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Civil Aircraft Airworthiness Data  
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events relating to airspeed  
control and handling (February  
1966 to December 1967)

by

*The CAADRP Special Events Working Party*

*(Co-ordinated by G. E. King, R.A.E.)*

LONDON HER MAJESTY'S STATIONERY OFFICE

1969

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CIVIL AIRCRAFT AIRWORTHINESS DATA RECORDING PROGRAMME

SPECIAL EVENTS RELATING TO AIRSPEED CONTROL AND HANDLING  
(FEBRUARY 1966 TO DECEMBER 1967)

by

The CAADRP Special Events Working Party  
(Co-ordinated by G. E. King, R.A.E.)

SUMMARY

A small number of jet aircraft in normal airline service are fitted with recorders which produce continuous trace records of airworthiness data for 14 parameters. Throughout the recording period the records have been searched for unusual occurrences, and each one has been studied to determine its nature and, where possible, its cause.

This Report describes a selection of events relating to airspeed control and handling which were found in records taken between February 1966 and December 1967.

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\*Replaces R.A.E. Technical Report 68195 - A.R.C. 31068.

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## 1 INTRODUCTION

The object of the Civil Aircraft Airworthiness Data Recording Programme is a systematic study of the normal operational flight of civil transports. A small number of aircraft in regular airline service are fitted with analogue paper trace recorders which collect data in the form shown in Fig.1. This is the type of record currently obtained (since November 1965) from second generation jets; prior to this date fewer parameters were recorded and the aircraft were earlier types. The whole programme is described fully elsewhere<sup>1</sup>.

From time to time unusual or extreme events (special events) are noted and this Report contains a selection of such events relating to airspeed control and handling which occurred to pure jet transport aircraft in scheduled airline operations. They are presented in the form of a reproduction\* of the original record, together with a description of the event, any relevant supplementary information and comments which represent the opinion of a Working Party comprising members of R.A.E., A.R.B., Benson Lehner Data Centre and the Airlines concerned.

The selections of Special Events issued to date<sup>2-5</sup> are all on the earlier type of record and this Report is the first selection of events from second generation jets recording 14 parameters.

## 2 NOTE ON SELECTION OF SPECIAL EVENTS

After the photographic record has been developed, it is examined and annotated by the airline concerned. It is then scrutinized by a member of the Working Party for Special Events, and finally examined in detail at the Data Centre during routine analysis. There are thus at least three stages in which a Special Event occurring during a recorded flight may be detected.

It is not possible to lay down a hard and fast guide as to what is regarded as an unusual or extreme event, but the following is a summary of the type of thing which is looked for in the search:-

- (a) Normal acceleration increment of about  $\pm 1.0$  g or larger.
- (b) Rapid and large changes of height or airspeed.

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\*Definition is necessarily lost in photographic reproduction of records; comments are based on observations from the original records.

(c) Excessive application of a control.

(d) Infrequent operational events such as abandoned take-offs, missed approaches, engine failures, engine-out landings etc.

(e) Unusual oscillations of any of the traces.

(f) Exceedences of operational limitations such as maximum operating speeds.

Despite the fact that each record is examined at least three times, it is unlikely that every unusual event will be detected; this is particularly true of certain of the operational events such as engine failure. Hence any frequencies derived from these data should be treated with caution.

### 3 SPECIAL EVENTS

#### 3.1 General comments

Fig.1 shows a sample of normal flight to familiarise the reader with the recorded parameters.

The events have been grouped according to flight phase.

#### 3.2 Take-off and climb

Seven events in this category are shown in Figs.2 to 7 with their respective descriptions (3.2.1 to 3.2.6).

#### 3.3 Descent

Three events in this category are shown in Figs.8 to 10 with their respective descriptions (3.3.1 to 3.3.3).

#### 3.4 Approach

Seven events in this category are shown in Figs.11 to 17 with their respective descriptions (3.4.1 to 3.4.7).

#### 3.5 Landing

Three similar events in this category are shown in Figs.18a, 18b and 18c with the description (3.5).

### 4 CONCLUDING REMARKS

The events described in this Report can in no way be described as hazardous situations but they do represent some of the extremes of behaviour

experienced in many hours of normal flying and as such they indicate problems in the following areas:-

- (i) Flap operating speeds.
- (ii) Pitch control.
- (iii) Airspeed excursions under manual and autopilot control.
- (iv) Auto-throttle performance.

(i) Fig.5 shows one of the largest exceedences of flap limiting speed so far recorded. Smaller exceedences occur not infrequently because the small margin between maximum flap speed and minimum clean aircraft speed presents the pilot with a difficult task at a busy period in the flight.

(ii) Pitch oscillations of the order of  $\pm 5^{\circ}$  can occur, as shown in Figs.3, 7 and 12. In these cases it is difficult to believe that the aircraft is being flown by reference to pitch attitude.

(iii) Figs.11, 16 and 17 are examples of low airspeeds being reached under manual control. They occurred in high work load situations i.e. aircraft positioning during a hold; radar controlled approach in turbulence; keeping watch for aircraft known to be in the vicinity, but not in radio contact.

Figs.6a and 6b are examples of a speed exceedence during climb caused by engaging the autopilot before the correct pitch attitude was achieved.

Figs.8, 9 and 10 are examples of a speed exceedence during descent whilst on autopilot. The use of the rate of descent lock to generate high rates of descent appears to be undesirable. The airspeed lock is much to be preferred.

(iv) Figs.13, 14 and 15 are examples of low airspeeds being reached whilst on auto-throttle.

In the first two instances the auto-throttle reached the limit of authority and was overridden by the pilot. However, the ability of the auto-throttle to give the required power at all times is currently being improved.

In the third case the auto-throttle stopped altogether and this was not noticed by the pilot until a low airspeed had been reached. It is possible that the pilot's airspeed scanning rate is reduced when on auto-throttle.





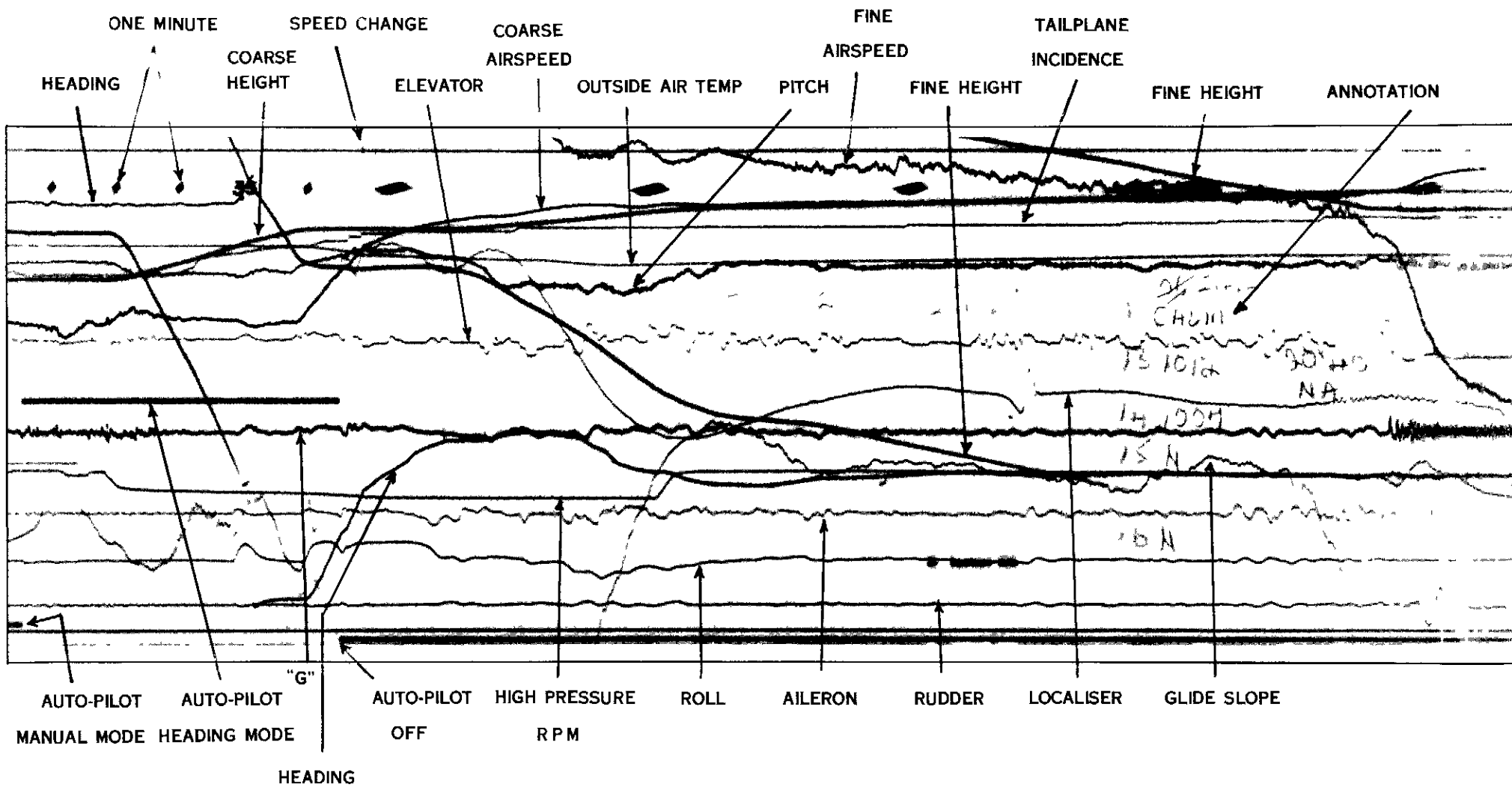


Fig.1. Sample record

### 3.2.1 Event in Flight 11673

Sector: Antigua/Barbados - December 1967

#### Description

The take-off from Antigua was achieved by a rotation at high speed and immediate unstick. Rotation should have been initiated at 126 kt for this weight but was delayed for 4 seconds (152 kt). (See Fig.2.)

