombay where more frequent and necessary so that the Court could get first hand information with regard to the work which was being done at BARC.

The investigation involved looking into matters concerning aviation, electronics, medicine etc. Not being familiar with these branches, the discussions which were held, were of immense help and assistance to the Court who had to understand all the evidence and information which it was gathering.

(e) The accident had attracted world wide attention. Right from the start of the investigation by the Court when the recorders were first opened in Bombay on 16th July, 1985 till the conclusion of the hearing, the Press and the TV were eager for information. It was felt that rather than the media resorting to speculation of getting wrong information, the Court itself or its representative should, as and when necessary, brief the media. In this connection interviews were given, both in India and abroad, which were broadcast over the television and printed in the Press. As a result of this, correct information was disseminated with regard to the progress of the investigation without disclosing the Court's opinion on the evidence which had been received.

(f) Finally, the Court had to conduct the formal investigation in Court. For this purpose it laid down the procedure which would be followed. Rule 75 of the Aircraft Rules required that the investigation would be in open court. It was, however, felt that in this particular case it would be advisable that some evidence should be obtained in Camera.

The Court, accordingly, recommended that necessary amendment should be made in Rule 75 so that the Court was given the power to hold certain proceedings in camera when the circumstances so warranted. The suggestion of the Court was accepted and that resulted in Rule 75(2) being amended and, as a result thereof, the Court was given the power to hold proceedings in camera if the stipulated conditions existed.

COMMENCEMENT OF FORMAL INVESTIGATION

1.5.1 The object of setting up a court to investigate into an accident is primarily to find out the causes and circumstances of the accident and thereafter to make recommendations. Such an investigation is not in the nature of an adversary litigation between the participants before the Court. As such it should be the endeavour of all the participants to assist the Court in arriving at a correct conclusion.

1.5.2 Under Rule 75 of the Aircraft Rules, the procedure which has to be followed in the investigation of an accident is to be determined by the Court itself. While laying down the procedure which is required to be followed, the endeavour of the Court has necessarily to be to adopt such procedure which would help the court in being able to complete its task satisfactorily, and in the shortest possible time. Whenever an accident takes place, it is of utmost importance that the cause of the accident must be ascertained at the earliest so that if any remedial measures are to be taken then those steps should be taken without any undue delay.

1.5.3 In the present case, there were a number of factors which had to be kept in view while determining the procedure whichshould be followed. The accident had occurred over international waters and approximately at a distance of about 5000 miles from the place where the investigation was to be conducted, namely, New Delhi. The ill fated flight itself had commenced from Canada, and this meant that most of the evidence would only be available there. Matters were not simplified by the fact that the debris itself was lying at the bottom of the ocean, 2 miles under water. It became apparent, at the very beginning, that to recover the entire debris would be a superhuman task and it will not be possible to do so within the limited time span which was available.

1.5.4 It was thought that it would be of assistance if all the participants got together so as to determine what procedure should be followed. The procedure had to be such which would give an effective opportunity of hearing to all the participants, without in any way unduly prolonging the investigation.

1.5.5 The Court decided that, in order to obtain the views, it would be necessary and advisable to have a Pre-hearing Conference.

1.5.6 The first decision which had to be taken was as to who were to be given a participants status. Keeping inview the provisions of Annex 13, participants status was given to Governments of Ireland, Canada, USA and India. Similar status was also given to Boeing Airplane Co. and Air India. As there might have been some similarities or dissimilarities between the present accident and the accident of the Japan Airlines Boeing 747-SR and also because there may have been a possibility of the present accident being linked with the explosion which had taken, place at Narita Airport, Tokyo on 23rd June, 1985, an Observer's status was given to the Government of Japan.

1.5.7 Notices for holding of the Pre-hearing Conference on 16th September, 1985 were accordingly issued on 29th August, 1985. The agenda for the Conference was to be as follows :-

a. To make suggestions to the Court for its consideration, regarding the procedure to be followed in the conduct of the formal proceedings in the Court.
b. To draw up a tentative list of witness.
c. To draw up a tentative list of exhibits.
d. To determine the areas to be inquired into
e. To fix a date for the commencement of the public hearing.
f. Any other matter with the permission of the Court.

1.5.8 Except for the Government of Japan, all the other participants were represented at the said Pre-hearing Conference. After discussions had been held between the Court and the Participants, some decisions were arrived at regarding different items of the agenda.

1.5.9 Firstly the following points were framed, indicating the areas to be inquired into by the Court:

a. Whether the accident was caused by a structural failure?

b. Whether the accident was caused by some human effort?
c. Whether the accident was caused by some criminal act?
d. Whether the accident was caused by an external non-criminal act?
e. Based on the evidence on record, what steps should or can be taken so as to ensure greater air safety.

1.5.10 It was further decided that, as suggested by all the participants, at least critical portions of the wreckage should be recovered.

1.5.11 With regard to the recording of the evidence it was decided that evidence will, in the first instance, be taken by filling affidavits or by filling statements alongwith affidavits. Copies of the same were to be supplied to the other participants for their consideration. These affidavits were to be filed on or before 18th October, 1985 and a second Pre-hearing Conference was to take place on 30th October, 1985 at New Delhi when it was to be decided as to which of the persons should be called for cross-examination. It was determined that it is only thereafter that hearing would commence in open court.

1.5.12 A tentative list of witnesses was also drawn up and it was decided that on the next date names of more witnesses may be added and, furthermore, the participants would be free to file any affidavits which they deem fit including affidavits in rebuttal.

1.5.13 Another important decision which was taken at the Pre-hearing Confence was that a Structural Group was formed consisting of (1) Mr. H.S. Khola or his nominee (2) Representative of the Canadian Government (3) Representative of NTSB, USA (4) Representative of Boeing Airplane Co., USA (5) Representative of Air India. This group was entrusted with the task of examining and analysing, initially in Seattle, USA, the video films and the still photographs of the wreckage. This group was also to indicate and decide the items of priorities of wreckage which had to be recovered. The report of this group was required to be submitted by 18th October, 1985. The report of the work done at Seattle was in fact submitted only on 25th October, 1985. This group was also given the liberty to associate any other experts or persons from Boeing or any other Authority. The group was also to inspect the floating wreckage which had already been salvaged and any further wreckage which would be salvaged.

1.5.14 Although the affidavits by way of evidence had to be filed by 18th October, 1985, it was only the Government of Ireland who filed an affidavit by at date. On behalf of the Government of India, an application was filed asking for more time. The reason stated was that the affidavit which had to be filed was to be of Mr. H.S. Khola but he was out of India as he was heading the structures group which was evaluating the video films and photographs at Seattle. The Court had no option but to grant further time to the Union of India to file its affidavits and this necessarily resulted in the adjournment of the Pre-hearing Conference which had been fixed for 30th October 1985.

1.5.15 As the salvage operations were reaching a critical point it became necessary for the Court to go to Cork on 27th October, 1985. Taking advantage of the presence of the Court in Cork, other participants also came there. Besides them, representatives of CP Air and Air Canada also arrived. At one of the informal meetings between the Court and the representatives of the participants, applications were filed by CP Air and the Air Canada, inter alia, praying that they should be permitted to participate in the investigation. It might be mentioned here that CP Air had interlined one of the passangers from Vancouver to AI-182, while Air Canada was the handling agents in Canada of Air India. After hearing the participants it was decided that participant status should also be given to these two viz., CP Air and Air Canada.

1.5.16 The participant had all filed their affidavits by way of submissions. The Court indicated that formal hearings would be held for the purpose of cross-examining some of the witnesses about three weeks after the receipt of all the reports of the various groups. While in Cork, in the first week of November, 1985 some of the salvaged pieces of the wreckage were brought there. After they were inspected by all the participants and their advisers, who were present in Cork, it was decided by the Court that further detailed metallurgical and other examination of those pieces would be done at BARC, Bombay. In order that there should be no undue delay the Court decided that a Group be constituted consisting of expert representatives of all the participants and also the nominees of the Court. This group was asked to carry out metallurgical and other examination of some of the critical pieces salvaged and give its report to the Court. The group consituted as a 'Committee of Experts' was as under :-

a. Mr. A.J.W. Melson, Canadian Aviation Safety Board, Canada.
b. Mr. R.K. Phillips, Canadian Pacific Air, Canada.
c. Mr. T. Swift, Federal Aviation, Administration, USA.
d. Mr. R.Q. Taylor, Boeing Commercial Airplane Co., USA.
e. Mr. J.P. Tryzl, Boeing Commercial Airplane Co., USA.
f. Mr. J.F. Wildey II, National Transportation Safety Board USA.
g. Mr. S.N. Seshadri, Bhabha Atomic Research Centre, India (Coordinator).

1.5.17 The parties were informed in Cork that the report of Mr. H.S. Khola, Inspector of Accidents, would be available by about 8th November, 1985. It was then decided that the statements of the first batch of witnesses should be recorded from 20th November, 1985. It was also agreed that if some of the reports of the experts were not received, further examination of the witness may have to postponed.

1.5.18 After receipt of the report from Mr. Khola. on the 8th November, 1985, a notice of the holding of the Public Hearing was issued to all the participants. This notice indicated that the hearing would commence on 20th November, 1985. In the meantime, a Public Notice was also published in the daily "Times of India" in Delhi and Bombay editions on 21st October, 1985 in which it was stated as follows :-

NOTICE AIR INDIA KANISHKA ACCIDFNT INVESTIGATION

The Government of India, vide Notification dated 13th July, 1985, appointed Hon'ble Mr. Justice B.N. Kirpal as a Court to investigate into the accident to Air India's Boeing 747 aircraft VT-EFO (KANISHKA) near the Irish Coast on 23rd June, 1985, when the aircraft was engaged on a scheduled passenger flight from Montreal to Bombay via London and New Delhi.

Any person having direct knowledge, who may desire to make representation concerning the circumstances or causes of the accident, may do so in writing in the form of an affidavit duly attested by an Oath Commissioner or a Notary Public and address the same to the undersigned so as to reach him within 15 days of the publication of this Notice.

S.N. SHARMA SECRETARY COURT OF INVESTIGATION COURT NO.10,DELHI HIGH COURT SHERSHAH ROAD NEW DELHI - 110 003

Pursuant to the aforesaid public notice no affidavit was received from any one.

1.5.19 The public hearing commenced on 20th November, 1985 and the first session concluded on 28th November, 1985. During this period statements of Mr. H.S. Khola, Wing Commander Dr. I.R. Hill and Sgt. Atkinson of R.C.M.P., Canada were recorded.

1.5.20 Till that date, report on the examination of the salvaged pieces had not been received. It was anticipated that the report would be available by mid December, 1985. In order to give the parties sufficient time to study the reports of all the experts it was decided that further evidence would be recorded from 22nd January, 1986.

1.5.21 After the reports were received from BARC; AIB; Farnborrough; NTSB; USA; and Mr. Bernard Caiger of CASB, Canada and the copies of the same had also been received by all the participants, recording of evidence commenced from 22nd January, 1986 and concluded on 30th January, 1986. In all statements of 13 witnesses were recorded.

1.5.22 At this stage it will be pertinent to make a few observations with regard to the procedure which was laid down for recording of evidence etc. As already indicated, most of the evidence was such which was not available in India. As a Court investigating the accident under the provisions of Aircraft Rules, it had no jurisdication to compel attendance of any witness from abroad. The Court also had no jurisdication, either under the Rules or under the provisions of Annex 13, to require any witness to be examined in a country other than the one in which the Court is holding the investigation. The Court was informed that, if called upon, some of the persons who were outside India may not be inclined to testify before the Court.

1.5.23 Faced with the aforesaid difficulty it became necessary, therefore, to evolve a procedure which would enable the Court to get the requisite information. As long as the Court was satisfied that the information which was being received was one which had been truthfully given by a person, it was immaterial as to the manner in which the information was received. It is for this reason that it was decided that evidence will, in the first instance, be given by way of affidavits. It was also provided that the statements could also be filed along with affidavits. This latter course was permitted so as to enable some of the statements, which had been recorded by members of the Royal Canadian Mounted Police, to be placed before the Court. These statements, of course, had to be accompanied, as they were, with the affidavits of the persons who had recorded the statements.

1.5.24 At one stage, by a formal application in writing, Air India had protested against this procedure being followed. By order dated 22nd November, 1985, an objection by Air India to the filing of the statements accompanied by affidavits, was dealt with by the Court in the following words :-

"With regard to the affidavits which have been filed by the Government of Canada, I would only like to observe in the Pre-hearing Conference on 16th September, 1985, it was decided that "Evidence will, in the first instance, 1985 be taken by filing affidavits or by filling of Statements along with affidavits." It was understood that if it is not possible to file affidavits of the persons who are in a position to give information then affidavits may be filed of other persons who may have recorded the statements of the persons who are in a position to give information. This is not an adversary litigation where one of the parties may lose because of lack of proof. One of the objects of setting up a Court to investigate into an accident is to find out the causes of the accident and to make recommendations. It is necessary for this purpose to get information which may be relevant. It is true that strictly speaking the statements which are annexed to the affidavits may not be admissible as evidence in a Court of Law when there is a litigation between the parties but considering limitations which we have, namely, where a Court like the present has no jurisdication to enforce the attendance of any witness who is outside this country and furthermore, the Court has no jurisdication to compel any one to give information, the procedure which was adopted was thought to be the most practical one for obtaining information in connection with the accident. Under the circumstances, the affidavits which have been filed along with the statements which have been annexed thereto which give information with regard to the accident, have to be taken on record."

1.5.25 Another advantage of following the aforesaid procedure was that the time which would have been taken in Court in examining of the witnesses was considerably reduced. After the participants had filed affidavits, the same were to be secrutinised and it was then to be decided as to which of the deponents or persons should be called for examination in Court. Effectiveness of this procedure which was adopted is apparent from the fact that though affidavits by way of evidence were filed in Court, ultimately only 13 witnesses had to be examined in Court and sitings were held in Court only on 14 days.

1.5.26 Written arguments were filed on the forenoon of the 4th February, 1986 and oral arguments were heard in the afternoon of that day. No written arguments or oral submissions were made by the Government of Ireland, CP Air or Boeing Company.

1.5.27 Mr. I.G. Whitehall, councel for the Government of Canada took exception to some of the submissions which were contained in the written submissions filed by Air India. Mr. Whitehall contended that the Court had opined that it will not go into the question of responsibility of the unfortunate accident and therefore, there was no; justification for Air India to include in its written submissions numberous passages which tended to fix responsibilities.

1.5.28 By the order dated 4th February, 1986, it was made clear that it was not the intention of the investigation to apportion blame if any lapse had been committed and, therefore, the Court would ignore any written submissions which tended to apportion blame or responsibility for any lapse of any participants. It might here be mentioned that such a question had earlier arisen while the statement of Sgt. Atkinson was being recorded. The Court had then held that it will not go into the question as to who was responsible for the accident. It was in view of this order that no evidence was led by any of the parties on the question as to who may have been responsible for any possible lapse which could have led to this accident.

2.1 Flight Preparation

2.1.1. Air India Boeing 747 aircraft VT-EFO 'Kanishka' was operating flight AI-181 (Bombay-Delhi-Frankfurt-Toronto-Montreal) on 22nd June, 1985. From Montreal it becomes AI-182 from

Mirabel to Heathrow Airport, London enroute to Delhi and Bombay. The aircraft arrived at Toronto from Frankfurt at 1830 Z and was parked at gate No. 107 Terminal 2 at L.N. Pearson International Airport. In accordance with the Canadian regulations, all the passengers and their baggage were off loaded to complete the customs and immigration checks. Transit cards were handed out to 68 transit passengers destined to Montreal who disembarked at Toronto for customs and immigration checks.

2.1.2. The flight from Toronto to Montreal was made up of the following:-

(I) Passengers originating at Toronto and their baggage.

(ii) Transit passengers, and their baggage, continuing their flight to Montreal.

(iii) Two diplomatic bags from Indian Consulate General, Vancouver via Air Canada Cargo Flight, and some Air India Mail.

(iv) Fifth Pod engine and its associated parts.

(v) Interline passengers and their baggage from connecting flights as detailed below:-

a)	Air Canada flight AC-102			
	from Sasktoon	-	2	Passengers
b)	Air Canada flight AC-106			
	from Edmonton	-	4	Passengers
c)	Air Canada flight AC-170			
	from Winnipeg	-	1	Passenger
d)	Air Canada flight AC-170			
	from Winnipeg	-	4	Passengers
e)	Air Canada flight AC-136			
	from Vancouver	-	10	Passengers

2.1.3. One passenger by name 'M. Singh', checked in at Vancouver on Canadian Pacific flight CP-060 (Vancouver-Toronto) of 22nd June 1985, and got his one piece of baggage interlined to Air India flight AI-181 even though he had no confirmed reservation on AI-181. This passenger, however, did not board the flight CP-060 at Vancouver and also did not check-in for Air India flight AI-181/182 at Toronto.

2.1.4 The checking-in of passengers for Air India flight AI-181/182 at Toronto began at 1830 Z. The checking-in of the passengers was carried out by Air Canada personnel who are the handling agents for Air India, and was supervised by Air India personnel. The Air Canada personnel indicated the computer sequeritial numbers (security numbers) on the passenger boarding card stubs. At about 1930 Z announcement was made for the primary security check of passengers and their hand baggage. The passengers passed through the Door Frame Metal Detector and their hand baggage was checked through X-Ray machine. The passengers were also subjected to physical security check with the help of Hand Held Metal Detectors. The transit passengers to Montreal and their hand baggage were also subjected to these security checks, while their checked in baggage, after clearance by the Canadian Customers authorities was placed by the passengers themselves on the conveyor belt while they were still in sterile area. In this way there was personal identification by the passengers of all checked in baggage, except the baggage which had been interlined to this flight.

2.1.5 The flight was closed for check-in at about 2150 Z. There were 10 'NO SHOWS' and 4 'GO SHOWS'. The security checked passengers remained in the holding area gate No. 107 till boarding was announced at about 2210 Z. At the boarding gate secondary security check of the passengers and their hand baggages was carried out. The passengers were frisked with the help of Hand Held Metal Detectors and their hand baggages were opened and physically checked.

2.1.6 The security numbers on the stubs were circled on the pre-numbered Security Control Sheet to ensure that all the checked-in passengers have boarded the aircraft. Passenger boarding was completed by 2300 Z. Traffic/Sales representative of Air India verified the Security Control Sheet with the number of stubs collected and the number of passengers checked-in. He found that all the 202 passengers, who had checked-in, had boarded the aircraft.

2.1.7 As stated earlier, 68 transit passengers had disembarked at Toronto for completing the customs and immigration checks. However, only 65 of these passengers re-boarded the aircraft as per transit cards collected at the boarding gate. It is in evidence that almost every flight of Air India to Canada, two or three transit passengers do not re-board the flight at Toronto. Some Toronto passengers travelling to India buy their tickets "Montreal-India-Montreal" instead of "Toronto-India-Toronto", for which the fare is higher, and they travel by bus to Montreal to catch the Air India flight to India. On their return journey, when they get down at Toronto for customs and immigration checks, they simply do not re-board the flight even though their reservations are upto Montrteal. These passengers sometimes inform Air India personnel at Toronto about their not re-boarding the aircraft. On 22nd June, 1985, however, no such passenger informed Air India personnel.

2.1.8 There was a crew change at Toronto. The flight and cabin crew members who took over the flight AI-181/182 had been laid over in Toronto for the week prior to the accident flight and were scheduled to take the flight upto London where they were to be relieved by another set of crew. Capt H.S.Narendra was the Commander of the flight, with Capt S.S.Bhinder as co-pilot and Mr.D.D.Dumasia as the Flight Engineer. In addition there were 19 cabin crew members. All the crew members reported together at the airport at 2130 Z. As per the practice existing at that time, the flight crew and cabin crew members were not subjected to frisking checks and their hand baggage were also not security checked. Their checked-in baggage was, howevewr, security checked along with the other checked-in baggage of passengers.

2.1.9 The interline baggage was brought to the international baggage make-up area by the Air Canada staff but, as mentioned earlier, it was not personally identified and matched with the passengers.

2.1.10 The checked-in baggage of the originating passengetrs and crew members of AI-181/182 was sent on a conveyer belt to the baggage make-up area. All the checked-in baggage along with the interline baggage was required to be security checked on the X-ray machine which was located in the baggage make-up area at the end of international belt No.4.

2.1.11 It has been reported that the X-ray machine worked intermittently for some period and at about 2045Z it broke down and there was no picture on the screen. The Machine could not be repaired on that day as it was a week-end and no technician could be contacted. Air India's Security Officer then advised that the rest of the baggage be checked with a PD-4 explosive detector provided by him. He also demonstrated the use of the PD-4 detec- tor to the concerned personnel. It has been reported that about 60 to 70 baggages were checked and cleared by the PD-4 detector.

2.1.12 The security checked baggage was loaded in the containers by the Air Canada personnel. The loading of the baggage in containers was over by about 2230 Z. The ramp personnel of Air Canada carried the container and loaded them in the aircraft.

2.1.13 From March, 1985, after the introduction of Air India flight AI-181 through Toronto, diplomatic bags from Indian Consulate General at Vancouver were being sent to India by Air India flight from Toronto. Accordingly, two diplomatic bags, duly sealed and escorted, were delivered to Air Canada office at Vancouver on 21st June and they arrived at Toronto by Air Canada flight AC-580. One of the bags Sl.No. 49 contained 13 empty large diplomatic bags while the other bag Sl.No.50 contained diplomatic mail. The total weight of the bags was 13.8 Kgs.

2.1.14 In addition to the above, a few envelopes containing some flight documents addressed to Accounts Office, Air India, Bombay, and one envelope addressed to Commercial Headquarters, Air India, Bombay from Air India Town Office in Toronto, were collected by Messrs Mega International.

2.1.15 The aircraft was refueled by CAFAS with 14,602 litres of fuel.

2.1.16 On 8th June No. 1 engine of Air India Boeing 747 aircraft VT-EGC had failed during take off. The failed engine was to be ferried to Bombay on flight AI-181/182 of 22nd June.

2.1.17 The failed engine and the associated parts were placed in Air Canada Engineering Hangar at Toronto airport since June 8,when
the aircraft was brought to the engineering hangar for engine replacement. Air India had requested Air Canada on 15th June for preparing the failed engine for installation as fifth pod mounting of the aircraft on 22nd June.

2.1.18 On 15th June Air India deputed one of their foremen to Toronto to bring back the failed engine. From 17th to 21st June, Air Canada technicians prepared the failed engine for installation as fifth pod. This preparation involved removal of cowlings, fan blades, locking of compressor rotors etc. Air Canada Engineering/Maintence personnel loaded the aircraft/engine parts on 4 pallets and one container. These pallets and container were then delivered at 0100 Z on 22nd June by Air Canada personnel to Messrs Mega International cargo warehouse at Toronto Airport within restricted airport area. (Messrs Mega International Cargo Warehouse at Toronto Airport within restricted airport area. (Messrs Mega International is the cargo handling agent of Air India at Toronto). The fifth pod engine was transported by Air Canada directly from their premises to the 'Kanishka' aircraft for mounting it on the fifth pod.

2.1.19 Installation of the engine on the fifth pod began immediately on arrival of flight AI-181 at Toronto on 22nd June and the work was completed by 1930 Z. One of the mechanics of Air Canada installed the Mach Air Speed Warning Switch in the Main Equipment Centre as part of the fifth pod engine installation.

2.1.20 The pre-loaded four pallets and one container were brought to the aircraft by M/s Mega International personnel from their warehouse in the afternoon of 22nd June for loading them into the aircraft cargo compartment at positions assigned by the Air Canada load agent. Difficulty was experienced while loading one of the pallets having inlet cowl of the pod engine. To enable loading of the cowl, Air Canada engineering/maintenance personnel removed door stop fitting from the aft cargo compartment door cut-out. After removal of the fittings, the cowl could be loaded. All the removed fittings were then reinstalled.

2.1.21. On account of the delay in loading the cowls, departure of the flight was delayed by one hour and twentyfive minutes.

2.1.22 Maintenance Manager of Air India, Montreal carried out the Terminal Transit Check 'E' of the aircraft and no snag was observed by him. The commander duly accepted the aircraft.

2.1.23 Senior Flight Despatcher, Air India, Toronto did the flight despatch of AI-181/182 for sectors Toronto-Montreal-London. He briefed the flight crew members about flight plan, weather, Air Traffic Control and fuel requirements. The flight plans for the sectors Toronto-Montreal-London were duly accepted and signed by the Commander.

2.2 Progress of the Flight

2.2.1. The Aircraft took off from Toronto Runway 24L at 0016 Z on 23rd June, 1985. The Maintenance Manager, Security Officer and Passenger Service Supervisor of Air India travelled on board the aircraft for their duties at Montreal. In all there were 270 passengers on board in addition to 22 crew members.

2.2.2. The route from Toironto to Montreal was V-98/JHL-594/MSS/V 203/FRANX at flight level 290. The flight was uneventful and the aircraft landed at Montreal at 0110 Z. No snag was reported by the flight crew. The aircraft was parked at Cluster 1 Bay No.114.

2.2.3 Sixtyfive passengers destined to Montreal along with the three Air India personnel mentioned above deplaned at Montreal. The remaining 202 passengers, who had joined the flight at Toronto, remained on board the aircraft as transit passengers were not allowed to disembark at Montreal.

2.2.4 Baggage handlers off loaded three containers of baggage, one valuable container and four cargo containers from the aircraft.

2.2.5 Transit Check 'C' of the aircraft was carried out at Montreal. The Flight Engineer also carried out his pre-flight inspection and found that rear latch handle of the fifth pod engine fan cowl was loose. He informed the same to an Air Canada Technician who flaired the handle and applied the high speed tape. There was no other snag observed during the inspection. The personnel of CAFAS refueled the aircraft with 96,000 litres of fuel. Total fuel on board at the time of take off from Montreal was 104,000 Kgs. which was adequate for 8 hours 40 minutes of flying. The commander accepted the aircraft and signed the 'Certificate of Acceptance' of the aircraft.

2.2.6 At approximately 2130 Z Air Canada personnel opened the passenger check-in counter for flight AI-182 (The flight AI-181 terminates at Montreal and the flight from Montreal to London-Delhi-Bombay is designated as AI-182). The checked-in baggage was sent to the baggage make-up area. Between 2300-2350 Z, a suspect suitcase was identified as the X-Ray showed what appeared to be some wires next to the suitcase opening. The suitcase was placed on the floor next to the X-Ray machine. Subsequently two more suspect suitcases were located. These suitcases were also placed next to the X-Ray machine to await the arrival of the Air India Security Officer who was to arrive on Air India flight AI-181 from Toronto. The remainder of the checked-in baggage, which cleared the security check, was loaded in containers by Air Canada personnel for loading on board the aircraft.

2.2.7 Two diplomatic pouches from the Indian High Commission, Ottawa were brought to Mirabel. After the flight arrived, one of the pouches of Category 'A' weighing 1 Kg. was given to the Flight Purser. The other Category 'B' pouch weighing 9 Kgs. was placed in an valuable container 14R.

2.2.8 No other cargo was accepted for this flight except a small package (weighing less than 1 Kg) containing medicines for cancer treatment of a patient in New Delhi. This parcel was received at 1530 Z on 21st June and was loaded in container 14R by Messrs Mega International on 22nd June, more than 24 hours after its receipt.

2.2.9 Five baggage containers, one valuables container and two empty containers were loaded in the aircraft.

2.2.10 The checked-in passengers with their hand baggage went to the departure sterile area. At the entrance to the departure sterile area security staff used X-Ray units and metal detectors to check passengers and their hand baggages.

2.2.11. At approximately 0100 Z, 23rd June, after the primary security check was completed, the passengers proceeded to boarding gate No.80. At this lcoation the secondary security check was done on passengers using hand held metal detectors. Hand baggages were also subjected to further physical and visual check by them.

2.2.12. A total of 105 passengers boarded the flight AI-182 at Mirabel Airport. It was determined that all the passengers who had checked-in, boarded the aircraft. There was no interline passenger. At Montreal there were five 'NO SHOWS' and two 'GO SHOWS'. In all 307 passengers were on board the aircraft. The flight plan and the load and trim sheet, however, indicated 303 passengers as four of the 6 infants were not included in the passenger list.

2.2.13. The seating distribution of the passengers was as given below:-

Zone/Class Total number of Seats Occupied seats Zone 'A' -First Class 16 1
Zone 'B'- Club Class 22 - Upper deck - Club class 18 7 Zone 'C' - Economy Class 112 104+ 2
Zone 'D' - Economy Class 86 84+ 1 Zone 'E' - Economy Class 123 105+ 3 377
301+ 6 (Infants)

2.2.14 The seating distribution of the 19 cabin crew members was as follows:-

Two at door L1 and two at door R1
Two at door L2 and two at door R2
Two at door L3 and one at door R3
Two at door L4 and one at door R4
One at door L5 and one at door R5
One in crew rest area, Zone 'A'
One in jump seat upper deck
One crew rest area upper deck.

2.2.15 The three suspected suit cases were not loaded on the aircraft and were detained in the baggage make-up room. After the names of the passengers to whom the suit cases had belonged had been identified the same were transferred to the decompression chamber of E1 A1 Airline where they were examined, with the aid of a Police Explosive Dog, with negative results. The suit cases were kept overnight in the said chamber and when they were opened it was found that they contained no explosive items.

2.2.16. No unclaimed baggage pertaining to the Air India flight was recovered either at Toronto or at Mirabel or Dorval Airport in Montreal.

2.2.17. The flight plan for the sector Montreal to London was filed on telephone by the Air India Flight despatch from Toronto to Dorval ATC Centre. He requested for route SHERBROOKE-COLOR-NAT XRAYBUNTY-MERLY-EXMOR-IBLEY-SAMTN-HAZEL-OCKHAM-LONDON at flight level 290 upto COLOR and flight level 330 thereafter. The reporting points on Track XRAY on that day were COLOR, 47N/50W, 49N/40W, 50N/30W, 51N/20W, 51N/15W, 51N/08W and BUNTY.

2.2.18 The aircraft took off from Montreal at 0218 Z. Its estimated time of arrival at London was 0833 Z. The CVR and the ATC tapes show that the flight was normal and quite uneventful. Suddenly at about 0714 Z, when the flight was being monitored by the Air Traffic Controller at Shannon, with the help of secondary surveillance radar, the aircraft disappeared from the radar scope. Subsequently, the ATC at Shannon got the know that the aircraft had met with an accident and its wreckage was sighted about 110 miles west south-west of Cork, Ireland.

PERSONNEL INFORMATION

2.3.1 Pilot-in-Command (Capt. H.S. Narendra)

2.3.1.1 Cap.t H.S. Narendra (age 561/2 years, date of birth 25th November, 1928) joined Air India on 1st October, 1956. He held ALTP Licence No. 247 valid upto 29th October, 1985 and FRTO No. 478 valid upto 23rd October, 1985. He was released as a Co-pilot on Boeing 707 aircraft on 21st July, 1960 and as a Commander on Boeing 707 aircraft on 17th September, 1964.

2.3.1.2 For conversion as Pilot-in-Command on Boeing 747 aircraft, Capt. Narendra had undergone ground training at Boeing Airplane Company, USA and simulator and aircraft flying training at Bombay in 1972. He completed his route checks for Pilot-in-Command endorsement between December, 72 and January, 73. He became a Commander on Boeing 747 aircraft on 14th February, 1973.

2.3.1.3 Details of Capt. Narendra's flying experience and licence renewal checks are as given below:

a. Total flying experience : 20, 379:15 hours

b. Flying experience on B-747 as
    (i) Pilot-in-Command : 6,364.50 hours
    (ii) Co-pilot : 123:45 hours

c. Day flying experience on B-747 aircraft : 3,980:00 hours

d. Night flying experience on B-747 aircraft : 2,508:35 hours

e. Flying experience during
    (i) last 6 months : 301:45 hours
    (ii) last 3 months : 159:40 hours
    (iii) last 30 days : 68:45 hours
    (iv) last 7 days : 9:00 hours

He had last flown as Pilot-in-Command on flight AI 181 (Frank- furt to Toronto) on 15th June, 1985.

f. Date of last licence renewal and IR check : 8 May, 1985

g. Date of last route check : 24 March, 1985

h. Date of last medical examination at CME, Delhi : 29 April, 1985

i. Date of last simulator refresher course : 19 December, 1984

j. Date of ground technical refresher course : 6/7 May, 1985

k. Date of last flight safety refresher course : 25 July, 1984

l. Rest period before operating the accident flight : 1 week

2.3.1.4 Records indicate that on 29th June, 1966, Captain Narendra was declared medically unfit for 2 months to reduce his weight by 10 Lbs. In February, 1973 he was advised to wear corrective by-focal glasses while flying. In May, 1975 he was again declared medically unfit for 3 months.

