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Fatigue Loadings in Flight:
Loads in the Tailplane and Fin of a Varsity

By

Anne Burns, B.A.

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Fatigue loadings in flight - loads in the tailplane and fin of a Varsity

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Anne Burns B.A.

SUMMARY

Data are presented on the number of load cycles of various sizes occurring in the tailplane and fin of a Varsity in normal ground and flight conditions. The conditions include flight in turbulence, take-off, landing, taxying, and ground running of the engines. The relative importance of the loads in the different conditions is illustrated by reference to the loads in a typical flight.

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1 Introduction

In June, July and August, 1955, a series of flight tests was made in a Varsity to obtain information on the fatigue loads in the main structure. The Varsity, a conventional twin-engined aircraft, is used mainly as a trainer, and in this capacity is subjected to more take-offs and landings than is usual for an aircraft of its type and size. Particular attention was therefore given during the tests to the take-off and landing conditions, although other flight and ground conditions were investigated also. This note presents the information obtained on the fatigue loads in the tailplane and fin.

2 Description of Flight Tests

A brief account of the instrumentation and flight tests is given in Appendix I. The main load measurements were bending moments about the tailplane and fin roots; bending moments were also measured half way out along the tailplane to give a check on tailplane load distribution. The measurements were obtained by means of electrical resistance strain gauges and continuous recording equipment, records being taken during ground running of the engines, taxying, take-off, landing, in the circuit, and during flight in turbulence. When flying in turbulence, accelerations at the aircraft c.g. were also recorded so that the relationship of the tail and fin loads to the c.g. accelerations, and hence to the gust velocities, could be ascertained.

3 Presentation of results

Information on the loads measured is tabulated in terms of changes in steady loads (Tables I and II), and in terms of numbers of load ranges exceeding various sizes (Tables III to VI). Appendix II describes the method used to analyse the variation of load in terms of numbers of ranges. The term range is defined in the usual manner and is twice the alternating load.

In order to summarize the information the numbers of load ranges exceeding various sizes are shown for the component conditions of a typical flight* (Fig. 3). The flight, which is intended to represent operational training, consists of 4 minutes engine running, 5 minutes taxying, a take-off, 33 minutes flight and a landing. Details of the estimation of the loads for the component conditions are given in Appendix III.

The graphs of Fig. 5 have been prepared so that the loads in turbulence can, if required, be related to operational data on gust frequencies. The curves show the relationship between the load and gust velocity ranges that are exceeded the same number of times in three samples of turbulence taken from the flight tests. These samples relate to flight at different airspeeds and the loads have been divided by the corresponding airspeed in an attempt to eliminate, as a first approximation, the effect of airspeed. The gust velocities are derived from the measured c.g. accelerations using the A.P.970 alleviation factor[1].

4 Results

Fig 3(a) shows that for the tailplane the most important loads from the fatigue aspect occur in take-off and ground running of the engines. These loads, usually referred to as ground buffeting loads, are more severe even than the loads in turbulence. For example the range in tailplane load associated with a 20 ft/sec gust range is exceeded six times more often during take-off and engine ground running than it is during turbulence. Other loads such as those in taxying and landing are not of much significance.

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* including associated ground conditions.

Fig. 3(b) shows that for the fin the predominant loads are those in turbulence, the range of fin load associated with a 20 ft/sec gust range being exceeded eight times more often in turbulence than in all the other conditions together.

When the bending moment ranges are plotted as a percentage of the corresponding estimated ultimate bending moment*(Fig. 4), the load levels for both the tailplane and fin are found to be similar.

Fig. 5 shows that there is a simple straight line relationship between the tailplane load ranges and the gust velocity ranges that are exceeded the same number of times. This relationship is very nearly independent of forward airspeed if the load is divided by this quantity. The straight line obtained, however, differs slightly from that predicted from simple theory (see dotted line of Fig. 5).

Although in the case of the fin loads, the relationship at 170 and 145 knots bears some similarity to that found on the tailplane, at 130 knots there is some other influence, perhaps a change in directional characteristics of the aircraft, so that a simple relationship cannot be found.

5 Conclusions

Information on changes in steady load and load cycles likely to produce fatigue damage in the tailplane and fin of a Varsity engaged in operational training has been obtained in special flight tests. The results show that for the tailplane the loads in ground running and take-off - i.e. the ground buffeting loads - are likely to be more important from the fatigue aspect than the loads in turbulence. In taxying and landing the tailplane loads are not of much significance. For the fin the flight test results show that the loads in turbulence are predominant.

The results indicate that tailplane loads can be related empirically to vertical gust velocities so that statistical information on gust occurrences can be used for estimating tailplane load occurrences. Fin loads and gust velocities do not appear to be simply related.

REFERENCES

No.	Author	Title, etc.
1		Air Publication 970, Vol. 1 Ch. 203 as amended 1st February, 1951.

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* Estimated on the assumption that at ultimate B.M. the maximum fibre stress in the spar boom at section A equals the allowable compressive stress.

APPENDIX I

Flight Tests

Instrumentation

British Thermostat strain gauges were attached and water-proofed with Araldite special strain gauge cement at the stations shown in Fig. 2. The signals from the gauges were fed into McMichael carrier wave amplifiers and recorded after amplification on a Films and Equipment 12 channel recorder. The stepped signal from a Type I.T.6-1 accelerometer attached to the fuselage at the c.g. position was also recorded on the Films and Equipment recorder.

When measuring changes in steady load, fixed signals were switched into the amplifiers to check for amplifier drift.

Calibration

The strain gauge signals were calibrated directly in terms of load by means of ground tests in which vertical loads were applied to the tailplane using shot bags, and side loads to the fin using tension pads and a linkage system. Ground calibration tests were made before the flight tests and those on the tailplane repeated after the flight tests. There appeared to have been a slight loss in sensitivity (about 5%) during the four months between calibration tests. As most of the tailplane loads were obtained during the early part of the flight tests the pre-flight calibration figures were used.

Test Flying

The aircraft was flown throughout the tests at an all up weight varying between 33,000 and 36,000 lb. The c.g. remained roughly the same throughout the flight at 30.4 ft aft of datum (limits 29.6 ft to 30.8 ft aft of datum). The aircraft was flown at all times by the pilot and not on auto-pilot.

