NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

TECHNICAL NOTE 2645

EFFECTS OF WING LIFT AND WEIGHT ON LANDING-GEAR LOADS

By Dean C. Lindquist

Langley Aeronautical Laboratory
Langley Field, Va.

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SUMMARY

In order to investigate the effects of wing lift and weight on landing-gear loads, drop tests were made with a small landing gear in the Langley impact basin. Wing lift was simulated in these tests by the mechanical application of a constant lift force to the test specimen throughout each impact. The tests covered a range of dropping weights between 1000 and 2500 pounds, wing lift factors between 0 and 2.0, and vertical contact velocities between 0 and 12 feet per second.

The results of this investigation show the variations of maximum landing-gear load, landing-gear load factor, and maximum upper-mass acceleration with changes in lift force and dropping weight at various vertical contact velocities.

INTRODUCTION

Although landing gears are generally designed and proof-tested for a specific landing condition, the aerodynamic lift forces and airplane weight at the instant of ground contact may vary over an appreciable range of values. For example, the specialized technique of landing aircraft aboard naval carriers can result in values of wing lift at contact with the carrier deck which may be appreciably greater or smaller than the weight of the airplane. In addition, many of the modern tactical military aircraft and some transport aircraft may be forced to make emergency landings in an overloaded condition, in which case the landing weight may be as much as twice the value of the minimum landing weight. Such large variations in wing lift and weight might be expected to have an appreciable effect on the magnitude of the maximum loads developed in a landing gear during an impact. Very little information, however, is available on the effects of these variables on landing-gear loads.

The purpose of this investigation is to determine the effects of wing lift and weight on maximum landing-gear loads by means of drop tests of a small landing gear in the Langley impact basin. Physical simulation of wing lift was obtained by the mechanical application of predetermined lift forces to the test specimen throughout each impact. The tests covered a range of dropping weights between 1000 and 2500 pounds, applied lift forces between zero and twice the value of the dropping weight, and vertical contact velocities between 0 and 12 feet per second.

SYMBOLS

F_g	maximum landing-gear load, pounds
g	gravitational constant, 32.17 feet per second per second
K_L	lift factor; ratio of lift force to total dropping weight
M_c	effective mass of lift mechanism, 1.3 slugs
n_g	landing-gear load factor; ratio of maximum landing-gear load to weight of upper mass
V_{v_o}	initial vertical contact velocity, feet per second
W_T	total dropping weight, pounds
W_u	weight of upper mass, pounds
$\ddot{y}_u$	maximum vertical acceleration of upper mass, feet per second per second

APPARATUS

Equipment

The basic equipment used in the present investigation is the Langley impact-basin carriage (references 1 and 2) which incorporates a four-bar parallelogram linkage for effecting the controlled descent of the test specimen. The vertical member of the linkage to which the test specimen is attached is referred to as the boom and is adapted to receive loading weights in the form of lead bars in increments of 50 pounds, as shown in figure 1. The minimum weight of the dropping mass including test specimen and instrumentation is 1000 pounds, which may be increased by the addition of the aforementioned lead bars to a maximum weight of 2500 pounds.

In order to simulate wing lift forces mechanically, the carriage incorporates a lift mechanism which is designed to apply any desired constant lift force up to 2500 pounds to the test specimen during an impact. The lift force is applied to the boom by means of a cable and sheave arrangement which connects the boom to the piston of a pneumatic cylinder in such a manner that the piston is forced to travel against the air pressure in the cylinder as the mass descends. Although the air pressure in the cylinder increases with piston travel, the incorporation of a special cam-shaped sheave in the cable system results in the application of an essentially constant upward force to the dropping mass during the course of the impact. The effect of the inertia of the lift mechanism under accelerated conditions is equivalent to an increase in the total dropping mass of 1.3 slugs without, however, increasing the weight of the dropping mass. The amount of lift force exerted on the dropping mass depends upon the air pressure supplied to the cylinder before each test. The vertical lift rod which can be seen attached to the base of the boom in figures 1 and 2 is one of two such rods which form the lower-end connection of the cable system. Varying the height of free drop of the boom prior to the engagement of the lift mechanism permits the attainment of sinking speeds up to approximately 12 feet per second.

Test Specimen

The landing-gear tested was originally designed as a main landing gear for a small military training airplane which had a gross weight of approximately 5000 pounds. The gear is of cantilever construction and incorporates an oleo shock strut. A 27-inch-diameter type I tire is fitted to the axle of a half-fork yoke which is attached to the lower cylinder of the strut.

