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Civil Aircraft Airworthiness Data Recording Programme: Some Characteristics of Severe Turbulence

by

G. E. King

Structures Dept., R.A.E., Farnborough

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CIVIL AIRCRAFT AIRWORTHINESS DATA RECORDING PROGRAMME: SOME CHARACTERISTICS OF SEVERE TURBULENCE

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G. E. King

SUMMARY

The characteristics of severe turbulence suggested by an initial study of continuous trace records have been tested by examining turbulence encountered over a larger number of flying hours.

Records from 23034 flying hours have been searched for patches of severe turbulence and those which produced the highest acceleration increments on the aircraft are presented in detail.

It is found that the largest acceleration increment in a patch is on average 1.3 times the value that would be predicted from a Rayleigh distribution of peaks. About a half of the patches occurred without warning, and examination of outside air temperature data suggests that little additional warning would be provided by a conventional ram air temperature measuring device.

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*Replaces R.A.E. Technical Report 69150 - A.R.C. 31835

CONTENTS

1 INTRODUCTION

An initial study of turbulence from continuous trace records has been described previously[1]. This was a complete analysis of the acceleration trace for 3284 flying hours and included the separation of gusts from manoeuvres, the total acceleration history and a distribution for the duration of turbulence. The previous work[1] suggested that the characteristics of severe turbulence are a non-Gaussian acceleration distribution, a short duration and a roughly one-in-three chance of occurring without warning.

The present study was undertaken to test these characteristics by examining the turbulence encountered in 23034 flying hours. A detailed study was made of the 36 patches of turbulence which produced the largest acceleration increments on the aircraft. The data presented for each patch include the peak acceleration distribution, the duration, and the degree of warning available to the pilot. The ambient air temperature-distance profile is also presented and the possibility of using this to provide warning of severe turbulence is discussed.

2 TYPE OF FLYING

The records analysed were obtained from four-engined pure jet civil transports carrying storm warning radar and are all the suitable records from the first phase of the CAADRP[2] programme.

Aircraft type III is a later version of type I, whilst type II is of a different manufacture.

The number of flying hours and the routes covered by each type are as follows:-

Type I 10945 hours	Flying from London to Europe, Africa, India, Far East, Australia and South America.
Type II 9436 hours	Flying from London to Europe, India, Far East, Australia, North America and West Indies.
Type III 2653 hours	Flying from London to Europe and the Near East.

3 PATCH SELECTION AND MEASUREMENTS TAKEN

The records were searched for high incremental accelerations and patches of turbulence were selected on the following basis to give about 200 flights per patch per aircraft: the actual results were 310, 194 and 192 flights per patch for types I, II and III respectively.

Aircraft type I - patches containing over 0.90 g increment.

Aircraft type II - patches containing over 0.75 g increment.

Aircraft type III - patches containing over 0.80 g increment.

For each patch the following measurements were taken:-

(i) Aircraft height, weight and airspeed at the time of the largest acceleration increment.

(ii) The duration of the patch to the nearest $\frac{1}{4}$ minute; patches of duration less than $\frac{1}{4}$ minute, however brief, are classed as $\frac{1}{4}$ minute.

(iii) The values of the acceleration peaks exceeding 0.25 g according to the mean crossing peak count method[3]. Small changes in acceleration are not included as only the largest peak between successive zero crossings is measured. The acceleration counts given are the number of peaks exceeding the relevant level; that is, the number of counts at, say, 0.5 g refers to actual values of 0.51 g and above; the final distribution is cumulative*.

(iv) Values of recorded air temperature, airspeed and height every $\frac{1}{2}$ minute for 10 minutes before and after the largest acceleration increment in a patch.

The degree of warning available was assessed by examining the airspeed trace and noting when the speed reduction, if any, was made.

4 PEAK ACCELERATION DISTRIBUTIONS OF THE PATCHES OF SEVERE TURBULENCE

The cumulative peak acceleration increment counts (disregarding sign as the counts are usually too few to give useful separate distributions) for each patch of turbulence are shown in tables 1-5, together with height, airspeed, weight, warning and duration data. Reproductions of the original records are given in Figs.1-35.

The distributions given in Tables 1-5 are shown in Figs.36-46 as plots of log counts (N) against acceleration increment (x) squared. In order to compare them with the Rayleigh[1] expression $N = N_0 \exp\left(\frac{-x^2}{2a^2}\right)$ (the crossing distribution of a Gaussian process) a straight line of slope $2a^2$ is fitted to the plots through the largest value of N. The rms value 'a' of a patch was calculated from the expression:-

*A measured value of, say, 0.5 g could be between 0.496 g and 0.505 g and therefore the levels exceeded should be 0.495 g etc. However the accuracy of the original data does not warrant this refinement.

$$2a^2 = \frac{\sum_{P=1}^{P=N} x_P^2}{N} - C^2 \qquad (1)$$

where C is the counting threshold; in this case 0.25 g.

The plots also show a value of P, which is the probability that any other patch of turbulence with similar value of 'a' and N will contain an increment exceeding the observed maximum x_m. Values of P were obtained from the expression:-

$$P = 1 - \{1 - \exp[(C^2 - x_m^2)/2a^2]\}^N. \qquad (2)$$

Some of the patches contain a small number of counts only, and the calculated values of a P should therefore be treated with caution. However, on average, the largest increment in a patch is about 1.3 times the expected value; all values of P are less than 50%, 27 ranging from 0 to 20%; the overall average value of P is 16%.

5 WARNING OF TURBULENCE

The aircraft in question generally cruise above the recommended rough air speed for the type; when turbulence is met a speed reduction is required. If the airspeed was reduced before the encounter it is assumed that some warning was available; if the airspeed was reduced during or just after an encounter it is assumed that no warning was available. In some cases, mainly during climb and descent, the airspeed was already low and no warning assessment can be made. The results are summarised as follows:-

Aircraft type	I	II	III	Total
No. of patches expected	3	0	4	7
No. of patches unexpected	9	5	3	17
Not known	1	9	2	12
Total	13	14	9	36

Thus approximately a half of the patches which produced the largest loads on these aircraft were encountered without warning. This is slightly more than found previously[1], but this could be caused by the use of higher g selection levels for this analysis. Of the 17 unexpected patches, 16 were of $\frac{1}{4}$ and $\frac{1}{2}$ minute durations whilst the expected patches ranged between $\frac{3}{4}$ and 3 minutes, indicating that the shorter a patch the less likely it is that any warning is available. This theory is supported by further study of data previously presented; 9 of the 10 unexpected patches lasted $\frac{1}{4}$ or $\frac{1}{2}$ minute, while the 4 expected patches ranged from $\frac{1}{2}$ to $2\frac{1}{2}$ minutes.

6 MEASUREMENT OF AIR TEMPERATURE

A total air temperature trace was available on all but three of the severe turbulence records and the measurements described in section 3 were made in order to examine the behaviour of a conventional temperature measuring device in an area containing severe turbulence.

The air temperature trace is obtained from a resistance type probe (Sangamo-Weston S110 exposed, unshielded) mounted on the lower fuselage near the nose. The temperature sensed by the probe is recorded directly with no correction for kinetic heating, and the temperature profiles were calculated using a simple correction. The system gives two thirds response in 10 seconds to a step change in temperature and therefore very sharp temperature gradients[4] will not be detected. Also the probe equilibrium temperature falls (less kinetic heating) whilst flying in saturated air containing free water and therefore the temperature changes at the lower altitudes are not necessarily real. The profiles shown for climb and descent should therefore be taken as an indication of the behaviour of a conventional instrument rather than as measurements of real temperature changes.

The calculated ambient air temperature profiles are shown in Figs.47-59 as plots of air temperature against nautical miles. The International Standard Atmosphere temperatures are also shown to allow for changes of temperature with height and not for absolute comparison purposes. Of the 33 profiles shown, 13 are for turbulence encountered during cruise; 4 of these show little change, 6 have some change during the encounter and the remaining 3 have some change before the encounter which could have provided a warning. The remaining profiles are for turbulence encountered during climb and descent and there are many discontinuities, some coinciding with turbulence and others not. This, coupled with the previously mentioned problem of false indications due to cloud and the rapidly changing height makes it unlikely that any warning could be obtained from this type of equipment during climb and descent.

7 CONCLUSIONS

The study of the most severe turbulence encountered in 23034 hours of flying by three types of aircraft verifies the conclusions reached previously, based on 3284 flying hours. Namely the characteristics of severe turbulence are:-

(i) Non-Gaussian - the measured maximum acceleration increment is on average 1.3 times the expected value.

(ii) A one in two chance of occurring without warning. The shorter a patch the less likely it is that any warning is available.

Furthermore it is unlikely that measurement of outside air temperature with conventional equipment can provide a reliable warning of the presence of severe turbulence.

Table 1

AIRCRAFT TYPE I - TURBULENCE PATCHES CONTAINING 0.91 g INCREMENT OR OVER

Patch	Ia	Ib	Ic	Id	Ie	If	Ig
Phase	CR	CR	CL	CL	CL	CL	DES
Duration min	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{2}$	$2\frac{1}{2}$
Aircraft height ft × 1000	33.8	33.0	6.0	18.8	19.1	9.5	15.5
Aircraft weight Kg × 1000	53	53	53	58	65	69	48
Indicated airspeed knots	255	265	256	218	257	260	204
Recommended rough air speed knots	213	213	213	223	235	242	204
Degree of warning	none	none	none	none	none	none	some
0.25	3	7	9	9	3	7	38
0.30	3	7	9	5	3	5	30
0.35	3	6	9	3	3	3	22
0.40	2	5	6	3	1	3	14
0.45	2	3	3	3	1	3	9
0.50	1	3	3	3	1	2	7
0.55	1	2	3	3	1	2	5
0.60	1	1	2	3	1	2	3
0.65	1	1	2	3	1	1	2
0.70	1	1	1	3	1	1	2
0.75	1	1	1	2	1	1	2
0.80	1	1	1	2	1	1	1
0.85	1	1	1	1	1	1	1
0.90	1	1	1	1	1	1	1
0.95		1		1	1	1	
1.00		1			1	1	
1.05		1			1	1	
1.10						1	
1.15						1	
1.20						1	
Acceleration increment (g)	Number of times acceleration exceeded						

Table 2

AIRCRAFT TYPE I - TURBULENCE PATCHES CONTAINING 0.91 g INCREMENT OR OVER

Patch	Ih	Ii	Ij	Ik	Il	Im
Phase	CL	CL	CR	CR	DES	DES
Duration min	1	$\frac{1}{4}$	$\frac{1}{4}$	$2\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{4}$
Aircraft height ft × 1000	8.3	11.0	31.0	32.3	6.0	29.0
Aircraft weight Kg × 1000	62	68	56	61	52	53
Indicated airspeed knots	196	251	265	235	220	260
Recommended rough air speed knots	230	241	219	228	211	213
Degree of warning	some	none	none	some	unknown	none
0.25	10	3	5	25	11	9
0.30	10	3	4	13	11	9
0.35	9	3	4	10	8	9
0.40	5	3	4	6	4	5
0.45	4	2	3	4	3	5
0.50	2	1	3	3	3	4
0.55	2	1	2	2	2	3
0.60	2	1	2	2	2	2
0.65	2	1	2	1	1	2
0.70	2	1	2	1	1	1
0.75	2	1	2	1	1	1
0.80	2	1	2	1	1	1
0.85	2	1	1	1	1	1
0.90	2	1	1	1	1	1
0.95	1	1	1		1	
1.00		1	1			
1.05		1				
1.10		1				
1.15		1				
1.20		1				
Acceleration increment (g)	Number of times acceleration exceeded					

Table 3

AIRCRAFT TYPE II - TURBULENCE PATCHES CONTAINING 0.76 g INCREMENT OR OVER

Patch	IIa	IIb	IIc	IId	IIe	IIf	IIg
Phase	CL	DES	CR	CR	CL	CR	CR
Duration min	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{3}{4}$	$1\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{4}$
Aircraft height ft × 1000	7.5	1.8	34.9	32.6	8.0	30.8	36.0
Aircraft weight Kg × 1000	96	80	108	92	98	110	85
Indicated airspeed knots	274	260	280	272	270	295	273
Recommended rough air speed knots	280	280	272	280	280	280	266
Degree of warning	unkown	unknown	none	unknown	unknown	unknown	none
0.25	7	5	13	13	13	6	8
0.30	5	4	13	10	10	5	8
0.35	3	3	11	5	6	2	6
0.40	2	1	9	4	6	2	6
0.45	2	1	6	4	5	2	5
0.50	2	1	6	3	5	2	5
0.55	2	1	5	3	5	1	5
0.60	2	1	3	2	5	1	4
0.65	2	1	2	1	4	1	2
0.70	1	1	2	1	4	1	2
0.75	1	1	1	1	3	1	1
0.80		1	1		2		1
0.85		1	1				1
0.90		1	1				1
0.95			1				
1.00			1				
1.05			1				
Acceleration increment (g)	Number of times acceleration exceeded						

Table 4

AIRCRAFT TYPE II - TURBULENCE PATCHES CONTAINING 0.76 g INCREMENT OR OVER

Patch	IIh	IIi	IIj	IIk	IIl	IIm	IIn
Phase	CL	CR	CR	DES	CR	CR	DES
Duration min	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{3}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$4\frac{1}{2}$	$1\frac{1}{4}$
Aircraft height ft × 1000	9.1	35.0	35.7	16.1	33.8	34.0	5.6
Aircraft weight Kg × 1000	84	89	98	84	111	98	84
Indicated airspeed knots	295	294	278	279	274	288	320
Recommended rough air speed knots	280	271	268	280	278	278	280
Degree of warning	unknown	unknown	unknown	none	none	unknown	none
0.25	7	5	4	4	11	37	11
0.30	7	5	2	4	7	33	3
0.35	4	5	1	3	7	22	1
0.40	3	3	1	3	7	17	1
0.45	3	3	1	3	7	12	1
0.50	3	2	1	1	5	4	1
0.55	2	2	1	1	3	2	1
0.60	1	2	1	1	2	2	1
0.65	1	1	1	1	2	2	1
0.70	1	1	1	1	1	2	1
0.75	1	1	1	1	1	2	1
0.80	1	1		1	1	2	1
0.85	1	1			1	1	
0.90		1			1		
0.95		1			1		
Acceleration increment (g)	Number of times acceleration exceeded						

Table 5

AIRCRAFT TYPE III - TURBULENCE PATCHES CONTAINING 0.81 g INCREMENT OR OVER

Patch	IIIa	IIIb	IIIc	IIId	IIIe	IIIf	IIIg	IIIh	IIIi
Phase	DES	DES	CL	DES	CR	CL	CL	CL	CR
Duration min	$\frac{3}{4}$	$\frac{1}{2}$	$1\frac{1}{4}$	$\frac{1}{4}$	3	1	$\frac{1}{4}$	$\frac{1}{4}$	1
Aircraft height ft × 1000	22.2	12.0	13.5	9.0	27.2	9.0	10.3	8.6	32.0
Aircraft weight Kg × 1000	53	53	55	54	51	58	61	61	58
Indicated airspeed knots	267	303	209	272	258	260	283	286	255
Recommended rough air speed knots	265	280	280	280	259	280	280	280	254
Degree of warning	some	none	unknown	unknown	some	some	none	none	some
0.25	21	21	38	10	73	23	1	7	34
0.30	19	16	32	7	52	19	1	6	31
0.35	16	11	23	4	40	18	1	4	28
0.40	9	9	18	4	29	16	1	1	26
0.45	9	7	18	4	21	10	1	1	22
0.50	8	5	11	3	11	9	1	1	17
0.55	7	3	6	3	8	5	1	1	16
0.60	6	2	5	2	7	4	1	1	13
0.65	6	2	3	2	3	4	1	1	8
0.70	5	2	2	1	3	3	1	1	6
0.75	5	1	1	1	2	3	1	1	6
0.80	4	1	1	1	1	3	1	1	3
0.85	3	1	1	1	1	2		1	3
0.90	1	1		1	1	1			1
0.95	1	1		1	1				1
1.00	1	1		1					1
1.05	1	1		1					1
1.10	1	1		1					1
1.15				1					1
1.20				1					1
1.25				1					
1.30				1					
1.35				1					
1.40				1					
1.45				1					
Acceleration increment (g)	Number of times acceleration exceeded								

REFERENCES

No.	Author	Title, etc.
1	G. E. King	Civil aircraft airworthiness data recording programme. Study of severe turbulence encountered by civil aircraft. A.R.C. C.P. 974 (1967)
2	The CAADRP Technical Panel	The civil aircraft airworthiness data recording programme. R.A.E. Technical Report 64004. A.R.C. 26490 (1964)
3	J. Schijve	Random load-time histories with relation to fatigue tests. Fatigue of aircraft structures. W. Barrois/E.L. Repley (Pergamon Press)
4	J. Burnham	Atmospheric turbulence and the SST: a review in the light of recent research. R.A.E. Technical Report 68096. A.R.C. 30547 (1968)

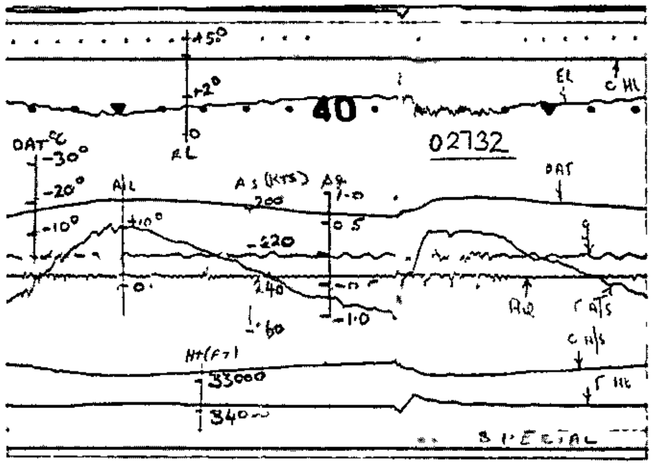
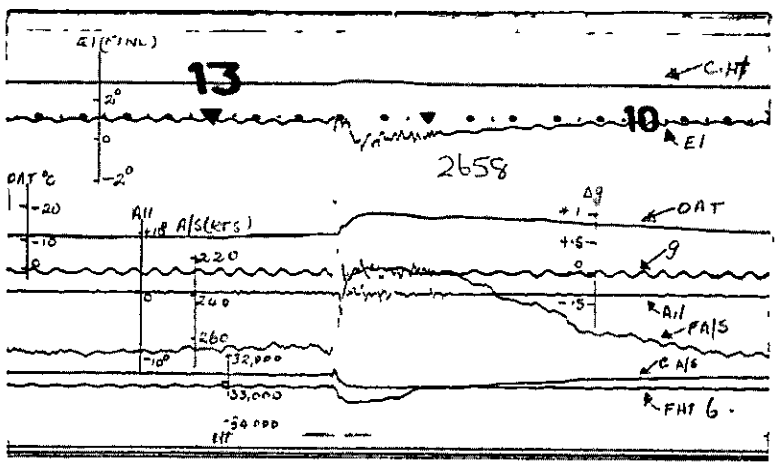