Take-offs and landings were recorded during the course of the tests and no special requests for heavy or braked landings were made, The take-offs and landings were made by a number of different pilots and at several aerodromes. No landings or take-offs were made on grass. Taxying was recorded when running on the runways and perimeter tracks.

For purposes of analysis a take-off was defined as the period from start of rolling to main undercarriage up, usually about 35 seconds. A landing was defined as a period of 35 seconds starting from the instant of touchdown. Records of the circuit when coming in to land were also taken, a circuit being defined as the period starting from the first lowering of the flaps or undercarriage, whichever was lowered first, and ending at touchdown (usually about 3 minutes).

Turbulence was recorded flying straight and level in the height band 2,000 to 7,000 ft above ground. Most of the turbulance was recorded in or below small to medium cumulus cloud.

A special technique was used in obtaining the ground to air measurements in order to minimise strain gauge drift. Using the long runway at Thurleigh the aircraft was taken off and held in level flight just above the runway at 90 knots, 1/3 flap, undercarriage down. A landing was then made straight ahead. By this means ground-air-ground measurements could be taken in quick succession and a 'flight datum' established. The change in steady load from the flight datum to flight at 2,000 ft, 145 knots, flaps and undercarriage up was then determined in the usual way by a quick succession of alternate readings in these two conditions.

Miscellaneous Results Not Included in Main Test

Comparison of Measured and Calculated Tailplane Load for 10 ft/sec Gust

The measured tailplane root B.M. corresponding to a 10 ft/sec gust* was 7.8 tons in. at 145 knots compared with a calculated value of 8.7 tons in. The calculated value includes allowance for downwash and pitching. Because of the presence of vibratory components in the measured value, for which no allowance is made in the calculations, the agreement achieved between measured and calculated values cannot be regarded as confirming the method of calculation.

Spanwise Distribution of Tailplane Loads

It is usual to assume the air loads are distributed along the tailplane span in proportion to the chord. On this assumption the ratio of mid span B.M. (position B of flight tests) to root B.M. (position A) is calculated to be 0.31. In the flight tests the corresponding measured ratio was 0.38 both in turbulence and in ground running of the engines, indicating a slightly greater concentration of load outboard.

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* The measured tailplane root B.M. is taken to be half the range of the tailplane root B.M. cycle which is exceeded the same number of times as a gust velocity cycle of 20 ft/sec range.

APPENDIX II

Analysis of Traces in Terms of Load Ranges

The term load range is used to denote the double amplitude of a load cycle which starts at some intermediate value, increases to a peak, decreases to a trough and then returns to the intermediate value. The order in which the peak and trough occur and the rate at which the load varies with time are immaterial. The analysis of the recorded traces in terms of numbers of load ranges exceeding certain sizes is carried out as follows.

Marking of Records

A trace is selected for analysis and all peaks and troughs forming cycles above a minimum size (usually 0.06" range but a higher value can be chosen) are first marked. It is convenient to use different coloured inks for different traces. Peaks and troughs are always marked alternately and so that the total number marked is even.

Reading of Peaks and Troughs

The distances of the marked peaks and troughs from the datum trace are then read in terms of divisions (1,000 divisions = 6") by a semi-mechanical trace analyser which types the distances as a column of 2 and/or 3 digit figures.

Analysis of Readings

The last digit representing 0.006" per unit is crossed out and any pairs of adjacent numbers which become identical when the last digit is removed are also crossed out. Adjacent peaks and troughs are then bracketed together in pairs starting at the smallest size of load cycle, i.e. adjacent figures differing by 10 divisions are first bracketed. The next step is to bracket adjacent figures differing by 20 divisions. Figures on either side of a pair or number of pairs of previously bracketed figures count as adjacent when bracketing a greater difference. The process is continued, always bracketing in order of size, until all the numbers are paired. The bracketing is best done using different colours and/or types of brackets to denote different sizes of load cycles. A count of each colour and/or type of bracket is made when the bracketing is complete.

Because of the neglect of the last digit the load cycles have now been counted in overlapping bands. For example:-

1st bracket denotes a range $\geq$ 0 and $<$ 20 divisions

2nd bracket denotes a range $\geq$ 10 and $<$ 30 divisions

3rd bracket denotes a range $\geq$ 20 and $<$ 40 divisions

4th bracket denotes a range $\geq$ 30 and $<$ 50 divisions

etc. etc.

By considering the odd brackets in one group and the even in another, two groups are obtained in which the bands do not overlap. Running sums are made for each group to obtain the total number of cycles whose ranges exceed 0, 20, 40 ..... divisions for one group and 10, 30, 50 ..... divisions for the other. The numbers of cycles whose ranges exceed the intermediate values of divisions in each group are then estimated by taking the R.M.S. of adjacent numbers of cycles. The two groups can then be added together directly to give the required total number of cycles whose ranges exceed 10, 20, 30, 40 ..... divisions. The final step is to interpret the divisions in terms of load from the calibration figures.

During take-off and landing there is a change in the steady load level which, when the above method is applied, usually gives rise to an apparent load cycle of large size (termed apparent since it really only represents half a load cycle). This apparent load cycle is best reduced by the change in steady load level to obtain the true load cycles exclusive of ground to air loads which can be added afterwards.

Analysis of Acceleration Traces

Traces of continuously varying acceleration can be analysed in exactly the same way. When the acceleration trace is a stepped one, peaks and troughs are denoted by their appropriate code numbers (see R.A.E. Form F.1020 V.S.) and these numbers written in a column and analysed as above except that there is now no third digit to remove. A difference in code number of 1 unit denotes a range equal or greater than 0.2g and less than 0.4g, a difference of 2 units a range equal or greater than 0.3g and less than 0.5g etc.