#### Comment

It is not known why the aircraft did not rotate at  $V_R$ . However the initial climb out is carried out with careful regard to pitch attitude, which results in good airspeed control. This demonstrates that an accurate climb out can be achieved even after a late rotation by strict adherence to the correct operating technique.

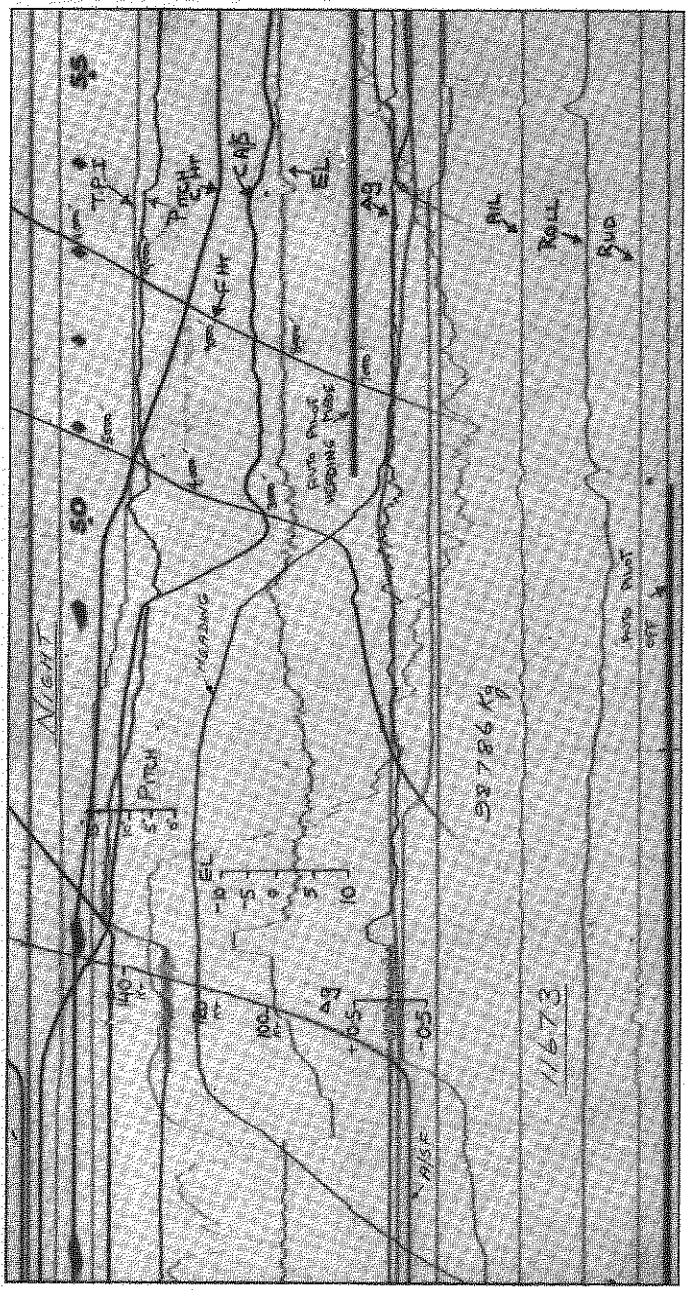


Fig.2. Event in flight 11673

### 3.2.2 Event in Flight 20375

Sector: Lima/Kingston - November 1967

#### Description

During the initial climb out from Lima in calm weather, the pitch attitude varied between  $6^{\circ}$  and  $18^{\circ}$  at 10 seconds period; this necessarily produced changes in normal acceleration and rate of climb (See Fig.3).

#### Supplementary information

The weather at Lima was calm, 9 miles visibility and 8/8 cloud at 1500 ft.

#### Comment

Integration of the acceleration trace shows that the aircraft was always climbing but the rate of climb varied between 580 and 2200 ft/min. The oscillation may have been initiated by the operation of trim (tailplane incidence) at unstick, but an accurate climb out can be achieved on this aircraft type even with gross mis-trim by strict attention to pitch attitude after unstick (see paragraph 3.2.1).

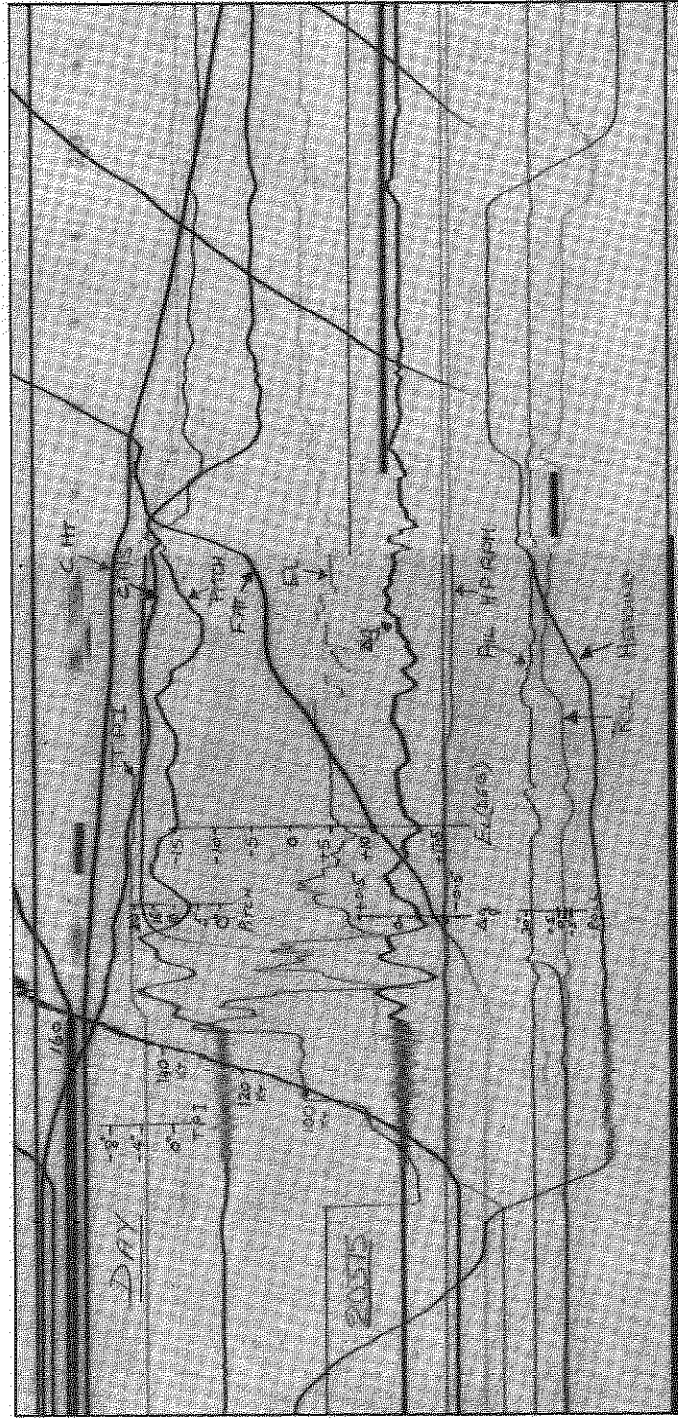


Fig.3. Event in flight 20375

### 3.2.3 Event in Flight 11425

Sector: New York/Montego Bay - September 1967

#### Description

As power was reduced for noise abatement during the climb, the aircraft entered a 120°/min turn and continued to climb at a reduced rate. The airspeed then started to fall and the aircraft was pitched down progressively to 3° nose down. The airspeed then started to build rapidly and +0.65 g increment was pulled to prevent flap limiting speed (229 kt) being exceeded. (See Fig.4.)

#### Supplementary information

The weather for half an hour before and after take-off was as follows:-

0251Z - Cloud 7000 ft scattered, Visibility 15 miles, Wind 330°/10 kt.

0351Z - Cloud clear, Visibility 15 miles, Wind 330°/12 kt.

#### Comment

A manoeuvre load of +0.65 g increment is an infrequent event, but this was produced in following a noise abatement/air traffic requirement in good weather at night. The event appears to be caused by excessive pilot work load i.e. turn, levelling off, noise abatement procedure and possibly radio calls simultaneously. This indicates the desirability of making departure procedures as simple as possible.