Fig.1. Patch 1(a)



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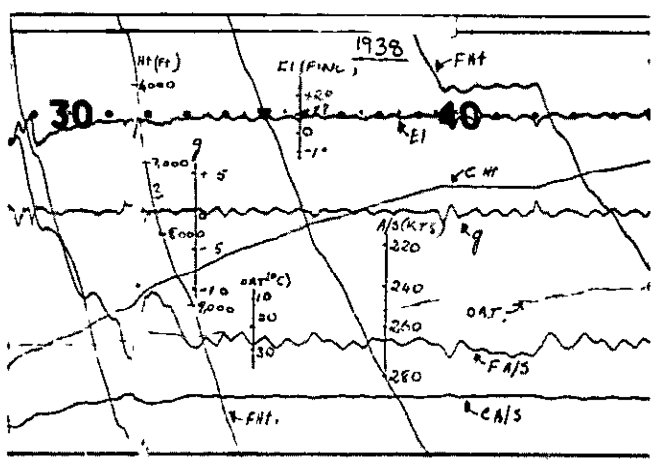

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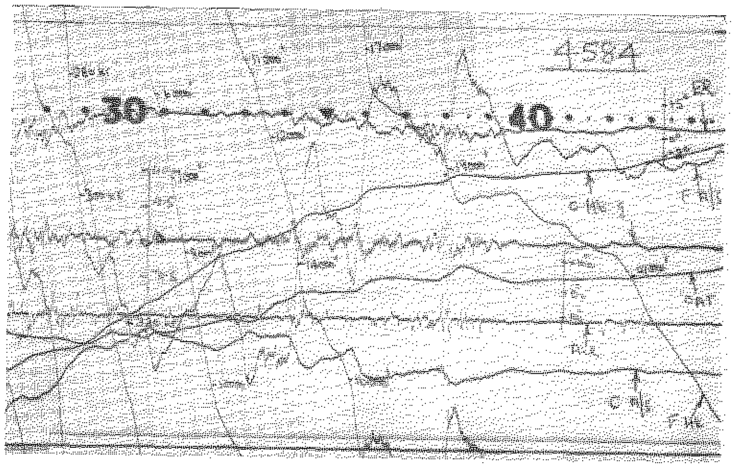

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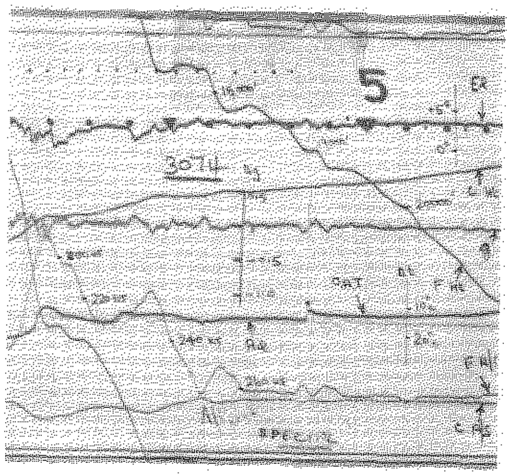
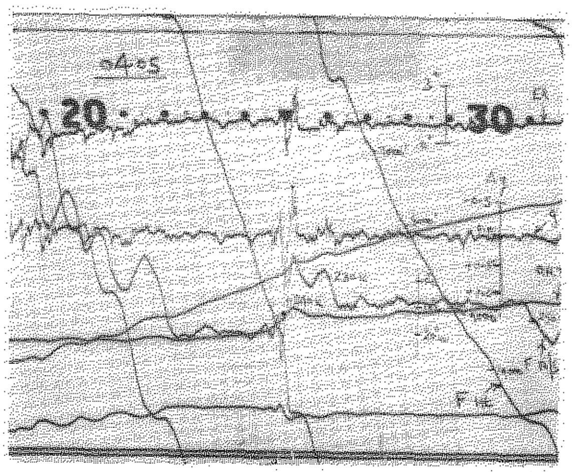


Fig.5. Patch 1(e)



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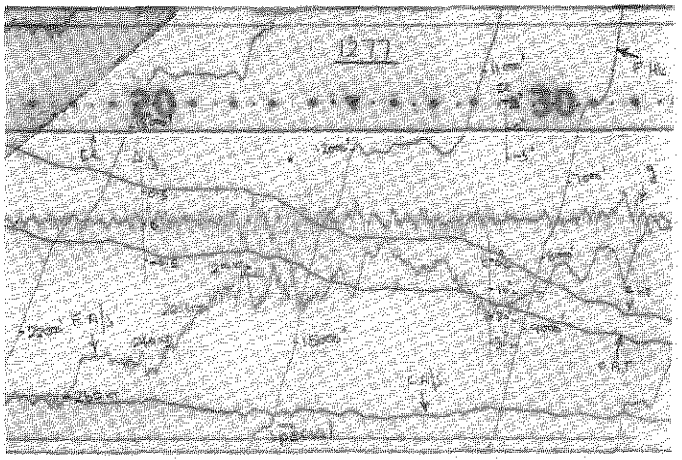

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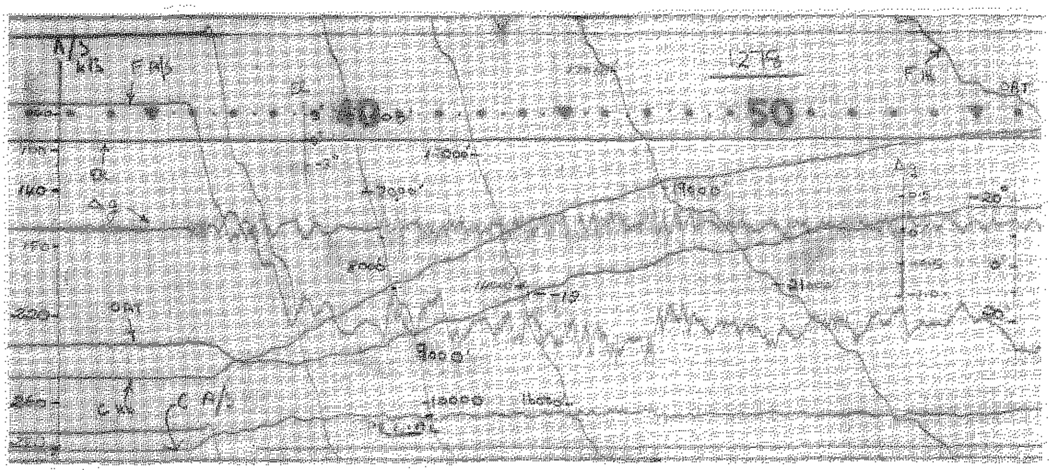

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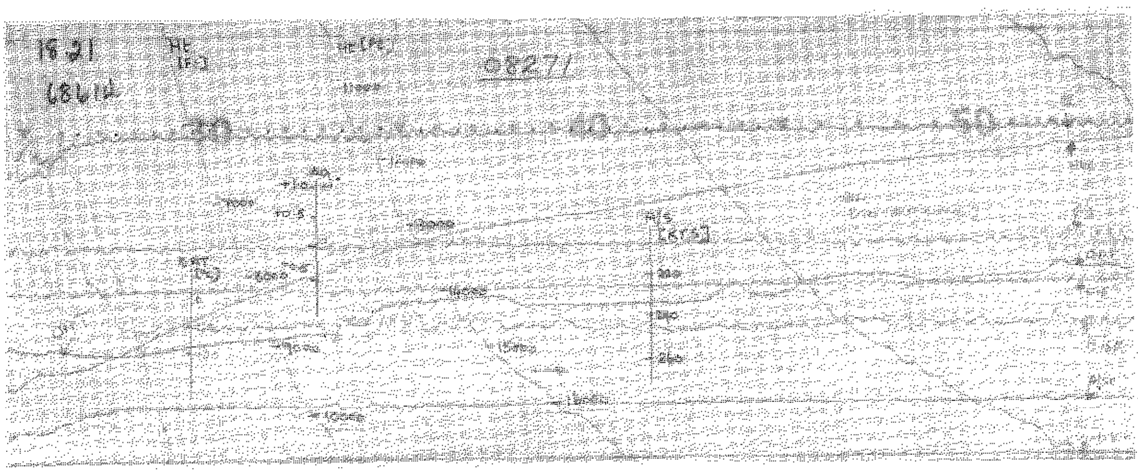
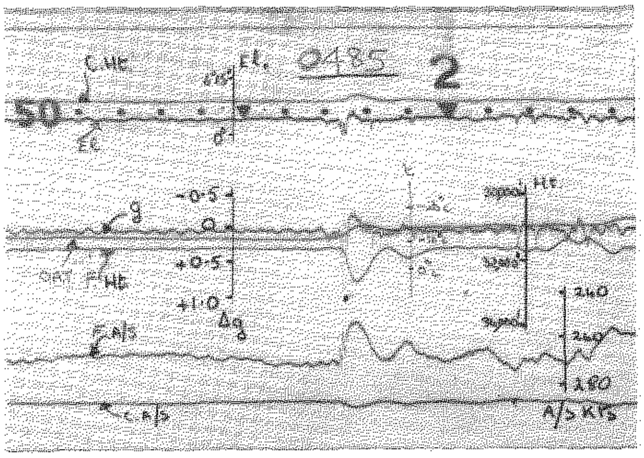


Fig9. Patch 1(i)



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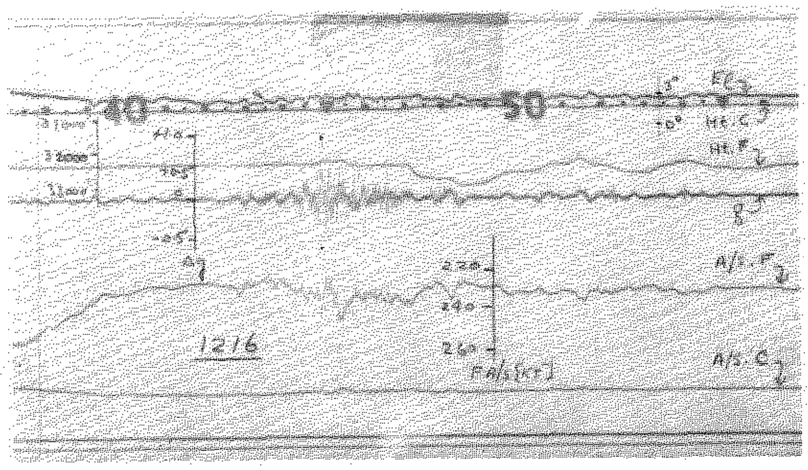
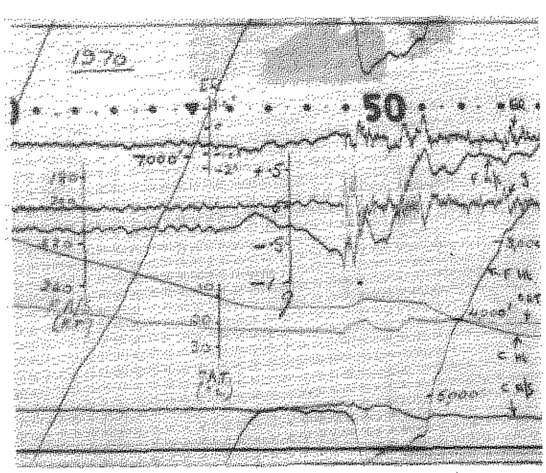


Fig.11. Patch 1(k)



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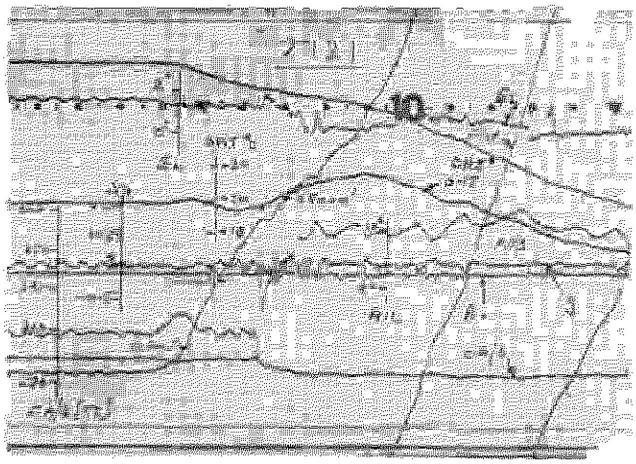

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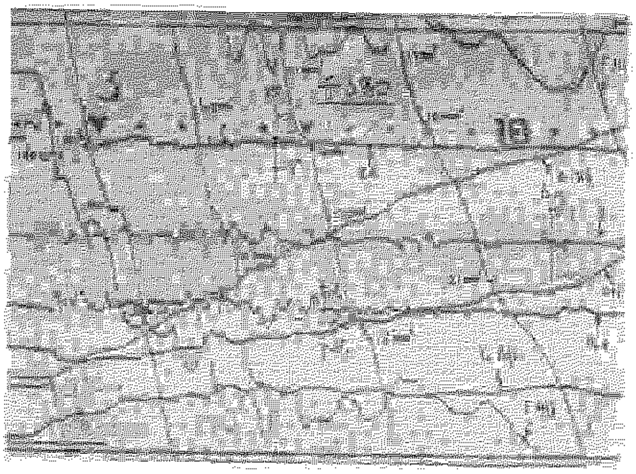

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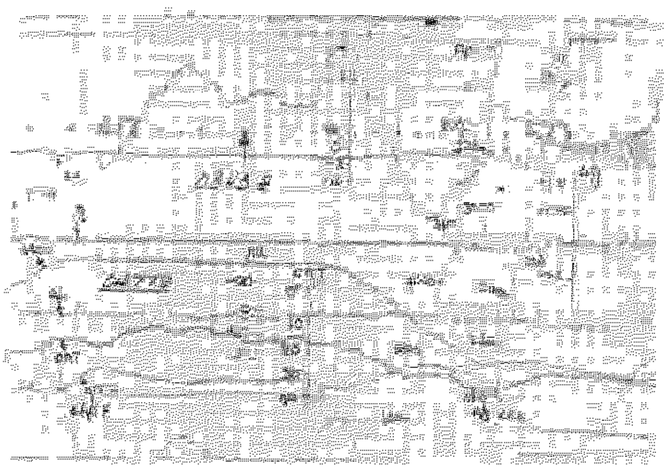

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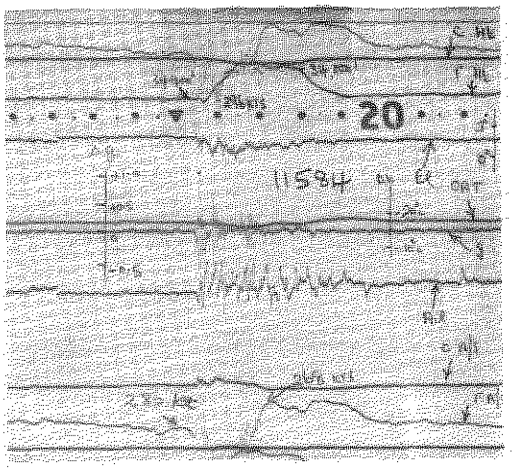

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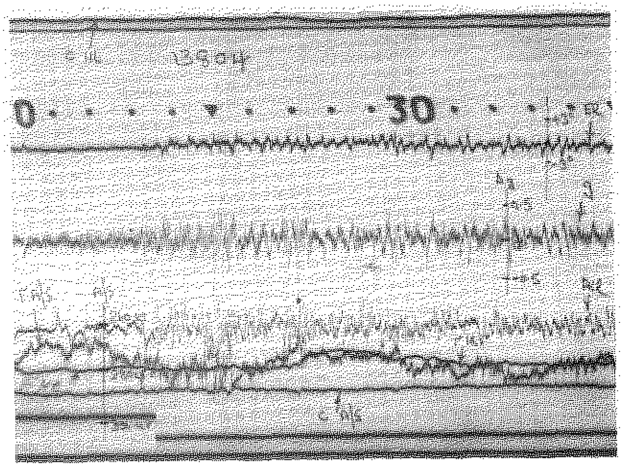

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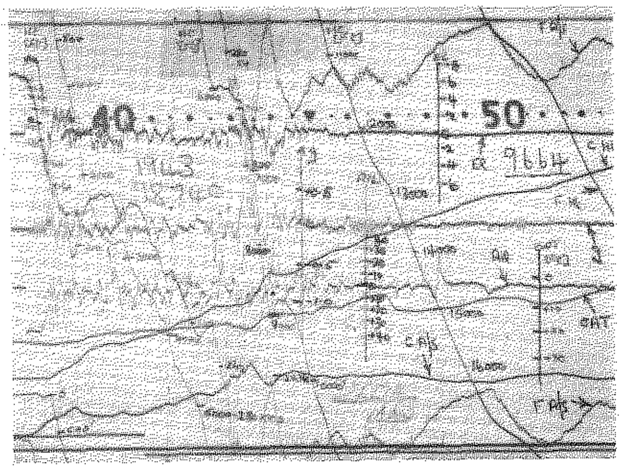

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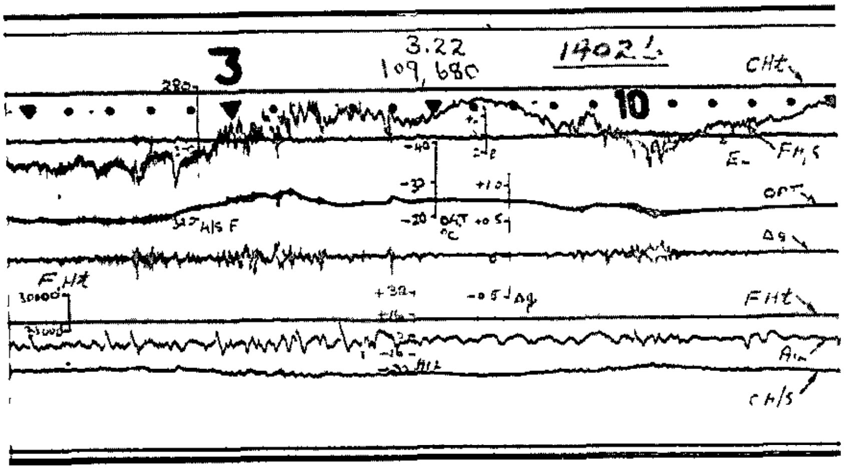