APPENDIX III

Estimation of Load Occurrences in Typical Flight

The numbers of occurrences of the tailplane and fin loads for the landing and take-off of the typical flight are mean values of the flight test results. The numbers of landings and take-offs analysed varied according to the significance of the loads and were as follows:-

Case	No. of Take-offs or Landings Analysed	No. of Load Occurrences	
		Mean	5% Confidence Limits
Tailplane B.M. Take-offs	12	25	25 ± 5.4
Tailplane B.M. Landings	7	3	3 ± 1.5
Fin B.M. Take-offs	3)	No. of occurrences too	
Fin B.M. Landings	3)	infrequent for analysis	

The columns on the right hand side show the mean number of occurrences and the 5% confidence limits for a load cycle corresponding to a ± 10 ft/sec gust cycle.

The tailplane loads in ground running of the engines were obtained on the assumption that the following ground running took place each flight:-

Engines	R.P.M.	Time
Both engines	2,400	5 seconds
Both engines	1,200	185 seconds
Port only	2,400	10 seconds
Port only	2,000	15 seconds
Starboard only	2,400	10 seconds
Starboard only	2,000	15 seconds

The flight tests showed that the loads at 1,200 R.P.M. were negligible. For other conditions the half minute recordings made in the flight tests were scaled down to the appropriate times.

For estimating the loads in turbulence the aircraft was assumed to spend 10 minutes at 130 knots, 1,000 ft (to represent the climb and descent) and 23 minutes at 145 knots, 2,000 ft*. It was estimated from operational data obtained on a number of aircraft that the average number of miles travelled to meet a 10 ft/sec gust (up or down) was 3.2 at 1,000 ft and 7.4 at 2,000 ft. Hence the Varsity in its typical flight would meet 16.3 up and down gusts of 10 ft/sec or, rounding up, 8.2 gust cycles of range 20 ft/sec**.

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* Based on average figures for Varsities engaged in training flights at Swinderby R.A.F. Station.

** It is assumed here that the number of cycles of range 20 ft/sec is equal to half the sum of the negative and positive 10 ft/sec gusts. A check from the flight tests showed that this method of estimating numbers of cycles gives a slight over-estimation.

As the relative frequency of the different sized gusts in the flight tests was compatible with that obtained operationally the flight test results were merely scaled to give 8.2 occurrences at 20 ft/sec. The corresponding tail and fin loads were then determined from Fig. 5.

The taxying loads for the typical flight were obtained by scaling up the number of occurrences in the 3 minute sample analysed to give the appropriate number of occurrences for 5 minutes.

TABLE I

Ground to air tailplane loads

A.U.V. 34,600 lb   c.g. 30.45 ft aft of datum

Condition	Tailplane Root B.M.*		
	Port tons-ins	St'b'd tons-ins	Mean tons-ins
Ground to air - 90 kts, a few ft above ground level 1/3 flap, undercarriage down	-23	-19.1	-21.05
Ground to air - 145 kts, 2,000 ft above ground level flaps and undercarriage up	-20.9	-14	-17.45

* Negative sign denotes a download on the tail

TABLE II

Tailplane loads due to lowering of flaps

Condition	Tailplane Root B.M.*		
	Port tons-ins	St'b'd tons-ins	Mean tons-ins
Lowering flaps from zero to 15° at 150 kts	-25.2	-22.5	-23.85
Lowering flaps from 15° to 30° at 120 kts	- 8.9	- 9.1	- 9
Lowering flaps from 30° to 47° at 115 kts	No significant change		

* Negative sign denotes a download on the tail

TABLE III

Tailplane Port Root Bending Moment Cycles

Load range	Number of Times Load Range is Exceeded																		
	Landing							Take-off											
Tons ins	No:1	2	3	4	5	6	7	No:1	2	3	4	5	6	7	8	9	10	11	12
5.7	39	31	21	26	40	63	19	130	105	93	120	91	109	126	129	126	139	122	137
8.5	19	13.4	11.7	12.9	17.5	25	8.2	92	74	58	74	79	82	94	88	75	102	82	83
11.4	8	6	6.8	5.5	6.2	13.3	4.9	61	52	33	42	52	56	62	49	43	72	55	49
14.2	5.3	3.8	6	2.7	3.5	5.2	3.3	41	37	20	22.2	34.5	41	41	27.3	26	49	37	29
17	2.9	3	5.4	1.4	2.4	2.2	2.5	27.5	26	13	10.7	23.2	32	28	17.3	12.9	33.6	23.4	17
19.9	1.4	2.4	2.8		1.4	1	2	18.8	16.2	8.2	4.4	12.7	19	19.5	9.9	7.1	24.5	16.4	10
22.7					1	1.4		11.6	10.7	4.9	0.7	4.7	9	12.6	5	4.5	15	12.5	5.3
25.6								7.9	5.4	2.9		0.7	4.5	5.6	2	1.7	7.4	8	2.9
28.4								5.7	2.8	1.6			2.4	2	1		2.5	5.7	1.4
31.3								3	2	0.7			1.2	2			1	2	
34.1								1.4	1.4									1	
36.9								1	1									1	
39.8								1										1	
42.6																		1	
45.4																			

Load range	Number of Times Load Range is Exceeded														
	Engine ground running-½ min each condition								Turbulence			Taxy-ing-3 mins	Circuit		
	St'b'd only			Port only			Both engines		3 mins each speed*						
Tons ins	2800	2400	2000	2800	2400	2000	2800	2400 rpm	170	145	130 kts		No:1	2	3
5.7	135	17.3	48	145	94	110	193	181	125	79	28.8	97	147	66	98
8.5	81	6	14.5	103	50	50	171	150	62	42	10.5	13.9	69	33	62
11.4	38	1	2.4	71	26	18.6	141	120	32.5	18.9	2.8	2.8	40	14.7	36
14.2	15.6	1		50	12.7	6.8	106	91	18.5	9.6			30	7.9	23
17	6.4			29	5	3	76	64	10.2	2.9			22	3	13
19.9	1.2			17.7	1.7	1.4	54	45	3.7				14	2.4	8.3
22.7				10.4	1		33	29	1.4				9.7	2	5
25.6				5			19	16.7					4.9	1.4	3.5
28.4				3			11.2	8.2					4	1	2.4
31.3				2			6.5	4					2.2	1	1.4
34.1				1			3.7	1.8					1	1	1
36.9							1.7						1		
39.8													1		
42.6													1		
45.4															

* 2 mins at 130 kts.

