

Department of Trade

ACCIDENTS INVESTIGATION BRANCH

Turkish Airlines DC-10 TC-JAV
Report on the accident in the
Ermenonville Forest, France
on 3 March 1974

Translation of the report published by the
French Secretariat of State for Transport.

No Appendices were published.

LONDON
HER MAJESTY'S STATIONERY OFFICE

SECRETARIAT OF STATE FOR TRANSPORT

COMMISSION OF INQUIRY

**ACCIDENT TO
TURKISH AIRLINES DC-10 TC-JAV
IN THE ERMENONVILLE FOREST
ON 3 MARCH 1974**

FINAL REPORT

Translation of the Report published by the
French Secretariat of State for Transport.

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February 1976

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Accident Details

Date and time of accident

Sunday, 3 March 1974
shortly before 1142 hrs GMT (*)

Aircraft

McDonnell Douglas DC-10-10
TC-JAV

Location of the wreckage

Ermenonville Forest (State owned)
at the place called 'Bosquet de Dammartin',
commune of Fontaine-Chaalis (Oise)

Mean elevation: 105 metres

Geographical co-ordinates:
49°08'30"N 02°38'00"E

Owner and operator

Turkish Airlines:
'TURK HAVA YOLLARI (THY)'

Type of operation

Public transport of passengers

Flight TK 981
Istanbul-Orly-London

Persons on board

Aircraft Commander: NEJAT
BERKOZ

11 crew members
334 passengers

Summary of accident

After a stop at Orly and a delay to its schedule because of the last minute embarkation of numerous passengers, TC-JAV took off for London at 1132 hrs.

Shortly after 1140 hrs, when the aircraft had reached 12,000 feet during climb, the Air Traffic Control recorded a transmission in the Turkish language, partly covered by heavy background noise and accompanied by the pressurization warning and then the overspeed warning; at the same time the aircraft radar return split in two and the secondary radar label disappeared.

Some seventy seconds later, the DC-10, flying at high speed and with a slight angle of descent, struck the treetops and disintegrated in the forest.

Consequences

Persons	Aircraft	Cargo	Third Party
Killed: 346	Wrecked	Destroyed	Substantial damage to State forest land

(*) All times in this Report are given in GMT. One hour should be added for French local time.

2 Composition of the Commission of Inquiry and Summary of the work

2.1 Commission of Inquiry

By Arrêté of 4 March 1974, the Minister for Transport appointed the following Commission of Inquiry:

<i>M. René Lemaire,</i>	Head of the Inspectorate of Civil Aviation	President
<i>M. Jean Forestier,</i>	Ingénieur Général de l'Armement	Vice-President
<i>M. Robert Mignard,</i>	Inspector Pilot of the Organisme du Contrôle en Vol (Flight Inspectorate)	
<i>M. Paul Guillevic,</i>	Ingénieur en Chef de l'Aviation Civile	
<i>M. Michel Vigier,</i>	Ingénieur, Accidents Investigation Bureau	
<i>Docteur Lavernhe,</i>	Member of the Civil Aviation Medical Council	

The Commission's mandate was to study the circumstances, investigate the causes and draw the appropriate conclusions and lessons from the accident which occurred on 3 March 1974 in the forest of Ermenonville to a DC-10 aircraft, registration TC-JAV, of Turkish Airlines.

In accordance with the provisions of Annex 13 to the Convention on International Civil Aviation, accredited representatives of the State of Registry and the State of Manufacture, assisted by technical advisers, took part in the work of the Commission. In addition, British and Japanese accredited observers were authorised to follow the course of the investigations, because the passengers included a large number of British and Japanese nationals.

Finally, in addition to the experts of the French Accidents Investigation Bureau, the Commission of Inquiry was assisted by numerous French experts (Centre d'Essais des Propulseurs de Saclay, Centre d'Essais en Vol de Brétigny, U.T.A. airline) and foreign experts (Turkish Government, Turkish Airlines, National Transportation Safety Board (NTSB), Federal Aviation Agency (FAA), McDonnell Dougal, Swiss Federal authorities, Swissair technical workshops and a sabotage expert of the United Kingdom Accidents Investigation Branch).

2.2 Summary of the work

Two days after the accident and after examination not only of the accident site but also of parts of the aircraft structure which were the first to become detached from the aircraft and were found 15 km further back below the aircraft's flight path, the President of the Commission decided to set up working groups whose members included various French and foreign participants in the Inquiry.

The work of these groups was concerned in particular with the following:

- Study of the main wreckage and its principal components, establishment of the wreckage trail, transfer of the wreckage to a hangar or laboratory for additional examination (servo controls) and examination of the documentation relating to the aircraft

maintenance and its airworthiness after the loss of the aft cargo door on the left-hand side.

- All the information on the basis of which the history of the flight could be reconstructed (particulars of the stop made by TC-JAV, operations on departure and progress of the flight) and, in particular, the play-back and transcript of the air/ground communications and the cockpit voice recording and also study of the radar films and the flight path so defined.
- Analysis of the data provided by the flight data recorder which was first read out in the USA in co-operation with the French experts.
- Study of the wreckage found below the aircraft's flight path, 15 km further back from the accident site, in particular the wreckage of the aft cargo door on the left-hand side and its component parts, the documentation regarding its design, functioning and maintenance and its handling on the aircraft's departure from Orly. These studies included various expert examinations in France and Switzerland and were facilitated by the loan and despatch to France of a new door having the same characteristics. The group engaged on this work also studied the circumstances of a previous accident to an aircraft of the same type, at Windsor (Ontario) on 12 June 1972, with which there were certain analogies.
- Examination of the bodies of the victims and the rescue operations.

The reports submitted by the above groups and the results of their work were examined during the plenary sessions of the Commission of Inquiry which held its final meeting on 6 November 1975.

3 Investigation

3.1 History of the flight

On Sunday 3 March 1974, DC-10--10, registration TC-JAV, landed at Orly at 1002 hrs, as scheduled for flight TK 981 Istanbul-Paris-London on which it was engaged.

On landing there were 167 passengers on board, of whom 50 disembarked at Paris.

The aircraft was parked on stand A2 of the west satellite of Orly-Sud air terminal, where it was taken over by THY station staff and personnel of the airport services.

As regards the security of the TC-JAV parking stand, there was a gendarme stationed at a fixed point and surveillance by a mobile patrol of three men.

The refuelling operations entailed the supply of 10,350 litres of Jet A1 fuel.

In addition to the airline personnel, Paris Airport staff concerned with flight preparation and traffic operations, baggage and cargo handling, technical operations (apron starter unit, aircraft towing) and aircraft cabin cleaning were involved with the aircraft.

The normal stop is for 1 hour but was increased to 1 hour and 30 minutes because of the last minute embarkation of numerous passengers from British Airways and Air France. These fresh passengers numbered 216 and embarked after passing through the routine police checks.

During the stop electrical power was provided by the auxiliary power unit from 1000 hrs until the engines were started (the apron starter unit initially arranged for was not used). The door of the aft cargo compartment on the left-hand side was closed at about 1035 hrs.

A radio car of the Air Transport Gendarmerie escorted the aircraft from the stand to the take-off runway threshold.

The sequence of events entailed by the departure procedure included the following, according to the times of the air/ground communications:

- 111130 hrs: first contact with Orly-Prévol for departure operations.
- 112400 hrs: clearance by Orly-Sol to taxi to runway 08.
- 112840 hrs: clearance by Orly-Airport to line up on the take-off runway — departure route 18¹ — initial climb to flight level 40.

¹ *Departure route 18 assigned to the aircraft included the following points: Tournan intersection, Coulommiers and Montdidier.*

The meteorological conditions were good:

- Wind: 060°/10 kt
- Cloud: 2/8 Cumulus at 900 m
- QNH: 1016.2 mb
- QFE: 1004.4 mb
- Temperature: 6.2°C

The aircraft took off at approximately 113030 hrs. The flight then proceeded as follows:

- 113300 hrs: Orly-Départ cleared the aircraft for flight level 60.
- 113400 hrs: TC-JAV reported at flight level 60 at which it was subsequently transferred to the North Area Control Centre.
- 113610 hrs: After contact was made with the Area Control, TC-JAV was cleared to climb to flight level 230.
- 113635 hrs: The Control asked the aircraft to turn to the left to Montdidier.
- 113700 hrs: Flight level 70 was reached.

The read-out of the flight data recorder shows that, in accordance with the THY operating rules, the climb was probably carried out in the automatic mode of the flight control system. The end of the turn to Montdidier and stabilization on a heading of 345° occurred at about 1138 hrs, flight level 90 was reached and the CAS was of the order of 300 knots.

Three or four seconds before 114000 hrs, the noise of decompression can be heard on the cockpit voice recording, the co-pilot said: 'the fuselage has burst' and the pressurization aural warning sounded.

- 114013 hrs: The controller who was following the progress of flight TK 981 heard a confused transmission, a heavy background noise mingled with words in the Turkish language and the pressurization warning and then the overspeed warning.

At the same time as the overspeed warning signal was heard, the label with the flight number '981' disappeared from the secondary radar scope. Flight level '130' remained on the scope for a few moments. On the primary radar the aircraft echo split in two: one part (which may correspond to the parts ejected from the aircraft) remained stationary at about 24 NM on a bearing of 045° from Orly and persisted for two or three minutes; the second part, the echo of the DC-10 itself, continued on a path which curved to the left from heading 350° to heading 280°.

- 114041 hrs: The confused transmission ceased to be received by the Control.

- 114104 hrs: A fresh very short transmission was recorded on the ground.
- 114106/07 hrs: A final transmission was heard and continued until 114113 hrs.

From 114150 hrs, the controller made repeated calls to TK 981 but received no reply.

The various recordings (air/ground communications, cockpit voice recorder, flight data recorder) show that about 77 seconds elapsed between the time of decompression and the impact with the ground.

The flight data recorder shows that, in the seconds immediately after depressurization, the speed of No 2 engine dropped sharply and the aircraft turned to the left (9°) and went into a nose-down attitude. This nose-down attitude increased rapidly (down to -20°) and the speed increased (360 knots) although Nos 1 and 3 engines had been throttled back. The pitch attitude then decreased progressively to -4° and the speed became steady around 430 knots (800 km/hr).

TC-JAV crashed in the forest of Ermenonville at the place known as 'Bosquet de Dammartin', in the commune of Fontaine-Chaalis (Oise), about 15 km from the village of Saint-Pathus over which initial decompression and the initial loss of parts of the aircraft occurred. There was no fire.

At the accident site, 37 km NE of Paris, the aircraft was flying at high speed, 430 knots (about 800 km/hr). It was banked to the left by about 17° and the angle of descent was of the order of 4°.

The aircraft cut through the forest from east to west and caused damage over a rectangular area of 700 m by 100 m.

There were no survivors from among the aircraft occupants.

No call was heard on the distress frequency (121.5 MHz).

3.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	12	334 ¹	—
Non-fatal	—	—	—
None	—	—	—

¹ Including 6 passengers ejected from the aircraft over Saint-Pathus about 15 km from the main point of impact

3.3 Damage to aircraft

After the ejection of the aft cargo door on the left-hand side and of various parts of the aircraft structure (floor, seats), the aircraft literally disintegrated on the subsequent impact at very high speed in the forest.

3.4 Other damage

The Senlis Waterways and Forestry Service has made the following assessment of the damage on the ground:

The damaged area covered 6.55 hectares made up as follows:

- 0.70 hectare: Scotch pines, 20 to 30 years old;
- 5.85 hectares: Scotch and maritime pines, 50 to 70 years old.

The damage is estimated at more than 220,000 Francs.

3.5 Crew information

THY is required to operate the DC-10-10 with the following crew members:

2 pilots, 1 flight engineer and 8 or 10 cabin staff.

(In cases where there is no ground engineer permanently stationed at the airport of destination, an additional engineer is carried by the aircraft in order to perform the ground engineer duties)

3.5.1 *Flight crew*

- **Aircraft Commander:** Mr Nejat Berkoz (Turkish nationality)

Age: 44

Condition: married, two children

Address: 4. Kisim T/O Blok No 32/1 Atakoy, Istanbul, Turkey.

- **Certificates and licences**

THY A.O. Air Transport Pilot Licence: F-27, 14. 10. 67; DC-9, 7. 6. 68;
DC-10, 8. 3. 73.

Transportation Pilot Licence No 294.

Validity of the licence: Medical fitness 20. 8. 74. Flight check: 8. 3. 74.

- **Flight time:**

Grand total: 7,003 hours 10 minutes including 1,392 hours 10 minutes at night.

In the type of aircraft to which the accident occurred: 438 hours 15 minutes.

During the two months preceding the accident: 25 hours 25 minutes.

During the 48 hours preceding the accident: 3 hours 50 minutes.

- **Aviation career**

After transfer from the Turkish Air Force to THY, Mr Nejat Berkoz piloted the following aircraft: F-27 DC-9 and DC-10.