2.3.1.5 Capt. Narendra was earlier involved in the following two incidents:

(a) On 25th August, 1984, while operating flight AI-1100 from London to Delhi, there was a deviation of the aircraft by about 170 nautical miles from the track over Rahimyar Khan in Pakistan. He was given necessary INS refresher and Route checks with particular emphasis on cross checking procedure.

(b) On 6th December, 1984, while operating flight AI-124 Delhi-Bombay, the aircraft was observed approaching runway 32 at Bombay Airport when runway in use was 27. Captain Narendra was given simulator training for a series of approaches and landings and visual circuits from right hand and left hands seats for approaches and landings on runway 27 at Bombay Airport.

2.3.1.6 Captain Narendra was not involved in any accident previously.

2.3.2 Co-pilot (Capt. S.S. Bhinder)

2.3.2.1 Capt. S.S. Bhinder (age 411/2 years, date of birth 30th November, 1943) joined Air India on 12th October, 1977. He held ALTP Licence No. 940 valid upto 25th July, 1985 and FRTO Licence No. 2290 valid upto 2nd February, 1986.

2.3.2.2 Capt. Bhinder was released as a Co-pilot on Boeing 707 aircraft on 18th November, 1978 and as a Co-pilot on Boeing 747 aircraft on 17th May, 1980.

2.3.2.3 Details of his flying experience and licence renewal checks are as given below:

a. Total flying experience : 7,489:00 hours

b. Experience on B-747 aircraft as Co-pilot : 2,469:30 hours

c. Day flying experience on B-747 aircraft : 1,426:15 hours

d. Night flying experience on B-747 aircraft : 1,043:15 hours

e. Flying experience during

(i) last 6 months : 157:45 hours

(ii) last 3 months : 65:00 hours

(iii) last 30 days : 20:15 hours

(iv) last 7 days : 9:00 hours

He had last flown as Co-pilot on flight AI-181 (Frankfurt to Toronto) on 15th June, 1985).

f. Date of last licence renewal check : 25th March, 1985

g. Date of last IR check : 23rd November, 1984

h. Date of last route check : 9 April, 1985

i. Date of last medical examination at CME Delhi : 14 January, 1985

j. Date of last simulator refresher course : 16 July, 1984

k. Date of last ground technical refresher course : 8/9 October, 1984

l. Date of last flight safety refresher course : 3 December, 1984

m. Rest period before operating the accident flight : 1 week.

2.3.2.4 Records indicate that Capt. Bhinder was not involved in any accident earlier.

2.3.3 Flight Engineer (Mr. D.D. Dumasia)

2.3.3.1 Flight Engineer Mr. D.D. Dumasia (age 57 1/2 years, date of birth 10th October, 1927) joined Air India on 27th December 1954. He held flight Engineer's Licence No. 37 valid upto 6th December, 1985. Mr. Dumasia was released as a Flight Engineer on Boeing 707 airecaft on 16th December, 1963 and on Boeing 747 aircraft on 6th February, 1974. He had a total flying experience of 14,885 hours out of which 5,512:35 hours were on Boeing 747 aircraft.

2.3.3.2 Last medical examination of Mr. Dumasia was completed on 1st October, 1984 at CME Delhi. He had completed simulator refresher course on 14th February, 1985, ground technical refresher course on 14/15th January, 1985 and flight safety refresher course on 13th

August, 1984.

2.3.4 Cabin Crew

2.3.4.1 A total of 19 cabin crew members were on duty on Flight AI-181/182 on 23rd June, 1985. Their brief details are as given below:

Sl.No. Names Designation Flight Safety course completed on 1. Mr. S.L. Lazar Inflight Supervisor 1/2 April, 1985 2. Mr. K.M. Thakur Flight Purser 18 February, 1985 3. Mr. Inder Thakur Flight Purser 9/10 May, 1984 4. Mr. Shukla Flight Purser 23 January, 1985 5. Mr. S.P. Singh Flight Purser 15 January, 1985 6. Mr. N. Vaid Asst. Flight Purser 2/3 May, 1985 7. Mr. B.K. Sena Asst. Flight Purser 3 December, 1984 8. Mr. N. Kashipri Asst. Flight Purser 12/13 Sept., 1984 9. Mr. J.S. Dinshaw Asst. Flight Purser 17/18 Dec., 1984 10. Mr. K.K. Seth Asst. Flight Purser 11/12 February, 1985
11. Miss Raghavan Airhostess 13 July, 1984 12. Miss S. Ghatge Airhostess 10/11 April, 1985 13. Miss R. Bhasin Airhostess 11/12 February, 1985 14. Miss L. Kaj Airhostess 17/18 April, 1985 15. Miss P. Dinshaw Airhostess 17/18 Dec., 1984 16. Miss S. Lasarado Airhostess 15/16 April, 1985 17. Miss E.S. Rodricks Airhostess 10/11 June, 1985 18. Miss S. Gaonkar Airhostess 3/4 April, 1985 19. Miss R.R. Phansekar Airhostess 29/30 April, 1985 AIRCRAFT INFORMATION

2.4.1 General

2.4.1.1. Boeing 747-237B 'Kanishka' aircraft VT-EFO was manufactured by Messrs Boeing Company under Sl.No. 21473. The aircraft was acquired by Air India on 19th June, 1978. Initially, it came with the expert Certificate of Airworthiness No. E-161805. Subsequently, the Certificate of Airworthiness No. 1708 was issued by the Director General of Civil Aviation, India on 5th July, 1978. The C of A was renewed periodically and was valid upto 29th June, 1985. From the beginning of June, 1985, C of A renewal work of the aircraft was in progress. The aircraft had the Certificate of Registration No. 2179 issued by the DGCA on 5th May, 1978. The commercial flight of 'Kanishka' aircraft started on 7th July, 1978.

2.4.1.2 The aircraft was maintained by Air India following the approved maintenance schedules. It had logged 23634:49 hours and had completed 7525 cycles till the time of accident.

2.4.1.3 The aircraft was fitted with four P & W JT9D-7J engines having thrust rating of 48650 pounds. The hours and cycles logged by the engines since new till the time of accident are as given below:

Engine No.1 : P662927-7J - 29,663:26 Hrs (9422 cycles)
Engine No.2 : P695610-7J - 20,810:28 Hrs (6031 cycles)
Engine No.3 : P695602-7J - 21,992:31 Hrs (6564 cycles)
Engine No.4 : P662926-7J - 32,332:15 Hrs (11295 cycles)

2.4.1.4 All the DGCA mandatory modifications and inspections applicable to the subject aircraft had been compiled with. No major component installed on this aircraft and its engines had exceeded the stipulated life period.

2.4.1.5 The last quarter Periodic Check of the aircraft was carried out on 24th May, 1985, at 23274:53 hours and 7439 cycles. Subsequent to this check, two Check 'B' schedules were carried out. The last Check 'B' was carried out on 17th June, 1985, at 23564:14 hours and 7510 cycles and was valid for 200 flying hours.

2.4.1.6 The aircraft had flown 359:56 hours and 86 cycles since last quarter Periodic Check and 70:35 hours and 15 cycles since last Check 'B' till the time of accident.

2.4.1.7 The last Flight Release Certificate was issued on 24th May, 1985 on completion of quarter Periodic Check and was valid for 1100 hours or 150 days elapsed time whichever occurred first. After the last departure from Bombay on 21st June, 1985, the aircraft had flown for 22:34 hours till the time of crash.

2.4.1.8 Mr. Rajendra, Maintenanace Manager, Air India, Montreal carried out the Terminal Transit Check 'E' of the aircraft at Toronto on 22nd June, 1985 and no snag was observed by him. No snag was reported by the flight crew during the flight from Toronto to Montreal. Transit Check 'C' of the aircraft for the flight AI-182 was carried out at Montreal by Mr. Rajendra and three Air Canada technicians. The flight engineer also carried out his pre-flight inspection and found that the rear latch handle of the fifth pod engine fan cowl was loose. He informed the same to Mr. P. Bayle, Air Canada technician who faired the handle and applied high speed tape. No other snag was observed during the inspection.

2.4.2 Previous Incidents and Snags

2.4.2.1 A maintenance Group was formed with representatives from Air India and Airworthiness Directorate with Mr. R.K. Paul, Senior Air Safety Officer as the Group Leader to scrutinise the maintenance documents and various defects experienced on this aircraft. The report submitted by the Group (Attachment 'B') indicates that the aircraft was involved in six incidents since the last C of A renewal, details of which are given below

(I) On 13th July, 1984 at Dubai -- flight AI-868 The aircraft returned after aborting take off due to no rise in the EPR and N1 on No.1 engine (Sl.No. 695612). The engine front and rear were checked and found OK. Slight wetness was noticed in the bleed outlets. No external oil leak was noticed. Oil quantity was topped up. The chip detectors and oil filter were found OK. EVC Ph filter was found
OK. EVC linkage wes exercised. The engine was run up and its operation was found satisfactory. The snag was suspected to be due to lack of pressurising air at low N1.

(ii) On 18th July, 1984 at Delhi -- flight AI-105 The right hand side fuselage skin between stations 480 and 500 in line with lower portion of forward cargo door cut-out was damaged by high lift. The same was repaired at Delhi. Permanent repair was carried out at Bombay. The repairs were accomplished using guidelines given in the Boeing Structural Repair Manual.

(iii) On 12th August, 1984, at Rome -- flight AI-135 The aircraft landed with No. 2 engine (Sl.No. 662826) shut down in flight due to oil pressure and oil quantity droping. On motoring the engine, oil leak was observed from metal line between F C O C and L O P switch at the switch end. The line was found cracked which was welded and refitted. The line was subsequently replaced at Bombay.

(iv) On 24th October, 1984, at London -- flight AI-104 There was total loss of No.1 hydraulic system fluid. The fluid leak was traced to inlet pressure adapter of flap control module in the left hand body gear wheel well. Two of the four bolts holding the adaptor on the flap control module had sheared. The hydraulic pump, seal, back-up ring and case drain filter were replaced. The flap control module was replaced when the aircraft arrived at Bombay.

(v) On 14th February, 1985, at Delhi -- flight AI-164 On arrival the leading edge honey comb of the left hand aft trailing edge flap was found damaged about 18 inches in length due foreign object damage. Necessary repair was carried out at Delhi. The aft flap was replaced at Bombay.

(vi) On 28th May, 1985, at Dubai -- flight AI-103 On arrival, the left hand wing to fuselage botton fairing forward rubber seal with strip was found turn off. Temporary repair was carried out at Dubai. Permanent repair was carried out subsequently at Bombay.

2.4.2.2 The flight snags recorded in the flight report books of the aircraft during the 4 1/2 month period prior to the accident were scrutinised by the Maintenance Group and the only significant repetitive defect observed was "R2 door not going to manual". On ground checks by the aircraft maintenance engineers, the operation of the selector was, however, found normal.

2.4.2.3 Prior to operating the accident flight, the aircraft arrived at Toronto from Frankfurt. Capt. R.K. Spencer was the commander of the flight. The flight crew had reported the following three snags:

(I) HF system No. 2 had a lot of distortion

(ii) E P R L indicator unserviceable in 'Go around' mode

(iii) Hydraulic system No.1 pressure indication unserviceable (This snag was carried forward from Delhi).

2.4.2.4 The Auxiliary Power Unit (APU) was unserviceable ex-Bombay and had been released under M E L.

2.4.2.5 For rectification of the above stated snag No.1, Shri Rajendra, Air India's Maintenance Engineer at Totonto checked the connections of the transreceiver and reracked the unit. No snag was reported on this system on Toronto-Montreal sector.

2.4.2.6 Snag No. 2 was carried forward.

2.4.2.7 Regarding the third snag, Mr. Rajendra has stated that the indicator showed 4000 P

S I pressure even with no pump running. He therefore, interchanged No.1 and No.3 indicators. The snag, however, persisted. He then replaced transmitter No.1 with a spare transmitter from the aircraft SE box and the snag was rectified. No rectification work was however, recorded by the AME in the Flight Report Book. No snag was reported on this system on Toronto-Montreal sector.

2.4.3 Installation of 5th Pod Engine

2.4.3.1 On 8th June, 1985, No.1 engine of Air India Boeing 747 aircraft VT-EGC operating flight AI-181 failed during take off at Toronto. The aircraft returned and the engine was replaced by a loaned engine from Air Canada. The removed engine was a P & W JT9D-7Q type (Sl. No. P702353-7Q).

2.4.3.2 Air India had planned to bring back the failed engine of VT-EGC aircraft to Bombay, as fifth pod on their flight AI-181/182 of 22/23 June, 1985 and had sent an Engineer along with the necessary kit to Toronto on 15th June, 1985. The engine borrowed from Air Canada on 8th June, 1985, was flown back to Toronto as a fifth pod engine on flight AI-181 of 22nd June, to return it to Air Canada.

2.4.3.3 Shri C.D. Kolhe, Controller of Airworthiness, Bombay examined the aspects relating to installation of the 5th Pod engine, loading of its components and certification of the related work. Shri Kolhe's report indicates that the failed engine and the associated parts were kept in the Air Canada engineering hanger at Toronto airport since June 8 when the aircraft was brought to the hanger for engine replacement. Air India requested Air Canada on 15th June, 1985, for prepairing the failed engine for installation as fifth pod engine on 22nd June. Accordingly, Air Canada's technicians undertook the preparatory work of removing the cowlings, fan blades, panels, locking of compressor, turbine rotors etc. on 17th June, 1985, and completed the work on 21st June, 1985. The fan blades (46 in number) from the failed engine were placed in 12 wooden shipping boxes provided by Air India. These boxes were then loaded in a container. The other components of the failed engine were loaded on 4 pallets.

2.4.3.4 Installation of the fith pod engine was carried out by Air Canada technicians and the individual items on the task card were certified by the individuals who had carried out the work.

2.4.3.5 Some difficulty was experienced while loading one of the pallets having inlet cowl of the pod engine. To enable loading of the cowl, Air Canada engineering/maintenance personnel removed door stop fittings from the aft cargo compartment door cut-out. After removal of the fittings, the pallet could be loaded. All the removed fittings were then re-installed. Removal and installation of the fittings was certified by Mr. Rajendra.

2.4.3.6 A question arose whether removal of the door stop fittings could have caused some difficulty in flight. From the video films of the werckage it was found that the complete aft cargo door was intact

and in its position except that it had come adrift slightly. The door was found latched at the bottom. The door was found lying along with the wreckage of the aft portion of the aircraft. This indicates that the door remained in position and did not cause any problem in flight. In the front cargo compartment, there were 16 containers out of which four were empty. Five containers had baggage of Delhi bound passengers. Container at Position 13L had baggage of the first class and London passengers and container at position 13R had crew baggage. The entire baggage of passengers ex-Montreal was loaded in containers at positions 12R, 21R, 22R, 23R and 24R in the front cargo compartment. Container at position 24L contained fan blades in wooden boxes and the other components of the pod engine. Valuable container was at position 14R.

2.4.3.7 In the aft cargo compartment, there were four pallets containing parts of the fifth pod engine and two containers at positions 44L and 44R containing baggage of Delhi bound passengers. The bulk cargo compartment contained passenger baggage bound for Delhi and Bombay. All the baggage and engine parts in the aft and bulk cargo compartments were loaded at Toronto.

2.4.3.8 The total weight of the fifth pod engine and its items was about 9000 kgs. As a result of carriage of the fifth pod engine, the payload of the flight was considerably reduced on London-Delhi sector.

2.4.3.9 At the time of take off from Montreal the aircraft had 104,000 kgs of fuel on board which was adequate for 08:40 hours of flying as against sector flying time of 06:15 hours. The flight plan fuel was calculated taking Paris as the alternate airport for London.

2.4.3.10 The load and trim sheet from the sector Montreal London was prepared and was duly counter-signed by the commander. The take off weight of the aircraft was 317,877 kgs which was within the maximum take off weight limit of 334,500 kgs. The estimated landing weight of the aircraft was 237,177 kgs which was also within the maximum landing weight limit of 256,279 kgs. The centre of gravity of the aircraft was at 21.3 percent of MAC at take off and the estimated C G position at the time of landing at London was 25.8 percent of MAC which was within the limits.

2.4.3.11 The load and trim sheet and the flight plan of the aircraft indicated that there was 301+2 passengers on board the aircraft whereas there were actually 301+6 passengers on board. The error occured because four of the six infants were not taken into account.

2.4.4 Corrosion Control Measures

2.4.4.1 Boeing Company have recommended various measure to control corrosion on Boeing 747 aircraft through different documents such as Maintenance Planning Data Document, Corrosion Prevention Manual and Service Bulletins. Compliance of these measures on Air India fleet is accomplished as follows:

(I) Support structure under galleys and lavatories

Boeing Company have recommended repeat inspections of under galley/toilet structure at intervals of 12000 hours. However, in order to detect corrosion at an early stage, these inspections are carried out by Air India at intervals not exceeding 9000 hours.

(ii) Fuselage Lower Bilge Area:

Boeing Company have recommended modifications to provide improved drainage systems by incorporation of various Service Bulletins. All the relevant modification have been completed by Air India on the affected aircraft. In addition to completion of these modifications, repeat inspection of lower bilge area is being carried out to meet the requirements of Boeing Service Bulletins.

(iii) Canted Pressure Deck:

In order to prevent water accomulation and consequent corrosion in the area, Boeing Company have issued SBs 51-2015, 51-2026 and 51-2032. Air India have incorporated Service Bulletins 51-2015, and 51-2032 on all their affected airplanes SB 51-2026 is being complied progressively.

(iv) Cargo Compartments:

Inspection of all the cargo compartment interior structures for corrosion and cracks is being accomplished periodically by Air India after removal of linings and insulation blankets.

(v) Aft Pressure Bulkhead:

During every equalised Periodic Check routine, the aft surface of aft pressure bulkhead is being visually inspected for corrosion condition and security of attachements. The forward surface of the pressure bulkhead, which is covered by aft toilets, is inspected after removal of toilets at intervals not exceeding 9000 hours although the recommended interval by Boeing Company is 12000 hours.

2.4.4.2 Air India has stated that in addition to the above specific measures, aircraft structure particularly the areas below toilets, galleys, cargo compartments, outflow valve area etc. which are prone to corrosion, are inspected for corrosion, cleaned and protected during every equalised Periodic Check. Air India have further stated that no serious corrosion problem has been experienced by them so far on their fleet.

2.4.5 Supplemental Structural Inspection Programme

2.4.5.1 In the case of airplanes which have completed 10,000 flight cycles as on June 30, 1983, Federal Aviation Administration (FAA) U S A and Boeing Company had recommended additional structural inspections known as Supplemental Structural Inspection Programme. In the Air India fleet, the first three 747 aircraft, namely, VT-EBE, VT-EBN and VT-EBO fell in this category and are known as 'Candidate Airplanes'. The subject aircraft (VT-EFO) had completed only 7525 flight cycles at the time of the accident on 23rd June, 1985, and therefore, the Supplemental Structural Inspection Programme was not applicable to this aircraft.

2.4.6 Special Corrosion Inspection of B-747 Aircraft Fleet of Air India

2.4.6.1 In order to examine whether corrosion to the aircraft structure of Kanishka aircraft could have contributed to the accident, a group was constituted by Mr. H.S. Khola, Inspector of Accidents to carry out special corrosion Inspection of all the Boeing 747 aircraft of Air India.

The group consisted of the following members:

(a) Senior Air Safety Officer of the D.G.C.A.

(b) Senior Airworthiness Officer of the D.G.C.A.

(c) Air India's Representative.

2.4.6.2 The inspection was carried out in the following areas:

(a) Below toilets and galleys

(b) Forward and aft cargo compartments belly areas - internally and externally

(c) The forward and aft pressure bulkheads

(d) Canted pressure web area from inside the passenger cabin.

(e) Area around outflow valves

(f) MEC area inside and outside.

2.4.6.3 The inspection reports submitted by the Group show that no corrosion was noticed on the significant primary structural members of the aircraft. Surface corrosion was, however, noticed on some of the members below the toilets and galleys. The corrosion observed during the inspection was of minor nature which is normally expected on such inspection schedule. The Kanishka aircraft was subjected to Periodic Check on 24th May, 1985 at 23,274.53 hours/7,439 cycles and no significant corrosion was observed. Among the Nine 747 aircraft inspected for corrosion, 5 aircraft had logged hours more than the Kanishka aircraft. Three of the aircraft had actually logged nearly double the flying hours. Taking into consideration that the corrosion prevention measures recommended by the Boeing Company were followed by Air India and that even the high life aircraft (45,000 hours approximately) subjected to corrosion inspection at the time when Periodic Check was due i.e. 1100 hours since previous check, had no significant corrosion, it is considered unlikely that Kanishka aircraft, which had logged only 23,275 hours since new and 360 hours since last Periodic Check, had corrosion which could have contributed to the accident.

METEOROLOGICAL INFORMATION

2.5.1 A report on the Meteorological conditions prevailing en-route near the location where the aircraft crashed was provided by the Meteorological Service, Department of Communications, Dublin, Ireland. This report covers a period of one to two hours before and after the time of accident (0714 Z).

2.5.2 From the report it is seen that the surface Synoptic Situation in the vicinity of 51∞N, 12.50∞W at 0715 Z on 23rd June was as given below:

Surface wind : 250/15 knots

Surface visibility : 10 Kms (occasionally 4 kms in drizzle)

Surface temperature : 13∞C

Cloud conditions : Cloud cover in the area was estimated to have been layered upto about FL 100 with a base of 600 feet. There is no evidence of cumulonimbus or thunderstorm activity.

Freezing Level : 700 feet.

2.5.3 With regard to Upper Air situation the report indicates that a mainly West or West North West airflow covered the area of FL 310 The Jet stream was centred at about 48∞N. The estimated wind and temperature at FL 310 were 270/65 knots and -47∞C. As per the report, at FL 310, 51∞N 12.50∞W and at 0715 Z any significant clear air turbulence was not expected.

2.5.4 Sunlight condition was prevailing at the time of accident. There were no sigmets valid for the area at that time.

AIDS TO NAVIGATION

2.6.1 The aircraft was equipped with Inertial Navigation System (INS) and was cruising normally at its assigned flight level 310 on track X-ray over Atlantic. It was under the control of Shannon Upper Area Control and was being monitored on the Secondary Surveillance Radar (SSR) located at Mount Gabreal. Till the time of accident, the aircraft was beyond the range of Shannon primary radar.

2.6.2 The aircraft entered Shannon airspace at the correct position and level and remained on the assigned track and flight level till it disappeared from the radar screen.

2.6.3. There is no evidence to indicate that AI-182 experienced any navigational problem during the flight.

COMMUNICATIONS

2.7.1 Two-way communication between the ill-fated aircraft and the ATS units of Canada and Ireland was maintained during the flight from Montreal till the time of crash. The communications were recorded on the ATC tapes. Transcripts of the relevant tapes were provided by the Canadian Aviation Safety Board and the Director of Air Traffic Services, Ireland.

2.7.2 From the Transcript of the conversations, it is observed that two-way communication between AI-182 and the various ATS units was normal. The last R/T contact with the aircraft was at 0709:58 Z when AI-182 informed Shannon UAC that it was squawking 2005. The tape transcript also shows that the aircraft did not transmit any information regarding the emergency on frequency 131.15 MHz on which it was last working with Shannon UAC or on distress frequency 121.5 MHz. Indecipheiable noise was, however, found recorded on the Shannon ATC tape just at the time of crash i.e. 0714:01 Z. Thereafter, repeated calls were made by Shannon UAC to AI-182, but there was no response.

SEARCH AND RESCUE

2.8.1 The report of the Search and Rescue Group gives the details of the Search and Rescue operations. From the report it is seen that at 0730 Z, Shannon UAC informed Marine Rescue Co-ordination centre (MRCC) shannon that AI-182, a Boeing 747 aircraft enroute Montreal-London had disappeared from the Secondary Surveillance Radar (SSR) at 0713 Z in position 51N/120W. Shannon UAC requested MRCC Shannon to take emergency section. At 0740 Z MRCC Shannon telephonically explained the situation to Valantia Coast Radio Station (CRS) and requested a PAN Broadcast urgently and to ask any vessels in area to keep sharp lookout and report to Valantia Radio. At 0746 Z Valantia Radio transmitted to all stations PAN message and above advice to ships. The transmission was repeated.

2.8.2 At 0750 Z, an Irish Naval Vessel AISLING reported on R/T to Valantia Radio that it was 54 miles from site of accident and was proceeding to the site. Valantia Radio passed on this information by Telex to MRCC Shannon. Between 0740/ 0750 Z MRCC briefed the Irish Naval Service (INS) Haulbowline, MRCC Swansea, RCC Plymouth and Irish Army Air Corps (IAAC) on the situation. At 0754 Z MRCC relayed a distress message to Shannon Aeradio via the Aeronautical Fixed Telecommunication Network (AFTN)

2.8.3 At 0803 Z Valantia Radio again transmitted the PAN message and the advice to ships. At 0840 Z Cargo vessel M W Laurentian Forest/HBWP (Registered in PANAMA and owned by Federal Commerce of Montreal, Canada) at position 51.09N/12.18W reported that it was 22 miles away from distress area and was proceeding there. Laurantian enquired if there were other ships in the area and was informed about position of Aisling. At 0813 Z Valantia Radio informed MRCC Shannon by telex about Laurentain Forest.

2.8.4 Between 0815/0820 Z, MRCC Shannon updated RCC plymouth and they advised that a Nimrod Rescue Aircraft would depart shortly for the area and that SEA KING helicopters were already enroute the Cork Airport initially. Edinburgh RCC advised MRCC Shannon that a Nimrod Rescue Aircraft was also being prepared at Kinloss. At 0820 Shannon Aeradio informed Valantia Radio that there was message from Shanwick Oceanic Control that aircraft were picking up ELT signal in position 51N/15W and 51N/08W and the actual position was beleived to be 51W/1250W. At 0833 Z, Valentia Radio sent message giving the above information and requesting ships in the area to report to Valentia Radio.

2.8.5 At 0842 Z, Ali Baba informed Valentia Radio that it was at position 5125.5N/0825.4W and was listening on 121.5 MHz. At 0850 Z Western Arctic informed Valentia Radio its position 5207N/1151W and that it would proceed in about 20 minutes after bringing in cable. At 0857 Z, High Seas Driller informed Valentia Radio that Vessel Kongstain could be released, ETA 51/2 to 6 hours and they would standby. At 0858 Z, Valentia Radio informed MRCC Shannon about reports from Ali Baba Western Arctic and High Seas Driller.

2.8.6 At 0905 Z, Laurentian forest reported to Valdentia Radio that it was 5 miles from SOS position 51N/12.5 W and it had not sighted anything. Between 0905/0908 Z, three more vessels viz. Atlantic Concern, MV Norman Amstel and MV Tasman reported their positions to Valentia Radio. At 0908 Z, Swansea advised MRCC Shannon that four Seaking helicopters and two Nimrod Aircraft were enroute.

2.8.7 At 0913 Z, Laurentin Forest reported to Valentia Radio that they had sighted what looked like 2 rafts about 2 miles away. At 0914 Valentia Radio informed MRCC Shannon about the report from Laurentian Forest.

2.8.8 At 0918 Z, Laurentian Forest reported to Valentia Radio that it had sighted wreckage in water at position 5101.9N/1242.5W and the liferafts were not inflated. Valentia Radio passed the message to MRCC Shannon at 0920 and also sent transmission about wreckage sighting. Lifeboats Valentia and Baltimore reported to Valentia Radio that they were proceeding to the position of wreckage.

2.8.9 At 0937 Z, Laurentian Forest reported that it had sighted 3 bodies in water. Valentia Radio informed the same to MRCC Shannon at 0940 Z. At 0945 Z, MRCC Shannon and MRCC Swansea decided that

for security and operational reasons Cork Airport would be the primary operational base and ATC Cork were informed of this decision.

2.8.10 At 0953 Z, S MYROLI informed Valentia Radio that it was 80 miles north of position and had a group of 10 to 20 French vessesls and desired to know if they should proceed to site. After consulting Laurentian Forest, S MYROLI was advised that it was not necessary. Valentia Radio kept on giving Mayday relay frequently.

2.8.11 At 1045 Z, a prohibited flying area was established with a radius of 40 N Miles from the datum point from sea level to 5000 feet. Falmouth Coast Guard reqested Valentia Radio the position of all ships in the distress area and those proceeding so that each vessel could be designated to search a particular area.

2.8.12 At 1126 Z, Laurentian Forest reported Valentia Radio that it had located numerous bodies in water and Seaking helicopter was hovering there. Valantia Radio Transmitted this information to all stations.

2.8.13 At 1133 Z, Valentia Radio informed Coast Guard Falmouth the position and ETA of various ships and also of the Lifeabouts Valentia and Beltimore. At 1150 Z, RRC Plymouth requested MRCC Shannon that "Le Aisling" assume duty as "On Scene Commander Surface Unit". At 1204 Z, information was received by Valentia Radio that 8 Spannish Trawlers were proceeding to distress position of AI-182 and their ETAs were between 1630/2000 Z. At 1246 Z, Star Orion informed Valentia Radio that it would be able to refuel any vessel in medium or small quantities at the accident site. Valentia Radio informed MRCC Shannon and Falmouth about the Spanish Vessels and Star Orion.

2.8.14 Falmouth requested Valentia Radio at 1303 to advise Laurentian Forest to inform Aisling that 8 Spanish trawlers would arrive in search area between 1600 Z and 2000 Z and Aisling should deploy trawlers in conjunction with lifeboats to recover bodies as it would be easier to recover than from large vessels. Valentia Radio sent the above message.

2.8.15 Laurentian Forest informed Valentia Radio at 1307 Z that 10 bodies were on Aisling, 4 on Helo, and they had some alongside and had launched lifeboats to pick them up. Valentia Radio informed the same to MRCC Shannon and Falmouth. At 1338Z, MRCC Shannon requested Valentia Radio to include the following in their broadcast:

"Vessels within 100 N Miles of datum 5101.9N/1242.5W are requested to proceed to search area and contact Aisling/EIYP. Any vessels recovering bodies or wreckage are requested to retain them on board and inform MRCC Falmouth of total number of bodies recovered."

2.8.16 Valentia Radio transmitted the above message at 1340 Z to all stations and also informed MRCC Shannon. At 1503 Z Aisling informed Valentia Radio that they had recovered 56 bodies. MRCC Shannon requested Valentia Radio to advise Aisling that if they could locate "Black Box", they should drop buoy. Valentia Radio advised Aisling accordingly. At 1530 Z, on advice from MRCC Shannon, Valentia Radio asked Baltimore, Courtmaesherry and Ballycotton lifeboats to return to base. At 1633 Aisling requested Valentia Radio to inform Falmouth that they were unable to transfer bodies to Valentia Lifeboat as latter was returning to base owing to fuel shortage. At 1659, Laurentia Forest informed Valentia Radio that 66 bodies had been picked up by then. Aisling advised Valentia Radio that Valentia lifeboat was returning with four bodies.

2.8.17 At 1721 Z Falmouth requested Valentia Radio to relay following to all surface units at scene:

1. One mimrod remaining on scene overnight.
2. All other air units will be recalled at 2200 Z. One Helo remains at 15 minutes notice at Cork
3. Air Search recommences at 240400 Z.
4. All Civil surface units will be released by 2200 and may proceed on passage. Bodies should be landed at Irish Post for transfer to receiving station at Cork Airport.
5. Warship Challenger, Emer and Aisling acknowledge".

