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Civil Aircraft Airworthiness Data Recording Programme. Special Events Related to Airspeed Control Practices (February 1963 to February 1966)

by the

CAADRP Special Events Working Party

(Co-ordinated by A. W. Cardrick,

R.A.E. and K. D. Mephan, R.A.E.)

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CIVIL AIRCRAFT AIRWORTHINESS DATA RECORDING PROGRAMME. SPECIAL EVENTS RELATED TO AIRSPEED CONTROL PRACTICES (FEBRUARY 1963 TO FEBRUARY 1966)

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SUMMARY

Since October 1962 continuous trace records of airworthiness data have been taken from a small number of aircraft in normal airline service. Throughout the recording period the records have been searched for unusual occurrences, and each of these has been studied to determine its nature and, where possible, its cause.

This Report describes a selection of events related to airspeed control practices which were detected in records taken between February 1963 and February 1966, and a study of exceedences of airspeed limitations.

CAADRP is a project administered by the Royal Aircraft Establishment in collaboration with the Air Registration Board, and involving a number of Airlines and Computer Instrumentation Limited.

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*Replaces R.A.E. Technical Report 69113 - A.R.C. 31672

CONTENTS

1 INTRODUCTION

The object of the Civil Airworthiness Data Recording Programme is a systematic study of the normal operational flight of civil transport aircraft. 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. Additional parameters have been introduced since the start of the recording and the whole programme is described elsewhere[1].

From time to time unusual or extreme events (Special Events) are noted; this Report contains a selection of such events related to handling techniques and control difficulties which concerned pure jet transport aircraft on scheduled airline operations between February 1963 and February 1966. The events 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., Computer Instrumentation Limited, and the airlines concerned.

Five reports[2-6] on selected Special Events have already been issued, and more will be issued in due course. It should be noted that it is not possible to relate the frequency of Special Events to the frequency of operational occurrences.

2 NOTE ON THE RECOGNITION 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 formulate precise directions for recognition of a Special Event but the type of things which are looked for may be summarised as follows:-

(a) normal acceleration increments exceeding ±1.0 g;

(b) rapid and large changes of height or airspeed;

(c) excessive application of a control;

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

(d) infrequent operational events such as abandoned take-offs, missed approaches, engine failures, engine-out landings etc.;
(e) unusual oscillations on any of the traces;
(f) exceedences of operational limitations such as maximum operating speeds.

Although every record is examined at least three times it is unlikely that every Special Event will be found; also there is no relationship between the number of events of a particular type chosen for this Report and the number of times similar events are detected. Hence, as stated in the last paragraph of the introduction, frequencies cannot be derived from these data. It is intended that frequency data will be summarised at a later date and will be based on the information contained in the full routine analysis programme.

Most of the events described in this Report have been detected under (b) and (f).

3 AIRSPEED LIMITATIONS

The aircraft contributing to this Report were flown either under V_{NO}, V_{NE} and M_{NO}, M_{NE} limitations or under V_{MO} and M_{MO} limitations, the latter being the more recent.

V_{NO} and M_{NO} are normal operating airspeed and Mach number respectively; they may be exceeded at the Captain's discretion when no appreciable atmospheric turbulence is likely to be encountered.

V_{NE} and M_{NE} are the speed and Mach number which may never be exceeded intentionally; an audible warning operates if either is exceeded.

V_{MO} and M_{MO} are maximum operating airspeed and Mach number and have approximately the same values in relation to V_D, the maximum design speed, as the superseded V_{NO} and M_{NO}; if either V_{MO} or M_{MO} is exceeded by more than a few knots an audible warning sounds.

A summary of this Notation is shown on page 10.

In addition to these limitations there are recommended airspeeds for specific parts of the flight; e.g. rotation, climb-out, flap operation, descent, threshold, touch-down, cruise; some of those are expressed as upper and lower limits, others as a single speed and others as a maximum or minimum; most are related to flight safety, but flap operating limits are related to fatigue life and cruise speeds to economic operation, either to conserve fuel or to preserve schedules.

4 SPECIAL EVENTS RELATED TO AIRSPEED CONTROL

4.1 Presentation of Special Events

Fifteen Special Events have been selected to illustrate the type of unusual occurrences related to airspeed control. These are presented, with brief comments, as Figs.2 to 16, and are arranged according to phase of flight from take-off to touch-down.

Events occurring during take-off and initial climb

Fluctuations of airspeed at low altitude. (Two examples)	Figs.2 and 3

Events occurring during climb

Exceedences of V_{MO} at low altitude	Fig.4
Exceedences of V_{MO} and M_{MO}	Figs.5a, b and c
Exceedences of V_{NO}	Fig.6
Exceedences of V_{NO} during steep climb	Fig.7
Unusual airspeed control	Fig.8

Events occurring during cruise

Airspeed oscillation resulting in exceedences of M_{NO}	Fig.9
Rapid reduction in airspeed	Fig.10
Turbulence encounter during reversion to cruise airspeed after a slowdown procedure. (Two examples).	Figs.11 and 12

Events occurring during descent

Exceedence of V_{NE}	Fig.13
Exceedence of V_{MO}	Fig.14
Coarse airspeed control during descent	Fig.15
Rapid airspeed reduction at low altitude	Fig.16 .

4.2 Salient features

Figs.2 and 3 illustrate airspeed and height fluctuations in the initial climb-out phase. The aircraft were not endangered by these fluctuations because they occurred at a safe height (> 400 feet) above the airfield; at very low height they could be dangerous.

The events depicted in Figs.4 and 7 occurred during periods in which the crew were concerned with diversion procedures.

The exceedences shown in Figs.5a, 5b, 5c and 6 appear to be associated with the maintenance of an airspeed close to the operating boundary.

For many years it has been the recommended practice to reduce speed when turbulence is encountered, preferably before the actual encounter. Doubt has been cast on the advisability of this practice, particularly if speed is reduced by means of a pull-up manoeuvre; the combination of a manoeuvre acceleration and a gust could result in an unacceptably severe load on the aircraft. Figs.11 and 12 give examples of reduction in airspeed accompanied by pull-up manoeuvres in the presence of turbulence, while Fig.10 shows the effect of slowdown procedures initiated before the onset of turbulence and with negligible elevator action.

The events shown in Figs.13 and 14 relate to instances during descent in which the airspeed inadvertantly exceeded that normally employed by approximately 54 and 46 knots respectively. In the first of these examples V_{NE} was exceeded by approximately 14 knots.

Fig.16 illustrates the use of a high airspeed in descent down to 3000 feet altitude, followed by a moderate pull-up manoeuvre to effect the reduction of airspeed necessary before flap operation.

5 ANALYSIS OF MAXIMUM AIRSPEEDS

5.1 Data selection

The maximum airspeeds reached during climb, cruise and descent for five types of multi-engined civil jet transports have been evaluated from CAADRP records. These speeds are compared with the operational limitations and the design maximum speeds for the appropriate type.

A sample of 200 flights was taken for each aircraft type; so far as possible these were consecutive flights, excluding training flights. All the aircraft were engaged on international flights and, therefore, it is thought that the data are representative of world wide operations by British operators.

The selected flights were each divided into three flight phases; climb, cruise and descent. The maximum airspeed reached in each flight phase was measured, together with the height at which it occurred. If the airspeed exceeded an operational limitation by a substantial amount, the time for which the limitation was exceeded was also noted.

5.2 Presentation of data

The data are presented by aircraft type and by flight phase as plots of airspeed against height in Figs.17 to 31. Information on the length of time spent in excess of the limitations for Aircraft Type E is presented in Fig.32

The operational limitations (see section 3) for the various aircraft types are also shown on the appropriate figures. It will be seen that two forms of limitations are used.

V_{NO}, M_{NO} and V_{NE}, M_{NE} are applied to aircraft C and D.

V_{MO}, M_{MO} are applied to aircraft A, B and E.

V_D applies to all types.

All the aircraft are provided with an excess speed warning when the limitation is expressed by a Mach number; aircraft types A and B are provided with an additional warning when the limitation is expressed as a speed.

It should be noted that the pitot-static system used for the recorder in types A and B is not identical with that used for the pilot's instruments. However, in these flight conditions, the indicated speed difference is not excessive. The CAADRP installation indicates about 10 knots less on Type A and 3 to 5 knots more on Type B than the pilot's instrument. These differences are taken from flight observations on the flight deck; allowance has been made for them in Figs.17 to 22 and is indicated by the dotted line.

5.3 Discussion

Aircraft type A

The usual operating speed was well within the maximum operating boundary and hence the number of occasions when the boundary was reached or passed was very small, even after allowing for the difference between pilot's instrument and CAADRP airspeed information. (Figs.17, 18, 19).

Aircraft type B

The maximum operating boundary was occasionally reached during climb. Cruise and descent were conducted at or very close to the boundary and hence there were a large number of occasions when the limit was exceeded. However, the limit was never exceeded by more than about 5-7 knots. (Figs.20, 21, 22)

Aircraft type C

The normal operating boundary was passed fairly frequently in all phases of flight; this could be deliberate operation. The M_{NE} boundary was occasionally exceeded by a small amount in cruise. (Figs.23, 24, 25).

Aircraft type D

The usual operating speed was well within the normal operating boundary and hence the number of occasions when it was crossed was very small, and the never exceed boundary was never reached. (Figs.26, 27, 28).

Aircraft type E

All phases of flight are commonly conducted at the maximum operating boundary, and hence speeds in excess of the limitation were frequently recorded. (Figs.29, 30, 31). However, the speed exceedences were rarely large, although often sustained (Fig.32) for a significant period.

6 CONCLUSIONS

Special Events are presented which relate to abnormal airspeed control practices. These are discussed with reference to the recorded airworthiness parameters and relevant supplementary data. Although in certain instances studies have been somewhat restricted by the absence of additional recorded data, particularly on throttle usage, a number of general conclusions can be drawn.

Most abnormal airspeed control practices occur inadvertently during periods of high pilot workload associated with such phases of flight as initial climb-out and the temporary holds often necessary in climb and descent.

While the evidence given here is not conclusive it indicates that slow-down by means of a pull-up after the onset of turbulence might produce a dangerously high load.

An analysis of data from 1000 normal operational flights of jet transports shows that small excursions above V_{NE} occasionally occur for aircraft with limitations expressed in this form, whereas, as might be expected, small excursions above V_{MO}/M_{MO} are common for aircraft habitually operated close to these boundaries.

Appendix A

AVAILABLE METEOROLOGICAL INFORMATION

A.1 Event in flight 05310

Special report from Kuala Lumpur:-

GMT	Surface wind	Weather	Visibility	Cloud	QNH	Temp/dew pt.
0800	270°/13 kt	Thunderstorms	2 nm 300°/250° otherwise 4 nm	2/8 Thunderstorms 800 ft 2/8 Cb 1700 ft 3/8 2000 ft 6/8 14000 ft	1008.9 mb	29°/24°C
0830	090°/12 kt	Low cloud Thunderstorms 020/060	800 yd 300/250° otherwise 2 nm	5/8 Thunderstorms 800 ft 2/8 Cb 1700 ft 3/8 2000 ft	1009.8 mb	-
0900	230°/15 kt	Thunderstorms 020/060	660 yd	5/8 Thunderstorms 600 ft 2/8 Cb 1700 ft 8/8 10000 ft	1010.4 mb	23°/23°

A.2 Event in flight 15902

Report from Kindley Field, Bermuda

GMT	Surface wind	Weather	Visibility	Temp/dew pt.
1955	070°/5 kt	Scattered cloud ceiling 4000 ft	9 nm	66°/43°F

Conditions steady

NOTATION

V_{NO} normal operating airspeed

M_{NO} normal operating Mach number

V_{NE} airspeed never to be exceeded intentionally

M_{NE} Mach number never to be exceeded intentionally

V_{MO} maximum operating airspeed

M_{MO} maximum operating Mach number

V_D maximum design speed

$V_{MO} \approx V_{NO}$

$M_{MO} \approx M_{NO}$

The single limitations V_{MO} and M_{MO} have superseded the double limitations V_{NO}, V_{NE} and M_{NO}, M_{NE}.

Audible warning when V_{NE}, M_{NE}, V_{MO} or M_{MO} is exceeded.

REFERENCES

No.	Author	Title, etc.
1	The CAADRP Technical Panel	The civil aircraft airworthiness data recording programme. R.A.E. Technical Report 64004 (1964) A.R.C. 264
2	The CAADRP Special Events Working Party	Special events of an operational nature (February 1964 to December 1964). R.A.E. Technical Report 65242 (1964) A.R.C. 278
3	The CAADRP Special Events Working Party	Special events of meteorological origin (November 1963 to December 1964). R.A.E. Technical Report 65243 (1965) A.R.C. 277
4	The CAADRP Special Events Working Party (Co-ordinated by G.E. King)	Special events of meteorological origin (January 1965 to December 1965) R.A.E. Technical Report 67071 (1967) A.R.C. 296
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) A.R.C. 297
6	The CAADRP Special Events Working Party (Co-ordinated by R. Ashford, Air Registration Board)	Special events - missed approaches (February 1963 to July 1967) A.R.B. Technical Note 93
7	The CAADRP Special Events Working Party (Co-ordinated by G.E. King)	Special events relating to airspeed control and handling (February 1966 to December 1967) R.A.E. Technical Report 68195 A.R.C. 31068
8	The CAADRP Special Events Working Party (Co-ordinated by A.W. Cardrick and K.D. Mephan)	Special events relating to handling and control (January 1963 to February 1966). R.A.E. Technical Report 69023 (1969) A.R.C. 314

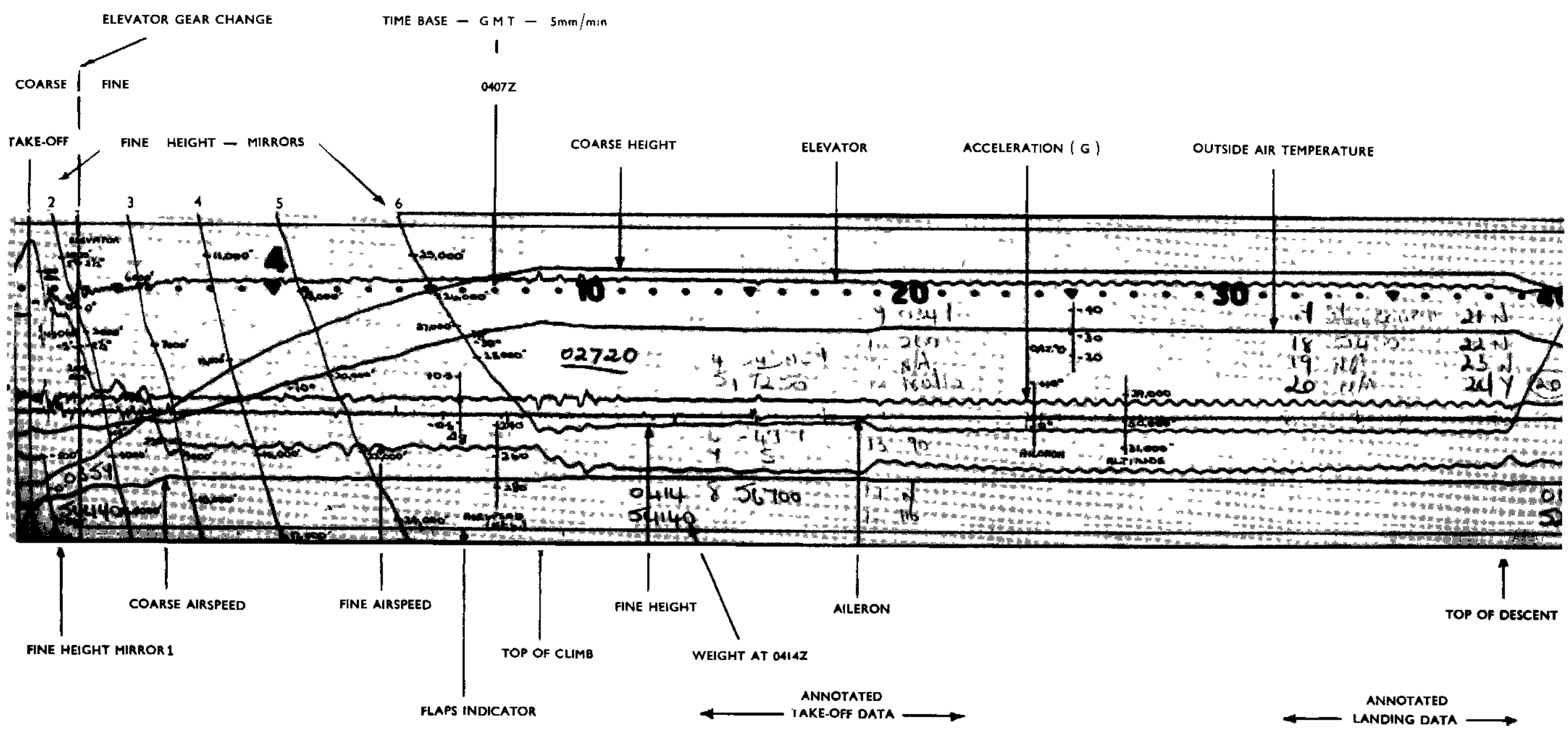

Fig.1. Portion of typical record

EVENTS OCCURRING DURING TAKE-OFF AND INITIAL CLIMB

FLUCTUATION OF AIRSPEED AT LOW ALTITUDE

Sector: (a) Take-off from Baghdad (type C) - May 1964, Flight 08052
(b) Take-off from London (type C) - May 1966, Flight 08071

DESCRIPTION

During each take-off, the indicated airspeed was allowed to fall after attaining climb-out speed, and thereafter fluctuated until 2000 feet altitude was reached. (Figs.2 and 3). Note that the time base changes with operation of the flaps.

SUPPLEMENTARY INFORMATION

Noise abatement procedures are normally practised at both airports.

COMMENT

In both instances the initial rate of climb was lower than normal and the airspeed was permitted to build up to a level well above the normal maximum. Following an increase in rate of climb, airspeed and height oscillations developed, which decayed only after the aircraft levelled out at 1700 feet and 3000 feet respectively. A similar oscillation developed at the top of the climb. In neither instance did the airspeed fall below the recommended minimum.