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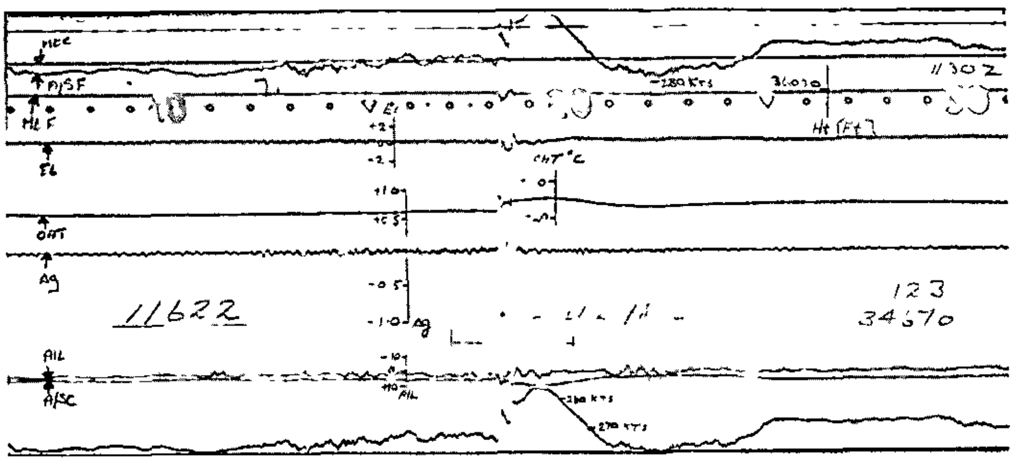


Fig.20. Patch 2(g)

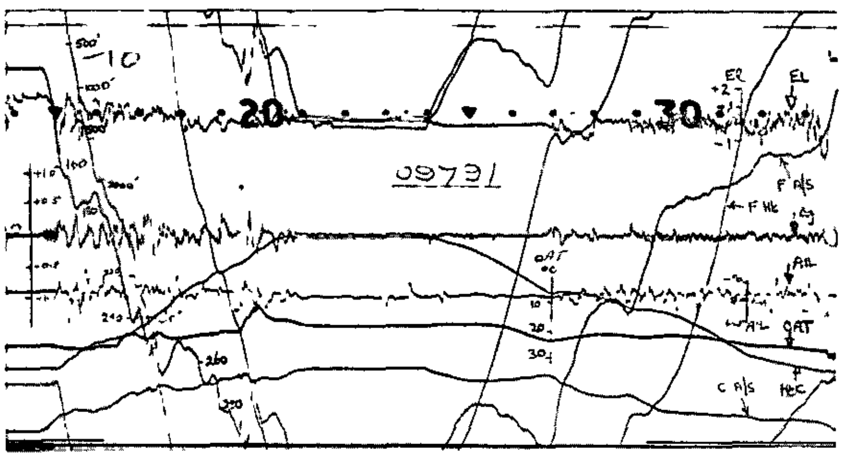


Fig.21. Patch 2(h)

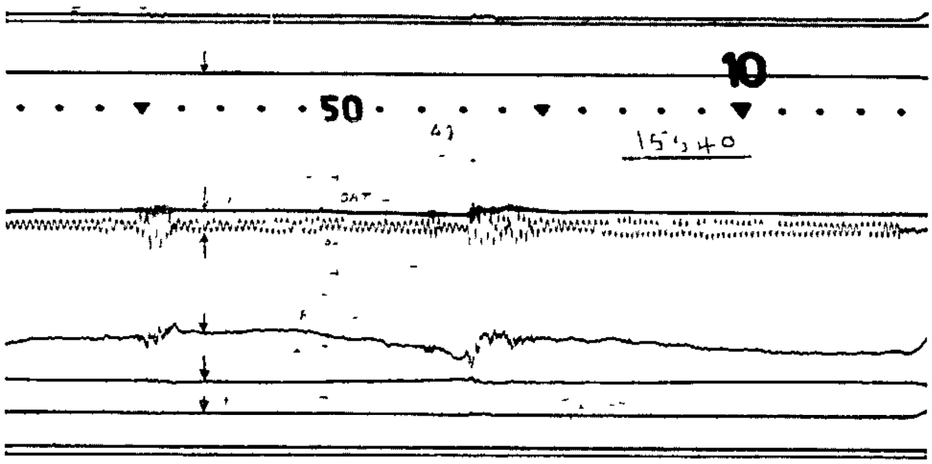


Fig.22. Patch 2(i)

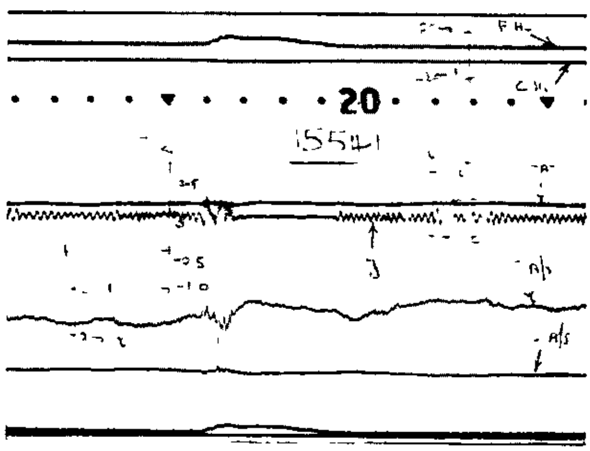


Fig.23. Patch 2(j)

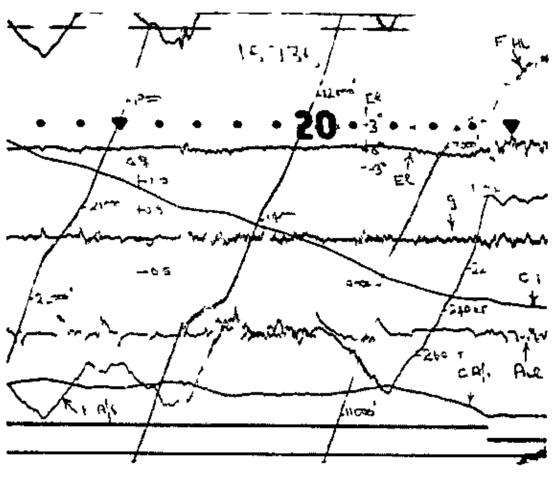


Fig.24 Patch 2(k)

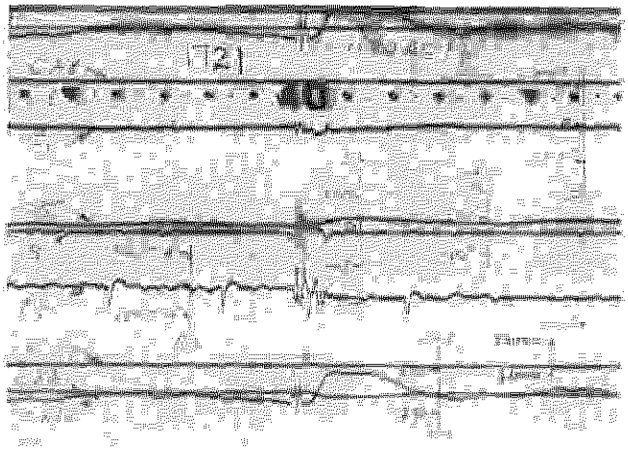


Fig.25. Patch 2(l)

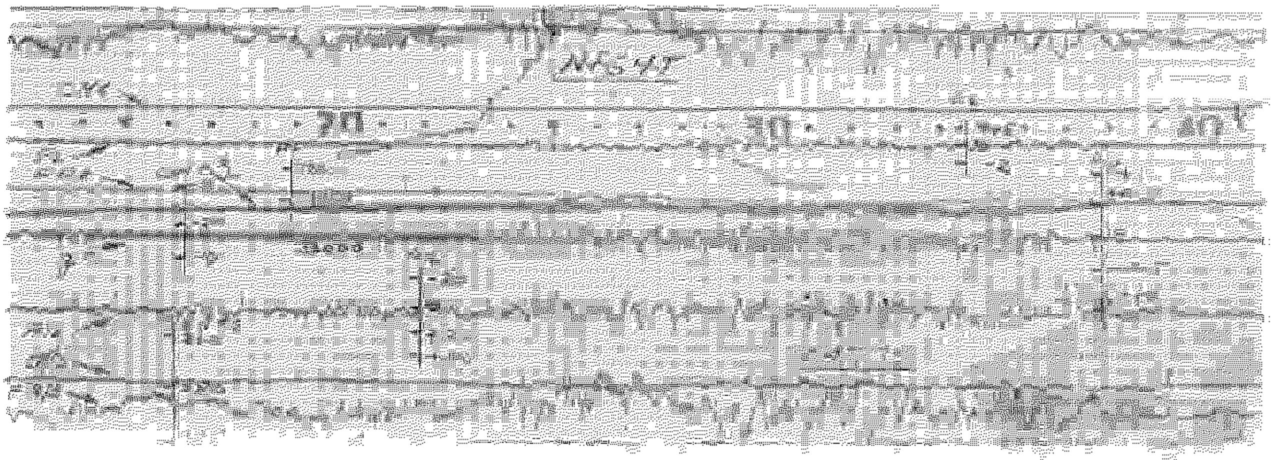


Fig.26. Patch 2(m)

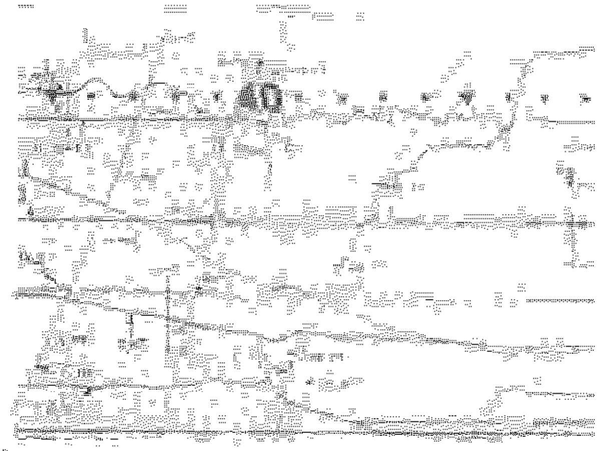


Fig.27. Patch 2(n)

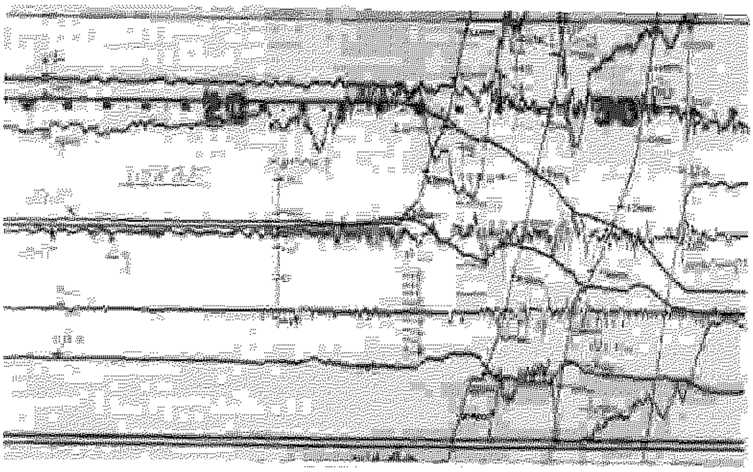


Fig.28. Patches 3(a)&(b)

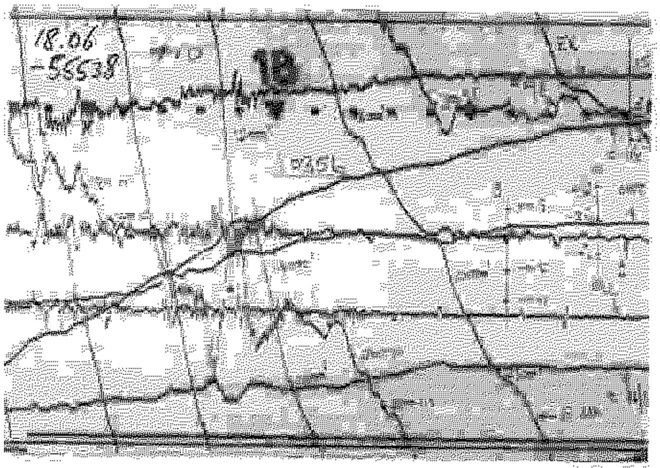


Fig.29. Patch 3(c)

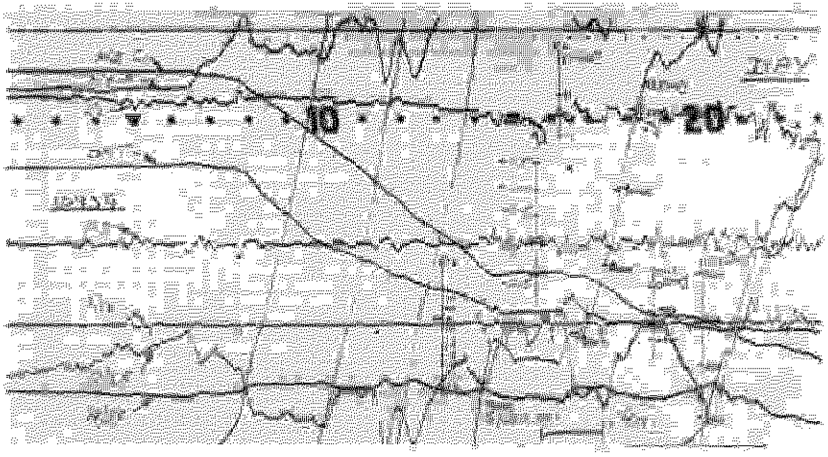


Fig.30. Patch 3(d)

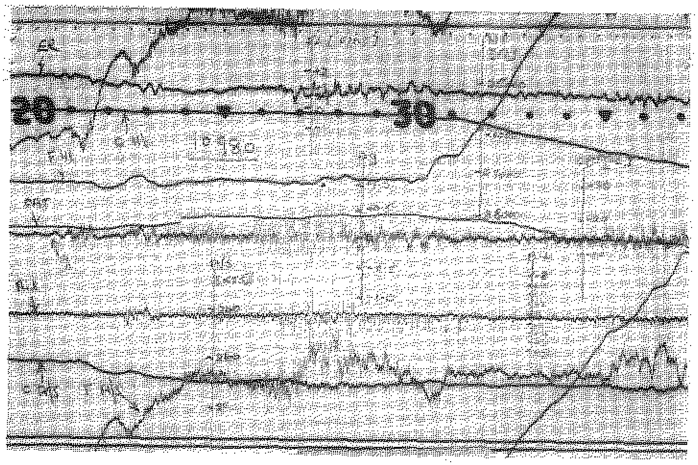


Fig.31. Patch 3(e)

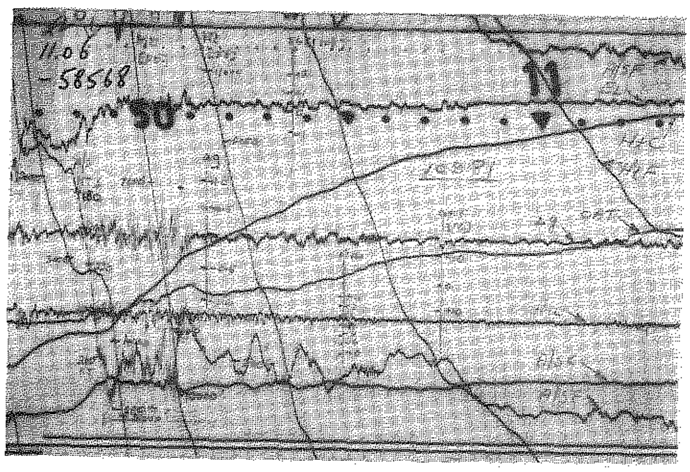


Fig.32. Patch 3(f)

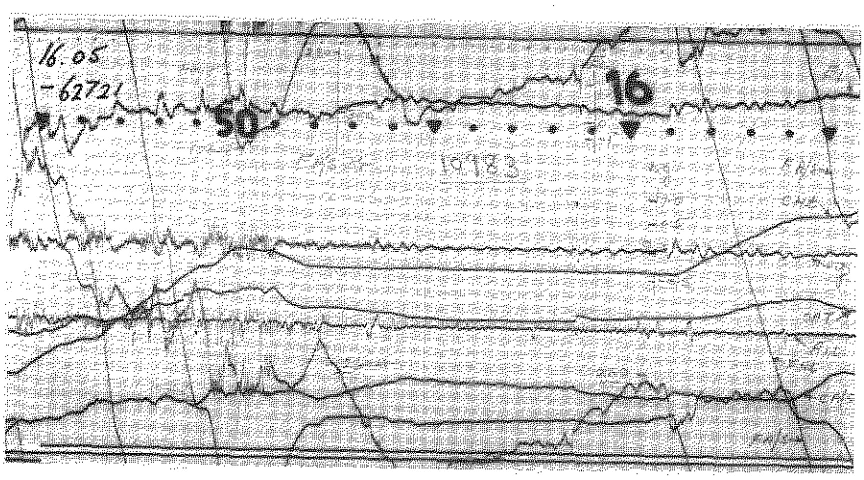


Fig.33. Patch 3(g)

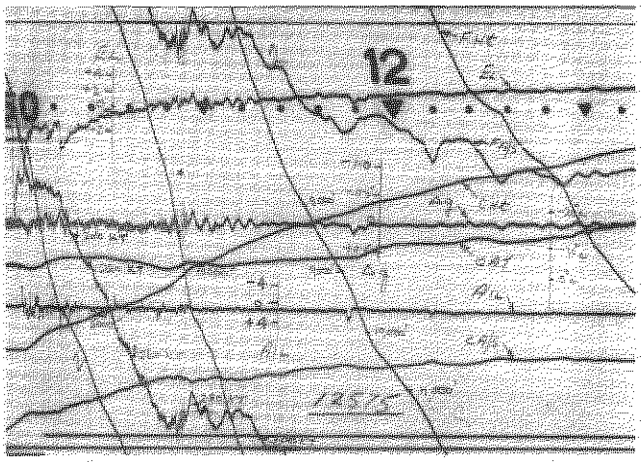


Fig.34. Patch 3(h)