TABLE IV

Tailplane Starboard Root Bending Moment Cycles

Load range	Number of Times Load Range is Exceeded																		
	Landing							Take-off											
Tons ins	No:1	2	3	4	5	6	7	No:1	2	3	4	5	6	7	8	9	10	11	12
4.8	51	34	24	36	44	61	22	129	127	127	130	132	136	126	126	146	144	132	148
7.2	29	18	19	22	22.5	36.5	11.5	83	98	83	85	111	105	100	92	87	105	107	87
9.6	16.5	9.7	11.8	14	14	15	5.7	57	69	57	57	79	76	74	60	42	69	76	49
12	9.3	6.9	6	3.2	7	5.6	2.8	36.5	48	30	35	51	56	51	32.4	22	45	56	26.5
14.4	5.3	4.8	4	2	5	2.7	0.8	25	37	17.8	21	30	37	37	19.6	11.8	27.5	46	14.3
16.8	3.2	2.8	4	0.8	4	1		17.7	25	11.3	11.6	19	23.5	25	10.2	6	15.8	34	7.8
19.2	1.9	2	3.4		1.8			9.2	15.6	7.5	4.5	12	17.4	15	5.7	3.7	7.6	23.9	3.6
21.6	1.2	1.4	3		1			4	8.2	5.1	1.4	3	13.7	10.2	4	2.1	2.4	17.5	2
24	1	1	2					1.2	4.8	1.8		1	8.7	5.7	1.6	1.2		12.7	1
26.4			2						2.7				4.2	3.5				9.9	
28.8									1.4				2.4	1.8				6.2	
31.2													1.4					2	
33.6																			
36																			
38.4																			
40.8																			
43.2																			
45.6																			
48																			

Load range	Number of Times Load Range is Exceeded														
	Engine ground running-½ min each condition								Turbulence			Taxy-ing-3 mins	Circuit		
	St'b'd only			Port only			Both engines		3 mins each speed*						
Tons ins	2800	2400	2000	2800	2400	2000	2800	2400 rpm	170	145	130 kts		No:1	2	3
4.8	169	96	91	170	69	50	196	190	168	102	33	94	121	54	99
7.2	142	57	49	115	14.6	15.8	172	164	85	40	10.6	22.3	81	31	59
9.6	108	22.5	25.1	66	3.8	4.3	144	128	42	18	4.7	6.6	46	15.5	39
12	80	7.3	9	35	1.4	1.4	118	95	21.5	8.2	2	1.9	31	6.8	26
14.4	57	3	3.2	16.5			94	70	10.7	4	1.4		21.7	3	18.1
16.8	32	1.4	1.4	8.9			70	51	4.8	2.4			16	1.4	10.5
19.2	18.6		1	5			49	32	4				12.9	1	6.2
21.6	12.7			2.2			33	19	1.8				10.9	1	4.4
24	7.7						20.7	12.9	1				8.7	1	2.7
26.4	4						14.2	8.2					6.3	1	2
28.8	2.1						9.2	5.5					4.4	1	1.4
31.2							4.7	3.7					3.5	1	
33.6							2.4	2.4					3		
36							1.4	1.4					1.7		
38.4							1						1		
40.8															
43.2															
45.6															
48															

* 2 mins at 130 kts.

TABLE V

Fin Root Bending Moment Cycles

Load range	Number of Times Load Range is Exceeded																				
	Landing			Take-off			Engine ground running-½ min each condition								Turbulence			Circuit			Taxying
							St'b'd only			Port only			Both engines								
Tons ins	No:8	9	10	No:13	14	15	2800	2400	2000	2800	2400	2000	2800	2400 rpm	170	145	130 kts	No:4	5	6	
5.6	27	42	65	78	40	23	77	11	2.5	97	13	2	147	102	174	108	36	53	64	68	Loads negligible
8.4	13.5	24	38	56	19.2	12.5	24.8	2.4		34	2.6		106	51	112	61	25	41	40	46	
11.2	16.3	8.7	18.6	25	7.8	9.5	6.6	1		8.4			65	22	70	44	19.5	31	28	33	
14.0	3.8	3.7	9.6	10.2	4.2	8	2.3			2.1			30	8.8	54	38	18	23	22	25	
16.8	3.0	2.4	6.7	6	3	6.2							12.7	3.4	42	30	15.8	18	18	21	
19.5	1.8	2.0	5.5	5.5	2.4	3.7							5.5	1.4	36	22	12.9	15.4	11.8	18	
22.3		2.0	4.4	3.8	2	2.4							1.7		32	16.2	10.9	10.5	9	11.6	
25.1		1.4		1.7	2	1.4									27	12.3	8.9	5.9	7.4	7	
27.9				1	1.4	1									22	10	7.5	4	5.9	4.4	
30.7				1		1									17.7	8.5	6.4	2.7	5	3.5	
33.5				1											13.1	5.2	4.8	1.4	3	3	
36.3				1											10.5	3.5	4		1.4	1.2	
39.1				1											9.7	2.4	3.4				
41.9				1											7		1.4				
44.7															4.2		1				
47.5															2.4		1				

TABLE VI

C.G. Accelerations

Acceleration Range	Number of Times Acceleration Range is Exceeded								
	Turbulence			Circuit					
g	170	145	130 kts	No:1	2	3	4	5	6
0.2	65	50	23	47	25	39	29	17.4	43
0.3	39	28.3	9.1	29	12.3	19	14.6	11.8	12.6
0.4	23.7	16.2	3.6	17.9	6	9.2	7.2	7.2	3.8
0.5	11.7	7		9.7	2.8	5.2	2	2.4	1.4
0.6	5.2	3		5	1.4	2.8	1		
0.7	2.7	1.4		2.7	1	1			
0.8	2			1.4					
0.9	1.4								