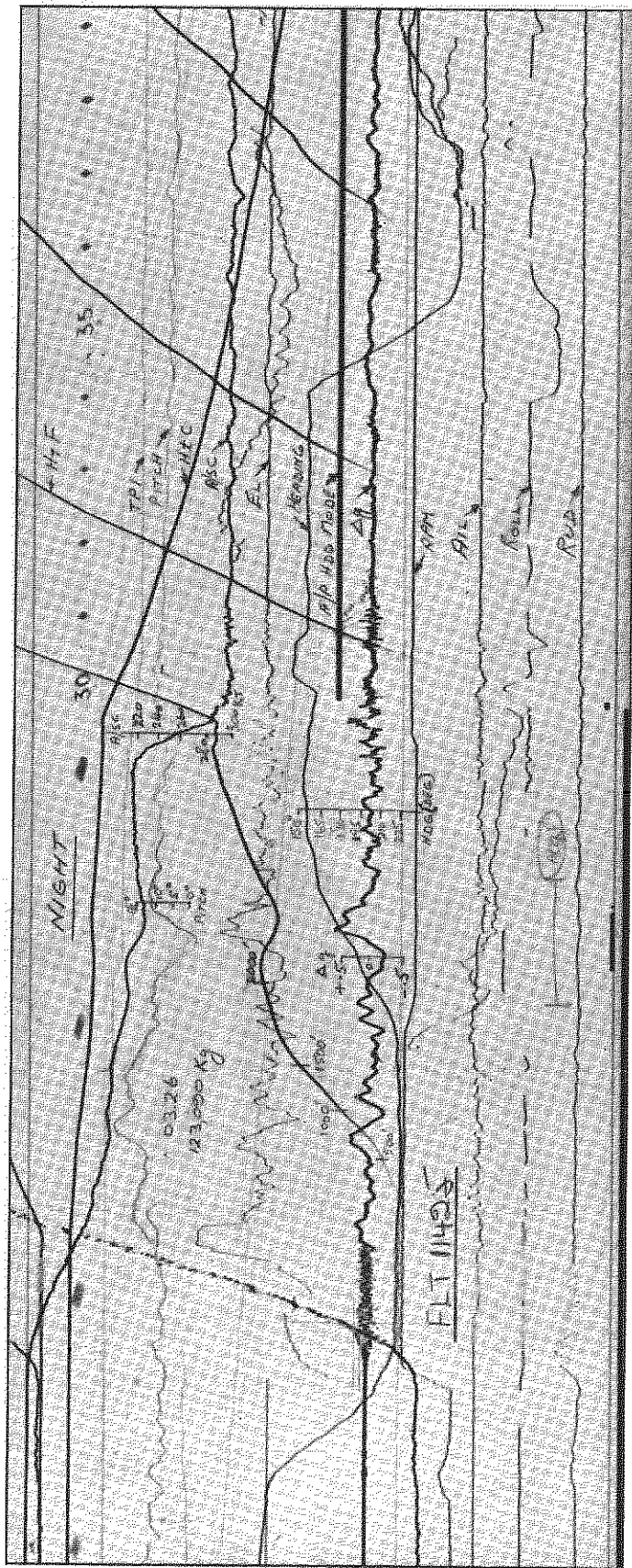


Fig.4. Event in flight 11425

### 3.2.4 Event in Flight 20135

Sector: New York/Prestwick - August 1967

#### Description

The flap limiting speed of 229 kt was exceeded by 23 kt with 6° flap at 4000 ft during climb out from New York. Note that the acceleration trace is unserviceable. (See Fig.5.)

#### Comment

The flap raising technique on this aircraft type is a difficult one at high weight due to the small difference between the maximum speed with flap and the minimum speed without flap. This event shows one of the largest speed exceedences so far recorded in similar circumstances.



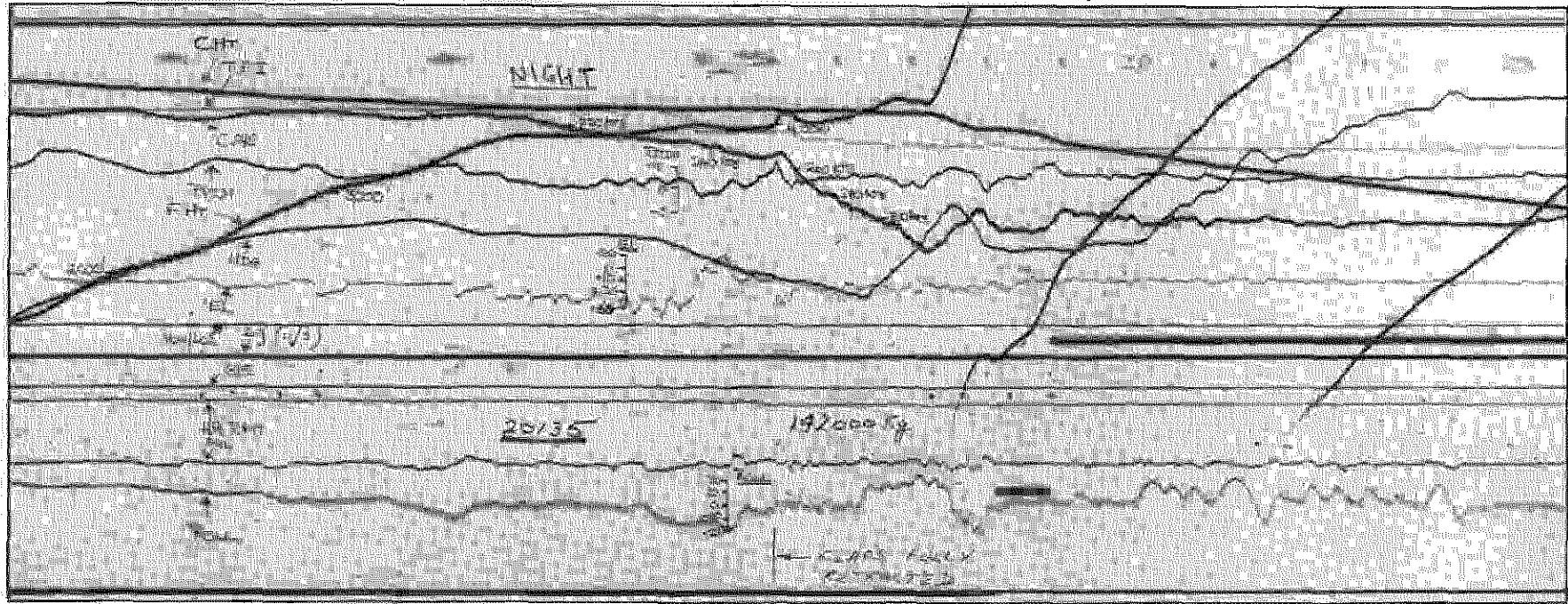


Fig.5. Event in flight 20135

### 3.2.5 Event in Flights 20346 and 20363

Sectors: Chicago/Montreal - November 1967

London/Shannon - November 1967

#### Description

Following flap retraction, the indicated airspeed was allowed to reach 335 kt.  
(See Figs.6a and 6b.)

#### Comment

Power was applied before the correct pitch attitude was achieved and with autopilot engaged the rate of pitch change available is limited. The normal climb out speed is 290 kt with  $V_{mo}$  at 333 kt.