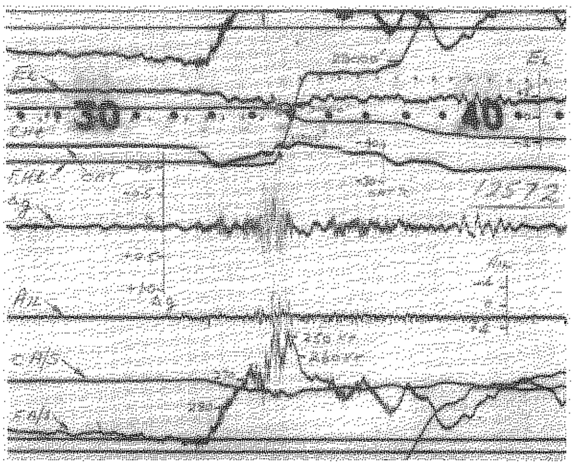
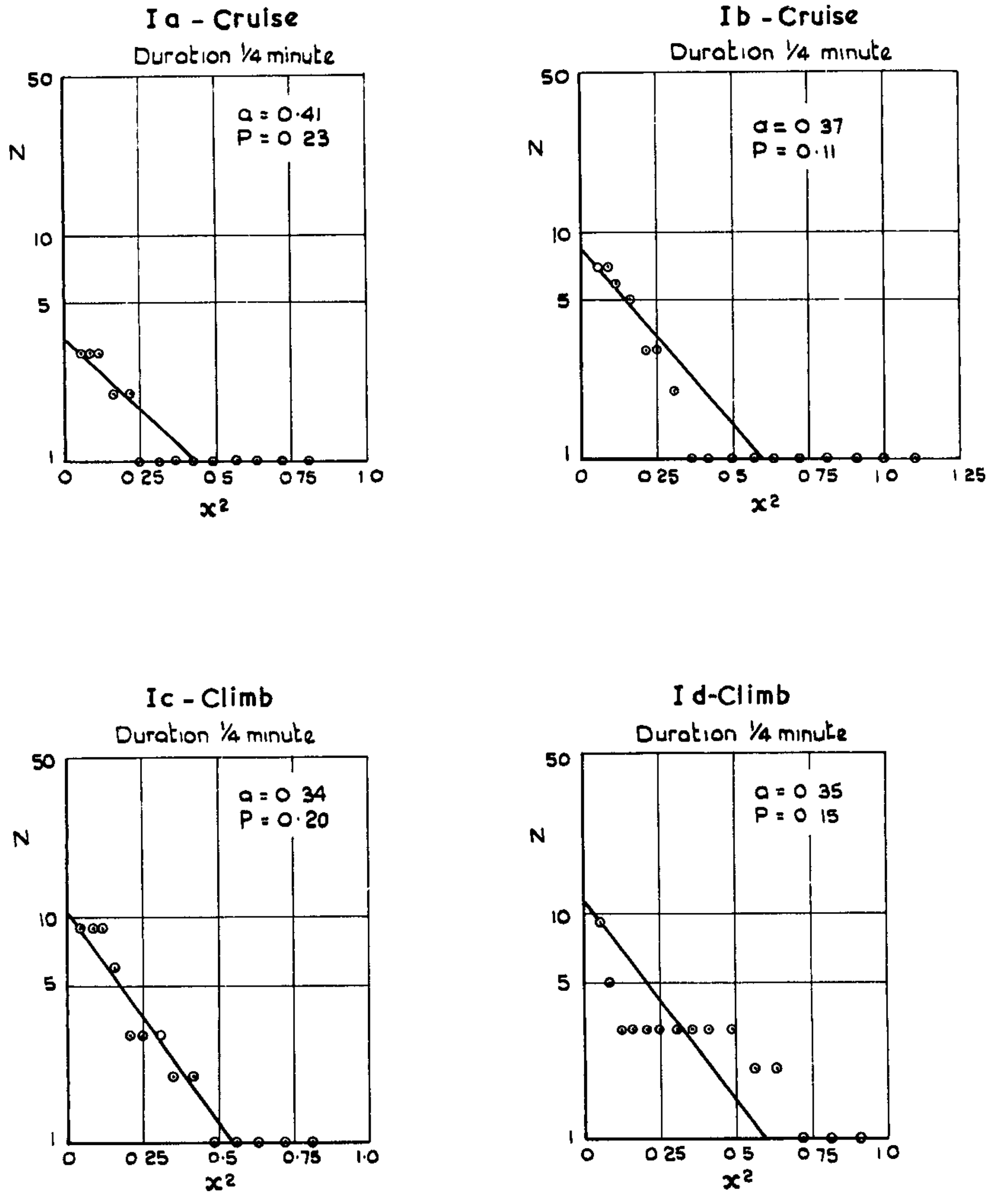
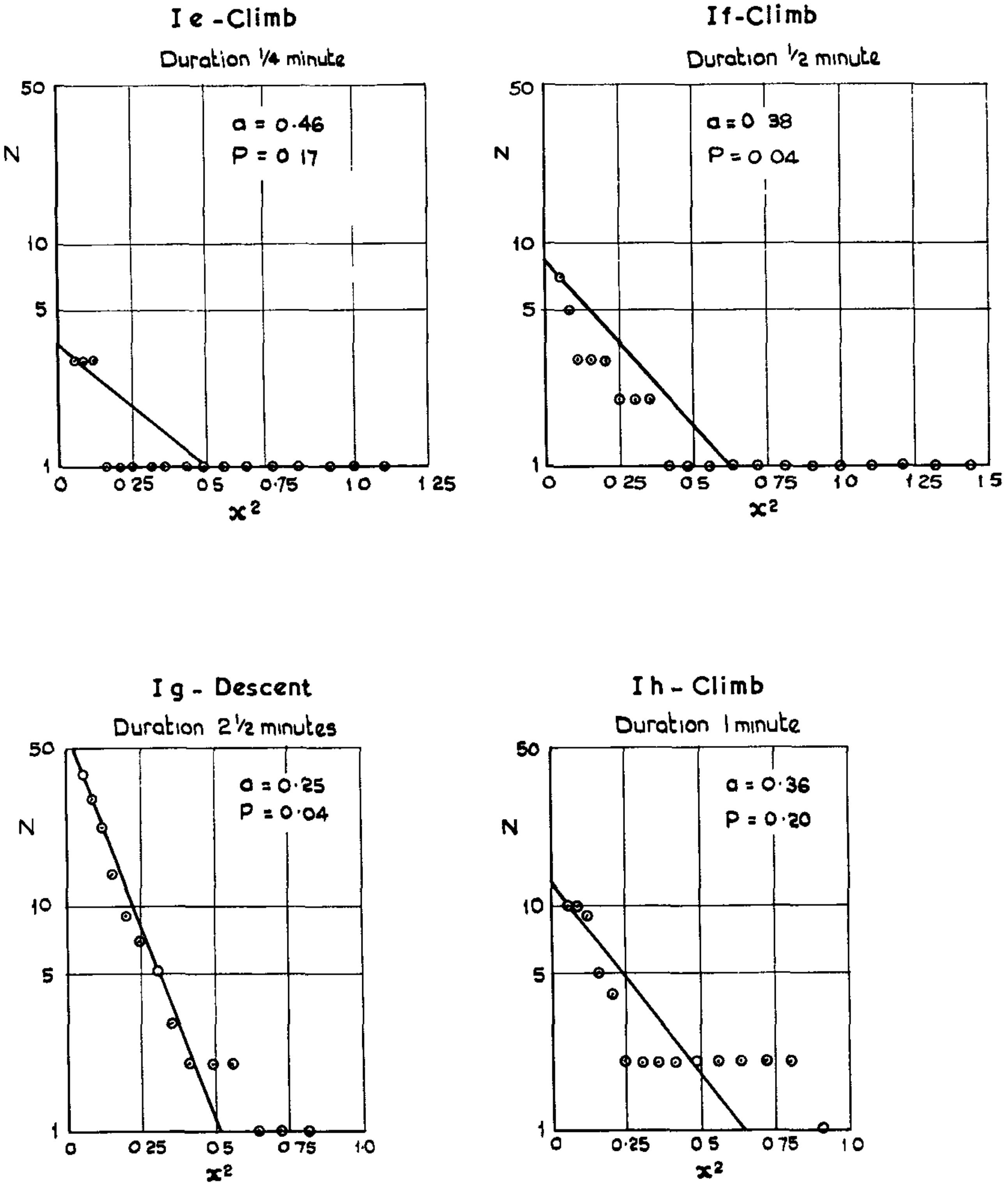


Fig.35. Patch 3(i)



N is the number of counts exceeding 'x' g
'x' g is the acceleration increment

Fig. 36 Aircraft type I - patches of turbulence containing over 0·90 g increment



N is the number of counts exceeding 'x'g
'x'g is the acceleration increment

Fig. 37 Aircraft type I - patches of turbulence containing over 0·90g increment

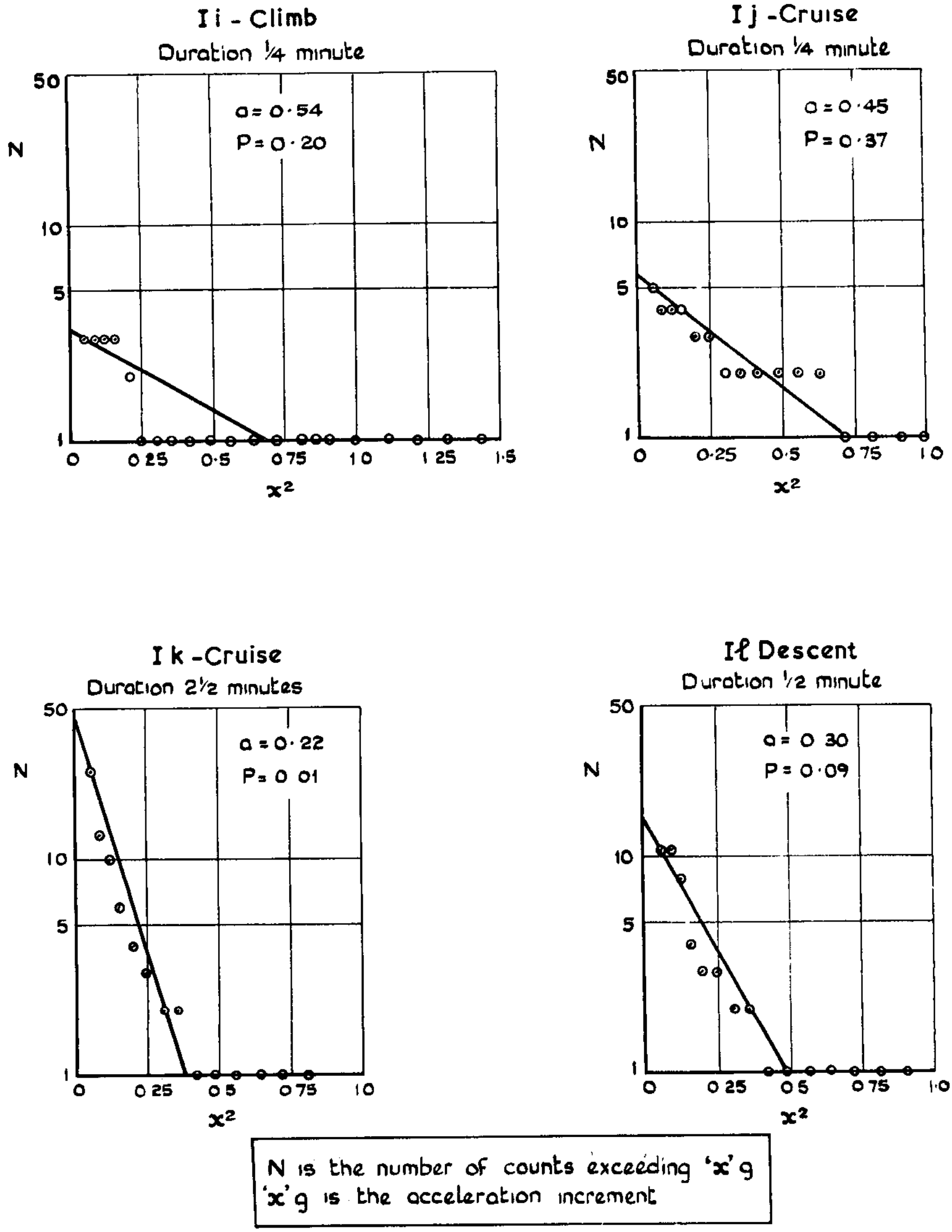
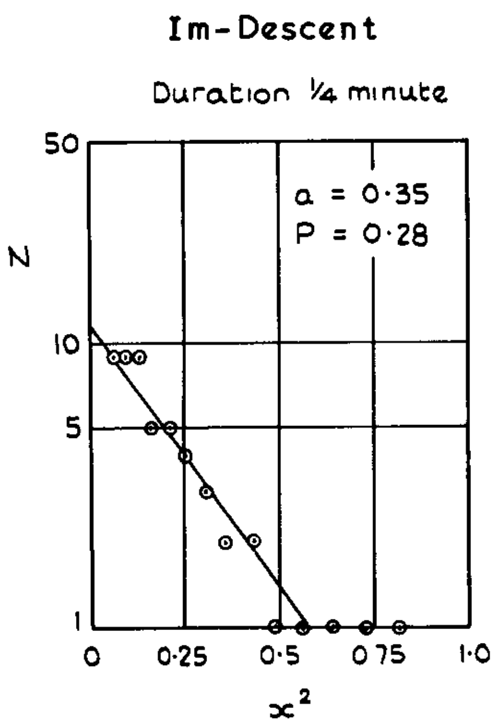
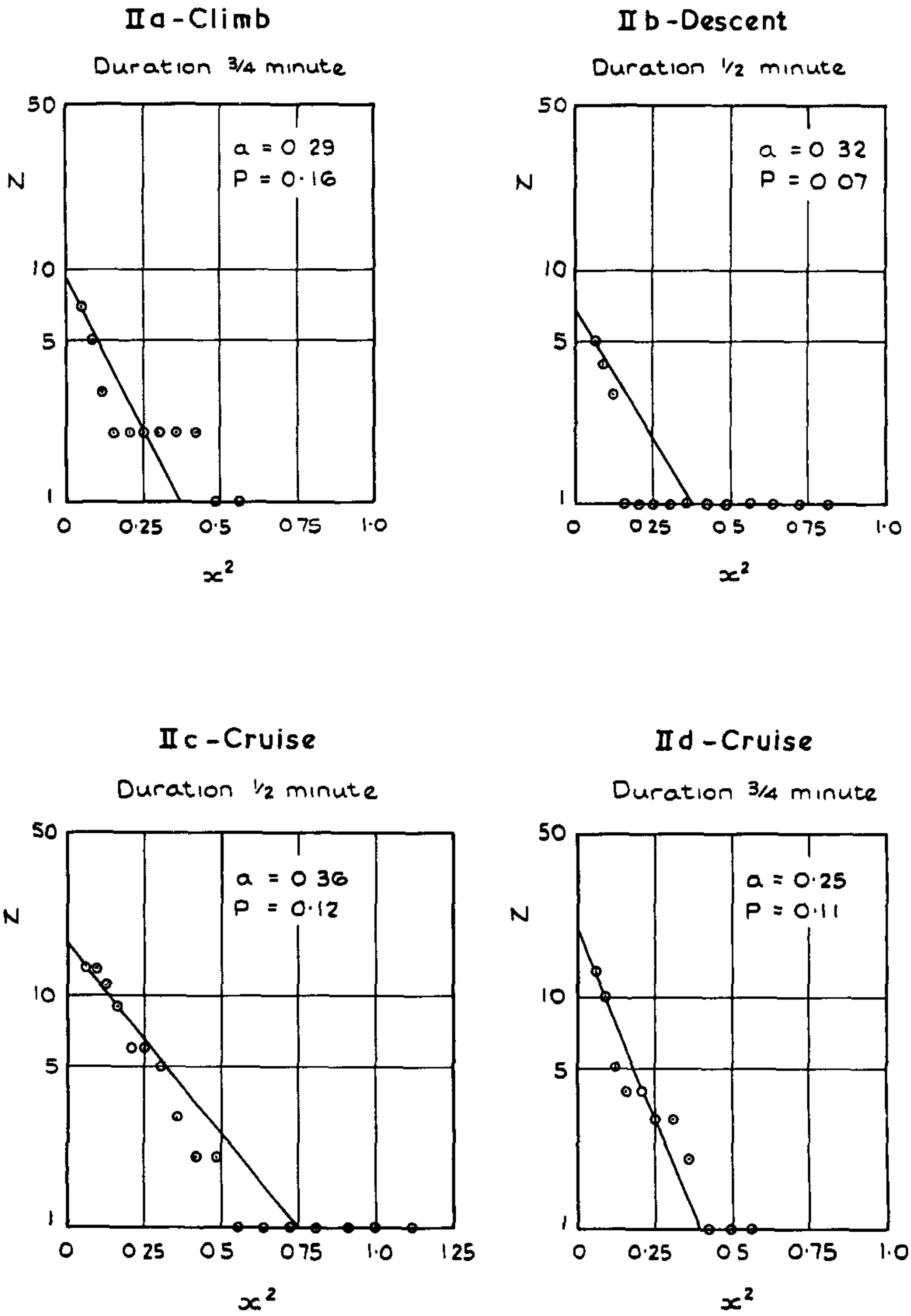