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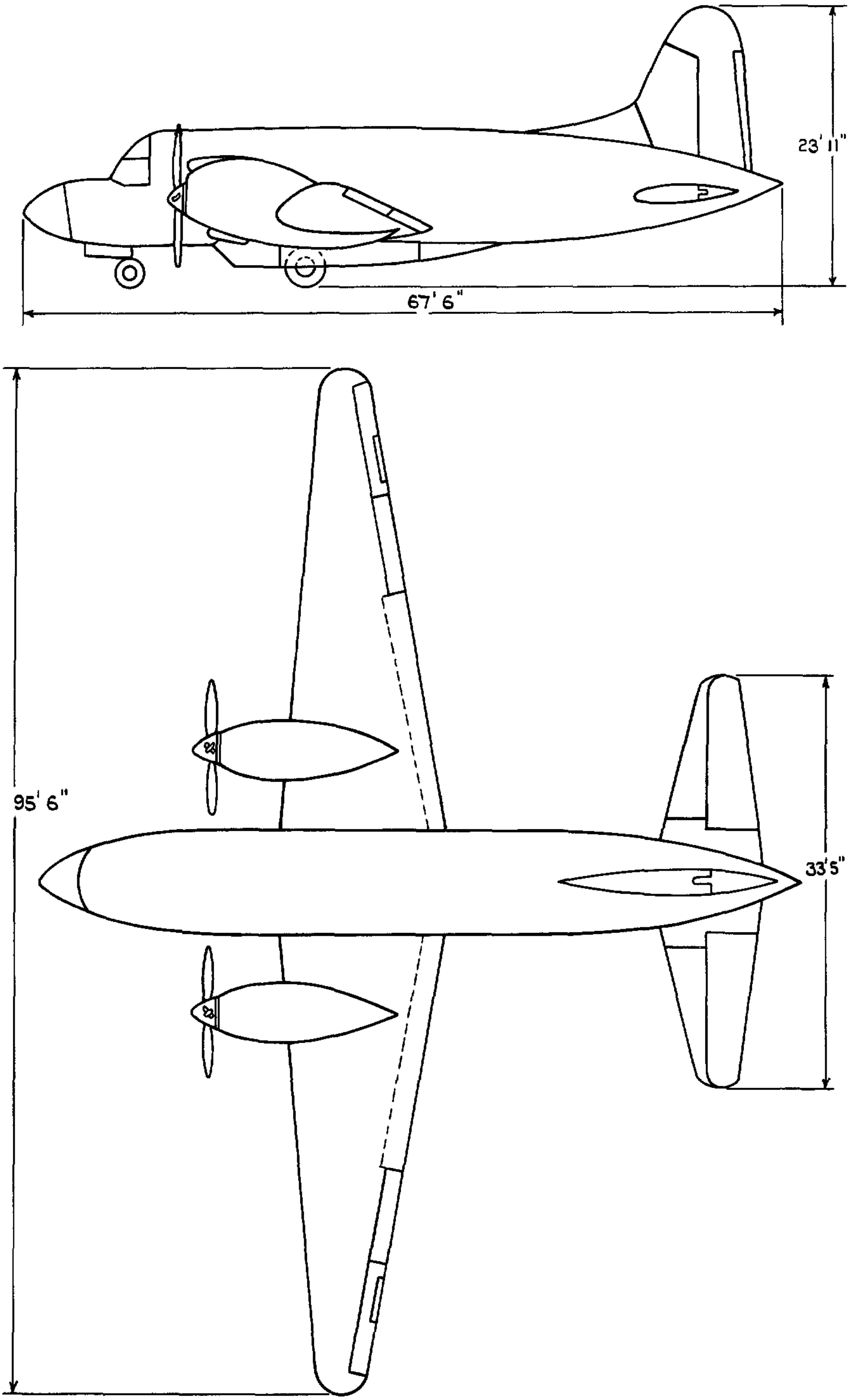
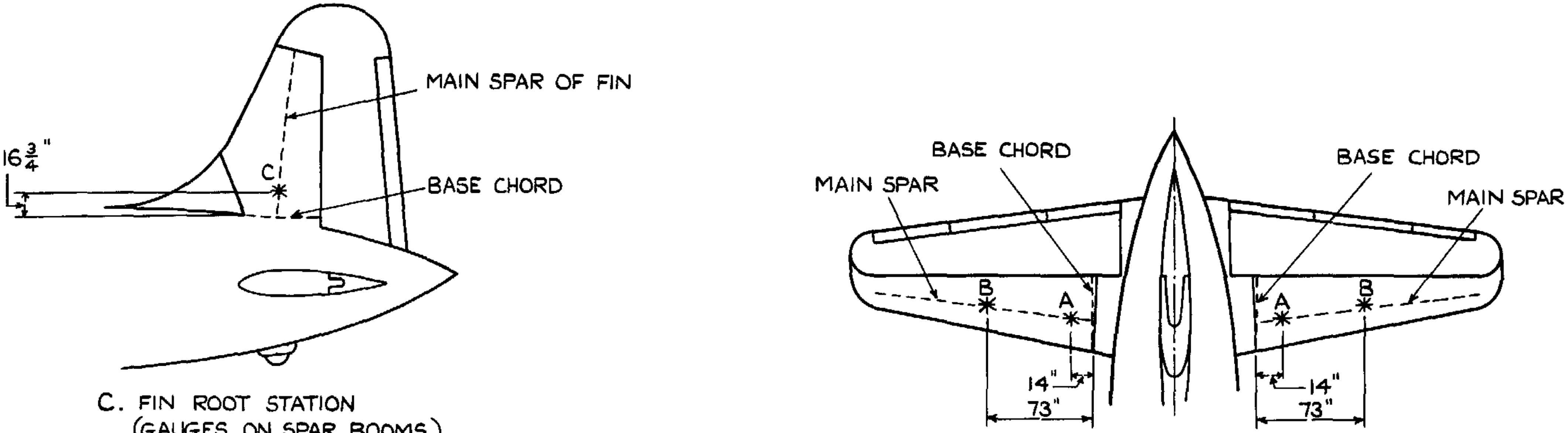