2.8.18 At 1723 Z Aisling informed Valentia Radio that they saw 3 Spanish vessels approaching and they were using Ch.16 which Aisling was using for co-ordination with RESCUE 52 and requested that Spanish Vessels be asked to stay outside 5 miles radius. Spanish Agent was told about Aisling request.

2.8.19. Valentia lifeboat informed Valentia Radio that they were heading for home (Valientia) at reduced spead of 11 knots and they had five bodies on board. At 1822 Z, Aisling requested Valentia Radio information on 'Black Box' that might help its location. Aisling was advised of ELT signal on 121.5 MHz. At 1840 Z Cork ATC Advised MRCC Shannon that a total of 64 bodies were in Cork.

2.8.20 At 1920 Z, MRCC Shannon downgraded the 'MAYDAY' Broadcast to 'PAN' (Urgency) Broadcast, Aisling informed Valentia Radio that 79 bodies had been recovered. At 1958 Z Laurentian Forest informed Valentia Radio that they were proceeding to Dublin. Valentia Radio thanked them for assistance.

2.8.21 At 2000 Z, MRCC Swansea advised MRCC Shannon that main air search would cease at 2200 Z and would recommence at 240400 Z. The overnight search would continue with one Nimrod providing air cover for the surface search by three warships. Vessels transiting the area were requested to keep a sharp look out and to report to HMS Challenger.

2.8.22 By 0300 Z on 24th June, four Seaking helicopters had deported from Cork to resume the airborne search. At that time the search area covered a six nautical mile radius of position 5059.2 N/1225.3W and the vessels Le Emer and HMS Challenger were requested to search this area. HMS Challenger was the coordinator of the surface search and Nimrod Rescue 02 was on-Scene-Commander.

2.8.23 At 0450 Z Rescue 02 reported sighting of wreckage in position 5101 M/1245 W. Between 0505 and 0543, three USAF Chinook helicopters departed from Cork Airport to join the search. At 0556, MRCC Swansea confirmed that there were 329 people on board the aircraft (Earlier reportes had idicated 325 people on board).

2.8.24 A continuous search was maintained throughtout the day (24th June) but only one further body and numerous pieces of wreckage were recovered. An extensive surface search was also maintained throughout the day and instructions were passed by MRCC Shannon to Valentia Radio requestiong all shipping to recover any wreckage or bodies sighted.

2.8.25 At 0900 Z, Capt. G Mc. Stay of Department of Communications advised MRCC Shannon that Aisling was bound for Cork, ETA 1300 Z and he (Capt. Mc Stay) was assuming responsibility for collection of wreckage. MRCC were also advised by Mr. Gregory of Britoil that their two vessels 'Constine' and 'Star Orion' were enroute to Foynes having picked up quantities of wreckage.

2.8.26 At 1740 Z, SRCC Plymouth advised Shannon that the Search will terminate at 242200 Z, at 1800 Z Falmouth MRCC advised MRCC Shannon to direct the Portisheal and Valentia Radios to concel Urgency Broadcast from 242000 and to release HMS Challenger and Le Aisling from the search at 242000 hours. All the aircraft were released at 24000. It was also decided that Le Emer would remain at the area. At 242003 Z, a message was transmitted to all stations on R/T and W/T that air and sea search was being terminated at 242000 Z and all the participant were thanked for their assistance.

INJURIES TO PERSONS

3.1.1 Post mortem examination was carried out by Irish Authorities at Cork. At that time Wing Commandor Dr. LR. Hill was also present. Subsequently Air Vice Marshall Kunzru also reached Cork. Both of them were members of the Medical Group which had been constituted by Mr. H.S. Khola.

3.1.2 By then 131 bodies had been recovered. None of the bodies of the flying crew were revocered. The bodies which were recovered represented 39.8 per cent of the victims. The exact seating position of passengers is not certain, because it is known if the passengers had changed their seats after the take off of the aircraft from Montreal. On the information which is available, the passengers were supposed to have been as follows:-

Passengers: Seats Occupied Bodies Available identified Zone A 16 1 0 Zone B 22 0 0 Upper Deck 18 7 0 Zone D 112 104 + 2 29 Zone D 86 84 + 1 38 Zone E 123 105 + 3 50 Sub-Total 377 301 +(6 infants) 117 Crew: Flight Deck 3 3 0 Cabin 19 19 5 Total 399 329 122

3.1.3 The Post-mortem reports were examined by Wing Commander Dr. Hill. He submitted two reports being Exhibits H-1 and H-2. He was also examined in Court as Witness No. 2. Dr. Hill who had developed a system which would indicate the severity of the accident and the injuries suffered. He used a scale from 0 to 4, with naught being no injury and 4 being a fatal lesion. Though there is some amount of subjectivity involved in the system, nevertheless categorising the injuries according to the sacle does give an overall picture of what had happened to the victims. After adding up all the injury scale for a particular body, Dr. Hill in his Report Exhibit H-1 divided the injuries as under:-

No. of victims Mild injury (0-49) total 34.4% 45% Moderate injury (50-99) 38.9% 51% Severe Injury (100-149) 25.2% 33% Catestrophic Injury (150 +) 1.5% 2 Total 100.1% 131 3.1.4 A further break up showing the overall injury score of the recovered victims is as follows:

Minor Moderate Severe Zone No. % % No. % % No. % % Total C 8 6.1 17.8 9 6.9 17.7 4 3.1 11.4 21 D 9 6.9 20 15 11.5 29.4 9 6.9 25.7 33 E 15 11.5 33.3 15 11.5 29.4 14 10.7 40 44 Unknown 13 9.9 28.9 12 9.2 23.5 8 6.1 22.9 33 Total 145 34.4 100 51 39.1 100% 35 26.8 100% 131 3.1.5 The reports submitted by Dr.Hill further indicted as follows

(a) There were 30 children recovered and they showed less overall injury. The average severity of injury increases from zone C to E and is significantly less in C than in Zones D and E.

(b) Flail pattern injuries were exhibited by eight bodies, five of these were in Zones E, one in Zone D, two in Zone C and one crew member. The significance of flail injuries is that it indicates that the victims came out of the aircraft at altitude before it hit the water.

(c) There were 26 bodies that showed signs of hypoxia (lack of oxygen), including 12 children, 9 in Zones C, 6 in Zone D and 11 in Zone E. There were 25 bodies showing signs of decompression, including 7 children. They were evently distributed throughout the zones, but with a tendency to be seated at the sides, particularly the right side (12 bodies).

(d) Twenty-three bodies showed evidence of receiving injuries from a vertical force. They tended to be older, seated to the rear of the aircraft (4 in Zone C, 5 Zone D, 11 inZone E, 2 crew and 1 unknown), and 16 had little or no clothing.

(e) Twenty-one bodies were found with no clothing, including three children. They tended to be seated to the rear and to the right (3 in Zone C, 5 in Zone D, 11 in Zone E and 2 unknown).

(f) There were 49 cases showing signs of impact-type injuries, including 19 children (15 in Zone C, 15 in Zone D, 15 in Zone E, 1 crew member and 3 unknown).

(g) There is a general absence of signs indicating the wearing of lap belts.

(h) Pathological examination failed to reveal any injuries indicative of a fire or explosion.

3.1.6 In his testimony in Court, Wing Commander Dr. I.R. Hill further stated that the significance of flail injuries being suffered by some of the passengers was that it indicated that the aircraft had broken in mid-air at an altitude and that the victims had come out of the aeroplane at an altitude. He further explained that if an explosion had occurred in the cargo hold, it was possible that the bodies may not show any sign of explosion. It may here be mentioned that the forensic examination of the bodies do not disclose any evidence of an explosion. Furthermore, the seating pattern also shows that none of the bodies from Zone A or B was recovered, in fact as per the seating plan Zone B was supposed to have been unoccupied. This Zone is directly above the forward cargo compartment.

3.1.7 Dr. Hill further stated that the pattern of the accident as suggested by the injuries indicated that it was a complex affair and there were at least two phases of injuries, one in the air and the other at water impact. In answer to a specific question that if there was an explosive device in the cargo

hold then could the passengers who were seated have suffered such injuries, the answer of Dr. Hill was that "it is possible". According to him, the pattern of injuries indicated that if there was an explosion in the aircraft it was more likely that the explosion had occurred in the rear cargo compartment than in the front cargo compartment. This conclusion was apparently based on the fact that, according to him, in zone E of the aircraft there were larger vertical load type injuries. Dr. Hill was also asked if he had to make any suggestions which would minimise injuries to passangers in the event of an accident. In answer, the witness made his suggestion in the following words
"There are very complicated things one would have to do such as rearward facing seats; having safety belts which incorporated restraint for the upper part of the body; increasing the space between aircraft seats; incorporating shocks absorbing system within the seat and using materials which do not break easily like plastic. We would also need fuel systems which would not immediately set on fire and furnishing which would be resistant to burining, and also passengers should not carry into the aeroplanes large amount of hand bags which only get in way in the event of evacuation, and I personally feel that the carriage of large amount of alchohol both in the passengers and in the aeroplane is a hazard to flight and safety. Finally the passengers should take heed of the flight safety instructions given to them by the crew of the aeroplane".

3.1.8 Air Vice Marshal Kunzru, witness No. 10 in his report dated 14th November, 1985, Ex.A-48, gave his comments not only on the post-mortem reports but also on the statement of Wing Commander Dr. I.R. Hill. With regard to the post-mortem examination, the comment of AVM Kunzru was as follows:

"All victims have been stated in the PM reports to have died of Multiple injuries. However two of the dead, one infant and one child, are reported to have dies of Asphyxia. There is no doubt about the asphyxial death of the infant. In the case of the other child (Body No. 93) there could be doubt because the findings could also be caused due to the child undergoing tumbling or spinning with the anchor point at the ankles. Three other victims undoubtedly died of drowning. There was no evidence of significant Lap-belt injuries.

Considering rupture of the ear-drum, without injury to skull, as a criterion to indicate rapid decompression, two cases may be considered to fall in this category.

Histological examination has been carried out only in 57 bodies out of 131. Lung examination on almost all of them showed decelerative changes. Six bodies (Nos. 6,22,70,103,121 and 131) showed presence of Bone Marrow Embolism in Lung Sections. Though not of much significance in this accident, this finding does indicate survicval after a bony injury for an undefined period of time No evidence of fire burns or explosive material, other than Kerosene burns on some bodies, which I had myself seen at Cork, could be found. Kerosene burns in such acidents is a fairly common findings and is of no significance".

AVM Kunzru generally agreed with the crash injury analysis on the victims which had been furnished by Wing Commander Dr. Hill. He, however, gave the following comments with regard to hypoxia, decompression and decelerative changes:

"Hypoxia : The main Post Mortem findings in hypoxia is generalised congestion if the hypoxia is of the type described as "hypoxic hypoxia". In other causes of hypoxia of more severe degree such as "histotoxic hypoxia", "asphyxia" or "drowning" additional histological findings such as petechial haemorrhages and generalised congestion, and lung findings such as haemorrhage and extrusion of alvoolar phagocytos are seen.

Decompression : The term used by Dr. Hill is "Decompression". It is presumed that he means "Rapid/Explosive Decompression" which occurs within one Sec. and not "decompression sickness" which takes a minimum of 5 to 7 mnts to occur even at 31,000 ft. altitude and which in this case can positively be ruled out.

The Post-Mortem and histological signs of rapid Decompressions are :-

(a) Possibility of rupture of Ear drums without any injury to the skull.
*(b) Patchy Lung Haemorrhages
*(c) Emphysomatus changes
*(These occur more commonly in those cases where the individual was in the phase of breathing-in at the time of decompression.

3.1.9 If it is assumed that the aircraft suddenly broke up in Mid-Air at an altitude of 31,000 ft. the bodies will be at once exposed to hypoxia and rapid decompression and as a consequence will suffer body changes as mentioned above. As the aircraft/occupants start descending, they will be exposed to increasing amounts of Oxygen and as soon as ;they come down below 15,000 ft. and then below 10,000 ft. the effect of hypoxia rapidly diminishes. Finally, the aircraft/individuals come down and hit the ground/water with a very heavy impact, thus submitting the individuals to extremely severe G-loads of decelarative type.

Decelerative Changes : Decelerative impact brings about well established changes in the lungs besides many other associated injuries. It is relevant to note the decelerative lung changes which are :-

(a) Patchy haemorrhages in Lung.
(b) Marked Emphysomatus Changes.
(c) Extrusion of alvoolar Phagocytes
(d) Desqummation of bronchcolar epitherium.

"Comparative study of the PM/histological findings of hypoxia, Decompression and Decelerative Lung injuries reveal that they are more or less similar. Decelerative injury being the most severe of the three and last to occur tends to so modify the Post-Mortem and Histological findings that it becomes extremely difficult and some times impossible to isolate one from the other."

3.1.10 AVM Kunzru was, therefore, of the opinion that in this accident evidence of hypoxia/decompression (except in 2 cases) had not been confirmed or established.

3.1.11 The difference of opinion between Wing Commander Dr. hill and AVM Kunzru, with regard to evidence of hypoxia and decompression, is of no significance in the present case. What is important to note, however, is that they have agreed that the injury pattern does indicate break up of the aircraft in mid-air and that the occupants of Zone E had suffered the greatest amount of injuries as compared to the occupants of the other zones.

MAPPING, WRECKAGE DISTRIBUTION AND SALVAGE

3.2.1 Introduction

3.2.1.1 Oceanographic charts indicated that the depth of sea in the crash area was about 6700 feet and the site appeared to be a flat sea bed, without any valleys or hills. The immediate necessity after rescuing/searching crash victims, was to locate and recover the digital flight data recorder (DFDR) and the cockpit voice recorder (CVR). The operation was unique of its kind and had never been undertaken earlier in the world at this depth of the sea. It required an equipment which could home on the transmitted signals from the underwater locater acoustic beacons fitted on DFDR/ CVR, identify the units, clear them from attachments/wreckages, grab them and bring them to the surface.

3.2.1.2 The pressure exerted by the water at 6700 feet below mean sea level is extremely high and the temperature is very low. No light penetrates to that depth and it is pitch dark. Scarab I fitted on French Ship "Leon Thevenin" which had undertaken the challenging job of locating DFDR and CVR, and recovering the same, was not designed to operate at 6700 feet depth. Its maximum design operating depth was only 6000 feet. However, it was decided to exceed the design operating depth for this emergency operation.

3.2.1.3 By using the preliminary information of probable area of location OF CVR and DFDR as indicated by ship 'Gardline Locator', the Scarab I was Lowered in the sea to locate and recover these units which it accomplished on 10.7.85 and 11.7.85 respectively.

3.2.1.4 Prior to recovery of DFDR/CVR by the ship 'Leon Thevenin', sufficient spade work was done by the ship 'Gardline Locator' (A ship provided by Accident Investigation Branch, U.K.) and 'Le Aoife' (an Irish Naval Ship). The survey of the crash area, carried out with the help of side-scan sonars fitted on these ships, had indicated a general distribution of the wreckage and a rough idea about the sizes of the parts. Each part of the wreckage was called a target. The method used for survey was triangulation with multiple passes through the crash site.

3.2.1.5 Next phase was the task of :

(a) Locating hundreds of pieces of wreckage by the combined use of sonar and video monitors.
(b) Video and still photography of the pieces of wreckage.
(c) Plotting the distribution of the wreckage.

All this was to be carried out under the directions of the Court.

3.2.2 Scarab

3.2.2.1 The means (vehicles/equipment) proposed to be used in the locating, mapping and video photography of the wreckage were the CCGS John Cabot and SCARAB II.

3.2.2.2 The John Cabot is an ice breaker of the Canadian Coast Guard. Since utilisation as an ice breaker is seasonal, the John Cabot is also equipped for submarine cable laying. In order to enlarge its capabilities in this regard, the John Cabot is equipped to have on its deck the Scarab and to operate it. Thus the John Cabot can be used for repair of submarine cables. The John Cabot has complete facilities for operation, maintenance and repair of the Scarab. This includes a Control Hut, a Test Room, Workshop, Stores etc. The John Cabot has considerable experience in work on deep sea bed.

3.2.2.3 The SCARAB II is a submersible craft assisting repair and burial of cables. As will be clear from the following details, the Scarab is not ipso facto a submarine. It is a total system for carrying out its complex functions.

3.2.2.4 The SCARAB II is a state-of-the-art system designed and built for tethered unmanned work at ocean depths of upto 6000 feet. Scarab's standard equipment are :

Two rugged manipulators.

A complete optical suite.

Six thrusters of 5 hp each.

CTFM Sonar.

Navigation System.

3.2.2.5 The manipulators have a choice of grippers/claws/cutters etc. of any required description and size. The Scarab has three TV cameras mounted on separate pan/tilt mechanism to allow real time observation and video tape documentation. A 35 mm still camera was also installed and used in the present work. There was a choice of quartz-iodide flood lights to provide illumination.

3.2.2.6 The location and control of the Scarab is accomplished through a phased array navigation system.

3.2.2.7 The Scarab was equipped with a 360∞ high resolution Sonar with a range of 1000 meters. The Sonar was also capable of interrogating and detecting 37 KHz and 27 KHz pingers. It can function independently of the ship's facilities and is equipped with power generators and semiautomatic handling equipment.

3.2.2.8 The John Cabot can salvage items, but it is not a salvage ship as it does not have the specialised high capacity cranes, derricks etc. required for salvage of large objects. Further, it does not have deck space for keeping large salvaged items like the wings, fuselage or tail surfaces of an aircraft as large as a 747. The John Cabot was, therefore, adequate and fully satisfactory for the work envisaged in this phase of the programme, as salvage of large items was not planned in this phase. The task was, as mentioned earlier, locating, mapping and photography of the hundreds of pieces of wreckage. (The salvage work was part of the next phase of the programme).

3.2.3 Control and Monitoring of Operations

3.2.3.1 It was realised that the operation proposed would pose problems of control, monitoring and logistics.

3.2.3.2 Consider : A ship operating on the high seas in international waters on the task of locating, mapping and video photographing the hundreds of pieces of wreckage. The state of art system for Sonar location and photography (Scarab) used by the ship for handling this task. The group located on shore in charge of the operations. Finally, the Court in Delhi was in overall charge of the operatins.

3.2.3.3 It was realised that a proper line of control and communication was essential if the operations were to be smooth and successful.

3.2.3.4 Therefore it was decided that the following would be the chain of command :

Court Investigating the Accident

(Mr. Justice B.N. Kripal)

Control Centre at Cork

(Court's representative)

CCGS John Cabot

(Commanding Officer)
Scarab
(Project Manager)

3.2.3.5 Because of the multiplicity of agencies involved in the operations, the need was felt for a proper delineation of power at all levels. It was, therefore, decided that :

a. Overall responsibility for the operations would rest with the Indian authority viz. the Court. This would cover the identification and definition of assignment of the overall tasks, laying down of the priorities, overall control of the coverage of the operation and, finally, the time schedule for the operation.

b. Decisions taken at the Control Centre, flowing from the above, were to be taken solely by the Court's representative. The experts from CASB, NTSB and Boeing were free to give their views and recommendations, but the final decisions were to be left to the Court's representative. Examples of such matters are : Track of the survey, areas to be covered by John Cabot, assignment of priorities for specific tasks, amount of time to be devoted to any piece of wreckage, whether any item of wreckage is to be picked up, etc.

c. Operation Control of John Cabot would be in the hands of the Canadian Coast Guard Officer in the Control Centre,
who would co-ordinate with the Commanding Officer of John Cabot. This would cover decision on feasibility or otherwise of operations under adverse weather conditions, manner of covering the area, method of retrieving any wreckage, etc.

d. Decisions relating to the Scarab (i.e. whether the weather was suitable for Scarab operations, whether the size, weight etc. of an item would permit its being picked up by Scarab, etc.) would be left to the Scarab Project Manager on Board John Cabot.

3.2.3.6 It might appear at first sight that in the above system excessive power was delegated at certain levels to the detriment of overall control. Any such impression would not be correct. In actual fact, because of proper delegation of responsibility and power at different levels, the operations were carried out with extraordinary efficiency, smoothness and coordination, In this connection, it is relevant to point out that the operations were not a uni-disciplinary one. The operation (aircraft accident investigation) was totally dependent on experts from other disciplines, like naval (coast guard) operations, deep sea photograph, salvage from sea bed etc. It was therefore, decided that for smooth and efficient operations, adequate power and responsibility should be delegated at all levels, particularly to specialists engaged in the different areas of work as above.

3.2.3.7 It was also considered that adequate communication was a sine qua non for smooth operation. Therefore, the following communication facilities were established :

Control Centre at Cork Airport
Telex
Telephones (2)

3.2.3.8 The ship John Cabot had both telex and telephone facility. These links were through satellite (IN MARSAT). The Control Centre was in continuous communication contact with John Cabot through telex and telephones. In order to establish a reliable and satisfactory line of communication it was decided that instructions or communication from Control Centre to the Indian experts on John Cabot would follow the path as under :

Control Centre
Court's representative --- Canadian Coast Guard Officer
John Cabot
Indian experts --- Commanding Officer

3.2.3.9 It was felt that this would eliminate any possibility of inconsistent or contradictory orders/messages going to John Cabot.

3.2.3.10 With a view to have an ordered system of communications between the control centre and John Cabot (which is essential for proper control and monitoring of the operations), it was decided that John Cabot would sent to the Control Centre daily Situation Reports (SITREPS) at specified times viz. 0800 hrs, 1200 hrs, 1600 hrs and 2000 hrs. This however did not preclude the despatch of telexes by both Control Centre and John Cabot at any other time.

3.2.3.11 In order to inform all agencies of the above system of Control and Communication a number of meetings were held. These were on 12.8.85 and 3.9.85 on board John Cabot and on a number of occasions at the Control Centre. The purpose of these meetings was not only to inform all concerned about the specific task, the programme and the line of control and communication but also to sort out differences and to understand the technical and operational difficulties faced by the personnel on the spot and to find a way out.

3.2.4 Daily Monitoring of Progress

3.2.4.1 It may be relevant to point out here that search, location and video photography work was to be carried out round the clock. Thus a considerable volume of data would be coming into Control Centre. This required regular, almost hourly, monitoring, study and analysis for (a) proper understanding of the data collected and (b) advising John Cabot of any changes in its programme, such as additional photography on an item etc. For this purpose (i) SITREPS were filed in the Control Centre (ii) all data (description, latitude and longitude) obtained on every target was tabulated and the cumulative list updated daily.

3.2.4.2 The location of the targets was plotted on charts every 4 hours. This was in addition to the plotting of targets carried out on John Cabot.

3.2.4.3 Every day (including holidays and week ends) all the officers posted at Control Centre assembled at about 0900 hrs. They studied the SITREPS received at 0800 hrs and any other telexes received from John Cabot in the night. The lists of targets were updated and the new targets plotted on the charts. John Cabot generally also sent brief remarks such as description, nature of failure/damage, dimensions etc. Discussions were held on the significance of the targets and their implications. Instructions if any to be telexed to John Cabot were also discussed. Similarly SITREPS received at 1200 hrs and 1600 hrs were studied.

3.2.5 Monitoring at Cork

3.2.5.1 The Scarab provided video tapes and still photographs. In the initial stages (upto 9.8.1985) the John Cabot was operating in peripheral areas and therefore few targets were found. Hence the output of videotapes was small. In fact upto 9.8.85, only about 10 targets were found and only 3 video tapes were used up. But later, when John Cabot came close to and into the crucial areas, video tapes were recorded at a fast rate. Further, still photography facility on the Scrab was activated at about this time. Therefore, arrangements were made periodically to obtain the video tapes and films from John Cabot. Video tapes and still photographs (these required to be processed) were transported from John Cabot to Cork Control Centre.

3.2.5.2 About 50 video tapes and nearly 3000 still photographs (positives and transparencies) provided the visual information on the targets.
Arrangements had to be made at Cork for such viewing and study of the video tapes and still photographs. Video equipment (TV monitor plus VCR) suitable for viewing the video tapes had to be arranged.

3.2.5.3 The still photography used special professional quality colour film (35 mm), each roll having 800 frames. The film was diapositive. These had to be developed and transparencies obtained from them. Thereafter negatives and prints had to be made. Special equipment for viewing the transparencies had to be provided for continuous work. The video tapes, transparencies and prints provided the principal means of monitoring of the results of the operation.

3.2.6 Operations

3.2.6.1 The Charts prepared by 'Gardline Locator' were on a different type of grid system, and had to be translated into LAT-LONG system, for use by John Cabot. For the convenience of search/mapping operation the search area was divided into 4 blocks viz. Block 1, Block 2, Block 3 and Block 4.

3.2.6.2 The navigation system used by John Cabot is PULSE-8 system. This system needs the transponders to be placed on the sea bed. These transponders help in getting the correct fix of a target and in obtaining relative positions of the targets on the sea bed which is highly useful for revisit for the purpose of rephotography or recovery. Initially 4 transponders were placed, and subsequently the number was increased as the search operation was continued. The strategic locations for placing the transponders was decided by considering :

(a) frequencies of relative transponders,

(b) distances required between relative transponders,
(c) wreckage distribution suggested by side scan sonar plots of Eithena and Garline Locator, and
(d) size of search area.

These transponders were calibrated to match the navigation system of the ship.

3.2.6.3 In order to obtain the maximum information from search, it was decided that the Scarab search paths should be as follows :

(a) Normally the search paths should be east to west, or west to east within the individual blocks.
(b) The pattern of search should be a parallel search method.
(c) Distances between the parallel paths to be 1,200 feet (i.e. 2 cable widths), for effective use of sonar fitted on the Scarab.
(d) If Scarab deviates from its planned path for photography or recovery, it should return to its planned path for further search.
(e) In each block, the search was to be made, at least 1/2 mile (North or South) beyond the last target sighted, so as to ensure no target is missed out from the given block.

3.2.6.4 However, when there was a need to modify the search pattern, due to wreckage distribution in particular areas, the following changes were made:

(a) Expanding box type search pattern was used in Block 1.
(b) Some North to South and South to North passes were made in Block 3.
(c) In Block 3 northern end, the distances between the search passes was reduced to 600 feet i.e. 1 cable width.

However, these deviations were made basically to improve the reliability of search in specific areas, as demanded by peculiar distribution of aircraft wreckage.

3.2.6.5 To facilitate identification of the wreckage located by Scarab it was necessary to position aircraft maintenance personnel on board the ship. As the aircraft structure was badly torn, mutilated and distorted, serious difficulty was anticipated in identification of small pieces of structure. It was therefore essential that these maintenance personnel were provided with aircraft photographs, manufacturing drawings, parts catalogue, wiring diagram manuals and maintenance manuals. Since carriage of such voluminous literature was not praticable, 3M micro film reader printer machines with micro film cassettes of the above literature were produced and installed on the ship. In case of difficulty of locating any particular information, the engineers were advised to contact Cork Search Centre by telex or telephone who, in turn, could seek the desired information from the manufacturers.

3.2.7 Wreckage Distribution

3.2.7.1 The wreckage distribution as determined by the mapping of the sea bed provided some distinct distribution patterns. The depth of the wreckage varies between about 6000 and 7000 feet, and the effect of the ocean current, tides and the way objects may have descended to the sea bed was not determined, thus some distortion of an object's relationship from time of water entry to its location on the bottom cannot be discounted. In general, the items found east of long 12∞43.00'W are small, lightweight and often made of a structure which traps air. These items may have taken considerable time to sink and may have moved horizontally in sea currents before settling at the bottom. Marks left on the sea bed beside some wreckage does indicate horizontal movement of the wreckage as it settled. Although badly damaged, sections 41, 42 and 44, and the wing structure were located in a relatively localized area centred about lat 51∞03.30'N and long 12∞47.80'W, and the wreckage scatter was oriented north/south. The wreckage scatter in this area was so dense that it is probable that some of the wreckage may not have been mapped or photographed. Section 46 and 48, including the vertical fin and horizontal stabilizer, extended in a west to east pattern with the western most identified aircraft component located at lat 51∞02.90'N and long 12∞50.1'N. The wreckage extended in a line about 110 degrees to an eastern position of lat 51∞02.04'N and long 12∞41.26'W, a distance of approximately 6.5 nautical miles. The aircraft structure had a random scatter pattern. That is, items such as the aft pressure bulkhead were broken into several pieces, and these pieces were located throughout the pattern. A third area which had some distinctive pattern was that of the engines, engine struts and components and was localized about lat 51∞03.25'N and long 12∞47.4'W in a northwest/southwest orientation. One of the operating engines was displaced 0.5 nautical mile to the north of this area, and it was also geographically separated from the wing structure. The number 3 engine nacelle strut was also separated from the rest of the engine components and was located about one nautical mile to the west-southwest at lat 51∞02.87'N, long 12∞48.05'W. The reasons for the displacement of the number 3 engine nacelle strut and one of the operating engines from the other engines are not known.

3.2.7.2 Details of the various targets which were identified by the Structures Group is contained in Appendix 1 of this Report.

3.2.8 The Break up Pattern

3.2.8.1 The forward fuselage section of the aircraft was found inverted and badly broken into many pieces, the major pieces being :

(I) Section of fuselage right side below cockpit windows containing part of the name 'Kanishka' (in Hindi) and 3 passenger windows (Target No. 192)

(ii) Portion of upper skin between B S 360 and B S 520 below window belt right side, up and over crown. This portion includes the crew door and last letter of the "Air India" (in Hindi) logo (Target No. 192).

(iii) Section of fuselage between B S 510 to B S 700, including the passenger window belt right side, up and over crown to include upper deck windows left side (Target No. 218).

(iv) Section of fuselage between B S 720 to B S 840 including left side passenger window belt, up and over crown to right side passenger window belt. Forward and upper edges of L H No.2 door cutout can be seen (Target No. 193).

(v) Large section of fuselage between B S 1000 to B S 1460 including left side passenger window belt, up and over crown to right side passenger window belt. This section was found lying on its right side (Target No. 137).

(vi) The lower portion of the fuselage skin/frame between the nose and B S 1000 was damaged past recognition except for a small portion with the forwarded cargo door (Target No.204) and another portion containing the aft access door cutout at B S 810 (Target No. 362).

3.2.8.2 The aft fuselage was found in the following major pieces :

(I) Section of RH fuselage skin between B S 1640 and B S 1940 below the window belt up to the crown (Target No. 321).

(ii) The RH fuselage bottom skin between B S 1820 (forward edge of C2 door) and B S 2060 and between two stringers above the door cutout to just below stringer 46 lap joint (Target No. 40).

(iii) The lower fuselage skin with stringers between B S 1480 and B S 1846 about 100 inches wide approximately (Target No. 7).

(iv) The LH fuselage skin panel between B S 1740 and B S 1880 about 110 inches wide (Target No. 11).

(v) The LH fuselage skin between B S 1460 and B S 1800 width 80 inches including No. 4L door and passenger windows (Target No. 28).

(vi) The RH fuselage skin between B S 1660 and B S 1920, from below window belt up to the crown including the 4R door cutout (Target No. 321).

(vii) A fuselage lower skin panel (containing out flow valve) between B S 2120 and B S 2240 and 120 inches wide (Target No. 320).

(viii) A fuselage LH skin panel (containing 5 windows with "T -" part of registration) between B S 1980and B S 2080 between stringers 19L and 24L (Target No. 369 and 26).

(ix) A fuselage LH skin panel between B S 1460 and B S 1800 with 8 stringers below the bottom of the door and 3 stringers above the top of the door (Target No. 28).

3.2.8.3 The tail portion of the fuselage was found in the following pieces:

(I) The lower fuselage skin between B S 2412 and B S 2598 about 20 stringers wide (Target No. 371).

(ii) The vertical fin with rudders attached was lying on the ground by itself with a portion of B S 2517 frame. This includes a small portion of the aft pressure bulkhead (Target No.37).

(iii) The horizontal tail with elevators attached was lying on ocean floor with the jack screw and drive motor attached (Target No. 31).

(iv) The fuselage tail cone aft of B S 2669 was found basically intact and lying separately (Target No. 27).

