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Fatigue Loadings in Flight-Loads in the Nose Undercarriage and Wing of a Valiant

by

E. W. Wells

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FATIGUE LOADINGS IN FLIGHT - LOADS IN THE NOSE UNDERCARRIAGE AND WING OF A VALIANT

by

E. W. Wells

SUMMARY

Data obtained on the number of load cycles of various magnitudes occurring in the wing and the nose undercarriage of a Valiant in normal ground and flight conditions are presented. The conditions include taxying, take-off, landing and flight in turbulence. An estimate is made of the loads in a typical operational flight to illustrate the relative importance of the various conditions.

A relationship is also established between the wing load and the acceleration at the aircraft c.g. when flying in turbulence. This enables the results for the flight tests to be linked to operational data obtained on gusts.

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1 INTRODUCTION

Flight tests were made in a Valiant BTR1 to obtain information on the fatigue loads in various parts of the structure. The loads in the tail unit have already been given[1]; this note deals with the vertical loads in the nose undercarriage and the bending moments at two stations in the rear spar of the wing. Fluctuating loads were measured during normal ground and flight conditions, including taxying, take-off, landing and flight in turbulence, but no steady loads were measured.

2 DESCRIPTION OF FLIGHT TESTS

An account of the instrumentation, flight and strain gauge calibration tests is given in Appendix 1. The measurements were obtained by means of electrical resistance strain gauges and continuous recording equipment.

Strain gauges were applied to the rear spar of the starboard wing at two stations. The first was at Station-36 which was in the wing centre section approximately midway between the aircraft centre line and the fuselage side. The second was at Station 227 which was near the outer end of the main undercarriage bay. The loads in the nose undercarriage were measured by strain gauges applied to the trunnion. Details of the wing strain gauge positions are shown in Fig.2

Acceleration was measured by means of a Type Structures 4 accelerometer mounted rigidly in the bomb bay at the aircraft centre line and near the c.g. Throughout this note the reading of this accelerometer is for convenience referred to as "c.g. acceleration" and it is pointed out that it includes some dynamic effects due to flexibilities of the structure.

Records showing the variation in load were taken during all normal ground and flight conditions. The aircraft was flown by a number of pilots and landings were made at three different aerodromes. Records of flight in turbulence were taken at airspeeds of 260 kts and 320 kts EAS and at heights varying from 100 ft above ground to 20,000 ft above mean sea level.

3 PRESENTATION OF RESULTS

Information on the loads measured is tabulated in terms of load ranges exceeding various sizes and is given in Tables 1 - 3. The method of analysing the measured loads in terms of numbers of load ranges exceeding various sizes is similar to that described in an earlier note[2] but it has been modified to enable the bulk of the computation to be carried out by Deuce .

The information is summarized by showing the number of load ranges exceeding various sizes for the component conditions of a typical flight (Figs.3 and 4). This flight, which is intended to represent an operational cross country flight carried out at an R.A.F. station, consists of 12 minutes engine running on the ground, 21 minutes taxying, a take-off, a 4 hours cross country flight and a landing. Details of the method of obtaining the loads for the various conditions of this typical flight are given in Appendix 2. It should be noted that the load ranges shown for take-off and landing in the above figures and in Tables 1 - 3 do not include the load cycle associated with the transition from ground to air that occurs once per flight.

Figs.5 and 6 show the relationship between the wing load and c.g. acceleration ranges exceeded the same number of times in turbulence at Stations-36 and 227 respectively. The curves are based on six records of flight in turbulence in which the aircraft was flown at various speeds, heights and weights. In each case the results have been reduced so that they correspond with those obtained at an all-up weight of 100,000 lb and a speed of 260 knots EAS. Fig.7 shows the relationship between wing load and c.g. acceleration ranges exceeded the same number of times for the component conditions of a typical flight. The curve showing the relationship for flight in turbulence is again for a weight of 100,000 lb, and speed of 260 knots. All wing bending moments are plotted in terms of the bending moment measured in a 1g pull-out carried out at the same conditions, i.e., 100,000 lb AUW. 260 knots EAS.

4 DISCUSSION OF RESULTS

4.1 Wing loads

Mean values of bending moment were not measured. It should be remembered, however, that fluctuations of bending moment are associated with a mean value of bending moment. It should be pointed out, for instance, that there is a marked difference between the mean bending moment in level flight and in taxying; the former puts the bottom surface of the wing in tension and the latter puts it in compression. During take-off and landing the mean load in the bottom surface varies from tension, when the aerodynamic wing lift is developed, to compression, when there is no aerodynamic lift.

Fig.3(a) shows that for Stn-36, which is near the root of the rear spar, flight in turbulence produces the largest number of load fluctuations in a typical flight. The loads from all the other conditions are much less severe and they only affect the total at the lower load levels. For Stn.227, which is near the outboard end of the undercarriage bay, Fig.3(b) shows that the highest changes of bending moment are produced mainly by turbulence and that the smaller and more frequent changes are caused predominantly by taxying.

Comparison of Figs.3(a) and 3(b) show that the ground conditions of taxying, take-off and landing are responsible for a much higher proportion of the load fluctuations at Stn.227 than they are at Stn-36. The loads occurring in these ground conditions are associated with three modes of displacement, two of which produce loads that appear only at the outer wing stations and a third which produces loads at both wing stations. The first mode has a frequency of approximately 1.25 c.p.s. and is produced by the aircraft moving as a rigid body on its undercarriage; variations of bending moment occur with this frequency only at Stn.227 and are due to the weight of the wing outboard of that station; at Stn-36 the bending moment from the weight of the wing is balanced by that from the reaction of the weight of the aircraft on its undercarriage and so does not appear. These effects occur at Stn.227 mainly during landing and taxying. A second mode having a frequency of approximately 5 c.p.s. appears to be the wing anti-symmetric mode. This produces loads at the outer station but, as might be expected, has a much smaller effect on the wing centre section. This frequency is present in all ground conditions and is especially noticeable during taxying and accounts for the taxying loads being such a high proportion of the total. A third mode with a frequency of approximately 2.25 c.p.s. is the wing fundamental flexural mode; its effects appear at both stations during all the ground conditions.

4.2 Nose undercarriage loads

Fig.4 shows that for the nose undercarriage the largest number of load fluctuations during the typical flight occur during taxying. At the lower load levels this condition accounts for approximately 75% of the total. The loads occurring during landing are next in order of severity and exceed the loads occurring during taxying at the higher load levels. The loads occurring during take-off are comparable but slightly less than those occurring during landing.

5 CONCLUSIONS

Information has been obtained on the number of load fluctuations of various magnitudes occurring in the nose undercarriage and wing of a Valiant engaged in operational flying duties. Measurements were confined to vertical loads in the nose undercarriage and bending moments at two stations in the wing; they were made in special tests covering all normal ground and flight conditions.

The results show that for the nose undercarriage the largest number of load fluctuations occur during taxying and they are exceeded only at the higher load levels by those that occur during landing. In the case of the wing, measurements made on the rear spar only, show that at Stn.-36, which is in the wing centre section, the largest number of load fluctuations in a typical flight occur during flight in turbulence. The load fluctuations due to take-off, landing and taxying are much less severe and those that occur during engine running on the ground are negligible. At Stn.227, which is near the outboard end of the main undercarriage bay, the highest changes of bending moment are produced mainly by flight in turbulence and the smaller and more frequent changes are caused predominantly by taxying. The load fluctuations that occur during take-off and landing are less severe than those that occur during flight in turbulence and those that occur during engine running on the ground are negligible.

LIST OF REFERENCES

No.	Author(s)	Title, etc
1	Burns, A.	Fatigue loadings in flight - loads in the tailplane and fin of a Valiant. ARC 19,437. February, 1957.
2	Burns, A.	Fatigue loadings in flight - loads in the tailplane and fin of a Varsity. ARC Current Paper No. 256. January, 1956.