— DC-10 training:

- (1) 24 hours training on the DC-10-10 simulator at the Douglas Factory Training Centre at Los Angeles, California (24. 1. 73 to 29. 1. 73).
- (2) Flying training in Turkey: 5 hours (5. 3. 73 to 8. 3. 73).
- (3) Line check in DC-10: 4 hours 30 minutes on 26. 4. 73; 7 hours 30 minutes on 29. 4. 73.
- (4) Advanced training: 8 hours on the simulator with United Airlines at Denver, Colorado, USA (18. 9. 73 to 19. 9. 73).

— Previous accidents:

None

— Co-Captain: Mr Oral Ulusman (Turkish nationality)

Age: 38

Condition: married

Address: 3 Blok Kat. 1 Daire. 5, Mërter, Istanbul, Turkey

— Certificates and licences:

THY A.O. Air Transport Licence: F-27, 23. 3. 68; DC-9, 5. 1. 69; DC-10, 8. 3. 73.

Transportation Pilot Licence No 315

Validity: Medical fitness: 17. 4. 74. Flight check: 8. 3. 74.

Turkish Air Force Brevet: 30. 8. 57.

— Flight time:

Grand total: 5,589 hours 25 minutes including 1,425 hours 10 minutes at night.

In the type of aircraft to which the accident occurred: 628 hours 5 minutes.

During the two months preceding the accident: 73 hours 45 minutes.

During the 48 hours preceding the accident: 3 hours 50 minutes.

— Aviation career:

After transfer from the Turkish Air Force to THY, Mr Oral Ulusman piloted the following aircraft: F-27, DC-9 and DC-10.

— DC-10 training:

- (1) 30 hours training on the DC-10-10 simulator at the Douglas Factory Training Centre, Los Angeles, California (24. 1. 73 to 2. 2. 73).
- (2) 5 hours 25 minutes flying training in the DC-10-10 in Turkey.

- (3) Line check:
 - 7 hours 30 minutes on 28. 4. 73.
 - 6 hours 30 minutes on 14. 5. 73.
 - 3 hours 30 minutes on 11. 1. 74.

- (4) Advanced training: 8 hours simulator training with United Airlines at Denver, Colorado, USA (12. 7. 73 to 13. 7. 73).

— Previous accidents

None.

— Flight Engineer: Mr Erhan Ozer (Turkish nationality)

Age: 37

Condition: married, three children

Address: Sipahioglu Cad. No 12 Kat 2, Yesilyurt, Istanbul, Turkey

— Certificates and licences:

THY A.O. Flight Engineer Licence issued on 8. 3. 73.

Validity: medical fitness: 18. 7. 74. Flight check: 14. 10. 74.

Turkish Air Force Brevet dated 30. 8. 57.

— Flight time:

Grand total: 2,113 hours 25 minutes including 350 hours at night.

In the type of aircraft to which the accident occurred: 775 hours 50 minutes.

During the two months preceding the accident: 119 hours 5 minutes.

During the 48 hours preceding the accident: 3 hours 50 minutes.

— Aviation career:

DC-10 training:

- (1) 25 hours 35 minutes simulator training at the Douglas Factory Training Centre at Los Angeles, California (24. 1. 73 to 29. 1. 73).

- (2) 10 hours DC-10-10 flying training in Turkey (5. 3. 73 to 9. 3. 73).

- (3) Line check:

- 4 hours 30 minutes on 25. 3. 73.

- 4 hours 10 minutes on 23. 9. 73.

- (4) Advanced training: 8 hours on simulator training with United Airlines at Denver, Colorado (14. 10. 73 to 15. 10. 73).

— Previous accidents

None.

- Aircraft Ground Engineer flying in the aircraft: Mr Engin Uçok (Turkish nationality)
Age: 45
Condition: married, 3 children
Address: Iskender Pasa Mah. Deynekli Sok 3/3, Fatih, Istanbul, Turkey.
- Certificates and licences:
Second Class Aircraft Maintenance (Mechanic) Licence No 185 issued on 19. 10. 67.
- Aviation career:
Mr Uçok was an aircraft ground engineer employed by THY Technical Management as an aircraft maintenance technician.

On 3 March 1974 the THY engineer permanently stationed at Paris was at Istanbul on a technical course. Mr Uçok had been taken on board TC-JAV as his replacement.

According to the THY company his duties were as follows: to supervise loading and unloading, transit maintenance and the supply of jet fuel.

3.5.2 Cabin personnel

- Chief Steward: Mr Hayri Tezcan (Turkish nationality)
Age: 30. Married, 1 child.
Certificates and licences:
THY A.O. Steward Licence issued on 20. 1. 68.

Flight time:
Grand total: 4,916 hours.

In the type of aircraft to which the accident occurred: 569 hours 30 minutes.
- Stewardess: Miss Gulay Sonmez (Turkish nationality)
Age: 21. Spinster.
Certificates and licences
THY A.O. Stewardess Licence issued on 18. 8. 71.

Flight time:
Grand total: 1,901 hours 30 minutes.

In the type of aircraft to which the accident occurred: 439 hours 25 minutes.
- Stewardess: Miss Nilgun Yilmazer (Turkish nationality)
Age: 23. Spinster.

Certificates and licences:

THY. A.O. Stewardess Licence issued on 11. 5. 72.

Flight time:

Grand total: 1,029 hours 55 minutes.

In the type of aircraft to which the accident occurred: 90 hours.

- **Stewardess:** Miss Sibel Zahin (Turkish nationality)

Age: 22. Spinster.

Certificates and licences:

THY A.O. Stewardess Licence issued on 11. 5. 72.

Flight time:

Grand total: 1,262 hours 15 minutes.

In the type of aircraft to which the accident occurred: 494 hours 50 minutes.

- **Stewardess:** Miss Semra Hidir (Turkish nationality)

Age: 20. Spinster.

Certificates and licences:

THY A.O. Stewardess Licence issued on 2. 4. 73.

Flight time:

Grand total: 741 hours 45 minutes.

In the type of aircraft to which the accident occurred: 74 hours 50 minutes.

- **Stewardess:** Miss Fatma Barka (Turkish nationality)

Age: 25. Spinster.

Certificates and licences:

THY. A.O. Stewardess Licence issued on 8. 11. 71.

Flight time:

Grand total: 1,465 hours 50 minutes.

In the type of aircraft to which the accident occurred: 297 hours 40 minutes.

- **Stewardess:** Miss Rona Altinay (Turkish nationality)

Age: 29. Spinster.

Certificates and licences:

THY A.O. Stewardess Licence issued on 11. 1. 67.

Flight time:

Grand total: 4,456 hours.

In the type of aircraft to which the accident occurred: 387 hours 15 minutes.

- **Stewardess:** Miss Ayse Birgili (Turkish nationality)

Age: 22. Spinster.

Certificates and licences:

THY A.O. Stewardess Licence issued on 1. 9. 71.

Flight time:

Grand total: 1,723 hours 15 minutes.

In the type of aircraft to which the accident occurred: 139 hours 5 minutes.

3.6 Aircraft information

3.6.1 Airframe

- **Owner and operator**

Turk Hava Yollari A.O. (Turkish Airlines Inc)

Address: Cumhuriyet Caddesi No 199-201, Sicli, Istanbul, Turkey.

- **Constructor**

McDonnell Douglas Corporation

- Type: DC-10-10

- Maker's Serial No: 46,704

- Date of first flight: 27. 2. 72

- Delivery date: 10. 12. 72.

- **Registration: TC-JAV**

- Certificate of Airworthiness and Certificate of Registration (combined in Turkey in the same document): No 342 dated 20. 12. 72 and valid (Certificate of Airworthiness) until 3. 12. 74.

- Last inspection at Istanbul: 21. 1. 74 (Inspection 5c-4)

- Pre-flight check carried out by Mr Sabri Bayraktar, Inspector (Istanbul).

- Total flying time: since manufacture: 2,955 hours 52 minutes (in the aircraft log book);

since the last periodic check: 'C' Check: 81 hours 34 minutes

'D' Check: 487 hours 17 minutes.

- **Previous accidents:** none.

3.6.2 *Engines*

Constructor: General Electric Company

Type and power: CF6-6D

Maximum take-off thrust: 18,144 kg

Airframe position (from left to right)	1	2	3
Maker's serial number	451 - 215	451 - 200	451 - 267
Total operating time	2,358 hours 1 minute including 1,983 hours 15 minutes in DC-10 TC-JAU	2,955 hours 52 minutes	2,195 hours 51 minutes including 1,497 hours 40 minutes in DC-10 TC-JAY
Since last general overhaul	374 hours 46 minutes		698 hours 11 minutes

3.6.3 *Equipment*

— **Flight instruments and systems:**

The comprehensive equipment complied with the standards required for public transport aircraft. The aircraft was equipped with an automatic flight control system (A.F.C.)

— **Communications and radio navigation**

(The aircraft radio installation certificate was destroyed in the accident.)

DC-10 TC-JAV carried the following equipment:

- 2 x Collins 618-2 D VHF COMM transmitter/receivers
- 1 x Collins 51-Y-4 ADF receiver
- 1 x Bendix MKA-28 C Marker receiver
- 1 x Bendix RDR — 1 F Weather radar
- 2 x Bendix PPI — 1 L Weather radar indicators
- 2 x Bendix ALA — 51 A Radio altimeters
- 2 x Bendix INA — 51 A Radio altimeter indicators
- 2 x Bendix RVA — 33 A VOR receivers
- 2 x Collins ILS — 70 ILS receivers
- 2 x Collins 860 — E 3 DME interrogators
- 2 x Collins 621 — A 6 ATC transponders

THY aircraft at Orly use Paris Airport services for what are known as the 'Traffic' operations which include the preparation of the load and trim sheets and the passenger manifests.

Weight

The initial Load Sheet was supplemented at the very last minute by the addition of 20 passengers.

The part of the Load Sheet at the bottom left-hand side of the printed form was not changed accordingly. It shows a total passenger weight of 23,170 kg and a take-off weight of 161,628 kg.

Passengers

The 'Passengers' item on the Load Sheet shows an entry of 306 adult passengers (male: 56 + 193; female: 57;) 6 children and 1 infant.

The corresponding load of 23,170 kg was calculated as follows:

306 adult passengers	x 75 kg	= 22,950
06 children	x 35	= 210
01 infant	x 10	= 010
		<hr/>
		23,170

The 'Last Minute Changes' item shows 20 additional passengers and a corresponding weight of 1,480 kg, ie a total of 333 passengers (326 adult passengers, 6 children and 1 infant) and a corresponding load of 24,650 kg.

The distribution of these last minute 20 passengers among the passenger compartments was not shown on the Balance Sheet.

In view of the item 'Last Minute Changes', the crew could have calculated the actual take-off weight to be 163,108 kg, as a result of the addition of the 20 extra passengers (1,480 kg).

The fact that the relevant take-off speeds used by the pilot were higher than those corresponding to the weight initially calculated, gives reason to suppose that the increase in the load was evaluated by the crew of TC-JAV.

Limitations applicable to DC-10-10 TC-JAV:

- Maximum take-off weight: 195,000 kg
- Maximum landing weight: 164,890 kg
- Maximum zero fuel weight: 151,950 kg.

On the day of the flight, the maximum take-off weight permitted under the limitations (landing limitation) was 172,600 kg (164,890 kg + estimated fuel consumption of 7,710 kg = 172,600 kg).

The actual take-off weight of 163,178 kg was within the required limitation for the flight in question.

In considering whether the centre of gravity position of TC-JAV for flight TK 981 was within the appropriate limits, a judgement can be formed on the basis of:

- the Flight Manual, section 1, page 4-1 (approved by the F.A.A.);
- the THY Balance Sheet used by the traffic staff.

For the planned and the actual zero fuel weights of 135,318 kg and 136,798 kg respectively, the Manual prescribes a forward limit of 8% M.A.C.

The centre of gravity envelope is established in the Manual on the assumption of complete and accurate knowledge of the loads as regards both weight and location in the aircraft. The centre of gravity diagram established on the basis of a calculation for possible errors is more stringent and fixed the forward limit at 10.2% M.A.C.

The 11.3% position calculated for TC-JAV was therefore within the limits referred to above.

In the same way, the centre of gravity position for the take-off weight was 16.7%; it was therefore within the limit of 12.6% fixed by the Flight Manual.

Freight and baggage

In order to distribute the load among the three cargo compartments of the DC-10-10, the traffic officers had to take into account the following considerations:

- The forward cargo compartment had been loaded at Istanbul with 2,896 kg of freight and baggage destined for London.
- The four containers loaded with 1,525 kg of baggage at Orly could be placed only in the central or forward compartments as the aft cargo compartment was kept for bulk cargo. There was no freight of this type for flight TK 981 on departure from Orly on 3 March. The four containers with 1,525 kg of baggage were placed in the central compartment.