3.2.9 Extent of Damage

Photographic and Video Interpretation of Wreckage

Photographic Interpretation

3.2.9.1 All wreckage sighted was recorded on video tapes and all major items were recorded on 35 mm positive film. During the course of the investigation, several members of the investigation team had the opportunity to view the tapes and photographs. Subsequently, when some items were recovered, it became apparent that the optical image presented on video and still film had some limitation with respect to identification of damage or damage pattern. For example, the sine wave bending of target 7 appeared in the video and photographs as a sine wave fracture, and some of the buckling on target 35 was not evident in either the video or photographs. The interpretation of damage through photographic/video evidence without the physical evidence might be misleading, and any interpretation should take this into acount.

3.2.9.2 Engines

The four operating engines were all extensively damaged. A view of the fan blades did not show signs of any rotational damage, and it could not be determined whether any pre-impact failures had occurred. The external damage to the engines varied, and at least one engine appeared to be attached to part of the nacelle strut. Except for the non-operational fifth engine, the engines could not be matched with their original positions on the aircraft.

3.2.9.3 Landing Gear

The nose, wing, and body landing gear were all located. Photographic examination indicated that all the gears were in the 'up' position at the time of impact.

3.2.9.4 Flaps and Spoilers

Positive identification of all the flap and spoiler surfaces was not made. All the flap jackscrews indicated that the flaps were retracted at impact. Of the spoilers identified, six had actuators attached. The actuators were in the fully retracted position.

3.2.9.5 Section 41

Section 41, consisting of the cockpit, first-class section, and electronics bay and identified as target 192, was found in a near-inverted attitude. This section was severely damaged. The electronics bay and cockpit areas could not be located within the wreckage. The first officer's seat was found on the sea bed near section 41 wreckage.

3.2.9.6 Section 42

Portions of Section 42, consisting of the forward cargo hold, main deck passenger area, and the upper deck passenger area, were located near section 41. This area was severely damaged and some of section 42 was attached to section 44. Some of the structure identified from section 42 was the crown skin, the upper passenger compartment deck, the belly skin, and some of the cargo floor including roller tracks. The right-hand, number two passenger door including some of the upper and aft frame and outer skin was located beside section 44. Scattered on the sea bed near this area were a large number of suitcases and baggage as well as several badly damaged containers. All cargo doors were found intact and attached to the fuselage structure, except for the forward cargo door which had some fuselage and cargo floor attached. This door, located on the forward right side of the aircraft, was broken horizontally about one-quarter of the distance above the lower frame. The damage to the door and the fuselage skin near the door appeared to have been caused by an outward force. The fractured surface of the cargo door appeared to have been badly frayed. Because the damage appeared to be different from that seen on other wreckage pieces, an attempt to recover the door was made by CCGS John Cabot. Shortly after the wreckage broke clear of the water, the area of the door to which the lift cable was attached broke free from the cargo door, and the wreckage settled back on to the sea bed. An attempt to relocate the door was unsuccessful.

3.2.9.7 Section 44

Section 44 containing the aircraft structure between B S 1000 and B S 1480 including that area where the fuselage and wings were mated was located and identified. This section was severely damaged but maintained its overall shape and was lying on its right side. Part of the left wing upper skin was attached to the fuselage and a large portion, about one third of the upper wing skin, separated and was lying against the fuselage crown skin. Some of the body and wing landing gears were found beside this section of the aircraft. The gear was detached from the main structure. The interior of the fuselage was extensively damaged.

3.2.9.8 Wing Structure

The wing structure was located near the forward area of the aircraft structure and towards the northern most area of the wreckage pattern. The wings showed extreme damage patterns with the top and bottom surfaces separated and the wing surfaces broken into segments.

3.2.9.9 Sections 46 and 48

Sections 46 and 48 contain that part of the aircraft structure aft of B S 1480 and, for purposes of this report, will include the horizontal stabilizer and vertical fin. This section of the aircraft was scattered in a west to east pattern about 6.5 nautical miles in length and exhibited severe break-up characteristics.

3.2.9.10 The aft cargo and bulk cargo doors were found in place and intact, and 5L, 5R and 4R entry doors were identified. Four segments of the aft pressure bulkhead were positively identified (targets 35, 37, 73 and 296). Much of the fuselage which was forward of the number five door and above the passenger floor area was not located, or if located was not recognisable as having come from a specific area of the aircraft.

3.2.9.11 Sections of the outer skin below the cargo area were located as was some of the cargo floor structure. Generally, the stringers and stiffeners are attached to the skin; however, the lower frames, which provided the cargo floor support, were detached from the skin. The rear cargo floor from B S 1600 to B S 1760 was located and was found to have little or no distortion; however, the lower skin and stringers were missing. A second portion of the aft cargo compartment floor containing cargo drive wheels and cargo roller trays was located. This structure was severely damaged and mangled.

3.2.9.12 The tail cone and the auxillary power unit (APU) housing were located and had received relatively minor damage; however, the APU had broken free and was never located.

3.2.9.13 A large portion of the outer skin panels showed signs of a force being applied from the inside out. On several pieces of wreckage, the skin was curled outwards away from the stringers and formers. This could have been the result of an overpressure.

3.2.9.14 The vertical tail was found in good condition, in a single piece with both rudders attached. The top cap was partially separated and a small dent was noticed in the middle of the leading edge at the bottom. A curved broken portion of fuselage was observed with a portion of the "Y" ring and pressure bulkhead attached. Another small segment of the pressure bulkhead was leaning on the lower section of the tail.

3.2.9.15 The horizontal stabilizer tail section was located and was one unit with the elevators attached. The actuator jackscrew was attached to the assembly. The stabilizer jackscrew ballnut was observed to be located at the upper jackscrew stop. This equates∞ to a full deflection of elevator trim. Since there is nothing on the DFDR or CVR to indicate a malfunction of the trim, it is deduced that this was not the lead event. It is not known if the position of the ballnut resulted from a pilot trim selection, a result of the initial event or if it rotated to the observed position under the influence of gravity. Two-thirds of the leading edge of the right horizontal stabiliser was missing and the auxilliary spar was exposed. There was localized damage to the right-hand root of the loading edge through about a span of five ribs. The leading edge skin and part of the leading edge ribs were torn downwards. Some localized damage to the root of the left leading edge was visible with the remainder of the leading edge undamaged. There was minor damage to the trailing edge of the outboard left elevator, and a major portion of the inboard left elevator was missing.

3.2.9.16 Passenger Seats

Many of the passenger seats located among the wreckage pattern and identified as having come from section 46 and 48 appeared to have the aft support legs buckled with little or no damage to the forward support legs. Seats located in the wreckage containing sections 41, 42 and 44 appeared to have varying types of damage, that is, aft support legs only buckled, and all legs buckled. One consistent feature noted was that in the majority of seats located it was possible to ascertain that the seat belts were not fastened.

3.2.10 Salvage Operations

3.2.10.1 During recovery operation the video tapes as well as photographs of the wreckage to be recovered, were supplied to the personnel on board the ship for facilitating identification and recovery of correct targets.

3.2.10.2 Whenever any component/part of the aircraft wreckage was salvaged it was essential to immediately subject the same to inspection and to identify the damage sustained during recovery operation. In order to oversee this critical operation, the Court deputed one of its Assessors, Dr. V. Ramachandran, to be on board the ships. Under his supervision, the components/parts were thoroughly washed with fresh water, dried and treated with corrosion inhibiting compounds. A detailed inspection was thereafter carried out, observations recorded and the targets were appropriately labelled and their numbers were painted thereon. A laboratory microscope was taken on board by Dr Ramachandran. With that, fragments of significance were segregated for further investigation. Indeed some of these fragments did give important clues.

3.2.10.3 All the investigating personnel on board the ship were provided with leather gloves, fisherman's shoes, raincoat, life floating suits, writing and labelling material, camera with coloured films, etc. Sufficient number of "body bags" were positioned on each ship to cater for the eventuality of recovery of bodies with the wreckage. This precaution helped when a body did come along with wreckage on 25.10.1985.

3.2.10.4 The ship John Cabot completed the operation of locating, mapping and photography of the wreckage and returned to Cork on 1.10.85 at 2020 hours. The next phase of operation was to recover the significant wreckage parts which would be useful for deciding the cause of the crash.

3.2.10.5 Subsequent to the accident to Japan Airlines Boeing 747 aircraft, suspected to have been caused by failure of the repair to the rear pressure bulkhead, NTSB and FAA decided to fund the U.S. Navy for a two week operation over the seas for recovery of significant pieces of wreckage. For this purpose, U.S. Navy appointed Commander J.R. Buckingham, a deep sea salvage expert, to head the recovery operation. An offshore supply vessel M.V. Kreuzturm, of Canada was hired by U.S. Navy to recover the wreckage with the help of Scarab on John Cabot. One nylon lift line together with winch and ram were installed on the ship prior to its sailing to Cork where it arrived on 4th October, 1985. One crane was installed on the ship Kreuzturm in Cork.

3.2.10.6 One inch dia Kevlar lines coated with black plastic for abrasion resistance and braided with Dacron lining were used by John Cabot as primary lift lines.

3.2.10.7 The structure group after studying the photographic data, had formulated a list of 32 targets for recovery on 3.10.85. A systemwise priority list proposed by the Court of Inquiry was received through Dr V. Ramachandran on 4.10.85. Using these two lists, and taking into account the operating restrictions imposed by two ship operation, a final list of targets was prepared for recovery by the ships, assigning a priority number to each target. However, as the recovery operation progressed, changes in priority list were made to achieve optimum utilisation of the ships.

3.2.10.8 A meeting was held at 1400 hrs. on 4.10.85 on board CCGS John Cabot to establish/clarify the priorities for the wreckage recovery operation and coordination between John Cabot, Kreuzturm and Cork Search Centre. All the personnel involved in the recovery operation were shown the slides and photographs of the targets which were chosen for recovery on priority basis. The method and procedure of the recovery operation was discussed in detail and finalised. Another meeting was convened on 6.10.85 to clarify the doubts and to present the picture albums containing various photographs of targets to be recovered. The mode of attaching grippers/grabbers to the targets at strong points was clarified. A serialised list of priorities was prepared based on the mode of operation indicated by the the crew of John Cabot and Kreuzturm. Dr Ramachandran was given the authority to make on-the-spot decisions during the salvage operations.

3.2.10.9 A detail log of the activities of the ships John Cabot and Kreuzturm which started the recovery operation of 10.10.85, reveals the following :

(a) The Scarab working independently recovered the following

(1) Basket at target 192 containing copilot's chair, 2 suitcases and radar antenna (12.10.85)

(2) Target 8 - Lower fuselage skin of aft cargo compartment. (11.10.85).

(3) Target 245 - Forward belly skin just aft of radome (16.10.85).

(4) Target 350 - Economy class seats and carpet (23.10.85).
(5) Target 296 - Piece of aft pressure bulkhead.
(b) The Scarab after attaching the grippers, bridal cable and lift line to the targets buoyed off the same to Kreuzturm which recovered the following targets :
(1) Target 362/396 - Forward cargo fuselage skin from station 700 to 840 and STR 41L to 43R. (16.10.85).
(2) Target 193 - Fueselage skin from station 720 to 860 and passenger door 2L (17.10.85)
(3) Target 223 - Nose landing gear pressure deck web and stiffeners, container pieces (staion 260-340)(19.10.85).
(4) Target 181 - Wing skin with forward cargo compartment SLIPPED OFF WITH GRIPPERS (21.10.85) AND WAS LOST.
(5) Target 399/358 - Fuselage skin from station 780 to 940 and STR 7R to 35R with 2R door (25.10.85). A body entrapped in target 399/358 was recovered. Another body which came upto surface with the wreckage fell off into sea and was lost while hauling the wreckage on board. The recovered body was identified as of Dr. Mathew Alexander, a Canadian passenger and was brought to Cork by Fisherman's vessel "Orion" at 0130 hrs. on 28.10.85 and was sent for Post Mortem etc.
(6) Target 7 - Aft cargo compartment fuselage skin from station 1480 to 1860 (26.10.85).
(7) Target 47/50 - Aft cargo floor structure with roller tracks, frames, latch etc. from station 1600 to 1760 (27.10.85).
(8) Target 117 - Three rows of coach class seats with passenger cabin floor boards, broken floor beam (28.10.85).
(9) Target 35 - Aft Pressure Bulkhead piece (30.10.85).

3.2.10.10 The Scarab experienced malfunctions with its arms, Sonar equipment, multiplex system, junction box, microprocessor unit, etc. off and on during the above period of operation. Fouling of lift line with umbilical cord was also experienced in the early stages of operation. Since the assigned recovery by Kreuzturm was over by 30.10.85, and as the Scarab became unserviceable due to breakdown of its power suppluy, the OSV MV Kreuzturm was directed to return to Cork to off-load the recovered wreckage and its operation was terminated, (Indian Government had funded the cost of operation of M.V. Kreuzturm from 21.10.85 onwards).

3.2.10.11 Since the Scrab continued to remain unserviceable, the ship John Cabot was called back to Cork. It anchored in Cork at 1100 hrs. on 5.11.85. All the wreckage on board the ship was transported to the boat yard, in the afternoon.

3.2.10.12 After detailed macro photography of the recovered wreckage, the experts group mentioned in section 1.5.16 prepared a detailed factual report after carefully inspecting each of the targets recovered. It was decided to send the wreckage to Bombay for which necessary crates were then prepared and the large pieces of wreckage were cut along the lines indicated by the experts group to facilitate their packing.

3.2.10.13 RCMP investigators carried out a close visual and microscopic examination of the fragments recovered with the wreckage, suitcases, seats and cushions, etc. For further laboratory analysis. Dr A.D. Beveridge collected a few samples.

3.2.10.14 The Scarab appeared to be serviceable on 19.11.85 and the ship John Cabot sailed for completion of recovery of left over targets, on 20.11.85. However, the serviceability of Scarab proved elusive, it became inoperable on 21.11.85 and the ship returned to Cork at 1700 hrs on 25.11.85.

3.2.10.15 Efforts were made to repair Scarab so that the ship John Cabot could sail again in order to salvage as many pieces as possible. It was fortunate that the weather had not deteriorated. Some of the important but small pieces which had to be recovered had been placed in a basket at the bottom of the ocean. The ship sailed out again after Scarab had been repared. The basket was sought to be lifted, but, unfortunately, when it reached near the surface of the sea it overturned and the contents of the basket spilled and were never traced again.

3.2.10.16 At this juncture it was decided that the salvage operations should be terminated. The ship returned and sailed for home in the first week of December 1985.

3.2.11 Examination of Wreckage

3.2.11.1 Floating Wreckage

Soon after the accident, a number of light weight parts of the aircraft were found floating over a wide area at the crash site. These were picked up by the ships engaged in rescue operations and were brought to Cork where they were kept in the boat yard. The floating wreckage recovery continued for four days i.e. upto 26th June.

3.2.11.2 Some of the wreckage items were subsequently washed to the west coast of Ireland. These were picked up by the Irish Police and were brought to Cork. Some wreckage items were taken by a ship to Halifax, Canada. These were flown to Cork by the Canadian Aviation Safety Board. With the assitance of Air India engineers, the wreckage items were identified, labelled, photographed and laid out in the boat yard hangar for examination.

3.2.11.3 The wreckage was initially examined at Cork by the Structures, Power Plant and Systems Group. It was subsequently transported to Bombay for further examination. A few wreckage items which were taken by the Spanish trawlers to Madrid were also transported to Bombay. Some wreckage items had washed to the west coast of England. These were collected by the Accident Investigation Branch of UK and were transported to Cork and then to Bombay.

3.2.11.4 The floating wreckage recovered constituted approximately 3 to 5 per cent of the aircraft structure. The major items of the wreckage recovered were :

Various leading edge skin panels of LH nd RH wing, LH wing tip, spoilers, leading edge and trailing edge flaps, engine cowlings, flap track canon fairings aft end pieces, landing gear wheel wall doors, pieces of elevator and aileron, toilet doors, cabin floor panels, cabin overhead and upper deck bins, passenger seats, life vests, slide rafts, hand baggages, suitcases etc. and three empty oxygen bottles.

3.2.11.5 The Structures Group which had been constituted by the Court examined the floating wreckage and submitted its report. From the report the following significant information about the damage to major items of the floating wreckage is noted :

(I) VT-EFO aircraft was carrying a -7Q engine on 5th pod and a -7Q 5th pod kit in the aft cargo compartment. It had therefore, in all 14 engine fan cowls (eight working engine fan cowls plus two 5th pod engine fan cowls plus two -7T engine kit fan cowls in the aft cargo compartment plus two -7Q engine fan cowls in the aft cargo compartment). Out of these 14 fan cowls, 9 cowls (6 of working engines plus 2 of -7J kit plus one of 7Q kit) and two additional pieces of fan cowls were found. Five of the fan cowls of working engines show folding damage lines at approximately 3 O'Clock and 9 O'Clock positions. The number 3 engine inboard fan cowl has severe impact damage on its leading edge and has small inward to outward puncture holes (not penetrating through outer skin) in the lower centre region. The two fan cowls of -7J 5th pod kit stowed in the aft cargo compartment exhibit severe damage. One of these cowls is broken in two pieces. One of the pieces is cut at one corner in an arc of about 20 inches diameter and its external skin is pealed back. The external surfaces of all the three pieces have considereable scratches, tears and holes from outside to inside. None of the punctures penetrates the inner skin. Some punctures are also present from inside to outside but none of these penetrates the outer skin.

(ii) Out of the 12 spoilers, seven (number 2, 3, 5, 7, 8, 9 and 12) have been retrieved. Of these, six have their actuators attached to them in fully retracted position. Six spoilers have splits in their lower skin with split edges curled into the cores of honeycomb. Number 8 spoiler (located just inboard of number 3 engine) has a concentrated local impact damage on front spar and trailing edge beam from forward to aft and up direction over a span of 2 feet starting from outboard of spoiler actuator.

(iii) The left hand wing tip assembly with a part of H F Antenna was retrieved. No burning/discolouration marks around lightning arrester of H F system were noticed. The rib inboard of the lightning arrester was found intact. There were no burn marks anywhere on the panel.

(iv) The right hand wing leading edge top panel inboard of number 3 engine with a position of kruger flap frame along with bull nose attached was recovered. The bull nose was found crushed from top in the area just below the stay rod and the lower surface of stay rod has scratch marks from front to rear.

(v) The right hand wing root leading edge (inboard of W S 268.81) shows an impact damage at the leading edge. Bottom skin and internal structure are torn away. The leading edge skin is caved in over a span of about 3 feet and shows signs of heavy body impact in air. The impact damage shows signs of downward and backward movement of the impacting body.

(vi) A 3' x 2' piece of right hand inboard trailing edge fore flap with accordian seal was recovered. The inboard 8" portion of leading edge was found damaged by impact of an object going from lower forward to upper aft.

(vii) All the floor panels recovered from upper deck and main cabin indicate that these were detached from their attachments in an upward direction from all sides.

(viii) One main deck blow out door located between B S 2040 and 2140 left hand side was available. Out of its four metal clips, one clip was broken off with 2 nylon rivet heads sheared.

(ix) The cockpit entry door and the side bulkhead panel were found fairly intact but had come out of their attachment.

(x) Twelve toilet doors, out of a total of 16, were available and were found fairly intact, but had come out of their attachments.

(xi) The available cabin interior panels and overhead bins of the main deck and upper deck have only minor damage.

(xii) The woodent boxes which contained the fan blades of 5th pod engine and were loaded in container at position 24L in the forward cargo compartment were found broken apart with no burn marks.

3.2.11.6 Wreckage Salvaged from Sea

The wreckage salvaged from the sea was visually examined at Cork by the Committee of Experts as mentioned in section 1.5.16 and the observations thereon recorded. Subsequently detailed metallurgical examination was carried out at the Bhabha Atomic Research Centre, Bombay by Dr. M.K. Asundi and Dr. G.E. Prasad of B.A.R.C., Mr. S. Radhakrishnan and Dr. R.V. Krishnan of National Aeronautical Laboratory and Mr. B.K. Athawale of the Explosives Research and Development Laboratory, under the guidance of Dr. V. Ramachandran. During this examination, representatives of CASB, CP Air and Boeing were present in the first week. These represntatives left Bombay while the metallurgical examination was being carried out. The metallurgical examination was continued and the aforesaid group submitted the metallurgical report to the Court in December, 1985.

3.2.11.7 Although all the recovered wreckage was examined, only those items exhibiting characteristics which provide some evidence as to what may have happened to the aircraft during its final moments of flight are discussed herein below :

3.2.11.8 Target 7 - Lower Fuselage Skin Panel

This skin panel was located below the aft cargo area and contained the keel beam. Target 7 extended from B S 1480 to 1850 and was about eight feet in width and 32 feet in length. The left edge had a full length rivet line tear and the torn edge was buckled in waves, like the trace of a sine wave. One the right side, between the one quarter and midway segment, a large flap of skin was attached. The skin was folded aft, diagonally underneath, from right to left and the paint was scoured off the leading edge. The forward break was at the joint at B S 1480. The skin tear located at about B S 1860 was irregular in nature. The forward keel joint splice plate was bent, and the keel joint bolt holes were distored and elongated.

3.2.11.9 This panel was examined by the committee of experts at BARC and according to their report the keel beam trunnion fitting beneath the outer chord of the station 1480 bulkhead had fractured at the aft set of bolt holes. The fracture surface of the right side of the trunnion fitting was clean. As per the report, it was typical of overload failure in tension. The fracture surface of the left side of the trunnion fitting was covered with corrosion products, especially, at one corner, due to sea water. After cleaning this area by the recommended techniques, scanning electron microscopy revealed morphology of overload fracture consisting of dimples. Away from this corner also the fracture was similar as being due to overload. There was no evidence of there having been any fatigue failure.

3.2.11.10 At B.A.R.C., a sample was cut from the corroded corner of the failed left side trunnion fitting and metallographic examination was carried out on the same. The said examination showed on a face perpendicular to the corroded fracture surface, pits due to corrosion by sea water.

The basic microstructure was however free from intergranular cracking. It was thus concluded by the experts that the material in the region corroded by sea water had not suffered stress corrosion cracking which generally manifests as intergranular cracking.

3.2.11.11 A piece of the trunnion fitting was cut and the hardness and electrical conductivity values were measured by the said experts. As per their report, the electrical conductivity values were within the specified limits.

3.2.11.12 Target 8 - Lower Fuselage Skin Panel

This skin panel was located below the aft cargo area and extended from B S 1860 to 1960 and from stringer 46L to 46R. The forward end of target 8 matched with the aft end of Target 7. A region of fracture along the rivet holes near stringer 46L was marked for SEM examination. SEM examination after cleaning revealed that the fracture was characterised by dimples along its length, including areas adjacent to the edges of the rivet holes. These features are consistent with an overload mode of failure.

3.2.11.13 According to the metallurgical report, there was no evidence of fatigue failure on this target.

3.2.11.14 Target 35 - Portion of Rear Pressure Bulkhead

Looking forward from behind the aircraft, this segment of pressure bulkhead occupied the 9 to 1 O'Clock position, the piece from 12 to 1 O'Clock position had the flange from the outer ring attached. The web below the outer ring flange had areas of buckling. From the 11 to 12 O'Clock position the outer edge showed sinusoidal buckling, and the edge sector at 9 O'Clock position was partially collapsed and its edge was turned under. Samples taken for optical stereo microscope and SEM examination revealed that the fracture characteristics were consistent with an ovrload mode of failure.

3.2.11.15 According to the metallurgical report, there was no evidence of fatigue or any other mode of failure.

3.2.11.16 Target 296 - Portion of Rear Pressure Bulkhead

Looking forward from the rear of the aircraft, this segment of the bulkhead occuped the 7 to 9 O'Clock position. Optical and SEM examination were undertaken on this item.

3.2.11.17 The fracture alont the left-hand edge of target 296 (viewed from the rear) was examined optically prior to removing any representative samples. The fracture was at the rivet line at a skin splice, except for a length of fracture about 15 inches long near the forward end, which was through the skin away from the rivet line. Most of the rivet holes along the fracture path showed some slight elongation and skin deformation.

3.2.11.18 Representative fracture samples were cut from the left-hand side and circumferential fracture edges of the fracture surfaces. Optial and SEM examination revealed that the fracture characteristics are consistent with an overload mode of failure.

3.2.11.19 Target 47 - Aft Cargo Floor Structure

This portion of the aft cargo compartment was located between B S 1600 and B S 1760. No significant observation was noted. There was no evidence to indicate characteristics of an explosion emanating from the aft cargo compartment.

3.2.11.20 Target 117 - Floor with Seats Attached

These seats were right-section doubles, located between B S 1880 and 1980 and were from rows 46, 47 and 48, F and G (Zone E). The seats were displaced to the left with the rear legs buckled to the left. The front leg supports exhibited only minor damage. The middle and rear doubles had aisle-side seat arms bent to the right. There was no impact damage to the seat backs or seat pans, and all life vests except one were gone from the underseat container bags.

3.2.11.21 In the metallurgical report it is stated that on an examination of this target it was also found that on the underside of this floor near the forward end, a number of dents and impact marks were observed. This region appeared to have suffered shrapnel penetration. This area was radiographed but no metallic fragment was detected.

3.2.11.22 Target 193 - Fuselage Side and 2L Entry Door

The fuselage segement was located between B S 720 and 840. The door and fuselage skin were buckled outwards, approximately in line with the buckling on the fuselage and 2R entry door directly opposite.

3.2.11.23 Target 399 - Fuselage around 2R Door

This target is shown in Fig. 399-1. A detailed description is given below :

TARGET 399 Fuselage Station 780 to 940 in the longitudinal
direction and stringer 7R down
to stringer 35R circumferentially.

This piece contained five window frames, one in the 2R passenger entry door. Three of the window frames, including the door window frame, still contained window panes. Little overall deformation was found in the stringers and skin above the door. The structure did contain a significant amount of damage and fractures in the skin and stringers beneath the window level. In the area beneath the level of the windows, the original convex outward shape of the surface had been deformed into an inward concave shape. Further inward concavity was found in the skin between many of the stringers below stringer 28R. The skin at the forward edge of the piece was folded outward and back between stringers 25R and 30R. Over most of the remaining edges of the piece a relatively small amount of overall deformation was noted in the skin adjacent to the edge separations. Twelve holes or damage areas were numbered and are further described.

No.1 : Hole, 5 inches by 9 inches with two large flaps and one smaller curl, all folded outward. Reversing slant fractures, small area missing.

No.2 : Hole, 2 inches by 3/4 inch, one flap folded outward, reversing slant fractures, one curled sliver, no missing metal.

No.3 : Triangular shaped hole about 2 inches on each side. One flap, folding inward, with one area with a serrated edge. No missing metal, extensive cracking away from corners of the hole, reversing slant fracture.

No.4 : Tear area, 8 inches overall, with deformation inward in the centre of the area. Reversing slant fracture.

No.5 : Fracture area with two legs measuring 14 inches and about 24 inches. Small triangular shaped piece missing from a position slightly above stringer 27R. Inward fold noted near the joint of the legs. An area of 45∞ scuff marks extend onto this fold.

No.6 : Hole about 2.5 inches by 3 inches with a flap folded outward, reversing slant fracture. Approximately half the metal from the hole is missing.

No.7 : Hole about 3 inches by 1 inch, all metal from the hole is missing. Fracture edges are deformed outward.

No.8 : Forward edge of the skin is deformed into an "S" shaped flap. Three inward curls noted on an edge.

No.9 : Inwardly deformed flap of metal between stringers 11R and 12R at a frame splice separation. No evidence of an impact on the outside surface.

No.10 : Door lower sill fractured and deformed downward at the aft edge of the door.

No.11 : Frame 860 missing above stringer 14R. Upper auxilliary frame of the door has its inner chord and web missing at station 860. A 10 inch piece of stringer 12R is missing aft of station 860.

No.12 : Attached piece of floor panel (beneath door) has one half of a seat track attached. The floor panel is perforated and the lower surface skin is torn.

3.2.11.24 Much of the damage on this target was on the skin and stringers beneath the window level, i.e., on the starboard side of the front cargo hold. The inside and outside surface of the skin in this region are shown in Fig. 399-2 and 399-3 respectively. There were 12 holes or damaged areas on the skin as described above, generally with petals bending outwards. The curl on a flap around hole no.1 shown in Figh 399-4 has one full turn.

This curl is in the outward direction. Cracks were also noticed around some of the holes. Part of the metal was missing in some of the holes. The edges of some of the petals showed reverse slant fracture. In one of the holes, spikes were noticed at the edge of a petal.

3.2.11.25 When this target was recovered from the sea, along with it came a large number, a few hundreds, of tiny fragments and medium size pieces, All of the fragmets were recovered from the area below the passenger entry door 2R. One of the medium size pieces recovered with this target was a floor stantion, about 35 inches long, shown in Fig. 399-5. It is a square tube. It had the mark station 880 painted on its inner face, i.e. facing the centre line of the cargo hold. The part number printed on this station is 69B06115 12 and the assembly number is ASSY 65B06115-942 E3664 1/31/78*. It was confirmed that this stantion belongs to the starboard side of the forward cargo hold. The inner face of the stantion had a fracture with a curl at the lower end, the curl being in the outboard direction and up into the centre of the station. Fig. 399-6 is a print from the radiograph of this station. The inward curling can be seen clearly in this figure. Curling of the metal in this manner is a shock wave effect.

3.2.11.26 A piece near the fracture edge of this stantion was cut, and examined metallographically. Fig. 399-7 and 399-8 show the micro-structure of this piece. Twins are seen in the grains close to the fracture edge. The normal microstructure of the stantion material is free from twins as shown in Fig. 399-9.

3.2.11.27 Fig. 399-10 shows a collection of small fragments recovered along with target 399. There were some curved fragments with small radius of curvature (A). Reverse slant fracture (B) was noticed in some of the skin pieces. A piece 3/4" x 1/2" and 3/16" thick was found to have three blunt spikes at the edge (C). This piece was metallographicaly polished on the longitudinal edge. The microstructre of the piece is shown in Fig. 399-11. It may be seen that the grains in this fragment also contain a large number of twins.

3.2.11.28 Target 362/396 Forward Cargo Skin

This piece indluded the station 815 electronic access door, portions of seven longitudinal stringers to the left of bottom centre and five longitudinal stringers to the right of bottom centre. The original shape of the piece (convex in the circumferential direction) had been deformed to a concave inward overall shape. Multiple separations were found in the skin as well as in the underlying stringers. Further inward concavity was found in the skin between most of the stringers.

3.2.11.29 The two sides of this piece are shown in Fig. 362-1 and 362-2. This piece has 25 holes or damaged areas in most of which there are multiple petals curling outwards. These holes are numbered 1 to 3, 4a, 4b, 4c and 5 to 23. These are described below. Unless otherwise noted, holes did not have any material missing :

No.1 : Hole with a large flap of skin, reversing slant fracture.

No.2 : Hole with multiple curls, reverse slant fracture.

No.3 : Hole with multiple flaps and curls, reversing slant fracture, one area of spikes (ragged sawtooth)

No.4A : One large flap, reverse slant fracture, one area of spikes.

No.4B : Hole with two flaps.

No.4C : Hole with two flaps, one area of spikes

No.5 : HOle with two flaps.

No.6 : Braching tear from the left side of the piece, reversing slant fracture.

No.7 : Hole, with one flap, one curl and one area of spikes.

No.8 : Very large tear from the left side of the piece with multiple flaps and curls, reversing slant fracture and at least two areas of spikes.

No.9 : Hole with multiple flaps, one curl.

No. 10 : 2.5 inch tear

No.11 : One flap

No. 12 : Grip hole, plus a curl with spikes on both sides of the curl.

No.13 : "U" shaped notch with gouge marks in the inboard/outboard direction. Three curls are nearby with one are of spikes. Gouges found on a nearby stringer and on a nearby flap.

No. 14 : Nearly circular hole, 0.3 inch to 0.4 inch in diameter. Small metal lipping on outside surface of the skin. Most of the metal from the hole is missing.

No. 15 : Hole in the skin beneath the first stringer to the left of centre bottom. Small piece missing.

No. 16 : Hole in the stringer above hole No. 15. Most of the metal from this hole is missing.

No. 17 : Hole through the second stringer to the left of centre bottom, 0.4 inch in diameter. The hole encompassed a rivet which attached the stringer to the outer skin. Small pieces of metal missing.