APPENDIX 1

DETAILS OF INSTRUMENTATION, CALIBRATION, FLIGHT TESTS AND MISCELLANEOUS RESULTS

INSTRUMENTATION

British Thermostat strain gauges were attached and waterproofed with Araldite Special Strain Gauge Cement at two stations on the rear spar of the starboard wing as shown in Fig.1 and on the trunnion of the nose undercarriage. The gauges at the two wing stations were arranged to measure bending moment, their positions are shown in more detail in Fig.2. The gauges on the nose undercarriage were attached to each side of the trunnion at the start of the cone. A pair of gauges were attached top and bottom on each side and the four gauges arranged as a bridge to measure the average bending moment of the two sides. The signals from the strain gauges were fed into a McMichael carrier wave amplifier and were recorded on a Films and Equipment 12 channel recorder. A Type Structures 4 accelerometer adapted to give a stepped acceleration trace was mounted on the roof of the bomb bay near the aircraft c.g. and its signal was also fed into the Films and Equipment recorder.

CALIBRATION

The strain gauges on the wing were calibrated on the ground in terms of bending moment by loading the wing with shot bags. The gauges were also calibrated in the air by subjecting the aircraft to pull-outs. These pull-outs were carried out with the airspeed remaining sensibly constant, the value of the acceleration in the pull-out being given by the accelerometer at the aircraft c.g. The all-up weight at which the pull-outs were carried out varied between 99,000 and 103,000 lb, the average being approximately 100,000 lb.

The gauges on the nose undercarriage trunnion were calibrated directly in terms of vertical load by jacking the nose wheel clear of the ground and then lowering it on to a weighing platform, the resulting change in load and trace deflection being measured. A calibration in terms of the ground to air load was also obtained by measuring the trace deflection produced by the change of vertical load in the undercarriage from the aircraft standing on the runway with the engines idling just before take-off to the point where the nose undercarriage was just clear of the ground. The average value for 10 take-offs was obtained.

FLIGHT TESTS

The aircraft was flown throughout the tests at an all-up weight varying between 87,500 and 113,500 lb. The weights at which the measurements of flight in turbulence were made varied between 96,000 and 108,500 lb. All the landings were made at less than 100,000 lb, the maximum permissible landing weight. The c.g. was kept within 47.33 ± 0.25 ft aft of the nose datum point (limits 46.93 to 47.75 ft aft of datum). The aircraft was flown at all times by the pilot and not by the auto-pilot.

Normal take-offs and landings were recorded during the course of the tests and they were carried out by a number of pilots and at three different aerodromes. Take-offs were carried out using two different techniques: the first was to hold the aircraft against the brakes until the engine speed had built up to 6000 r.p.m. the brakes were then released and the aircraft allowed to roll forward; the second was to allow the aircraftto run freely forward as the engines were opened up. In each case, for the purpose of analysis, the take-off was considered to start when the engine run up commenced and to end when the aircraft was clear of the runway and had reached a speed of 150 knots EAS. This was the speed at which the undercarriage was normally retracted, an event which could be detected easily on the records. This was also the speed at which the stepped accelerometer began to operate so that any loads occurring after this point could be conveniently classed as flight loads. A landing was defined as starting 5 seconds before the initial impact and lasting for a total of 40 seconds.

The taxying loads were measured at three aerodromes: Boscombe Down, Thurleigh and Farnborough. The loads were most severe at Farnborough where a considerable amount of turning and frequent application of the brakes were involved. The Boscombe Down and Thurleigh records were taken while the aircraft was taxying down long straight perimeter tracks and although this taxying was carried out at higher forward speeds it produced only very light loads.

Records of flight in turbulence were obtained when flying straight and level at airspeeds of 260 knots and 320 knots EAS. Measurements were taken at the two airspeeds in three flight bands: 50-100 ft above ground, 2000-7000 ft and 14,000-20,000 ft above mean sea level. The third and highest height band was intended to cover turbulence above 25,000 ft but unfortunately, during the period of the flight tests, no turbulence was found above 20,000 ft. Most of the turbulence in the two upper height bands was found by flying in or just below small to medium cumulus clouds. Turbulence encountered in the lowest height band was the results of several effects which included convective air currents and light to medium winds.

EFFECT OF TAKE-OFF TECHNIQUE ON NOSE UNDERCARRIAGE LOADS

As mentioned in the previous section two different techniques were used for take-offs. The first was to allow the aircraft to run freely forward as the engine r.p.m. increased and the second was to hold the aircraft stationary, by means of the brakes until the engine speed built up to 6000 r.p.m. If the change of vertical load on the nose undercarriage from the aircraft stationary on the ground with its engines idling to the point in the take-off where the wheels are just clear of the ground is taken as the normal change of load in a take-off, then use of the former technique produces this normal change of load. Running up the engines against the brakes, as in the latter case, resulted in a considerable increase in download on the nose undercarriage, the load returning to its normal value when the brakes were released. Analysis of eight take-offs in which the second technique was used showed that this increase in download resulted in a total change of vertical load approximately 70% greater than the normal change of load, the maximum value being approximately 80% greater.

APPENDIX 2

ESTIMATION OF LOAD OCCURRENCES IN A TYPICAL FLIGHT

TAKE-OFF AND LANDING

The numbers of occurrences of wing and nose undercarriage loads in landing and take-off are the average values obtained from the analysis of twelve landing and take-off records.

The 95% confidence intervals* for the number of occurrences of load cycles at Stn.227 corresponding approximately to a 5 ft/sec gust range at 250 knots, EAS 120,000 lb A.U.W., are as follows:-

Case	No. of take-offs or landings analysed	Number of occurrences	
		Mean	95% confidence intervals
Take-off	12	23.6	23.6 ± 4.37
Landing	12	9.7	9.7 ± 3.77

The loads occurring at Stn.-36 during take-off and landing are considerably smaller and confidence limits are not given.

TAXYING AND GROUND RUNNING OF ENGINES

The amount of taxying and the average engine running times were obtained from the results of intensive flight trials carried out on Valiants at an R.A.F. station. The distance taxied during each flight was about $3\frac{1}{2}$ miles at speeds of 10 to 15 m.p.h. giving a total taxying time of 21 minutes per flight. Taxying loads for the typical flight were therefore based on a total time of 21 minutes made up as follows: 16 minutes at the rate of loading appropriate to Farnborough, $2\frac{1}{2}$ minutes at the Boscombe Down rate and $2\frac{1}{2}$ minutes at the Thurleigh rate.

Using the average engine running times in the R.A.F. trials in conjunction with the engine running connected with aircraft servicing based on R.A.E. practice, a programme of engine ground running tests was built up. This programme entailed running the engines in a number of conditions including running all engines at 6000 r.p.m. and running each engine separately up to 7850 r.p.m. but in all cases the loads imposed on the wings and nose undercarriage were very small and were less than the smallest load range used in the analysis.

TURBULENCE

For the estimation of wing loads in turbulence the typical flight was taken as a cross country flight of 4 hours duration. Details of this flight were based on information received from three R.A.F. stations. The take-off weight was 126,000 lb. Details of the flight plan are given in the following table together with the number of gusts of 10 ft/sec or greater encountered during each stage of the flight.

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* Intervals within which there is a 95% probability that the true mean lies.

These numbers were calculated using the curve shown in Fig.8 which shows the miles to meet a gust of 10 ft/sec or greater and is based on operational data obtained on a number of aircraft. The occurrences of gusts of other magnitudes were obtained from Fig.9, which shows the relative occurrence of gusts of different magnitudes.

Condition	Height (ft)	Time	Mean airspeed (kts.IAS)	No. of up or down gusts > 10 ft/sec
Take-off	0 to 1,000	1.75 mins	160	1.9
Climb	1,000 to 2,000	16.5 mins	250	0.32
	2,000 to 5,000		303	0.8
	5,000 to 20,000		290	0.95
	20,000 to 40,000		250	0.13
Climb cruise	40,000 to 45,000	3 hrs 20.35 mins	203	2.1
Descent	45,000 to 2,000	14.4 mins	240	1.95
Approach	2,000 to 200	7 mins	160	6.6
	200 to 0		125	0.3
	Total	4 hrs		15 gusts

From the number of gusts of 10 ft/sec or greater, shown in the table above, and from Fig.9 the number of gust ranges of 10, 20 and 30 ft/sec were calculated for each section of the flight. A factor of 0.75 was used to allow for the difference in number of ranges obtained from a direct count and from the geometric means of counts of equal up and down accelerations.