Fig. 38 Aircraft type I - patches of turbulence containing over 0·90 g increment



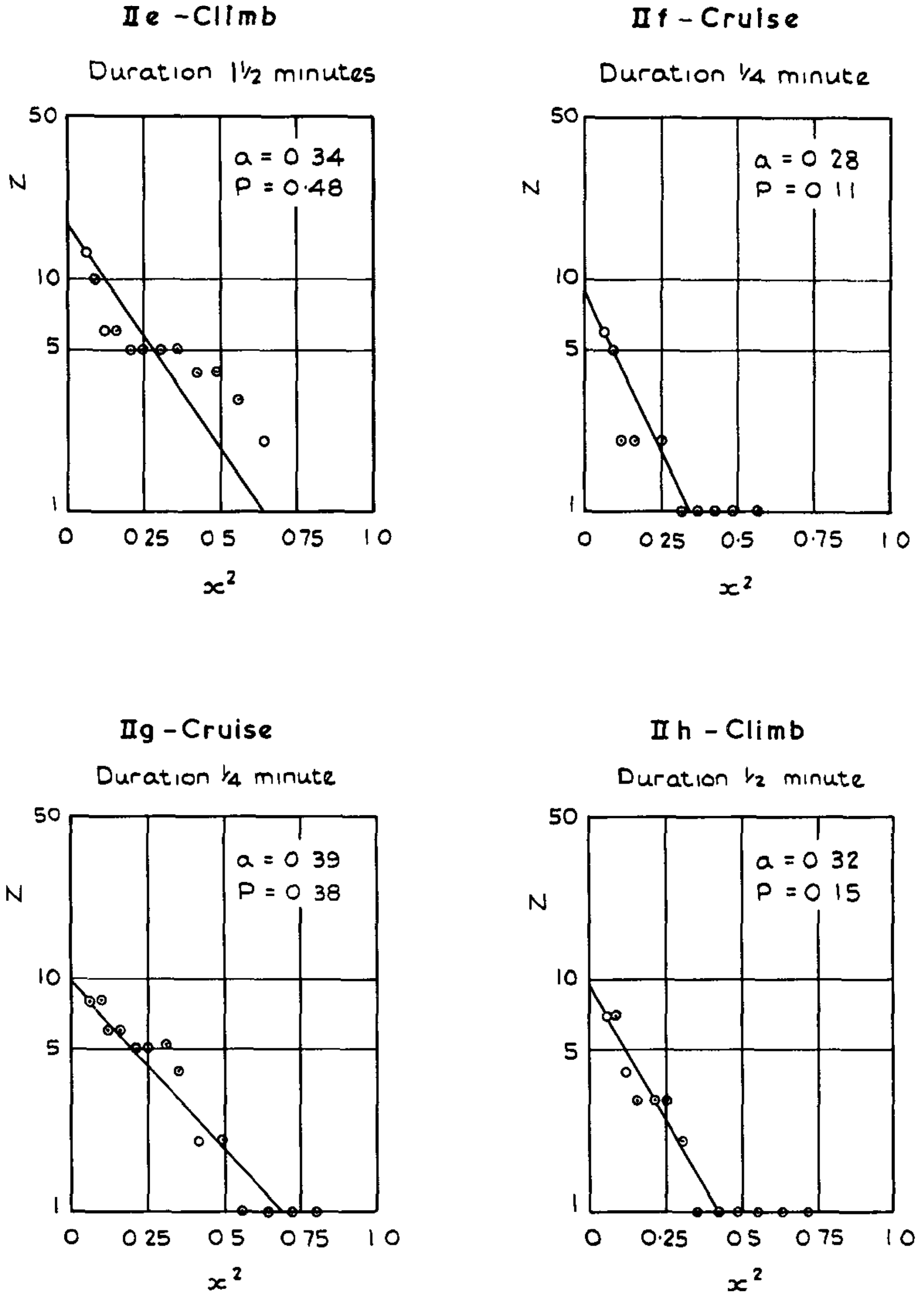
N is the number of counts exceeding 'x' g
'x'g is the acceleration increment

Fig 39 Aircraft type I-patches of turbulence containing over 0·90g increment



N is the number of counts exceeding 'x'g
'x'g is the acceleration increment

Fig. 40 Aircraft type II - patches of turbulence containing over 0·75 g increment



N is the number of counts exceeding 'x'g
'x'g is the acceleration increment

Fig. 41 Aircraft type II - patches of turbulence containing over 0·75g increment

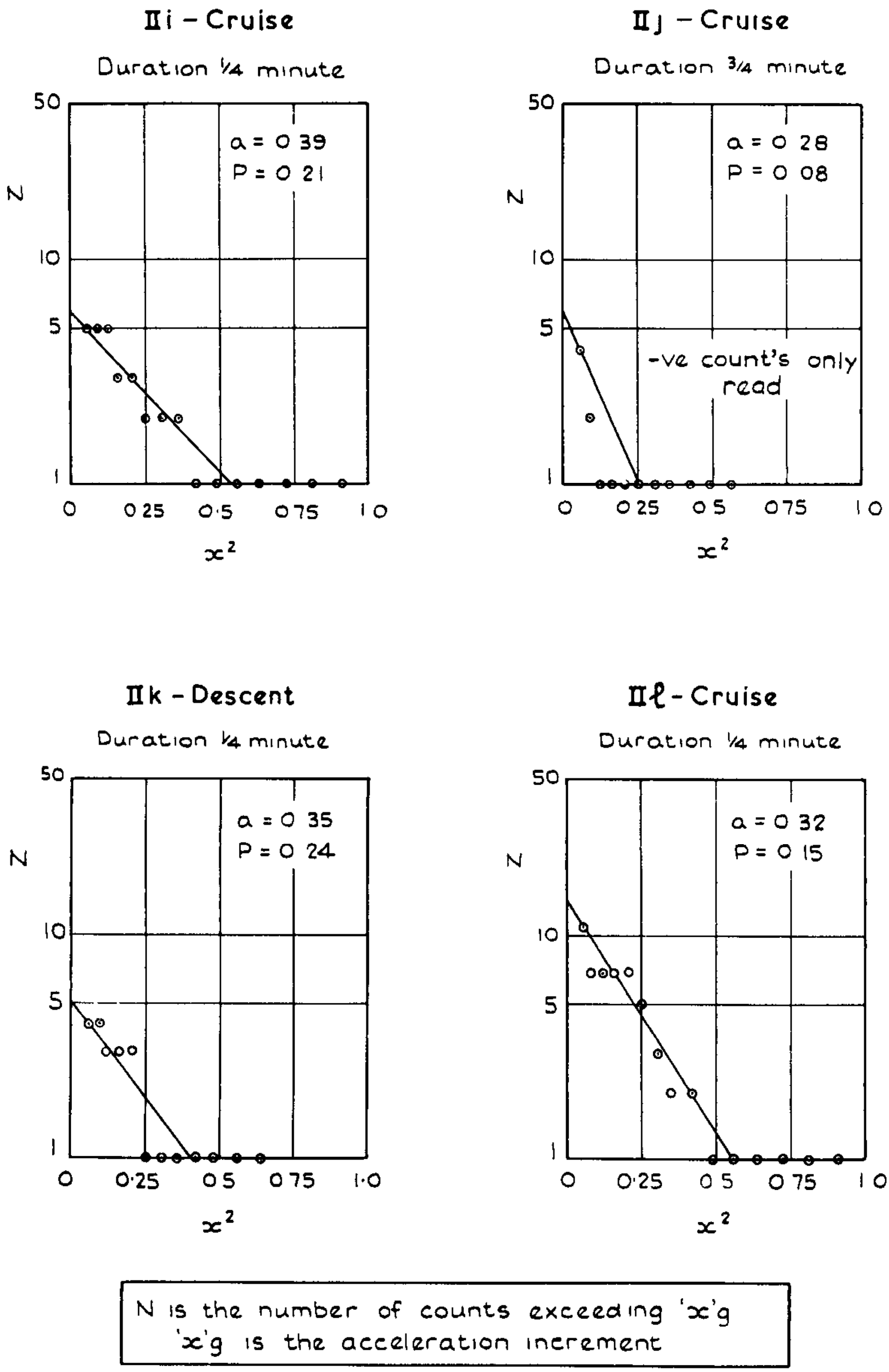
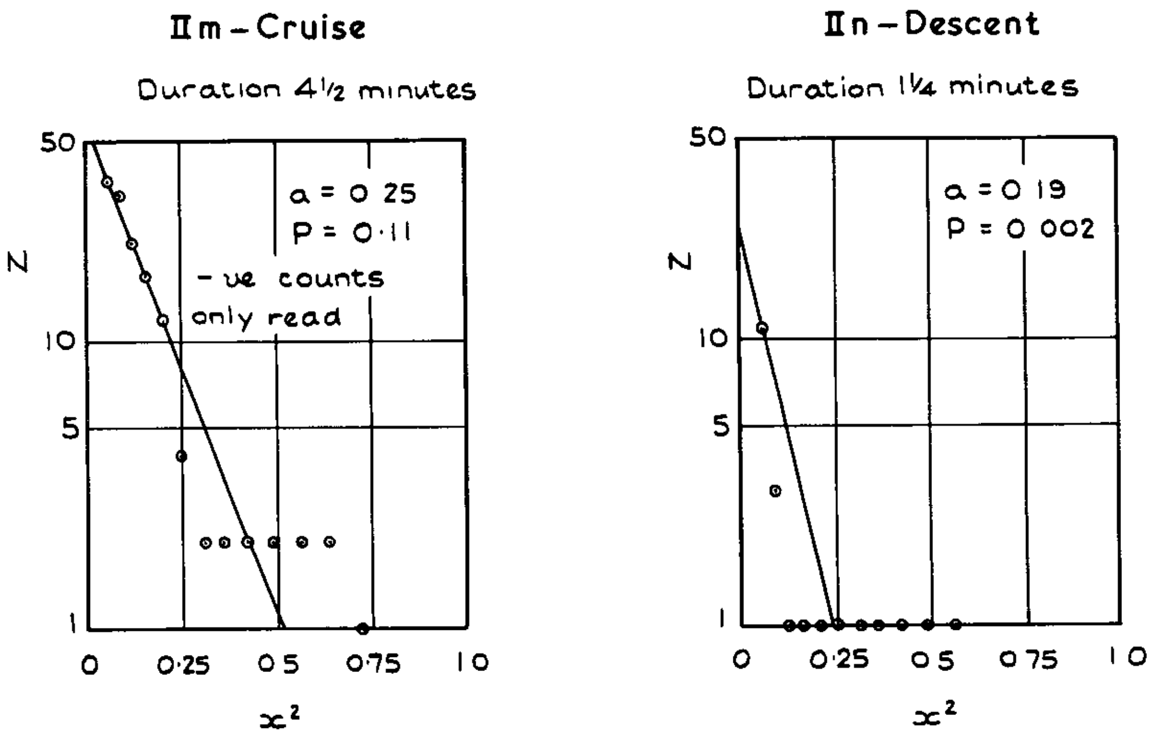
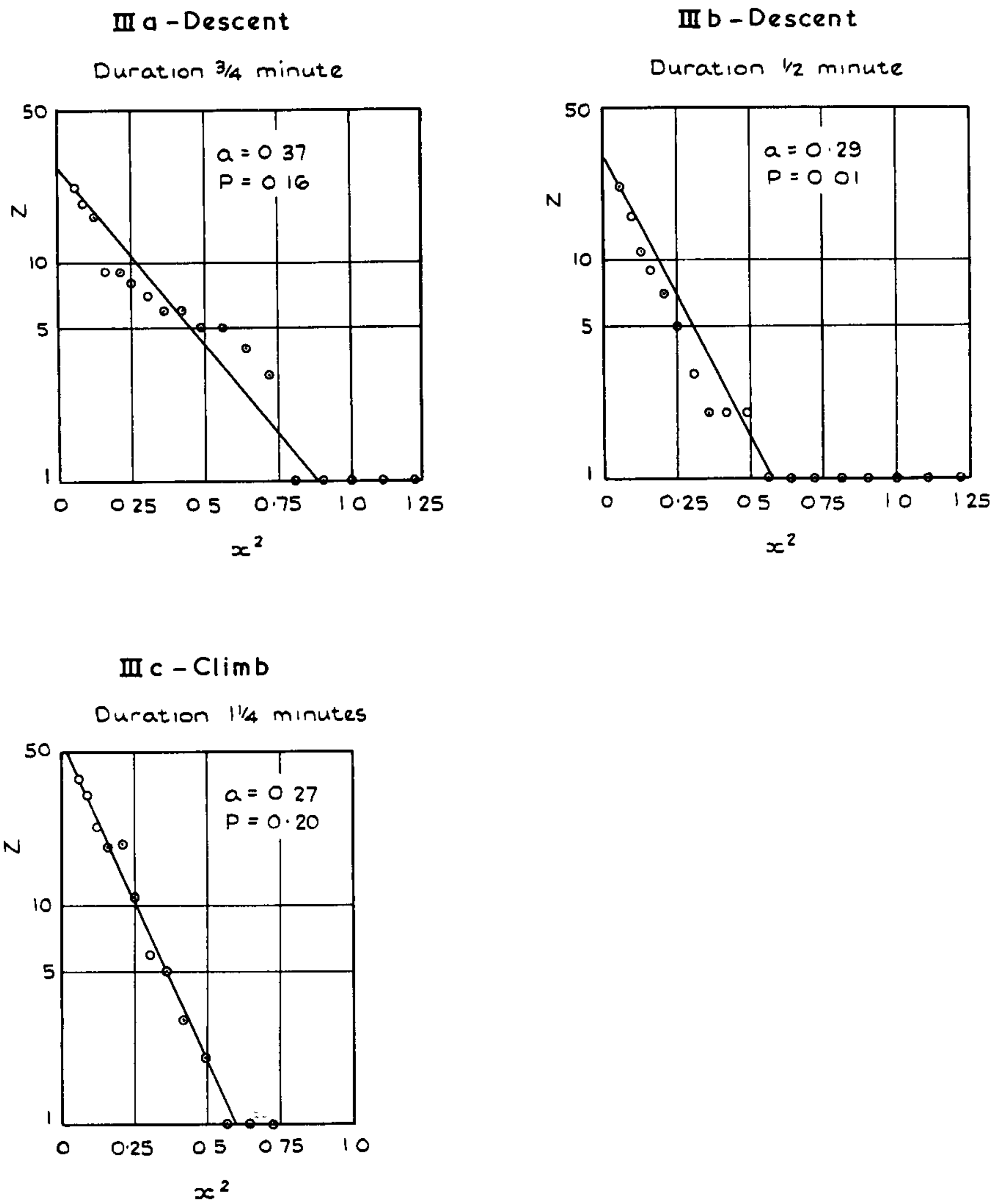


Fig 42 Aircraft type II - patches of turbulence containing over 0 75g increment



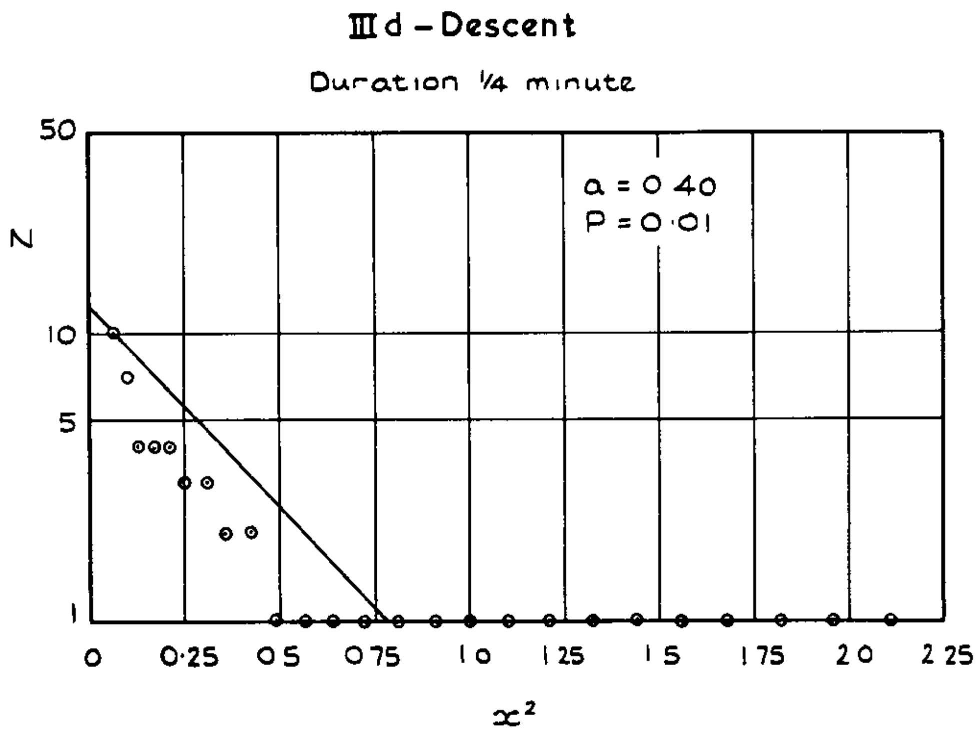
N is the number of counts exceeding 'x'g
'x'g is the acceleration increment

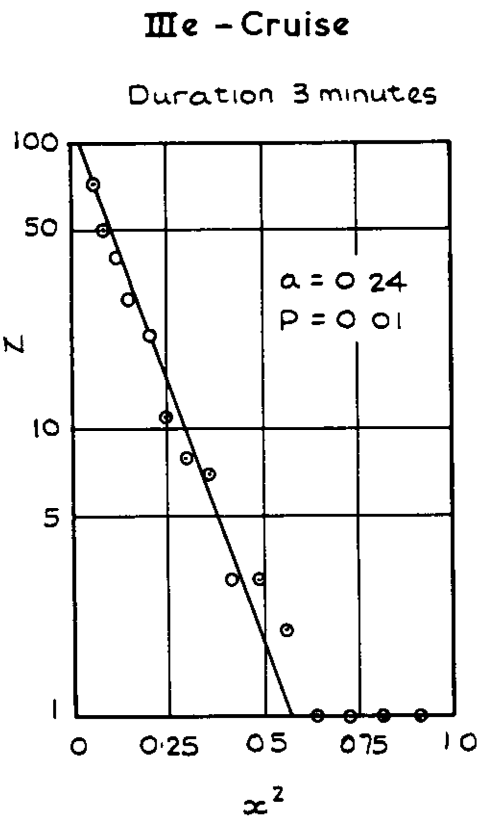
Fig. 43 Aircraft type II – patches of turbulence containing over 0·75g increment