The shock strut used in these tests had been modified for other investigations by removing the metering pin and replacing the original orifice with an orifice of smaller diameter. The size of the smaller orifice was calculated to produce approximately the same maximum landing-gear load factor as in the original design at a sinking speed of 10 feet per second. The details of the orifice and the internal arrangement of the shock strut are shown in figure 2.

The total dropping mass is comprised of the upper or sprung mass and the lower or unsprung mass. The upper mass includes the outer cylinder of the shock strut and all the dropping mass above the cylinder. The lower mass consists of the inner or lower cylinder, the shock-strut fluid, and the remaining parts of the landing gear which move relative to the upper mass when the shock strut is compressed. The weight of the lower mass was constant at 131 pounds.

Instrumentation

The present investigation is based primarily on measurements of upper-mass acceleration and initial or contact vertical velocity. Acceleration measurements of the upper mass were obtained by means of an unbonded strain-gage type of accelerometer having a natural frequency of 85 cycles per second. The vertical velocity of the landing gear at the instant of ground contact was determined by an impulse type of electromagnetic generator consisting of a permanent magnet attached to the upper mass which moved past a coil fixed to the carriage. The instant of tire contact was determined by means of a microswitch recessed in the landing platform. A view of the landing gear and instrumentation is shown in figure 1.

All instruments produced an electrical output which was recorded by an oscillograph. The galvanometers were damped to 65 percent of critical damping and had natural frequencies such that the response was essentially flat up to frequencies commensurate with the measuring instrumentation.

The measurements obtained are believed to be accurate to within the following limits:

Lift force, percent	±10
Upper-mass acceleration, g	±0.13
Initial vertical velocity, feet per second	±0.1

TEST PROCEDURE

In the present investigation the carriage was restrained horizontally and used in much the same manner as a conventional drop test machine. The dropping mass was released from a given height and allowed to fall freely to obtain the desired vertical contact velocity before engaging the lift mechanism. The magnitude of the lift force was preset by inflating the pneumatic cylinder of the lift mechanism to the required pressure before each test.

The tests were made with dropping weights of 1000, 1500, 2000, and 2500 pounds at vertical contact velocities ranging up to 12 feet per second and included wing lift factors of 0, 0.50, 0.75, 1.00, 1.25, 1.50, 1.75, and 2.00. Because of equipment limitations, lift forces greater than 2500 pounds could not be applied; consequently, the higher lift factors could not be investigated for the larger weights. In the free-fall drop tests the lift mechanism was disconnected; hence, there was no increase in the effective dropping mass due to the inertia of the lift mechanism for these impacts. All tests were made with the strut vertical and without wheel prerotation.

PRESENTATION OF RESULTS

Table I shows the test conditions investigated and gives experimental values of the contact or initial vertical velocity V_{v_o} and the resulting maximum acceleration of the upper mass $\ddot{y}_u/g$. Also presented are values of the maximum landing-gear load F_g, defined as the force on the upper mass, which were calculated from the acceleration measurements by means of the following equation:

$$F_g = W_u\left(\frac{\ddot{y}_u}{g} + 1\right) - W_T K_L + M_c \ddot{y}_u$$

Values of the landing-gear load factor n_g, defined as the ratio of F_g to the weight of the upper mass W_u, are also given in table I. The weight of the upper mass is equal to the total dropping weight W_T minus the weight of the lower mass which, as previously mentioned, was 131 pounds.

The data from table I are presented in figures 3 and 4 which show the variations of F_g and n_g with V_{v_o}, and $\ddot{y}_u/g$ with V_{v_o}, respectively, for constant values of K_L at each of the four dropping weights. In order to permit a direct comparison of the effects of lift force and weight on F_g, n_g, and $\ddot{y}_u/g$ at constant values V_{v_o}, the curves of figures 3 and 4 were cross-plotted against K_L as shown in figures 5 and 6 and against W_T as shown in figures 7 to 9.

DISCUSSION OF RESULTS

Effects of Lift Force on Loads

The curves in figure 5 show that in the lower range of lift forces $(K_L < 1.0)$ an increase in K_L (or in lift force) by a given amount results in a decrease in n_g (or in F_g) by roughly the same amount throughout the middle range of V_{v_o}. As a typical example, figure 5(b), which presents the results obtained in tests with an intermediate weight (W_T = 2000 lb), shows that an increase in K_L from 0 to 1.0 results in a reduction in n_g of approximately 1.0 at a vertical velocity of 7 feet per second. Variations in K_L produce similar changes in n_g for the other weights tested over the same range of K_L and V_{v_o}. The corresponding values of $\ddot{y}_u/g$ vary only slightly as shown by the nearly flat curves in figure 6 and by the narrow band of data in figure 4. This effect is to be expected since a change in K_L produces an opposite change in n_g of approximately the same magnitude.