As shown in Table 1, six records of flight in turbulence were analysed; they were for two speeds in three height bands with all-up weights varying between 96,500 lb and 108,500 lb. A graph was drawn for each wing station showing for each of the six records the variation in wing bending moment ranges with c.g. acceleration ranges occurring an equal number of times. There was a certain amount of variation between results from the six records and an attempt was made to eliminate the effect of the different all up weights and speeds at which the records were taken. Differences in all up weight were due to the consumption of fuel in wing and fuselage tanks and hence affected the wing bending moments per g, and the differences in speed affected the proportion of lift taken by the tail and hence again the wing bending moments per g. The differences in height appeared to have little effect on the results. Using data obtained from the firm on the tail loads, lift, wing weight and fuel distributions, the wing bending moment at stations -36 and 227 were calculated for an incremental acceleration of 1g at the conditions appropriate to each of the six records and also at a standard condition of 100,000 lb and 260 knots, the average condition at which pull-outs were carried out in flight. The original curves for the six records were then multiplied by the factor $\frac{\text{1 g BM at standard condition}}{\text{1 g BM at record condition}}$ and the curves were replotted and were found to be in good agreement. A line was drawn through all the points and represents the relationship between wing bending moment ranges and c.g. acceleration ranges for an all up weight of 100,000 lb and an airspeed of 260 knots EAS. The basic curve for each wing station is shown in Figs.5 and 6.

Using data on airspeed, height, all up weight and fuel state obtained for compiling the typical flight conditions, the basic curves shown in Figs.5 and 6 were modified and new curves obtained representing conditions corresponding to three stages of the typical flight:- take-off and climb, climb-cruise, descent and approach. These curves gave an approximate relationship between wing bending moment and vertical acceleration for the three stages of the typical flight. The value of vertical acceleration for gust ranges of 10, 20 and 30 ft/sec for each individual section of the typical flight was then calculated and the corresponding wing bending moment read off from the curve appropriate to the flight stage. Once this relationship between gust velocity and wing bending moment was established a plot could be made, for each section of the flight, of the number of occurrences of wing bending moment ranges. From these plots it was possible to total the number of occurrences at discrete values of the range and to draw the turbulence curve for the typical flight shown in Fig.3.

TABLE 1 Bending moment cycles in rear spar of wing in centre section. (Stn.-36)

Load Range		Number of times load range is exceeded												High Mach No. Buffeting ½ min. each condition		Ground engine running
				Taxying			Turbulence									
tons ins.	÷ 1g pull-out B.M.	Take-off	Landing	Thurleigh	Boscombe Down	Farnborough	100 ft		2000 ft		14,000-20,000 ft					
							260 kts	320 kts	260 kts	320 kts	260 kts	320 kts				
		Mean of 12	Mean of 12	2.5 mins.	2.5 mins.	5 mins.	180 secs	350 secs	160 secs	270 secs	290 secs	90 secs	0.81 to 0.82M	0.83 to 0.84M	
248	0.103	30	9.3	15	-	12	214	494	268	365	258	85	2	5	Loads Negligible
372	0.155	16.2	2.2	3		1	172	437	191	287	177	64		3	
496	0.207	8.2		1			139	358	144	239	124	52		2	
620	0.258	3.5		1			115	284	99	201	96	45		1	
744	0.310	1.6		1			91	226	81	167	72	35		1	
868	0.361						72	178	63	146	58	32		1	
992	0.412						60	138	55	124	47	27			
1116	0.465						47	105	41	102	33	20			
1240	0.515						39	82	29	84	19	19			
1360	0.568						31	59	26	68	14	18			
1490	0.620						24	46	19	53	13	15			
1610	0.670						21	38	18	45	11	15			
1740	0.722						19	30	14	40	9	13			
1860	0.774						17	28	13	34	8	11			
1980	0.825						11	19	10	28	7	8			
2110	0.876						7	14	10	26	5	6			
2230	0.930						5	10	9	23	4	5			
2360	0.980						5	6	4	20	4	5			
2480	1.03						4	5	3	14	3	4			
2600	1.09						4	3	3	10	3	4			
2730	1.14						3	3	2	9	3	4			
2850	1.19						2	3	2	8	2	3			
2980	1.24							2	2	6	2	2			
3100	1.29							2	2	5	1	2			
3220	1.34							1	2	5	1	1			
3350	1.40								2	2	1	1			
3470	1.45									2	1	1			
3600	1.50									2	1	1			
3720	1.55									2	1	1			
3840	1.60									1	1	1			
3970	1.65										1				

TABLE 2 Bending moment cycles in rear spar of wing near outboard end of undercarriage bay. (Stn.227)

Load Range		Number of times load range is exceeded												High Mach No. Buffeting ½ min. each condition		Ground engine running
				Taxying			Turbulence									
							100 ft		2000 ft		14,000-20,000 ft					
tons ins.	÷ 1g pull-out B.M.	Take-off	Landing	Thurleigh	Boscombe Down	Farnborough	260 kts	320 kts	260 kts	320 kts	260 kts	320 kts			
		Mean of 12	Mean of 12	2.5 mins.	2.5 mins.	5 mins.	180 secs	350 secs	160 secs	270 secs	290 secs	90 secs	0.81 to 0.82M	0.83 to 0.84M	
107	0.094	61	68	113	100	473	249	543	305	403	275	91	2	23	Loads Neglibible
161	0.141	44	37	42	26	272	198	502	226	334	205	71	1	5	
215	0.189	32	19	18	3	138	161	413	168	269	138	61		3	
269	0.236	24	10	4	1	69	141	341	127	239	114	51		2	
322	0.286	18	5	3		37	116	266	96	198	86	40		2	
376	0.330	13	2	2		19	99	217	79	162	65	39		1	
430	0.377	9	1	1		7	80	172	65	135	56	32			
483	0.424	7		1		3	64	137	55	115	42	26			
537	0.471	5				1	49	107	42	100	27	23			
591	0.519	3					41	81	34	80	16	20			
644	0.565	2					33	61	26	66	16	20			
696	0.612	1					29	48	21	49	13	18			
752	0.660						25	41	18	42	11	12			
806	0.707						21	27	16	35	7	9			
859	0.754						15	22	13	31	7	7			
913	0.804						11	18	11	29	7	7			
967	0.850						8	13	9	23	7	7			
1020	0.895						7	11	7	21	5	6			
1074	0.945						5	9	6	19	3	6			
1128	0.990						5	6	4	16	3	5			
1181	1.04						3	5	4	15	3	5			
1235	1.08						2	3	3	11	2	3			
1289	1.13						2	2	3	8	2	3			
1343	1.18						2	2	2	6	1	3			
1396	1.23						2	1	2	5	1	2			
1450	1.27						1		2	4	1	1			
1504	1.32								1	3	1	1			
1557	1.37									2	1				
1611	1.41									1	1				
1665	1.46									1	1				
1718	1.51									1	1				
1772	1.56									1	1				
1826	1.60									1					
1880	1.65									1					
1933	1.70									1					

TABLE 3 Vertical load cycles in nose undercarriage

Load Range		Number of times load range is exceeded					
		Take-off	Landing	Taxying			
Vertical load tons	÷ by Ground/Air load	Mean of 12	Mean of 12	Thurleigh 2.5 mins.	Boscombe Down 2.5 mins.	Farnborough 5 mins.	Ground engine running
1.17	0.176	25	31	15	34	61	Loads Negligible
1.76	0.265	17.1	22	3	7	35	
2.34	0.352	12.3	15.5	1	3	19	
2.93	0.440	8.6	11.7	1	2	10	
3.51	0.528	5.5	7.8	1	1	9	
4.10	0.617	3	4.5		1	2	
4.68	0.705	1.2	2.7			1	
5.27	0.792		1.8				

TABLE 4 CG acceleration cycles

Acceleration Range g	Number of times acceleration range is exceeded											Ground engine running
	Take-off	Landing	Taxying			Turbulence						
			Thurleigh	Boscombe Down	Farnborough	100 ft		2000 ft		14,000 to 20,000 ft		
						260 kts	320 kts	260 kts	320 kts	260 kts	320 kts	
	Mean of 12	Mean of 12	[illegible].5 mins.	2.5 mins.	5 mins.	180 secs	350 secs	160 secs	[illegible]70 secs	290 secs	90 secs	
0.2	23.5	22.2	3	2	14	112	344	91	172	108	35.5	No counts
0.3	8.9	6.2				72	221	58	108	66	25.7	
0.4	3.3	1.72				46	141	37	68	40	18.6	
0.5	1.67	0.6				29.4	86	22.5	49	22	12.9	
0.6	0.6					19.2	55	14.7	35	13.7	7.9	
0.7						13	31	10.7	22.5	8.7	5.5	
0.8						8.6	15.7	6.2	14.5	5.7	4.5	
0.9						5	9.7	3.8	9.5	4.4	3.4	
1.0						2.2	5.6	2.4	4.4	3.4	2.4	
1.1							2	0.8	1.8	3.0	2	
1.2							1		1	1.8	2	
1.3									1	1	1.4	
1.4										1		