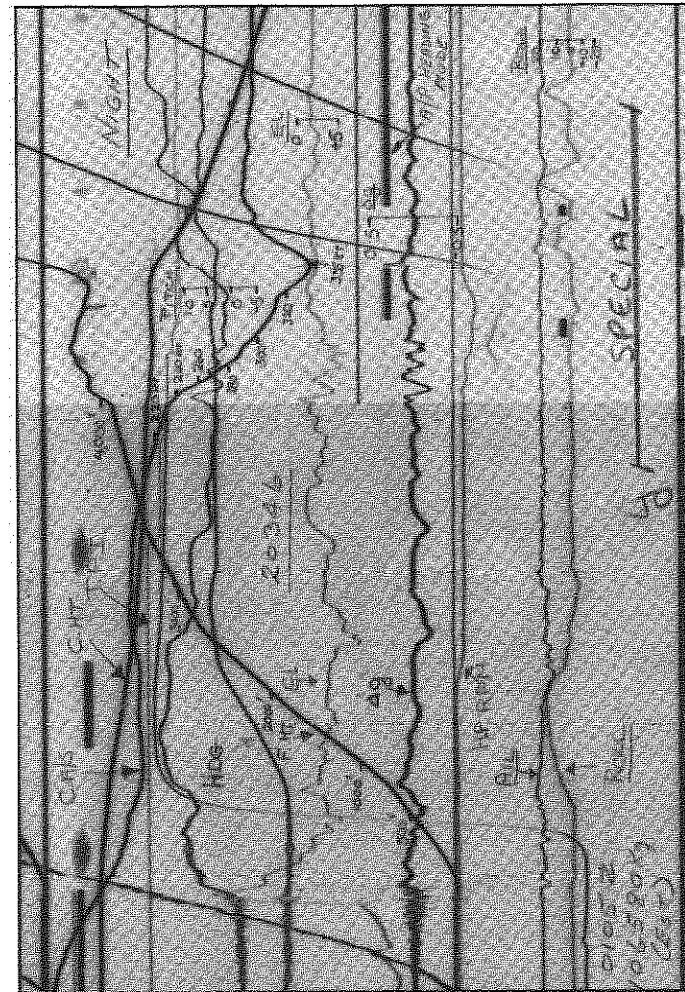


Fig.6a. Event in flight 20346

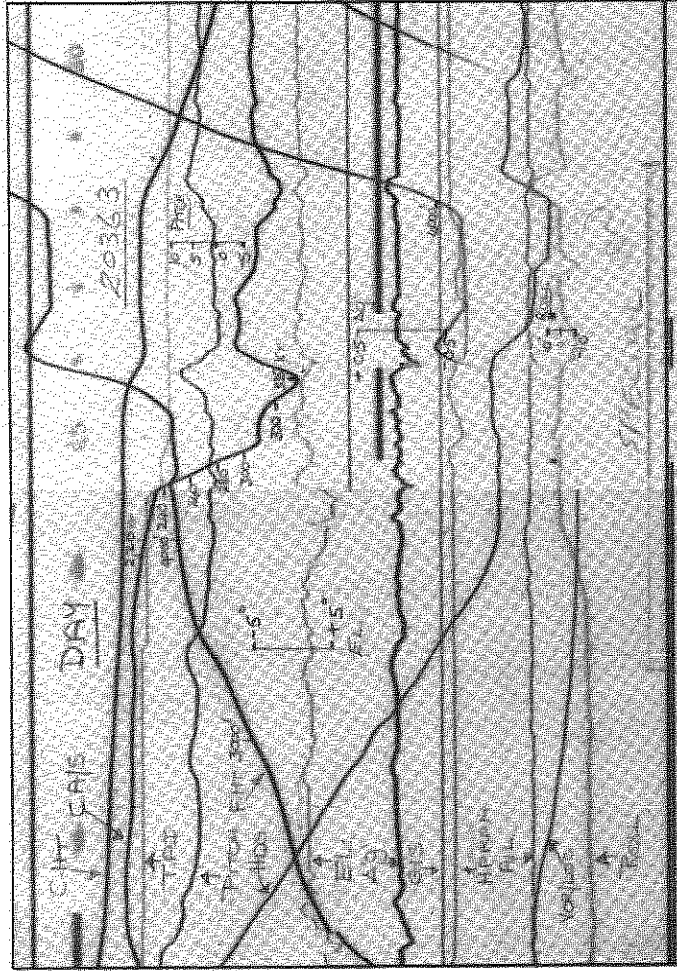


Fig.6b. Event in flight 20363

### 3.2.6 Event in Flight 2047

Sector: Montreal/London - December 1967

#### Description

The aircraft was flown with autopilot off during the climb and pitch changes of up to  $12^{\circ}$  occurred with the rate of climb varying between 3800 ft/min climb and 500 ft/min descent. There was light to moderate turbulence present. (See Fig.7.)

#### Comment

The precise flight path obtained during climb when using the autopilot (see Figs.3 and 4) is not possible with the autopilot off, but the deviations in this event appear to be excessive. They were caused by failure to maintain a constant pitch attitude.

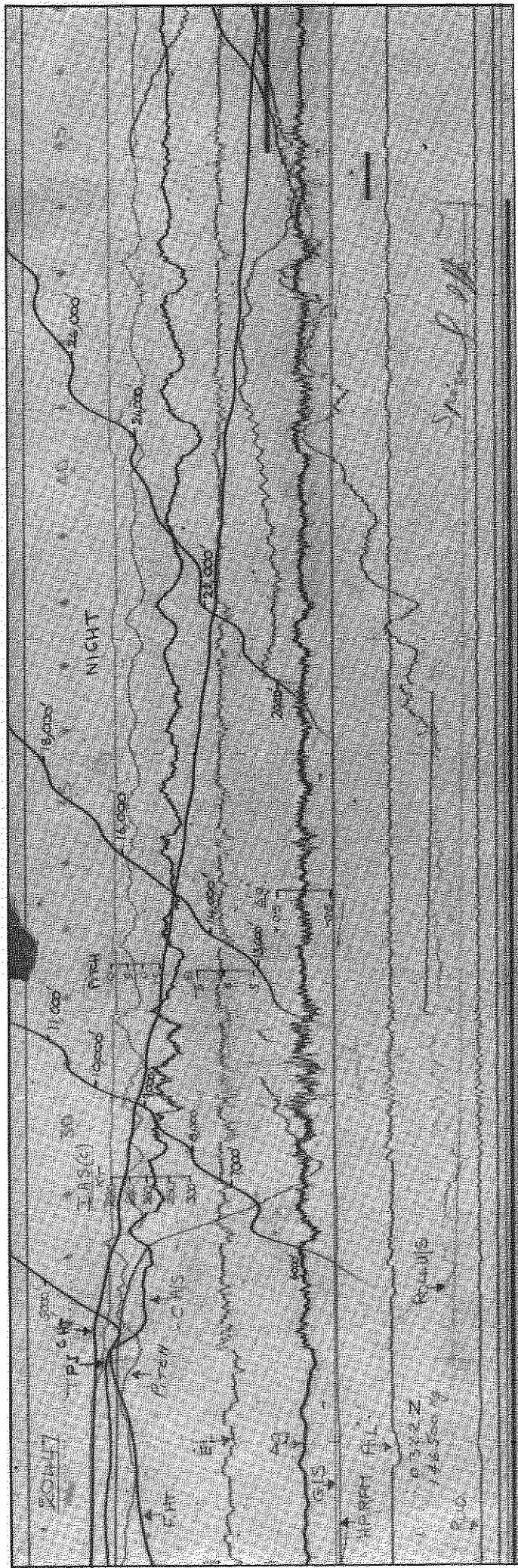


Fig.7. Event in flight 20447

### 3.3.1 Event in Flight 40108

Sector: London/Paris - July 1966

#### Description

During the descent, the indicated airspeed reached 401 kt with a rate of descent of 6400 ft/min after the autopilot had been disconnected at 390 kt.  $V_{mo}$  is 380 kt ias. (See Fig.8.)

#### Comment

The following pilot comment was obtained:-

"The initial descent was carried out using rate of descent lock to achieve a high rate of descent at 370 kt. A turn was initiated while still on rate of descent lock, which necessarily caused an increase in airspeed. After the autopilot had been disconnected a further increase in airspeed took place and this was caused by the correct decision to level the wings before easing out of the drive."

The descent procedure has now been changed and speed lock is used in descent.

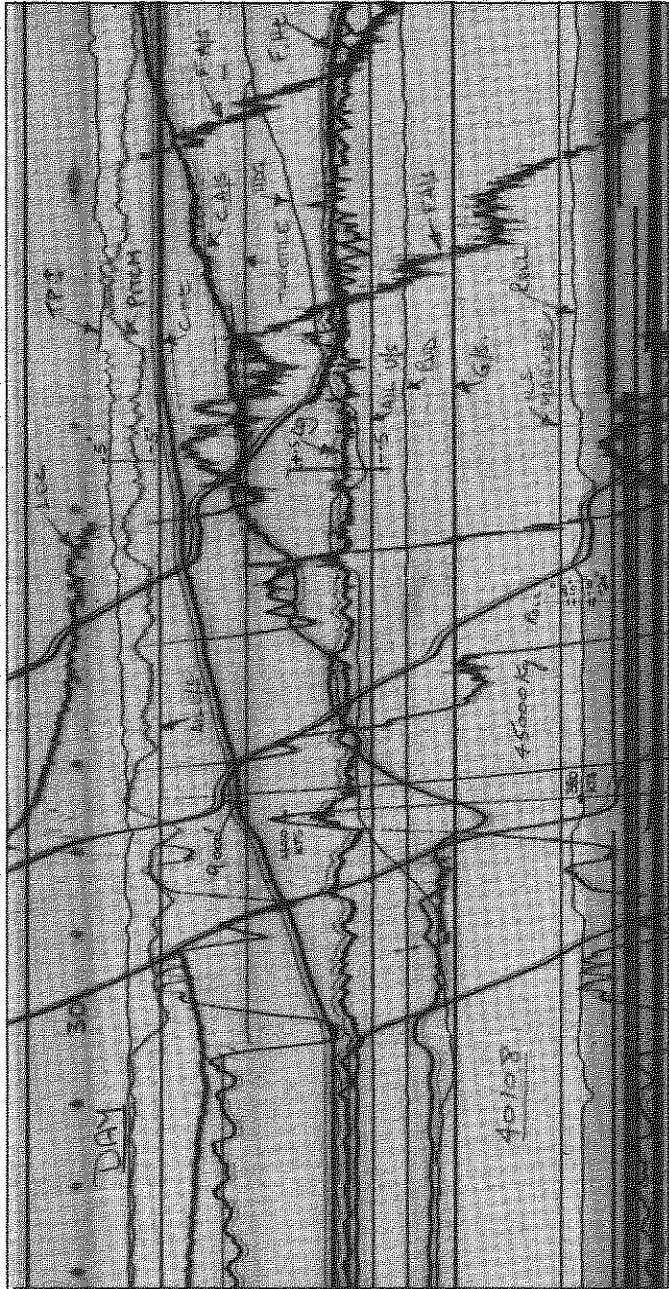


Fig. 8. Event in flight 40108

### 3.3.2 Event in Flight 51902

Sector: London/Vienna - August 1967

#### Description

During the descent, the indicated airspeed reached 400 kt with a rate of descent of 8000 ft/min after the autopilot had been disconnected at 390 kt.  $V_{mo}$  is 380 kt ias (see Fig.9).

#### Comment

This is a similar incident to 3.3.1.