No. 18 : Hole at the aft end of the piece between the third and fourth stringers to the left of centre bottom. The hole consisted of a circular portion (0.4 inch diameter), plus a folded lip extending away from the hole. The metal from the circular area was missing.

No. 19 : Hole with metal folded from the outside to the inside, about 0.6 inch by 1.5 inch. Flap adjacent to the hole contained a heavy gouge mark on the outside surface of the skin.

No. 20 : Hole containing a piece of extruded angle.

No. 21 : Hole containing a piece of extruded angle.

No. 22 : Hole with one flap.

No. 23 : Hole about 0.3 inch in diameter, with tears away from the hole. Small piece missing.

3.2.11.30 Fig. 362-3 to 362-7 show a few of these holes. There were also cracks or tears around some of the holes. The curls around some of the holes had nearly one full turn. In the large tear between body stations 700 and 740 and stringers between 41L and 45L, there were many pronounced curls as shown in Fig. 362-8. On the edges of the petals around several holes, reverse slant fracture was seen at a number of places. This slant fracture is at an angle of about 45∞ to the skin surface, the fracture continuing in the same general direction but with the slope of the slant fracture reversing frequently.

3.2.11.31 Sharp spikes were observed at the edges of the holes or at the edges of the petals around the holes No. 3, 4A, 4C, 7, 8 (at two locations), 12, 13 and 16. Some of the spikes are shown in Fig. 362-9 to 362-12. One of the holes, No. 14, on the skin was nearly elliptical with metal completely missing, as shown in Fig. 362-13. On the inside surface of the skin, paint surrounding this hole was missing. Hole No. 16 was through the hat section stringer, as shown in Fig. 362-14. In this, most of the metal was missing. On the inside of the hat section, the fracture edge of this hole had spikes, as shown in Fig. 362-15. Hole No. 17 was through the stringer and the skin, as shown in 362-16.

3.2.11.32 Through holes No. 20 and 21, extruded angles were found stuck inside, as shown in Fig. 362-17 and 362-18 respectively. In the petal around hole No. 20, there was an impact mark by hit from the angle as seen in Fig. 362-19 photographed after removing the angle. Such a mark was not present in the petals around other holes.

3.2.11.33 On the skin adjacent to hole No. 13 gouge marks were noticed, Fig. 362-20. These marks were on the inside surface of the skin. To check whether these could be due to rubbing by the bridal cable of Scarab during the recovery operations, a sample of bridal cable was obtained from "John Cabot" and gouge marks were produced by pressing this cable against an aluminium sheet. The gouge marks thus produced, as shown in Fig. 362-21, appear to be different from those observed near hole No. 13.

3.2.11.34 A piece surrounding hole No. 14 was cut out and examined in a Jeol 840 scanning electron microscope at the Naval Chemical and Metallurgical Laboratory, Bombay. Fig. 362-22 and 362-23 are the scanning electron micrographs showing the inside surface and outside surface of the skin around this hole. Flow of metal from inside to outside can be seen from these figures. Energy dispersive x-ray analysis was carried out on the edges of this hole. Only the elements present in this alloy and sea water residue were detected.

3.2.11.35 A portion of the skin containing part of hole No. 14 was cut, polished on the thickness side of the skin and examined in a metallurgical microscope. Fig. 362-24 shows the microstructure of this region. The flow of metal along the edge of the hole can be seen from the shape of the deformed grains near the hole. This can be compared with the bulk of the grains shown in Fig. 362-25, away from the hole. In addition, in Fig. 362-24, a series of twin bands can be seen in some of the grains near the hole. Fig. 362-26 shows these bands at a higher magnification. Normal deformation rates at various temperatures do not produce such twinning in aluminium or its alloys. It may be noted that this microstructural feature is absent in the microstructure of the skin, away from hole No. 14, Fig. 362-25.

3.2.11.36 Metallography was also carried out on a petal around hole No.7 and on a curl with spikes around hole No. 12. The microstructures indicate twins, however they could not be recorded due to their poor contrast.

3.2.11.37 Small pieces containing the spikes around holes No. 12 and 16 were cut and energy dispersive x-ray chemical analysis on the region of spikes in both was carried out in the Jeol 840

SEM. Only elements present in the alloys and sea water residue were detected.
3.2.11.38 A number of small fragments were found along with the forward cargo skin in target 362. Amongst them was a piece from the web of a roller tray. This has pronounced curling of the edges towards the drive wheel, Fig. 362-27.
3.2.11.39 Another small fragment was found from the above target. This piece, identified as specimen No. 12 in box No. 1, target 362, has a number of spikes along the edge. A scanning electron micrograph of the spikes is shown in Fig. 362-28. The sides of the spikes on SEM examination revealed elongated dimples as shown in Fig. 362-29, characteristic of shear mode of fracture. Metallography was carried out on the thickness side of this specimen. Fig. 362-30 and 362-31 show the microstructure near the apex of the spike and at the root of the spike respectively. Extensive twinning can be seen in these regions of the spikes.
3.2.11.40 Another fragment recovered with target 362 and identified as specimen No. 8 in box No. 1, also showed extensive twinning. The microstructure is recorded in Fig. 362-32.
3.2.11.41 Reference has also to be made to two other reports concerning wreckage.
3.2.11.42 The floating wreckage recovered was initially examined at Cork. On 25th June, Mr. Eric Newton a retired investigator of AIB, UK, was requested to examine the floating wreckage recovered and other materials with specific reference to the possibility of explosive sabotage having taken place. Mr. Newton examined the floating wreckage, passenger clothings and the other materials recovered from the crash victims The findings of Mr. Newton on the material available at that time are summarised below:

a. Taking the scatter of the wreckage and bodies into consideration and the condition of the limited wreckage recovered indicates that the aircraft had broken up in flight before impact with the sea.

b. Detailed examination of the structural wreckage recovered did not reveal any evidence of collision with another aircraft. Nothing was found suggestive of an external missile attack.

c. There was no evidence of fire internal or external.

d. There was no evidence of lightning strike.

e. Examination of all available structural parts recovered, did not reveal any evidence of significant corrosion, metal fatigue or other material defects. All fractures and failures were consistent with overstressing material and crash impact forces

f. Examination of clothing from the bodies did not show any explosive fractures or any signs of burning. The seat cushions and head cushions also did not show any explosive characteristics.

g. The damage to the suitcases (14 large and 29 small) which were examined was due to impact crash forces. The presence of 14 large suitcases could, however, indicate that one of the baggage containers had been broken to permit these suitcases to escape.

h. A number of lavatory doors and structure also did not show any damage consistent with explosion. The flight deck door showed no explosion damage inside or outside.

i The circumstatnial evidence strongly suggests a sudden and unexpected disaster occurred in flight.

j. There was no significant fire or explosion in the flight deck, first and tourist passenger cabin including several lavatories and the rear bulk cargo hold.

3.2.11.43 The other report dated 30th November, 1985 is of Mr. V.J. Clancy. Mr. Clancey had examined the wreckage and had also taken part, though only for a few days, in the metallurgical examination which was being conducted at BARC, Bombay.
3.2.11.44 Mr. Clancey examined practically all the items of wreckage which had been brought to BARC and in his report he has dealt with all of them. His report contained a description of the recovered items and also his comments thereon.
3.2.11.45 With regard to the aforesaid target 362, he observed that there were about 20 holes in it clearly resulting from penetrations from inside.
3.2.11.46 He further stated that:
"In addition to the fact that perforation was from inside there are certain features which suggest that they were made by high velocity fragments such as are produced by an explosion. These features are:
(a) Presence of toothed or spiked edges at some parts of the metal which had petalled out from

the perforations.
"Tardif and Sterling (Canadian Aeronautics and Space Journal, 1969, 16, 1, 19-27) obtained spiked fractures in fragments from sheet alloy subjected closely to an explosion. They stated that they had not obtained this effect in fractures otherwise produced.

(b) Presence of marked curling, in some cases of more than 360∞, of some of the petals. Tradif and Sterling stated that such curling was a feature of explosively produced fragments.

(c) The virtual absence of scratches or score marks on the petals such as might be expected if something were slowly forced through the metal.

(d) The virtual absence of other impact marks on the inside surface such as might have been produced by a massive impact with a substantial object. This suggested that the production of at least many of the perforations were separate independent events.

(e) One perforation (identified as No. 14) resembles a "bullet hole", that is cleanly punched out - a type of hole usually associated with a high velocity missile.

"There is evidence that the forward part of this item had been folded back inwards along the line of station 760 and then bent back again along a line slightly forward of this station.

"Such folding, may be violently produced on impact with the water, could have brought broken metal of stringers or stiffeners into forceful contact with the internal surfaces producing perforations outwards. The overlap of such folding would conceivably have covered the area up to station 800 and thus included most of the perforations.

"One hole identified as No. 13, was almost certainly caused by a slipping wire rope used as a sling.

"Part of the inner surface, aft of station 780 was superficially blackened as if by soot from a fire. Swabs were taken by me of this area
and are being examined by R.A.R.D.E. for evidence of fire or explosives".

3.2.11.47 There were several hundred small fragments which were recovered from the same general area as Target 362. While dealing with these Mr. Clancey observed that the production of a large number of small fragments is generally regarded as indicative of an explosion. One piece out of this was isolated, which was about one inch square of sheet alloy, and it was noted by Mr. Clancey that this piece had characteristic spikes on one edge similar to those described by Tardif and Sterling. (This piece is the same as shown in Fig. 362-28).

3.2.11.48 Mr. Clancey also examined a few suit cases which had been recovered. One particular suit case to which reference was made by him was of red plastic material with blue lining. With regard to this he stated that the damaged lining, severely tattered, resembles that of one found after an explosion in an aircraft in Angola. In that case microscopic examination showed definite evidence of damage by an explosion.

3.2.11.49 The later part of the report of Mr. Clancey contained his opinion. With regard to Target 362 his opinion was as follows:

"The features discernible to a careful close visual examination point towards the possibility of an explosion but taken alone do not justify a firm conclusion.

"Curling of petals and spiked or toothed fractures may be observed in other events than explosions despite the failure by Tardif and Sterling to obtain them in their limited number of attempts. It is probable that these features indicate a rapid rate of failure but not necessarily of a rapidity which could only be produced by an explosion.

"A more detailed study, metallurgical and fractographic, is required.

"The studies by Tardif and Sterling were done on fragments produced from aluminium alloy in contact with the explosive. Very little information is available on the behaviour of aluminium alloy some distance
from the explosive and subjected to attack by secondary fragments. To determine this some trials will be necessary, to obtain reference samples for comparison.

"The single "bullet hole", No. 14, strongly supports an explosion hypothesis but, being the sole example of its kind, is not, by itself determinative.

"If the forward part of this item was forcefully and rapidly folded back to impact on the other part it might explain the other features apparent to visual examination. It would require detailed laboratory examination and tests to eliminate this possibility".

3.2.11.50 The opinion of Mr. Clancey about the small fragments was as follows:

"The production of a large number of small fragments is generally regarded as a pointer towards an explosive cause but cannot be relied upon unless it is clear that they could not have been produced by some other means. It is known that the break-up of an aircraft at high speed may produce great fragmentation.

"The single spiked fragment must be regarded as important but a single specimen is not, by itself, determinative."

3.2.11.51 It appeared to the Court that the report of Mr. Clancey required certain clarifications. It was suggested to Boeing Commercial Airplane Company by the Court that Mr. Clancey should appear as a witness. The Court received a message to the effect that Mr. Clancey felt that he could not add anything useful to his report.

3.2.11.52 A close examination of the report of Mr. Clancey shows that the opinion expressed by him in the later part of the report is at considerable variance with the observations contained in the earlier part of the report. Particularly with regard to Target 362 and the small fragments, Mr. Clancey has stated in his observations that there was strong evidence of explosion. In his opinion, however, he has stated that more detailed study is required. It is interesting to note that though Mr. Clancey has referred to the opinion of Tardif and Sterling, he has not chosen to contradict the conclusions arrived by them. Mr. Clancey has also not stated as to what could possibly have caused the special features which were noted on Target 362.

3.2.11.53 We find the metallurgical report inspires more confidence. Not only is reference and reliance made in the report to other expert opinions contained in various articles written by experts all over the world, certain explosion experiments were also carried out by the experts which led them to the same conclusion.

3.2.11.54 The particulars of the experiments so carried out and the results obtained therefrom have been stated in their report as follows:

EXPLOSION EXPERIMENTS

"To determine the damage by high velocity fragments or shock waves on a structure similar to the one in aircraft cargo hold, the following experiments were conducted on November 30 and December 1, 1985 at the Explosives Research and Development Laboratory, Pune, using plastic explosive (PEKI) and different mixtures of plastic explosive and TNT. The explosive was kept in a box made of sheet metal of 6" x 6" x 6" of 1/16" thickness. This box was kept inside another box made of sheet metal 2' x 2' x 2' of .04 or .06" thickness. The boxes were made of 2024 aluminium alloy sheets used for aircraft skin. To the inner surface of the outer box, hat section stringers similar to those used in the aircraft were riveted. The quantity of explosive used in the inner box was varied from 60 g to 100 g. The explosive was detonated with an electrical detonator. After the explosions the fragments and the panels were collected and examined.

"Experiments were also conducted to produce explosive damage on skin panels, individual hat section stringers and individual stantion tubes. In the case of stantion tubes experiments were carried out placing the explosive charge both inside and outside. The quantity of explosive used was varied from 5 g to 50 g.

"Various types of damages were recorded on all the targets. These include punched holes, petaling and curling around holes, spikes at fracture edges, curved fragments with small radius of curvature and reverse slant fracture. Fig. EXP-1 shows a collection of fragments. The features mentioned above are shown in Fig. EXP-2 to EXP-7. It may be noticed that the features produced by experimental explosion were similar to the features observed largely in target 362 of the wreckage. The small fragments had features similar to those in the fragments from targets 362 and 399.

"Metallography was carried out in (a) a specimen surrounding a punched hole in the skin (b) a specimen surrounding a hole in the stringer, (c) a curl in the stantion and (d) spikes in a fragment. In all these cases, the grains adjacent to the area of explosive damage are having twins. Two typical microstructures are shown in Fig. EXP-8 and EXP-9. Away from these areas the microstructure is normal. Thus it is confirmed that twinning in the microstructure of these structural members is a unique feature of explosive fracture, not produced by any other measns known so far."

3.2.11.55 The findings in the said metallurgical report are also strengthened by the observations of Eric Newton in the article "Investigating Explosive Sabotage in Aircraft" published in the International Journal of Aviation Safety, March 1985, p. 43. Mr. Newton is an acknowledged authority in the detection of explosive sabotage in aircraft. The conclusions contained in the article are based on his review of incidents of explosion between 1946 and 1984 which were known to him. Some of the conclusions arrived at by him which were relevant in the present case are when he states "Generally speaking, the smaller the fragment, higher the velocity of the detonation. Minute fragmentation is indicative of high explosive having been used, and provides clues to the focal point or region of the explosion. The mode of break up of the aircraft itself and its sequence of failure is usually very complicated and quite without the logic dictated by normal aerodynamic overstressing".

3.2.11.56 Mr. Newton has also observed that curling, cork-screwing, and saw tooth edges may also be indicative of an explosion though such fractures by themselves may not be conclusive evidence that an explosion was involved. Firmer evidence, according to him, was of fusing of metal, scorching, pitting and blast effect. He further states that "Perhaps the most conclusive material evidence to be found on metal specimens is cratering, very often in groups, often minute and numerous".

3.2.11.57 Mr. Newton also refers to the positive explosive signatures which remain on a detonation in an aircraft. These positive singatures, according to him, are as follows:

"(a) The formation of distinctive surface effects such as pitting or very small craters formed in metal surfaces, caused by extremely high velocity impacts from small particles of explosive material. Such craters, when viewed under the microscope, have raised and rolled over edges and often have explosive residue in the bottom of the crater.

"(b) Small fragments of metal, some less than 1 mm in diameter, which, under the scanning electron microscope, reveal features such as rolled edges, hot gas washing (orange peel effect, surface melting and pitting and general evidence of heat; such features have been proved and observed following explosive experiments with known explosives). Supporting strong evidence would be if such fragments (normally found embedded in structures, furnishing or suitcases) were found embedded in a body where evidence of burning of tissue is present at the puncture entry and where the fragment came to rest.

"(c) As well as surface effects on metal fragments produced by explosives there are deformation mechanisms which are peculiar to high rates of strain at normal temperature. At normal rates of strain metals deform by usual mechanism associated with dislocation movement. However, because this process in an explosion is thermally activated at very high rates of strain, there is insufficient time for the normal process to occur. In some metals such as copper, iron and steel, deformation in the crystals of the metal takes place by 'twinning', that is to say by parallel lines or cracks cutting across the crystal. Such a phenomenon can occur only if the specimen has been subjected to extreme shock wave loading at velocities in the order of 8000 m/sec. Such specimens, usually distorted must be selected with care, prepared in a metallurgical laboratory, polished, mounted and microscopically examined. Where such twinning of the crystals is found it establishes (a) that the specimen was close to the seat of the explosion and (b) that a military type explosive had been used with a detonating velocity of 8000 m/sec or more. Twinning is rarely produced when shock impact loadings are below 8000 m/sec.

"The above features, singly or combined, are considered to be proof positive evidence of a detonation of a high explosive; they could not be produced in any other way."

3.2.11.58 The metallurgical report indicates that the microscopic examination (conducted by them) discloses such features being present which had been described as positive signatures of the detonation of an explosive device in an aircraft by Mr. Newton. Furthermore, twinning effect has also been noticed at a number of places - around holes and in fragments. These have been categorised by Mr. Newton as positive signature of an explosion.

3.2.11.59 In the primary zone of explosion, metallic structures disintegrate into numerous tiny fragments and usually these fragments contain the above mentioned distinct signatures of explosion. In the present case the explosive damage had occurred at an altitude of 31000 feet when the aircraft was flying over the ocean. The fragments that formed due to explosion must have been scattered over a wide area and it is impossible to locate and recover all of them from the ocean bed. Nevertheless, some of the fragments which were recovered along with the targets 362 and 399 do contain signatures of explosive fracture.

3.2.11.60 From the aforesaid discussion it would, therefore, be safe to conclude that the examination of targets 362 and 399 clearly reveals that there had been a detonation of an explosive device on the Kanishka aircraft and that detonation has taken place not too far away from where these targets had been located.

FIRE

3.3.1 There is no evidence that there was any fire on board the aircraft before it met with the accident.

3.3.2 Amongst the floating wreckage, however, was found, what was later on identified as, a spares equipment box belonging to this aircraft. This box was charred on one side and partially on the bottom. The depth of charring suggested that the burning time was three to four minutes. This box contained some sand and small shellfish. The flesh from the shelfish appeared to be charred, indicating that the box was subjected to fire after the occurrence.

FLIGHT RECORDERS

3.4.1 Recovery of Flight Recorders

3.4.1.1 Recovery of the flight recorders was a very difficult and challenging job. At the site of accident, depth of water is about 6700 feet. The job involved fixing the location of recorders and then retrieving them. For this purpose three ships viz. Guardline Locator (a ship provided by Accident Investigation Branch of U.K.), Le Aoife (an Irish Naval Ship) and Leon Thevenin (a French Cable laying ship, charterd by the Government of India) were utilised. Guardline Locator and Le Aoife were solely for fixing the positions of recorders and also had the capability to lift the recorders with the help of its scarab.

3.4.1.2 Both the Cockpit Voice Recorder and the Digital Flight Data Recorder were fitted with Dukane Underwater Acoustic Beacons (Pingers) which enabled establishing the location of flight recorders under water. The Beacons are designed to provide a signal at 37.5 Ò 1 Khz frequency that can be heard for approximately 2 miles in any direction for 30 days after water entry. Its high strength case permits operation in water depth to 20,000 feet. Its pulse repetition rate is not less than 0.9 pulse per second.

3.4.1.3 On 4th July, 1985, Guardline Locator reported strong possibility of two separate sound sources of frequencies between 39 KHz and 42 KHz. On 5th July, Guardline Locator gave coordinates of an area, which it believed contained the pinger. Guardline Locator later reported that using a Dukane Hand Locator, it had located pinger (2) at 5102.6N, 1248.6W. Leon Thevenin then concentrated its search in this area for retrieving the recorders.

3.4.1.4 In response to a query, Messrs Dukane Corporation advised that Pinger transducer is made of ceramic and if cracked during impact, its frequency could be elevated. The pulse rate should, however, be uneffected. Keeping this in mind, the Leon Thevenin increased its Sonar Band one upper frequency limit from 40 KHz to 45 KHz.

3.4.1.5 On 9th July at about 2300 hours the Scarab of Leon Thevenin located the Cockpit Voice Recorder at 5102.67N, 1248.93W and the recorder was brought on the deck at 0747 hrs on 10th July. The CVR was kept in a drum filled with water. The scarab was again lowered on 10th July in the same area and at about 2130 hours faint signals were picked up on Sonar. By about 2200 hours the signals became louder and the pulse rate frequency was calculated to be 72 transmissions per minute. At about 2230 hours the DFDR was also located at 5103.10N, 1249.59W and it was brought on deck at 0245 Z on 11th July.

3.4.1.6 The DFDR was also placed alongside the CVR in the drum filled with water. Leon Thevenin was then advised to return to Cork with the Flight Recorders. Leon Thevenin reached Cork on the morning of 12th July and the flight recorders were placed in two specially fabricated water tight steel containers filled with water. The recorders were then carried to Bombay on the same day by Mr. Satendra Singh, Reginal Controller of Air Safety, Bombay, accompanied by Mr. Vishwanath of Air India for preparing read-outs and transcript of the recorders. Necessary precautions were taken to ensure that the data recorded was not affected during transportation to Bombay.

3.4.1.7 Both the recorders reached Bombay on the morning of 13th July and were kept in the office of the Regional Controller of Air Safety under Armed Police Guard.

3.4.2 Description of Flight Recorders

3.4.2.1 Kanishka was equipped with a Fairchild A-100 Cockpit Voice Recorder Serial No. 5809 and a Lockheed 209E Digital Flight Data Recorder Serial No. 1282. These were each equipped with Dukane Underwater Acoustic Beacons and were installed adjacent to each other in the cabin on the left side near the rear pressure bulkhead.

3.4.2.2 The CVR records all crew communications and sounds in the cockpit on a continuous tape loop which has a tape speed of 1-7/8 inches per second. The Recorder has two heads, one head which erases the previous recording and the second which records the current information and thus the last 30 minutes of recorded signals are retained, the previous being automatically erased. It continuously records convervations/sounds from 4 different sources on the following four separate channels:

Channel 1 : Radio channel of pilot

Channel 2 : Radio channel of flight engineer

Channel 3 : Cockpit Area Mike

Channel 4: Radio channel of co-pilot.

3.4.2.3 The serial digital signal recorded by the DFDR was generated by a Teledyne Flight Data Acquisition Unit installed in the forward electronics bay below the cabin floor. Adjacent to this unit was a Lockheed Model 280 Quick Access Recorder that recorded the same serial digital signals on to a 50 hour cassette.

3.4.2.4 The DFDR records 52 basic parameters on a magnetic tape. The tape preserves records of the last 25 hours. The serial digital signal has a bit rate of 768 bits per second and is recorded at a tape speed of 0.37 inches per second.

3.4.3 Examination of Flight Recorders and Tapes

3.4.3.1 General

The recorders brought to Bombay from Cork were opened on 16th July, 1985 at the Air India's Facilities in Bombay in the presence of the Court and Assessors. A team of foreign experts including one each representatives from both the Recorder Manufacturers, three from National Transportation Safety Board, one from Canadian Aviation Safety Board and one from NRC Flight Recorder Playback Centre, Canada were present when the tapes were taken out of the recorders. Apart from them, representatives of the Government of India and Air India were also present.

3.4.3.2 Cockpit Voice Recorder

When the unit was removed from its shipping and storage container, some mechanical damage was immediately evident. The top of the cover had been deformed inwards, probably due to initial external

strong attachments for the horizontally mounted Underwater Acoustic Beacon. The plate had torn away from the light structure behind it. The cause of the damage was not obvious. The light outer cover was removed by cutting it open with hand shears and pliers.

3.4.3.3 When the armoured and insulated containment was opened, the tape transport was found to be in relatively good condition and the tape physically undamaged. Eighteen inches of the tape was pulled from the centre of the tape stack and the tape cut near the stack well clear of the end of recording. The tape was then removed from the recorder, transferred to standard tape reels, laboriously cleaned several times with distilled water and dried with lint free absorbent material.

3.4.3.4 Digital Flight Data Recorder

When the recorder was removed from its shipping and storage container, it was noted that there was very little external damage. A cover on the rear section was removed and it was observed that, when viewed from the front of the recorder, the right hand edges of the four rearmost printed circuit cards were displaced towards the front of the recorder. The left hand edges were restrained by plug-in connectors to the boards. The rearmost card, that controls track selection on the tape, and the one in front of it, had bowed along the right-hand edges and popped out of their plastic guides in the top and bottom of the recorder. Deflection of the other two cards had occurred following failure of the attachments of the right hand ends of the plastic guides to the chassis. The damage could have been caused by a high lontitudinal decelaration, as would occur if the front face of the recorder impacted the water.

3.4.3.5 When the tape deck was opened, it was found that the tape was intact but had become dislodged from the last tape guide when the tape was moving in the direction of the odd-numbered tracks and had also jumped out of the adjacent end-of-tape sensor. One edge of the tape had been streteched in this area. The drive belt to the tape transport was still in its correct position. The tape was stuck to the third tape guide in the odd-numbered track direction and suffered some damage when it was finally detached from it. This was repeaired with a splicing tape.

3.4.3.6 The location of the record heads was marked on the back of the tape with a waterproof felt pen. It was noted that there was slightly more tape on the supply reel for the odd tracks than on the other reel. The tape reels and tape were removed from the recorder, keeping the tape wet with distilled water, and the tape transferred to the standard reels for meticulous cleaning. During the cleaning process, it was found that the edge of the tape had also been stretched locally 336 inches down- stream from the splice repair in the odd track direction. The tape was dried by patting it with absorbent lint-free material before loading it into a serviceable recorder as this was the only means by which it could be replayed at the Air India base.

3.4.3.7 The circuit card controlling track selection was removed from the accident recorder and the status of the latching relays checked to determine the last track on which recording was being made. It was found that the relay states indicated Track 1, but since this requires all relays to be set in the same condition, it was considered possible that they had been mechanically set on water impact. The card was subsequently inserted to another recorder and the Track 1 setting confirmed on a test bench.

3.4.3.8 When a change in track selection was attempted, it was found that the relays would not switch, probably due to the effects of salt water corrosion or high water pressure. It was decided that Track 1 would be considered as the most likely one to contain the accident data with the possibility that it could have occurred on any of the other tracks. When the data was recored, the accident information was found some distance past the mid-point of Track 1.

3.4.4. Recovery of Information

3.4.4.1 Cockpit Voice Recorder Tape

The spool was removed from the CVR and was washed with distilled water, dried and loaded on to another spool. The cleaned and dried tape was taken to the Bhabha Atomic Research Centre (BARC), and a copy of the tape was prepared which was used for preparing transcript and carrying out further analysis. The transcript of the CVR conversation is given in Appendix 2.

3.4.4.2 Shannon Air Traffic Control Tape

A copy of this tape that contains all radio communications between the aircraft and Shannon was provided to the Indian Authorities by the Air Traffic Control Authorities, Shannon. The recording also included the short series of unusual sounds that occurred about the time of the accident.

3.4.4.3 When the CVR and the ATC tapes were played it was found that some adjustment in speed was necessary so as to synchronize the two. This adjustment was independently carried out by different experts who analysed the CVR tapes.

3.4.4.4 Digitial Flight Data Recorder Tape

The Lockheed representative had brought a Lockheed Model 235 Copy Recorder from his plant. This unit copies all the 25 hours of data from the recorder by running it at high speed for only two passes of the tape, an operation lasting only 16 minutes. A copy tape was made by this procedure before embarking on the standard Air India recovery procedure to serve as a back-up tape in the event of physical damage to the original tape in subsequent playback.

3.4.4.5 Air India playback equipment for the DFDR required that the tape be re-installed in another DFDR in which it was driven at high speed. In the standard playback procedure, the tape was first run to the beginning of Track 1 through 6 sequentially on to a computer tape followed by a repeat of Track 1. The computer tape was then taken to Air India's main computing facility where selected information was printed out in engineering units.

3.4.4.6 The first printouts showed that the accident was recorded on Track 1, as indicated by the latching relays, and suggested a rather abrupt end to the recording. There was a loss in bit synchronization in word 26 of the last Subframe 3 of data that was followed by a normal Subframe 4. Prior to the loss in bit synchronization, all measurements appeared normal. Plans were made to borrow the high speed oscillograph recorder previously used to studythe final CVR signals from

BARC to examine the end of the recorded serial digital signal in detail.
3.4.4.7 Meanwhile, the critical section of the tape and the heads of the playback recorder were re-cleaned and a second transfer of data on to the computer tape was made. Printouts from this computer tape showed no significant difference from the first one.
3.4.4.8 The recorder was then opened and the tape positioned about 1.5 inches before the final resting place of the tape that was clearly indicated by head imprints on the magnetic oxide coating side. A high speed oscillograph record of a few seconds of data was made and visually decoded. It was found that the recorded GMT was 21 hr 16 min. This time corresponded to 15 min or about 333 inches of the tape after start of the oldest recording downstream of the accident.
3.4.4.9 The tape was then re-positioned using a Lockheed analogue playback unit, that had a display of the recorded time and a stopwatch was used to locate the accident timing. Two oscillograph copies of the end of the serial digital data were made, the second one having more data preceding the end. Visual reading of the traces confirmed that recording became erratic and irrecoverable at the end of Word 26 in Subframe 3 at the recorded time of 07 h : 14m : 35s. The erratic signal continued for about 0.27 inches of the tape before switching back to the data recorded 25 hours earlier.
3.4.4.10 Examination of the printouts confirmed a suspicion that the complete Subframe 4 of data following the partial Subframe 3, was data from 32 seconds earlier that had not been cleared from the data buffer in the computer and that Word 26 of the Subframe 3 was the last normal measurement provided by the recorder.
3.4.4.11 The end of recording occurred at the point on the tape at which some damage had been observed during the cleaning process. It was apparent that, after the end of the recording, the tape had run on for 336 inches before finally coming to rest.
3.4.4.12 A copy tape of the DFDR tape was made at Bombay and taken to Ottawa. Data from the accident flight, the preceeding Toronto-to-Montreal flight and part of the cruise conditions of the earlier flight to Toronto were transcribed on to the computer tape. The tape was edited to minimize errors and converted to engineering units using standards calibration. Time histories of all parameters for periods of interest were plotted. In addition, chart records were made of all parameters in raw data form for the total duration of the last lap of the flight.
3.4.4.13 The DFDR read out shows that the aircraft was cruising at an altitude of 31,000 ft. and a computed air speed of 296 knots till it suddently stopped recording at 07:14:35 GMT recorded time.
3.4.5 Reports received by the Court
3.4.5.1 The CVR was taken to B.A.R.C. This tape was played by the CVR group a number of times and hard copies of the time information were also prepared using an ultra violet (UV) Recorder. The group consisted of Mr. Satendra Singh, Regional Controller of Air Safety of D.G.C.A., Mr. S.N. Seshadri of BARC, Mr. Paul C. Turner of NTSB, USA, Mr. John G. Young of NTSB, USA and Mr. P. dE Niverville of CASB, Canada. On 18th July, 1985 this group made the following observations after playing the aforesaid tape (UV recording of CVR is at Fig. 1) :-
"The first visible rising signal volume was observed on channel number three the CAM channel It reaches a maximum in about 50 milliseconds. At this time noticeable disturbances are observable on the other three channels. A smaller disturbance is observable on channels 2 and 4 earlier than observable on channel 1. A major disturbance is observed to begin approx. ninety milliseconds following the initial observation on channel number 3 (CAM), on channels 1,2 and 4. Following this point
at 75 milliseconds the CAM signal subsides to a lower level but much higher than observed ambient (prior to disturbance) where it remains for approximately 375 milliseconds from initiation when it ceases. Channel four goes off at the same time. Channel 1 goes off twenty five milliseconds earlier. Channel two is inconclusive and had a different pattern. All four channels exhibit a disturbance at approx. 450 milliseconds. The cockpit voice recorder power then shuts off at 650 milliseconds.
The Shannon area control centre tape made the night of the accident was examined and printed. It shows a signal was received at approximately the time the aircraft disappeared from radar. It isn't conclusive at this time that the signal originated from the accident aircraft. The signal was received

in pulses for approximately five seconds."