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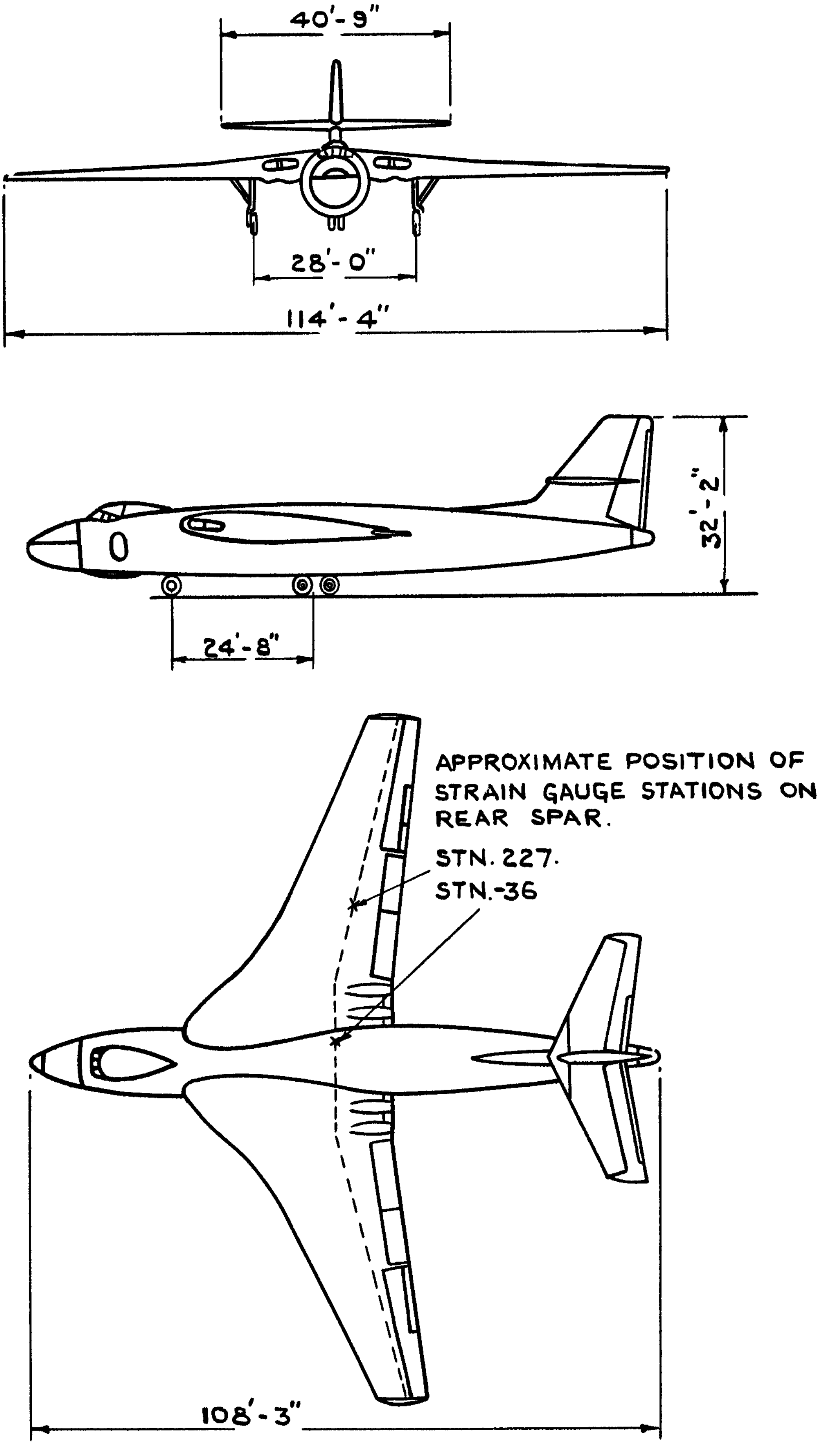


FIG.1. GENERAL ARRANGEMENT OF VALIANT.

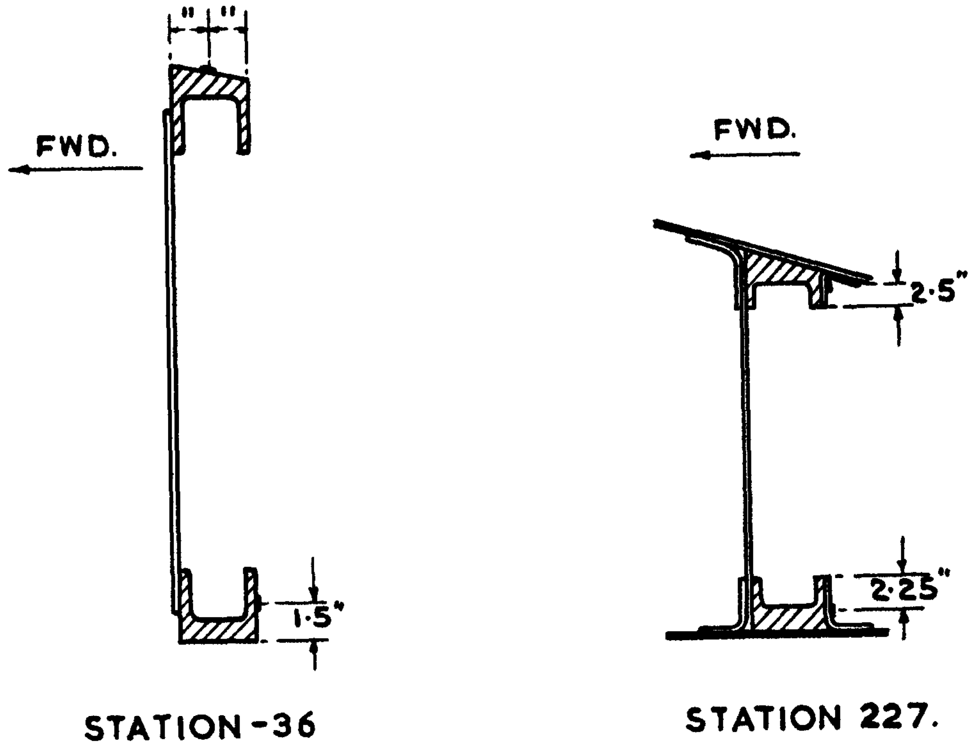
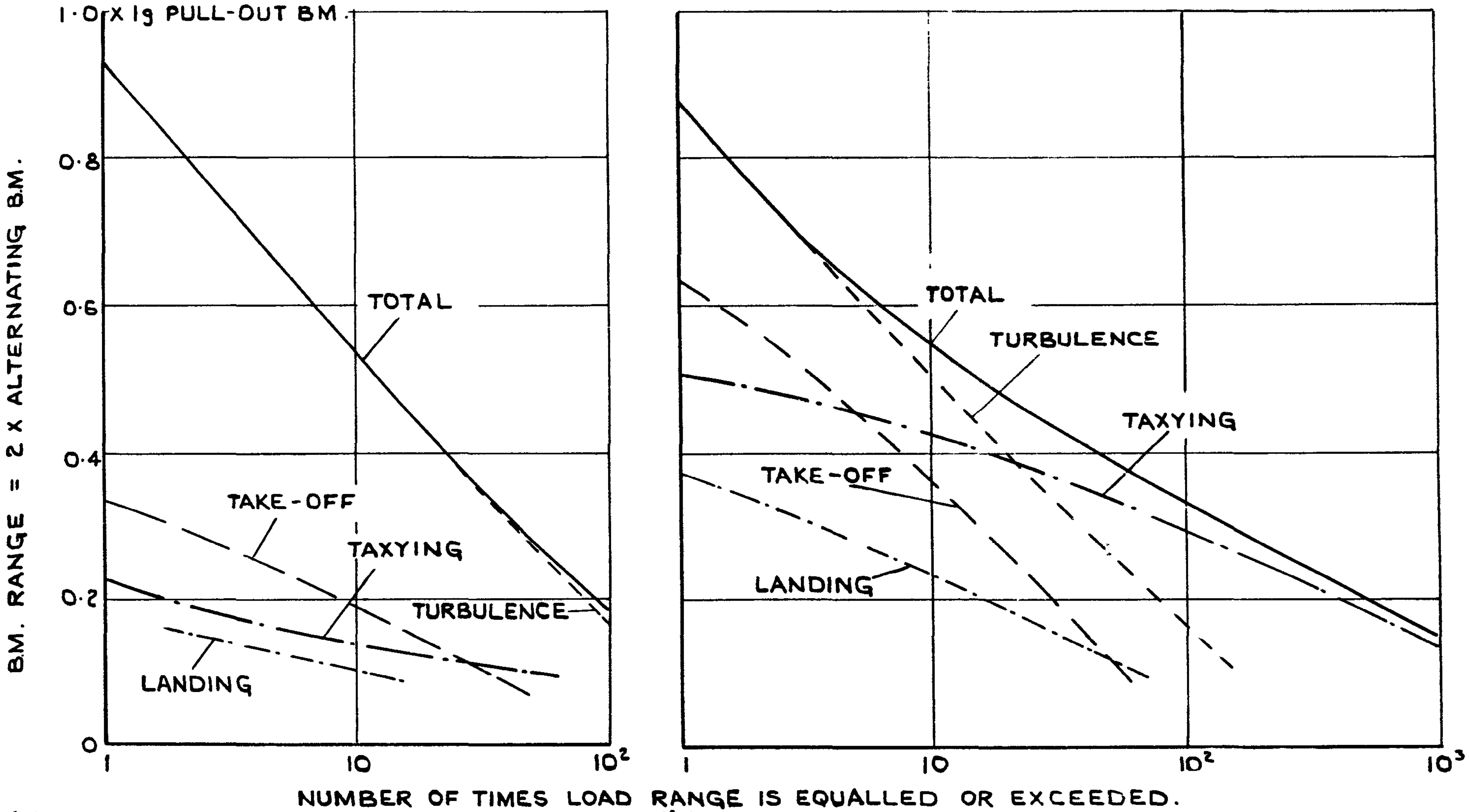