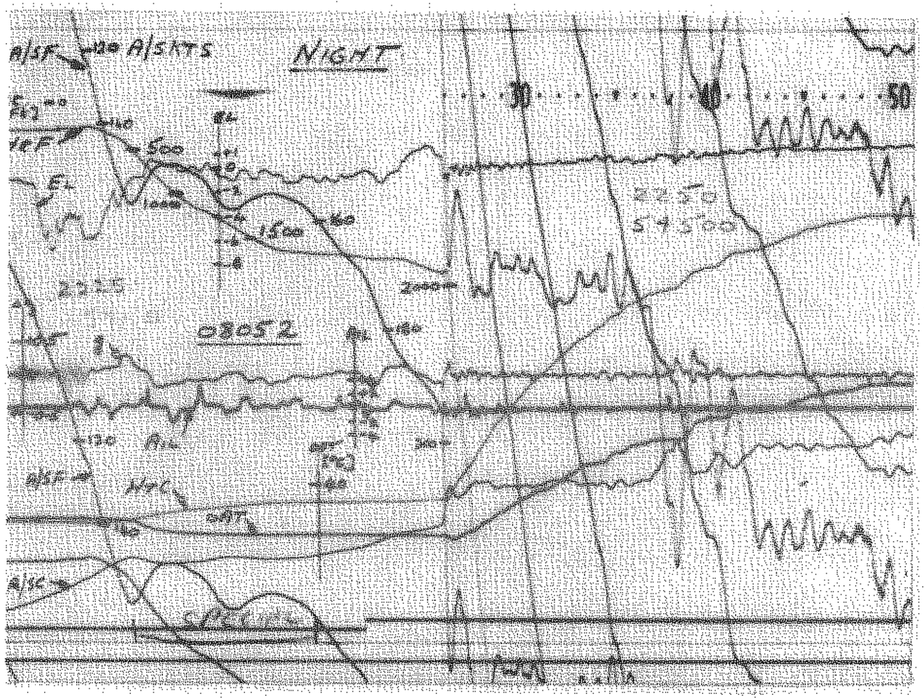

Fig.2. Event in flight 08052

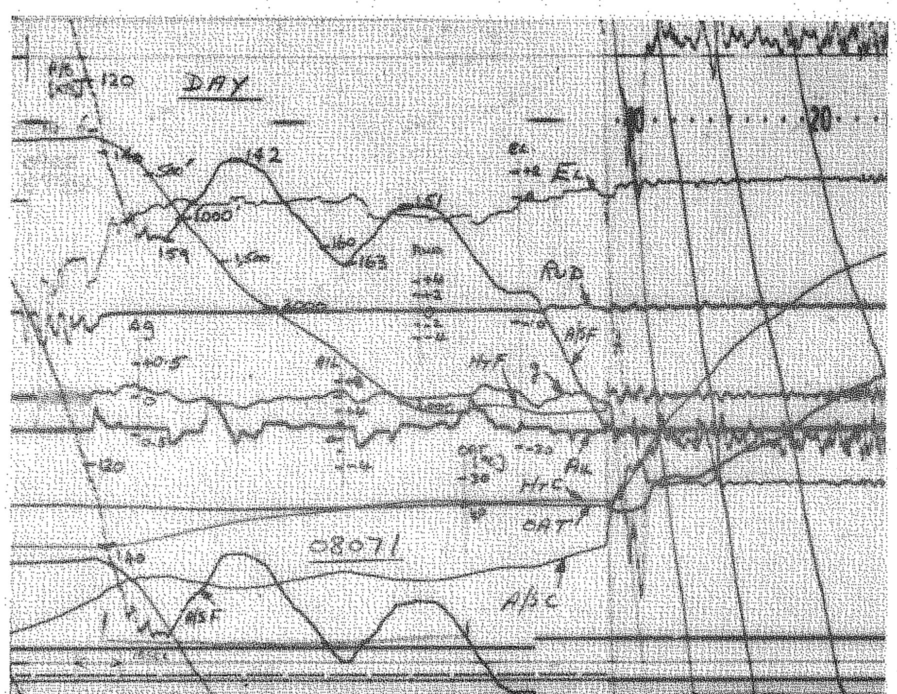

Fig.3. Event in flight 08071

EVENTS OCCURRING DURING CLIMB

EXCEEDENCES OF V_{MO} AT LOW ALTITUDE

Sector: Madrid - Manchester (type E) - January 1964, Flight 06325

DESCRIPTION

During climb and re-routing after diversion (at 7000 ft) from London to Manchester, airspeed built up to 335 knots for a very brief period, and then slowly decreased to 280 knots. Sixteen minutes later the airspeed built up to 334 knots but decreased immediately afterwards.

NOTE: The elevator transducer was unserviceable at the time that this recording was made.

SUPPLEMENTARY INFORMATION

The maximum operating speed, V_{MO}, for this type of aircraft is 330 knots. An overspeed warning horn operates at approximately 6 knots above this speed.

COMMENT

The exceedences may have been the result of a high workload on the pilot during diversion.

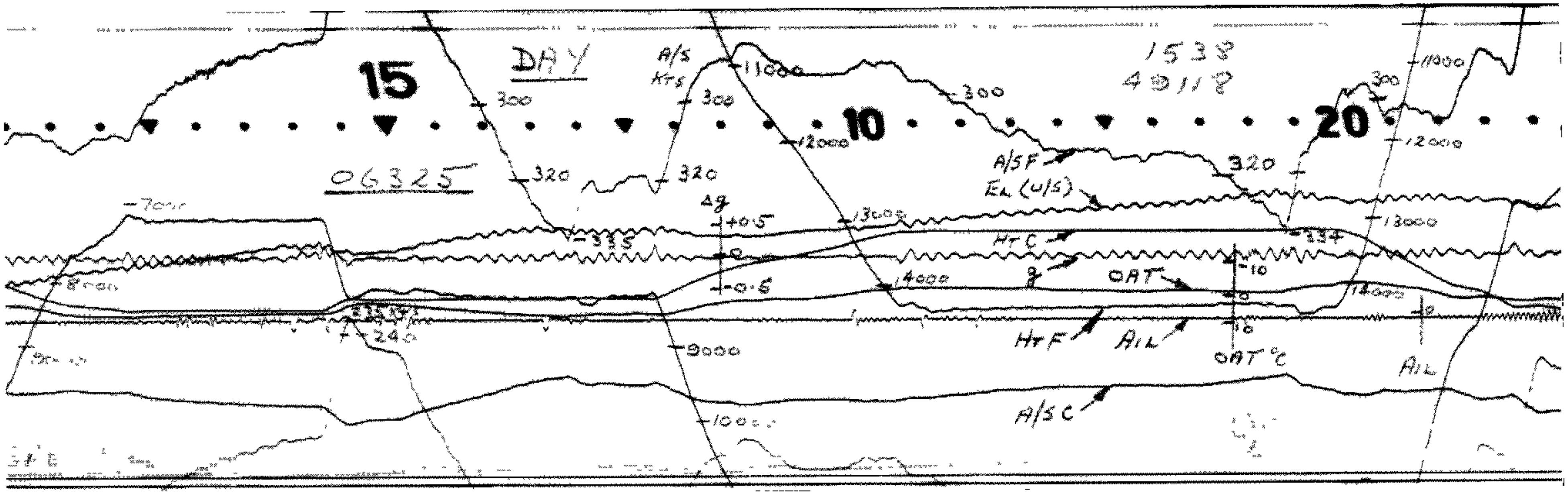

Fig.4. Event in flight 06325

EVENTS OCCURRING DURING CLIMB

EXCEEDENCES OF V_{MO} AND M_{MO}

Sector: Milan - London (type E) - June 1964, Flight 09626

DESCRIPTION

During the last seven minutes of climb and the first ten minutes of descent several airspeed and Mach number exceedences occurred.

SUPPLEMENTARY INFORMATION

V_{MO} for this aircraft is 330 knots. Figs.5b and 5c show the indicated speed-height-time histories for the periods in question, together with the maximum operating airspeed - Mach number envelope.

COMMENT

The aircraft was flown to the boundary of the operating envelope, apparently with the assistance of autopilot speed lock. V_{MO} was not significantly exceeded during the climb but it is probable that the Mach number warning horn sounded at 27000 feet. Limitations were observed in the subsequent cruise, but V_{MO} was substantially exceeded when descent was temporarily checked at 6000 feet, probably while the pilot was anticipating clearance to flight level 50.