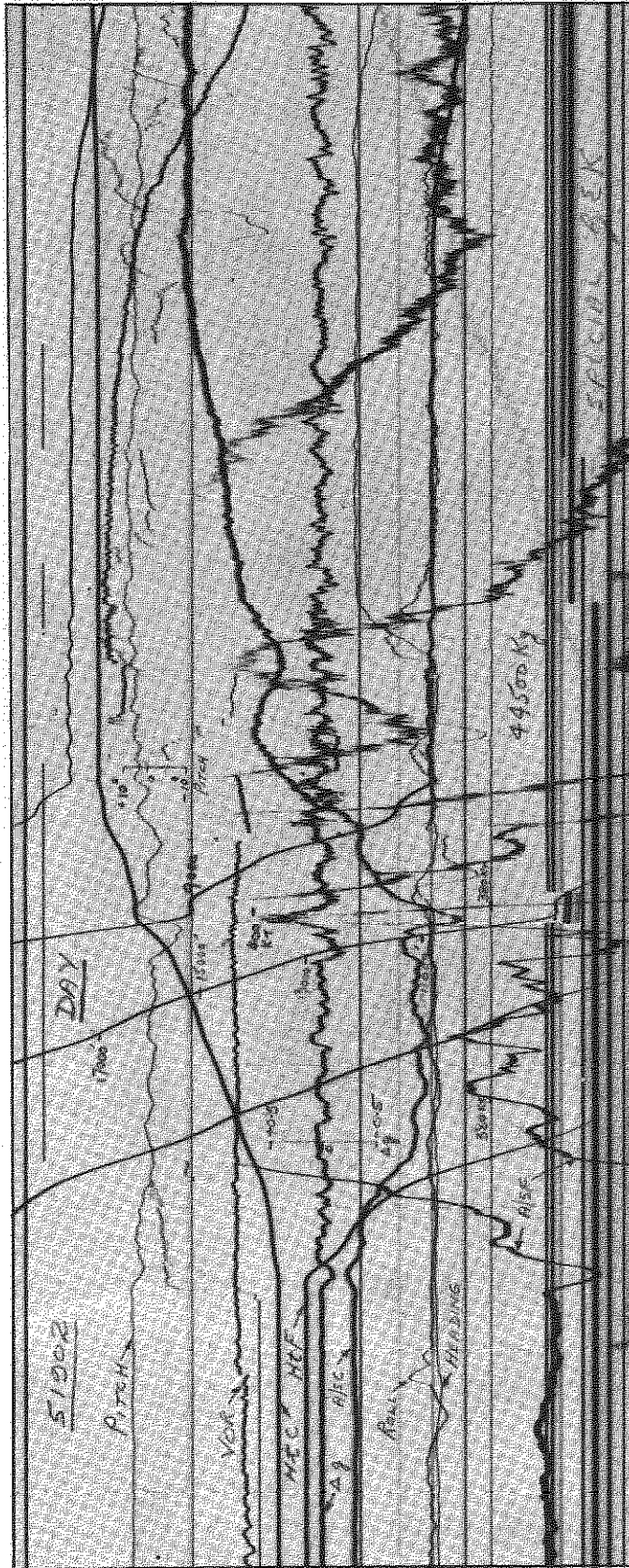


Fig.9. Event in flight 51902

### 3.3.3 Event in Flight 51967

Sector: Zurich/London - September 1967

#### Description

During the descent the indicated airspeed reached 390 kt with a rate of descent of 8000 ft/min. This was terminated by a manoeuvre of +0.2 g increment at the end of which the aircraft entered a 25° bank turn. The rate of descent then increased again to 5200 ft/min at which point the autopilot was disconnected and the wings levelled before pulling a manoeuvre of +0.5 g increment. The extremes of pitch attitude reached were -12° and +14°. Throughout the period the airspeed was reducing to allow operation of droop/flap. (See Fig.10.)

#### Comment

The event was almost certainly caused by overcontrolling with the autopilot speed selection control whilst on speed lock.

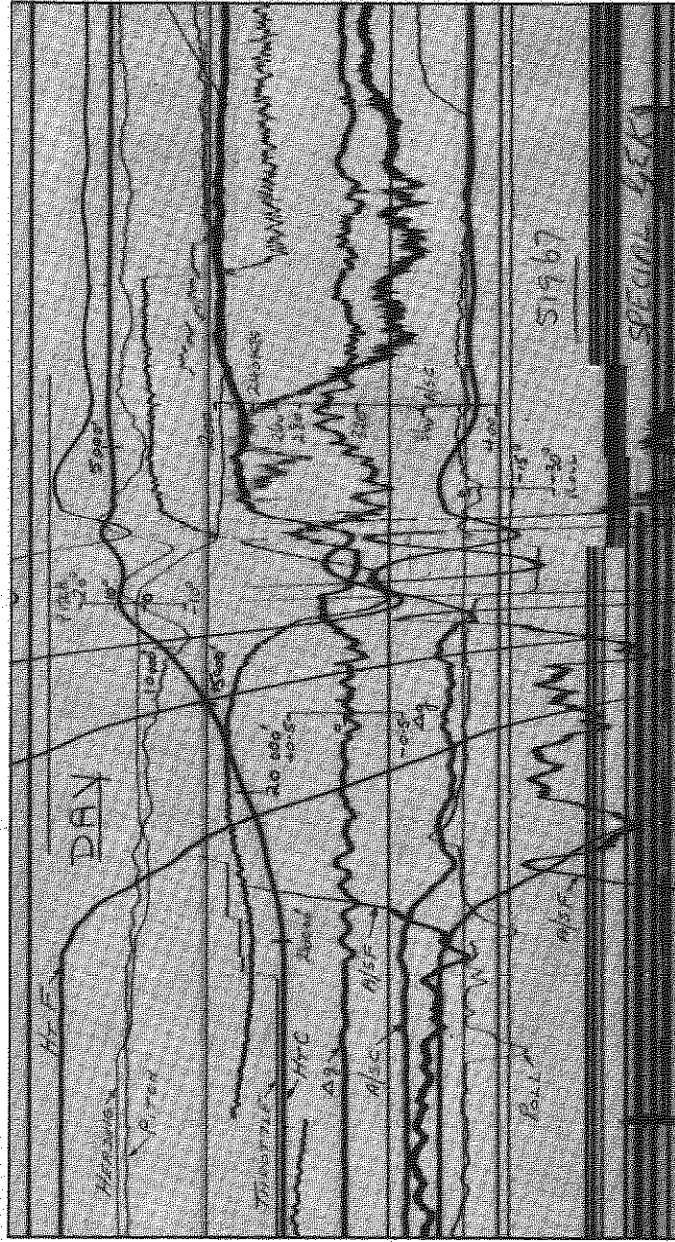


Fig.10. Event in flight 51967

3.4.1 Event in Flight 11284

Sector: Colombo/Bombay - July 1967

Description

During a hold at 6300 ft, the aircraft was pitched down 14° to produce a rapid speed increase from the lowest value of 145 kt. (See Fig.11.)

Comment

It would appear that either the low airspeed was noticed only at the end of a procedure turn, or the undercarriage warning horn operated causing the pilot to take vigorous corrective action.

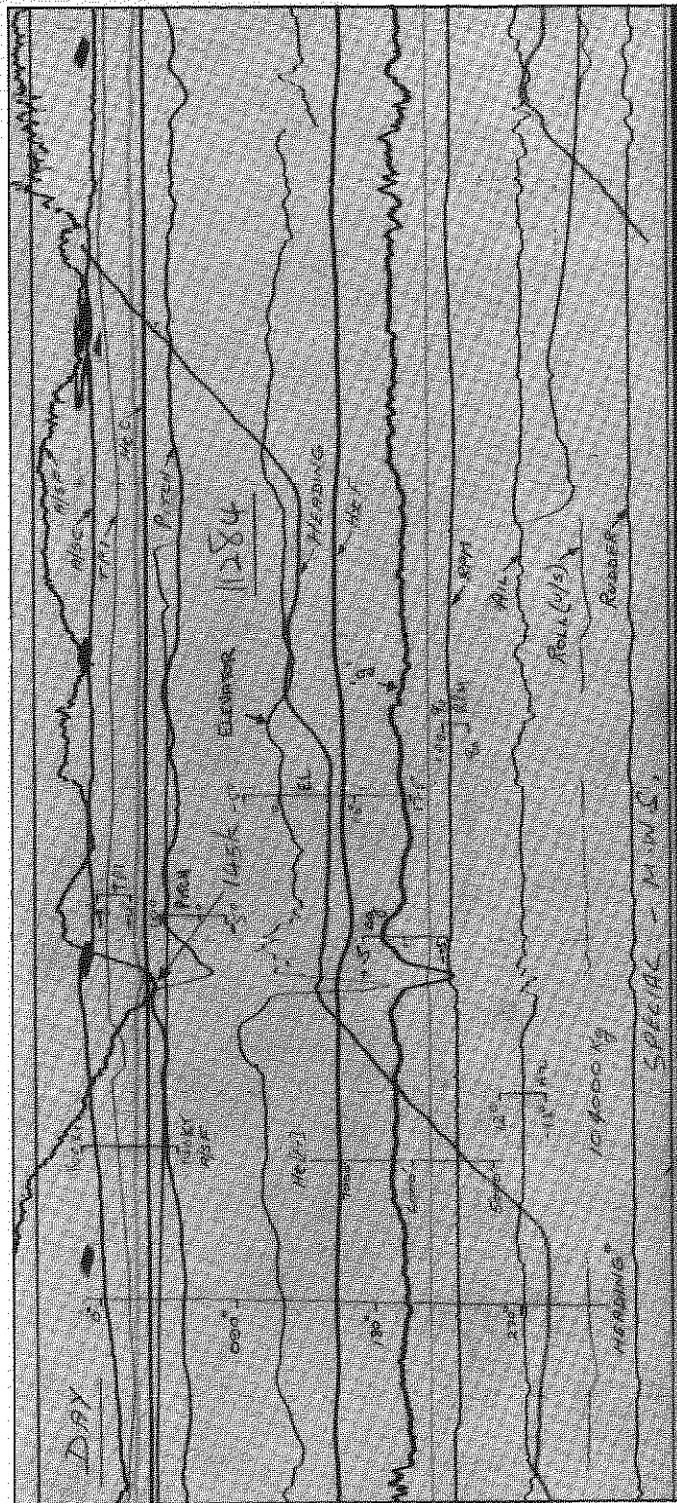


Fig.11. Event in flight 11284

### 3.4.2 Event in Flight 1124-2

Sector: New York/London - July 1967

#### Description

A pitch oscillation of  $\pm 5^\circ$  amplitude developed at about 2000 ft altitude during a manual ILS approach (see Fig.12).