FIG. 2. SKETCHES SHOWING STRAIN GAUGE POSITIONS ON REAR SPAR OF WING.

(NOTE :- THESE DIAGRAMS ARE NOT TO SCALE)



(a) STATION-36. REAR SPAR OF WING IN CENTRE SECTION

(b) STATION 227. REAR SPAR OF WING NEAR OUTBOARD END OF U/C BAY.

FIG.3.(a & b). WING LOADS IN COMPONENT CONDITIONS OF A TYPICAL FLIGHT.

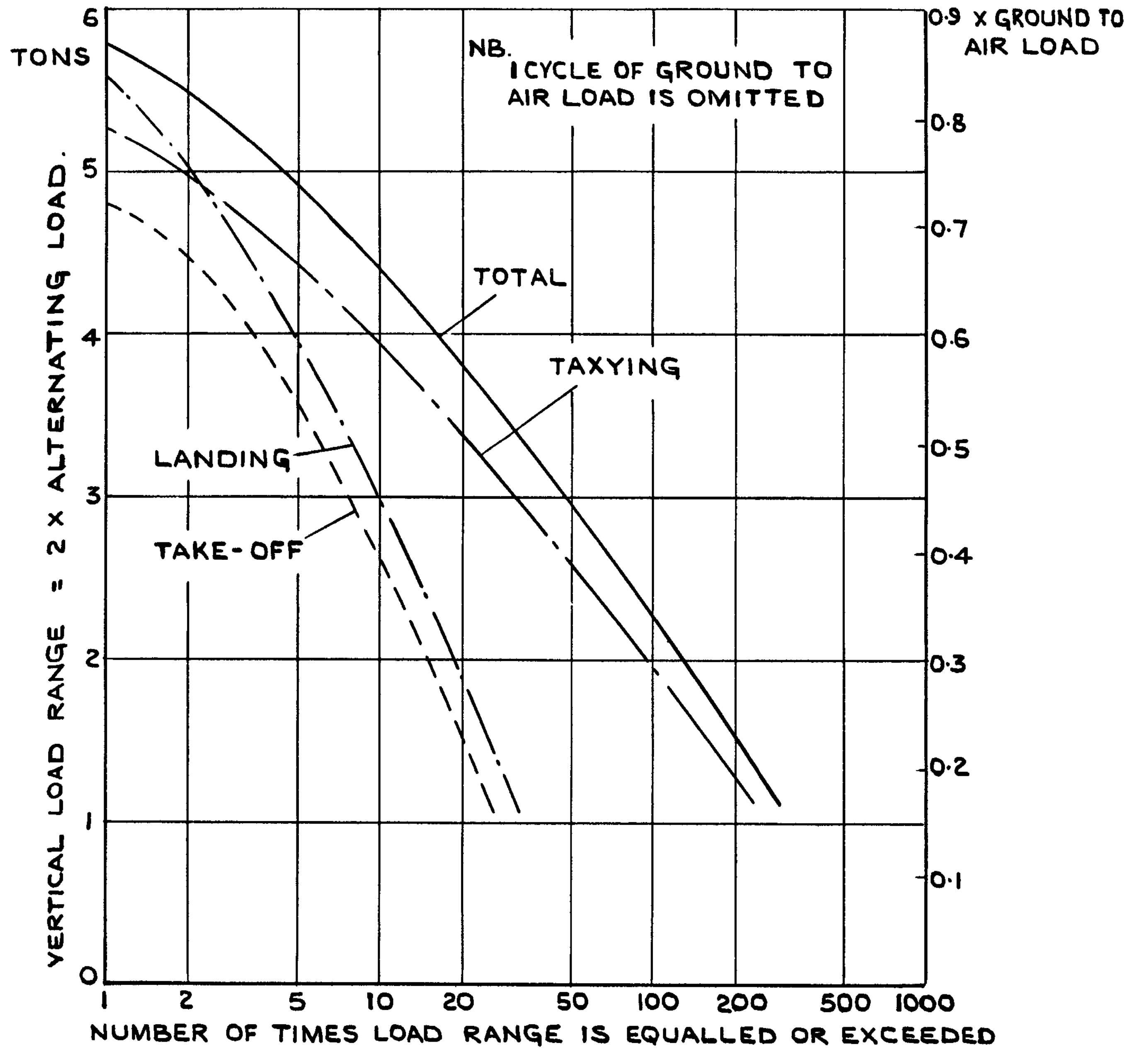


FIG. 4. NOSE UNDERCARRIAGE LOADS IN COMPONENT CONDITIONS OF A TYPICAL FLIGHT.