3.4.5.2 The tape was again played on 19th July, 1985 and a further report was prepared which was signed by the aforesaid persons and Mr. B. Caiger of NRC, Canada. In this report it was stated as follows:-

"The Shannon area control centre tape was again printed at .05"/second per inch speed from approximately 22 sec. before the first broadcast from the accident aircraft at 0709.58 until Radio carrier with indecipherable modulation can be heard at 0714:01. The print contains a time encoded signal.

A similar print was made from the CVR channel 4 (Co-Pilot's) of the same audio as received on the ATC tape. Although the tape speed is different, the events when corrected for tape speed errors occur at the same time. It appears that the ATC recording contains the beginning of the aircraft breaking until power is lost to the transmitter since channel one and channel four (Capt + Co-pilot's radio) appear to contain a transmitted signal on the CVR. It is probable that the ATC signal at 0714:01 coincides with the final quarter second of CVR radio channels".

3.4.5.3 On the date i.e. 19th July, 1985, Mr. Paul Turner of NTSB also gave an additional report which is to the following effect :-

"During my observations of numerous cockpit voice recorders I have heard and observed a number of aircraft breakages due to various causes. In this case the explosive sound on the CAM channels occurs prior to any electrical disturbance observable on the selector panel signals. Electrical disturbances can generally be seen prior to audio signal when explosive sounds originate at any significant measureable distance from the microphone (15 feet) and in the area where there is significant electrical systems. It is my opinion that an explosive event occurred close to the cockpit. The CAM signal which follows the explosive event shows a very much higher noice level than cockpit ambient 85 db, indicating to me the cockpit area was penetrated and opened to the atmosphere. The selector panel signals show signatures similar to those of an aircraft breaking up and are apparantly caused by electrical systems disturbance (circuit breaker blowing, fuse switching etc.). The lack of Mayday call and apparent inadvertant signal from the cockpit crew incapacitation. The transmitter coming on due to breakup is phenomena observed previously.

This contains only my personal opinion and in no way should be considered a final determination of cause without corroborating evidence".

3.4.5.4 Copies of the tapes were also sent to some of the participants who wanted to carry out independent analysis.

3.4.5.5 With regard to DFDR the Court received reports from Dr. Caroll Roberts of NTSB and report dated 11th November of Mr. B. Caiger.

3.4.5.6 With regard to CVR the Court received reports from Mr. B. Caiger dated 11th November, 1985, report dated November, 1985 of Mr. R.A. Davis, Head, Flight Recorder Section, Accidents Investigation Branch, Farnborough, U.K., report dated 31st August, 1985 of Mr. S.N. Seshadri of BARC, Bombay.

3.4.6 Court Observations

3.4.6.1 Digital Flight Data Recorder

The reports of Dr. Caroll Roberts and Mr. Caiger which also coincide with the report submitted by Mr. Satendra Singh disclose that the DFDR showed no evidence of abnormal values of any of the many parameters being monitored upto a point at which the recorded data signal became irregular for a fraction of a second and recording ceased. Both the DFDR and the CVR stopped at the same time.

3.4.6.2 The short period of irregular digital data that occupied only 0.27 inches of tape, most probably indicates that the recorder was subjected to a sharp angular acceleration in the left wing down sense about the aircraft longitudinal axis.

3.4.6.3 According to Mr. Caiger's report the possibility that the digital recorder was subjected to a sharp disturbance more rapid than violent motion of the aircraft lends some credence to the possibility of a detonatiaon of an explosive device in the aircraft. The other alternative, according to Mr. Caiger, which could have led to this was that the Flight Data Acquisition Unit in the main electronics bay .or its power supply were suddenly disturbed. As the Lockheed Quick Access Recorder was not recovered from the wreckage, this possibility could not be investigated further. A perusal of the DFDR print out, however, shows that whereas there was a speed limit of 290 knots (.81 Mach) of the aircraft due to carriage of the 5th pod engine, in actual fact the aircraft's speed during cruise varied from 287 to 296 knots. Mr. H.S. Khola asked the Boeing Airplane Company to examine the effect of aircraft cruising at a speed of 296 knots with a 5th pod engine installed on it. The Boeing company sent a reply, inter alia, stating as follows:

"The operating speed limit of Air India 747-237B, JT9D-7J with fifth engine pod was 290 knots indicated airspeed, with an altitude limit of 35,200 feet. Flight testing of this model airplane configuration was successfully accomplished to a dive speed of 386 knots calibrated airspeed and 0.92 Mach number, with no adverse effects.

In the event that the operating speed placard was exceeded an increase in perceptible vibration levels would be felt. As the dive Mach number (0.92) is approached the buffet vibration would increase to level that could become objectional to the flight crew, but would not he bazardous".

3.4.6.4 It would thus be clear that if no adverse effects could have been noticed with a dive speed of 386 knots calibrated airspeed and 0.92 Mach number, there was little likelihbood of the aircraft having been subjected to any adverse effect by reason of the speed varying from 287 to 296 knots while it was cruising at a height of about 31,000 feet.

3.4.6.5 Cockpit Voice Recorder

The Court received four reports of the CVR tape analysis. These reports were of Mr. B. Caiger, Mr. R.A. Davis, Mr. S.N. Seshadri and Mr. Paul C. Turner. Whereas the first three experts appeared and deposed in Court, Mr. Paul Turner did not come.

3.4.6.6. There were certain aspects of the report of Mr. Turner which required clarification. After the Court had failed to secure his presence, it sent a questionnaire to Mr. Turner for his answers thereto. It is indeed unfortunate that till now no reply has been received. It is in this background that the report dated 13th November, 1985 of Mr. Turner and the reports of other experts have to be judged and analysed.

3.4.6.7 Mr. B. Caiger's Report and Deposition

Mr. Caiger has said in his report that the Cockpit Area Microphone signal was studied in detail. According to him, in an aircraft, sound can be transmitted by multiplicity of paths. If an explosive device was located close to the microphone then the short wave from the disturbance would cause a sharp rise in pressure which was not noticed. From more remote location, however, structurally transmitted sounds could reach the microphone first and induce more complex signals. According to Mr. Caiger, at this time he did not have any evidence from occurrences of this nature that would permit any meaningful comparisons or conclusions.

3.4.6.8 Mr. Caiger obtained from the manufacturers details of Automatic Gain Control (AGC) on the cockpit area microphone. According to the information so provided it was indicated that the decrease in amplitude of the recorded noise over about 33 msec after the peak level was reached 40 msec from the start of the disturbance is most probably due to the AGC and that the actual envelope of the pressure levels at the microphone continued to increase until 90 msec from the start before establishing at about four times the recorded level until the 160 msec point when the recorded amplitude started to decrease rapidly. Mr. Caiger could not find any explanation for this marked reduction. Mr. Caiger further recorded that the large amplitude lower frequency signature, that immdediately followed this reduction, is similar to signatures observed by the manufacturer when there was an abrupt break in the line from the cockpit area microphone pre-amplifier output to the voice recorder. No similar signature was observed in tests on the crew audio channels when the appropriate lines to the recorder were similarly interrupted.

3.4.6.9 The observation of Mr. Caiger with regard to ATC tape was as follows :-

"The ATC recording that followed the cockpit area microphone sounds appears at first to contain a series of short intermittant sounds. Closer study reveals that the background noise only returns to its steady level for about 160 msec immediately after the first low level noise and again for about 85 msec just over halfway through the 5.4 sec duration of the recordings. At the end of all routine radio transmissions, a damped sine wave transmitter keying signature is observed with a frequency in the region of 450 Hz. In the accident recordings, only two of these are observed".

"Listening to the sounds, it also appears that a human cry occurs near the end of the recordings. Spectral analysis of these sounds and comparison with voice limitations reveals that the accident sounds do not contain all the pitch harmonic frequencies normally associated with such voice sounds. The origin of all the sounds has not been identified."

3.4.6.10 From the aforesaid investigation Mr. Caiger concluded that :-

"From the voice and data recorders, Air India Flight 182 was proceeding normally enroute from Montreal to London, England at an altitude of 31,000 feet and a computed airspeed of 296 knots when the cockpit area microphone detected a sudden loud sound the cause of which has not yet been identified. The sound continued for about 0.35 seconds, and then almost immediately, the line from the cockpit area microphone to the cockpit voice recorder at the rear of the pressure cabin was most probably broken. This was followed by a loss of electrical power to the recorder".

"The initial waveform of the cockpit area microphone signal is not consistant with the sharp pressure rise expected with detonation of an explosive device close to the flight deck but, with the multiplicity of paths by which sound may be conducted from other regions of the aircraft, we cannot at this time exclude the possibility that it originated from such a device elsewhere in the aircraft".

"Within 1 to 2 seconds of the first detection of the loud sound on the cockpit area microphone, a series of unidentified noises were recorded on the Shannon ATC tape. These extended over a period of 5.4 seconds and are assumed to have origniated from VT-EFO. They gave the impression of abnormal conditions on the flight deck".

3.4.6.11 In his evidence in court, Mr. Caiger explained about Automatic Gain Control. He stated that the CAM channel of the CVR had an Automatic Gain Gontrol in a pre-amplifier that is installed close to the microphone. This AGC is designed to prevent excessively loud signals from saturating the microphone and the associated electronics. He further stated that from the tests conducted by the manufacturers it could be concluded that most likely at 45 msec. point the AGC came into effect which gradually reduced the signal over the next 33 msec. before letting it stabilise at a roughly constant value. This figure of 33 msec. was taken by Mr. Caiger not by carrying out any experiment himself but it was provided to him by the manufacturers. He also stated that there was no positive indication of structural failure being evident from the flight recorders. Mr. Caiger was asked to explain as to what was the reason for loud sound to which reference had been made in his report. In answer to the said question from the Court he said that there could be a number of reasons. The detonation of an explosive device not close to the microphone was one possibility, the occurrence of some type of structural failure was another possibility. He was further of the opinion that at the present stage of development in structural acoustics, he did not think it was possible to come up with any reasonable estimate of the location of either explosive device or some type of possible structural failure. When asked for his opinion about the sequence of events which he could determine by looking at the sound spectrum, he said as follows:

"From the study that we have made which have of course been augmented by studies done by several other groups it would appear that there was a very sharp bang that was detected by the CAM. Approximately one-third of a second after this happened the line from the CAM to the CVR was disconnected but intermitant power supply was still being sent to the voice recorder for approximately one and a half seconds. During this 1-1/2 seconds period sounds were being transmitted from the 'Kanishka' aircraft that tend to suggest that the aircraft was in some distress. Though it is difficult to be specific about the basis on which we assesss the state of the aircraft, this signal ceased after a period of 5.4 seconds and we have no more audio information concerning the aircraft from that point onwards."

3.4.6.12 Mr. R.A. Davis's Report and Deposition

Mr. R.A. Davis in his report on the analysis of CVR has stated that he did not have with him a faithful copy of the original CVR tape. The tape supplied to his contained signals which warranted investigation but any measurement could be hampered by a decreased signal to noise ratio due to the copying process. Mr. Davis however analysed the tape which admittedly according to him was not of good quality. Mr. Davis in his report states that he carried out a spectrum analysis of the different channels of the CVR. The spectra did contain the sound of a bang. He however, could not find any significant low frequency content in the spectrum which according to him, would have been expected if the sound was of a high explosive detonation.

3.4.6.13 While carrying out detailed study of the tape he also looked out for any evidence of various audio warning signals which may have been buried in the noise. One such audio warning which could have been detected was that of pressurisation warning. Mr. Davis stated that this warning possessed a very defined frequency spectrum which was not present in the signal of the CVR of Kanishka. With regard to this he, however, stated that absence of this signal was not surprising as any decompression would take a finite time before reaching the warning level. Mr. Davis further observed that the presence of warnings due to attititude display disagreement, excessive speed and fire were investigated but with negative results.

3.4.6.14 During the course of investigations, Mr. Davis had compared Kanishka CVR recording with the recordings of an explosive decompression on a DC-10, a bomb in the freight hold of a B-737 and a gun shot on the flight deck of a B-737. According to Mr. Davis the spectrum of VCR tape of B-737 showed a much low frequency content with very little content at upper frequencies. This bomb, in the forward baggage hold of B-737, had exploded while the aircraft was at a low level and therefore the CVR did not have the sound accompanied with that of depressurization. That aircraft had landed safely. Mr. Davis, however, observed that if Kanishka's accident was caused by detonation of a high explosive device, then the spectra should have shown large low frequency content, but this was absent. He further opined that, even if there was a possibility of a bomb remote from the flight deck and of a low power, even then the characteristics of a bomb would still be apparent in the time record. He also analysed the spectrum of the sound of the hand gun shot on a B-737 flight deck and according to him the said signal was sharp edged and did not compare with that of Kanishka's signal.

3.4.6.15 Mr. Davis also analysed the sounds recorded on the ATC tape. He concluded that the sounds emanated from Air India's Kanishka aircraft. According to him the transmission from the ATC is "chopped" until at approximately 2.7 seconds into the transmission a loud noise lasting about 200 milliseconds is heard. This is followed about 0.5 seconds later by a sound which increases in volume. This sound was similar to that heard in other accidents where there had been a rapid increase in airspeed.

In the noise which continues until the end of the transmission is heard a crying sound. This was originally thought to be a human cry. He, however, noted that a human cry would contain more harmonics than was noticed in this case. It was also reported by Mr. Davis that knocking sounds which were heard during the transmission were initially thought to be due to hand-held microphone vibration. This was discounted because of the frequency of the sounds. He noticed that almost identical sounds were heard on the DC-10 CVR after the decompression had occured and the source of that sound had not been identified. On the DC-10 the pressurization audio warning commenced 2.2 seconds after the decompression. Analysing the ATC tape Mr. Davis observed that no such warning was identified during the open microphone transmission.

3.4.6.16 In conclusion, Mr. Davis reported as follows :-

"It is considered that from the CVR and ATC recordings supplied for analysis, there is no evidence of a high explosive device having detonated on AI 182.

"There is strong evidence to suggest that a sudden explosive decompression occurred but the cause has not been identified.

"Although there is no evidence of a high-explosive device, the possibility cannot be ruled out that a detonation occurred in a location remote from the flight deck and was not detected on the microphone. Such a situation would be most unusual, if not unique, in that we have never failed to detect sounds of structural failure, decompression, explosives etc., on any accident CVR, even though the event occurred at the rear of the aircraft. If such a device was used on AI 182 it is considered that it would have to be a very small device in order not to be detected (unlikely in itself). Such a device would be unlikely to cause the sudden total destruction which occurred in this instance. It is considered that a device of sufficient power to produce this effect could not fail to be detected on the CVR. The B-747 explosions referred to earlier, blew holes several feet wide in the structure but the crew were still able to control and operate the aircraft.

"It must be concluded that without positive evidence of an explosive device from either the wreckage or pathological examinations, some other cause has to be established for the accident".

3.4.6.17 In reply to a question it was stated by Mr. Davis, when he was examined in Court, that it was true that there was no evidence that rapid decompression was caused by any structural failure. In an answer to another question, as to whether in his opinion there is a low frequency content present in every situation whereever there has been a high explosive device detonated, Mr. Davis answered in the affirmative, he however added that "But we do not have sufficient numbers to indicate that that would always be the case". Mr. Davis, however, agreed that DC-10 aircraft was quite dissimilar to Boeing 747, and the sound of an explosive decompression in the aft cargo hold of a DC-10 would not be identical to an explosive decompression in the aft cargo hold of a Boeing 747.

3.4.6.18 Mr. Davis further agreed that he was looking for low frequencies in Kanishka tape, but he did not know what type of low frequencies should be looked out for because there was no available data anywhere in the world for the sound of a bomb explosion in a Boeing 747. Mr. Davis was however emphatic in saying that he could not measure the distance of the origin of the sound from the cockpit area mike. In his report, and also in the earlier part of the examination, Mr. Davis had referred to the absence of low frequency component in the spectrum and had sought to conclude that such absence showed that there was no detonation of a high explosive device. In an answer to the question put by the Court however, Mr. Davis appeared to have altered his stand. This is evident from the following deposition of Mr. Davis :-

"Court Ques Am I to understand that there must necessarily be a low frequency whenever an explosion occurs?

Ans. No. What we thought was there would be. There was only one sample of explosion in B-737. But we would need more accidents of that nature to able to say that yes we must have a low frequency component.

Court Ques: Am I to understand that the absence of a low frequency component would not therefore necessarily mean that the sound was not that of an explosion?

Ans. Because of the absence of a low frequency component we would not be able to say positively that there was an explosion or it was not explosion."

Court Ques : Would the frequency of a particular type of sound change depending upon the environment in which that sound occurs?

Ans Yes.

Court Ques If an event results in low frequency sounds in one type of environment, can it mean that the same event can result in a high frequency sound in a different environment?

Ans. That must be possible".

3.4.6.19 Mr. S.N. Seshadri's Report and Deposition

A detailed analysis of the CVR and the ATC tapes was also carried out by Mr. S.N. Seshadri at BARC. For the purposes of comparison, CVR tapes of Iranian Air Force Boeing 747 accident as well as that of Indian Airlines Boeing 737 accident were also analysed at BARC.

3.4.6.20 The original CVR tape of Kanishka was played on a 4 channel tape recorder modified to run at 1-7/8" per second. The output of this tape recorder was copied faithfully on an eight channel HP 3968A instrumentation tape recorder. Channels 1 to 4 were used for recording the CVR data and channels 5 for recording a time marker. For further processing and signal analysis this copy of the original tape was used.

3.4.6.21 The observations of the data so recorded, as contained in the said report inter-alia are as follows :

"Repeated and careful listening to all the four channels revealed the presence of explosive sounds on all these channels occuring nearly at the end at the same time. Speech information is present on channels 3 and 4 during the last few minutes. Channel 1 does not contain any speech data during this period. Channel 2 contains indecipherable speech data about 20 to 25 seconds before the explosive sound".

"It was decided to analyse in detail the tape data during the final few seconds within which significant audio and electrical changes were observed to be present. Data from all the four channels were displayed on a Tektronix 2-channel storage oscilloscope Model 466 for initial observations. Based on this study the relevant portion of the tape was selected for more intensive snalysis. Simultanious ultraviolet recording of all the four channels on this portion of the tape was next carried out". The following observations are relevant.

1. Channel 3, which corresponds to the area mike shows the first indication of a rising audio signal. This instant is termed, for conveniece, as zero time reference. The signal level rises from the ambient level in the cockpit by about 18.5 db in approximately 45 milliseconds. The signal then starts falling and stablises at a level about 10 db higher than the ambient level before zero time. The signal continues to remain at this level for about 275 milliseconds. The total duration of the signal from zero reference is thus about 360 milliseconds.

2. Channels 1 and 2, which are the radio channels of the pilot and the flight engineer respectively, show start of electrical disturbance signals 45 milliseconds from zero time at which the audio signal on channel 3 is at its maximum. These signals, which have do minant frequencies in the range of 70 to 210 Hz, persist for about 100 milliseconds on both channels. Subsequent to this, channel 1, shows an audio burst lasting about 200 milliseconds. Channel 2 shows a delayed audio burst lasting 25 milliseconds, 220 milliseconds from zero time, or in other words, 175 milliseconds after the peak signal from channel 3. A low amplitude tail appears after this burst and lasts around 40 milliseconds. Channel 4 which is the co-pilot's radio channel shows an electrical disturbance commencing at 85 milliseconds from zero time and lasting around 60 milliseconds. The frequency distribution during this period is similar to those on channels 1 and 2. This is followed by an audio burst of 230 milliseconds duration. The frequency spectra of the audio portions of channels 1,2 and 4 are reasonably similar."

3.4.6.22 "Correlation of Events of ATC Shannon Tape and Channel 4 of CVR tape :

"It was observed that during the last few minutes before the stoppage of the CVR, information recorded on the ATC tape and channel 4 of the CVR tape are identical. However, the ATC tape contains a series of audio bursts approximately corresponding to the instant at which a single explosive sound is recorded on channel 4. Thus a doubt arose whether the series of audio bursts recorded on the ATC tape had originated from channel 4 of Kanishka CVR since these are not recorded on the CVR tape. In order to obtain an answer to this it was necessary to check with very good accuracy the simultaneity of the explosive sound on channel 4 and the series of audio bursts on the ATC. The procedure followed for the same is given below.

"The ATC Shannon tape and the CVR tape were run on two independent tape recorders. It was found that the speeds of the two tapes were mismatched. In order to match speeds the earliest speech signal on both the tapes.

"Seven seventy that checks maintain three five zero" was used as the reference point. The speech signals which mostly contain the conversation between the co-pilot and ATC Shannon lasts for about 146 seconds. Channel four was kept ready for starting exactly at the reference point. The ATC was next played starting well before the reference point. The tape recorder playing channel 4 was started manually exactly at the time when the reference point on the ATC was audible. By noting the time of ending of the conversation on both the tapes which corresponds to "Right Sir squaking two zero zero five one eight two" the speed of the recorder playing the ATC tape was corrected by pitch control to approach the speed of CVR tape. The process was repeated a number of times till audibly the speeds were matched. The two tapes were next synchronously played and both the channels were simultaneously recorded on a third recorder to a point well after the explosive sound on channel 4. This tape was used for all further analysis.

"The first significant observation was that the explosive sound on channel 4 coincided with the beginning of the series of audio bursts on the ATC tape as heard by the ear. It was thus clear that both the recordings correspond to those generated by Kanishka during its last moments.

"To confirm this preliminary conclusion which was judged solely by the ear, accurate instrumented tests were carried out. The two channels were simultaneously recorded on an ultraviolet recorder at the four speeds, 0.1"/sec, 1"/sec, 10"/sec and 160"/sec for study of synchronism as well as frequency details. It was noticed that the two waveforms were not exactly suynchronised though by the ear they appeared to be so. In order to find out exactly the difference in synchronisation the following tests were done:

UV recordings at 16" per second were taken at three representative points relating to the communication of ATC with Kanishka. These points correspond to speech portions at 070838 "Five eh Squawking and eh Air India", at 070958 "Right Sir Squawking" and near the blast on channel 4. It was found that the ATC was running slightly faster. At the first point the ATC was leading by 90 milliseconds, and at the second point by 130 milliseconds. The time interval between these points is about 80 sec. By extrapolating this lead to the time of the blast which occurs about 243 sec. from the second point, it is clear that the lead of the ATC with respect to channel 4 at this point will be given by 130 + (130-90) (243/80) which is approximately 250 milliseconds. This error is very small."

"Thus one can conclude that the sounds recorded on the ATC Shannon tape are those which emanated from Kanishka during its last seconds."

3.4.6.23 "Frequency Analysis:

Mr. Seshadri also carried out frequency analysis of the CVR and the ATC tapes. His opinion with regard to the same was the follows:

"Significant audio and electrical disturbances were observed in the final few seconds of the CVR tape. It was therefore decided to analyse all the four channels for their frequency contents at the various places in this pertinent region. For Fourier analysis of each signal, digitized time data of 200 milliseconds duration was processed. The frequency analysis was carried out using Bruel & Kjaer model 2033, high resolution signal analyser. Frequency spectrum was computed over a base band of 2 KHz with a resolution of 5 Hz.

3.4.6.24 "The frequency analysis of electrical disturbances in channels 1,2 and 4 indicate presence of low frequencies in the region of 20 Hz to 600 Hz. The dominant frequencies are in the range of 70 Hz to 210 Hz.

3.4.6.25 "The frequency spectrum of the background noise in channel 3 just before the explosive sound has a broad band spectrum with some dominant frequencies in the region of 650 Hz to 1550 Hz. At the bang, many additional frequencies appear. The frequency spectrum of bang on channel 3 indicates an increase in the bandwidth.

3.4.6.26 "The frequency spectrum of channel 1 at the bang position indicates a fairly broad spectrum with dominant frequencies in the range of 150 Hz to 1 KHz. Channel 2 displays a frequency spectrum at the bang position in which low frequencies are dominant. It has a significant frequency range between 20 Hz to about 1 KHz. The frequency spectrum of channel 4 at the bang is wide-band with a broad peak in the range of 150 Hz to 800 Hz.

3.4.6.27 "At the beginning of the crackling sound, the frequency spectrum shows narrow band peaks around 1.6 KHz. About 90 and 300 milliseconds later, the spectrum changes with additional peaks appearing around 400 Hz, 600 Hz and 1150 Hz. Frequency analysis was also carried out at 600, 800 and 1000 milliseconds before the start of the crackling sound."

3.4.6.28 The conclusions which were arrived at by Mr. Seshadri on the basis of what he had heard and after studying the various spectra were as follows:

"The signal in channel 3 of the CVR which corresponds to the cockpit Area Mike shows the first signs of an audio disturbance. The signal

time data of 200 milliseconds duration was processed. The frequency analysis was carried out using Bruel & Kjaer model 2033, high resolution signal analyser. Frequency spectrum was computed over a base band of 2 KHz with a resolution of 5 Hz.

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3.4.6.28 The conclusions which were arrived at by Mr. Seshadri on the basis of what he had heard and after studying the various spectra were as follows:

"The signal in channel 3 of the CVR which corresponds to the cockpit Area Mike shows the first signs of an audio disturbance. The signal peaks to its maximum of 18.5 db above ambient level in about 45 milliseconds. A loud audible blast is heard when this channel is played at this point. An analysis of the frequency spectra before this loud blast and during the blast shows a definite change in the frequency composition. From all the above results it can be concluded that an explosion occurred in the aircraft. The exact position in the aircraft at which the explosion occurred is likely to be about 40 to 50 feet from the Cockpit judging from the rise time of 45 milliseconds.

3.4.6.29 "Explosive sounds on all the four radio channels preceded by electrical disturbance reinforce the evidence provided by channel 3.

3.4.6.30 The synchronised recording and detailed analysis of the ATC and channel 4 confirm that the sounds recorded in the ATC Shannon tape are undoubtedly attributable to the transmissions from AI 182 Kanishka during its last moments. The sounds indicate possible breaking up of the aircraft in mid air and the air blast which follows a decompression. A very detailed UV recording does not indicate the presence of a second explosion."

3.4.6.31 "Copies of CVR tapes of well understood air crashes pertaining to an Indian Airlines Boeing 737 in 1979 and Iranian Air Force Boeing 747 in 1976 were analysed for possible reference in connection with the analysis of the CVR tape of Kanishka.

3.4.6.32 "A definite explosion near the Cockpit was the cause of the crash of the Indian Airlines Boeing 737. An explosive sound recorded on the Cockpit Area Mike shows a rise time of about 8 milliseconds which corresponds to a distance of about 8 feet. This indicates that the rise time is a measure of the distance from the Cockpit Area Mike at which an explosion has occurred.

3.4.6.33 "The Iranian Air Force Boeing 747 broke up in mid air. Analysis of the CVR tape clearly indicates that the frequency spectra of the electrical disturbances are similar to those obtained for Kanishka. Thus the series of audio bursts recorded on the ATC Shannon tape have been most probably generated by the break-up of kanishka in midair.

3.4.6.34 Mr. Seshadri was also examined in Court on 27th January, 1986. In his deposition he very succintly explained some aspects of the work which was done by him. He also dealt with the aspect of AGC to which reference has been made by Mr. R.A. Davis and Mr. Paul Turner in their reports. The relevant part of the testimony in this connection is as follows :-

"We wanted to make sure that the CVR recording and the ATC corresponded to the same aircraft Kanishka. When we played the tapes for the first time we found that there was a difference of about 1 second. Though this figure may be tolerable because of the accuracy of the tape speeds, we wanted to investigate further to make really sure that the ATC corresponded to Kanishka. For this purpose we had simultaneously "recorded channel 4 of the CVR and the ATC on a single tape on 2 channels after synchronising the common speech signals to the best of our ability by the ear. We started with the first speech which was available on both the tapes, namely, "770 that checks maintain 350". This was a conversation with the TWA aircraft which is available on both channel 4 and the ATC. The last sound which is recorded common to CVR and ATC is the speech of the co-pilot who says "right Sir, squaking 2005 182". After this recording though by the ear the explosive sounds on the ATC. as well as the CVR seemed to match, we wanted to check it in more detail. For this purpose we had detailed UV recordings of different portions of the synchronised tapes pertaining to the conversation between ATC and Kanishka. This was done and we noticed that the ATC was running slightly fast. We had about 80 seconds reference time of conservation from Air India Boeing Kanishka and the ATC for reference and we had to extrapolate the information in this section for another 243 seconds at which time the explosive sound occurs. During the beginning of this 80 seconds reference period, we find that the ATC was leading by 90 milli-seconds and at the end of 80 seconds the lead of ATC was 130 milli-seconds. Thus, in 80 seconds, the ATC had gained 40 milliseconds.

"This extrapolated to 243 seconds and gives a figure of 250milliseconds. This is how we arrived at the conclusion that both are synchronised within 250 milliseconds. I would like to bring to the notice of the Court that we have taken great pains to confirm this information by reapeating the tests a number of times. We did not take the 400 cycle signal available on the tape as the time reference. We took for reference the bunching of signals produced by the conversation and the gaps in between the convervation which are very clear on both tapes. Hence we are sure that our results are right. The UV recording which was made has been filed along with my report.

"The main channel which was examined was the CAM channel. This was agreed to by all the experts who were present during the first analysis of the tape at the BARC between 16th and 20th July, 1985. One of the most noticeable things is that channel 3 which corresponds to cockpit area shows the first sign of disturbance. Let us say for reference that the disturbance starts at 0 time. In about 45 milliseconds the signal rises to a peak value which is approximately 18.5 db above the ambient level before the commencement of the signal. After this point the signal decays roughly exponentially in about 40 milliseconds to be almost a steady level which is 10 db above the ambient level before the explosive sound. From this we could draw conclusions. Assuming that an explosion occurred on the aircraft. The explosion produces a shock wave with a steep wave front which travels in air as well as through the aluminium body and the speed of travel will depend upon the distance of the explosive from the point of observation. It will depend on the cube root of the explosive and it will also depend on the ratio of the distance to the cube root of the weight of the explosive. The shock wave is very fast. It can travel at about 10 times the speed of sound. Also when the shock wave hits the aluminium body of the aircraft the vibrating panels which are defined by the stringers and longerons transmit the sound to the CAM location. Because the speed of sound in aluminium is about 19,200 feet per second which is 16 to 18 times that of the speed of sound in air and the shock velocity is also about 10 to 12 times. This signal will be received "first by the CAM. Nevertheless the shock wave gets attenuated diffracted and refracted during its travels to the cockpit. Hence the signal received at the cockpit will be an attenuated signal and this small signal we have taken as instantaneous with the time of explosion. As the time passes the sound waves travel from the explosion site reinforcing the sound in the cockpit area thereby there is a rise time. Then when all the complete sound information is transmitted we get the peak of the signal and thus the rise time corresponds to the delay between the first rise in signal to the peak as compared to the speed of sound. One may ask the question what is the speed of sound because the aircraft has an explosion and is exposed to the outside environment but since the de-pressurization of the aircraft through the explosive fracture will take a minimum of a few seconds, we can reasonably assume that the pressure of the air in the aircraft corresponds to about 5000 to 6000 feet of altitude. At this presure and temperature, the sound velocity is roughly 1000 feet per second and from the 45 milliseconds delay we concluded that the explosion should have occurred about 40 to 50 feet from the cockpit. A question may be asked that the decay of the signal might be due to the AGC of the CVR coming into action. Mr. Turner, who is an acknowledged expert in the field of CVR has reported that Messrs Fairchild tested the cockpit voice recorders with a 10 db rise and fall of signals at the threshold of AGC and they got a result indicating a decay time of 33 milliseconds. The fall in the waveform of Channel 3 is about 40 milliseconds and is well near 33 milliseconds, so an argument may be advanced that the sound continued to remain steady and the fall in the signal level was effected by the AGC. In order to confirm this we tested the Cockpit Voice Recorder which was identical to the one which was on Kanishka by applying 1 KHz waveform of rectuangular modulation. To our surprise, we found that the decay time roughly was 130 milliseconds as compared to 33 milliseconds given by Mr. Turner. We repeated the tests with an initial background and without any background at all. We further tested with ramp waveforms, in other words, "slowly rising and falling waveforms of triangular shape with modulations of 1000 cycle carrier. This also confirms our finding. In order to clarify how the tests were performed so that others can judge whether it was a realistic test, I will explain the procedure. The modulated waveform was produced by a signal generator. This was fed to an amplifier. The amplifier output was fed to a loudspeaker. The output of the amplifier was checked to ensure that there was no distortion. Thus the signal going into the loudspeaker is the same modulated signal which has been applied at the input of the amplifier. This sound coming from the loudspeaker was recorded on the CVR through the CAM in the laboratory. This is how the test was performed. We were given a CVR tape by the Department of Civil Aviation purported to be that of an explosion which occurred on a Boeing 737 aircraft which crash- landed at Madras. We did the CVR analysis of this aircraft. We first recorded the output of the CVR of Indian Airlines CAM channel on a UV recorder. We found the rise time to be very small. This was of the order of a few milliseconds, about 8 milliseconds or so. We have been told that the explosion occurred just by the side of the front toilet i.e. just behind the cockpit. This to some extent confirms that the rise time is related to the distance of the explosion from the detecting CAM. The next thing that we did was the frequency analysis of this waveform. Mr. Davis has indicated in his report that if an explosion occurs on board the aircraft there should be low frequencies present. When we analysed the frequencies of the Kaniskha aircraft Channel 3, we did not find very low frequencies in case of an explosion abroad the aircraft. When we analysed the Boeing 737 tape we did not find any low frequencies in the signals. The report of Mr. Davis also provides the frequency analysis of a pistol shot which has been fired in the cockpit of the aeroplane. This also shows no low frequency components. So our conclusion, that it is not essential for low frequencies to be present in case of an explosion abroad an aircraft, was confirmed. I will go a step further to say that the frequency received by an area mike which responds to an explosive action abroad the aircraft will contain frequencies of the structure of the defracted " and dragging shock wave, the resonant frequencies of the aluminium panels defined by the longerons and the stiffening channel members and also some frequencies which may be of objects that the shock wave encounters in its path. It is, therefore, impossible to calculate the frequency spectrum that one would expect in the cockpit due to an explosion taking place in the aircraft".