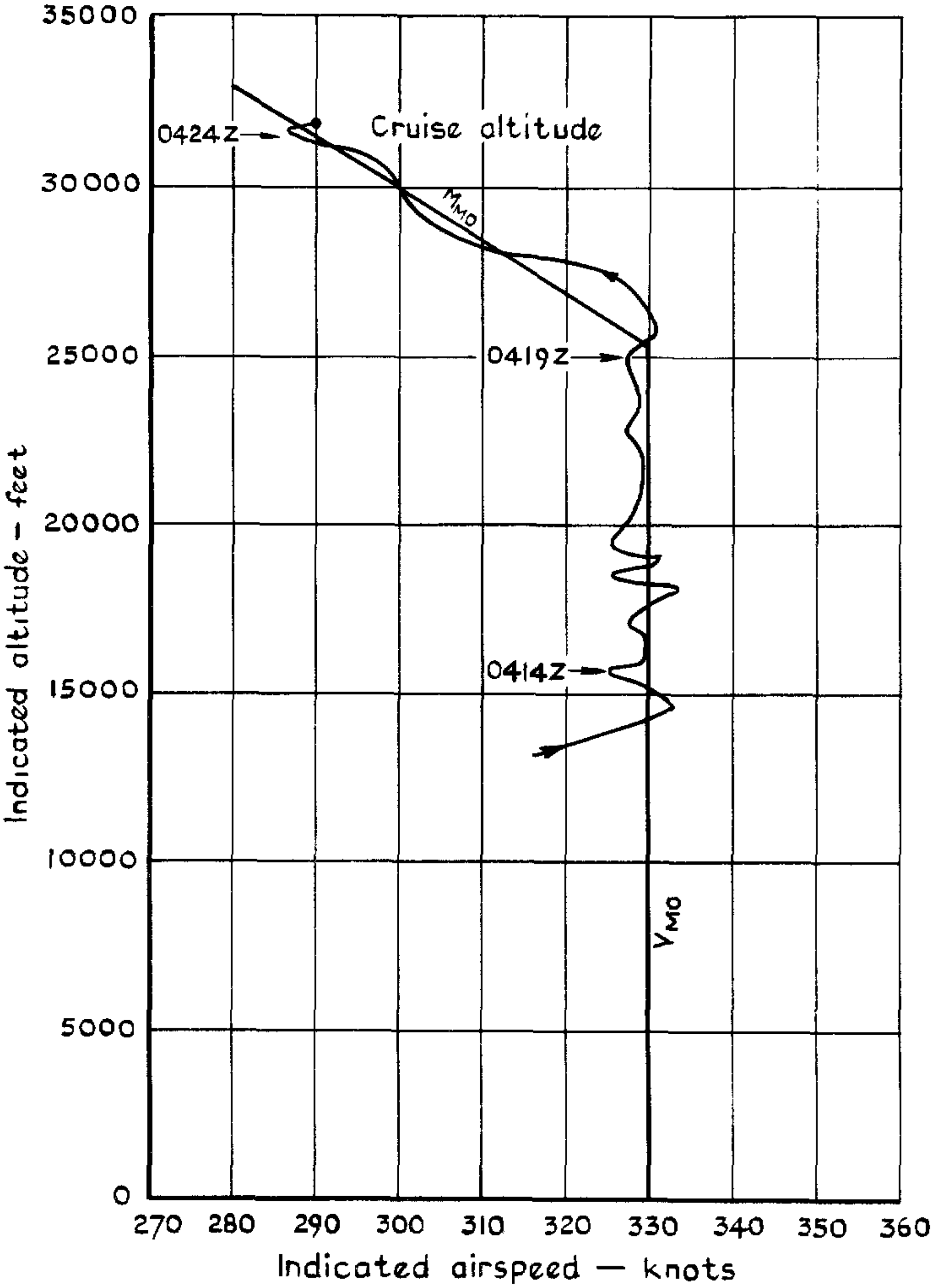

Fig 5b Airspeed v altitude — climb

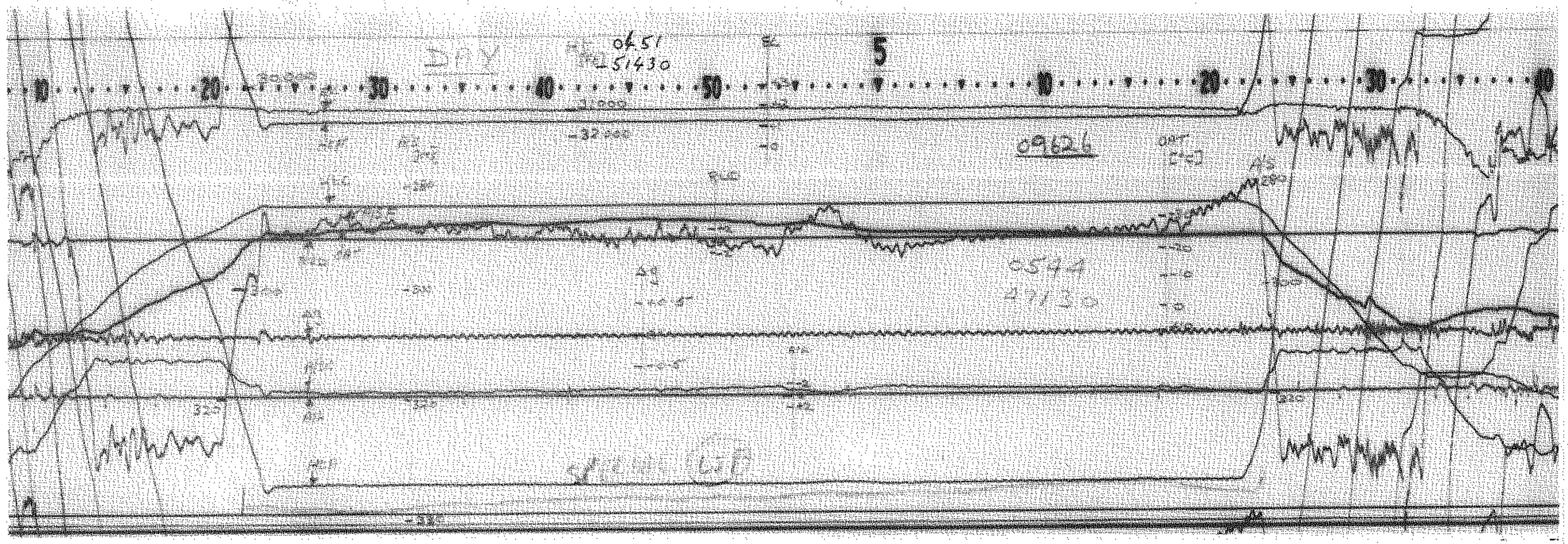

Fig.5a. Event in flight 09626

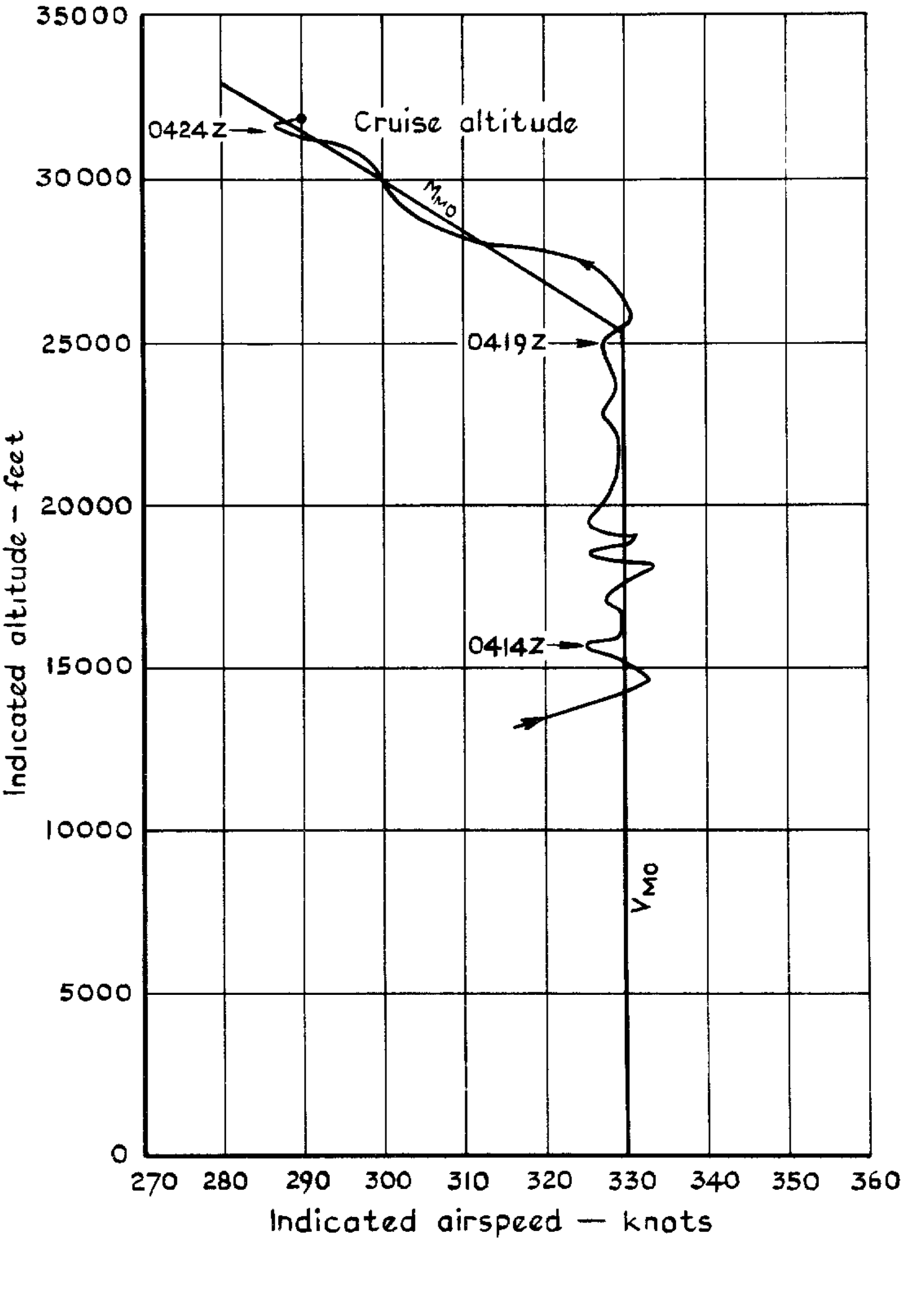

Fig. 5b Airspeed v altitude — climb

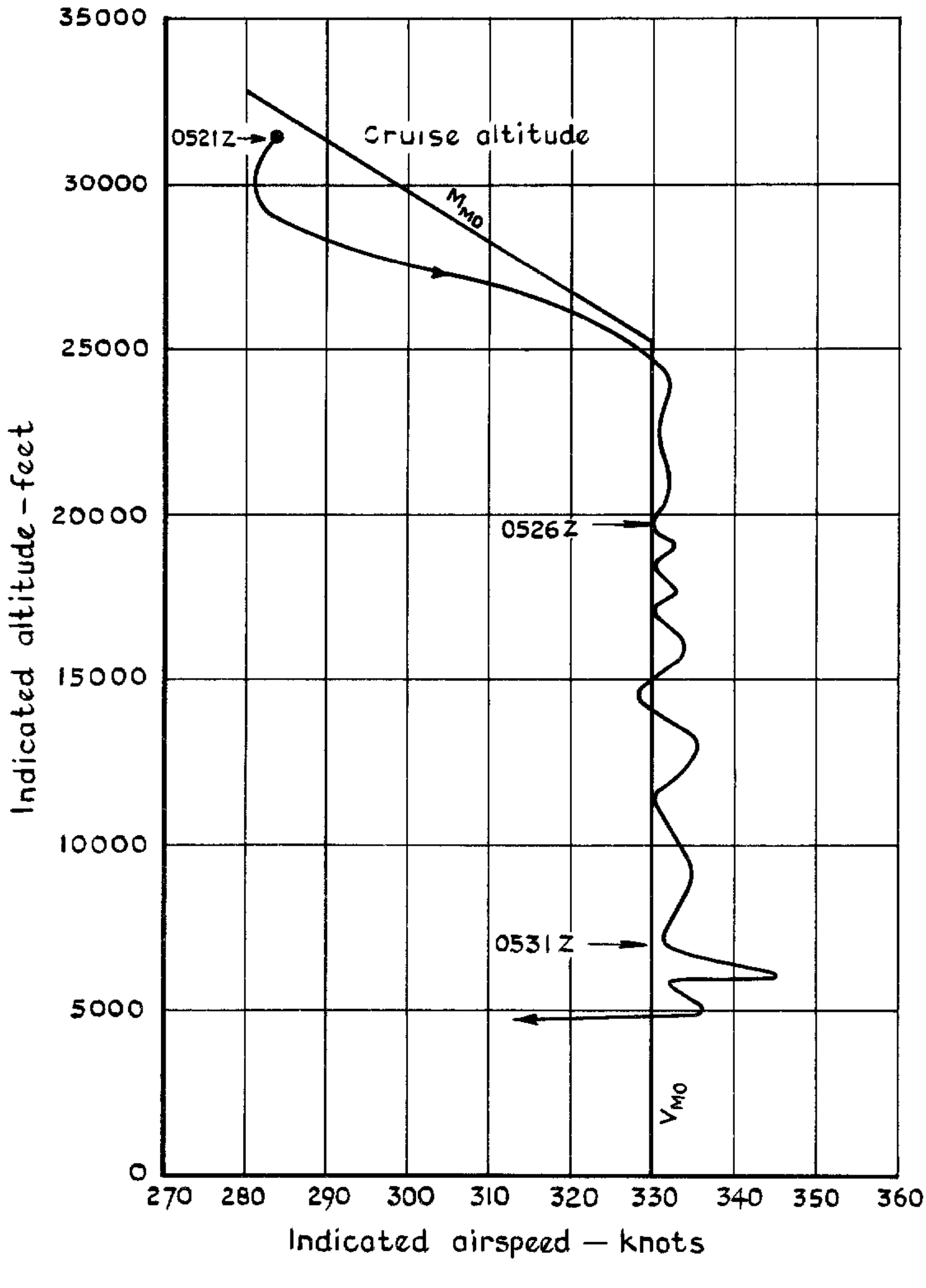

Fig.5c Airspeed v altitude — descent

EVENTS OCCURRING DURING CLIMB

EXCEEDENCES OF V_{NO}

Sector: London - Rome (type C) - January 1964, Flight 05664

DESCRIPTION

Just after reaching the top of climb at 29000 feet, the airspeed slowly rose to 277 knots then fell to 265 knots without a change in flight level; the airspeed then returned to 278 knots, before decreasing once more.

SUPPLEMENTARY INFORMATION

At this altitude the normal operating limit speed (V_{NO}) for this aircraft was 270 knots. V_{NE} is 290 knots.

COMMENT

These exceedences suggest that the throttle settings were not trimmed and monitored with sufficient regard to the flight conditions. Fig.24 shows that it is usual for V_{NO} to be exceeded by this aircraft type.

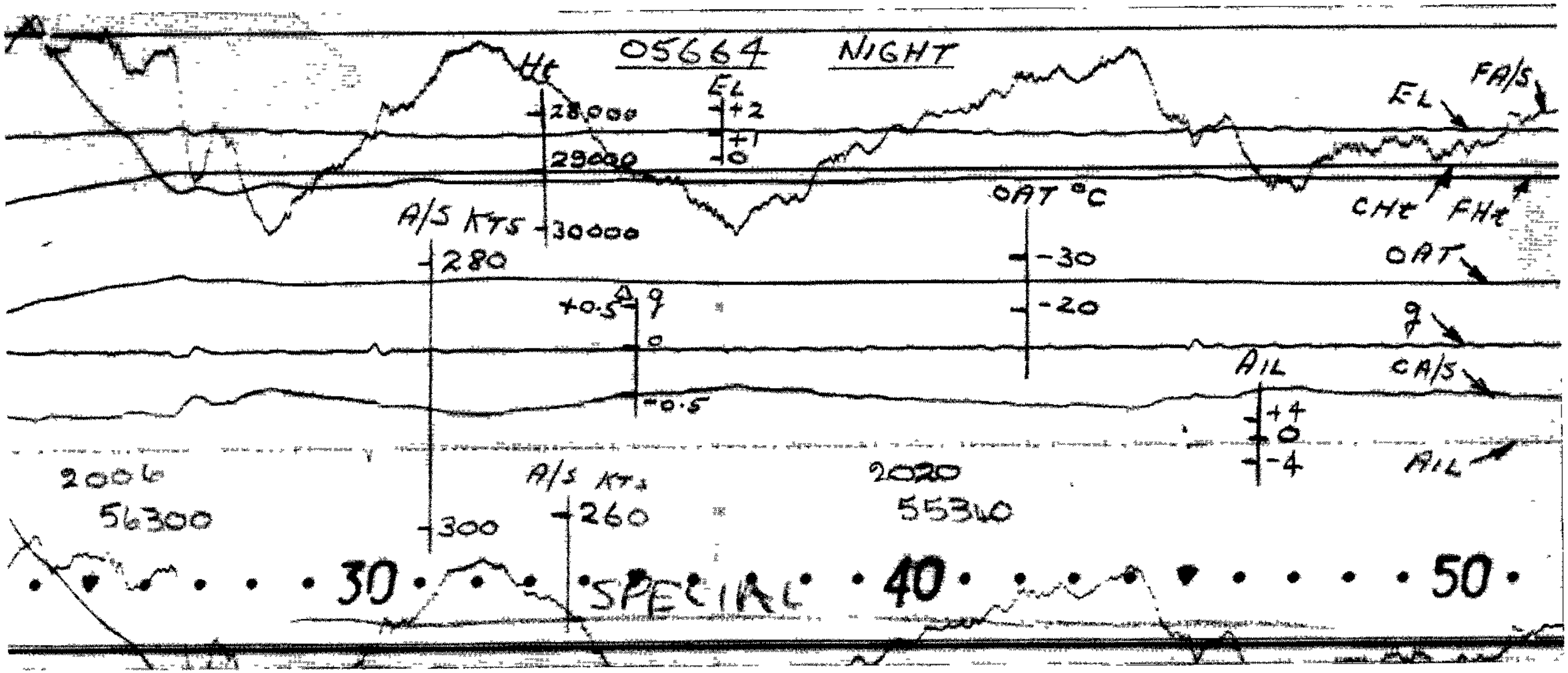

Fig. 6 Event in flight 05664

EVENTS OCCURRING DURING CLIMB

EXCEEDENCES OF V_{NO} DURING STEEP CLIMB

Sector: Colombo - Singapore (type C) - November 1965, Flight 05310

DESCRIPTION

The aircraft overflew Kuala Lumpur and exceeded the normal operating speed, V_{NO}, on four occasions in so doing. The exceedences were 7 knots, 3 knots, 7 knots and 14 knots.

SUPPLEMENTARY INFORMATION

Captain's voyage report states:

"When at Port Swettenham, weather at Kuala Lumpur was: thunderstorms at 500 ft, visibility 800 yards, and rain, with no improvement expected for two hours. Only flight plan fuel uplifted at Colombo due to good forecast and cost. Diverted Singapore."

See also Appendix A, meteorological Report 1.

COMMENT

V_{NO} for this aircraft is 270 knots and V_{NE} is 300 knots. Wide fluctuations in airspeed occurred once during the descent at about 10000 feet, and three times during the steep climb back to 25000 feet. Airspeeds of 277, 273, 277 and 284 knots were recorded. The surges in airspeed are not associated with the presence of turbulence and may have been due to the particular throttle control technique employed. Fig.24 shows that it is usual for V_{NO} to be exceeded by this aircraft type.

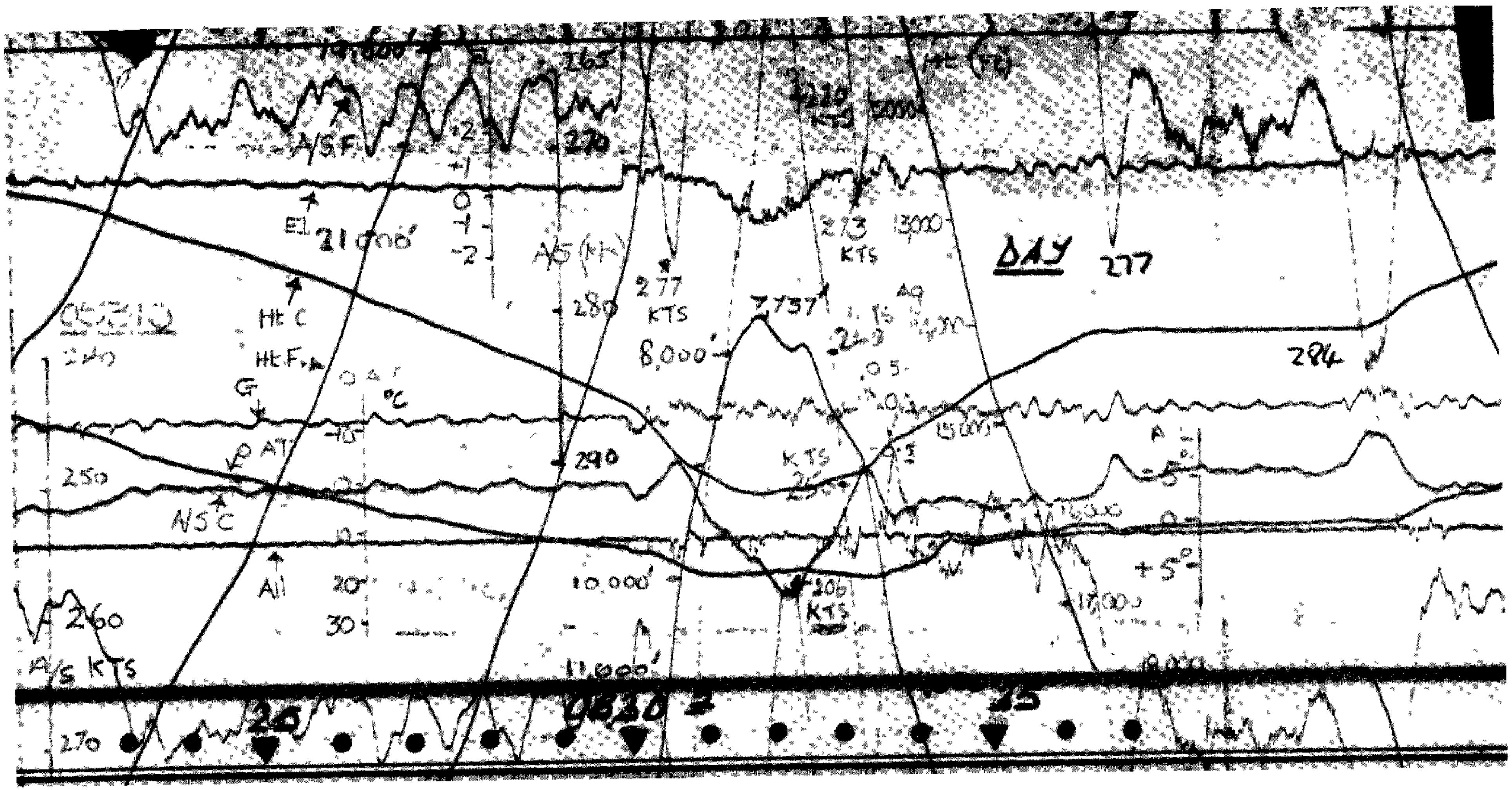

Fig.7. Event in Flight 05310

EVENTS OCCURRING DURING CLIMB

UNUSUAL AIRSPEED CONTROL

Sector: Beirut - Karachi (type D) - February 1965, Flight 13791

DESCRIPTION

After climbing to 25000 feet the aircraft levelled out and airspeed was allowed to build up by 50 knots to 330 knots before climb was sharply resumed with an 0.5 g manoeuvre.

SUPPLEMENTARY INFORMATION

The recommended climb speed for this aircraft is 280 knots up to 34000 feet, with speeds of up to about 300 knots permitted in the absence of turbulence. M_{NO} at 25000 feet was 0.852 (360 knots) and M_{NE} was 0.887 (376 knots).

COMMENT

It is likely that after the aircraft had reached 25000 feet, clearance to a higher altitude was anticipated and throttle settings were not trimmed to maintain a constant speed. Consequently when climb was resumed after two minutes the airspeed had reached 330 knots. This speed is well below M_{NO} and it is not known why a 0.5 g manoeuvre was used in these circumstances.

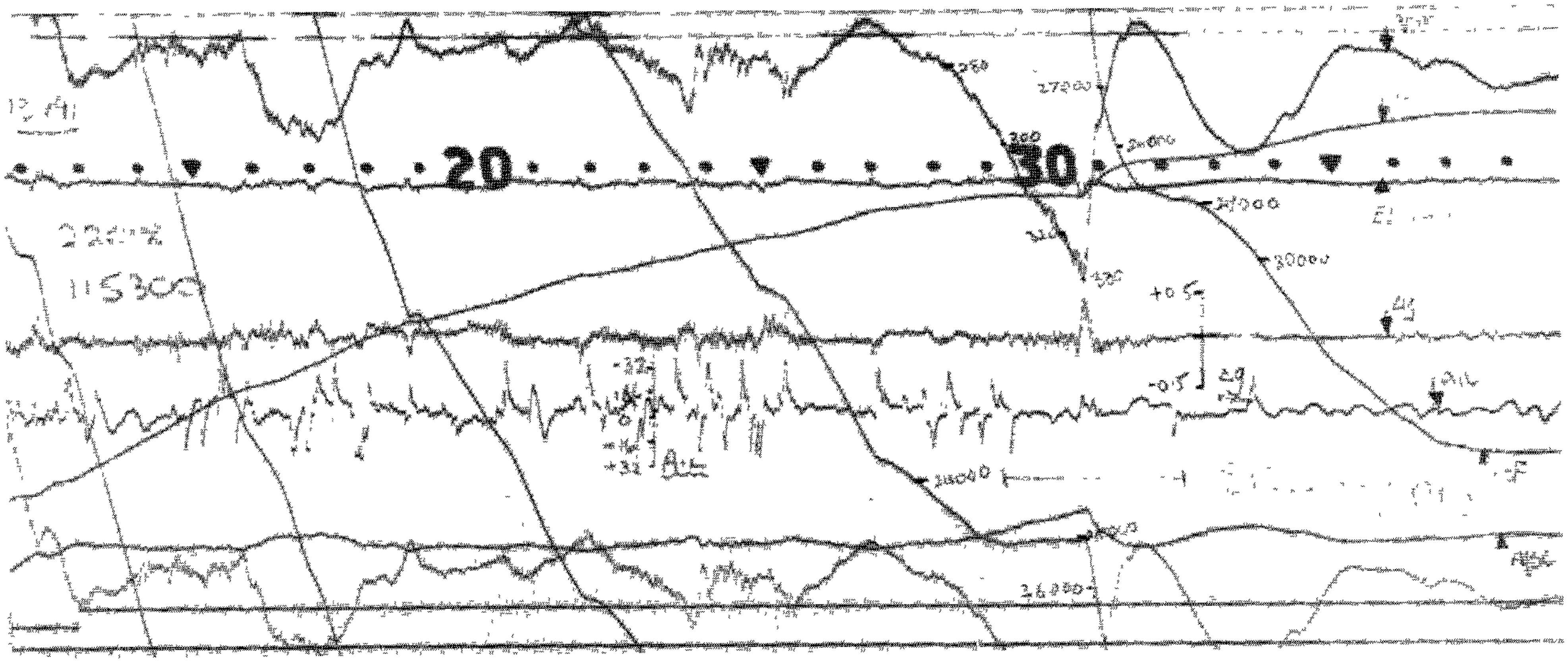

Fig.8. Event in Flight 13791

EVENTS OCCURRING DURING CRUISE

AIRSPEED OSCILLATION RESULTING IN EXCEEDENCES OF M_{NO}

Sector: Rome - London (type C) - June 1964, Flight 08457

DESCRIPTION

After cruise was established at 33000 feet, there were fluctuations in airspeed between 252 and 273 knots with a period of 6 to 8 minutes. Between 0816 and 0823 Z, and again between 0837 and 0846 Z, the normal operating Mach number (M_{NO}) was exceeded by 6 knots, and 4 knots respectively.

SUPPLEMENTARY INFORMATION

The airspeed corresponding to M_{NO} (0.75) for this aircraft type is 264 knots at 33000 feet and 270 knots at 31000 feet.

COMMENT

These long period oscillations almost certainly resulted from rather infrequent, and consequently relatively coarse, adjustments to the throttle settings. There was no audible warning of the exceedence of M_{NO} as would be the case with a M_{MO} limitation.