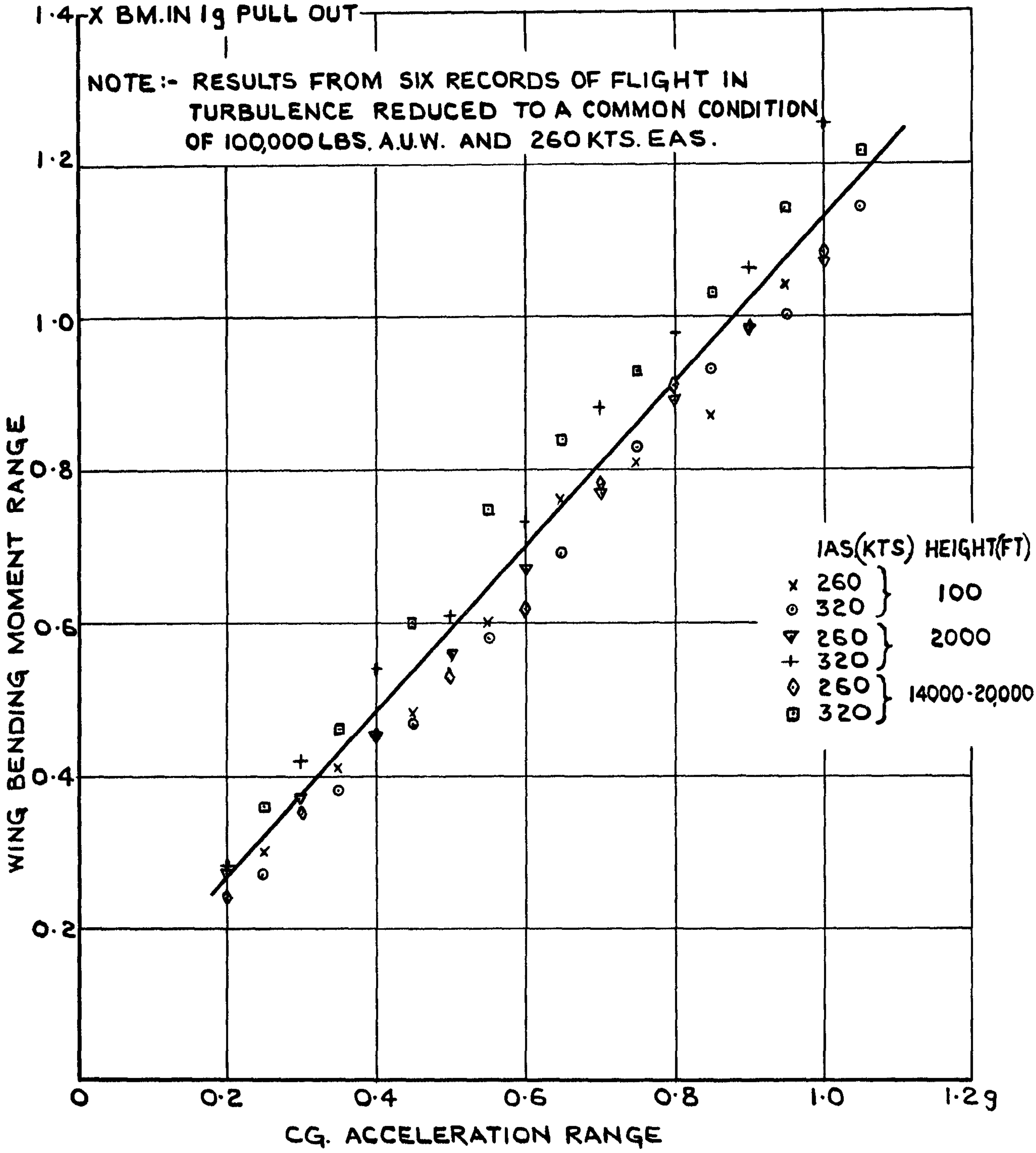


FIG.5. RELATIONSHIP BETWEEN LOAD RANGES IN THE REAR SPAR OF THE WING AT STN -36 AND CG. ACCELERATION RANGES EXCEEDED THE SAME NUMBER OF TIMES IN TURBULENCE

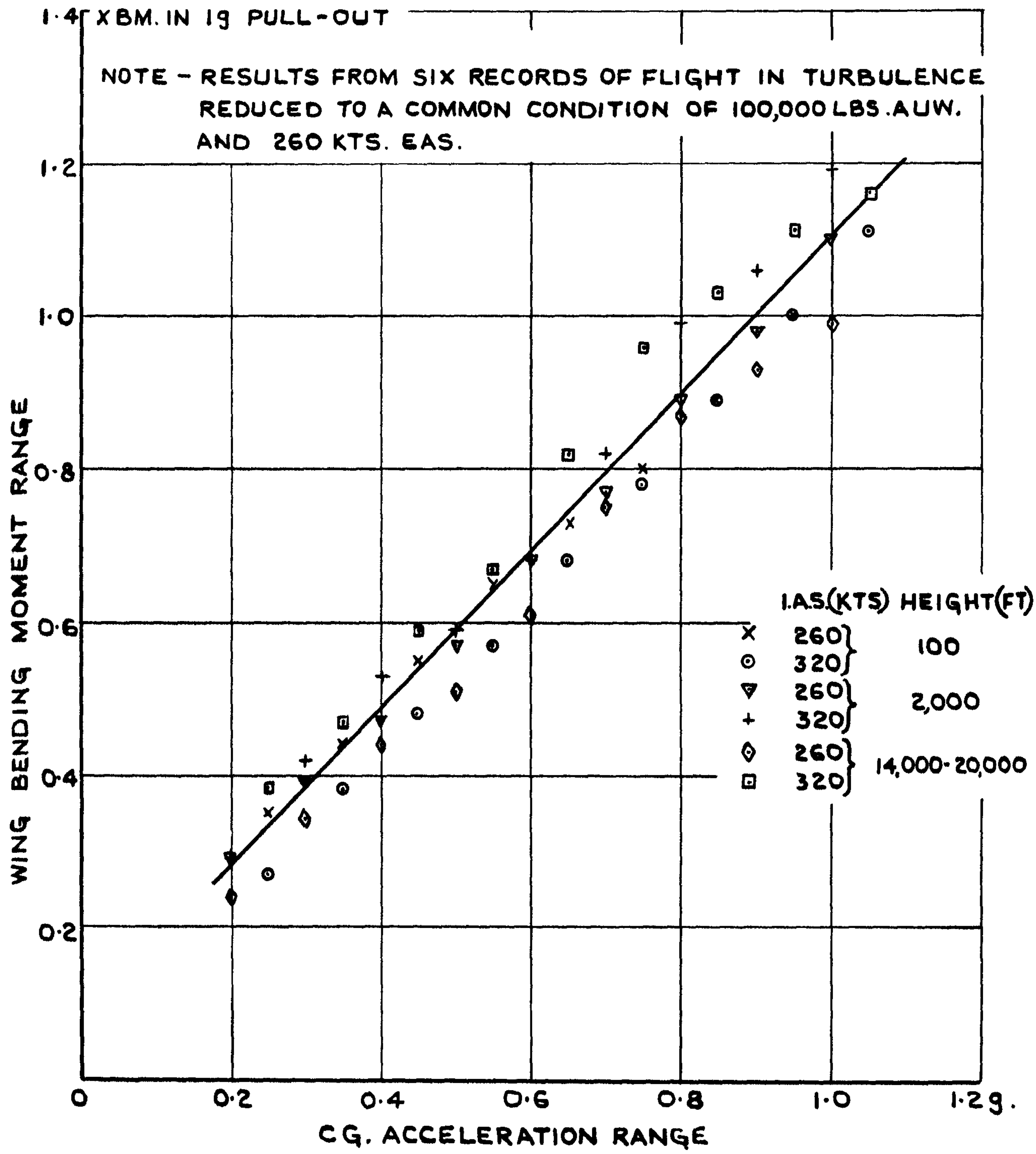
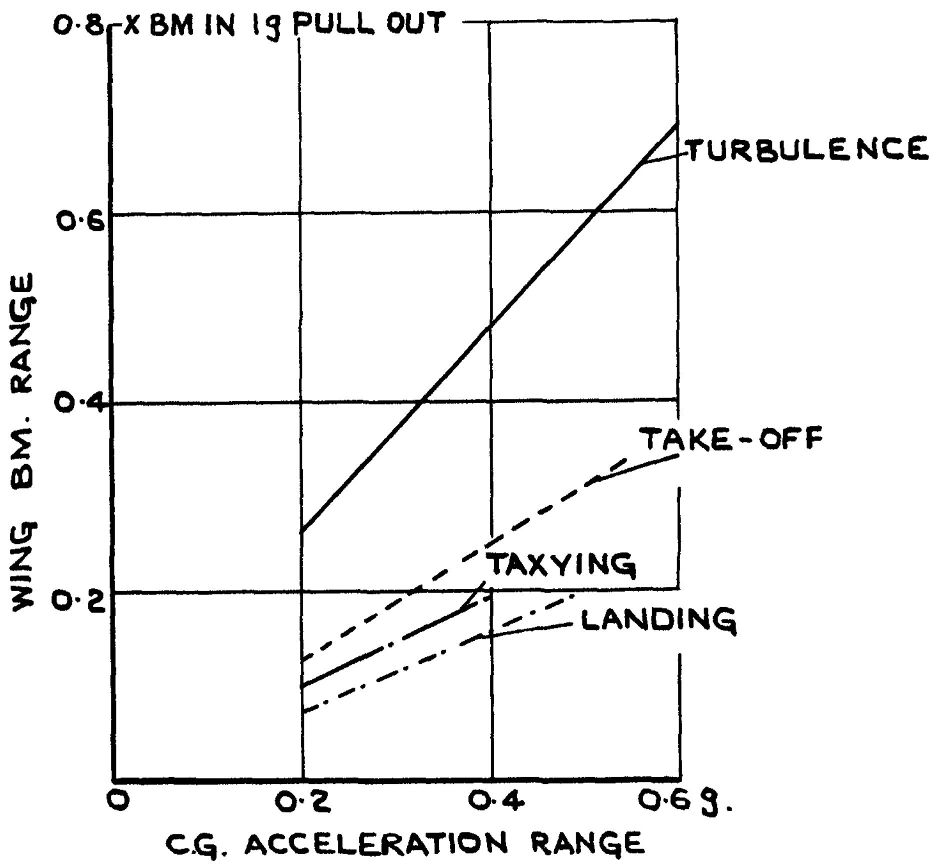
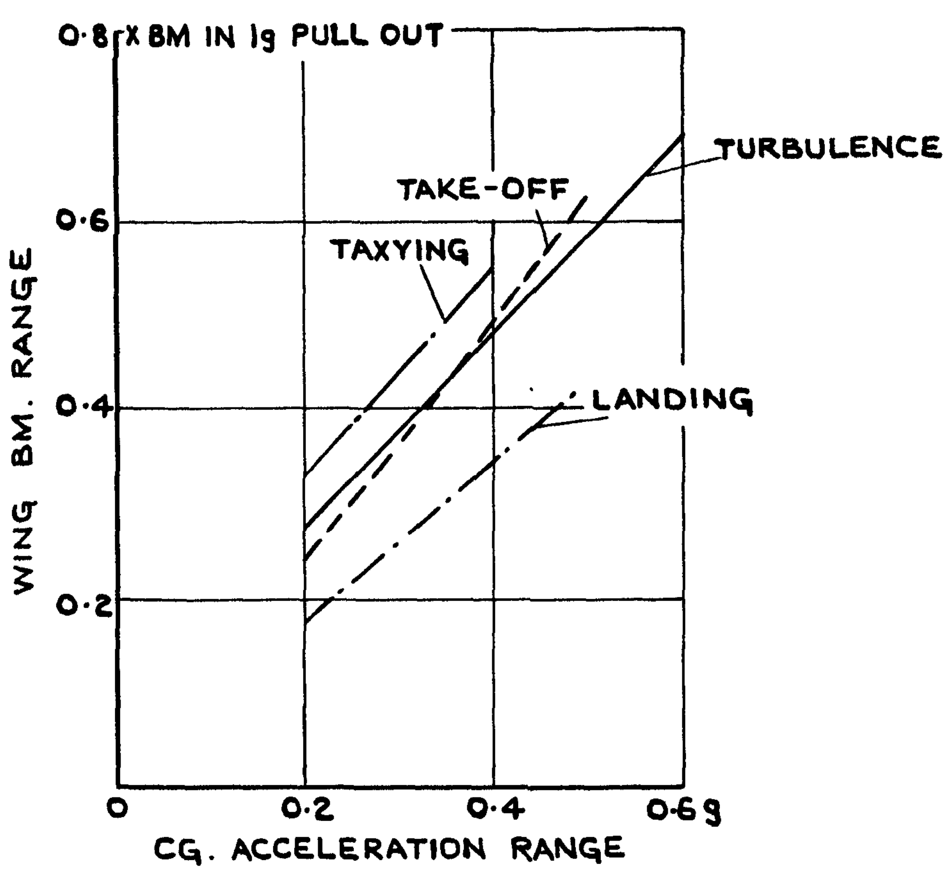