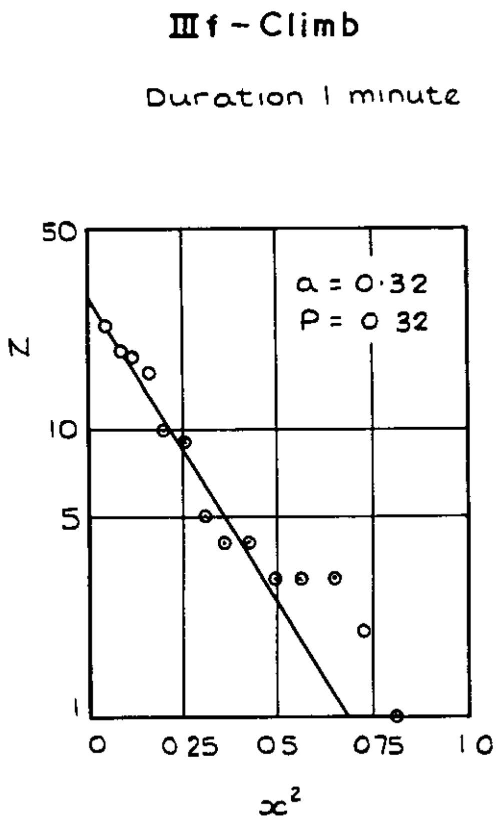


N is the number of counts exceeding 'x'g
xg is the acceleration increment

Fig 44 Aircraft type III - patches of turbulence containing over 0 80g increment

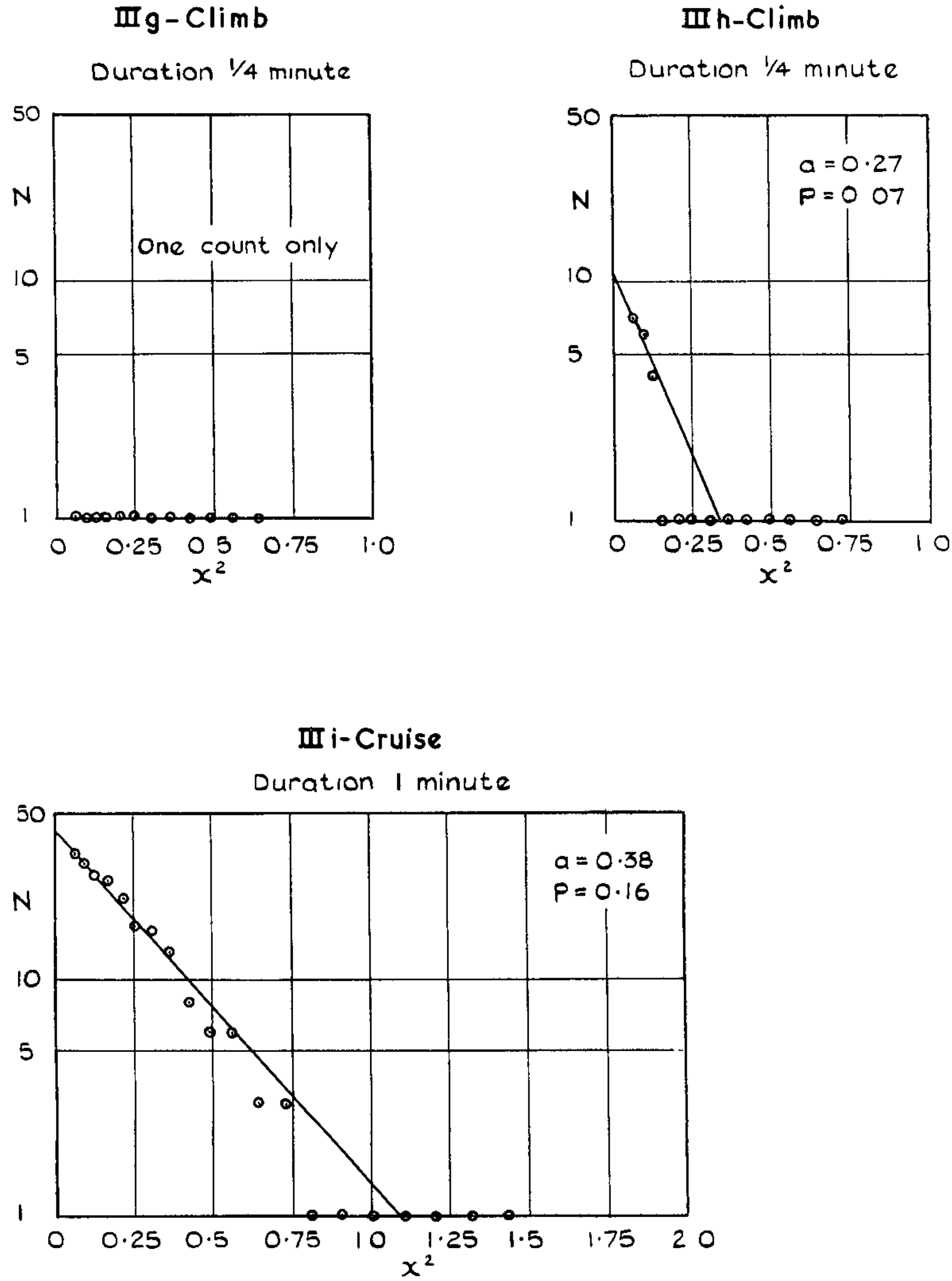






N is the number of counts exceeding 'x'g
'x'g is the acceleration increment

Fig. 45 Aircraft type III – patches of turbulence containing over 0·80g increment



N is the number of counts exeeeding 'x'g
'x'g is the acceleration increment

Fig. 46 Aircraft type III - patches of turbulence containing over 0·80g increment