During the short stop at Orly, there was no reason connected with the centre of gravity position to transfer to the central compartment the containers loaded into the forward compartment at Istanbul.

Passengers

The planned distribution of passengers among the three cabin compartments at the time of completion of the Load and Trim Sheet was as follows:

- | | | |
|---------------------------|-----------------------------|-----|
| - compartment 1 (forward) | (capacity: 86 passengers): | 76 |
| - compartment 2 | (capacity: 108 passengers): | 98 |
| - compartment 3 (rear) | (capacity: 151 passengers): | 140 |

ie a total of 314 passengers as shown on the diagram on the right-hand side of the form used.

Hypotheses regarding the variation in the calculated position of the centre of gravity, as a function of:

- the presence of the last minute passengers;
- the fuel consumption between the time of take-off and the time when failure of the airframe occurred;
- the loss of persons and parts of the aircraft during flight.

Number of passengers on board: 332 adults and children + 1 infant.

Passengers shown on the centre of gravity diagram: 314*.

Passengers regarded as a causal factor in a possible change in the centre of gravity position: 18 (excluding 1 infant).

Recapitulation

Forward centre of gravity limit for zero fuel weight

- FAA Approved Airplane Flight Manual: 8% M.A.C.
- Centre of gravity diagram: 10% M.A.C.

Forward centre of gravity limit for weight with fuel on board

- FAA Approved Airplane Flight Manual: 12% M.A.C.

First possibility (less favourable): The 18 passengers were distributed between compartments 1 and 2:

Compartment 1: 86 passengers (+ 10)
Compartment 2: 106 passengers (+ 8)
Compartment 3: 140 passengers (no change).

Fuel consumption estimated at 2,060 kg, corresponding to about 24,000 kg of fuel on board at the time of depressurization.

- Centre of gravity position for zero fuel: 9% M.A.C.
- Centre of gravity position (on depressurization): 15% M.A.C.
- Centre of gravity position after the loss in flight of passengers and aircraft structure (about 500 kg) 14% M.A.C.

* The weight and centre of gravity sections of the Load and Trim Sheet showed a difference of 1 person on board (313 and 314 passengers). The figure of 313 has been taken in the present discussion of possibilities. The fact that there was subsequently found to be one more passenger does not entail any change in the following data.

For the zero fuel weight:

- centre of gravity position within the forward limit according to the Flight Manual
- centre of gravity position outside the forward limit by 1%, according to the diagram.

For the weight with fuel:

- centre of gravity position always within the forward limit.

Second possibility: The 18 passengers were distributed among compartments 2 and 3:

Compartment 1: 76 passengers (no change)
Compartment 2: 105 passengers (+ 7)
Compartment 3: 151 passengers (+ 11).

- Centre of gravity position for zero fuel: 11.6% M.A.C.
- Centre of gravity position on depressurization: 16.8% M.A.C.
- Centre of gravity position after the loss of weight from the rear of the aircraft: 16.0% M.A.C.

Conclusions

In both cases the centre of gravity position remains within the normal limits.

The possibility of movement of passengers forward as a result of panic on the collapse of the floor cannot be regarded as a possible hazard for the centre of gravity position. In the less favourable of the above two hypotheses, at least 50 passengers would have had to move in order to bring the centre of gravity position to its forward limit with fuel.

Although the distribution of the 332 passengers over the 345 cabin seats is not known, centre of gravity problems cannot be regarded as factors aggravating the situation which occurred as a result of the ejection of the aft cargo door.

3.7 Meteorological information

Between 1100 and 1200 hrs on 3 March 1974, the northern half of France was under the influence of unstable air masses. The cloud amount was small, 1/8 to 3/8 cumulus, base between 500 and 1,000 metres. Visibility was good, not less than 15 kilometres.

The upper wind and temperature were as follows:

500 m: 030°/10 knots	+ 0.5°C
1,000 m: 040°/10 knots	- 3°C
1,500 m: 050°/18 knots	- 6°C
3,000 m: 010°/15 knots	-15°C
4,000 m: 350°/08 knots	-20°C
5,000 m: 340°/12 knots	-39°C

The local meteorological conditions at Orly and at Charles de Gaulle Airports (15 km from the point of impact) during the period when the accident occurred were as follows:

	Orly Airport		Charles de Gaulle Airport (Roissy)	
	1130 hrs	1200 hrs	1100 hrs	1200 hrs
Visibility (km)	above 10	20	15	15
Surface wind (degrees and knots)	060/10	060/10	360/5	040/10
Cloud (octas and metres)	2/8Cu/900 1/8Ci/7,500	2/8Cu/900 1/8Ci/7,500	1/8Cu/450 1/8Ci/8,000	2/8Cu/600 1/8Ci/8,000
QNH (millibars)	1016.2	1016.2	1016.5	1016.5
QFE "	1004.4	1004.4	1003.1	1003.1
Temperature	+ 6	+ 6.2	+ 5	+ 5.9
Dew-point		-0.2	+0.3	-0.1
Relative humidity (%)		56	72	61

The ground observations and air reports in the accident area shortly after the time of impact agree with the above reports

3.8 Aids to navigation

Before take-off from Orly the crew of TC-JAV had received instructions from the Control to follow departure procedure 18 and to set transponder code 2.3.5.5.

3.8.1 *Departure procedure 18* implied use of the following VORs:

- OL: 111.2 MHz, installed at Orly Airport - 48°43'N" - 02°23"E.
A DME (CH 49) at 48°42'55"N - 02°22'50"E is associated with this VOR.
- CLM: 112.9 MHz: 48°50'40"N - 03°00'51"E. There is an NDB (CLM), 413 kHz, at the same site.
(DME CH 76 was not in operation on the date of the accident.)
- MTD: 115.8 MHz (on the date of the accident): 49°32'05"N - 02°29'24"E.
An NDB (MTD), 377 kHz, is sited at 49°33'13"N - 02°28'30"E.
(Impact occurred at about 24 NM on a bearing of 172° from MTD.)

There was no recorded failure of the above radio aids during the period of the flight of TC-JAV.

3.8.2 *Radars*

There is continuous film recording of the primary radars of Orly and Le Bourget Airports. These films have been used to reconstruct the DC-10's flight path from its departure from Orly up to the vicinity of the point of impact.

- Geographical co-ordinates of Le Bourget primary radar: 02°26'11"E – 48°56'54"N.
- Geographical co-ordinates of Orly primary radar: 02°23'39"E – 48°43'51"N.

The range setting of the scopes was 30 NM and the concentric markers were at 5 NM intervals.

- The North Area Control Centre is equipped with primary and secondary surveillance radars with a full detection area of 100 NM. These radars are installed within the perimeter of Orly Airport.

There is no film recording of the secondary radar and the information that the secondary radar 'label' disappeared from the radar screen, approximately at the time when the over-speed warning was heard on the frequency, was obtained from the report of the head of watch and the duty air traffic controller. At that time the transponder altitude indication was flight level 130.

Code 7700 'state of emergency' was not set by the crew, which could hardly have been expected under the circumstances.

Under item 10 S.S.R. of the flight plan filed before the departure of the DC-10, the letter 'I' was inserted, corresponding to a responder with 4096 codes in modes A and B. Normally, the letters J.K. should have been entered under item 10 of the flight plan, since they relate to equipment for the automatic transmission of the pressure altitude, which applied to the equipment of TC-JAV.

3.9 **Communications**

Transcripts of the recordings of the communications between the various ground services and the aircraft are appended.

The times shown on the transcripts have been determined on a uniform basis established from the time tracks and checked by listening to the recordings.

As regards the communications with the North Control Centre, it was thought advisable to include some communications with other aircraft on the frequencies of 131.35 MHz, 128.1 MHz and 128.3 MHz (transmission on all 3 frequencies in the case of Paris Control) in addition to the communications established on 131.35 MHz with TK 981.

(a) **Paris-Orly Airport**

No problem of a technical nature or relating to intelligibility arose during the following communications:

- 111130 hrs to 111420 hrs - Orly-Prévol on 120.5 MHz
 - 111430 hrs to 112830 hrs - Orly-Sol on 121.7 MHz
 - 112840 hrs to 113200 hrs - Orly-Airport on 118.7 MHz
 - 113210 hrs to 113600 hrs - Orly-Départ on 127.75 MHz
- (b) North Area Control Centre - Paris Control (131.35 MHz)
- 113610 hrs to 113710 hrs, five routine communications between TK 981 and ACC/N which call for no comment.
 - 114010 hrs: a very short signal immediately preceding the communication by the Control may give reason to think that this was the beginning of a transmission from TC-JAV (pressurization warning).
 - 114013 hrs to 114041 hrs: transmission which may or may not have been a call addressed to the Control. The words heard correspond to a dialogue between the crew members regarding the serious situation which was developing on board. The pressurization aural warning (until 114022 hrs) and overspeed warning (from 114022 hrs to 114041 hrs) were also included in this transmission.
 - 114104/05 hrs: very short transmission on 131.35 MHz which could have come from TC-JAV.
 - 114106/07 hrs to 114113 hrs: still on frequency 131.35 MHz, carrier wave transmission, not modulated, which broke off at a time which seems to correspond to that of the accident.
 - 114150 hrs to 114650 hrs: eight calls to TC-JAV from Paris Control, to which no reply was received.
 - Distress frequency of 121.5 MHz: between 113600 hrs and 115000 hrs. No call or abnormal noise was recorded on this frequency.

3.10 Aerodrome - Airport services

At 1000 hrs on 3 March, DC-10 TC-JAV, arriving from Istanbul, was parked on aircraft stand Alpha 2.

Stand A2 is located in front of the north side of the finger which extends Orly-Sud terminal building on the west side. Telescoping air-bridges, linked to the finger, run between the terminal building and the aircraft.

Numerous personnel dealt with TC-JAV during its stop of 90 minutes:

- Air Transport Gendarmerie and Air Police, to deal with the security of the aircraft on the ground and the control of passengers embarking in the aircraft;
- Turkish Airlines (station superintendent and his staff);

- Shell-Française, for refuelling;
- Finally, in addition to the cabin cleaners, airport services proper were provided by Paris Airport and its sub-contractor, the Samor Company.

3.10.1 *Paris Airport personnel*

The Paris Airport personnel included:

- An operation officer, M. Marteau, responsible for the technical flight preparation.
- A traffic officer, M. Salaun, responsible for the aircraft loading on the basis of the centre of gravity position and available capacity.

These persons were also responsible for the despatch and receipt of messages regarding flight TK 981.

- A supervisor, M. Merlier, responsible for liaison between the operations and traffic personnel on the one hand and the aircraft on the other.
- An apron co-ordinator, M. Baudouin, who co-ordinated the various apron services for the DC-10.

Although their work was not solely concerned with the Turkish Airlines aircraft, three apron engineers dealt with it:

- On the arrival of TC-JAV, M. de Altis put the wheel chocks into position and also the DU 812-2 aerodrome starter unit. The starter unit was not used because the aircraft auxiliary power unit functioned satisfactorily.
- On the aircraft's departure from stand A2, M. Baby carried out the pushback operations with his tractor.
- When the aircraft was ready to taxi, on its departure for London, M. Vaudry removed the wheel chocks and the safety locks.

3.10.2 *Passenger and cargo handling*

3.10.2.1 **FREIGHT AND BAGGAGE HANDLING**

These operations were carried out by the personnel of the Samor Company under an agreement between THY and Paris Airport.

The personnel comprised:

- A cargo-handling foreman, M. Voisin.
- Three drivers of cargo handling equipment, M. Dumas, M. Pereira and M. Cavaco.
- Three cargo-handling operatives, M. Delfau, M. Tacheau and M. Mahmoudi.

Forward cargo compartment

This compartment, with a load of 2,896 kg put on board at Istanbul and destined for London, the terminus of flight TK 981, was not opened at Orly.

Central cargo compartment

Personnel who worked on the central cargo compartment: M. Cavaco, M. Voisin and M. Dumas.

Equipment used: S.O.V.A.M. container-handling scissor lift, type PE 45.

Unloading: 1,111 kg of freight — one batch of empty pallets — one mail bag of about 40 kg.

The unloading operations were completed by about 1015 hrs.

Loading: 1,525 kg of baggage belonging to passengers who embarked at Orly.

The loading operations began at 1055 hrs and were completed by about 1105 hrs. The door was closed at about 1110 hrs by M. Cavaco.

Aft cargo compartment

Personnel responsible for the aft cargo compartment: M. Pereira, M. Delfau, M. Mahmoudi and T. Tacheau.

Equipment used: Cochram cargo-conveyor elevator (maximum height 5 metres).

Unloading: 915 kg of baggage — 335 kg of mail bags (the compartment was emptied completely).

The unloading operations were completed by about 1025 hrs.

Loading: Nothing was loaded into this compartment (freight or baggage).