FIG. 6. RELATIONSHIP BETWEEN LOAD RANGES IN THE REAR SPAR OF THE WING AT STN. 227 AND C.G. ACCELERATION RANGES EXCEEDED THE SAME NUMBER OF TIMES IN TURBULENCE.



STATION - 36.



STATION 227.

FIG. 7. RELATIONSHIP BETWEEN WING LOAD RANGES AND CG. ACCELERATION RANGES EXCEEDED THE SAME NUMBER OF TIMES IN VARIOUS CONDITIONS.

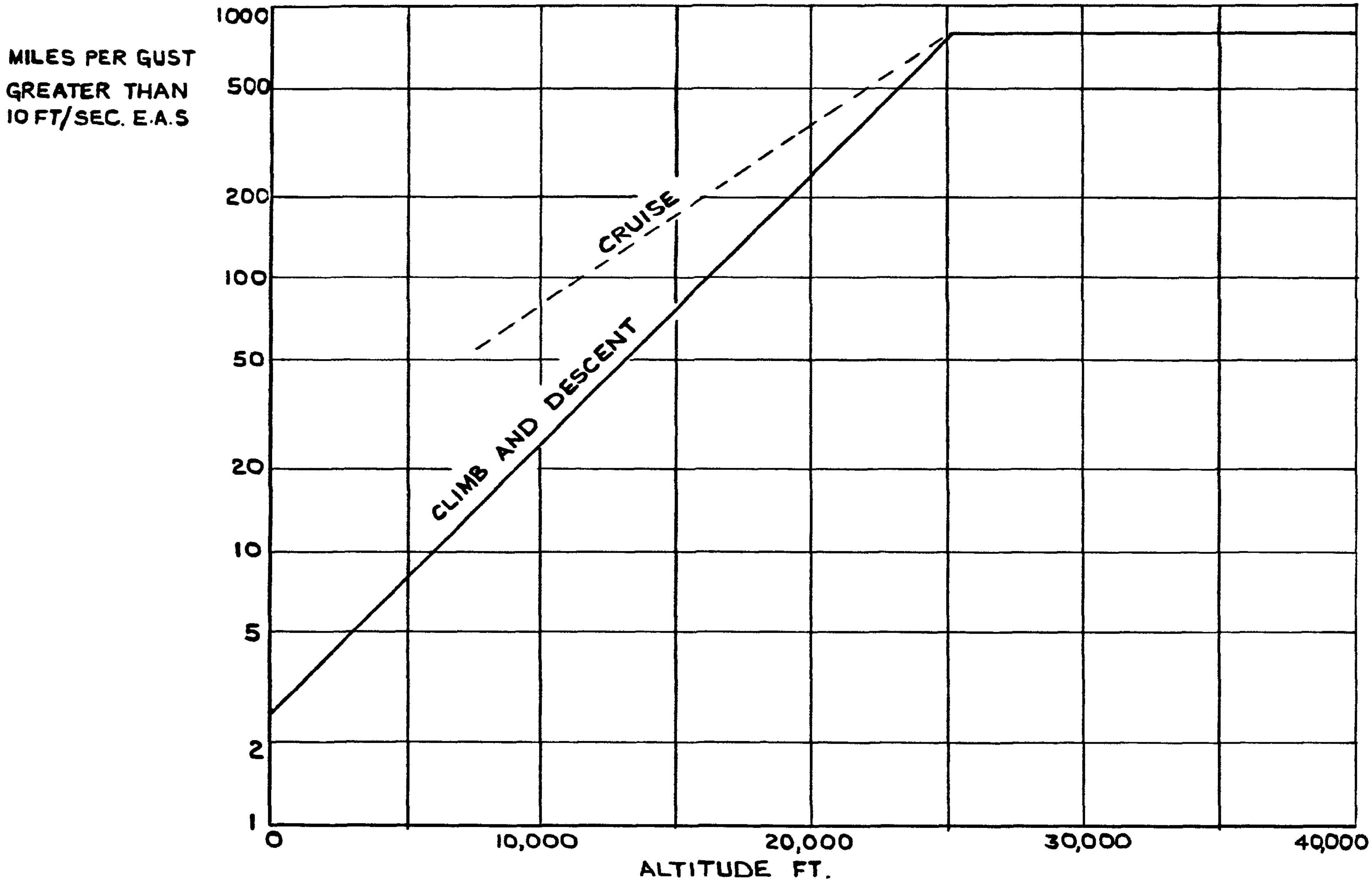


FIG. 8. FREQUENCY OF OCCURRENCE OF GUSTS EXCEEDING 10 FT/SEC. E.A.S. AT DIFFERENT HEIGHTS.