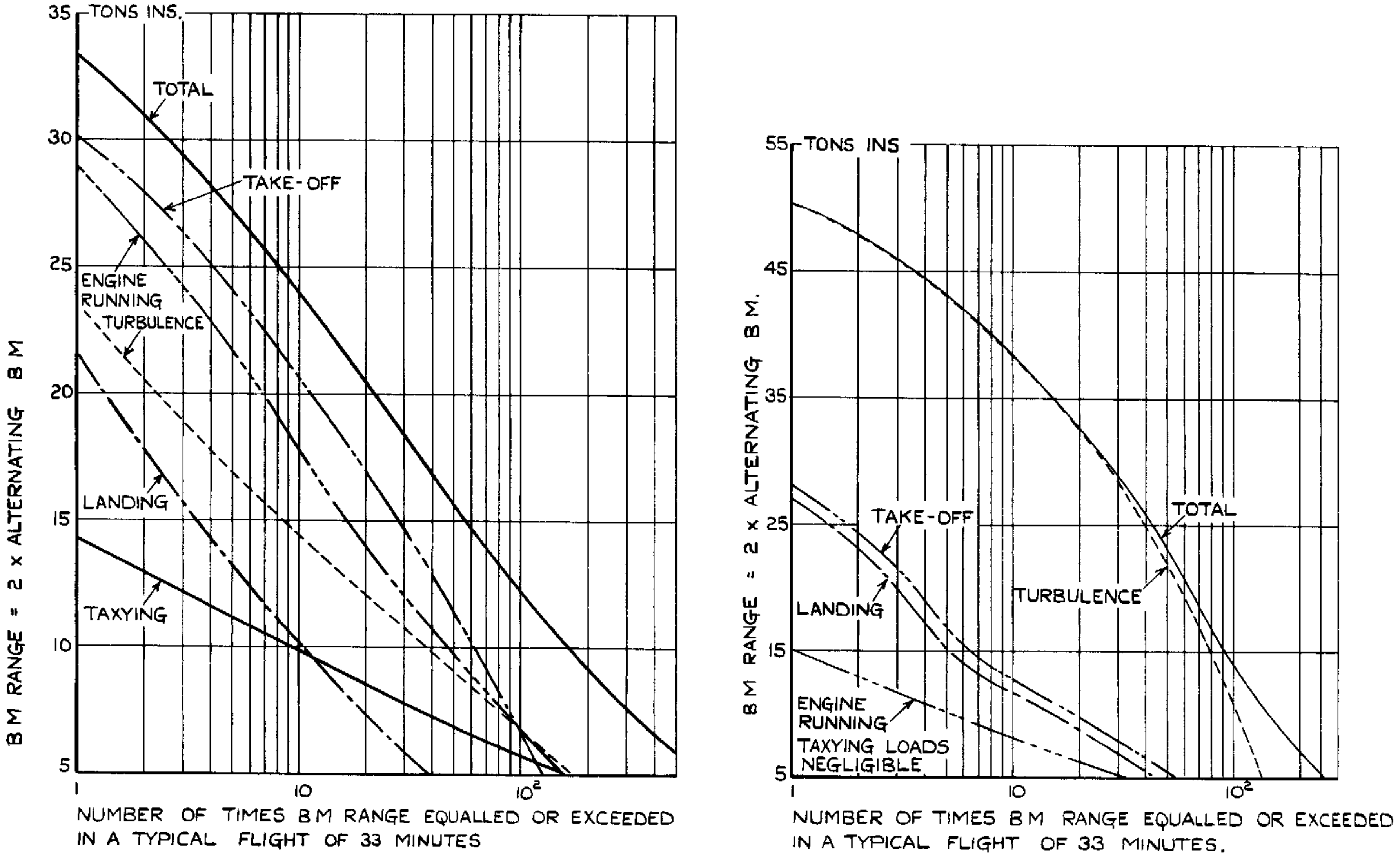
FIG. I. GENERAL ARRANGEMENT OF VARSITY.



C. FIN ROOT STATION
(GAUGES ON SPAR BOOMS)

A TAILPLANE ROOT STATIONS
B. TAILPLANE MID SPAN STATIONS
(GAUGES ON SPAR BOOMS)

FIG. 2. STRAIN GAUGE STATIONS ON FIN AND TAILPLANE.



(a) TAILPLANE ROOT B.M (POS. A.)

(b) FIN ROOT B M. (POS. C.)

FIG. 3 (a & b) TAILPLANE AND FIN LOADS IN COMPONENT CONDITIONS OF TYPICAL FLIGHT.
INCLUDING ASSOCIATED GROUND CONDITIONS
(FLYING TIME = 33 MINUTES)