The cargo door was closed at about 1035 hrs by M. Mahmoudi who has stated that he proceeded as usual, without any particular difficulties, and that he did not notice any abnormality. M. Mahmoudi has also stated that he did not look through the view port, a procedure which he had seen but which he never carried out himself and the purpose of which he did not know.

3.10.2.2 PERSONNEL OF THE THY COMPANY

The apron personnel of the THY Company did not take part directly in the cargo handling and loading operations.

In the absence of the station engineer who was on a training course at Istanbul, another engineer had been taken on for flight TK 981. After the closure of the aft cargo door

on the left-hand side by M. Mahmoudi, no one saw that engineer or any other crew member inspect the lock pins by looking through the view port provided for that purpose, and their non-engagement was therefore not detected. Moreover, once M. Mahmoudi's work was completed, inspection would have entailed the positioning of equipment beneath the view port in order to gain access.

3.10.2.3 MOVEMENT OF PASSENGERS IN THE PASSENGER COMPARTMENTS

- 50 passengers destined for Paris disembarked at Orly.
- 216 passengers destined for London embarked.

3.10.3 *Refuelling*

Shell-Française refuelled DC-10 TC-JAV with 10,350 litres of Jet A1 fuel.

At the time when the fuel was supplied, the Shell detector test for water in the fuel proved negative.

Eight fuel samples, taken from airport tanks 11 and 21, were examined by the fuel and lubricants laboratory of the Centre d'Essais des Propulseurs de Saclay and the results of the examination were satisfactory (report No 1057-LC 74).

The refuelling began at 1015 hrs and was completed at 1030 hrs.

3.10.4 *Security*

Security service is provided by the Air Transport Gendarmerie. For this purpose an aircraft is guarded throughout its time on the apron and is escorted to the threshold of the departure runway.

Stand A2 was guarded by a gendarme from 1005 hrs to 1129 hrs.

Two gendarmes escorted the aircraft from stand A2 to the threshold of the take-off runway 08.

The passengers who embarked at Orly and also their baggage passed through the security search control.

Nothing was reported by any of the personnel responsible for these various routine operations.

3.10.5 *Taxying*

Between aircraft stand A2 and the threshold of runway 08, the crew of flight TK 981 took the following route:

- Push-back operation, as the aircraft was in a 'nose in' position in front of the south air terminal satellite.
- Taxiway passing between stands A5 and A6 and D11 and D13.

- Right-hand turn and taxiway No 1, and after stand E9 left-hand turn for taxiway 37.

3.10.6 *Runway used*

The take-off runway 08, QFU 080°, used by TC-JAV has a length of 3,310 m and a width of 45 m.

The lighting includes high intensity and low intensity approach and runway lights.

The mean aerodrome elevation is 89 m.

3.11 *Flight recorders*

3.11.1 *Cockpit voice recorder*

In accordance with national and international requirements, TC-JAV was equipped with a cockpit voice recorder (CVR), type Collins, model 642 C-1. The cockpit voice recorder was located alongside the flight data recorder, inside the aft cargo compartment and immediately to the rear of the aft cargo door on the left-hand side.

The CVR was found about 150 metres beyond the initial point of impact in the forest of Ermenonville and was considerably damaged, but the recording could still be heard. It was first played back and copies made at the French Air Navigation Technical Service, in the presence of French and foreign experts of the Commission of Inquiry.

Appended is the transcript of this recording; the times were established in agreement with the time tracks of the communications between the aircraft and the control services (Airport and ACC North).

It should be noted that the time which elapsed, seventy-seven seconds, between the noise of decompression and the end of the CVR recording is practically identical with that measured on the flight data recorder. Nevertheless, for the period in question there is a time shift of the order of thirty seconds between the time supplied by the flight data recorder (indication taken from the clock of the flight engineer's panel) and the time common to the ACC/Tower/CVR (ACC time = flight data recorder time minus 30 seconds). With allowance for the various factors available for the purposes of comparison, this discrepancy appears to be approximately constant and of the same magnitude throughout the flight.

In addition to the information provided by the communications recorded on the ground and the various observations entered on the transcript appended, the CVR recording reveals in particular the following points during the last phase of the flight:

- Decompression heard at 113956 hrs.
- Pressurization warning heard almost immediately and for slightly less than 25 seconds.
- Identification of the nature of the accident by the crew.

- Overspeed warning heard at about 114023 hrs, probably until the end of the recording (although very faint during the last moments) ie for 50 seconds.
- CVR recording stopped at 114113 hrs.

3.11.2 *Flight data recording*

In accordance with national and international requirements, TC-JAV was equipped with a flight data recorder, type Sunstrand Data Control, model 573 A, maker's serial number 2104, located under the floor on the left-hand side, alongside the cockpit voice recorder and immediately to the rear of the aft cargo door on the left-hand side.

The flight data recorder was found in the area of the main wreckage, about 600 m from the initial point of impact. The outer case was substantially damaged on impact (no trace of fire or smoke); the vicalloy magnetic tape was very dirty, bent and broken in two places. The recorder was taken to the USA where the NTSB arranged for the tape to be read out at the premises of the firms of Sunstrand and Teledyne, in the presence of French experts from Brétigny Flight Test Centre and the Accidents Investigation Bureau. The read-out was established in graphical form and subsequently a fresh read-out was made at the Brétigny Flight Test Centre on the RESEDA installation, using the calibrations established for the KSSU group. The results obtained were in agreement.

Appended are graphs showing the variations in the parameters during the flight and the accident.

The principal points regarding the read-out may be summarised as follows:

- **Take-off:** 1131 hrs (flight data recorder time).

Take-off was made with reduced thrust, rotation began at 143 knots, ie 4 knots below the predetermined V₂, and the ground roll time was of the order of 40 seconds.

During the take-off, the horizontal stabilizer setting was about $-6\frac{3}{4}^{\circ}$, the maximum attitude reached was 19° , while the elevator angle changed progressively from 8° to 11° .

- **Climb:** 1132 hrs to 1139 hrs (flight data recorder time).

The climb progressed normally. It should be noted that there was a stretch of level flight at 6,000 feet for more than two minutes (1135 hrs to 1136 hrs). Shortly before reaching 12,000 feet, the aircraft climbed at 300 knots indicated air speed with a rate of climb of 2,200 feet a minute. The attitude was of the order of 3° , the horizontal stabilizer was set at $\frac{3}{4}^{\circ}$ nose-up and the elevators were 2° to 3° aircraft nose-up.

Accident:

It can be deduced that depressurization occurred at 114026 hrs at about 11,500 feet. Two seconds later the following conditions were found:

- An angle of some 10° , to the left of the two rudder control surfaces; the change in heading to the left was 9° .

- A nose-down movement of the elevator surfaces of which the angle had decreased by about 3°, while the aircraft's attitude decreased accordingly.
- The horizontal stabilizer angle recorded changed from ½° nose-up to 6½° nose-down.
- The speed of No 2 engine had fallen to 45% by 114029 hrs.

(Only one item of this information is aberrant, that relating to the setting of the horizontal stabilizer, limited by a mechanical stop to an angle smaller than that recorded after the depressurization. In addition, the horizontal stabilizer cannot move so swiftly and a change in angle as large as that recorded would inevitably have given rise to far larger vertical accelerations than those recorded. The transducer of the movement of the stabilizer is in a forward position in the aircraft, on the cable which transmits this information to the cockpit, and it is more than likely that the doubtful value recorded corresponds to tension of this cable, associated with the damage to the floor.)

The aircraft nose-down attitude became rapidly steeper, -20° was reached 22 seconds after decompression and simultaneously the speed increased to 362 knots, although Nos 1 and 3 engines had been throttled back.

At the end of minute 1140 hrs, the speed reached 400 knots at 7,200 feet, the ailerons seemed to function correctly and the angle of bank to the left did not exceed 20°.

At the beginning of minute 1141 hrs, the attitude began to decrease progressively and the speed to stabilise around 430 knots without this appearing to be due to the control surfaces.

Impact occurred at 114143 hrs (flight data recorder time) at an attitude of -4°, a speed of 423 knots and on a heading of 281°.

3.12 Wreckage

3.12.1 *Main wreckage*

The DC-10 made impact with the ground in the department of Oise at a place called 'Le Bosquet de Dammartin' in the commune of Fontaine Chaalis.

The accident site is located in a small enclosed valley, running from east to west and covered with Scotch and maritime pines. The ground is rugged with some rock outcrops on the east side. The average elevation is 105 metres. The area affected by the aircraft impact exceeded 65,000 square metres. The aircraft literally disintegrated into fragmented wreckage. It cut a swath through the forest some 700 metres long by 100 metres wide.

On the initial impact with the tops of trees about 10 metres high, the aircraft was on a heading of 280°, with a pitch attitude close to -4° and an angle of bank to the left of the order of 17°. This information has been obtained from the flight data recording and inspection of the site, both of which gave the same indications. The very high speed was between 420 and 430 knots (800 km/hr).

If this initial impact on the edge of the 'des Epines' forest road is taken as the point of origin for the measurement of distance on the wreckage trail, it becomes evident that in the violence of the impact the airframe was completely shattered. The wreckage recovered came from both forward and rear parts of the aircraft structure.

Impact with the ground was made about 330 metres away from the initial point of impact. Along this distance of 330 metres the aircraft cut through hundreds of trees. Wreckage of the wings and the frames of the forward doors was found along a trail 100 to 150 metres wide. At a point about 220 metres along and 60 metres south of the centre line of the swath, the cockpit voice recorder was found; it had been installed in the rear part of the aircraft on the left-hand side, below the leading edge of the vertical stabilizer.

Between 170 and 270 metres along the wreckage trail, traces of kerosene were found along both the north and south edges of the valley, providing evidence of the points where the fuel tanks broke up. Wreckage of No 3 engine was also found on the north side of the area devastated by the aircraft.

Between 250 and 270 metres, along this same north side, numerous small pieces of wreckage were found, mainly of the wings and the engines. The airframe touched the ground at a point between 330 and 440 metres along the trail. A violent explosion ensued and the practical disintegration of the aircraft. In this area, numerous small fragments from all parts of the aircraft were found intermingled.

From 400 to 600 metres, various pieces of wreckage, generally small in size, were found scattered over the whole width of the crash area. The flight data recorder was found at the left-hand edge of this section of the trail. At the end of this section there were two fairly large pieces of wreckage, the tail aft body and part of the fuselage with a door frame and nine windows.

No 2 engine was recovered at 650 m, on the 'de la cavée' road. This engine had remained sufficiently intact for its component parts to be examined.

The last wreckage was found 700 metres from the initial point of impact.

3.12.2 *Wreckage found at Saint-Pathus*

On the morning of 4 March, French experts accompanied by police officers from Saint-Pathus found the bodies of six passengers, parts of the aircraft seats and the wreckage of the aft cargo door, beneath the aircraft's flight path and 15 km before the main wreckage.

Aft cargo door on the left-hand side

The wreckage of this door was composed of:

- The lower part of the door with the 4 latches and their complete control and locking mechanism, and also the push rod controlling the lock tube.

The electric motor of the latch actuator was not found.

- Part of the door including the locking handle with the link and the vent door shaft and also the detached top fitting of the push rod.

The vent door was not found.

- The cargo door operating arm.

All these parts came down in free fall into newly ploughed fields and were embedded in the fairly soft earth so that they were little damaged on impact with the ground; any fractures occurred on ejection from the aircraft.

A visual inspection of the wreckage was carried out immediately at the sites where it was found, with the following results:

- absence of any marks of fire or over-heating;
- incomplete closing of the door latches;
- non-engagement of the lock-pins;
- the electric motor of the latch actuator had become detached from its mounting and was not found;
- the handle was out of its housing (open position); the trigger which retains it in its housing had been forced and was difficult to work;
- the links controlling the latches had not reached over-centre and any slight force exerted on the latches caused displacement of the actuator assembly of which the upper part was no longer fixed positively to the door structure.

All these parts were then taken to Le Bourget and subsequently to Saclay Test Centre for more detailed laboratory examination.

Identification of the door

Two references were ink-stamped on the door in two different places:

First reference: P/N NFA 6070-501 N

S/N 46704/11 FG401

Second reference: P/N NFA 6070-507

The following indications were inscribed under the reference:

F/N	EDITION	PROD	INSP ACCEPT
29	1	05804	ZAI 04

The document DOUGLAS NFA 6070 'W' confirmed the door reference of NFA 6070-507 (the vent door installation had caused the reference to be changed from 501 to 507).

Principal findings of the examination of the door wreckage

- On the instruction plate for manual opening of the latch actuator, there was a hole,

not prescribed by Douglas and drilled by THY, in order to gain direct access to the drive mechanism (incorrect execution of SB 52-38).