#### Supplementary information

The Heathrow weather at 0600Z was as follows:-

Wind 260°/10 kt, Visibility 6 km, drizzle, Cloud 2/8 ST 600 ft, 8/8 ST 900 ft, 7/8 SC 4500 ft.

#### Comment

There was conflict between the elevator and trim during localiser capture and this may have produced the changes in pitch. The glide slope was joined from above which introduces further difficulties.

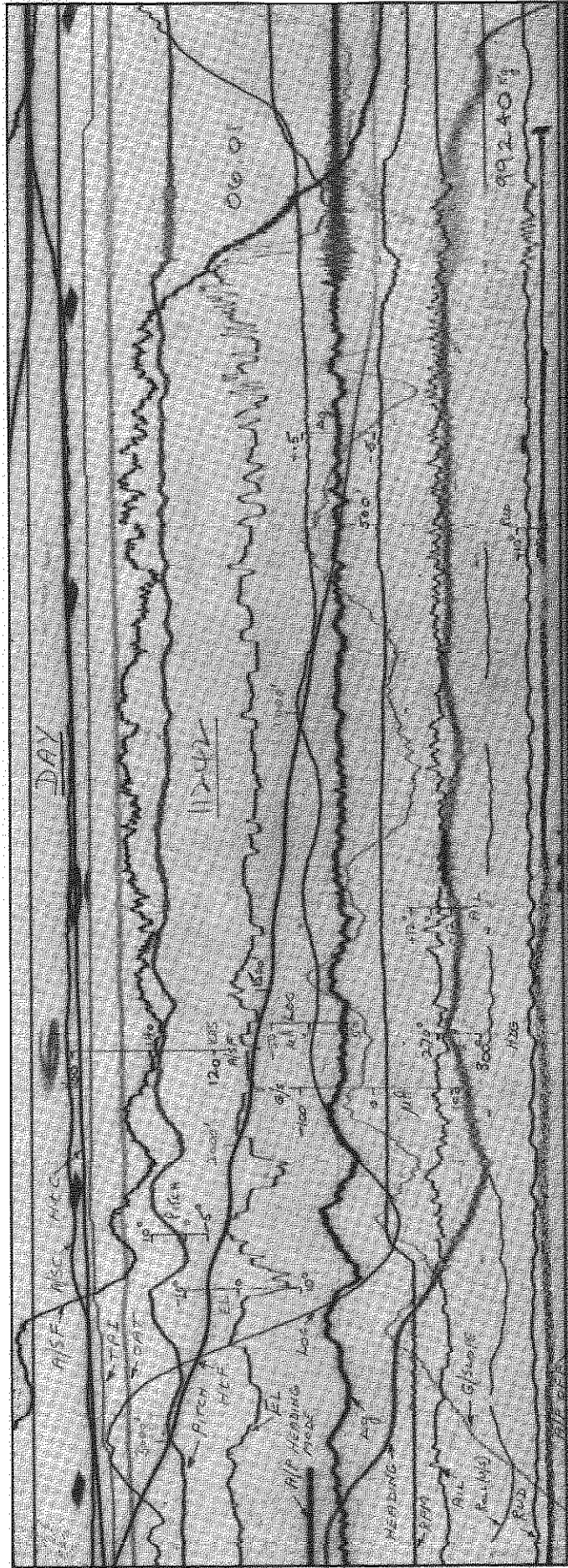


Fig.12. Event in flight 11242

### 3.4.3 Event in Flight 50147

Sector: London/Copenhagen - February 1966

#### Description

During the final approach the indicated airspeed fell to 137 kt whilst the auto-throttle, having reached the limit of authority, was overridden by hand to full throttle. (See Fig.13.)

#### Supplementary information

The weather at Copenhagen was as follows:-

11.20Z Wind 060°/25 kt, Visibility 4 km, Snow, Cloud 6/8 1300 m.

#### Comment

The fall in airspeed was probably caused by wind shear which the auto-throttle was inadequate to deal with, as no pull up manoeuvre was initiated just prior to the reduction. The power was set to the minimum for 5 seconds before the loss in airspeed; this may have aggravated the slow response of the auto-throttle.



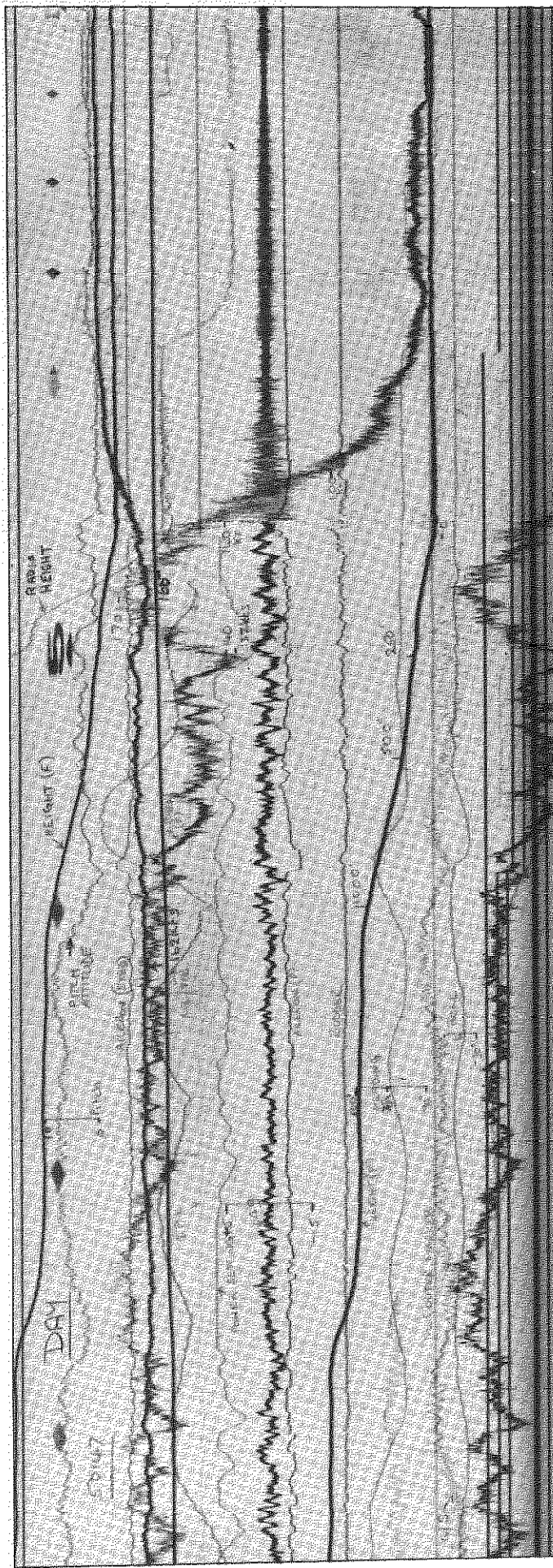


Fig.13. Event in flight 50147

#### 3.4.4 Event in Flight 50691

Sector: London/Paris - October 1966

##### Description

During a manual ILS approach into Paris, the auto-throttle reached the limit of its authority when the airspeed fell to 138 kt. (See Fig.14.)

##### Supplementary information

The weather at Paris was as follows:-

1400Z Wind 020<sup>o</sup>/7 kt, Visibility 6 km, Cloud 7/8 500 ft.

##### Comment

The first part of the approach was coupled (i.e. the autopilot was following the localiser and glide slope signals), but was disconnected through poor following. The manual following was still no better and the low airspeed occurred in this region, probably because of a sluggish auto-throttle.