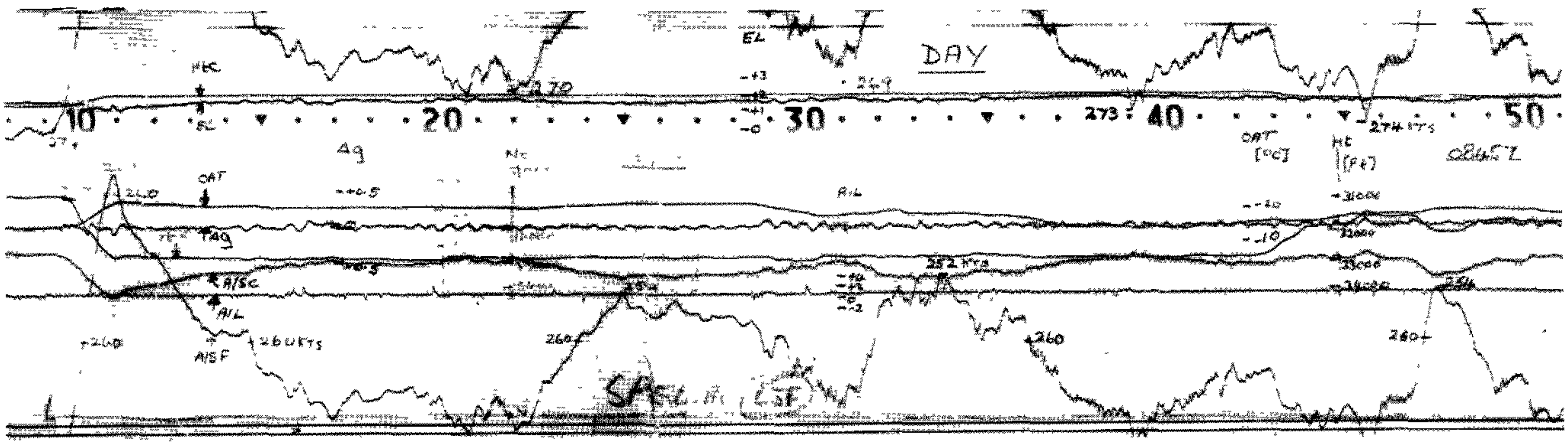

Fig.9. Event in flight 08457

EVENTS OCCURRING DURING CRUISE

RAPID REDUCTION IN AIRSPEED

Sector: Rome - London (type E) - January 1964, Flight 06513

DESCRIPTION

During cruise, airspeed was reduced sharply in one minute from 285 knots to 250 knots and then further to 242 knots. After 4 or 5 minutes cruise airspeed was regained.

COMMENT

The slight disturbance on the g trace, which occurs almost simulataneously with the speed reduction suggests that cloud or cloud tops were seen and appropriate throttling action taken to reduce airspeed in anticipation of turbulence. In the event, the turbulence appears to have been only light.

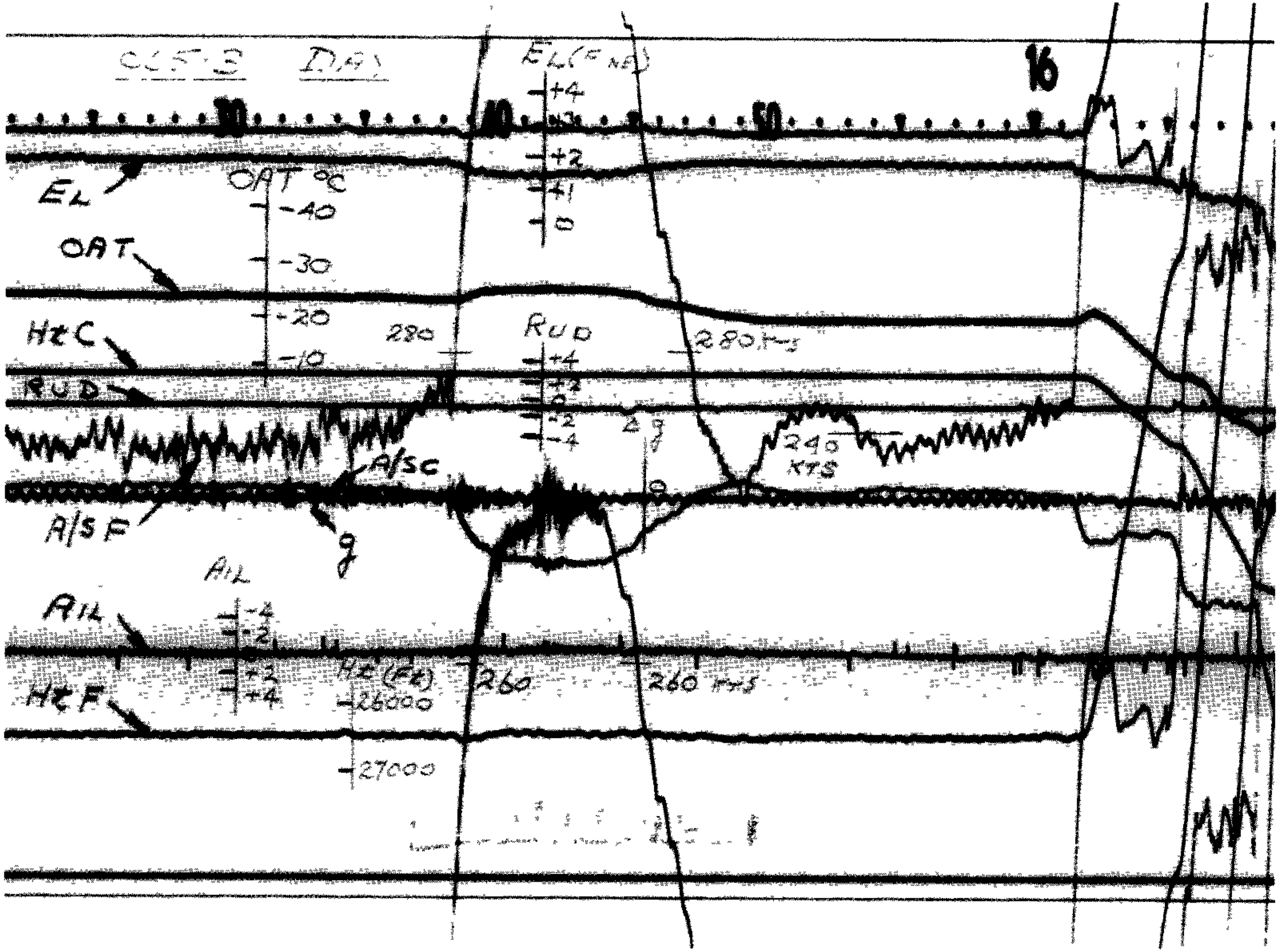

Fig.10. Event in flight 06513

EVENTS OCCURRING DURING CRUISE

TURBULENCE ENCOUNTER DURING REVERSION TO CRUISE

AIRSPEED AFTER A SLOWDOWN PROCEDURE

Sector: (a) Delhi - Rangoon (type C) - August 1963, Flight 02732
(b) Djakarta - Singapore (type C) - February 1963, Flight 00411

DESCRIPTION

(a) Fig.11 The following sequence of trace movements has been extracted from the original record since it is impossible to make such accurate measurements from the reproduction record in this Report.

(i) Prior to the incident the aircraft was being flown under control of the autopilot and was oscillating at an amplitude of ±0.05 g and a frequency of 2 c/min. Airspeed was increasing following a slow-down and had almost reached cruise level.

(ii) A normal acceleration of +0.9 g was experienced and indicated airspeed increased rapidly. Height began to increase and aileron amplitude increased.

(iii) About 2 seconds later a small upward movement of the elevator occurred together with a -0.7 g acceleration increment.

(iv) About 2 seconds later the top of the 200 foot height increase was reached. A large downward movement of the elevator occurred together with a -0.5 g acceleration increment.

(v) About 2 seconds later with the aircraft losing height, and while the elevator was being returned to the neutral position, a +0.4 g acceleration increment occurred.

(vi) About 17 seconds later still, at the bottom of the 500 foot height decrease, a small upward movement of the elevator ($\frac{1}{3}$ degree) and a +0.4 g acceleration increment occurred.

(vii) 1 minute later a stable manual flight condition was regained; aileron activity reduced to normal after a further 2 minutes. Autopilot was re-engaged a further 2 minutes later.

(b) Fig.12 During cruise, airspeed was reduced rapidly at 1244 Z in moderate turbulence. It was then permitted to increase slowly, but at 1249 Z a surge in airspeed was followed by a rapid climb and a decrease in speed. Normal acceleration increments in the range ±0.8 g were experienced, including a manoeuvre contribution of ±0.2 g.

DEDUCTIONS FROM DESCRIPTION OF Fig.11

The shape of the traces and sequence of movements suggest that:-

(i) the oscillation was caused by the autopilot, in height lock mode,

(ii) the +0.9 g was caused by an unexpected large gust, as no significant elevator activity can be detected until 2 seconds later,

(iii) the elevator movement ($\frac{2}{3}$ degree) alleviated a probable downward acceleration more extreme than -0.7 g,

(iv) the elevator movement ($1\frac{1}{3}$ degree) probably contributed to the downward acceleration of -0.5 g,

(v) the elevator movement probably contributed to the upward acceleration of +0.4 g.

COMMENT

The initial +0.9 g acceleration is almost certainly a gust, but the control surface movements suggest that either autopilot or pilot action may have played some part in determining the magnitude of the subsequent accelerations experienced. In Fig.11 both indicated airspeed and indicated height show simultaneous rapid pressure changes whereas in Fig.12 only the indicated airspeed changes rapidly at the onset of turbulence. It is therefore likely that the sudden speed change in Fig.12 is due to a horizontal gust, whereas the changes in Fig.11 are likely to be due to static pressure errors induced by the pitch and roll manoeuvre present at the time.

The +0.9 g was experienced at normal cruise speed and was therefore probably unexpected. Indicated airspeed decreased by 40 knots in the next 40 seconds, which was probably due to horizontal wind shear, although it is possible that an engine power reduction contributed to this rapid deceleration, (i.e. about 0.1 g).

V_{NO} for this aircraft is 270 knots and this speed must not be exceeded in turbulence.

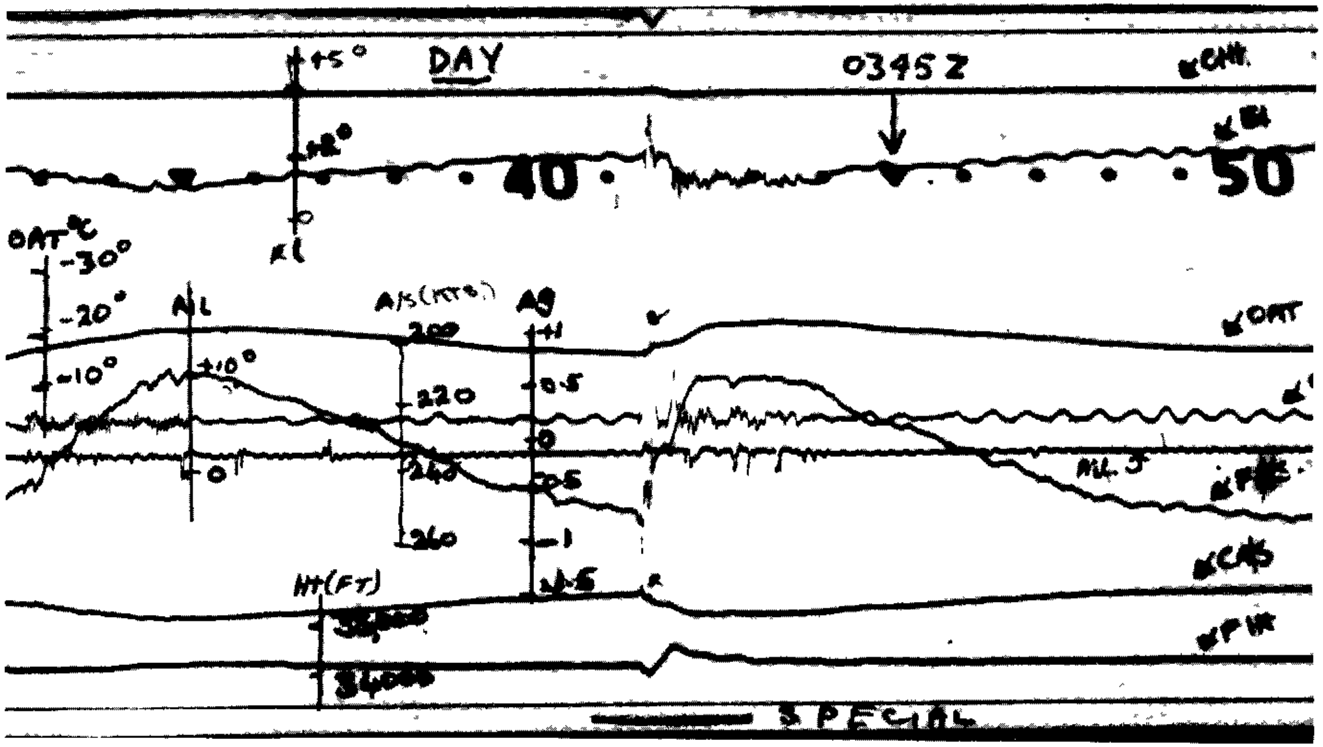

Fig.11. Event in Flight 02732

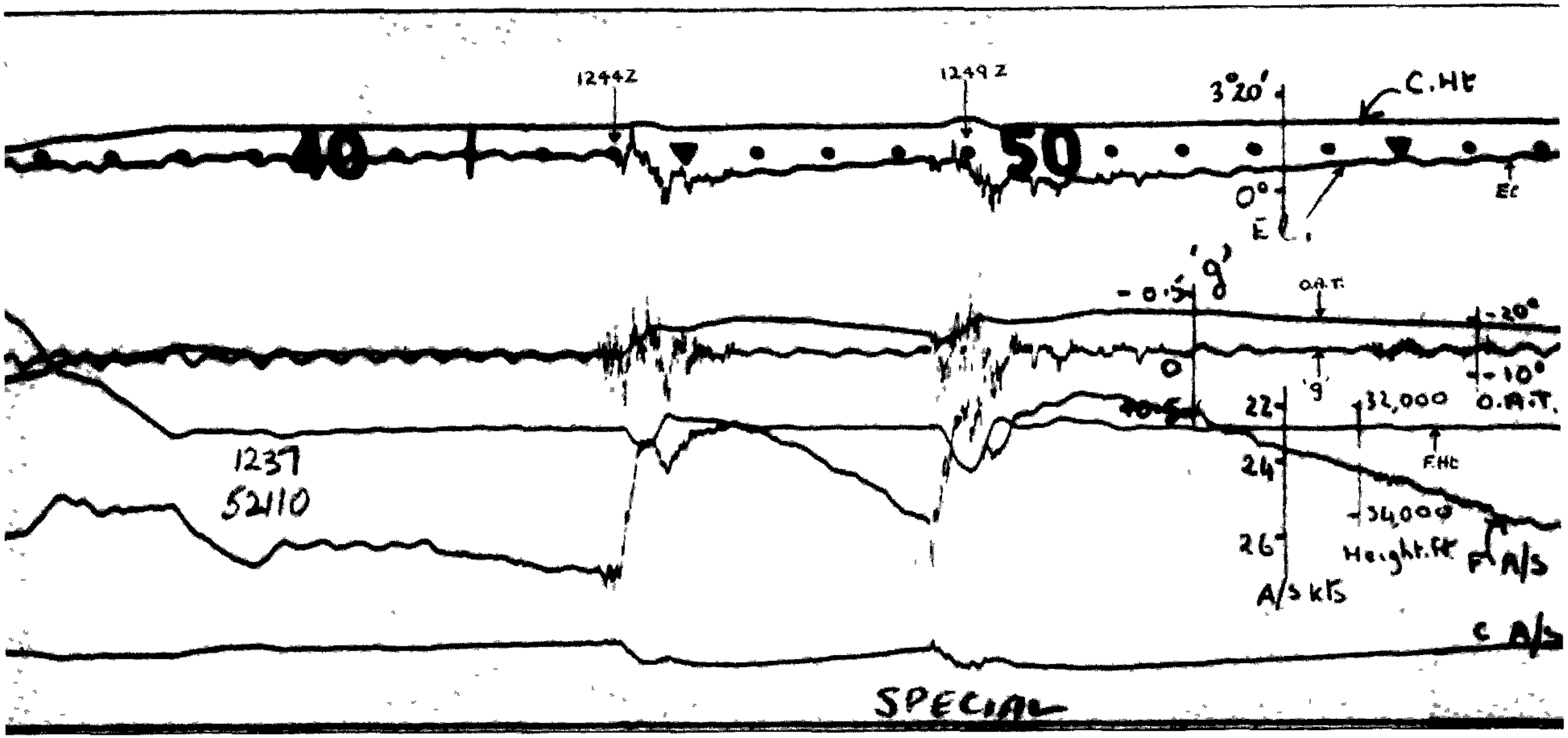

Fig.12. Event in Flight 00411

EVENTS OCCURRING DURING DESCENT

EXCEEDENCE OF V_{NE}

Sector: Rio de Janeiro - Sao Paulo (type C) - May 1963, Flight 01207

DESCRIPTION

At the beginning of descent into Sao Paulo, the airspeed built up to 314 knots at 21000 feet height. V_{NE} was exceeded by 14 knots for $\frac{1}{2}$ minute. Recovery involved an acceleration increment of +0.3 g.

SUPPLEMENTARY INFORMATION

V_{NE} for this aircraft is 300 knots; descent speeds do not normally exceed 260 knots.

COMMENT

Approximately $2\frac{1}{2}$ minutes after the end of cruise the rate of descent had increased to a moderate 1800 feet/minute. However, during this time airspeed was permitted to increase rapidly and the overspeed warning horn almost certainly operated before speed was decreased by checking the descent with a 0.3 g manoeuvre.