3.4.6.35 In answer to a question Mr. Seshadri categorically stated that the word "explosion" in his report meant "a bomb, a very fast device".

3.4.6.36 Mr. Paul C. Turner's Report

Lastly, a reference may be made to the report dated 13th November, 1985 of Mr. Paul C. Turner. The evaluation of Mr. Turner of the analysis done by him of the CVR and the ATC tapes, as contained in the said report, was as follows:-

"With the foregoing as background, we can make several observations. The CVR record on the CAM channel, captain's channel and flight engineer's channel show that they were all affected at about the same time; the copilot's perhaps 20 milliseconds later. Major disturbances which are recognized as electrical system disturbances can be seen to begin about 60 milliseconds after the initial disturbance. This approximates the time it would take for the electrical system protective circuitry to become active.

3.4.6.37 "A steep wave front which would be indicative of a shock wave cannot be seen on the CAM channel sound spectrum; however, the spectrum analaysis shows that impulse type sounds occurred at the beginning of the event recorded on the CAM channel of the CVR. Since audio signals propagate through aluminium approximately 16 times the speed of sound in air, the CAM channel would probably have been affected by structurally transmitted noise before being affected by airborne noise. The geometry of the aircraft was such that structure borne disturbances could be recorded before the airborne transmitted information appeared at the cockpit microphone and an air transmitted shock wave or steep wave front may not be evident on the CVR.

3.4.6.38 The captain's and copilot's selector box channels recorded signals which appeared to be electrically inducted and similar to those seen on the Huete Boeing 747 breakups. These are then followed by a signal resembling audio frequency noises similar to an open microphone in a noisy environment or the opening of a receiver squelch. Both effects have been seen during aircraft breakups. The audio noise on the captain's and copilot's channels appears to have come from a different source. The flight engineer's channel does not contain audio noise. A spectral diagram of the copilot's and captain's channel noises just show broad band noise across the spectrum. The signal frequncies extend beyond the frequency range of a microphone both on the high and the low end. It does not fit the normal microphone envelope. Spectral diagrams of the event on the CAM channel show the normal microphone preamplifier envelope summed with wide band signal of unspecified origin. Since the signal quits abruptly with a doublet, it indicates that the interference was added upstream of the CVR and was not just reflected in the CVR power supply.

3.4.6.39 "The CVR record shows a signal stayed on for about 200 milliseconds when it appears that the power may have been interrupted to both the radio channel and the CAM channel of the CVR at the same time. It further appears that the signals to the CVR were probably interrupted at 360 milliseconds from the initial disturbance possibly by severance of the signal wires. It further appears from the action of the erase head and record that the main electrical system began to fail at this point and the CVR bus voltage value dropped to a value below 70 volts but not below 20 volts. This fluctuating voltage continued intermittently for a minimum of 1-1/4 seconds at which time the voltage evidently dropped to some value below 20 volts and the recorder ceased to operate. The power for operation of the No. 1 VHF transmitter can be explained by the operation of the standby bus and battery and connection of the No. 1 VHF radio to this standby bus.

3.4.6.40 "The necking down of the signal to a low value shows that no signal was coming to the CVR from the CAM preamplifier. The lack of a signal on the radio channels, which do not need to be erased before being recorded, further suggest that the wires were severed or

"that the transmission to Cork began after what appeared to be the loss of the primary electrical system approximately 1-1/2 seconds following the event. Standby power would have become available upon loss of the primary power, the number one VHF would have become available, and CVR would have ceased to operate.

3.4.6.41 "The action of the erase circuitry in the CVR suggests that the fluctuating voltage seen was coming from the main electrical system bus. Anything else causing this fluctuating voltage down stream of the CVR circuit breaker would probably blow it.

3.4.6.42 "The signal received in Ireland indicated that a radio, most probably this aircraft's No. 1 VHF transmitter, stayed operational for about 5.4 seconds following the event at which time the entire aircraft electrical system ceased to function. This assumes that the No. 1 transmitter ceased to operate due to standby bus failure.

3.4.6.43 "In the conclusion, it appears that a catastrophic event occurred on Kanishka. It was reflected in all channels of the CVR and the CVR power supply at the same time. The main electrical bus began to fail within 0.35 second and the standby bus survived for only 6 seconds more at which time the aircraft's electrical system ceased to function. It appears that the event occurred in a manner to affect the cockpit area microphone operation severely and to force operation of the automatic gain control on the CVR. This loud noise continued for the life of the aircraft's main electrical system as reflected in the CVR.

3.4.6.44 "The mechanism of how the ATC transmission was made from Kanishka to Cork is unclear. The sound was not recorded on the CVR, indepentent studies by Canadian and British investigators have the Cork ATC call originating approximately 1-1/2 seconds following the event on the CVR. This is about the time that standby power would have become available to the No. 1 VHF.

3.4.6.45 "This report should be viewed as an accident investigation tool only and used in conjunction with other evidence gathered during the investigation.

3.4.6.46 "The United States Noard/Space Command has confirmed that there was no incoming space debris in the vicinity of Ireland on June 23, 1985."

3.4.6.47 It is pertinent to note that according to Mr. Turner there was "catastrophic event" which had occurrred on Kanishka. He has, however, not elucidated as to what this event was.

3.4.6.48 After the receipt of the report, the Court requested the NTSB that Mr. Turner should come and depose. It is unfortunate that permission was not granted to him. Faced with this situation and as it was thought necessary that some clarification was called for, the Court sent a telex to Mr. Turner whereby he was asked to give replies to the queries contained therein. He was requested that the reply be sent by 27th January 1986. A copy of the telex was also forwarded to the American Embassy at New Delhi for sending the same to NTSB by way of confirmation. Previously all communications addressed to NTSB were being routed through American Embassy. No reply has been received by the Court till this day either from NTSB or from Mr. Paul Turner. According to paragraph 5.14 of Annex 13 the State is required, on request from the State conducting the investigation of an accident, to provide to that State with all the relevant information available to it. It was, therefore, obligatory on the NTSB to have seen that the information sought for by the Court by way of answers to the queries was supplied.

3.4.6.49 Court Evaluation

From the reports of all the experts and the testimonies of M/s Caiger, Davis and Seshadri it is clear, and it is agreed to by all of them, that there was a breakup of the aircraft in mid-air. The experts also agreed that the sounds recorded on the ATC Shannon tape at 0714:01 Z emanated from the Kanishka aircraft.

3.4.6.50 Mr. Caiger has not said either in the report or in his statement as to what was the cause of the bang. Mr. Davis, on the other hand, is categorical in stating in his report that there was explosive decompression (meaning rapid decompression) on the aircraft. He has, however, stated in the report that there is no evidence of an explosive device. The main reason for his coming to this conclusion is that he had not been able to find low frequencies in the spectra of the CVR of Kanishka. Mr. Seshadri, on the other hand is equally vehement in concluding that an explosive device had detonated in the front cargo hold of Kanishka.

3.4.6.51 It may be that the frequency spectrum of Kanishka CVR did not contain low frequencies but, as has been admitted by Mr. Davis himself in answer to a Court question, it is not necessary that in the case of every detonation there must necessarily be low frequencies in the spectrum. Frequency spectra of 'Kanishka CVR before 'bang' and at the 'bang' position are shown in Figs. 2 & 3, indicating presence of additional high frequncies at the bang. Indeed in the case of Indian Airlines Boeing 737, which admittedly was a case where there was an explosion of a device within about 8 feet of the CAM, the frequency analysis showed absence of low frequencies. Frequency spectrum of Indian Airlines Boeing 737 CVR is shown at Fig. 4. Merely, because therefore, there were no low frequencies present would not mean that there was no detonating device on board the Kanishka. The CVR of Indian Airlines Boeing 737 has not been analysed either by Mr. Caiger or Mr. Davis. The analysis was, however, conducted by Mr. Seshadri and as is evident from his report, there were marked similarities between the spectra of Indian Airlines 737 and Air India's Kanishka CVR. One of the important reasons for coming to this conclusion, which has been indicated by Mr. Seshadri, is the rise time of the bang signal. From the analysis of the Indian Airlines Boeing 737 tape it was observed that it had taken 8 milliseconds for the peak to be reached. It was also seen that the explosive device was approximately 8 feet away from the cockpit area mike. Keeping this in view Mr. Seshadri observed that in the case of Kanishka the peak of the bang signal was reached in about 40 milliseconds. He, therefore, concluded that the origin of the bang sound was about 40 feet away from the cockpit area mike.

3.4.6.52 It would be pertinent to note that even according to the report of Mr. Davis the rise time in the case of Kanishka, which has been given for the peak is about 40 milliseconds. He, however, does not attach much importance to this because according to him after about 40 ms automatic gain control would become effective.

3.4.6.53 Mr. Davis has no personal experience of the time which it would take for the Automatic Gain Control to take effect. He has got the figures from the manufacturer. Mr. Davis admitted that the time which it will take for the AGC to be effective is not indicated in any published document of the manufacturer.

3.4.6.54 Mr. Seshadri, however, personally carried out the experiments on a Boeing 747 by using an instrument similar to what was on board Kanishka. From the testimony of Mr. Seshadri it is apparent that the results which he got were different. As per his testimony, for the AGC to be effective it will take 130 ms. If this be so then it may be possible to conclude that in the case of Kanishka the peak was reached in 40 ms. and thereafter the signal decayed and the signal was in no way effected by the AGC.

3.4.6.55 A reference may also be made, at this stage, the frequency spectrum of the sound of the hand gun which was fired on a boeing 737 flight deck. Frequency spectrum prepared by Mr. R.A. Davis is shown at Fig. 5. He has stated that the rise time for reaching the peak is almost instantaneous. Same is the case with regard to the frequency spectrum prepared by him of a bomb in a B-737 aircraft where the bomb had been placed in the freight hold which is shown in Fig. 6. A perusal of that spectrum also shows that the peak was reached in approximately 5 ms. The forward freight hold compartment of Boeing 737 is much more than five feet away from the cockpit area mike. If the theory of Mr. Seshadri was to be applied then as per the frequency analysis of this Boeing 737 bomb, the distance from the area mike could not have been more than 5 ft. It is, however, known, as per the report of Davis, that the bomb was actually in the freight hold which would mean not nearer than about 25 feet.

3.4.6.56 From what has been stated in the various reports, as well as in the testimony of the 3 experts who apperared in the Court, the only safe conclusion which can be drawn is that possibly enough study has not been done, due to lack of adequate data, which can lead one to the conclusion as to the exact nature of the sound and the distance from which it originated.

3.4.6.57 The fact that a bang was heard is evident to the ear when the CVR as well as the ATC tapes are played. The bang could have been caused by a rapid decompression but it could also have been caused by an explsoive device. One fact which has, however, to be noticed is that the sound from the explosion must necessarily emanate a few milliseconds or seconds earlier than the sound of rapid decompression because the explosion must necessarily occur before a hole is made, which results in decompression. In the event of there being an explosive detonation then the sound from there must reach the area mike first before the sound of decompression is received by it. The sound may travel either through the air or through the structure of the aircraft, but if there is no explosion of a device, but there is nevertheless an explosive decompression for some other reason, then it is that sound which will reach the area mike. To my mind it will be difficult to say, merely by looking at the spectra of the sound, that the bang recorded on the CVR tape was from an explosive device.

3.4.6.58 There are various hypothesis and theories which the experts have to investigate before any acceptable conclusions are arrived at. It so happens that in the present case we have the opinions of four experts, but they do not agree with one another on some material aspects. Two of the experts, namely, Mr. Caiger and Mr. Davis are categorical in saying that it is not possible to measure the distance of the origin of the sound on the cockpit area mike, whereas Mr. Seshadri has come to a different conclusion. Mr. Paul Turner in his report dated 13th November, 1985 in silent on this aspect, though in his earlier report dated 19th July, 1985 he had categorically said that there was an explosive device close to the cockpit.

3.4.6.59 With regard to the nature of the sound also we have 3 different opinions. Mr. Caiger is unable to give the nature of the sound, Mr. Davis says it is rapid decompression while Mr. Seshadri says it is a sound of an explosive device followed by decompression.

3.4.6.60 In the absence of any other technical literature on the subject, it is not possible for this Court to come to the conclusion as to which of the Experts is right. The only conclusion which can, however,
be arrived at is that the aircraft had broken in midair and that there has been a rapid decompression in the aircraft. Just as it is not possible to say that the spectrum discloses that the bang is due to an explosive device similarly, and as has also been admitted by Mr. Caiger and Mr. Davis, it is not possible to say that the bang is due to break up of a structure.

3.4.6.61 The bang could have been due to either of the aforesaid two causes i.e. a bomb explosion or the sound emanating due to rapid decompression. The advantage of carrying out the said analysis is that a number of possible causes of the accident are eliminated. On the other hand, if the analysis is viewed in conjunction with other evidence on the record it is further possible to determine the exact nature or cause of the bang. In the present case the bang, as already noticed, could have been due to the sound originating from the detonation of a device or by reason of rapid decompression. Other evidence on the record, however, clearly indicates that the accident occurred due to a bomb having exploded in the forward cargo hold of Kanishka. The spectra analysis and the conclusions of Mr. S.N. Seshadri are corroborated by other evidence.

TESTS AND RESEARCH

3.5.1 During the course of investigation a number of groups were formed to study and analyse evidence and data which was available. Materials like CVR, ATC and DFDR tapes were also given to the various participants.

3.5.2 The groups as well as other experts studied and analysed the material with them and submitted their reports which have been referred to earlier.

3.5.3 The experts examining the CVR tapes did carry out a number of tests. Different graphs and traces were prepared and the sound was analysed by them. The result of their analysis has been referred to in Chapter 3.4 on Flight Recorders.

3.5.4. The metallurgical examination of some of the recovered pieces was carried out at BARC. The examination of some of the pieces showed different types of damages having been recorded on the targets such as petalling and curling round the holes, spikes etc. The said team carried out certain explosion experiments. Their report on the experiments so carried out has already been set-out in paragraph 3.2 above.

3.5.5 The Indian Air Force has set up an Institute of Aviation Medicine at Bangalore. The Court visited the said Institute on 9th December 1985. During that visit an experiment was conducted in the explosive decompression and high altitude chamber to demonstrate what actually happens during explosive decompression and subsequently on exposure to hypoxia.

3.5.6 Subjects were taken to 8,000 feet in the explosive decompression chamber with oxygen. They were exposed to an altitude of 25,000 feet within one second. During the course of this explosion a loud bang was heard and inside the chamber there was misting and drop in temperature. After this the chamber was allowed to run at 22,000 feet for roughly two minutes and an experiment to show the adverse affects of hypoxia on the subjects was done. In this experiment, subjects were asked to write a given sentence while their oxygen supply was cut off. It was observed that initially the subjects kept on writing the sentence correctly and then after about 120 seconds they started making errors while writing the sentence and finally they stopped writing. At this stage oxygen was re-started and within a few seconds, the subjects started writing their sentence once again. The experiment was completed at this stage and the altitude chamber was brought down to ground level.

3.5.7 The subjects were taken out and were asked questions as to what did they feel. They explained that at the time of explosive decompression, they heard a loud bang, felt cold and saw misting inside the chamber. They also found air escaping from their lungs. On further enquiry about the experiment pertaining to hypoxia, they said that they felt light headed and after that they did not know what happened till they once again noticed that they were writing on a piece of paper.

SECURITY

3.6.1 The evidence and the statements filed on record show that Canadian Security arrangements in place prior to 23rd June, 1985 met the international requirements for civil air transportation. However, before this date, the emphasis was on preventing the boarding of weapons including explosive devices in hand baggage. Hence, the screening of checked baggage was only undertaken in conditions of a heightened threat as was the case with respect to Air India flights.

3.6.2 Air India, as required by Canadian regulation, had a security programme. Because of the threat level assessed against the Airline, Air India had more extensive security measures than almost any other Canadian or international airline. These measures were generally in accordance with the recommended procedures of the ICAO Security Manual for special risk flights. Air India had also requested and had received and arranged for extra security for the month of June, 1985. For Air India flight 181/182, Air India provided a security officer from its New York Office to oversee the security at Toronto and Montreal.

3.6.3 As it became apparent during the course of investigation that security would be an important aspect whilch would require the attention of the Court, Mr. Rodney Wallis, Director, Facilitation and Security, International Air Transport Association was good enough to appear in Court on 24th January, 1986. His testimony on certain aspects of security was recorded in camera by the Court on that date. The expert evidence has been taken into consideration while formulating some of the recommendations.

INTERNATIONAL COOPERATION

3.7.1 The manner in which persons and organisations from five different countries combined their resources and efforts in connection with this accident is an object lesson in international cooperation.

3.7.2 From the time the accident occurred, till the conclusion of the investigation proceedings by the Court in Delhi, there has been a consistent interplay amongst different persons and organisations. When all the persons got together, for the first time, at Cork the group was very heterogeneous. Each one had his own point of view, which did not necessarily coincide with that of another. At times, the atmosphere was charged with a bit of tension which continued even when the Court was constituted to investigate into the accident.

3.7.3 It was noticed that not only were the participants a bit apprehensive and suspicious but, during the course of investigation, there were also occasions when there appeared some acrimony

between a few of them.
3.7.4 In such a sensitive situation, careful handling was called for. The participants' honesty of purpose could not be doubted. All that was wanted was that there should be an effort to try and understand the point of view of all the persons. This is precisely what the Court tried to do.
3.7.5 It is indeed fortunate that the efforts of the Court, in this regard, succeeded. After the Court had decided that it was not the purpose or the function of the investigation to affix responsibility for any lapse which may have been committed, one could see the general relieving of tension. With the passage of time there was a gradual building up of the confidence of the participants in the conduct of the investigation. The participants' interest for air safety transcended all barriers and any apprehension or suspicion, which was present in the minds of some, was soon dispelled. In its place there grew a deep sense of urgency, anxiety and cooperation in an effort to see that all the participants rendered utmost assistance for the satisfactory completion of the task in hand.
3.7.6 The main beneficiary of this international cooperation was not only the Court investigating the accident but it was the cause of air safety which benefited the most. Countries and Organisations went out of the way to help each other, financially and otherwise, even when they were not obliged to do so. Money and services were readily and voluntarily offered and usually the requirements of the Court were always fulfilled.
3.7.7 As the accident had occurred only about 100 miles off the coast of Ireland, the centre of activity, initially, was centred at Cork. The Government of Ireland, and the Irish people in particular, acted as though they regarded this as a national disaster. Not only did they render every assistance with regard to the search and rescue operation, hospital facilities, police etc. but the people acted as if one of their own kith and kin had died. In the situation which existed they were pillars of strength to the relatives of the deceased. Not only did complete strangers comfort such relatives but, more often than not, they even joined in their grief. The residents of Cork did everything possible to try and mitigate the sorrow of the victims' relatives. Everyone did their small bit, even the children of Cork queued up to place flowers at the coffins of the victims.
3.7.8 The Representatives of the Government of Canada also came to the scene, at the initial stages itself, and rendered full help and cooperation till the last. The major brunt of the mapping and the salvage operations was borne by Canada. Willingly and without any demur it incurred huge expenses, which must have been to the tune of a few million dollars, in carrying out these operations. It rendered full help and assitance to the Court whenever called upon to do so. For example, it offorded full facilities and help to the team which had been sent to Canada by the Court in August, 1985. It was only with the help of the Canadian Government, and the CASB and RCMP in particular, that the Court was able to obtain evidence and information relating to the accident. Without Canadian help the conduct of the investigation would have only been speculative in nature.
3.7.9 On their own, and without any request from the Court or from the Government of India, the Government of United States decided to lend a helping hand in the salvage operations. This was done
at a very critical juncture when financial help and expertise were required so as to salvage the important critical pieces of the wreckage. It arranged for the services of a salvage expert and it also made necessary arrangements for the deployment of a second ship, duly fitted with necessary equipment to enable it to salvage some of the heavier pieces of the wreckage. The Court understands that the amount which was contributed in meeting the expenses by the United States was to the tune of U.S. $ 700,000.
3.7.10 The Government of United Kingdom also provided ship and helicopters in connection with the search and rescue operations. Even during the time when salvage operations were being carried out it was the British Helicopters which assisted in transporting personnel to and from the ship which were engaged in the salvage operations. The A.I.B. at Farnborough, on being asked by the Court to do so, carried out a very detailed analysis of the CVR and the ATC tapes.
3.7.11 Being the state of Registry of the aircraft and also the state holding the investigation, the major brunt of the work fell on the shoulders of officers of the Government of India and BARC. They acted as coordinators who had to oversee the work being carried out by persons belonging to diverse organisations and coming from different countries. Young engineers of Air India took turns in going aboard the ships and manning the Control Centre at Cork. They worked in conjunction

with the engineers of Boeing and CASB and the crew members of the ships during the salvage operations. Without their enthusiastic participation the progress of the salvage operations would have been severely hampered.

3.7.12 The Scientists from BARC and National Aeronautical Laboratory, Bangalore were ever ready and willing to work together with the experts from abroad. Whenever called upon to do so, they rendered whatever assistance which was desired by the Court and the other participants.

3.7.13 It was seen that when the persons, coming from different countries and backgrounds, worked together with sincerety and honesty of purpose then they functioned smoothly and harmoniously, and usually arrived at an agreed solution or finding. These days it is indeed rare to see such a degree of international cooperation between different persons, organisations and countries.

ANALYSIS AND CONCLUSIONS

4.1 From the evidence which is available what has now to be determined is as to what caused the accident.

4.2 Finding the cause of the accident is usually a deduction from known set of facts. In the present case known facts are not very many, but there are a number of possible events which might have happened which could have led to the crash.

4.3 The first task is to try and marshal the facts which may have a bearing as to the cause of the accident.

4.4 It is undisputed, and there is ample evidence on the record to prove it, that Air India's Kanishka had a normal and uneventful flight out of Montreal. The aircraft had been in air for about five hours and was cruising smoothly at an altitude of 31,000 feet. The readout from the CVR shows that there was no emergency on board till the catastrophic event had occurred. This is corroborated by the printout available from the DFDR. The event occurred at approximately 0714 Z and that brought the aircraft down, and it probably hit the surface of the sea within a distance of 5 miles. The time within which the plane came down at such a steep angle could not have been more than very few minutes. There was a sudden snapping of the communication between the aircraft and the ground. The aircraft had also suddenly disappeared from the radar.

4.5 It is evident that an event had occurred at 31,000 feet which had brought down 'Kanishka'. What could have possibly happened to it? The aircraft was apparently incapacitated and this was due either to it having been hit from outside; or due to some structural failure; or due to the detonation of an explosive device within the aircraft.

4.6 Evidence indicates that after the event had occurred, though the pilots did not or were not in a position to communicate with the ground, they nevertheless appeared to have taken some action. According to Mr. Laflamme, witness No. 12, the examination of the wreckage showed that spoilers had been deployed and this must have been done with a view to enter into emergency descent. He has further speculated that such an emergency descent would support or perhaps cause a rupture in the forward area or a partial damage to the hydraulic system or damage to the control system which created such a condition that the pilots were not able to control the flight. The wreckage fruther showed that the jack screw for the stabilizer trim was found in the nose-up position and it was hard to explain how this got there merely as a result of impact with the water. The trim being in that position could only have been due to the pilot selecting it or as a result of a situation created by an explosion. In that position, and at a high aircraft speed, there would have been an extremely high g-loading on the aircraft.

4.7 It can further be speculated that if an explosion takes place in the forward cargo compartment, the oxygen stream might have been damaged so that when the pilots donned their masks as part of the emergency drill for explosive decompression, they were not breathing enriched oxygen and the time of useful consciousness at about 31,000 feet would be significantly less than 30 seconds under high stress and if the pilots became unconscious as a result of this, then the aircraft would have got out of control which would explain the subsequent events.

4.8 None of the participants have produced any evidence which could lead one to the conclusion, that there was any external hit to the aircraft. In fact in the report dated 13th November, 1985, Mr. Paul Turner has stated as follows:

"The United States Norad/Space Command has confirmed that there was no incoming space debris

in the vicinity of Ireland on June 23, 1985."
4.9 Thus we are left with only two of the possibilities viz., structural failure or accident having been caused due to a bomb having been placed inside the aircraft.
4.10 After going through the entire record we find that there is circumstantial as well as direct evidence which directly points
to the cause of the accident as being that of an explosion of a bomb in the forward cargo hold of the aircraft. At the same time there is complete lack of evidence to indicate that there was any structural failure.
4.11 The circumstantial and direct evidence which leads to the aforesaid conclusion is as follows :
A. Connection with an explosion at Narita Airport :
On 23rd June, 1985 there was an explosion at the Narita Airport. The explosion occurred when a bomb exploded in a suit case which was to be interlined to Air India's Flight No. 301 from Tokyo to Bangkok. The following events, which had occurred prior to this explosion, clearly establish the connection between the two incidents :
(i) On 19 June 1985, at approximately 1800 PDT (0100 GMT, 20 June), a CP Air reservations agent in Vancouver received a telephone call from a male with a slight Indian accent. He identified himself as Mr. Singh and informed the agent that he was making bookings for two different males also with the surname of Singh. One booking was made in the name of Jaswand Singh with CP 086 from Vacouver to Dorval on 22 June 1985 to link with AI 182 departing from Mirabel. The other booking was to Bangkok using CP 003 from Vancouver to Tokyo and AI 301 from Tokyo to Bangkok. This booking was made in the name of Mohinderbel Singh. A local telephone contact number was given and the call lasted about one-half hour.
(ii) On the same date at approxmimately 1920 PDT (0220 GMT), another reservations agent for CP Air was contacted and requested to change the booking for Jaswand Singh. The confirmed flight on CP 086 was cancelled and a reservation was made on CP 060 from Vancouver to Toronto, and a request to be wait-listed on AI 181/182 from Toronto to Delhi was made.
(iii) On 20 June, 1985 at about 1210 PDT (1910 GMT), a male appearing to be of Indian origin purchased the tickets with cash from a CP Air Ticket office in Vancouver. The booking in the name of Mohinderbel Singh was changed to L. Singh and the booking using the name of Jaswand Singh changed to 'M. Singh'. The telephone contact number was also changed. The final itinerary was as follows :
(a) M. Singh - CP 060 Vancouver - Toronto Confirmed Scheduled to depart Vancouver at 0900 PDT, 22 June 1985
- AI 181 Toronto - Montreal Wait-listed Scheduled to depart Toronto at 1835 EDT, 22nd June, 1985
- AI 182 Montreal - Delhi Wait-listed Scheduled to depart Montreal at 2020 EDT, 22nd June, 1985
(b) L. Singh - CP 003 Vacouver - Tokyo Confirmed Scheduled to depart Vancouver at 1315 PDT, 22 June, 1985
- Air India 301 Tokyo - Bangkok Confirmed Scheduled to depart Tokyo at 1705 time in Tokyo, local 23 June, 1985
(iv) On 22 June, 1985 at about 0630 PDT (1330 GMT), a caller identifying himself as Mr. Manjit Singh called the CP Air reservations office. The caller spoke with a heavy Indian accent and wanted to know if his booking on AI 181/182 was confirmed. The caller was informed by the agent that the was still wait-listed out of Toronto and offered to make alternate arrangements to Delhi. The caller stated that he would rather go to the airport and take his chances. The caller also asked if he could send his luggage from Vancouver to Delhi and was told he could not check his baggage past Toronto unless his flight was confirmed.
(v) On Saturday morning, 22 June, 1985, a CP Air passenger agent worked check-in position number 26 at the CP AIR ticket counter, Vancouver International Airport, and recalls dealing with a passenger of Indian origin booked on CP 060 and then on to Delhi. The passenger stated that he wanted his bag tagged right to Delhi from Vancouver. After checking the computer, the agent explained that since he was not confirmed past Toronto his baggage could not be interlined. The

passenger insisted and, as the line-up were long, the agent relented and interlined his suitcase. The flight manifest for CP 060 shows that 'M. Singh' checked in through this passenger agent, was assigned seat 10B, and checked one piece of baggage.

(vi) The flight manifest for CP 003 shows that on the same day the person using the name of 'L. Singh' with an interline ticket to Bangkok also checked through the same counter, was assigned seat 38H, and checked one piece of baggage.

(vii) A check of CP Air's records and interviews with passengers on flights CP 003 and CP 060 indicates that the persons identifying themselves as 'M. Singh' and 'L. Singh' did not board these respective flights.

(viii) In a statement of William Long, annexed to the affidavit of I.G. Pole, Police Officer, City of Toronto, he has stated that on 22nd June, 1985 he was employed as a driver whose responsibility was to deliver interlined baggage between terminal 2 to Terminal 1 and vice versa at Toronto. He has further stated that he had picked up 4 bags from Terminal 1 which were destined for terminal 2 Air India. Three of these bags were from U.S. Air originating from New York city. Regarding the last bag he stated as follows :

"The fourth bag destined for Air India was, I distinctly remember looking at the baggage tag and it was pink with the CP logo in blue and letters saying CP on it there were also numbers but I can't remember the number, from CP Air and I remember it was from Vancouver. On the bottom of the tag it said vancouver using the initials YVR and the flight number which I can't remember. The bag was destined for India. When I arrived at the CP Air belt there were a number of bags from other airlines on the belt included in these were the three U.S. Air bags destined for Air India. As I was finishing loading the carts, a CP Air station attendant who had been unloading bags from containers, I noticed as I checked once more for anymore bags, drop another bag on the conveyer belt. This was the bag destined for Air India. It was dark brown Samsonite Hard sided Type 01A on the Baggage Identification Chart. After they were loaded onto the cart I took them over to Air Canada domestic belt at Gate 89-91".