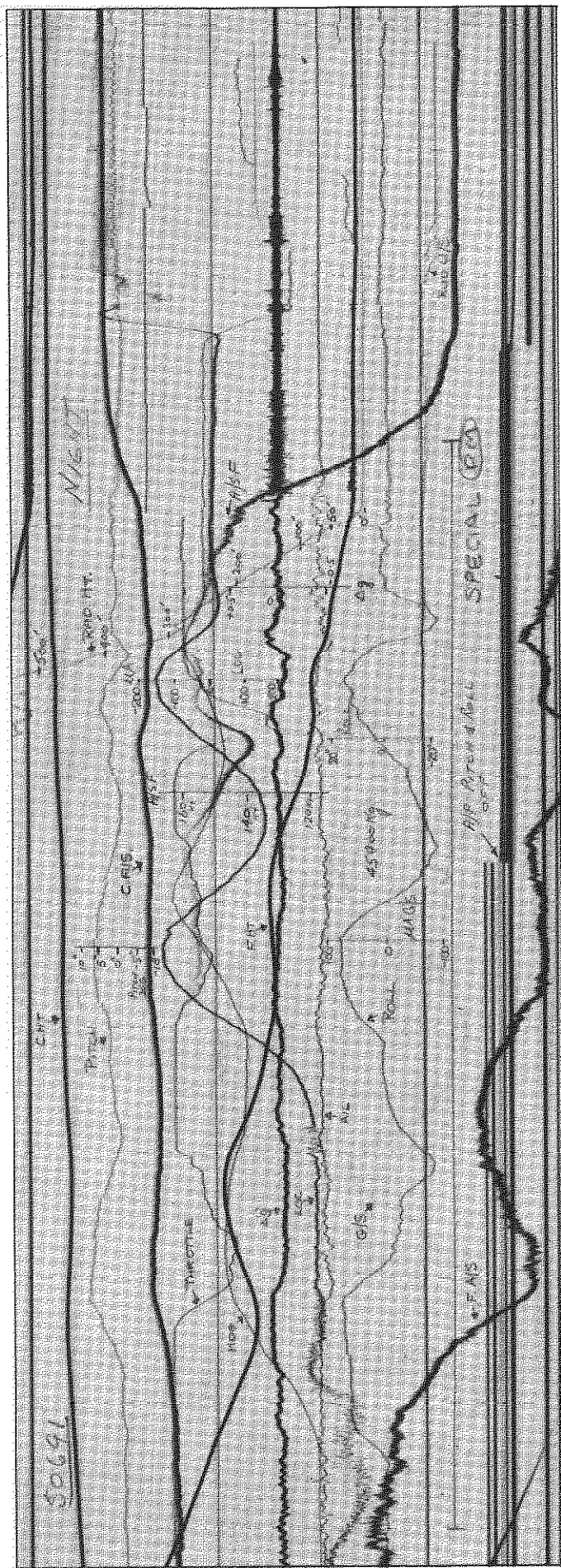


Fig.14. Event in flight 50691

### 3.4.5 Event in Flight 50937

Sector: London/Paris - January 1967

#### Description

During the approach into Paris, the auto-throttle remained at a constant setting for 35 seconds allowing the airspeed to fall from 153 kt to 130 kt before full power was applied by the pilot. (See Fig.15.)

#### Comment

It is not known if the stall warning operated. It should have been set above 125 kt, i.e. at least 8% above the stalling speed of 116 kt.

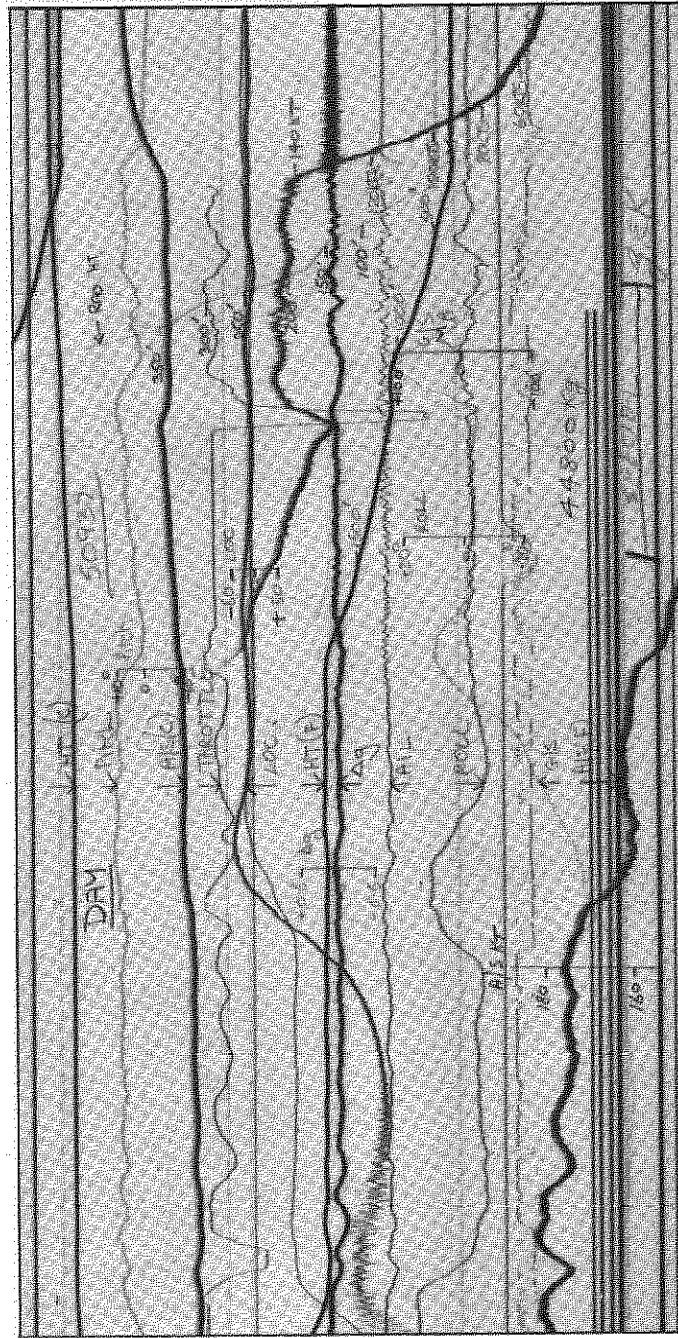


Fig.15. Event in flight 50937

### 3.4.6 Event in Flight 10846

Sector: London/New York - January 1967

#### Description

During the approach into New York the airspeed fell to 120 kt at 1500 ft. The sequence of events over the preceding 25 seconds was as follows:-

- (1) Power was increased and the airspeed built to 155 kt.
- (2) The aircraft was pitched up progressively to 12° nose up.
- (3) The airspeed fell to 128 kt.
- (4) The control column was moved rapidly forward.
- (5) The airspeed continued to fall and did not increase until 8° nose down and 120 kt had been reached; at this time the normal acceleration increment was -0.6 g.
- (6) The aircraft continued to pitch down with increasing airspeed and finally reached 12° nose down.  
(See Fig.16.)

#### Supplementary information

The weather at New York was as follows:-

18.51Z - Overcast, Visibility 5 miles, wind 090°/25 gusting 30 kt.

The pilot reported that this was a radar controlled approach without ILS and it was very turbulent. The airport was closed after this landing.

#### Comment

This event appears to have been caused by slow pilot reactions to pitch changes, but the situation may have been aggravated by long wavelength turbulence or wind shear.

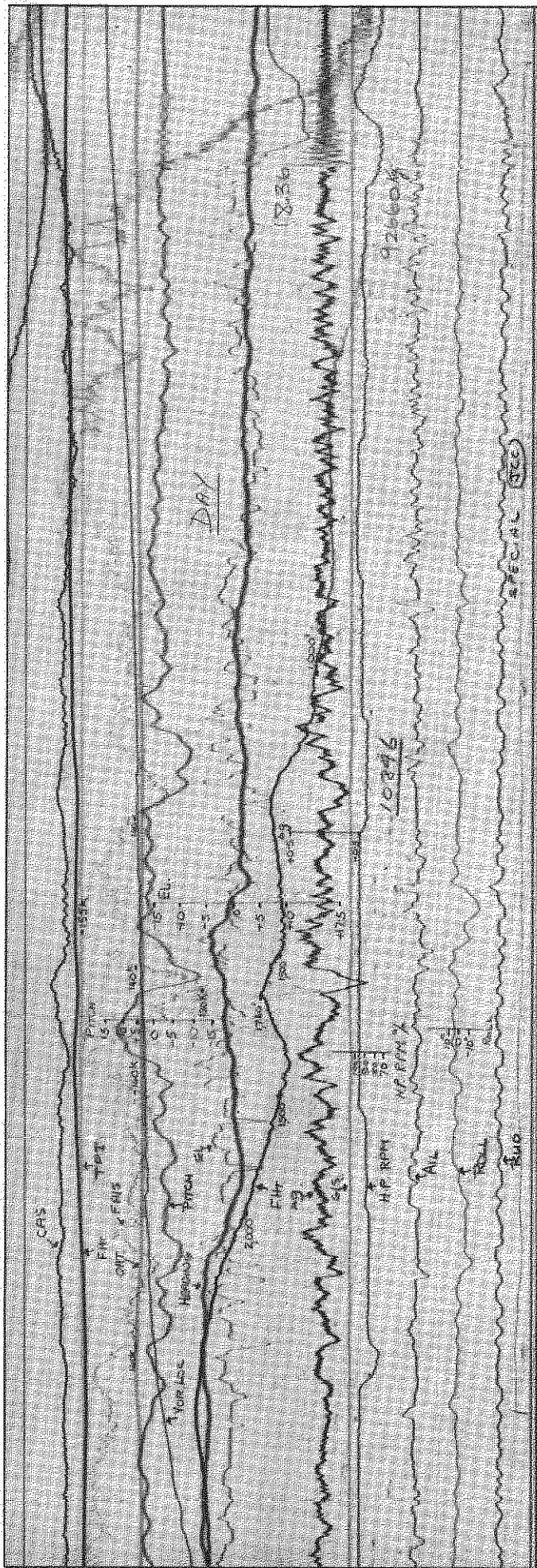


Fig.16. Event in flight 10846

### 3.4.7 Event in Flight 20194

Sector: Montreal/Chicago - September 1967

#### Description

During the approach into Chicago, the airspeed fell to 123 kt. Threshold speed for this weight is 128 kt. (See Fig.17.)