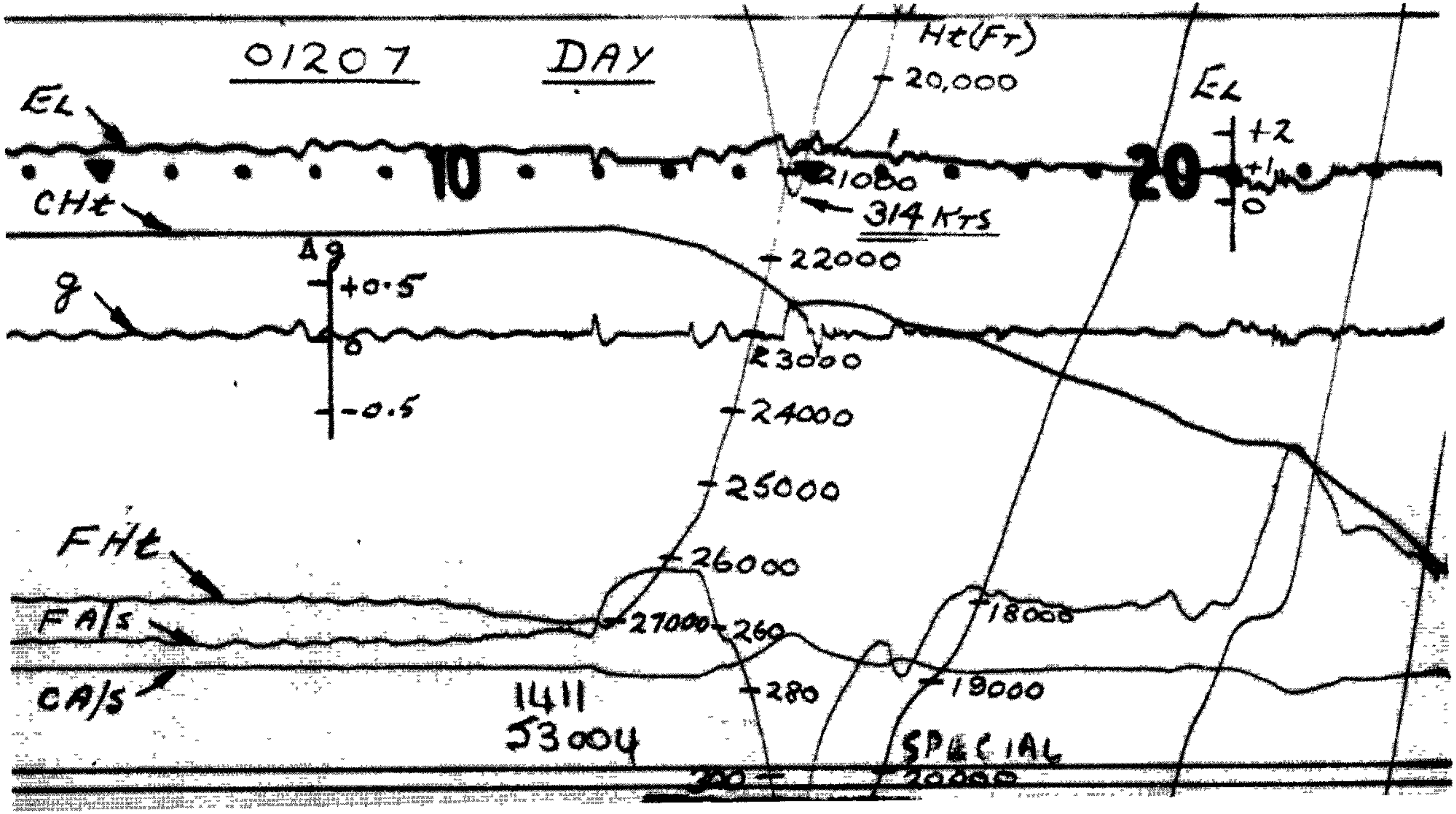

Fig.13 Event in flight 01207

EVENTS OCCURRING DURING DESCENT

EXCEEDENCE OF V_{MO}

Sector: Kingston - Lima (type D) - July 1965, Flight 15622

DESCRIPTION

After a normal descent to 18000 feet, rate of descent and airspeed increased to about 3000 feet/minute and 366 knots respectively during a period of approximately $1\frac{1}{2}$ minutes. Recovery was initiated at an altitude of 14300 feet and descent was resumed after a gain in height of 200 feet. Note that the time base changes with operation of the flaps.

SUPPLEMENTARY INFORMATION

The normal descent speed for this aircraft is 280 knots although airspeeds of up to about 320 knots are permitted in the absence of turbulence. At this altitude the maximum operating speed, V_{MO}, is 358 knots.

COMMENT

Since there is no evidence of turbulence, a slight increase in airspeed to about 320 knots may well have been intended. However, it appears that airspeed increased sufficiently rapidly to result in an inadvertent exceedence of V_{MO} before the crew were alerted, possibly by the operation of overspeed warning horn, at about 364 knots.

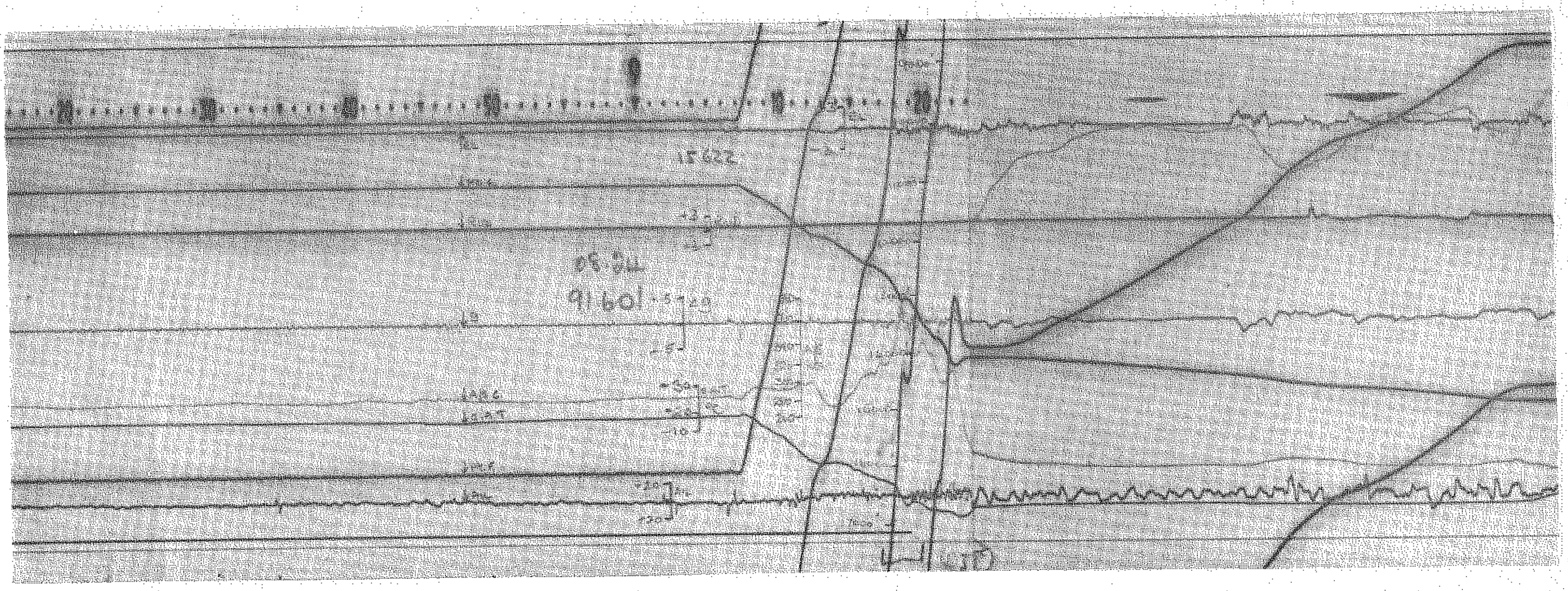

Fig.14. Event in Flight 15622

EVENTS OCCURRING DURING DESCENT

COARSE AIRSPEED CONTROL DURING DESCENT

Sector: Khartoum - Cairo (type C) - December 1963, Flight 05341

DESCRIPTION

At 27000 feet, during descent into Cairo, the airspeed fell sharply from 269 knots at top of cruise and 26000 feet to 237 knots at 25000 feet and then increased slowly to 262 knots at constant altitude, before falling rapidly to 228 knots at 23000 feet. As the descent continued the speed increased to 266 knots at 12000 feet and then reduced to approach speed.

COMMENT

The aircraft was apparently given initial clearance to descend from the cruise altitude to flight level 250. The fluctuations in airspeed are almost certainly associated with rather infrequent changes in throttle setting. V_{NO} for this aircraft is 270 knots up to 32000 feet.

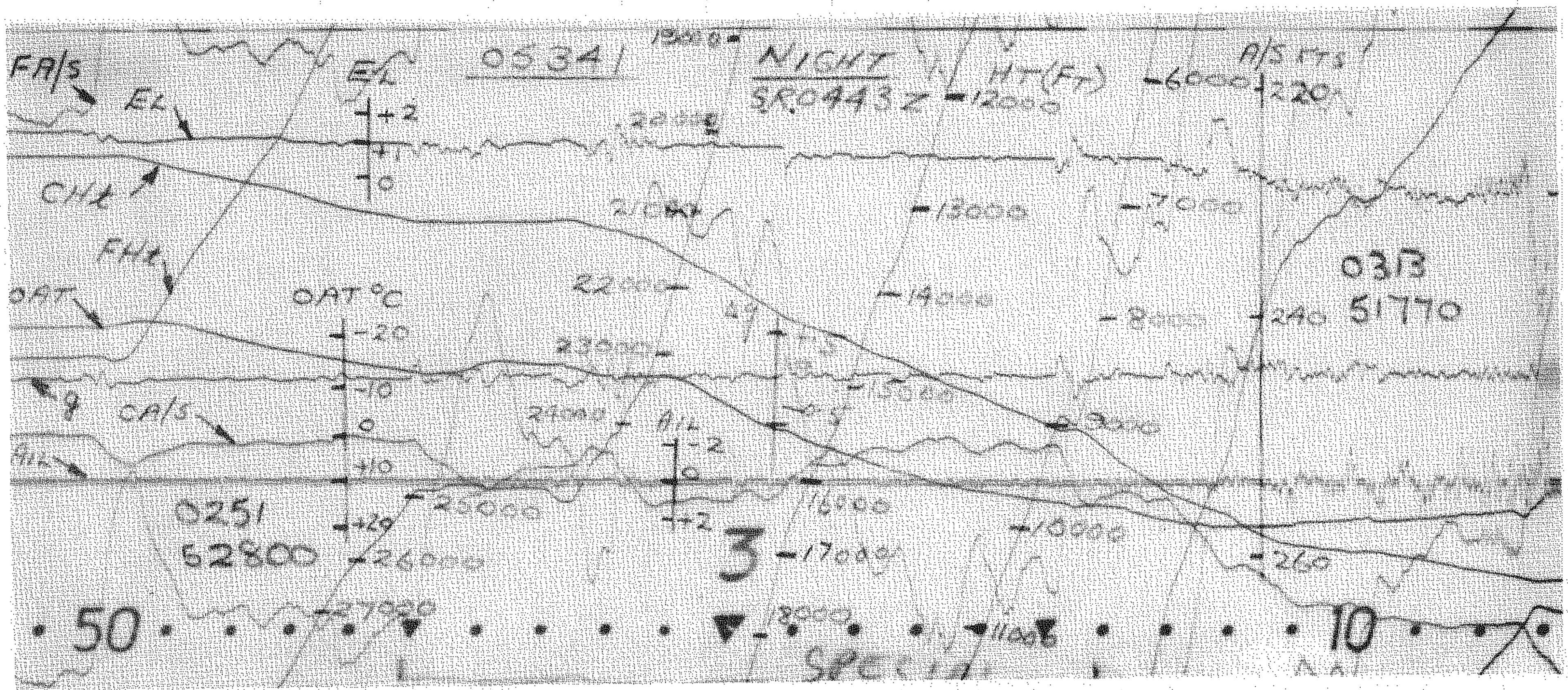

Fig.15 Event in flight 05341

EVENTS OCCURRING DURING DESCENT

RAPID AIRSPEED REDUCTION AT LOW ALTITUDE

Sector: London - Bermuda (type D) - October 1965, Flight 15902

DESCRIPTION

A normal descent was maintained until 6 minutes before touchdown when the aircraft reached 3000 feet with an airspeed of 310 knots. Over the next 2 minutes, in which the aircraft gained 700 feet in height, the airspeed decreased to below 200 knots before flaps were lowered and the descent was resumed.

SUPPLEMENTARY INFORMATION

The normal descent speed for this aircraft is 280 knots but airspeeds of up to about 320 knots are permitted in the absence of turbulence.

Surface weather data for Bermuda are presented in Appendix A Met. Report 2.

COMMENT

This is an example of the use of high airspeed in descent down to very low altitude, followed by a late pull-up manoeuvre to effect the reduction in airspeed necessary before flap operation.

The use of this technique is not particularly rare in the operation of this type of aircraft, but in this example, the pull-up was made in the presence of scattered cloud and light turbulence.