At the higher values of V_{v_o} for values of K_L less than 1.0 the curves of figures 5(a) and 5(b) show that changes in K_L are accompanied by much larger changes in n_g. In this region the impacts are of such severity as to cause the tire to bottom or reach its maximum pneumatic deflection. The sudden increase in the stiffness of the tire when tire bottoming occurs causes a sudden increase in the shock-strut telescoping velocity and, consequently, a sudden increase in the hydraulic resistance of the strut which results in greater values of n_g. The load on the landing gear at which tire bottoming occurs is indicated in the figures by the horizontal line at 9500 pounds, which corresponds to the load on the tire at which the dynamic-load deflection characteristics radically change. At the highest velocities and largest dropping weights where tire bottoming may occur, therefore, an increase in K_L may prevent the tire from bottoming and developing excessive values of n_g. The effect of K_L on $\ddot{y}_u/g$ in the tire-bottoming region is shown in figures 6(a) and 6(b) by the rapid decrease in $\ddot{y}_u/g$ as K_L is increased at the higher values of V_{v_o}.

At the lower values of V_{v_o} for values of K_L less than 1.0 almost all the impact energy is comprised of the potential energy associated with the settling of the unbalanced weight to its static position. An increase in the lift factor in this region reduced n_g by an amount slightly greater than the increase in K_L as shown, for example, by the curves in figure 5 for the limiting case of V_{v_o} equal to zero.

For the higher values of lift force ($K_L > 1.0$), the decrease in n_g is generally not so great as the increase in K_L, particularly in the lower range of V_{v_o}, as shown, for example, by the curves in figure 5(d) which include values of K_L up to 2.0. The corresponding values of $\ddot{y}_u/g$ in this region increased with K_L as shown by the curves in figure 6(d). At the highest velocities for values of K_L greater than 1.0, however, the change in n_g again was approximately equal to the change in K_L and the effects of changes in K_L on $\ddot{y}_u/g$ again become quite small.

Effects of Weight on Loads

It can be seen from figure 7 that F_g increases with W_T for most of the range of V_{v_o} and K_L, as would be expected. However, the increase in F_g is not in the same ratio as the increase in W_T. For example, in figure 7(a) at V_{v_o} equal to 7 feet per second, an increase in W_T

from 1000 to 2000 pounds or an increase in W_T by a factor of 2 increases F_g from approximately 4150 to 6250 pounds or an increase in F_g by a factor of only 1.5. In general, the percent increase in F_g corresponding to an increase in W_T is much less than the percent increase in W_T particularly in the lowest range of V_{v_o} and highest range of K_L, where F_g remains nearly constant.

At the highest values of V_{v_o} and lowest values of K_L, because of the effects of tire bottoming, an increase in W_T by a factor of 2 resulted in an increase in F_g by nearly the same factor. In figures 7(a) and 7(b) it is of interest to note that at the highest values of V_{v_o} the slope of each curve following the transition from the pneumatic-tire-and-oleo shock absorber to the hard-tire-and-oleo shock absorber is approximately the same as the slope of the curves below the tire-bottoming boundary. Because of the lack of data in the transition region, the fairing of the dashed part of the curves is somewhat arbitrary.

Figure 8 shows that n_g decreases quite rapidly with W_T for most of the range of V_{v_o} and K_L investigated. This decrease would be expected since it was previously noted that over the same range of test conditions the percent increase in F_g was not so great as the corresponding percent increase in W_T. In the tire-bottoming region the transition from a pneumatic tire to a hard tire is again noted by the abrupt increase in the slope of the curves in figures 8(a) and 8(b) at 11 feet per second. Following the transition, n_g again decreases with further increases in W_T.

The curves of figure 9 show that $\ddot{y}_u/g$ decreases quite rapidly with W_T for most of the range of V_{v_o} and K_L investigated. As would be expected, the variations in $\ddot{y}_u/g$ are seen to be similar to those shown by the curves of figure 8 for n_g; however, because of the combined effects of dropping weight and lift force, n_g is either greater or smaller than $\ddot{y}_u/g$ depending upon the magnitude of the difference between the weight and lift force.

Since, in general, values of $\ddot{y}_u/g$ were much greater for the lighter dropping weights, the results indicate that, if an aircraft is designed only for a maximum- or gross-weight condition, critical loads in attachments for concentrated weights such as engine mounts may occur during landings made in a light-weight condition, even though these attachments may be satisfactory for the heavy-weight condition.