- The link (LINK ASSY P/N ADA 7366-501), between the locking handle and the vent door shaft, was bent.
- The additional support plate specified for the vent door shaft by SB 52-37 had not been installed¹.
- The push rod (LINK ASSY P/N ADA 7372), between the vent door shaft and the lock tube, was bent and the two crank attachment rivets were sheared.
- The forward bottom structural corner of the door was deformed. This damage, due to contact with the ground after a fall of 3,600 metres, had caused slight deformation of the lock tube and the mounting of the lock limit switch.
- The end of the lock tube was chamfered as prescribed by SB 52-37. Rough file marks and irregular scoring showed that this work was done manually.
- The striker of the unlock limit switch had two DOUGLAS P/N AFA 3210-1 shims, surmounted by a third shim with no reference number and consisting of a thin crumpled piece of metal leaf with numerous folds on the side which had to come up against the roller of the unlock limit switch. The presence of this part, unusual in equipment to aeronautical standards, was surprising and could only have entailed imprecision and erratic functioning of this switch which closes the circuit to the latch actuator in the sense of opening the latches only. This defective installation had no effect on safety but could have been the source of numerous difficulties in opening the door.

3.13 Medical and pathological information

It had already been decided on the day after the accident to take the remains of the passengers and crew members to the Institut Médico-Légal de Paris, for the purpose of the Inquiry.

In view of the exceptionally large number of victims the medical team encountered difficulties, as the Institut did not have facilities on a scale related to this type of accident.

The results of the examination of the bodies of the victims were as follows:

Lesions observed

From the traumatological standpoint, the lesions could be classified into two categories:

¹SB 52-37 does not list TC-JAV among the aircraft affected by the relevant modification which ought to have been carried out by the manufacturer before delivery. As a result of an oversight by the manufacturer, the aircraft was delivered without the modification and the start of its application to the lock tube seems to show that work had begun on correcting the error retrospectively.

(a) In the case of the bodies recovered at the main accident site in the forest of Ermenonville, there was a high degree of fragmentation (nearly 20,000 fragments were listed) associated with the violence of the impact.

(b) On the other hand, the six bodies found near Saint-Pathus were complete, although presenting fractures and serious visceral lesions. Careful examination showed:

- that there were no external burns;
- that there were no external lesions which could be associated with the projection of metal or other fragments as the result of an explosion caused either by a criminal act or otherwise;
- by X-ray examination, that there was no evidence of deep penetration by metal fragments.

Toxicological examination

Routine toxicological examinations were made of the six bodies ejected over Saint-Pathus and of a number of fragments recovered at Ermenonville and selected at random. No evidence was detected of:

- carbon monoxide;
- cyanhydric derivatives;
- chlorine derivatives;
- alcohol.

Identification

188 bodies or parts of bodies were positively identified by the use of a number of techniques:

- finger-printing (in particular in the case of Turkish and Japanese nationals, because of the existence of national finger-print records);
- examination of teeth;
- bone measurements;
- clothing, personal effects.

It should be noted that finger-printing was of great assistance and that the use of a computer proved to be essential for processing the enormous quantity of data required for identification purposes.

3.14 Fire

The circumstances of the impact (disintegration at very high speed in the trees) were such that there was practically no fire, apart from a few very minor localised outbreaks where fires of short duration persisted for only a few moments.

Jet A1 fuel was used and there were about 23,500 litres on board at the time of impact.

3.15 Survival aspects – Rescue operations

3.15.1 *Survival aspects*

The accident occurred in two phases which left no chance of survival for the 346 occupants of the DC-10. The first phase occurred at 1140 hrs over the commune of Saint-Pathus, where six of the aircraft occupants were ejected at an altitude of about 3,600 metres.

The second phase was that of the impact at 1141 hrs, when the aircraft flew into the forest at a speed of 430 knots (800 km/hr), leaving no chance of survival for its occupants.

3.15.2 *Rescue operations*

The Air Traffic Control was immediately aware of the loss of radio and radar contact and was able to locate the area of the accident, thereby simplifying the task of the alerting and search services (VHF calls, to which no reply was received, from 114150 hrs to 114650 hrs; telephone enquiries in conjunction with Orly, Le Bourget and Creil, from 1144 hrs to 1238 hrs).

The rescue operation was already well under way when the DETRESFA message was transmitted by the North Area Control Centre at 1200 hrs and the presumption of accident message at 1240 hrs.

After information had been obtained at the accident site, the accident notification message was transmitted at 1615 hrs and the DETRESFA termination message at 1650 hrs.

At 1840 hrs, Doullens Centre announced that the SAR operation had ended at 1732 hrs.

In addition to the occurrences recorded by the North Area Control Centre, the crash of the DC-10 was reported by 1145 hrs to the Senlis Gendarmerie Brigade by the Surveilliers C.R.S. (riot police) Station (Val d'Oise). From 1145 hrs onwards, exceptionally large scale rescue facilities (air and ground) were put into operation by the civil and military authorities (police, armed forces, civil emergency centres, Paris Airport, etc).

Within a very short time, at 1215 hrs, the first rescue teams arrived at the site. The conveyance of the bodies of the victims to the church of Saint-Pierre de Senlis began at 1345 hrs.

The bodies recovered near the villages of Saint-Pathus and Oissery were taken to Meaux hospital.

Seventeen emergency centres (civil and military facilities) with fifty-six vehicles of various kinds were used and about three hundred persons took part in the operations on the first day.

Finally, the operations for the transfer of the aircraft wreckage began on 8 March and were completed on 20 March.

3.16 Tests and research

3.16.1 *Examination of No 2 engine*

No 2 engine, General Electric CF6-6D, serial number 451-200, was examined at the Centre d'essais des propulseurs de Saclay. Its examination gave rise to the following conclusions:

- the mechanical damage found on examination was due to the impact;
- the engine was not lit at the time of impact;
- the engine was running down at the time of impact;
- there was no trace of fire.

3.16.2 *Examination of the servo controls and of a horizontal stabilizer jackscrew*

The servo controls (four for the elevator, two for the rudder and four for the ailerons) were recovered and found to be only very slightly damaged; they could therefore be examined.

The examination was made in the UTA hydraulics laboratories at Le Bourget. The electrical characteristics of the electro-hydraulic flow control valves were checked and no abnormality detected, either in the hydraulic part or in the electrical part.

An examination was also made of one of the two jackscrews for the control of the horizontal stabilizer; on this screw the nut was found to have jammed at the time of impact.

On examination of the jackscrew and its nut, the number of exposed threads between the bottom of the screw and the bottom of the nut could be measured. These measurements made only on this one screw gave for the stabilizer angle on impact a value very close to the position recorded before the loss of the door.

3.16.3 *Examination of the latch actuator of the aft cargo door on the left-hand side*

The irreversible actuator was taken off the door. The two bolts which attach the bracket on which it is mounted, were found sheared: the shearing force was estimated at 4,700 daN.

The shaft extension was 277.5 mm measured between the axis of the connection of the actuator to the structure and the axis at the end of the actuator ram (where it is connected to the torque tube). Normal extension required for correct closing of the latches is 297 mm.

A thorough expert examination, with the collaboration of the Swiss Federal authorities, was subsequently carried out in the Swissair laboratories at Zurich, which are approved for the maintenance of this equipment.

The following points became evident:

- (1) Incomplete extension can result only from premature stoppage of the electric motor. As the latter has not been found, it is impossible to say whether this premature stoppage was caused by a failure intrinsic to the motor, or by the operation of the thermal protection device or by the accidental cut-off of the electrical power supply.

It should be noted that the edges of the restraining flanges of the 4 latch cranks showed heavy marks (detachment of paint and metal) made by the lock pins (fig 8). These marks were not produced during the last flight, for in that case the latches would have been engaged. They show that in earlier circumstances the operation whereby over-centre is achieved was incomplete, for the pins must pass freely without any friction (figs 1 and 5).

- (2) The washers of the ball (thrust) bearing which transmits the force for closing the latches were broken.

During a compression test of an identical ball (thrust) bearing a force of about 2,000 daN caused the failure of the washers. As the force which sheared the two top attachment bolts (4,700 daN) was considerably greater, it seems normal that a bearing in good condition would have fractured when transmitting such a force.

During the various tests carried out at the Swissair laboratories at Zurich, in the presence of members of the Commission of Inquiry, the actuator with the fractured bearing, fitted with a motor in good condition, operated on the test bench under a test load of 665 daN (1,500 lbs). On the other hand, it failed to continue to operate beyond 1,080 daN (2,415 lbs) although according to its specifications it should have reached the minimum 'limit load' of 1,160 daN (2,600 lbs).

In conclusion, two hypotheses can be formulated regarding the condition of the bearing before the operation to close the cargo door at Orly Airport:

- (1) The condition of the bearing had already deteriorated. Such deterioration increases the load on the electric motor and may cause the cut-off of the electrical power supply through the normal operation of the thermal protection system.
- (2) The fracture of the bearing was a consequence of the abnormal force transmitted immediately before the ejection of the door.

3.16.4 *Check of the electrical operation of the switches of the door circuit*

A check of the electrical operation of the 5 switches installed on the door gave the following results:

CLOSE LIMIT WARNING SWITCH: Satisfactory functioning

COCKPIT CALL SYSTEM SWITCH: Satisfactory functioning
UNLOCK LIMIT SWITCH: Satisfactory functioning
CLOSE LIMIT SWITCH: Satisfactory functioning
LOCK LIMIT WARNING SWITCH: Did not function (arm distorted)¹

3.16.5 *Check of the adjustment of the locking system*

(a) Lock limit warning switch

The following repairs were made to the wreckage of the door:

- straightening of the lock tube;
- straightening and putting back into position the mounting of the lock limit warning switch;
- replacement of the lock limit warning switch damaged during the crash, by a new switch of the same type.

After re-assembly of the parts, the following observations were made:

- The striker P/N 7797-3 located at the end of the lock tube had ten shims, ie:

1 shim P/N ADA 7773-1
8 shims P/N ADA 7773-501
1 shim P/N ADA 7773-503

with a total thickness of 15.9 mm.

- When the lock tube was pushed towards the locked position, the switch switched off the flight deck warning light, although the ends of the lock pins were still 3 millimetres away from the restraining flanges (fig 3). It should be noted, moreover, that according to the Maintenance Manual, the ends of the lock pins in the unlocked position must not be more than 2 mm away from the flanges.

In conclusion, the adjustment of the lock limit warning switch was defective and caused the flight deck warning light to go out when the latches were not necessarily closed.

(b) Adjustment of the lock tube

The two rods of adjustable length by means of which the extreme positions of the lock tube can be varied were straightened and their adjustments measured (the lockwire locking the adjustment nuts had remained in position).

¹After removal and cleaning: satisfactory functioning (it should be noted that this switch was located in the area where the door structure was damaged on impact).

The adjustments were as follows:

link P/N ADA 7366: distance between centres = 302.79 mm
push rod P/N ADA 7372: distance between centres = 914.38 mm

These adjustments were then made to the corresponding rods on a door of the same type loaned by McDonnell Douglas, from which the support plate specified by SB 52-37 had been removed, thus making it conform to the definition of the door with which TC-JAV was equipped.

3.16.6 *Tests on a door with the same definition as that of TC-JAV*

The results of examination of this door adjusted as described above in accordance with the measurements made on the wreckage were as follows:

(1) Latches closed, locking handle closed

The four lock pins were engaged behind the restraining flanges and prevented the opening of the latches, but they were only partly engaged. The ends of the lock pins were 1.6 mm short of the rear face of the flanges (fig 4).

The official adjustment documentation – Maintenance Manual, Revision 4, January 1973 – stipulates that the ends of the lock pins, in the locked position, must protrude for 6.35 mm beyond the rear face of the flanges (fig 5).

In consequence, with this adjustment the lock tube in its locked position was $6.35 + 1.6 = 7.95$ mm short of the correct locked position.

(2) Latches open

When the latches were open, the movement of the handle towards the closed position was stopped when the lock pins came up against the front faces of the flanges.

Tests carried out on the same door, with varying adjustments of the extreme positions of the lock pins, showed that the force which has to be applied to the handle in order to force its closure depends on the extreme position (locked) to which the lock tube is adjusted.

When this adjustment is in accordance with the manufacturer's requirements, ie when the ends of the lock pins protrude for 6.35 mm beyond the rear faces of the flanges, it is physically impossible to force the handle even in the absence of the support plate for the vent door shaft (SB 52-37).

On the other hand, when this distance of 6.35 mm is decreased, the force required for forced closure also decreases. It becomes theoretically nil when the end of the lock pin is in line with the front face of the flange.

During the tests carried out (with the lock tube adjustment 7.95 mm short of the correct position) the handle could therefore be closed (and the vent door apparently closed) with a force of 22 daN (about 50 lbs) (fig 7).

This closure was possible only because of deformation of the mechanism providing control transmission for the operation of the lock tube. The principal deformation affected the vent door shaft. The additional support plate specified by SB 52-37 (fig 6) was designed precisely to prevent such deformation.

It should be noted that the partial engagement of the lock pins as reproduced on the new door corresponds to the friction marks which they made on the edges of the flanges of the door of TC-JAV, which occurred only on the leading half of the edges (fig 8).