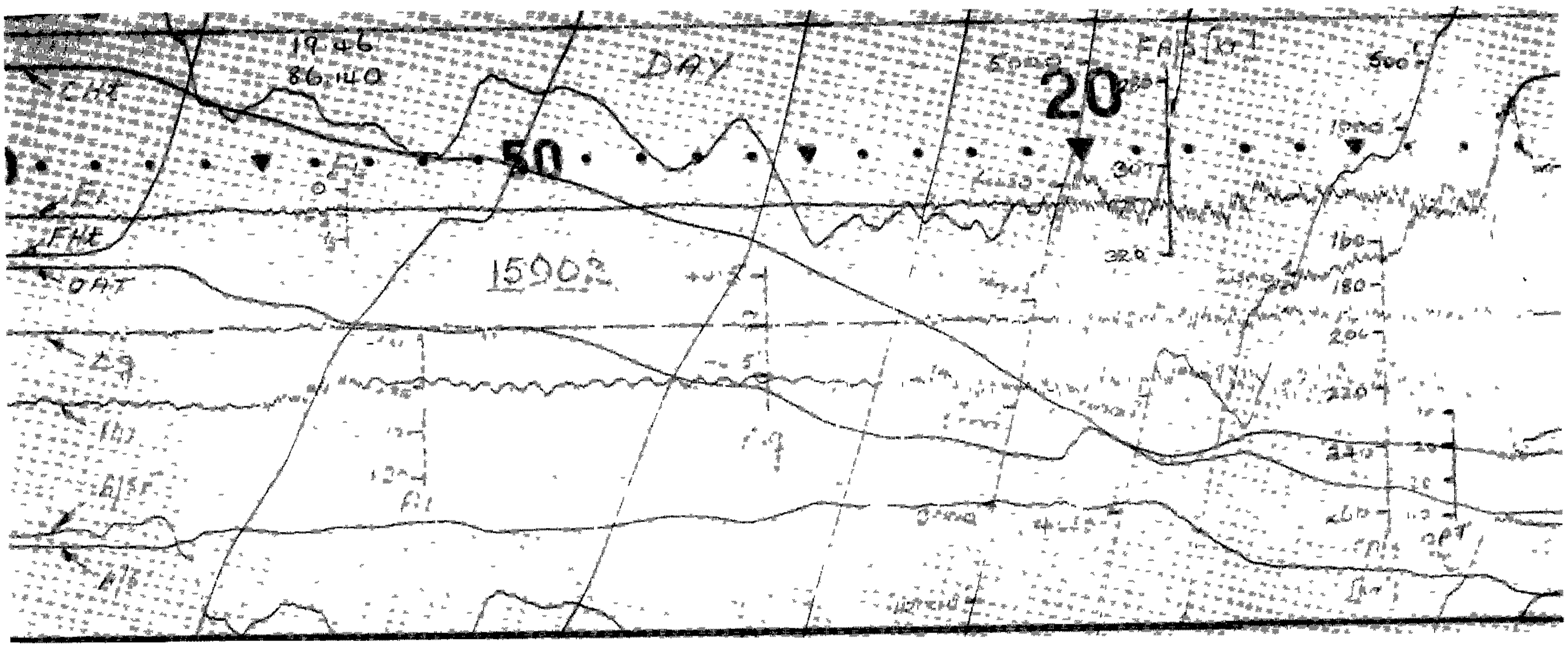

Fig.16. Event in Flight 15902

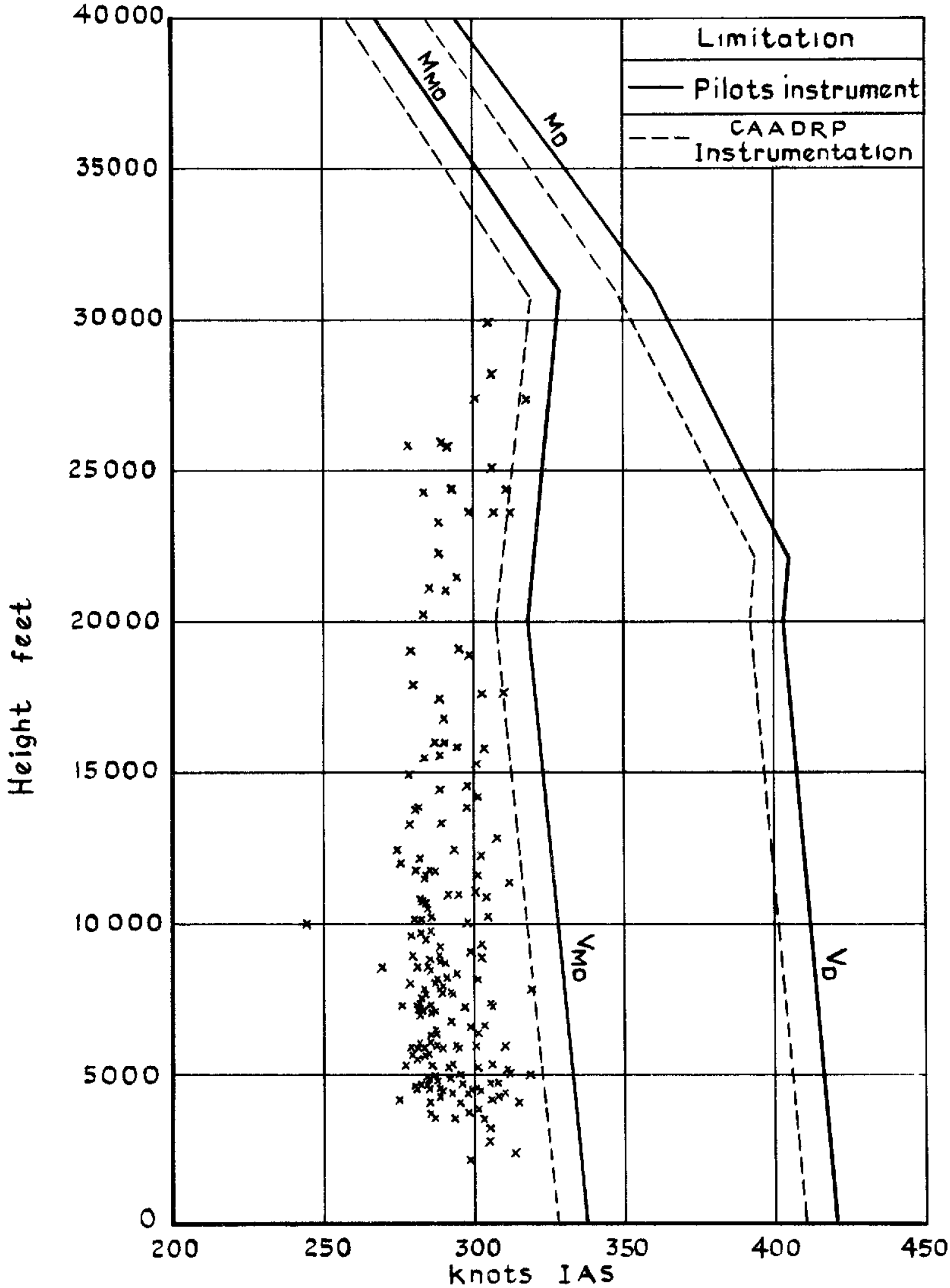

Fig. 17 Maximum speed v height aircraft A — climb

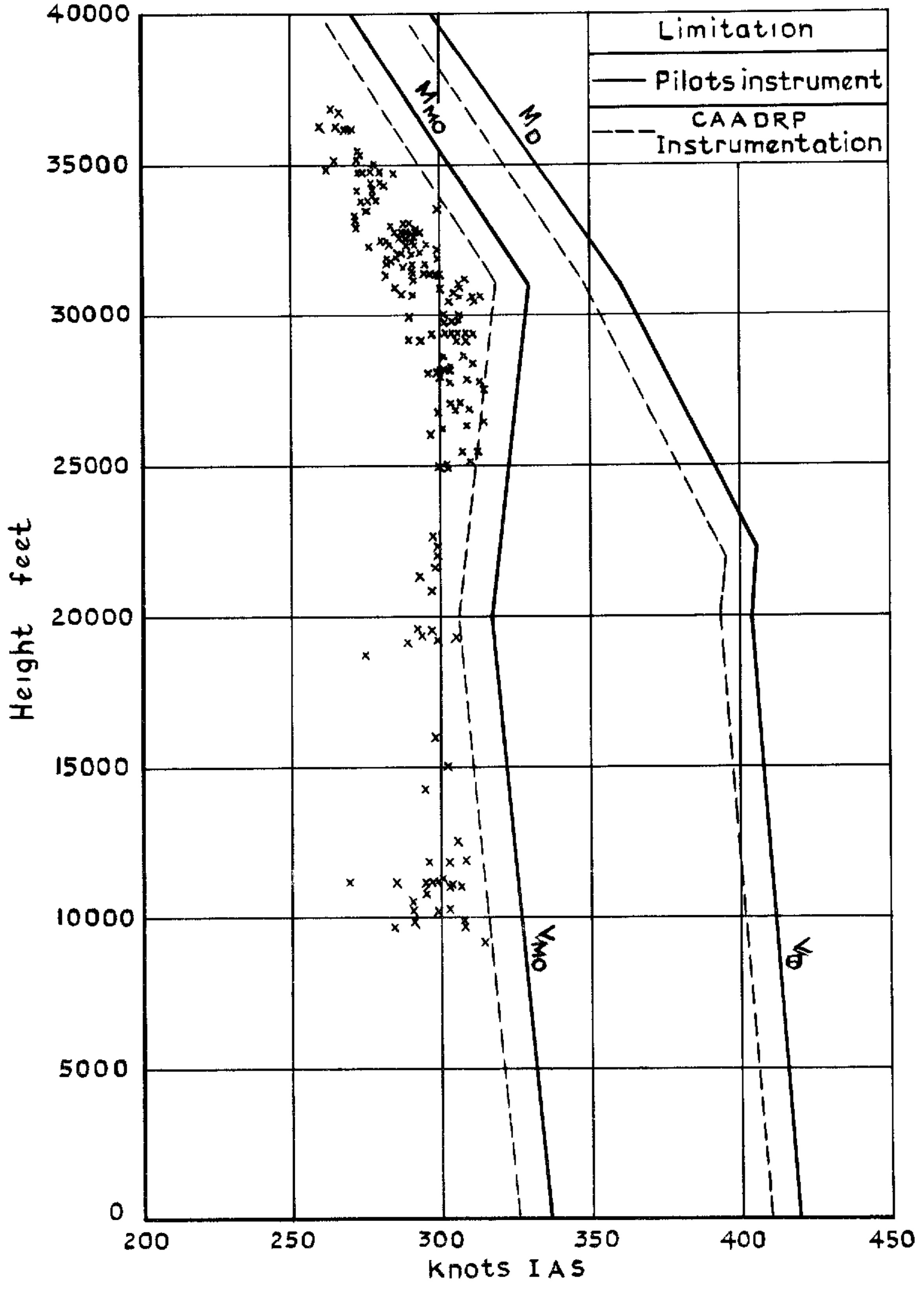

Fig.18 Maximum speed v height aircraft A — cruise

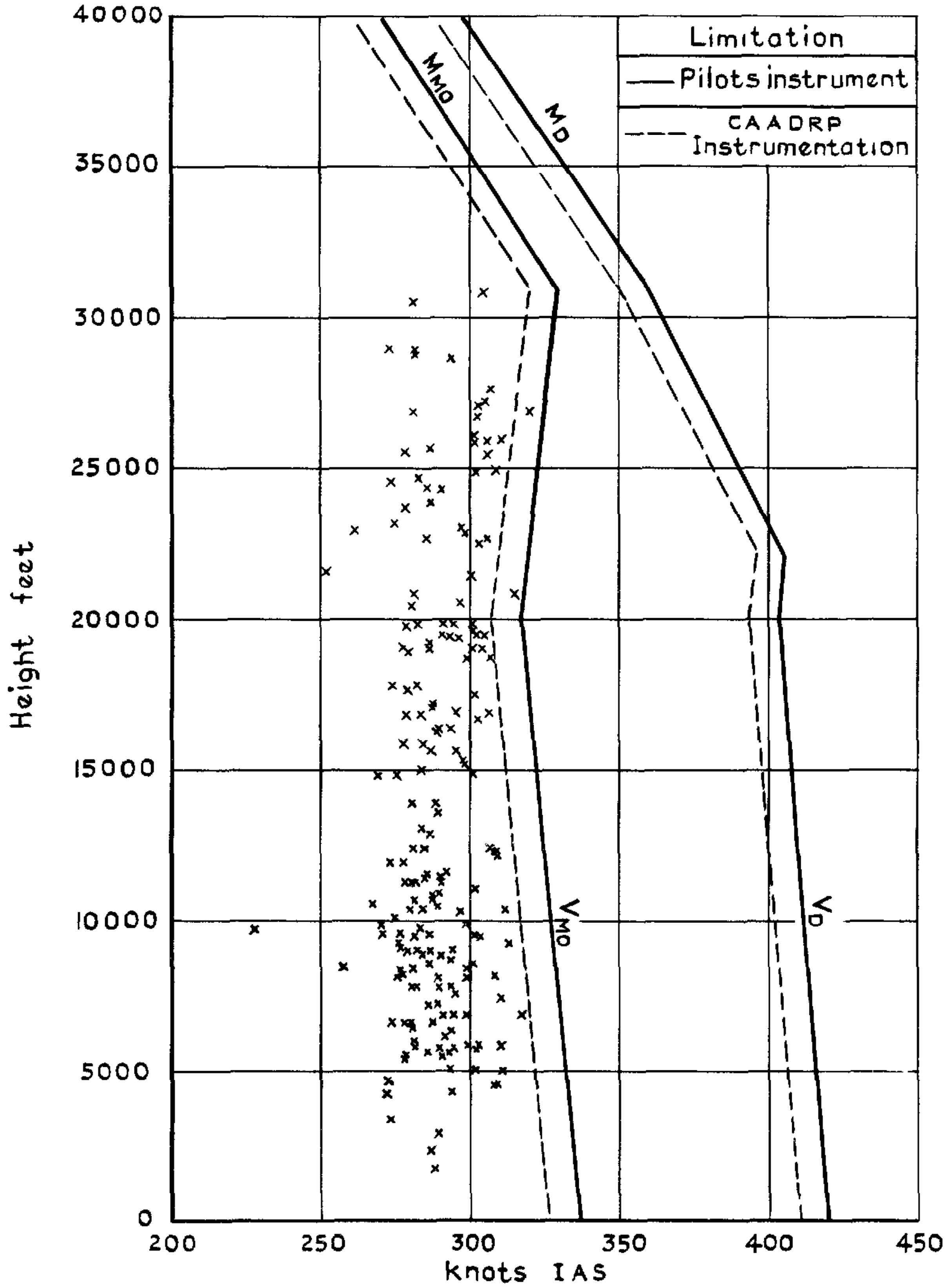

Fig 19 Maximum speed v height aircraft A — descent

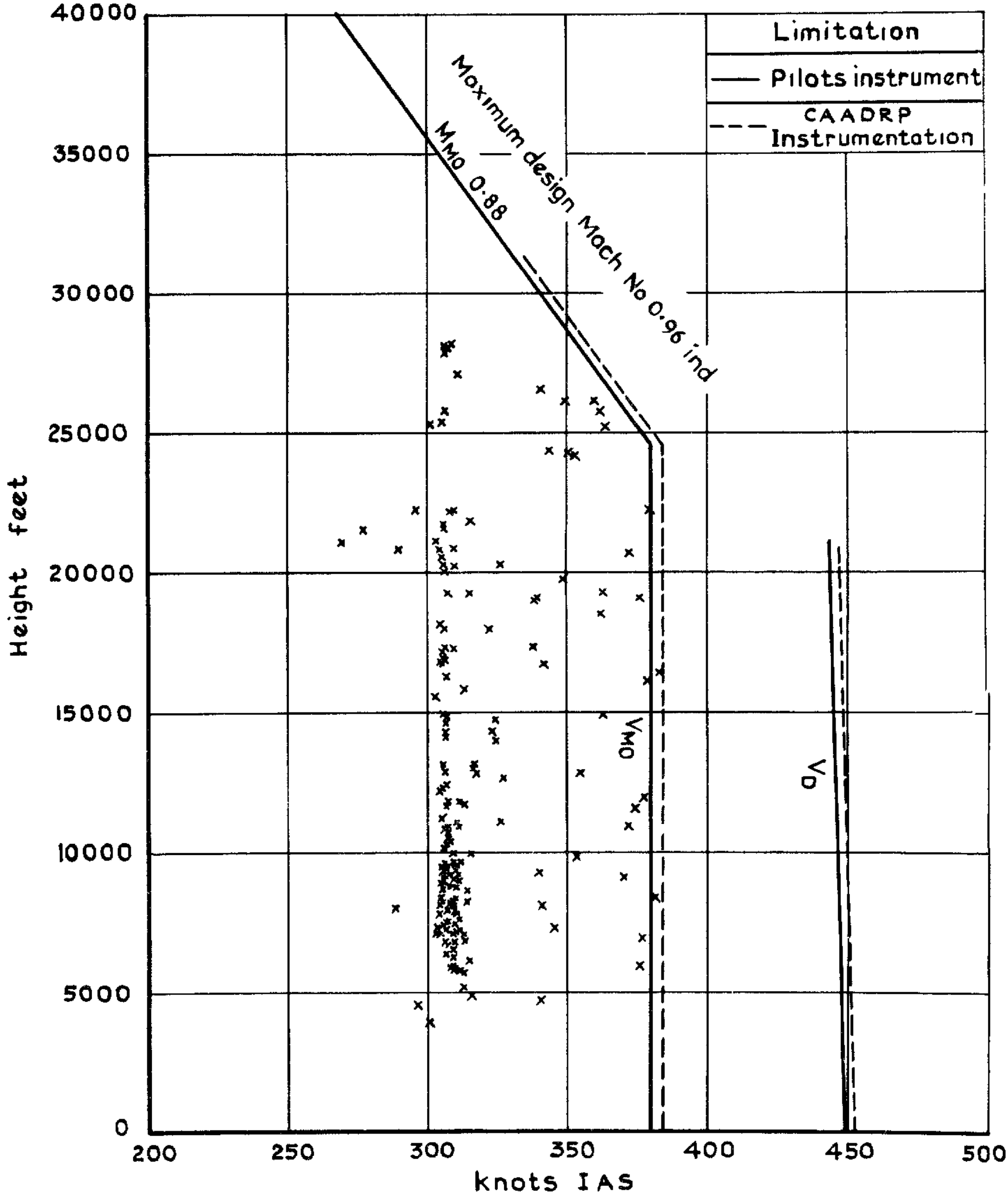

Fig. 20 Maximum speed v height aircraft B — climb

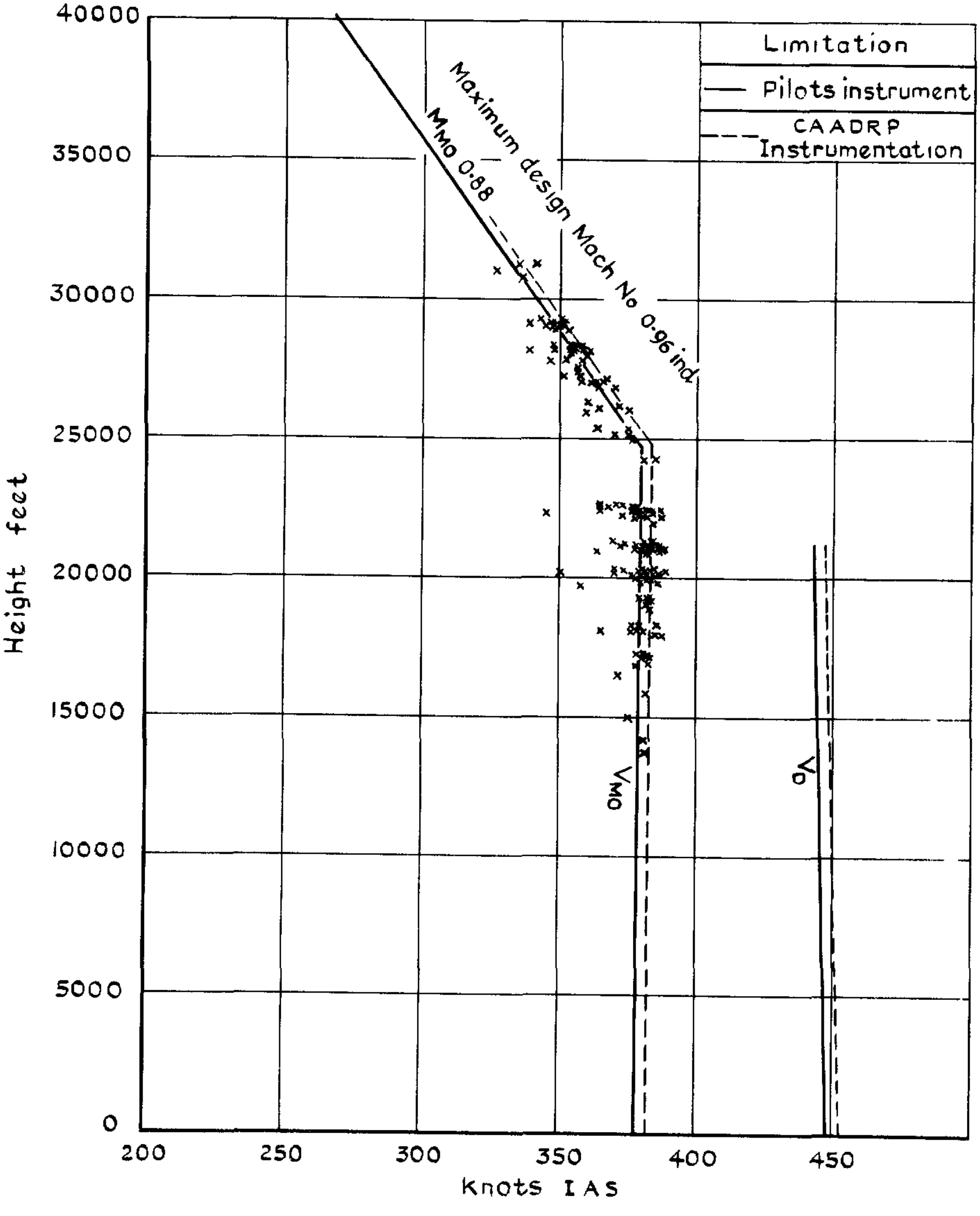

Fig. 21 Maximum speed v height aircraft B — cruise

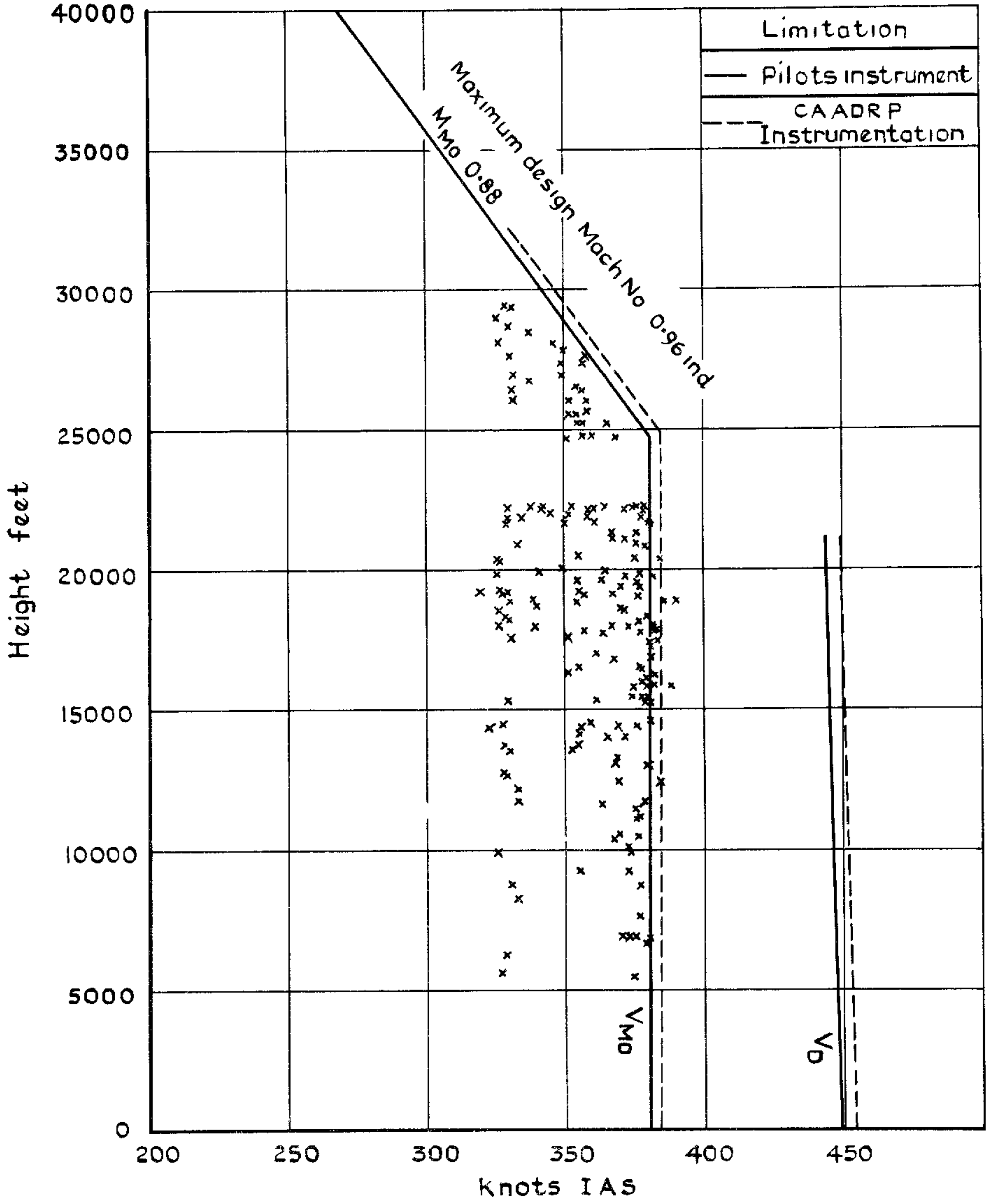

Fig. 22 Maximum speed v height aircraft B —— descent

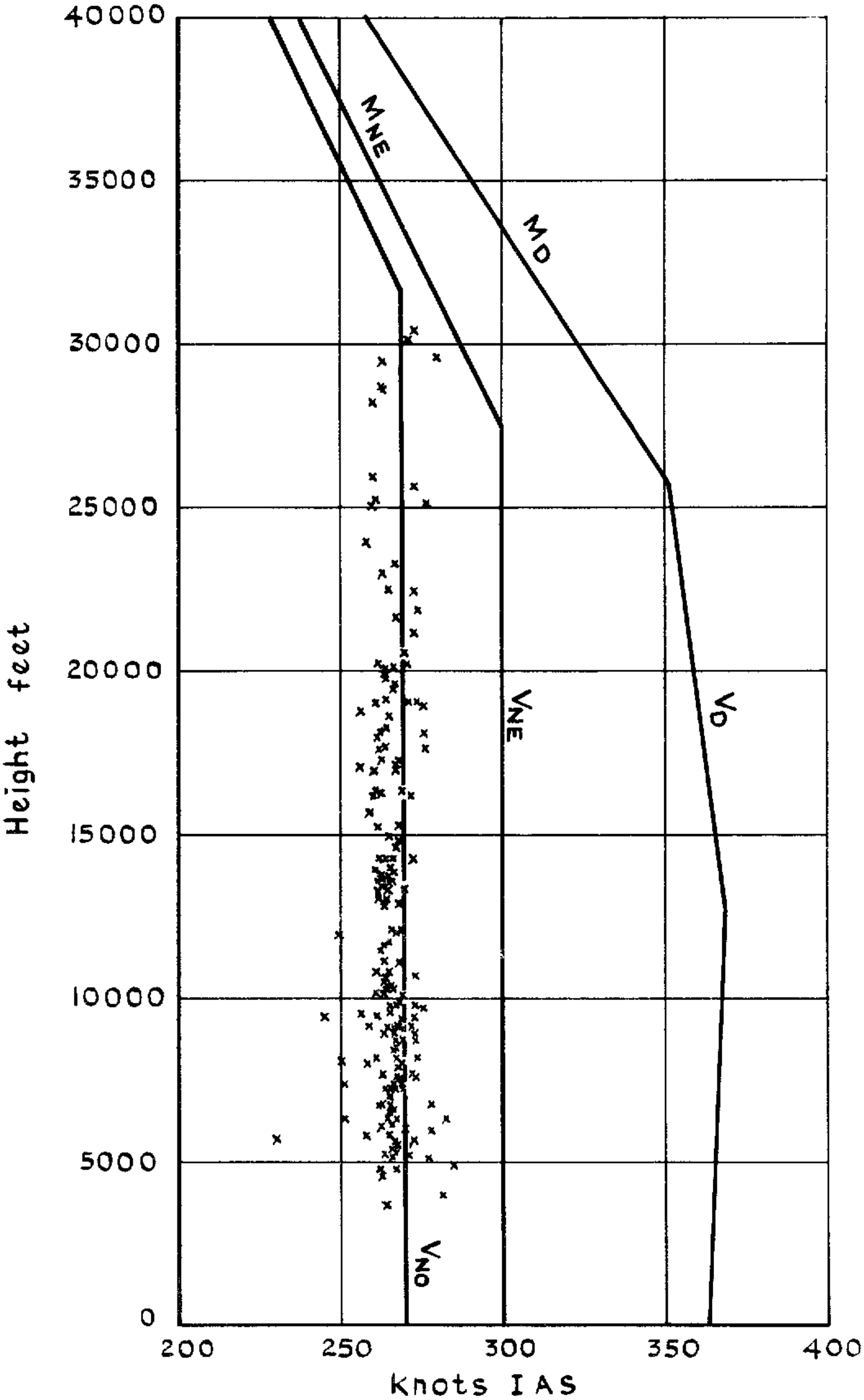

Fig 23 Maximum speed v height aircraft C — climb

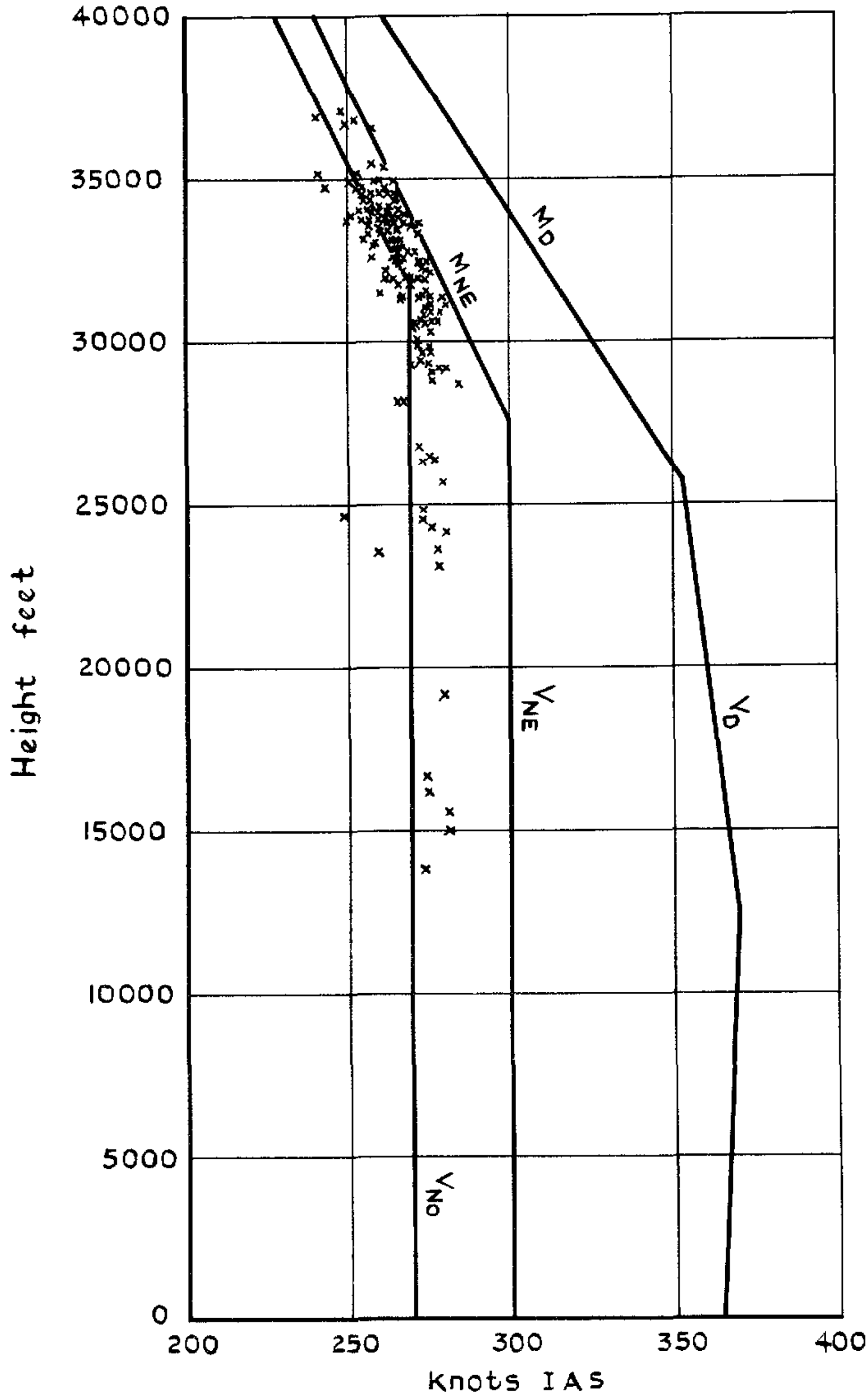