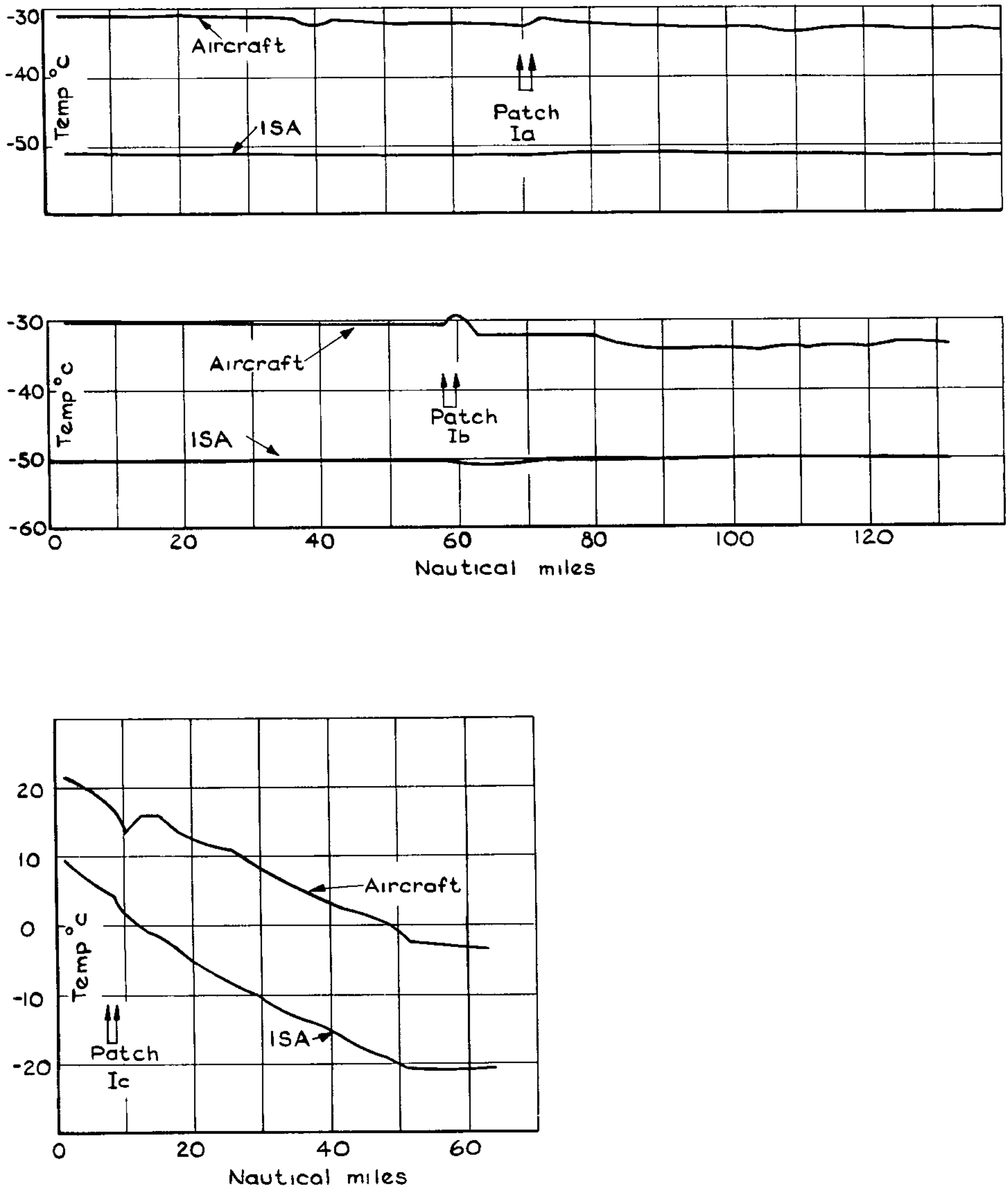


Fig. 47 Temperature profiles for turbulence patches Ia, Ib and Ic

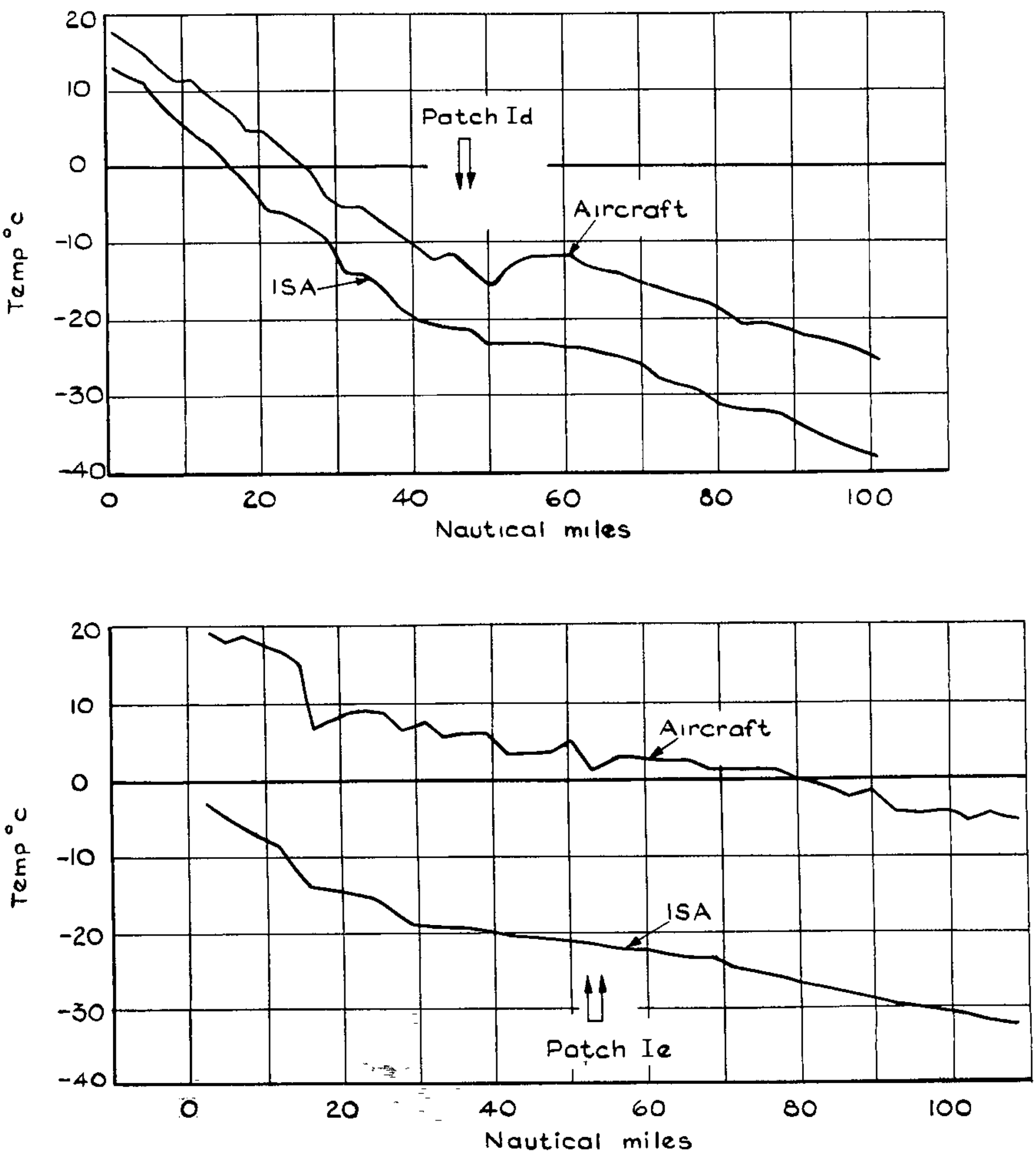


Fig. 48 Temperature profiles for turbulence patches Id and Ie

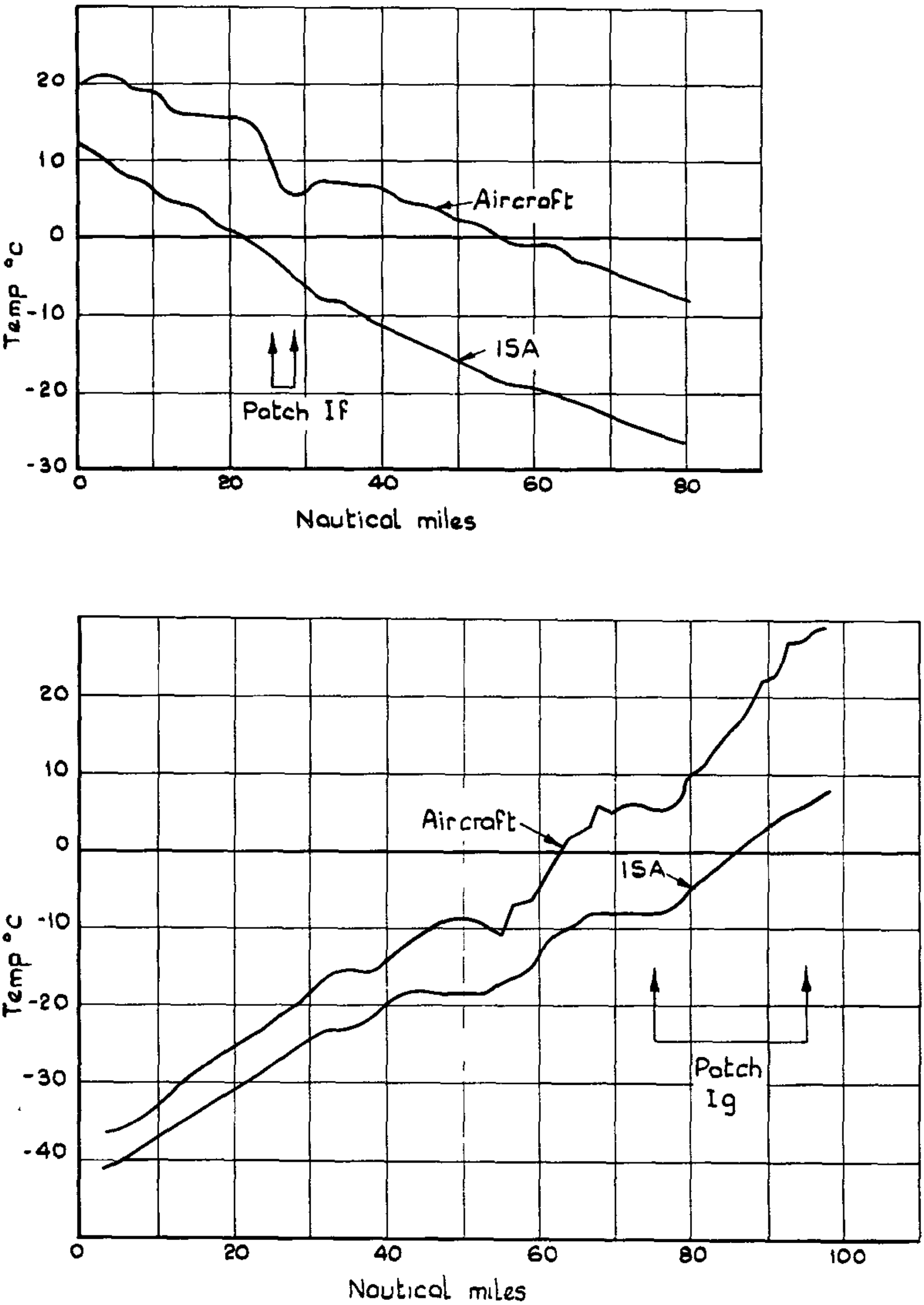


Fig. 49 Temperature profiles for turbulence patches If and Ig

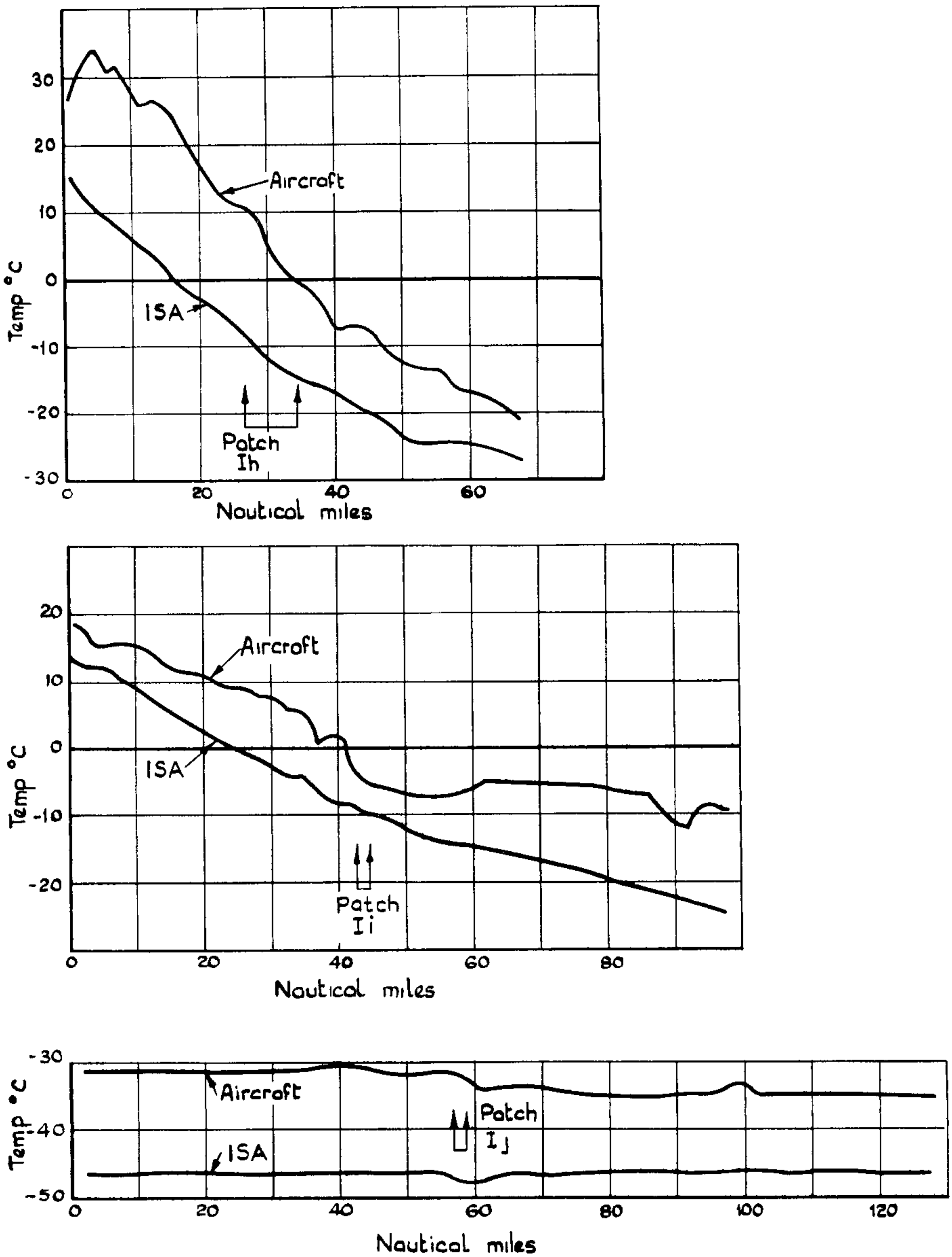


Fig. 50 Temperature profiles for turbulence patches Ih, Ii and Ij

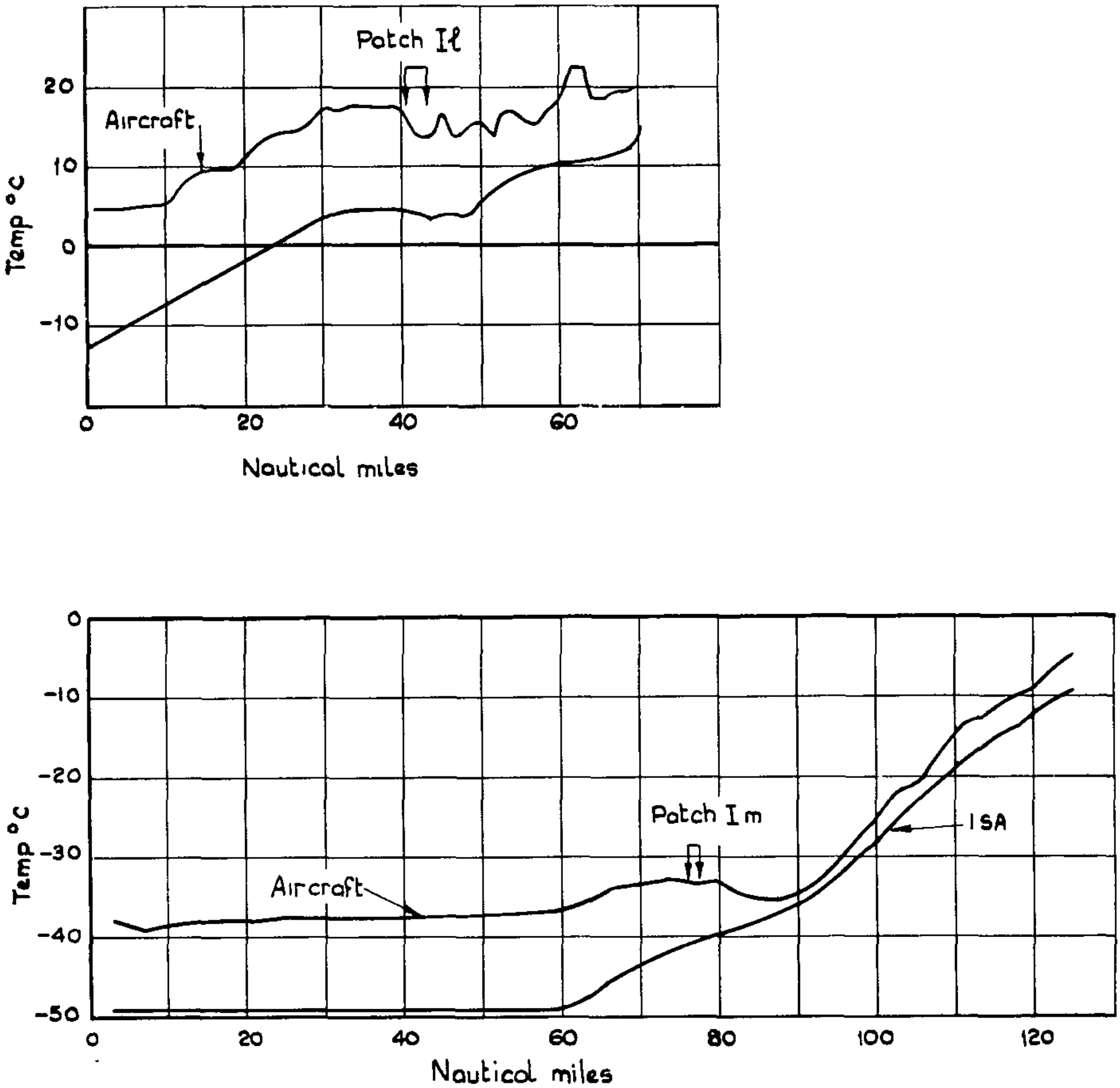


Fig. 51 Temperature profiles for turbulence patches Iℓ and Im

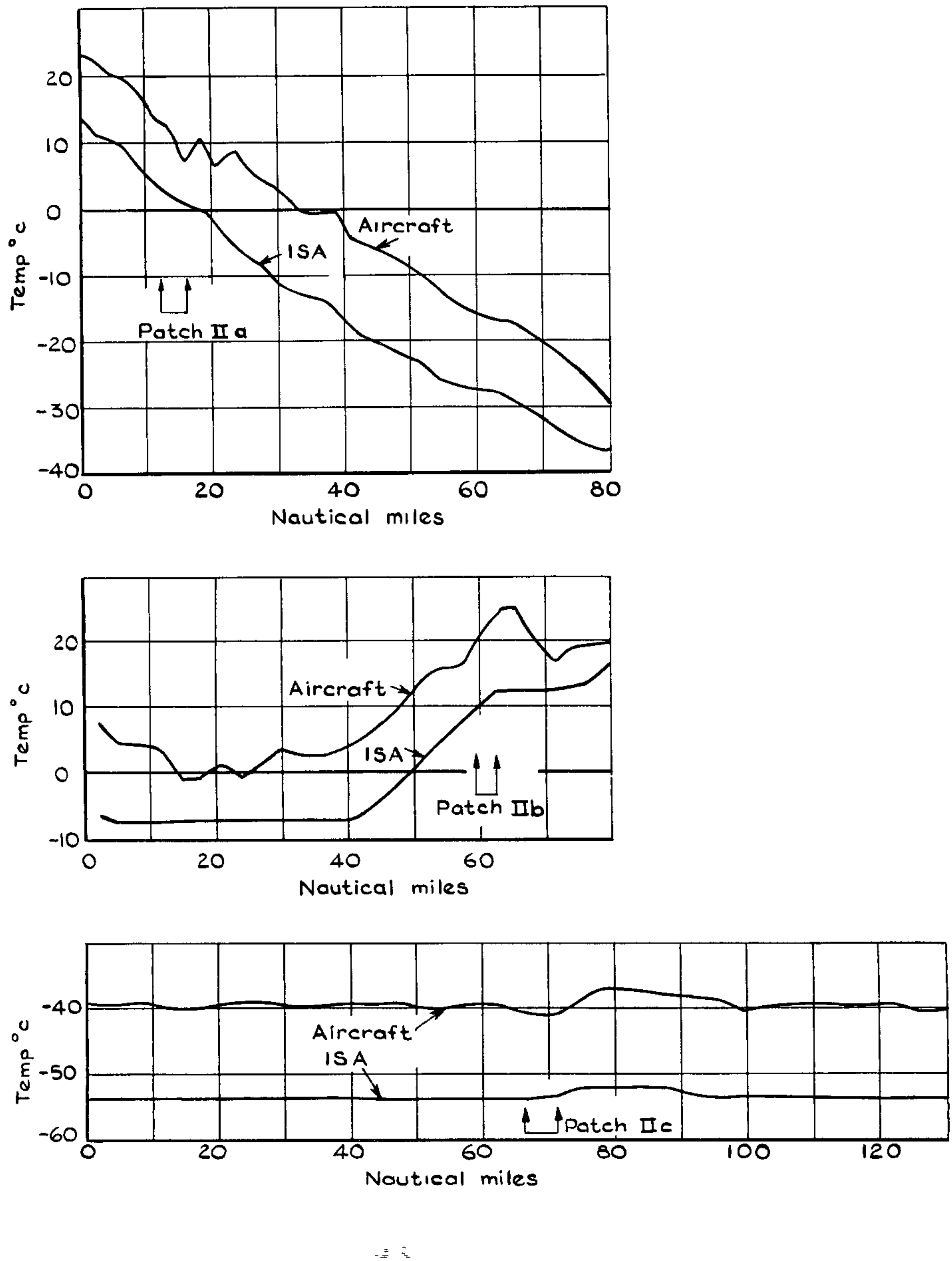


Fig. 52 Temperature profiles for turbulence patches IIa, IIb and IIc

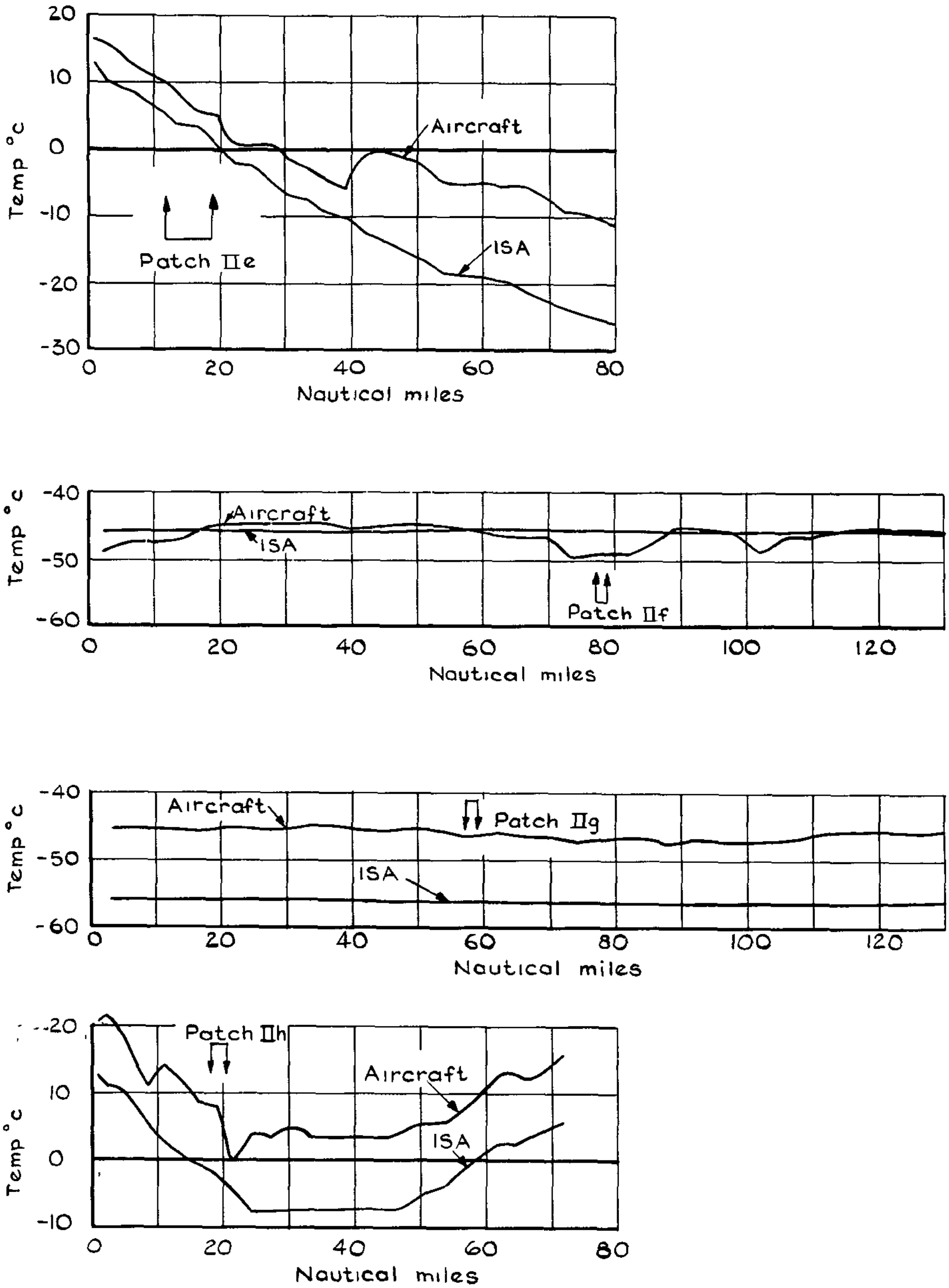


Fig. 53 Temperature profiles for turbulence patches IIe, IIf, IIg and IIh

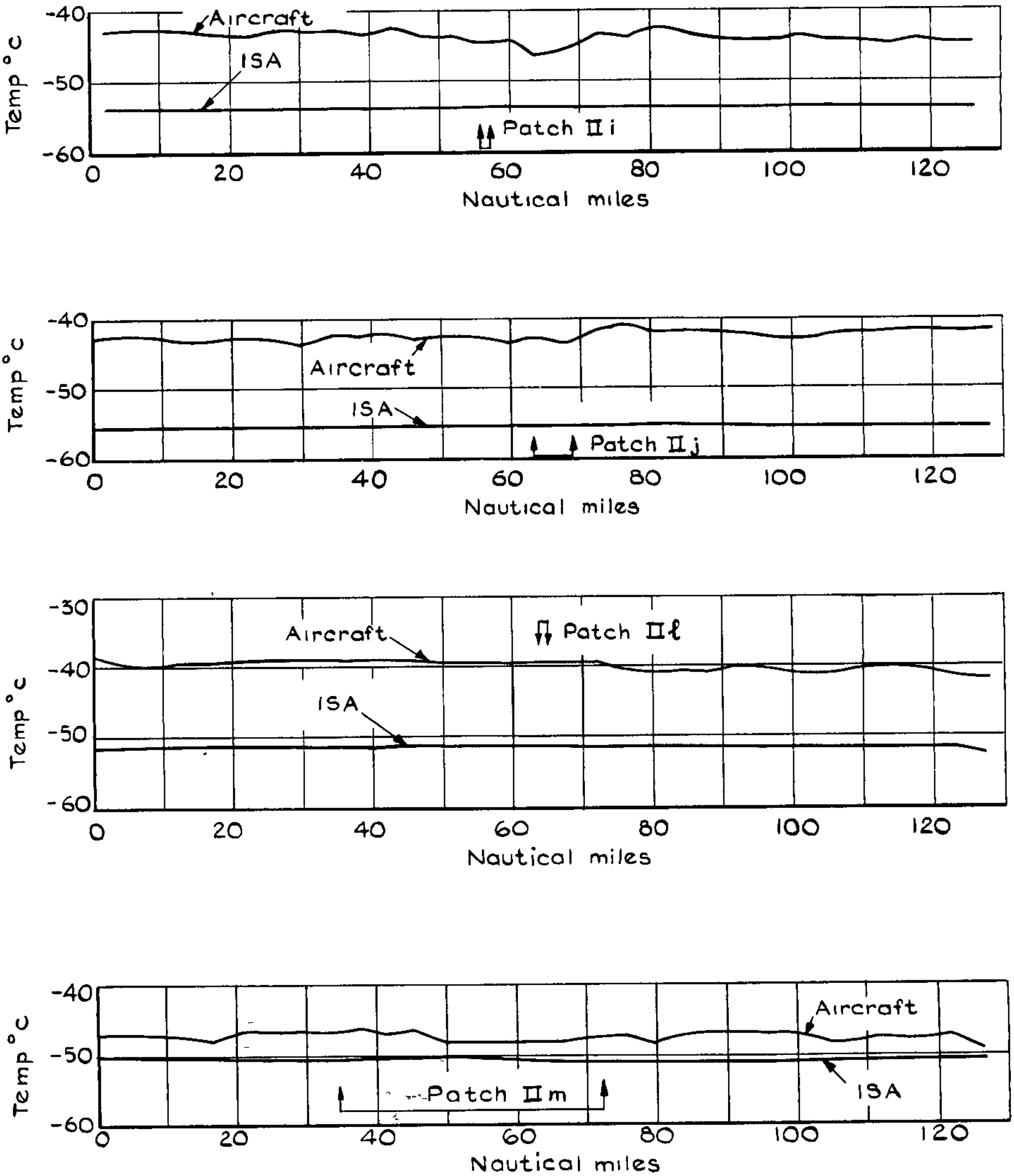


Fig. 54 Temperature profiles for turbulence patches IIi, IIj, IIℓ and IIm

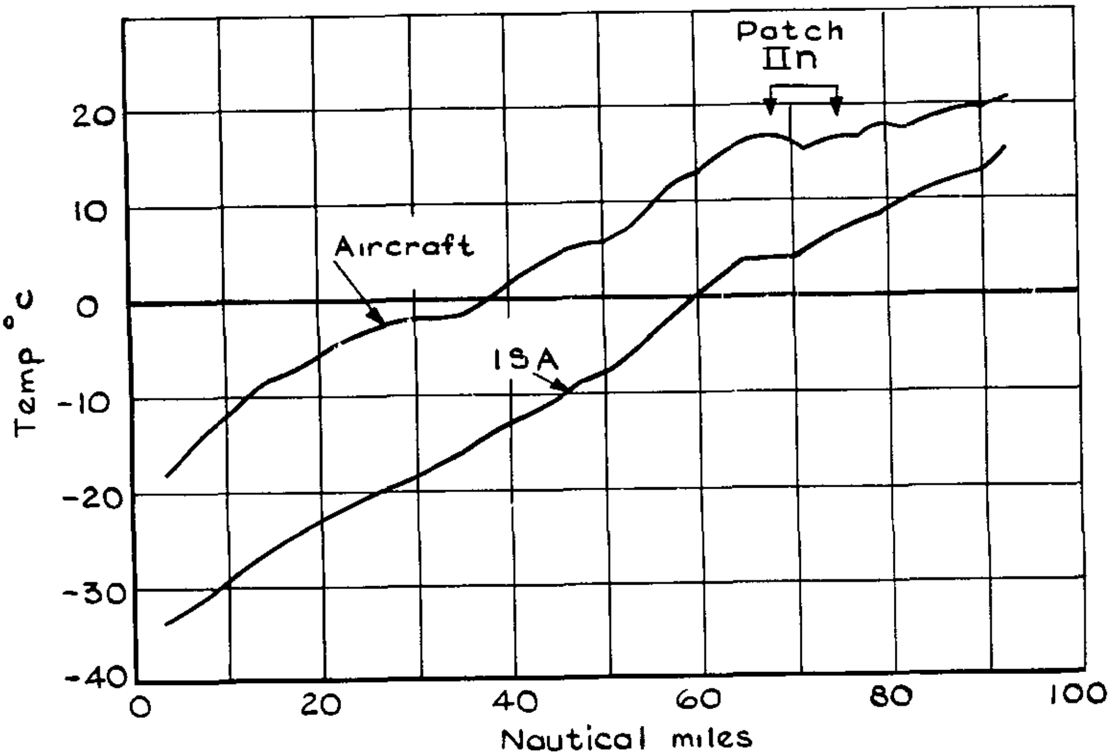


Fig. 55 Temperature profile for turbulence patch IIn

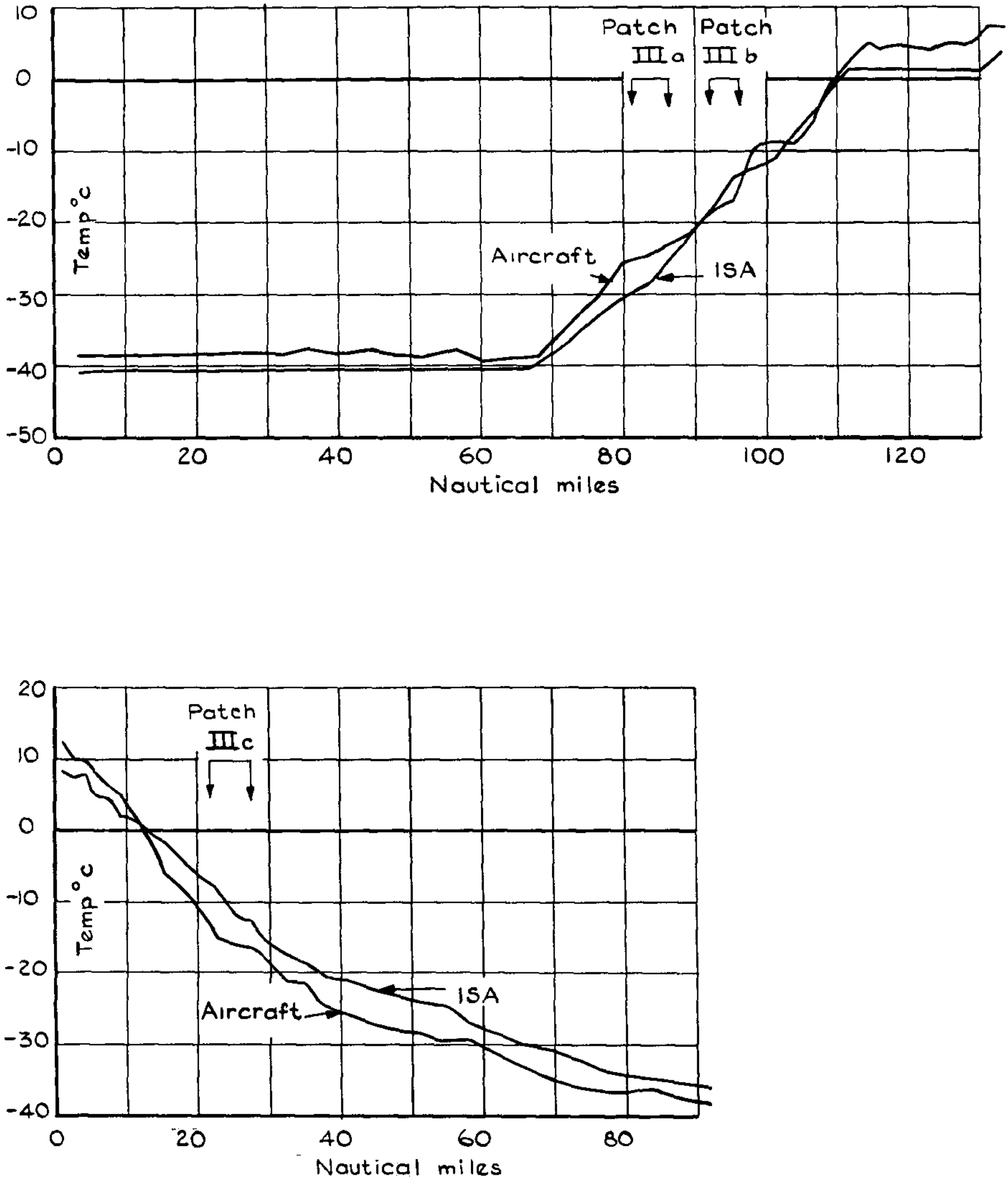
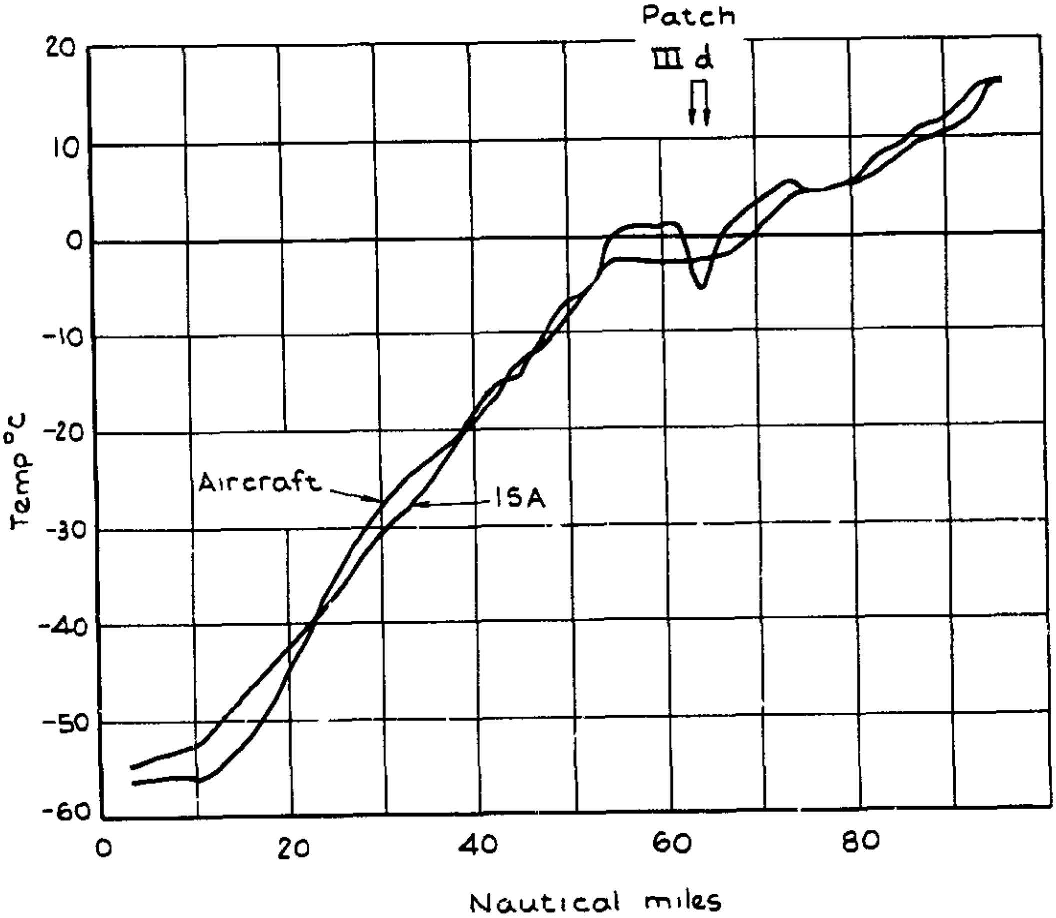


Fig. 56 Temperature profiles for turbulence patches IIIa, IIIb and IIIc



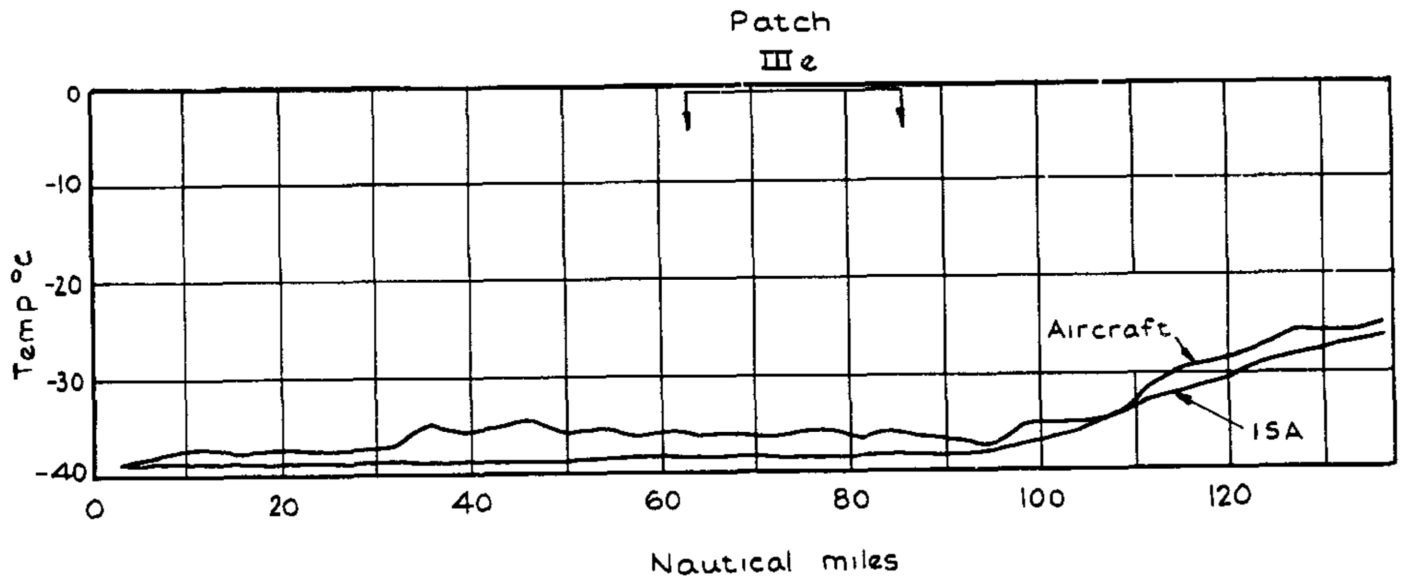


Fig. 57 Temperature profiles for turbulence patches IIId and IIIe