Conclusions

The new door

Because of the defective adjustment of the extreme positions of the lock tube, the handle could be closed without excessive force, although the latches were not completely closed.

Defective closure could not be detected from the external appearance of the handle, vent door and cargo door, unless a visual inspection was made through the view port provided for that purpose.

Door of TC-JAV

The thickness of the striker shims made any correct adjustment of the lock pins impossible; any attempt to bring the ends of the lock pins to the correct distance of 6.35 mm beyond the rear face of the flanges inevitably led to damage to the lock limit warning switch. The incorrect adjustment of this switch caused the flight deck warning light to go out when the door was still unlocked.

Because of the insufficient protrusion of the lock pins, the locking handle and vent door could be closed without excessive force, although the lock pins were stopped by the front face of the flanges (fig 7).

From the production and inspection documents received by the National Transportation Safety Board from Douglas, the aircraft manufacturer, it appears that the adjustments of the lock pins on fuselage No 29 (TC-JAV) gave a minimum pin protrusion of 0.25 inches (6.35 mm), account being taken of the accomplishment and verification of the work specified in EO ADA 7797 Change A.

These documents merely provide guarantees in accordance with prescribed forms, but the adjustments in question were also those shown in the Maintenance Manual (in particular Revision 4, January 1973) and had to be verified or applied again by the operator whenever any work was carried out on the door.

In brief, examination of the wreckage of the door of TC-JAV revealed defective adjustment of the lock limit warning switch. In addition, after the rods of a new door of the same definition had been adjusted to the dimensions measured on TC-JAV, it could be judged that the adjustment of the lock pins was likewise incorrect in the locked position.

The adjustment reconstructed in this way is consistent with that of the lock limit warning switch and also with the friction and other marks found on the lock pins and flanges. Finally, it provides an explanation of why the locking handle could be operated without excessive force although the latches were not fully engaged.

3.16.7 *Research: accident on 12 June 1972 to DC-10-10, N 103AA near Windsor, (Ontario)*

In the course of its work, the Commission of Inquiry studied the report of the National Transportation Safety Board, dated 28 February 1973, relating to the loss in flight of a similar aft cargo door on the left-hand side from an American Airlines DC-10-10.

Although the course of events and some of the causes are not exactly the same, nevertheless that accident presents points in common with the accident to TC-JAV:

- The latches were not fully closed and the latch lock pins were not in place.
- The flight deck warning light had gone out before effective locking had occurred.
- The altitude reached by the American Airlines DC-10 was of the same order as that of TC-JAV when the door opened and the two bolts (connecting the fixed part of the latch actuator to the door structure) failed under the same conditions.
- In the absence of pressure relief vents of adequate size between the passenger cabin and the aft cargo compartment, the sudden decompression in the cargo compartment caused damage to the cabin floor and its structure. This damage was less severe than in the case of TC-JAV in which the floor was more heavily loaded, but the functioning of the control cables was impaired in various ways, although it did not become completely impossible to control the aircraft.

In the conclusions of the NTSB report, it is stated that the probable cause of the accident was the incorrect engagement of the latching mechanism and the design characteristics of the system which permitted the door to be apparently closed when the latches were not fully engaged and the lock pins were not in place. Two recommendations had been issued by the investigators:

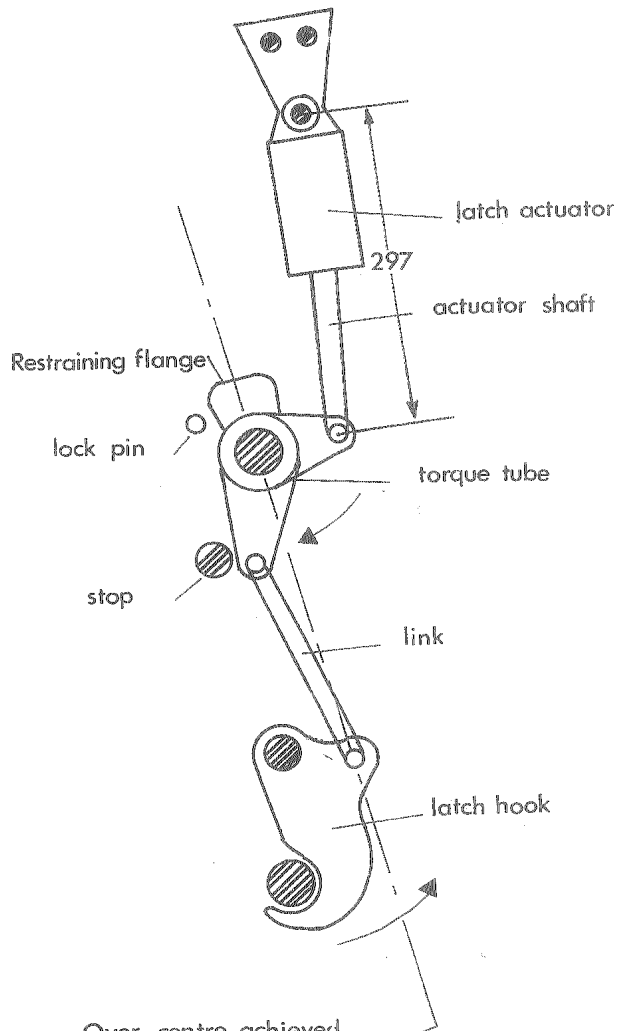
- modification to the locking system to make it physically impossible to position the external locking handle and vent door to their normal door-locked positions unless the lock pins are fully engaged;
- the installation of pressure relief vents between the cabin and the aft cargo compartment to minimise the pressure loading on the cabin flooring in the event of sudden depressurization of the cargo compartment.

The first of these recommendations had given rise to the modifications specified in Alert Service Bulletin 52-35 and in Service Bulletins 52-27 and 52-37 (in the case of 52-37, only a start had been made with its application to TC-JAV).

Other modifications of the door closing system and methods of mitigating the effects of sudden depressurization of the aft cargo compartment were still under study at the time of the accident to TC-JAV.

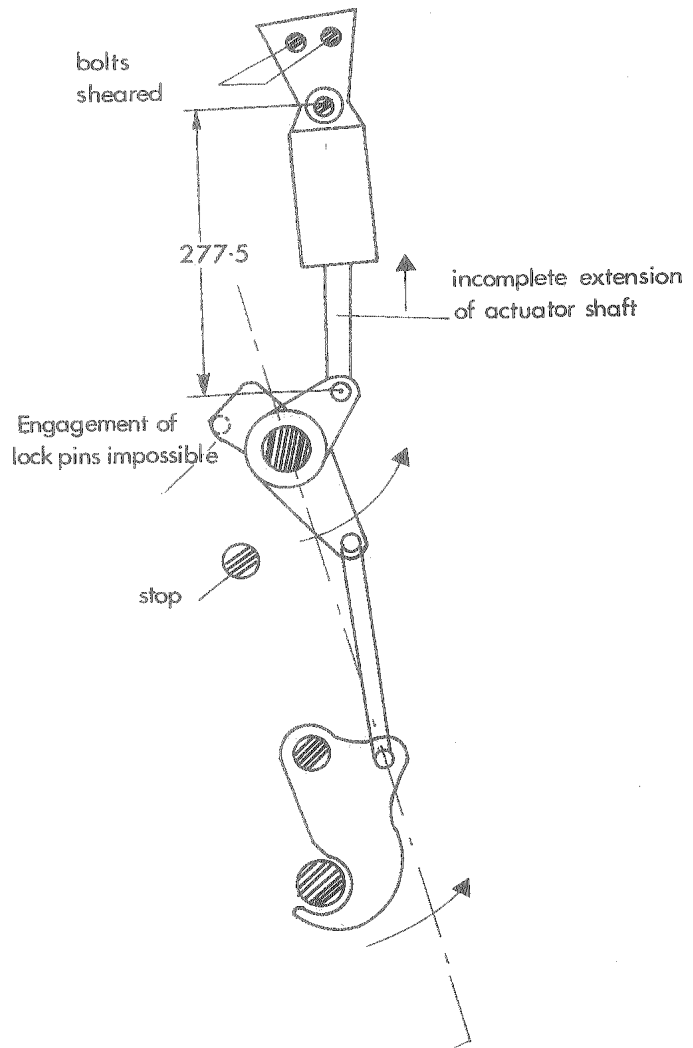
DC-10 AFT CARGO DOOR
Latch Closing System

Fig. 1





Over-centre achieved
System irreversible
Correct closure

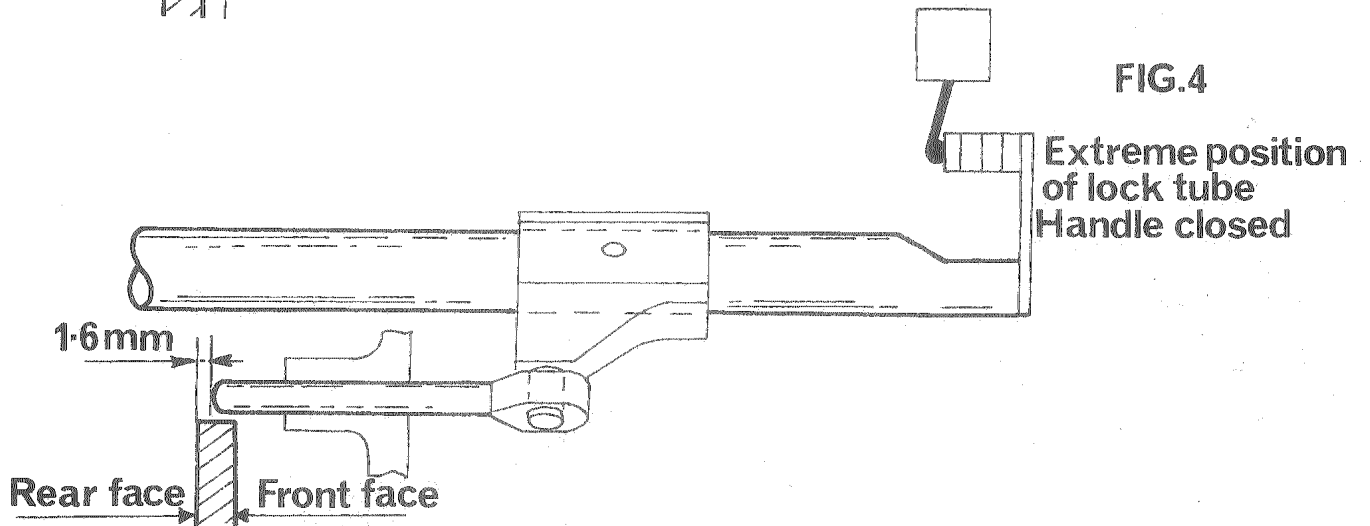
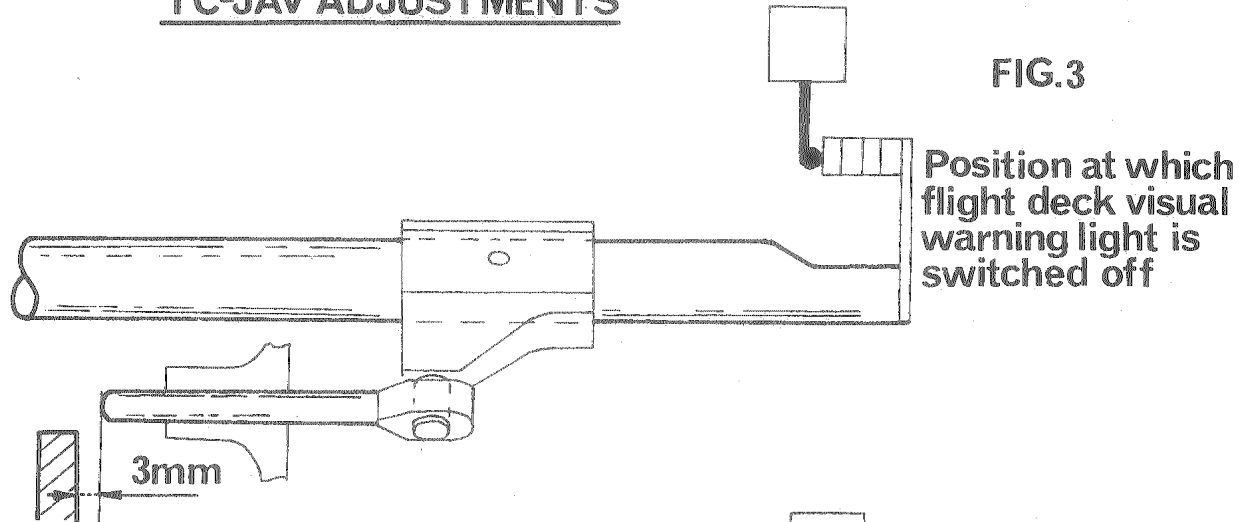
Fig 2