Fig. 24 Maximum speed v height aircraft C — cruise

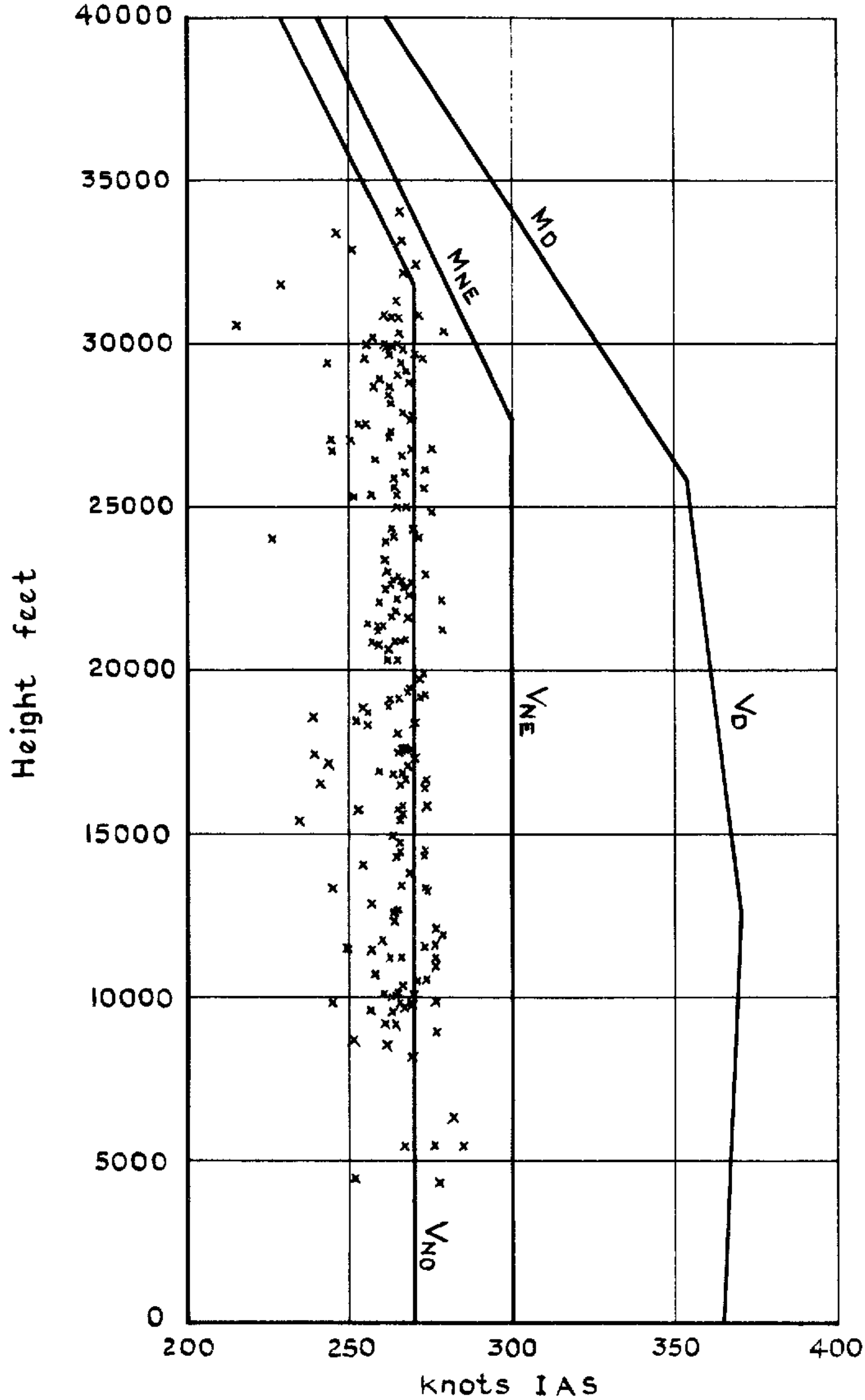

Fig. 25 Maximum speed v height aircraft C — descent

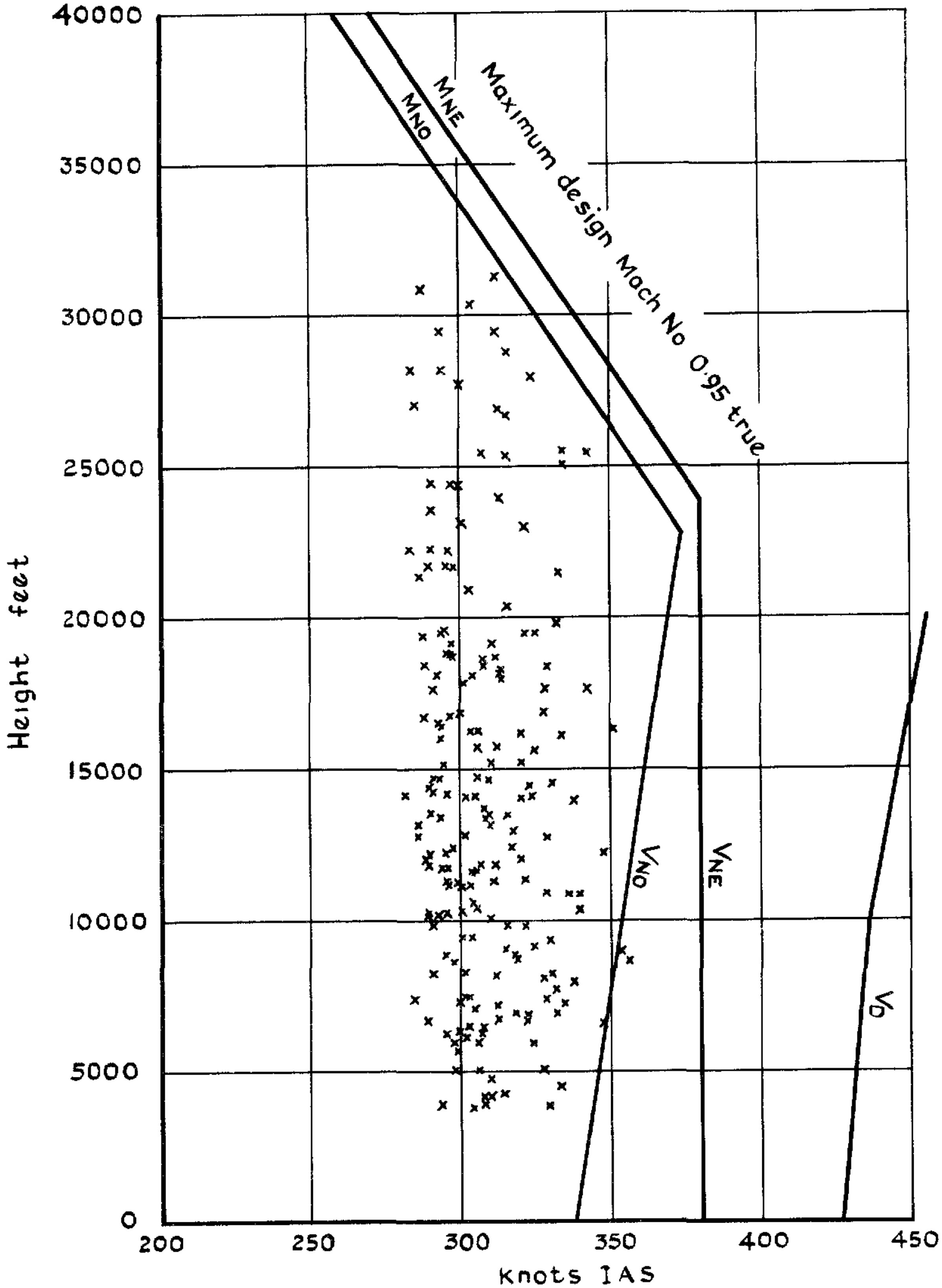

Fig. 26 Maximum speed v height aircraft D— climb

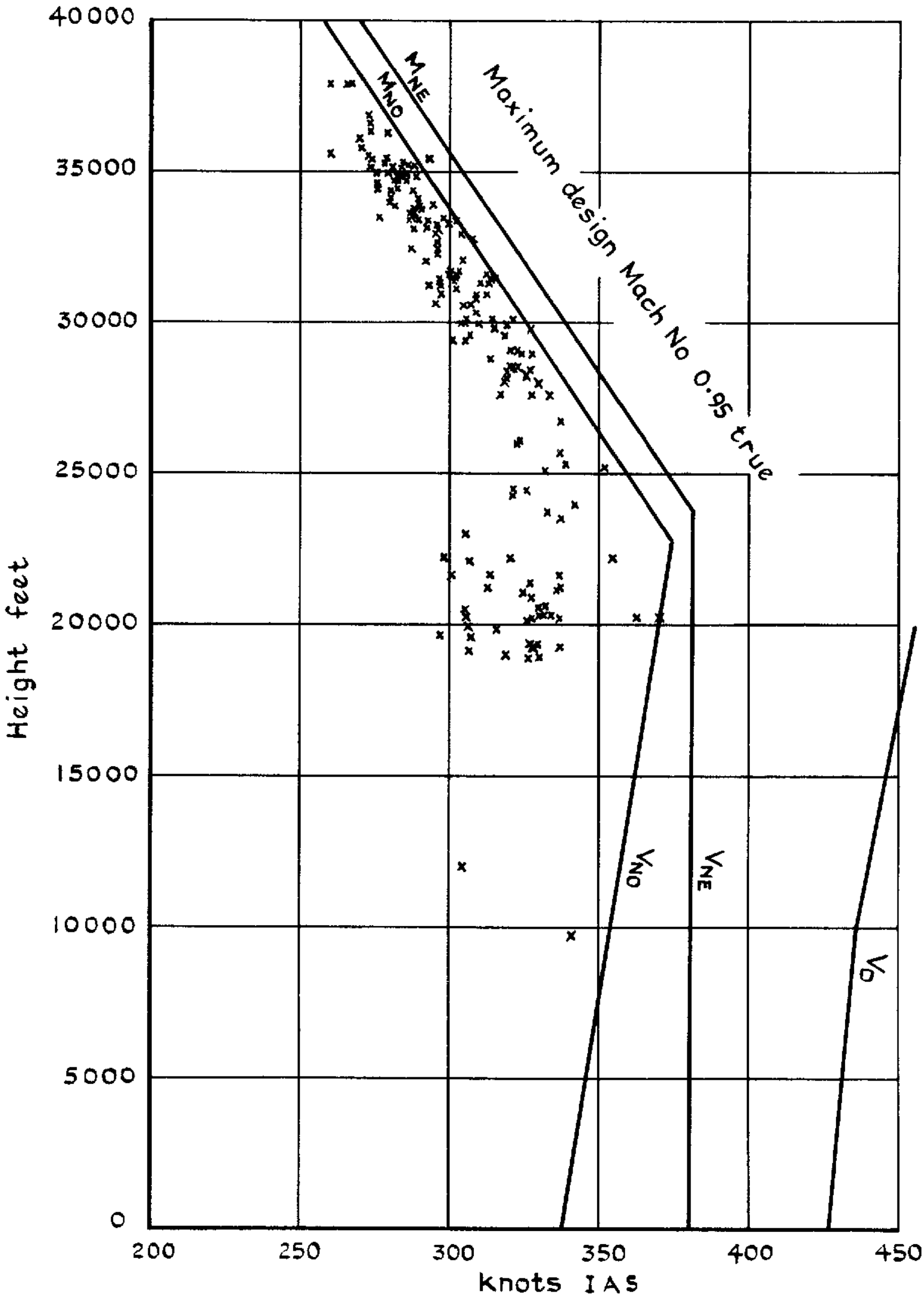

Fig 27 Maximum speed v height aircraft D — cruise

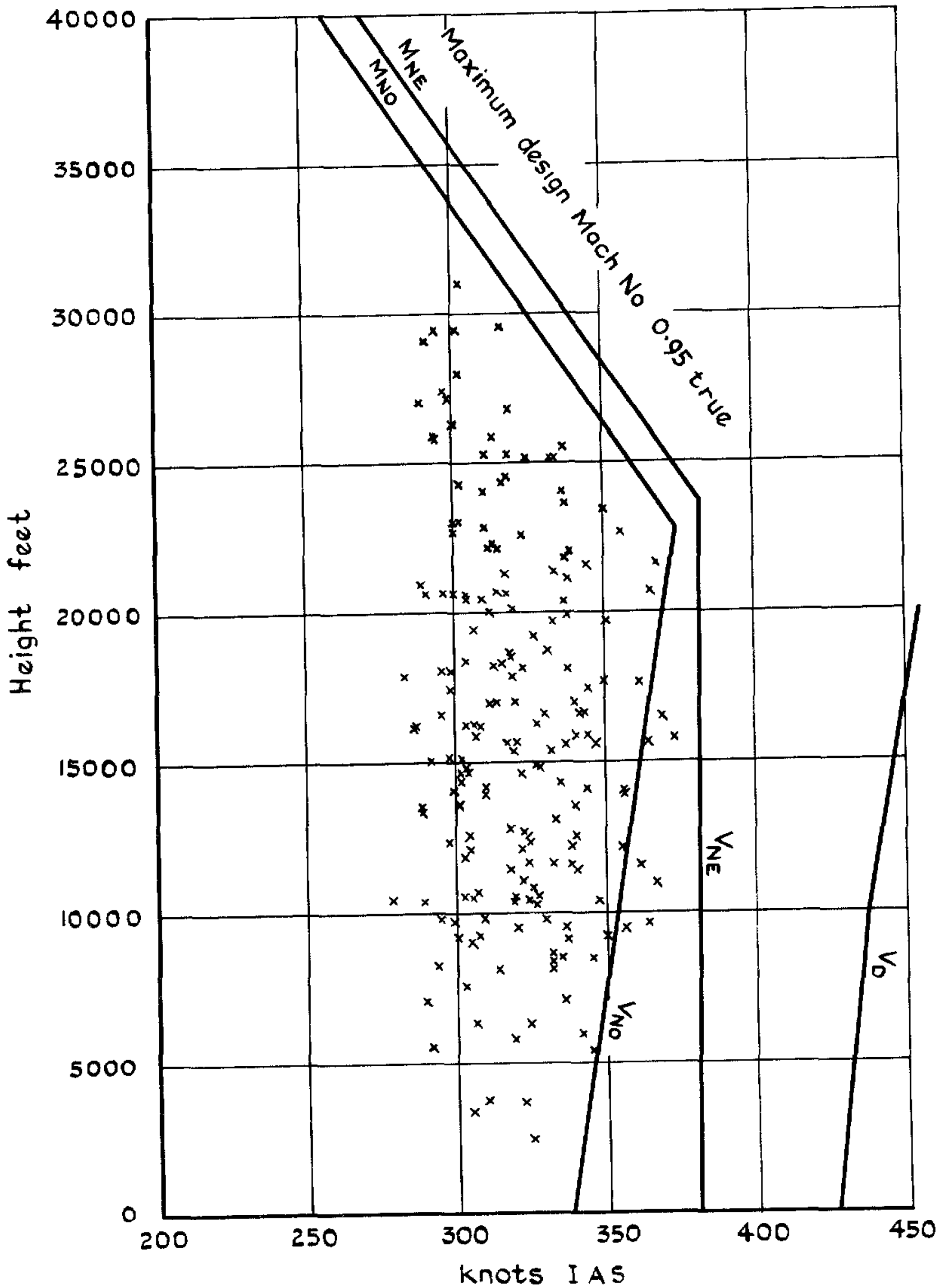

Fig.28 Maximum speed v height aircraft D — descent

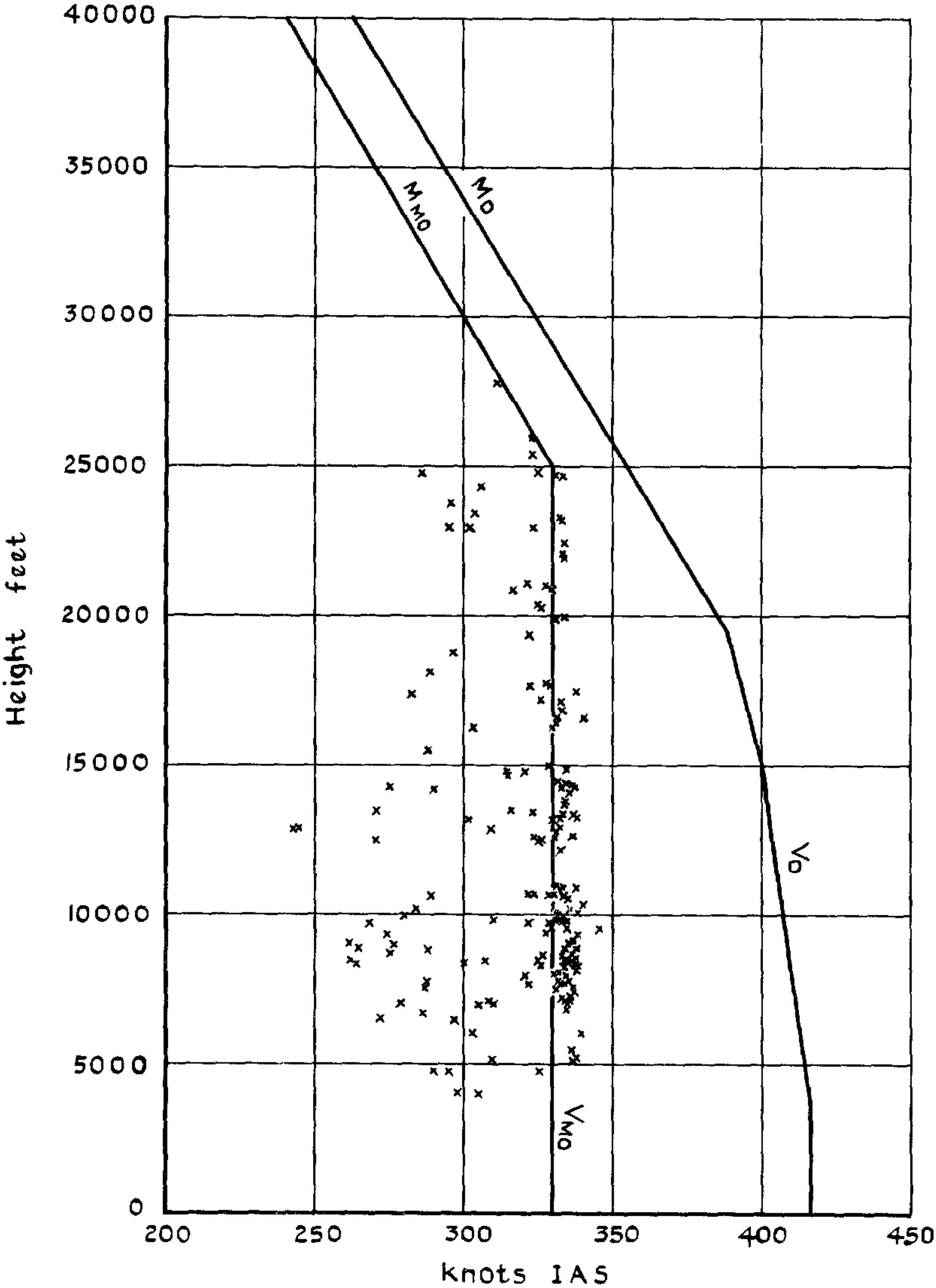

Fig. 29 Maximum speed v height aircraft E — climb

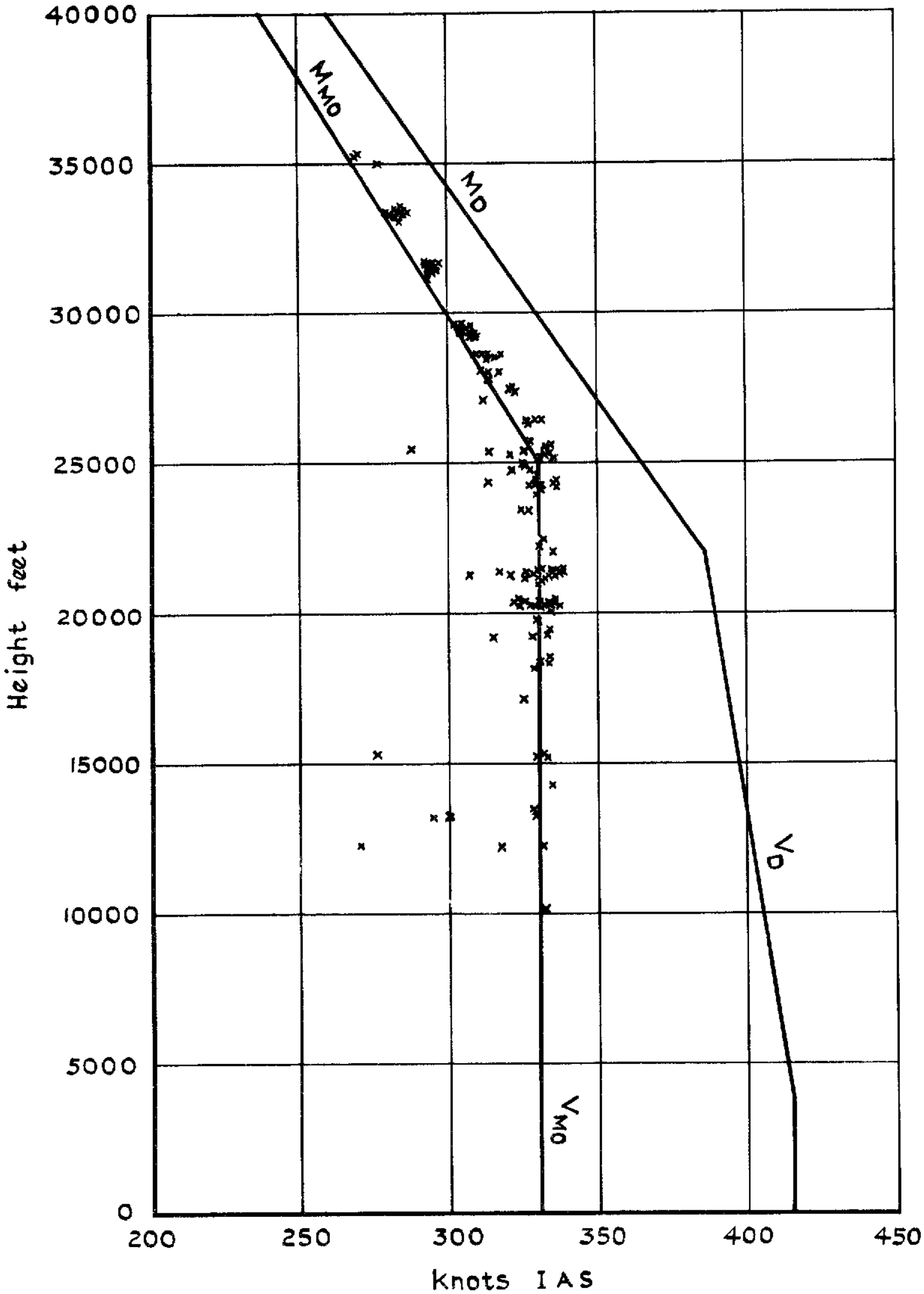

Fig.30 Maximum speed v height aircraft E — cruise

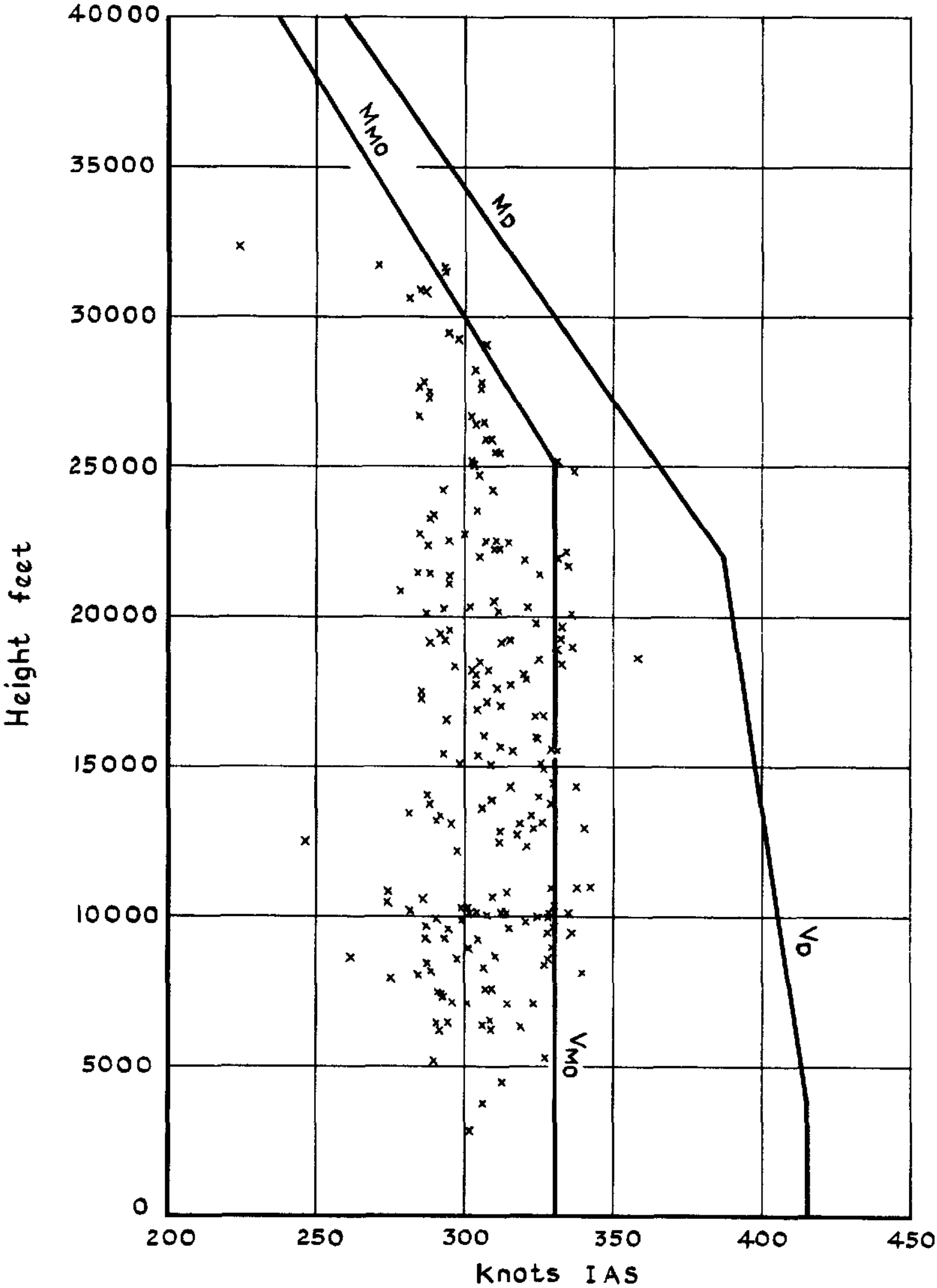

Fig. 31 Maximum speed v height aircraft E — descent

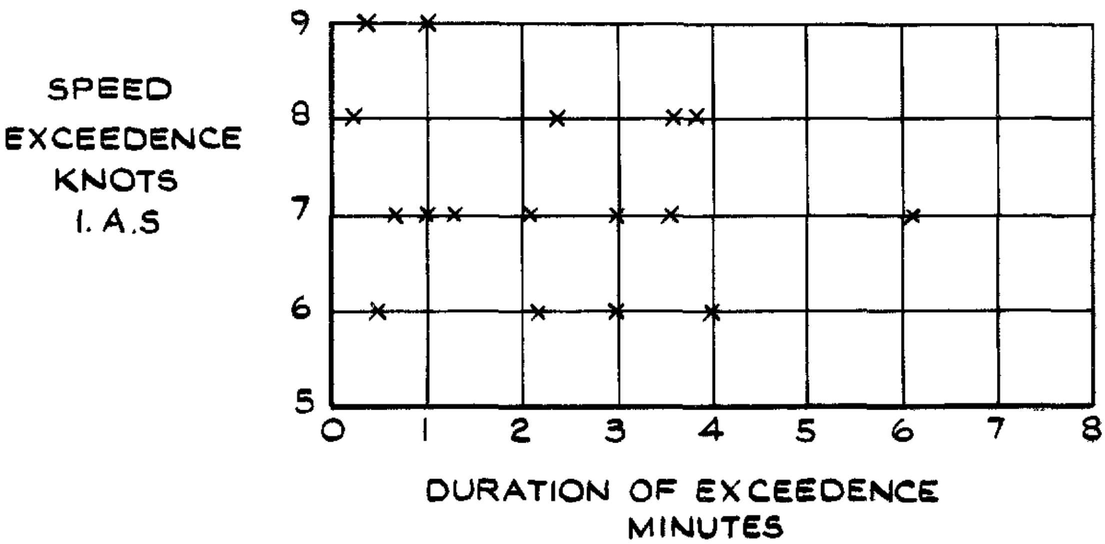

FIG.32 V_{MO} EXCEEDENCES IN CRUISE (max RECORDED CRUISE SPEED) AIRCRAFT 21

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A.R.C. C.P. No. 1088
June 1969

The CAADRP Special Events Working Party — 629.13.075, 629.13.08

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SPECIAL EVENTS RELATED TO AIRSPEED CONTROL PRACTICES
(FEBRUARY 1963 TO FEBRUARY 1966)

Since October 1962 continuous trace records of airworthiness data have been taken from a small number of aircraft in normal airline service. Throughout the recording period the records have been searched for unusual occurrences, and each of these has been studied to determine its nature and, where possible, its cause.

(over)

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