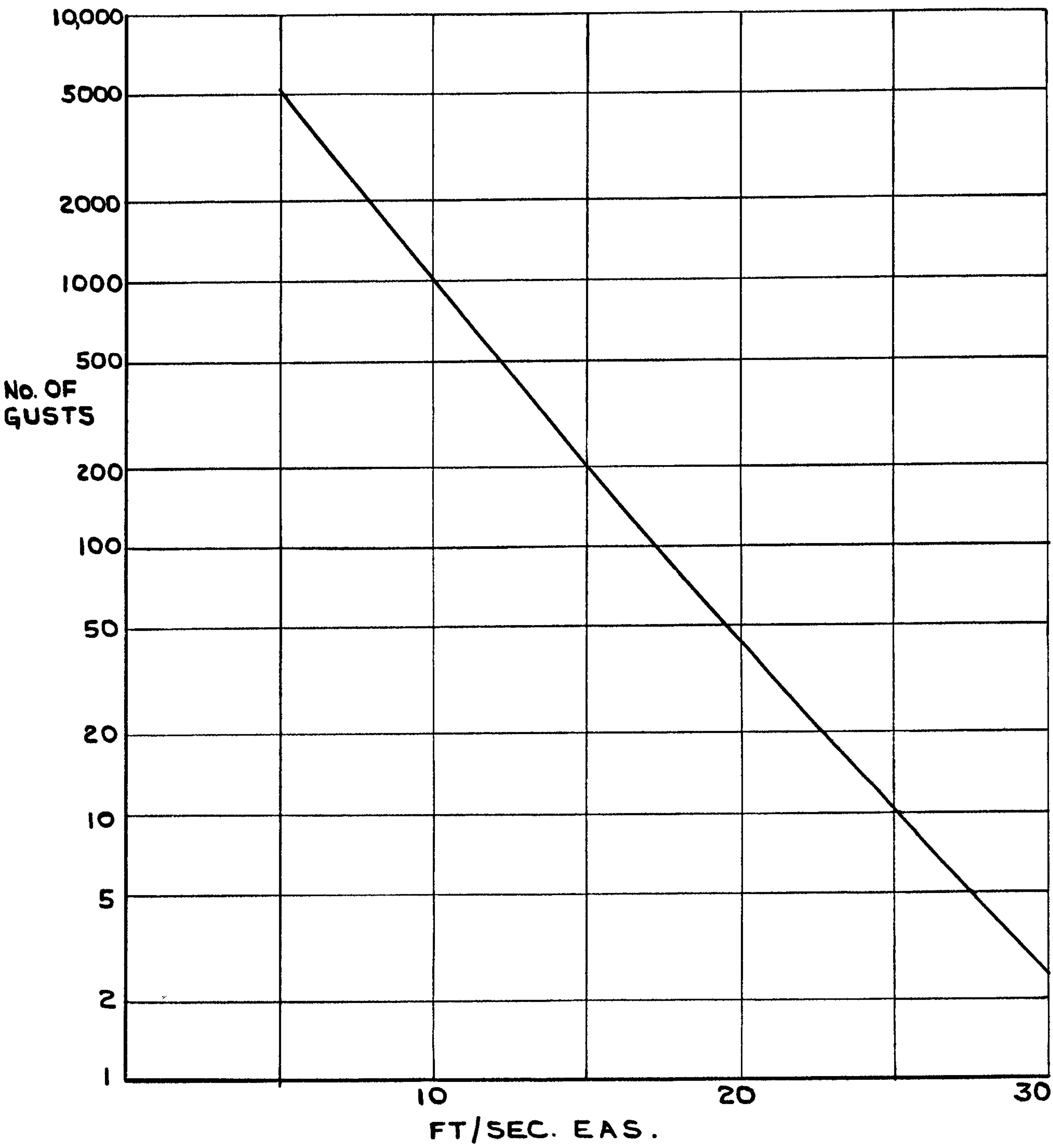
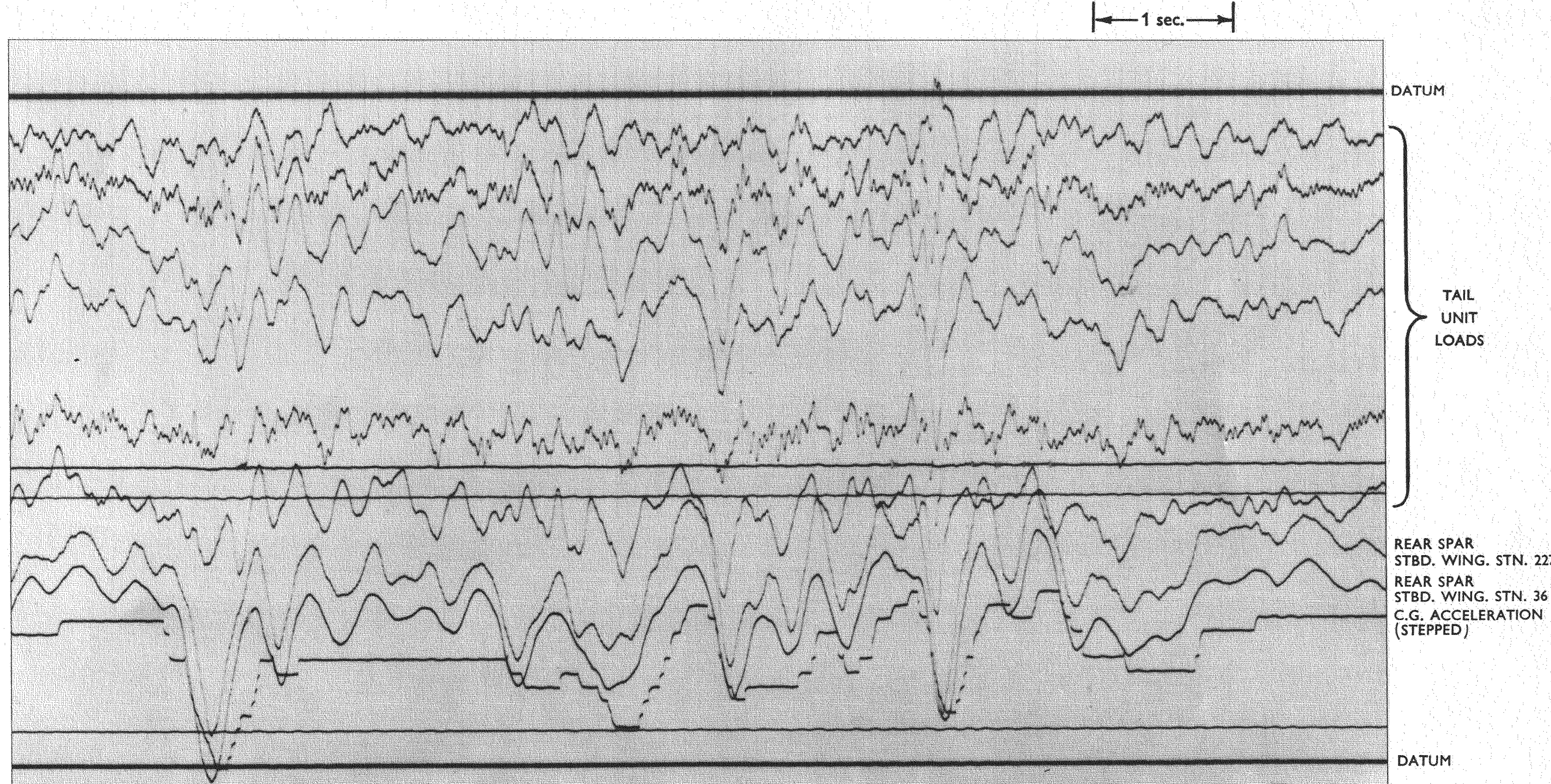


FIG.9. NUMBER OF GUSTS EXCEEDING DIFFERENT MAGNITUDES. PER THOUSAND EXCEEDING 10 FT/SEC. E.A.S.



CONDITIONS:- 260 KTS. E.A.S., 12,500 FT., A.U.W. 102,000 LB.

FIG.10. TYPICAL RECORD OF LOADS IN TURBULENCE

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C.P. No. 521

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533.6.048.5:
629.13.014.3:
629.13.015.14.6 (Valiant)

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Wells, E. W. June, 1958.

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