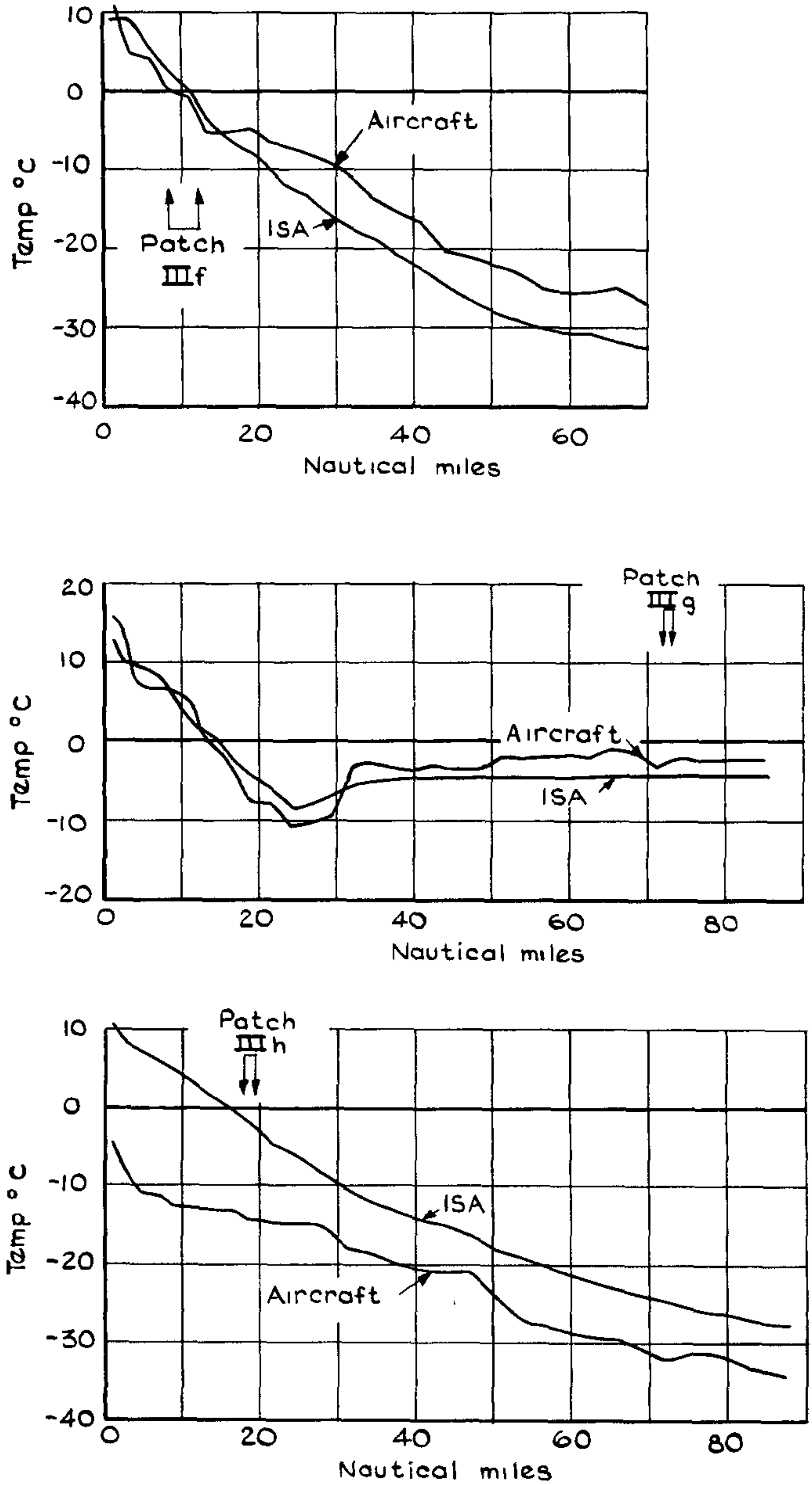


Fig. 58 Temperature profiles for turbulence patches III f, III g and III h

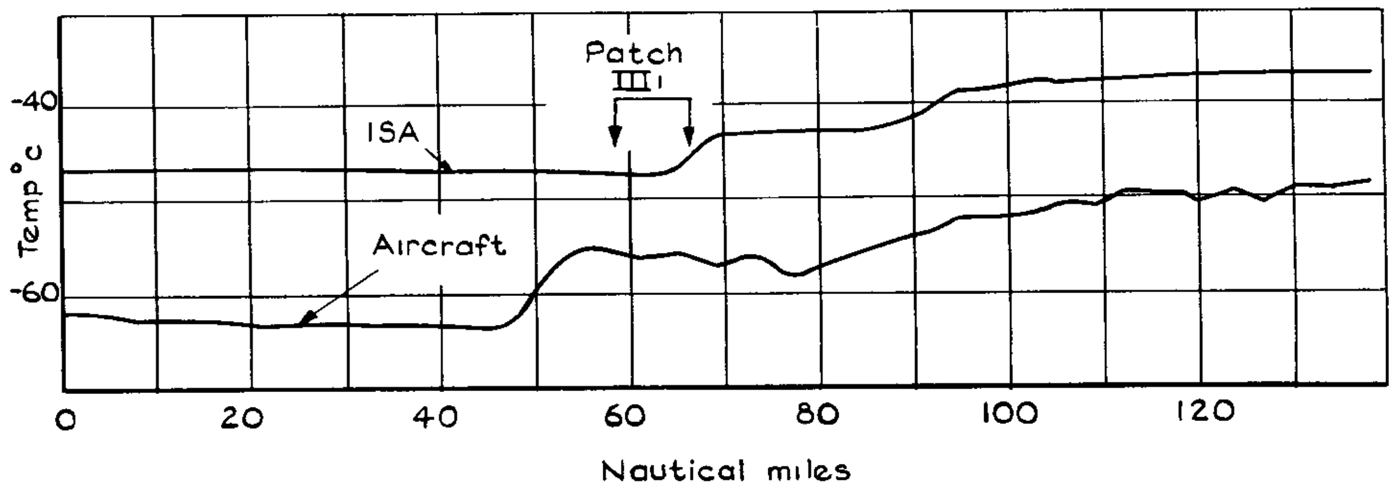


Fig. 59 Temperature profile for turbulence patch III i

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July 1969

King, G.E. 551.551

CIVIL AIRCRAFT AIRWORTHINESS DATA RECORDING PROGRAMME SOME CHARACTERISTICS OF SEVERE TURBULENCE

The characteristics of severe turbulence suggested by an initial study of continuous trace records have been tested by examining turbulence encountered over a larger number of flying hours.

Records from 23034 flying hours have been searched for patches of severe turbulence and those which produced the highest acceleration increments on the aircraft are presented in detail.

It is found that the largest acceleration increment in a patch is on average 1.3 times the value that would be predicted from a Rayleigh distribution of peaks. About a half of the patches occurred without warning, and examination of outside air temperature data suggests that little additional

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warning would be provided by a conventional ram air temperature measuring device.

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