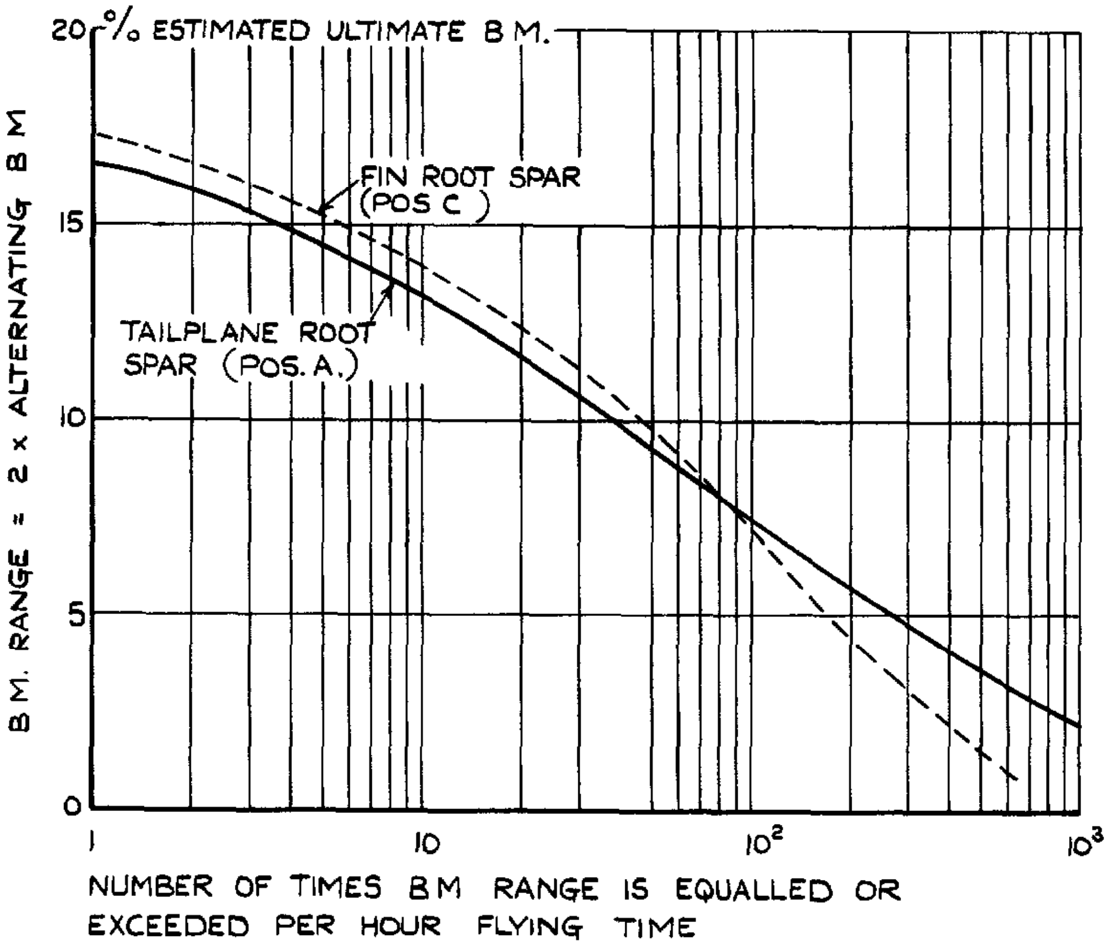
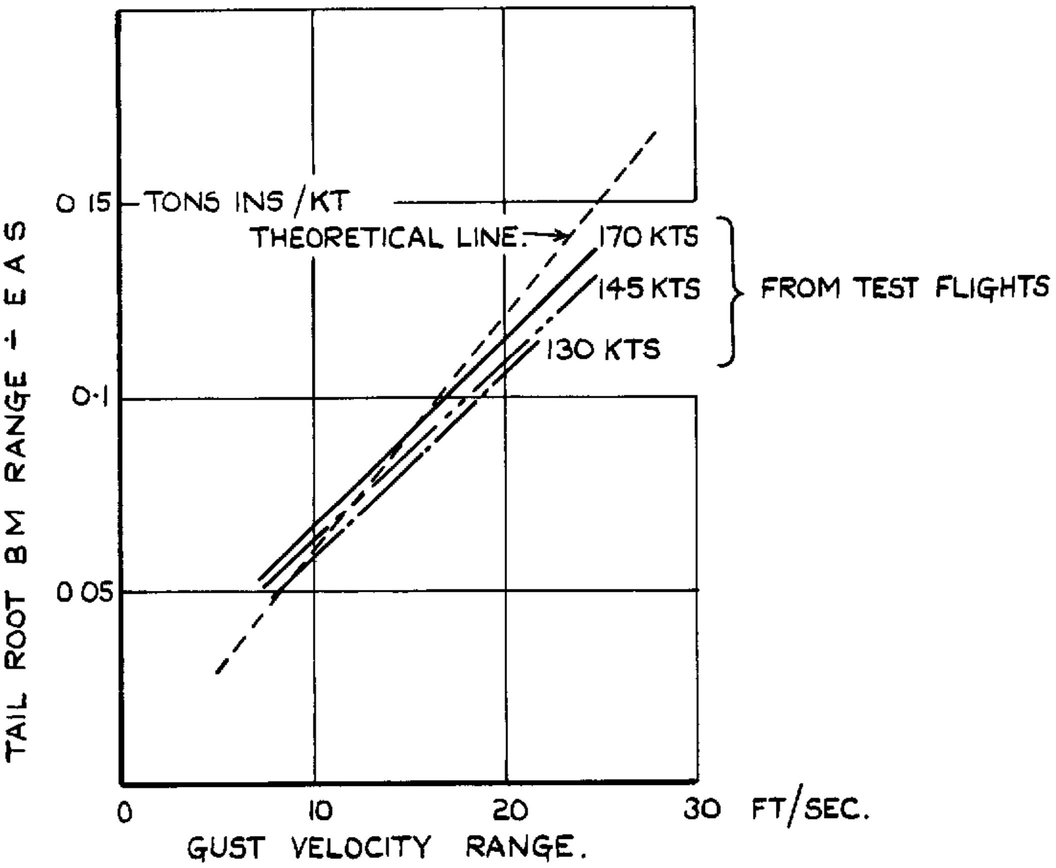


FIG.4. RATE OF OCCURRENCE OF LOAD RANGES.
(BASED ON TYPICAL FLIGHT INCLUDING ASSOCIATED GROUND CONDITIONS)