To further questions posed to him, Long stated that this bag from CP Air weighed approximately 70 lbs and there was something which rattled inside the bag. He could not say what it was but he said that "it sounded small". When specifically asked whether he thought there was something big inside the bag, he answered in the affirmative, and added that he did not know what was in it but it was heavy. There was discrepancy in the time when he is alleged to have picked up the bags which he had indicated in his schedule when compared with CP Air Vancouver flight which had arrived at 1622 hours. When this was pointed out to Long, he answered "I could have may be got the time wrong, it was during the busy period. It could have been an estimate time. But I do remember the bag came off CP air. It could have been 16:34 Hrs. I don't know."

(ix) The aircraft departed from Toronto for Mirable and London with the suitcase unaccompained by the passenger who had checked it in at Vancouver. Similarly, CP Air 003 departed Toronto for Tokyo with the baggage of one passenger 'L. Singh' to be interlined to Air India flight AI 301 to Bangkok even though 'L Singh' had not boarded that flight.

(x) The linking of the two occurrences namely the blast at Narita Airport and the Air India accident becomes startingly evident if we look at the following chronology of events:

CPA 003 (VANCOUVER-TOKYO) CPA 060 (VANCOUVER-TORONTO) Connection to Connecting to Air India 301 Air India 182 WESTBOUND EASTBOUND All Times GMT

Thurs 20 June, 1985 0057 A male called C.P. Air Reservations in Vancouver and after discussing a number of routings, booked a one-way ticket and CPA 060 to Toronto with connections to Air India 182 under the name of Jaswand SINGH. A return ticket was also booked on CPA 003 to Tokyo connecting with Air India 301 to Bangkok in the name of Mohinderbel SINGH.

1912 A male attended the CP Air Ticket Office in Vancouver. He paid $ 3005.00 in cash for the above tickets after changing the ticket of Mohinderbel SINGH to L. SINGH and changing from a return to a one-way ticket. He changed the Jaswand SINGH ticket to M. SINGH.

Saturday 22 June A Mr. SINGH called Reservations and got 1330 confirmation on his one-way ticket to Toronto with luggage to be sent through to India. M. SINGH checked in with seat 10B confirmed to 1550 Toronto. Wanted suitcase interlined to AI 182. Agent relents. 1618 CPA 060 departed Vancouver 18 minutes late. M. SINGH not in assigned seat. L. SINGH checked in for CPA 003 and one suitcase interlined to Air India 301. Assigned seat 38H. CPA 060 arrived Toronto 2022 12 minutes late. Some passengers and baggage interlined to AI 181.

CPA 003 departed 17 min. late for Tokyo. L. SINGH not in 2037 assigned seat. Sunday 23 June Air India 181 departed 0015 Toronto for Mirabel 1 hour 40 minutes late. 0100 Air India arrived Mirabel. 0218 Air India 182 departed Mirabel 1 hour 38 minutes late. CPA 003 arrived Narita Airport, Tokyo. Arrived 14 minutes early 0541 Baggage cart explodes in transit area. 2 killed, 4 injured, 0619 0714 Air India 182 disappeared from Radar

Air India 301 departed Narita. 0805 0815 Air India 182 Scheduled arrival Heathrow (fuel stop).

(xi) It would indeed to too much of a coincidence that two persons, whose tickets were bought at the same time and who had checked in under the names of 'L. Singh' and 'M. Singh' missed their respective flights, more so when 'M. Singh' had insisted at the check in counter at Vancouver that he should be interlined, even though his seat from Toronto on AI 181/182 was not confirmed, and his baggage (one suitcase) accepted and be routed through to Delhi. If there had been some reason for 'gate no-show' by both of them, one would ordinarily have expected both, or at least one of them, to have made efforts, at that time or thereafter, either to ask for refund of money or they should have contacted the airline staff at the Airport and asked that they should be put on another flight.

(xii) A large amount of money had been spent on the purchase of the two tickets and a question which comes to mind is as to why was this money spent if both the tickets were to be wasted and no one was to travel on them, after having checked in and obtained boarding cards. Furthermore, no effort has been made by any of these two persons to try and lodge a claim for the baggage which they had checked in.

(xiii) The aforesaid facts clearly indicate the connection between the travel plans of so called 'L. Singh' and 'M. Singh'. In fact the manner in which the reservations were changed to the names of 'M. Singh' and 'L. Singh' shows the anxiety of some one to hide behind the identity of persons who bore notorious names.

(xiv) The interlined baggage exploded at Narita Airport and there is strong probability that the suticase from Vancouver, which was interlined to AI 182, contained a device similar to the one which had exploded at Narita Airport on 23 June, 1985.

B. CVR and DFDR both stopped simultaneously:

There was simultaneous interruption of electrical power to the flight recorders. The electrical supply could have been interrupted either because of the cables being cut or because of total electric failure. Power supply wires to the CVR and the DFDR run under the passenger cabin ceiling on the left and the right hand side. The supply of electricity through these cables originates from the MEC compartment, which is in front of the forward cargo hold. If the CVR and the DFDR had stopped due to the breakage of electrical supply wires as a result of possible explosion in the aft cargo hold there would have had to be an instantaneous break of almost the entire section of fuselage, because both these recorders had stoped simultaneously. In such a catastrophic event it is not possible that the bottom skin panels of the aft cargo compartment would remain undistorted, or would have no rupture or holes in them. Furthermore, in such an event the tail portion of the aircraft would have been found in the beginning of the wreckage trail, but this was not so. On the other hand, and explosion in the forward cargo compartment would have resulted in damage to the electrical buses located in the MEC and that would, in turn, result in cutting off the electrical power supply causing simultaneous stoppage of the recorders.

C. The ATC Transponder Stopped Transmitting :

The transponder is located at the bottom of the one of the forward rakes immediately forward of the front cargo compartment. Signals from this also stopped being received by the secondary radar at Shannon. Keeping in view that the CVR and the DFDR had stopped simultaneously at about the same time, when the signals from ATC transponder had also ceased, it is reasonable to presume that there must have been a complete breackdown of electrical supply which had affected all the three units. The only event which could have caused such a damage to paralyse the entire MEC compartment could only have been an explosion in the forward cargo hold. It was not possible that any rapid decompression caused by a structural failure could have disrupted the entire electricl power supply from the MEC compartment. In known cases of aircraft being subjected to rapid decompression there has never been such an instantaneous and total stoppage of electrical power and in fact aircrafts have been known to have continued to fly and communicate with the ground even after decompression.

D. Non-supply of Oxygen :

Oxygen supply cylinders are located in the ceiling of the forward cargo compartment. Any rupture of the only pipeline which supplies oxygen to the passengers would result in there being no surge of oxygen flow, which alone drops the oxygen masks. The inspection of the wreckage shows that there is no indication of the oxygen masks ever having dropped. A rupture of this pipeline, simultaneously with power rupture, could only have been caused if there had been a detonation of the explosive device in the front cargo hold.

E. Damage in air :

The examination of the floating and the other wreckage shows that the right hand wing leading edge, the No. 3 engine fan cowl, right hand inboard mid flap leading edge and the leading edge of the right hand stabilizer were damaged in flight. This damage could have occurred only if objects had been ejected from the front portion of the aircraft when it was still in the air. The cargo door of the front cargo compartment was also found ruptured from above. This also indicates that the explosion perhaps occurred in the forward cargo compartment causing the objects to come out and thereby damaging the components on the right hand side.

F. Evidence of Overpressurization :

The examination of the structural panels and the other parts of the forward cargo compartment and the aft cargo compartment, recovered from the sea bed, indicates that overpressure condition had occurred in both the cargo compartments. The failure of the passenger cabin floor panels in upward direction also indicates that overpressure was created in both the compartments. It cannot be disputed that whenever an explosive detonates very high pressure shockwaves are formed which travel in all directions and high speed fragments of the container, or the loose material, also move away from the source of explosion. It is, therefore, clear that there was overpressurization in the cargo compartments which resulted in such rupture of the cabin floor panels.

G. Holes in the front cargo hold panels

While the skin panels of the aft cargo compartment are fairly straight and undamaged, the panels of the front cargo compartment are ruptured and have a large number of holes. This shows that there was occurrence of an event in the front cargo compartment and not in the aft cargo compartment.

H. Buckling of Seats :

The seats towards the rear of the aircraft had only the aft legs buckled, whereas the seats towards the front had both the front and the aft legs buckled. This indicated that the whole floor was subjected to a vertical force and was more severe towards the front. Moreover, the upper deck storage cabin was found among floating wreckage. The bottom of this cabin was pushed up in the shape of a dome with no evidence of impact damage. This deformation was indicative of having been caused, possibly, as a result of a shockwave.

I. Metallurgical Examination Results :

A metallurgical examination, especially of Targets 362 and 399, clearly confirms that there was an explosion in the forward cargo compartment. Microscopy around some of the holes discloses that they have such characteristics like twinning which can be present only if the holes had been puntured due to the detonation of an explosive device.

J. CVR Tape Analysis :

The report of CVR tape analysis by Mr. S.N. Seshadri also corroborates the aforesaid evidence i.e. that there was a bomb in the forward cargo hold of the aircraft.

RECOMMENDATIONS

5.1 ICAO, IATA and the States should :-
(a) undertake an ongoing review of established aviation security standards to prevent the placement of explosive substances on board commercial aircraft;
(b) establish a programme of monitoring the implimentation of security measures in airports around the world, in cooperation with the Governments concerned. For each airport studied, it should report its findings and recomend any improvements that may be required;
(c) consider establishing a group of civil aviation experts to investigate serious breaches of security. The purpose of these investigations would be to determine the facts of an incident so that necessary measures could be developed and implemented world wide to prevent similar breaches in the future.
Note : As it may take some time for ICAO and IATA to implement these recommendations, at least those countries which have international air traffic should take up effective measures without delay.
5.2 ICAO should :-
(a) develop a model clause on security that could be used in the bilateral air agreements that govern the exchange of air traffic rights between countries;
(b) consider establishing standards for the training of security personnel.
5.3 IATA should develop practical procedures for reconciliation of interlined passengers and their baggage at intermediate airports.
5.4 Interlining of checked-in baggage should not be done if a passenger does not have a confirmed reservation on the onward carrier flight.
5.5 The baggage of interlined passengers should be matched with passengers by the onward carriers before loading the baggage on the aircraft.
5.6 Whenever a Government becomes aware of particular high risk security threat it should notify not only the airline at risk, but also all connecting airlines in order that extra precaution can be taken at potential points of introduction of interline baggage into the system.
5.7 When an Airline is aware of a high security threat it should communicate the same to the host state as well as, if possible and prudent, to the other airlines operating there.
5.8 Passenger count should be done at boarding gate and in case of 'no gate show' of a passenger, his baggage must be off-loaded.
5.9 All checked-in baggage, whether it has been screened by X-ray machine or not, should be personally matched and identified with the passengers boarding an aircraft. Any baggage which is not so identified should be off-loaded. This is advisable as examination of the baggage with the help of an X-ray machine has its own limitations and is not fool proof. Some explosives hidden in Radios, Cameras etc. may not be readily detected by such a machine. In fact an explosive not placed in a metallic container will not be detectable by an X-ray machine. Similarly, a plastic explosive can be given an innocuous shape or form so as to avoid detection by an X-Ray. Reliance on an X-Ray machine alone may in fact provide a false sense of security.
5.10 Effectiveness of the instrument known as PD-4 is highly questionable. It is not advisable to rely on it.
5.11 All unaccompanied baggage should be placed on the aircraft after their contents have been physically checked. In the alternative, it should be loaded only after it has been placed in a decompression chamber and the host state is satisfied that the baggage is clean and the shipper has been identified.
5.12 Airlines should have effective backup security equipment or procedures available in case of machanical break down of security equipment.
5.13 All hand baggage, including that of the crew, should be opened and the contents physically checked even if the said baggage has been x-rayed. This will no doubt be a bit time consuming and laborius but if security is to be meaningful, then slight inconvenience has to be endured in order to ensure a safer flight.
5.14 The manufacturers of aircraft should take effective steps for protecting sensitive parts of the aircraft from explosive damage.
5.15 Studies should be undertaken to determine the feasibility of physically separating the avionics bay and emergency oxygen systems from the cargo area in aircraft so that these sensitive and essential areas of the aircraft cannot be damaged or destroyed by a relatively small explosive

deivce concealed in luggage.
5.16 The seats should have safety belts which can act as restraint for the upper part of the body e.g. like a shoulder harness with inertial restraint.
5.17 The seats in the aircraft should be so designed so as to incorporate shock absorbing systems within the seat and they should be manufactured by using material which does not break easily.
5.18 In addition to the cockpit voice recorder, there should be in the cockpit a video/scanning camera which would record the movements and the audio sounds in the cockpit. This will not only assist in ascertaining as to how the pilots act during as emergency but, in the case of hijacking, would also assist in the identification of the hijackers.
5.19 The CVR should record all the conservation and sounds in the cockpit for the entire duration of the flight, and not merely for the last 30 minutes.
5.20 The CVR and the DFDR should be powered from two alternative sources of energy.
5.21 The oxygen for the flight crew should be supplied from two different sources i.e. in the event of an emergency the pilot and the co-pilot must don the oxygen mask and the oxygen must be supplied from different source.
5.22 Suitable provisions should be incorporated in Annex 13 which would give power to an Investigator to record evidence outside the country of investigation and also to summon witness from abroad. It should also be mandatory on the contracting States to give information sought for by an Investigator.

(B. N. KIRPAL)
February 26, 1986 COURT

We agree with the conclusions and recommendations stated above.

ASSESSORS
(V. Ramachandran) (J.S. Gharia)
(J.S. Dhillon) (J.K. Mehra)
(B.K. Bhasin)

ACKNOWLEDGEMENTS
When I was appointed as the Court to investigate into the accident, the magnitude of the task involved was known. With the help, assistance and cooperation of a team of dedicated workers, the work was, however, completed in not too long time. The assistance received from those who helped me cannot be too highly praised.

From amongst my Assessors, Captian B.K. Bhasin was the only one who was permanently stationed in Delhi. We met for the first time on 15th July, 1985 and little did I realise then that, by the time our work would be over, how much I would be depending upon him. Not only was his advice on the technical aspects of flying and air safety invaluable but, whenever any difficulty or a problem arose, I invariably turned to him for assistance and advice which I readily got. I found him having a very practical and positive approach to all the problems but, at the same time, he very rightly was not prepared to compromise on any principal issues.

The only interest Dr. V. Ramachandran appeared to have was to do his work to perfection. No praise can be too high for the manner in which this Metallurgist from landlocked Bangalore volunteered and boarded the salvage ships which were carrying out operations in the cold and choppy waters of Atlantic Ocean. He sarificed all comforts and went to sea with a view to be present on board the ships at the time when salvaged pieces of wreckage were brought on board. His deep knowledge of metallurgy greatly assisted the examination of the salvaged pieces of wreckage. In this connection the entire metallurgical examination was planned and organised by him.

Whenever any information was required concerning explosives, Mr. J.S. Gharia was ever eager and in a position to provide the information.

Mr. J.K. Mehra looked into the engineering aspect of the accident and he spent a lot of time in going through various Air-India Maintenance Manuals. He always made discussions very lively and interesting.

Captain J.S. Dhillon came out of his retirement and provided useful information to the Court on some aspects of flying.

This work would never have been satisfactorily completed without the help and assistance received

by the Court from late Mr. S.N. Seshadri of Bhabha Atomic Research Centre. From the time when the CVR was first played by him at BARC on 16 July, 1985 till the very end, he most willingly and pleasantly undertook any assignment which was given to him by the Court. It was a great national loss when he suddenly passed away on 2nd February, 1986, only a few days after he had deomonstrated his brilliance when his testimony, regarding the analysis of the CVR tape, was recorded by me in the Court.

I am also grateful to the other Scientists and staff of B.A.R.C. who rendered considerable assistance to the Court. The facilities made available by Dr. P.K. Iyengar, Director, B.A.R.C. with regard to the finalisation and completion of the report cannot be easily forgotten. In the absence of late Mr. S.N. Seshadri, with whom I had developled a personal rapport, Dr. Ashok Mohan and Mr. V.K. Chadda met with all our requirements in the finalisation and preparation of the Report. Dr. Asundi of BARC and the other Metallurgists of that Organisation and of the National Aeronautical Laboratory also spent a considerable amount of their time and energy in successfully carrying out metallurgical tests and examination of the salvaged pieces.

During the investigation I had to visit Ireland on two occasions. I immediately realised the extent of help, assistance and guidance which was being rendered to all of us by Mr. Kiran Doshi, the Indian Ambassador to Ireland. There was no problem to which he did not have a solution. On my visit to Dublin not only did I enjoy the hospitality of Kiran and his wife Razia but it also gave an opportunity to personally meet Mr. Mitchel, the Minister of Communications, and senior officials of his Ministry, and to express my gratitude to them for all the help and assistance which the Government and people of Ireland had, most willingly, rendered.

At Tokyo the Indian Ambassador and members of his staff looked after all our needs and arranged meetings with the Japanese officials whom we wanted to meet.

As representatives of the Court in Cork, Mr. P.R. Chandrasekhar and Mr. C.D. Kolhe did a commendable job. They kept me informed of the progress which was taking place at Cork and, whenever required to do so, they took vital decisions while coordinating the mapping and salvage operations.

Mr. H.S. Khola, Director of Air Safety, New Delhi willingly carried out all the directions of the Court. Special mention must also be made of Mr. Satendra Singh, Regional Controller of Air Safety, Bombay, who worked day and night when the flight recorders were first opened and the copies of the tapes made and the data analysed.

I have also to express my gratitude to the Counsel who assisted the Court in the Investigation. Without their help and cooperation, it would not have been possible to complete the work in 7-1/2 months.

On my trip to Bombay, the Staff and Management of Centaur Hotel made my stay very comfortable. It was like a home away from home. The work done during the salvage operarations by four young engineers of Air-India was highly commendable and valuable. All of them namely, Mr. Balasubramanium, Mr. L.S. Carvalho, Mr. G.D. Nayar and Mr. A.K. Sheode, worked round the clock even during adverse climatic conditions.

The Registrar of the Delhi High Court, Ms. Usha Mehra spared no efforts in rendering every assistance whenever the same was required. She ably marshalled all the resources available in the High Court in order to ensure the smooth and efficient functioning of my office. My own personal staff in particular, headed by Mr. V.P. Ahuja, Court Master and Mr. Balram Chopra, Private Secretary, as usual, rose to the occasion. While Mr. Ahuja kept complete control of hundreds of documents and affidavits which had been filed, Mr. Chopra besides bearing the brunt of the typing work, very ably supervised the work of other Stenographers.

It was most fortunate that I was able to persuade Mr. S.N. Sharma to accept the trying job of being the Secretary to the Court. His vast experience in such Investigations, he had been a Secretary in three such Investigations earlier, made my task much lighter. Moreover, as an Aircraft Engineer, he was always ready to explain technical intricacies involved in the case. Without his help I could not have completed my work within the stipulated time.

(B. N. KIRPAL)

26th February, 1986 COURT

POSITIVELY IDENTIFIED DEBRIS AIR INDIA 747 VT-EFO KANISHKA AIRCRAFT

SECTION TARGET LAT LONG DESCEIPTION 41 DOOR 192 51 03.28 12 47.74 FIRST CLASS AND COCKPIT AREA (+ UPPER DECK DOOR) 41 131 51 03.21 12 47.93 LEFT HAND UPPER DECK SLIDE MECHANISM 41 134 51 03.28 12 47.81 NOSE LANDING GEAR 41 265 51 02.37 12 44.51 LANDING GEAR DOOR (NOSE GEAR) 41 244 51 03.56 12 48.19 UPPER DECK WINDOW TRIM (REVEAL) 41 63 51 02.51 12 47.37 2 FIRST CLASS SEATS 41 77 51 02.59 12 47.83 2 FIRST CLASS SEATS 42 DOOR 193 51 03.30 12 47.85 PIECE OF FUSELAGE, WING PLUS LANDING GEAR (#2 LEFT DOOR) 42 138 51 03.37 12 47.77 SMALL PIECE OF WRECKAGE (BS 800) 42 200 51 03.347 12 47.831 Dual Heat Exchanger 42 DOOR 204 51 03.33 12 47.87 FORWARD CARGO DOOR + FLOOR 42 255 51 03.72 12 48.01 GALLEY COMPLEX (UPPER DECK) 42 232 51 03.49 12 47.92 'P93' RACK MARKED 'DANGER HIGH VOLTAGE' (BS 670) 42 327 51 01.62 12 43.03 NACA SCOOP 42 DOOR 358 51 03.39 12 47.86 MASS OF DEBRIS (#2 RIGHT DOOR) 42 361 51 03.384 12 47.848 BOX MARKED "FAN BLADES" 42 362 51 03.372 12 47.840 MASS OF DEBRIS FUSELAGE SKIN 42 383 51 03.32 12 47.81 MASS OF DEBRIS WITH UPPER DECK FLOOR 44 DOOR 137 51 03.30 12 47.80 CENTER FUSELAGE SECTION WITH #3 LEFT DOOR 6 WINDOWS AFT OF DOOR AND 13 WINDOWS FORWARD. LEFT UPPER WING SKIN AND ONE MAIL LANDING GEAR ATTACHED. 44 103 51 02.86 12 46.37 LANDING GEAR DOOR 44 105 51 02.81 12 46.04 LEFT WHEEL WELL LANDING GEAR DOOR 44 186 51 03.32 12 47.825 KEEL BEAM 44 195 51 03.32 12 47.78 WING STRUCTURE 44 224 51 03.46 12 48.49 TWO WHEELS FROM MAIN LANDING GEAR 44 239 51 03.62 12 47.38 MAIN BRAKE UNIT WITHOUT AXEL, PLUS EQUALIZING ROD 44 240 51 03.62 12 47.44 MAIN TIRE AND RIM 44 241 51 03.62 12 47.40 MAIN TIRE AND RIM PLUS AXEL 44 242 51 03.61 12 47.40 MAIN BRAKE UNIT 44 267 51 03.35 12 44.45 PART OF LANDING GEAR DOOR 44 275 51 02.13 12 44.10 BODY LANDING GEAR DOOR 44 279 51 02.30 12 44.64 MAIN LANDING GEAR DOOR 44 280 51 02.26 12 44.61 SECTION OF MAIN LANDING GEAR DOOR 44 343 51 03.285 12 47.809 MAIN LANDING GEAR DOOR 59 51 02.57 12 45.73 SECTION OF LANDING GEAR 44 218 51 03.41 12 47.86 STEP WELL AREA (STA 1250-1480)
46 6 51 02.79 12 49.44 SMALL MOTOR 10" x 8" (FAN) 46 7 51 02.90 12 49.92 LOWER SKIN OF CARGO AREA 4' x8' (BS 1480)) 46 #11 51 02.04 12 45.44 PIECE OF OUTER SKIN BODY STATION #1760 PART NO. 65B04325-403 46 25 51 02.21 12 46.27 BODY FRAME (BS 1660-1680) 46 26 51 02.20 12 46.72 CABIN SECTION WITH 4 WINDOWS (ABOVE 'T' IN REG No.) 46 28 51 02.31 12 47.02 SKIN PANEL 1460-1800 46 33 51 02.49 12 48.28 AFT FUSELAGE SKIN PANEL 'YOUR PALACE IN THE SKY' (AFT OF #5 DOOR) 46 34 51 02.49 12 48.29 RIGHT HAND FUSELAGE SKIN PANEL AT DOOR #5 46 DOOR 40 51 02.47 12 47.41 CARGO DOORS C2, C3 46 47 51 02.39 12 46.61 REAR CARGO FLOOR 46 50 51 02.38 12 46.60 CARGO FLOOR (STA 1500) 46 DOOR 74 51 02.49 12 47.71 FIVE FRAMES AND DOOR-PORT SIDE AFT (#5 LEFT DOOR) 46 78 51 02.52 12 47.95 FRAME SECTION (SHEAR WEB STA 2000-2020) 46 87 51 02.58 12 48.43 BUILT UP STRUCTURE (STA 2412) 46 DOOR 97 51 02.52 12 47.38 FUSELAGE SKIN SECTION WINDOW BELT AREA WITH DOOR FOLDED UNDER FRAME 46 DOOR 101 51 02.84 12 47.14 5 WINDOWS AND DOOR (#4 RIGHT DOOR) 46 292 51 01.81 12 44.24 FRAME (STA 2240) 46 321 51 02.39 12 46.61 '4R' DOOR ENTRANCE WITH NO DOOR AND 10 WINDOWS (BS 1700) 320 51 01.84 12 44.59 FUSELAGE BOTTOM SKIN NEAR OUTFLOW VALUE 46 336 51 01.34 12 42.03 BULK CARGO COMPARTMENT FLOOR AND STRUCTURE 46 369 51 02.17 12 46.20 FUSELAGE PANEL SECTION, 4 WINDOWS 48 31 51 02.37 12 48.43 HORIZONTAL STAB 48 37 51 02.47 12 47.99 VERTICAL TAIL FIN (+ PRESSURE BULKHEAD SECTION) 48 35 51 02.50 12 48.08 AFT PRESSURE BULKHEAD (25%) 48 22 51 02.19 12 45.68 ELECTRICAL PANEL (RUDDER RATIO JUNCTION BOX) 48 27 51 02.20 12 46.83 APU HOUSING 48 66 51 02.59 12 47.54 BODY FRAME (BS 25XX) 48 67 51 02.55 12 47.50 FUSELAGE SKIN (3 FRAMES FORWARD OF APU BS 2638) 48 68 51 02.57 12 47.55 FUSELAGE SECTION (BS 2598) 48 73 51 02.51 12 47.70 PART OF PRESSURE BULKHEAD 48 75 51 02.47 12 47.63 FRAME FOR

OVERHEAD LUGGAGE COMPARTMENT (ROW 46 F-G) 48 88 51 02.90 12 48.84 CONTROL LINKAGE FROM TAIL OF AIRCRAFT (ELEVATOR CONTROL QUADRANT) 48 99 51 02.71 12 47.92 FUSELAGE SKIN SECTION (BS 2598) 48 296 51 02.03 12 43.17 PART OF PRESSURE BULKHEAD 48 314 51 01.84 12 44.19 APU AIR DUCT 48 371 51 02.51 12 48.28 AFT FUSELAGE SKIN 10'x15' (HORIZ. STAB CUTOUT)
SECTION TARGET LAT LONG ENGINES 7.13 108 51 02.97 12 47.12 AIRCRAFT ENGINE (WITH STRUT) 149 51 03.26 12 47.38 ENGINE AND STRUT 154 51 03.32 12 47.75 ENGINE SECTION (5th ENGINE) 171 51 03.16 12 47.16 TURBINE SECTION OF ENGINE (POSSIBLY COMPLETE ENGINE) 235 51 03.63 12 47.07 AIRCRAFT ENGINE ENGINE PARTS 106 51 02.98 12 46.41 ENGINE COWLING (INLET) MARKED 'A124' (5th ENGINE) 109 51 02.97 12 47.11 STARTER FOR AIRCRAFT ENGINE 111 51 03.02 12 47.20 ENGINE COWL 116 51 02.99 12 47.80 ENGINE DEVICE 124 51 02.85 12 48.47 FIFTH ENG CENTER DOME 150 51 03.25 12 47.36 PART OF ENGINE 151 51 03.29 12 47.42 SMALL PART OF ENGINE 152 51 03.31 12 47.44 LOWER PORTION OF ENGINE 153 51 03.31 12 47.44 LOWER ENGINE COWLING 155 51 03.32 12 47.44 FAN INNER EXIT AREA 156 51 03.32 12 47.43 PART OF ENGINE 158 51 03.23 12 47.35 PART OF ENGINE COWLING 159 51 03.25 12 47.29 ENGINE COWLING 161 51 03.26 12 47.29 PORTION OF ENGINE COWL 165 51 03.20 12 47.21 THRUST REVERSER SLEEVE 166 51 03.20 12 47.21 UNIDENTIFIED ENGINE PARTS 167 51 03.21 12 47.24 UNIDENTIFIED ENGINE PARTS 168 51 03.20 12 47.22 UNIDENTIFIED ENGINE PART 169 51 03.18 12 47.20 UNIDENTIFIED ENGINE PARTS 170 51 03.19 12 47.19 PART OF DIAPHRAM (OIL COOLER) 172 51 03.25 12 47.21 ENGINE EXHAUST CONE 173 51 03.27 12 47.38 ENGINE EXHAUST CONE AND EXHAUST 237 51 03.690 12 47.10 ENGINE PARTS CASE 238 51 03.72 12 47.10 ENGINE INLET COWL 206 51 03.34 12 47.50 SECTION OF ENGINE EXHAUST STAGE #7 207 51 03.35 12 47.49 ENGINE HOT SECTION AREA 208 51 03.37 12 47.51 ENGINE TAIL CONE 214 51 03.19 12 47.36 CASCADE VANE
STRUTS 7.12 4 51 02.87 12 49.05 #3 ENGINE NACELLE STRUT 157 51 03.23 12 47.36 STRUT (SIMILAR TO 149) 110 51 03.15 12 47.16 NACELLE STRUT WING PARTS 17 120 51 03.01 12 47.98 OUTBOARD AILERON (50%) 16 135 51 03.28 12 47.81 TRAILING EDGE FLAP AND DRAG JACK 16 136 51 03.31 12 47.81 TRAILING EDGE FLAP JACK SKREW 12 140 51 03.35 12 47.83 LEADING EDGE SECTION OF WING 14 145 51 03.34 12 47.85 WING LEADING EDGE VARIABLE CAMBER FLAP 16 177 51 03.34 12 47.91 TRAILING EDGE FLAP 12 181 51 03.38 12 47.87 LOWER CARGO COMPARTMENT AND WING LOWER SKIN 16 183 51 03.38 12 47.87 SECTION OF FLAP SKIN 16 188 51 03.33 12 47.81 TRAILING EDGE FLAP WITH JACK SKREW 16 189 51 03.32 12 47.80 TRAILING EDGE FLAP WITH SKREW JACK 16 191 51 03.32 12 47.78 FLAP ACTUATOR AND FLAP TRACK 16 194 51 03.32 12 47.77 TRAILING EDGE OF FORE FLAP 16 253 51 03.32 12 47.86 PIECE OF TRAILING EDGE FLAP 16 254 51 03.40 12 47.86 PIECE OF TRAILING EDGE FLAP 16 264 51 02.47 12 44.74 TRAILING EDGE FLAP FAIRING 16 277 51 02.18 12 44.40 WING FLAP 16 344 51 03.294 12 47.802 TRAILING EDGE FLAP AND FLAP TRACK 16 384 51 03.33 12 47.80 T/E FLAP TAPER AND DRIVE SHAFT 16 398 51 03.325 12 47.85 PIECE OF TE MID FLAP 15 190 51 03.32 12 47.79 SPOILER ACTUATOR 14 187 51 03.34 12 47.81 LEADING EDGE FLAP SECTION 14 387 51 03.33 12 47.853 PIECE OF L/E FLAP MECHANISM
12 54 51 02.38 12 45.86 LE FROM WING 12 202 51 03.33 12 47.86 WING LOWER SKIN 12 221 51 03.39 12 47.89 UPPER EDGE LEFT WING 12 225 51 03.38 12 48.78 SMALL PIECE OF WING LEADING EDGE PANEL 12 222 51 03.38 12 47.94 WING FILLER & WING PARTS 12 243 51 03.59 12 47.85 PIECE OF LEADING EDGE FLAP 12 252 51 03.38 12 47.84 LOWER WING SECTION 12 262 51 03.85 12 46.92 MID LOWER WING SKIN, ONE AFT FLAP TRACK WITH JACK SKREW 12 266 51 02.36 12 44.46 LANDING GEAR DOOR 12 297 51 01.91 12 43.18 PART OF WING TIP 12 345 51 03.28 12 47.842 'REAR WING SPAR' 12 365 51 03.338 12 47.842 REAR SPAR RIB WITH SPOILER ACTUATOR 12 379 51 03.315 12 47.785 WING REAR SPAR AND SPOILER STA 1150 12 381 51 03.40

12 47.88 LE OF WING SECTION 12 182 51 03.38 12 47.87 POSSIBLE REAR SPAR, (WING STA 802 I.D. ON PART) 17 274 51 02.19 12 43.57 LEFT INBOARD AILERON