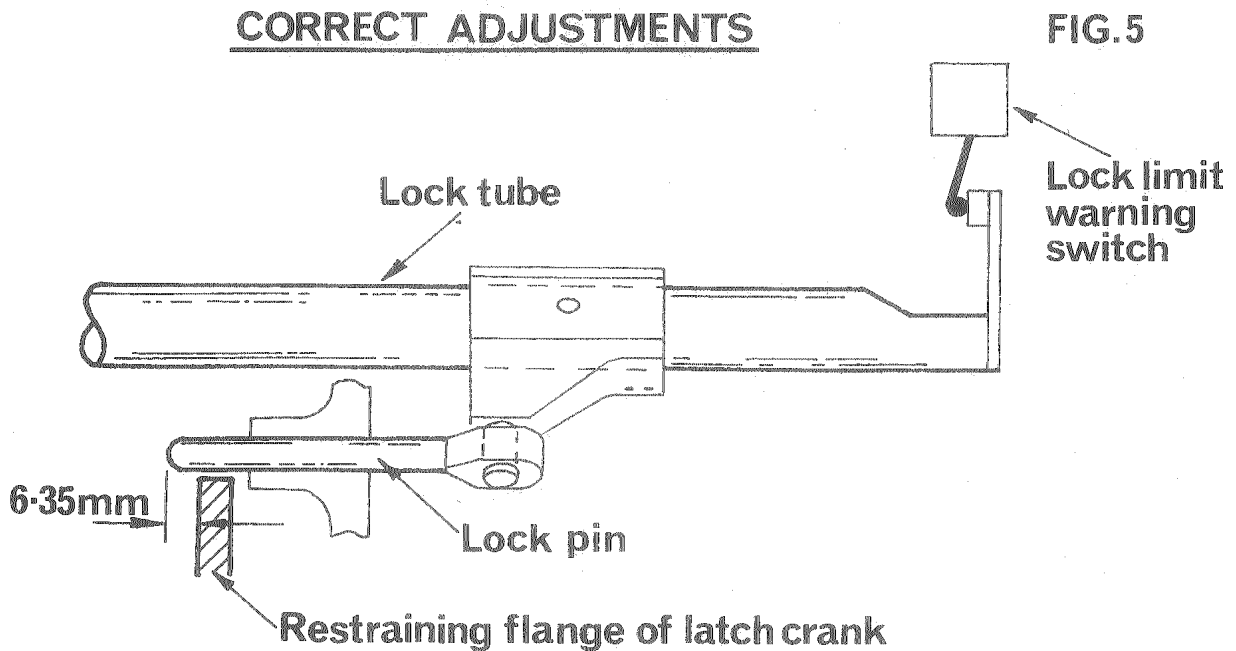
Over-centre not achieved
System reversible
Incorrect closure

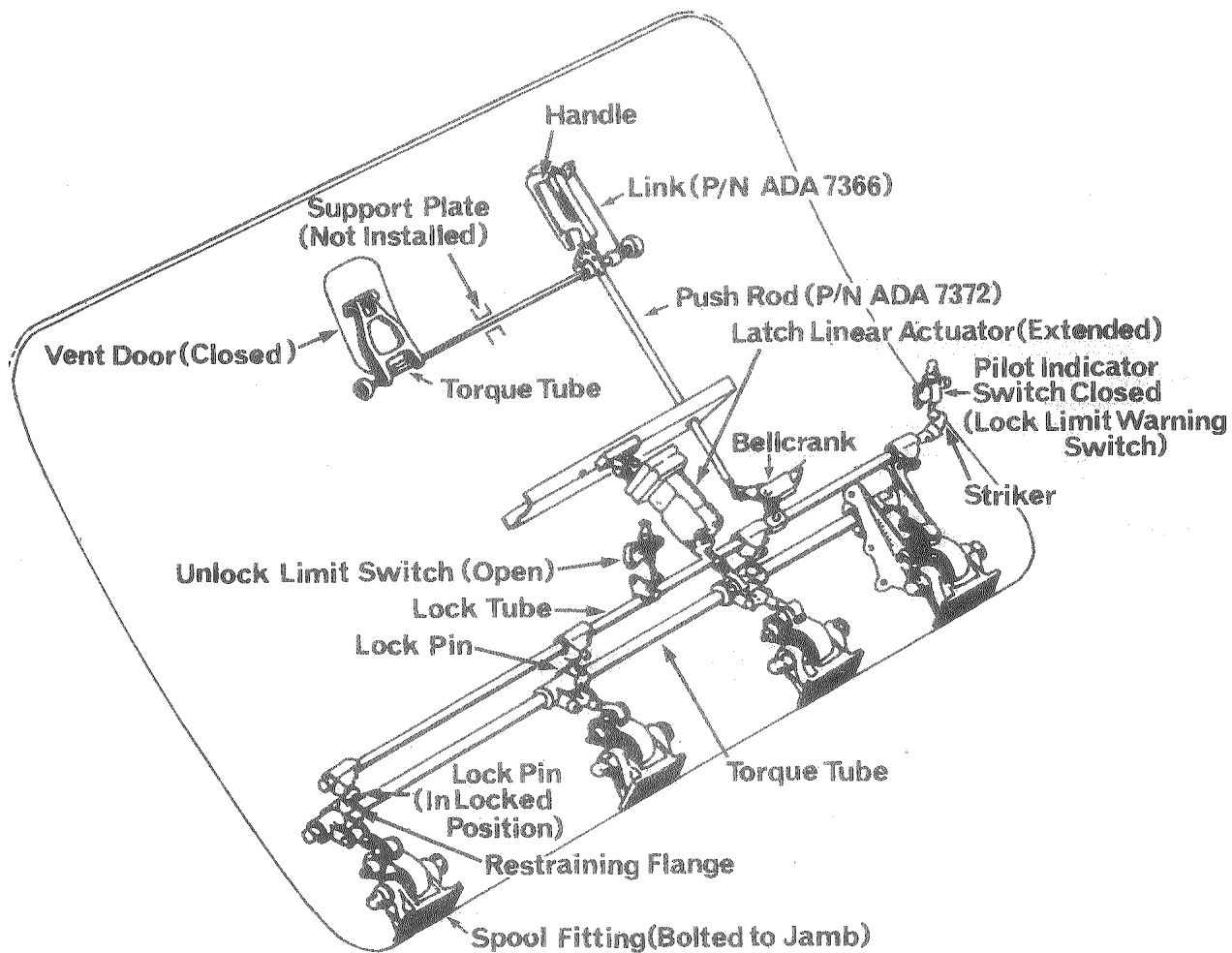
-  Fixed points on the structure
-  Direction of forces transmitted by the latches

TC-JAV ADJUSTMENTS



CORRECT ADJUSTMENTS





**CLOSING AND LOCKING MECHANISM
(CLOSED AND LOCKED POSITION)**

FIG. 6

FORCED CLOSURE

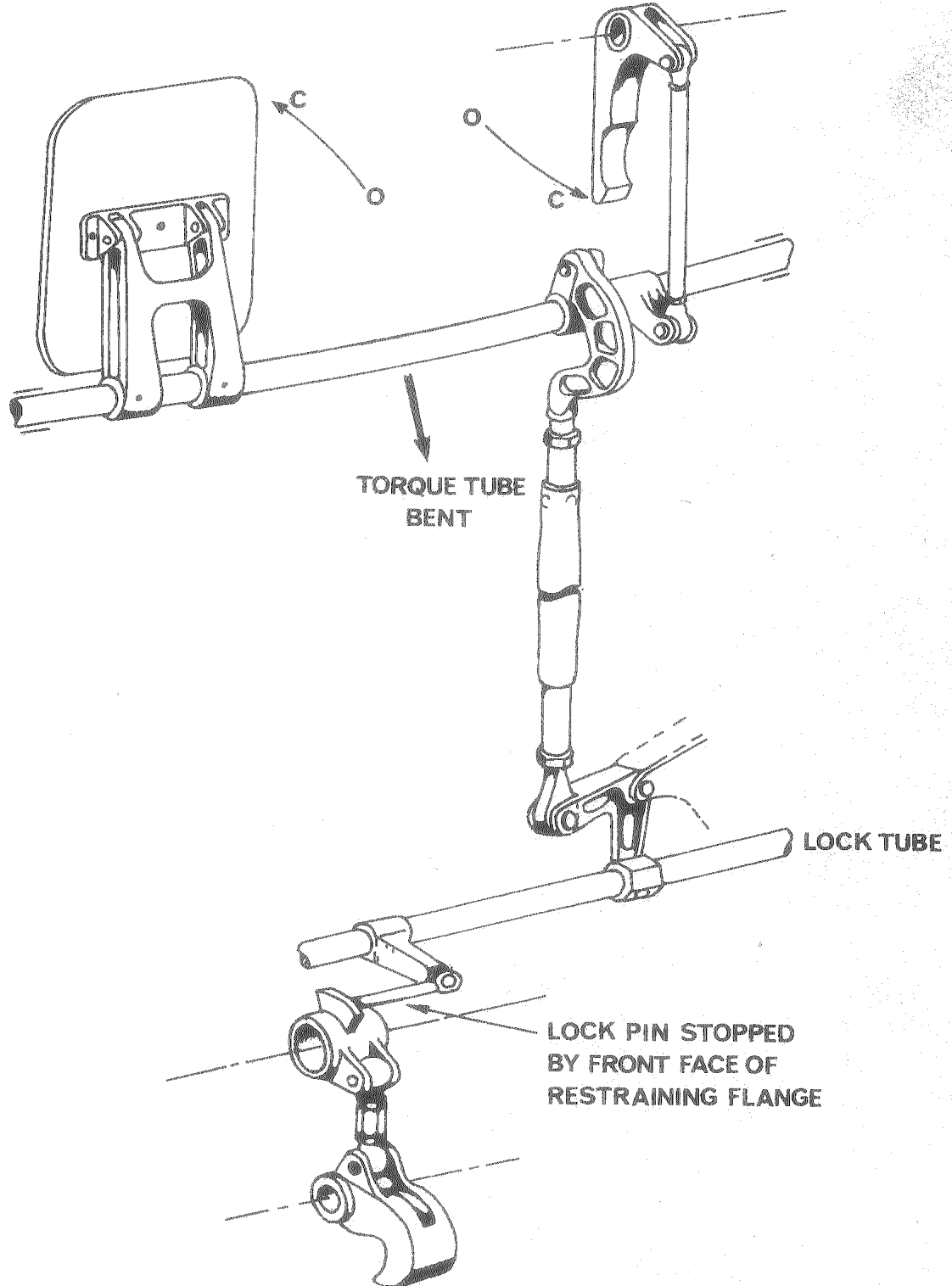


FIG.7

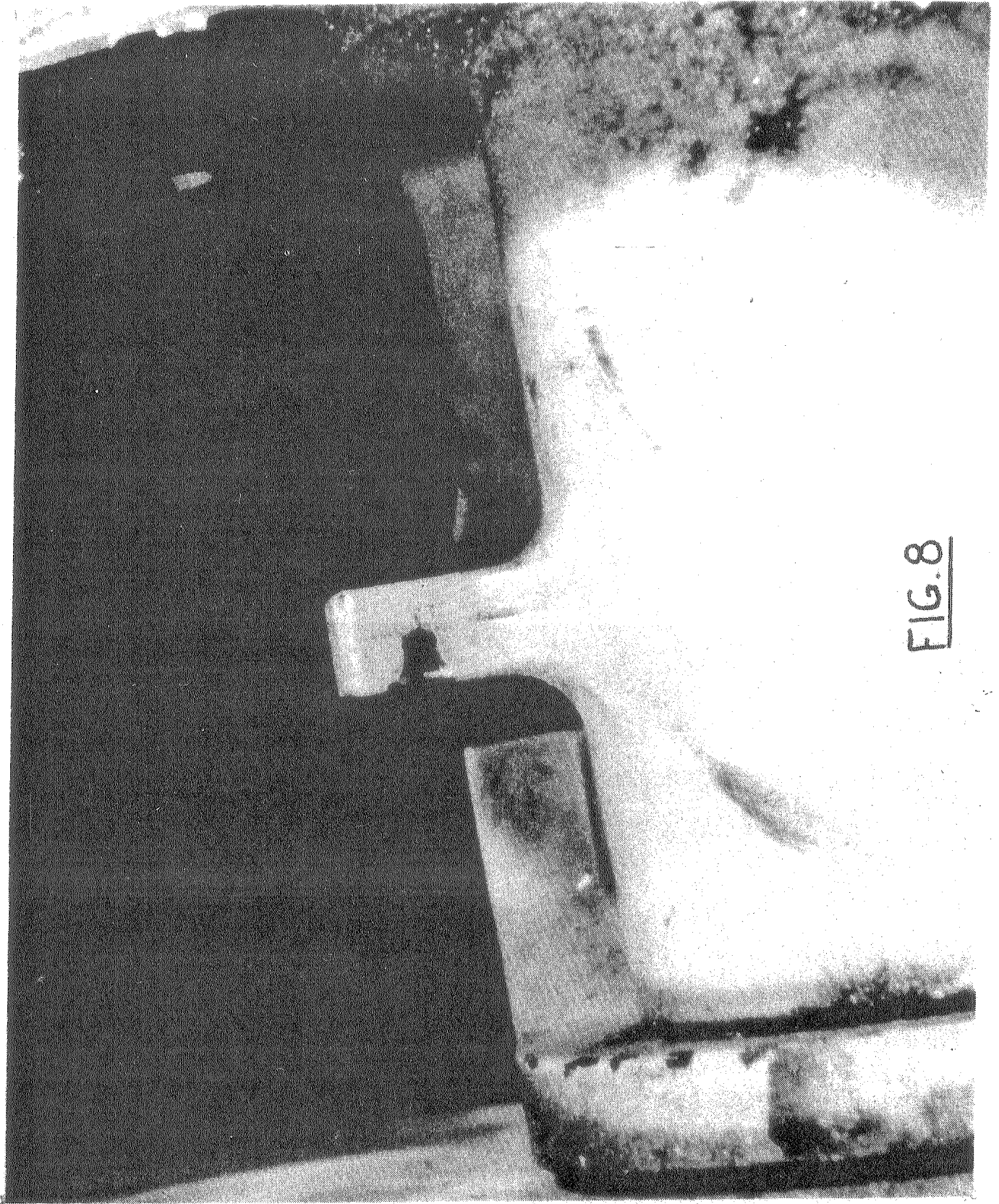


FIG. 8

4 Analysis

4.1 Analysis of the process of ejection of the aft cargo door on the left-hand side

The initiating factor in this accident was the opening and ejection of the aft cargo door during flight.