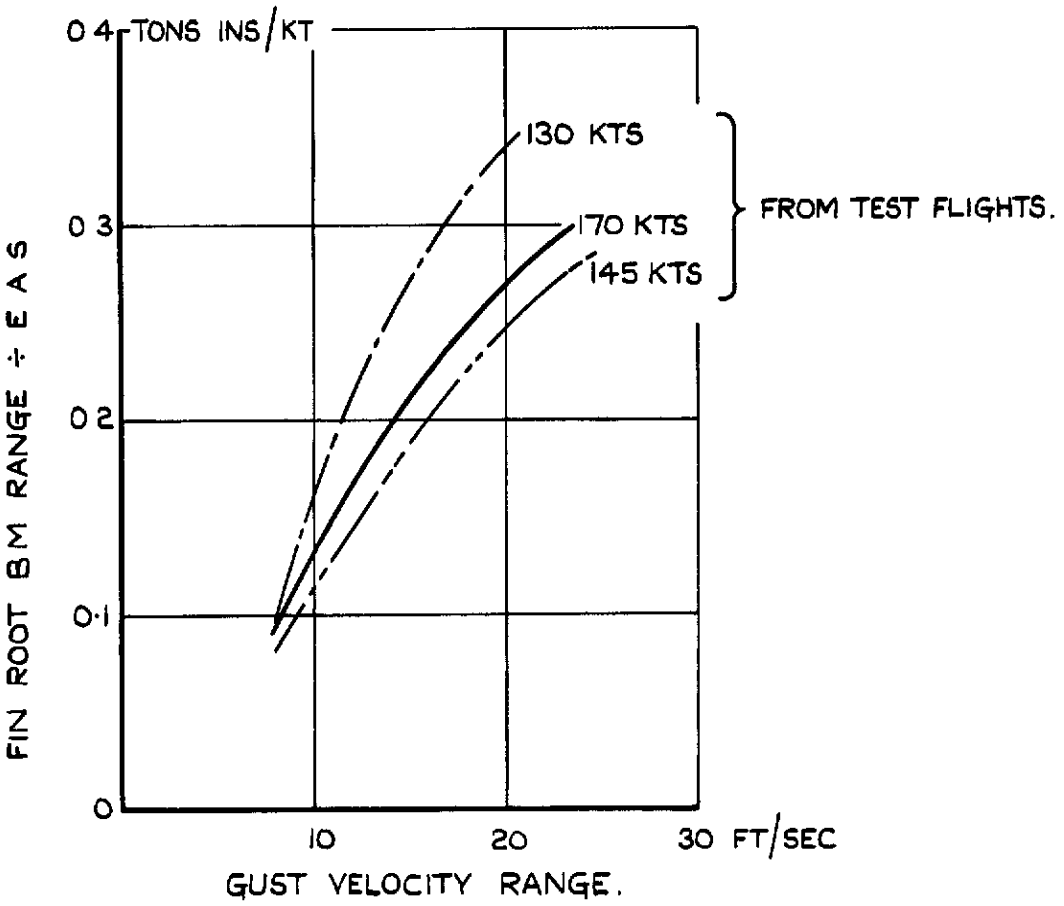
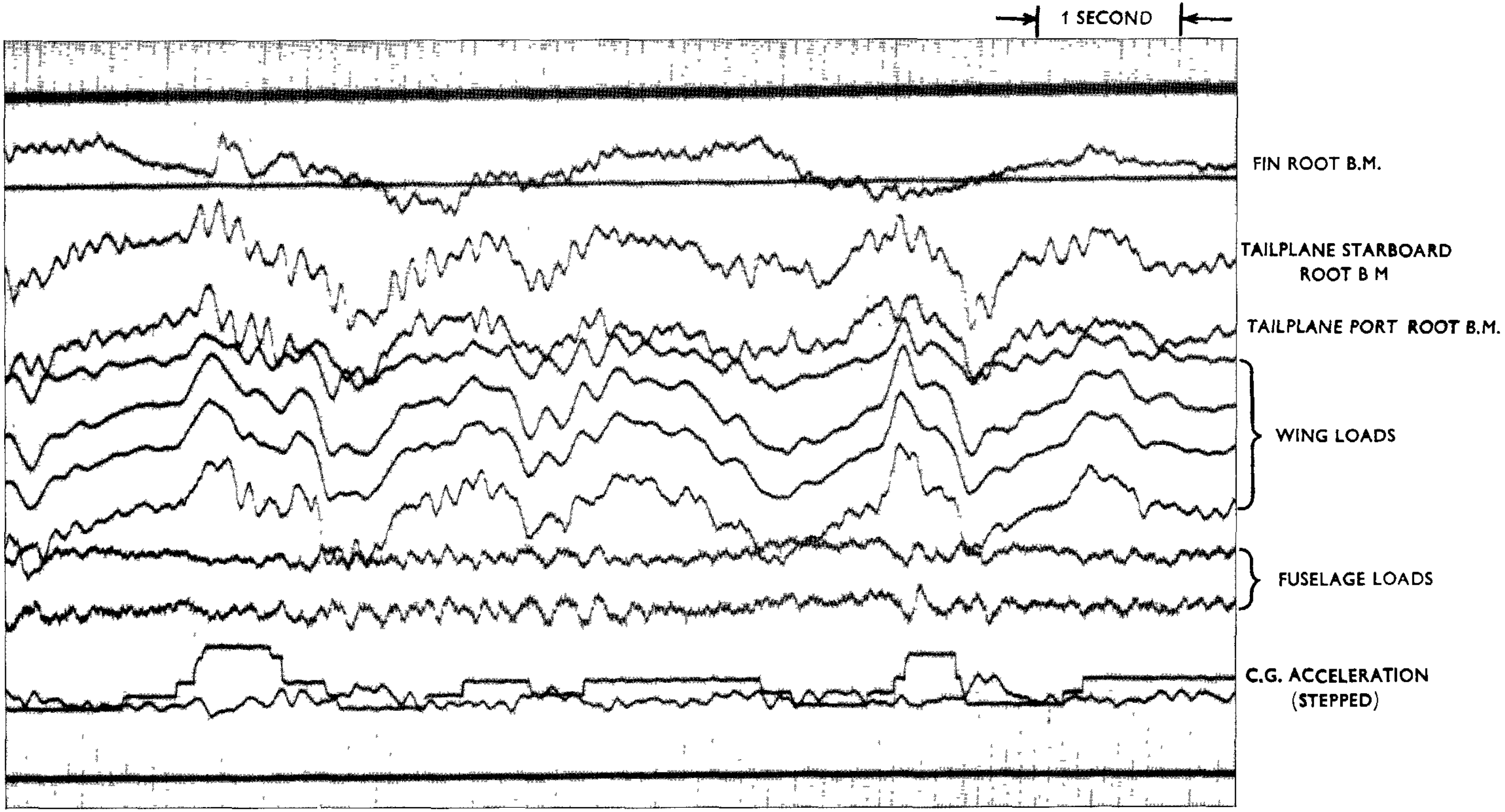


FIG.5. RELATIONSHIP BETWEEN LOAD RANGES AT THE TAIL UNIT AND VERTICAL GUST VELOCITY RANGES EXCEEDED THE SAME NUMBER OF TIMES.



CONDITION.- 170 knots E.A.S. 4000 ft

FIG.6. TYPICAL RECORD SHOWING LOADS AND ACCELERATIONS IN TURBULENCE

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