#### Supplementary information

A.T.C. had requested the captain to maintain 2000 ft and keep a look out for an aircraft known to be in the area but not in radio contact. Clearance to descent arrived late and another circuit had to be flown.

#### Comment

The airspeed fell to a low value because of distractions, but the recovery did not involve the large manoeuvres of 3.4.1 and 3.4.6.



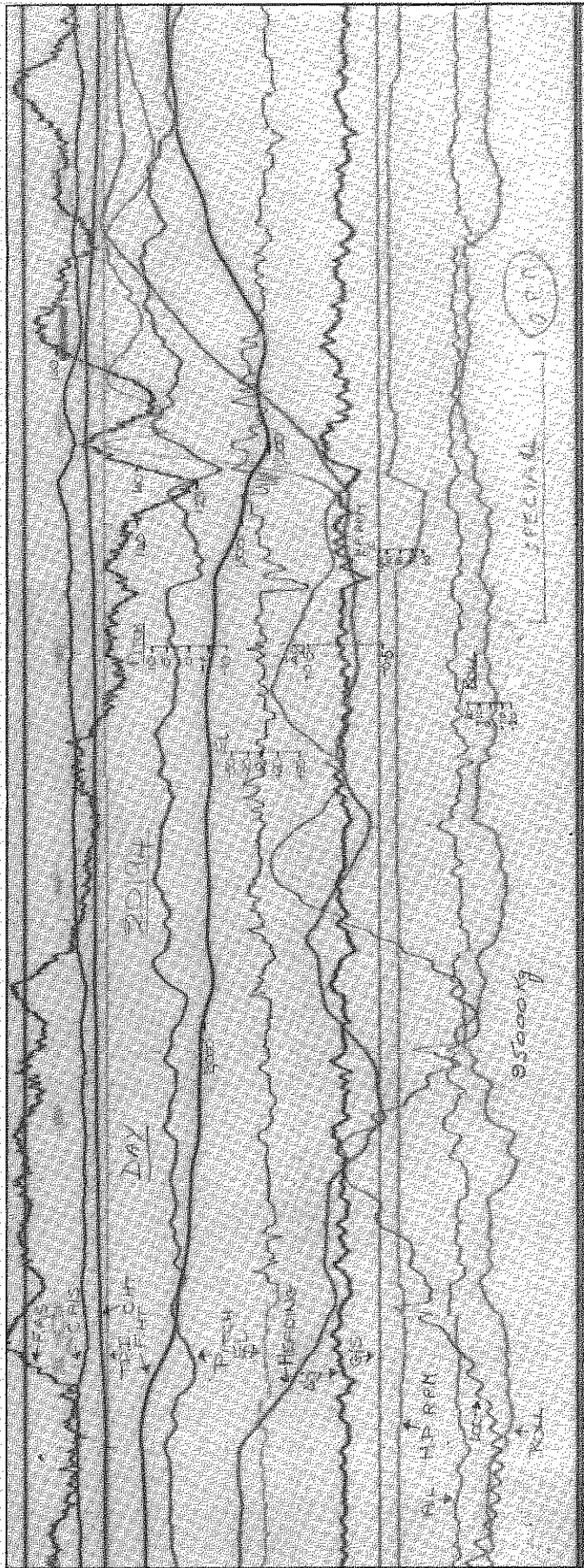


Fig.17. Event in flight 20194

### 3.5 Events in Flights 11208, 11213, 11462

Landings at Kingston, Detroit and Manchester

#### Description

During the ground roll, full left and right rudder was used (see Figs.18a, 18b, 18c).

#### Supplementary information

Meteorological conditions and runways used were as follows:-

Kingston - wind  $120^{\circ}/18$  kt, visibility 14 nm runway 11

Detroit - wind  $310^{\circ}/12$  kt, visibility 12 miles runway 21

Manchester - wind  $180^{\circ}/11$  kt, visibility 8 km runway 24

#### Comment

None.



Fig.18c. Event in flight 11462

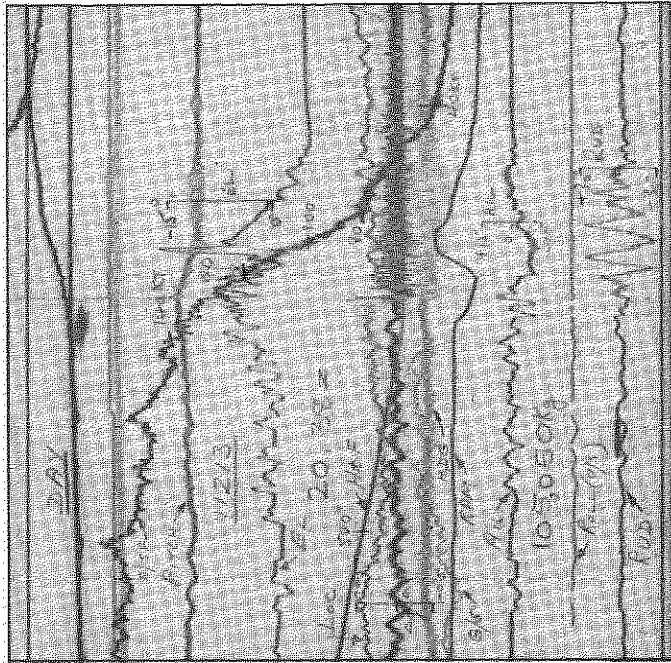


Fig.18b. Event in flight 11213

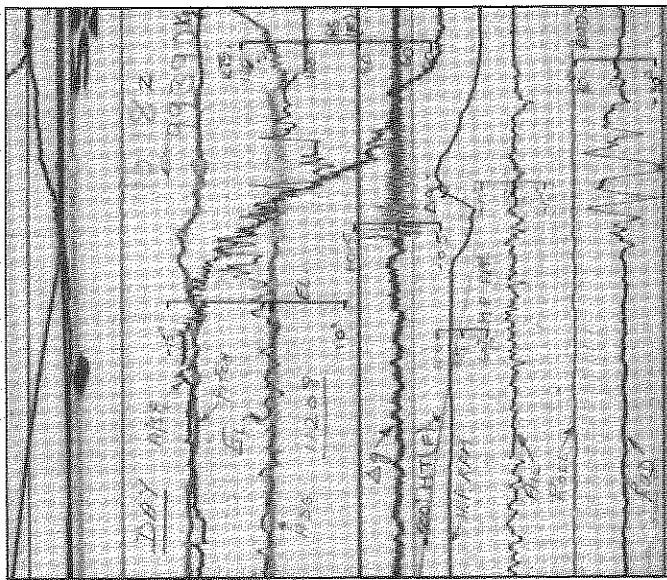


Fig.18a. Event in flight 11208

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<u>No.</u>	<u>Author</u>	<u>Title, etc.</u>
1	The CAADRP Technical Panel	The civil aircraft airworthiness data recording programme. R.A.E. Technical Report 64004 (1964)
2	The CAADRP Special Events Working Party	Special events of an operational nature (February 1964 to December 1964). R.A.E. Technical Report 65242 (1965)
3	The CAADRP Special Events Working Party	Special events of meteorological origin (November 1963 to December 1964). R.A.E. Technical Report 65243 (1965)
4	The CAADRP Special Events Working Party (Co-ordinated by G.E. King, R.A.E.)	Special events of meteorological origin (January 1965 to December 1965). R.A.E. Technical Report 67071 (1967)
5	The CAADRP Special Events Working Party (Co-ordinated by A.C.G. Seal Air Registration Board)	Special events relating to autopilot induced control disturbances (May 1963 to December 1965). R.A.E. Technical Report 67157 (1967)

<p>A.R.C. C.P. No.1051 August 1968</p> <p style="text-align: right;">629.13.053.3 : 533.6.015.32</p> <p>The CAADRP Special Events Working Party (Co-ordinated by G.E. King, R.A.E.)</p> <p>CIVIL AIRCRAFT AIRWORTHINESS DATA RECORDING PROGRAMME</p> <p>SPECIAL EVENTS RELATING TO AIRSPEED CONTROL AND HANDLING (FEBRUARY 1966 TO DECEMBER 1967)</p> <p>A small number of jet aircraft in normal airline service are fitted with recorders which produce continuous trace records of airworthiness data for 14 parameters. Throughout the recording period the records have been searched for unusual occurrences, and each one has been studied to determine its nature and, where possible, its cause.</p> <p>This Report describes a selection of events relating to airspeed control and handling which were found in records taken between February 1966 and December 1967.</p>	<p>A.R.C. C.P. No.1051 August 1968</p> <p style="text-align: right;">629.13.053.3 : 533.6.015.32</p> <p>The CAADRP Special Events Working Party (Co-ordinated by G.E. King, R.A.E.)</p> <p>CIVIL AIRCRAFT AIRWORTHINESS DATA RECORDING PROGRAMME</p> <p>SPECIAL EVENTS RELATING TO AIRSPEED CONTROL AND HANDLING (FEBRUARY 1966 TO DECEMBER 1967)</p> <p>A small number of jet aircraft in normal airline service are fitted with recorders which produce continuous trace records of airworthiness data for 14 parameters. Throughout the recording period the records have been searched for unusual occurrences, and each one has been studied to determine its nature and, where possible, its cause.</p> <p>This Report describes a selection of events relating to airspeed control and handling which were found in records taken between February 1966 and December 1967.</p>
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