Expert examination of the wreckage of the door, of which the closing system (latches, latch actuator and operating mechanism) was found in good condition, has revealed various deficiencies. The latter were such that the aircraft's take-off was undertaken with the latches very near to their correct position when closed, but at the same time the links which control the latches had not achieved over-centre (fig 2) and as a natural consequence the lock pins could not have been engaged.

Under these conditions, the chain of operation between actuator and latches is not irreversible: any force exerted on the latches is re-transmitted to the actuator instead of being absorbed by the 4 stops provided for that purpose (fig 1).

The actuator withstood the compression force without displacement of its shaft, since it is irreversible. It therefore transmitted the force from the 4 latches to the two bolts (titanium 0.25 inch in diameter) which attach its fixed part to the door structure.

The force on the latches is directly proportional to the difference between the pressure inside the fuselage and atmospheric pressure. The force is nil on take-off and increases progressively with altitude up to about 22,400 feet.

There is no way of knowing what measures were taken by the flight crew as regards cabin pressurization. No malfunction had been reported and the flight level of 240 chosen for cruise and the fact that the aerodromes of departure and arrival had the same elevation give reason to assume that pressurization was under automatic control. In that case, at 12,000 feet the cabin altitude was close to sea level and the fuselage pressure differential must have been between 330 and 360 mb (4.7 and 5.2 psi). It should be noted that these are figures of the same magnitude as those estimated in connection with the previous accident at Windsor (Ontario).

The force transmitted to the actuator attachment bolts is the product of the force on the latches and the position of the lever arms of the system. (When the link arm pivots are at dead centre the force on the actuator bolts is zero; the force increases as the arms move away from the dead centre position.)

The door therefore remained closed as long as the two bolts attaching the actuator to the door structure withstood the increasing pressurization force.

When the two bolts gave way, the latches opened and the door opened suddenly after breaking the top shaft of the door actuator.

As a result of the sudden stress on the fuselage combined with the dynamic pressure of the air, the door broke into several pieces and became detached from the aircraft

For the configuration of the door of TC-JAV, the studies undertaken have shown that the incomplete closing of the latches resulted from incomplete extension of the actuator shaft.

The tests and research on the parts recovered from the wreckage failed to establish the process with certainty.

- Either the control switch was maintained in an active position for too short a time (the modification contained in SB 52-44¹ had not yet been applied to TC-JAV so that a visual light indicator showing that the shaft had reached the end of its travel was not available to the operator).
- Or the extension of the actuator shaft stopped too soon because of:
 - the slip of its torque limiter;
 - the normal operation of the thermal protection trip device of the electric motor;
 - accidental cut-off of the electrical power supply.

Since the electric motor of the actuator was not found after the accident, it is impossible to establish which of the above reasons was the cause of the actuator's malfunction.

Finally, it should be noted that the door had had to be closed by the manual drive tool on numerous earlier occasions, which would confirm the hypothesis of erratic functioning of the actuator.

4.2 Consequences of the ejection in flight of the aft cargo door on the left-hand side

The loss of the door caused an almost instantaneous drop in the pressurization established in the cargo compartment beneath the passenger cabin floor.

The various pressure relief vents between the cargo compartment and the passenger cabin are not of a size to accommodate a discharge of air as large as that which passed through the door which had suddenly opened. As a result, there was an instantaneous excess pressure above the floor of the order of 36 KPa (about 3.6 tonnes/m²) ie the same order of magnitude as in the case of N 103 AA (cf paragraph 3.16.7).

In the case of TC-JAV, this excess pressure, added to the normal stresses on the floor, caused damage such that parts of passenger seats were ejected from the aircraft together with six passengers probably occupying two triple seat units in line with and above the cargo door. This damage was therefore clearly more substantial than in the case of N 103 AA in which the initial floor loading was lighter.

Studies were undertaken in an attempt to reconstruct the damage sustained by the controls, but the impairment of their functioning could not be established in precise detail. Nevertheless, because all the horizontal stabilizer and elevator control cables are routed

¹Parts ordered by THY and supplied by Douglas, but modification not yet carried out.

beneath the floor of the DC-10 and because of the priority assigned in this aircraft to each of these mechanical controls, the state of airworthiness of TC-JAV after the loss of the cargo door and the disruption of the floor structure must have been such that the crew were left with no means of regaining sufficient control of the aircraft.

5 Conclusions

5.1 Results of the Inquiry

The findings of the Inquiry are as follows:

- The crew members held the certificates, licences and qualifications required for the performance of their duties in the type of aircraft and on the flight in question.
- The aircraft was certificated, equipped and operated in accordance with national and international requirements; both on take-off and at the time of the accident, its load and centre of gravity position were within the appropriate limits.
- Nevertheless, as regards the aft cargo door on the left-hand side:
 - A Service Bulletin 52-37, specifying the installation of a support plate designed to prevent forced closing of the locking handle and the vent door in the case of incomplete engagement of the latching system, had not been applied to the aircraft before delivery and this oversight had not been detected at the time of delivery. It was found, however, that work on the application of this modification had begun on the lock tube where chamfering had been roughly carried out.
 - While the aircraft was in service, a modification (direct access to the drive mechanism) had been carried out in a way which did not comply with Service Bulletin 52-38.
 - The adjustments of the lock pins and the lock limit warning switch were incorrect.
 - The striker of the unlock limit switch had two shims of Douglas origin, surmounted by a shim with no reference and of a quality not to aeronautical standards.
- During the aircraft's stop at Orly, the aft cargo door on the left-hand side had been closed without any apparent abnormality, the locking handle had been pulled down and the vent door closed, although the lock pins were not engaged and no visual inspection had been made through the view port provided for the purpose of verifying that the lock pins were in place.
- The take-off and climb progressed without incident until the aircraft reached approximately 12,000 feet at about 1140 hrs.
- At that time, the aft cargo door on the left-hand side opened in flight and became detached from the aircraft structure.
- The drop in pressure in the cargo compartment caused an immediate pressure

differential which was sufficient to cause the disruption of the floor structure and the consequent ejection of six passengers, their cabin seats and various pieces of wreckage.

- The deformation and disruption of the floor led to serious impairment of the controls of No 2 engine and of the flight controls of which the cables run under this part of the aircraft structure and the damage was such that it was impossible for the crew to regain control of the aircraft.
- Because of the design of the mechanism as a whole, the incomplete application of modification SB 52-37 (absence of support plate specified) and the adjustments found on measurement to be incorrect (lock pins and striker), it was possible for the door locking handle to be pulled down without the use of any abnormal force and for the flight deck visual warning light to be switched off, when the latches were not fully engaged and the lock pins not in place. The tests and research have confirmed incomplete engagement of the cargo door latches and in correlation the non-engagement of the lock pins.
- The Inquiry into an accident at Windsor (Ontario) on 12 June 1972 had provided evidence of the grave risks entailed by sudden depressurization of the cargo compartment: the inadequacy of the pressure relief vents had resulted in the disruption of the floor under which the flight control cables run, thereby causing the jamming or rupture of the cables.

5.2 Causes of the accident

The accident was the result of the ejection in flight of the aft cargo door on the left-hand side: the sudden depressurization which followed led to the disruption of the floor structure, causing six passengers and parts of the aircraft to be ejected, rendering No 2 engine inoperative and impairing the flight controls (tail surfaces) so that it was impossible for the crew to regain control of the aircraft.

The underlying factor in the sequence of events leading to the accident was the incorrect engagement of the door latching mechanism before take-off. The characteristics of the design of the mechanism made it possible for the vent door to be apparently closed and the cargo door apparently locked when in fact the latches were not fully closed and the lock pins were not in place.

It should be noted, however, that a view port was provided so that there could be a visual check of the engagement of the lock pins.

This defective closing of the door resulted from a combination of various factors:

- incomplete application of Service Bulletin 52-37;
- incorrect modifications and adjustments which led, in particular, to insufficient protrusion of the lock pins and to the switching off of the flight deck visual warning light before the door was locked;

- the circumstances of the closure of the door during the stop at Orly, and, in particular, the absence of any visual inspection, through the view port, to verify that the lock pins were effectively engaged, although at the time of the accident inspection was rendered difficult by the inadequate diameter of the view port.

Finally, although there was apparent redundancy of the flight control systems, the fact that the pressure relief vents between the cargo compartment and the passenger cabin were inadequate and that all the flight control cables were routed beneath the floor placed the aircraft in grave danger in the case of any sudden depressurization causing substantial damage to that part of the structure.

All these risks had already become evident, nineteen months earlier, at the time of the Windsor accident, but no efficacious corrective action had followed.

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COMMISSION OF INQUIRY
INTO THE ACCIDENT TO
TURKISH AIRLINES DC-10 TC-JAV
ON 3 MARCH 1974

246, rue Lecourbe - 75015, Paris

Safety Recommendations

1 After the accident near Windsor, Ontario, two safety recommendations were issued by the National Transportation Safety Board (N.T.S.B.):

- Recommendation A-72-97 relating to the modification of the cargo door locking system to make it impossible to position the locking handle and vent door to their normal door-locked positions unless the lock pins are fully engaged.
- Recommendation A-92-98 relating to the means of minimising the effect on the flooring in the event of sudden depressurization of the cargo compartments.

The Ermenonville accident has shown that the modifications made to the locking system, modifications moreover incompletely applied to TC-JAV, were inadequate and that the measures proposed to mitigate sudden decompression had not been carried out.

Since the accident, the certification authorities and the manufacturer have decided to put new procedures and modifications into operation.

The Commission is of the opinion that their application should be mandatory and that they should be implemented as soon as possible in the case of all aircraft of the type in question.

In general, the Commission recommends that in the case of all the aircraft particular attention should be paid to the efficacy of the cargo door closing, locking and checking systems, and also to the behaviour of the flooring in the case of sudden depressurization of the cargo compartments.

2 Alongside the above measures, the fact remains that the case of TC-JAV has shown that the necessary redundancy of the flight controls could be inadequate when the routing of the systems as a whole was concentrated at points where structural damage could occur.

The case of TC-JAV has also drawn attention to the possible consequences of damage to a control circuit, damage which should never inhibit the operation of the surviving circuits.

3 The Commission recommends that the training of personnel responsible for operating the cargo doors or checking their closure should be organised in accordance with a detailed programme established by agreement between the manufacturer and the airline and approved by the official services.

4 Examination of the procedures used after the Windsor (Ontario) accident, in order to advise the manufacturer and the airline of the necessary modifications, has shown that the method of the 'airworthiness directive' was not used; for that reason, the recommended measures were not mandatory and appropriate means were not employed to bring the matter to the attention of those concerned.

The Commission recommends that the mandatory procedure of 'airworthiness directives', whatever the financial repercussions, should be selected whenever safety could be at serious risk.

5 As a result of the magnitude of the disaster and, in particular, the large number of victims, there were considerable difficulties in the recovery, preservation and identification of the bodies. It became apparent, in particular, that the Institut Médico-Légal de Paris and the Paris hospitals did not have facilities on a scale related to this type of situation.

The Commission recommends that a study should be made of the measures required to take account of the new problems raised by the large capacity of the aircraft.