SUMMARY OF RESULTS

An investigation has been made to determine the effects of lift force and weight on the loads developed in a small landing gear during vertical impacts covering a range of vertical contact velocities.

The data show that, in general, for most of the range of test conditions, an increase in the lift factor reduced the landing-gear load by an amount which was roughly equal to the applied lift force. As a result, variations in lift force had only a slight effect on the maximum accelerations of the upper mass. At the highest vertical contact velocities and for lift factors less than 1.0, however, tire bottoming occurred and changes in lift force were accompanied by much larger differences in landing-gear load.

An increase in weight resulted in an increase in the maximum landing-gear load which was not proportionately so large as the increase in the weight. This relationship was indicated by the rapid decrease in landing-gear load factor with increasing weight. The maximum upper-mass acceleration as well as the landing-gear load factor was much higher for the lighter weights. This result indicates that aircraft may experience critical loads in attachments for concentrated masses in landings made under light-weight conditions.

Langley Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Field, Va., November 14, 1951

REFERENCES

1. Batterson, Sidney A.: The NACA Impact Basin and Water Landing Tests of a Float Model at Various Velocities and Weights. NACA Rep. 795, 1944. (Formerly NACA ACR L4H15.)

2. Milwitzky, Benjamin, and Lindquist, Dean C.: Evaluation of the Reduced-Mass Method of Representing Wing-Lift Effects in Free-Fall Drop Tests of Landing Gears. NACA TN 2400, 1951.

TABLE I

LANDING-GEAR LOADS

K_L	W_T (lb)															
	2500				2000				1500				1000			
	V_{v_o} (fps)	$\frac{\ddot{y}_u}{g}$	F_g (lb)	n_g	V_{v_o} (fps)	$\frac{\ddot{y}_u}{g}$	F_g (lb)	n_g	V_{v_o} (fps)	$\frac{\ddot{y}_u}{g}$	F_g (lb)	n_g	V_{v_o} (fps)	$\frac{\ddot{y}_u}{g}$	F_g (lb)	n_g
0	-----	----	------	----	0	0.37	2,561	1.37	0	0.21	1,656	1.21	0	0.33	1,151	1.33
	2.83	0.70	4,027	1.70	2.83	.67	3,121	1.67	2.83	.92	2,622	1.92	2.83	1.16	1,877	2.16
	4.09	.91	4,525	1.91	4.09	1.10	3,925	2.10	4.09	1.48	3,395	2.48	4.09	1.89	2,511	2.89
	5.03	1.22	5,259	2.22	5.03	1.49	4,644	2.49	5.03	1.96	4,045	2.96	5.03	2.45	2,998	3.45
	6.55	1.77	6,550	2.77	6.55	2.24	6,046	3.24	6.55	2.72	5,086	3.72	6.55	3.59	3,984	4.59
	8.31	2.66	8,659	3.66	8.31	3.07	7,607	4.07	8.31	3.71	6,448	4.71	8.31	4.87	5,097	5.87
	11.06	6.08	16,761	7.08	11.06	6.19	13,438	7.19	11.06	5.98	9,556	6.98	11.06	7.02	6,969	8.02
0	-----	----	------	----	0	.32	2,467	1.32	0	.17	1,600	1.17	0	.10	956	1.10
	2.15	.48	3,506	1.48	2.15	.48	2,766	1.48	2.15	.56	2,136	1.56	2.15	.84	1,596	1.84
	3.66	.77	4,193	1.77	3.66	.93	3,607	1.93	3.66	1.14	2,923	2.14	3.66	1.66	2,312	2.66
	4.69	1.15	5,093	2.15	4.69	1.32	4,327	2.32	4.69	1.64	3,614	2.64	4.69	2.25	2,820	3.25
	6.29	1.72	6,444	2.72	6.29	2.05	5,700	3.05	6.29	2.46	4,737	3.46	6.29	3.30	3,737	4.30
	8.11	2.60	8,528	3.60	8.11	2.96	7,401	3.96	8.11	3.54	6,215	4.54	8.11	4.61	4,871	5.61
	10.88	5.54	15,481	6.54	10.88	5.90	12,896	6.90	10.88	5.56	8,974	6.56	10.88	6.79	6,772	7.79
.50	5.35	1.27	4,169	1.76	5.05	1.41	3,563	1.91	4.87	1.68	2,942	2.15	4.70	2.09	2,276	2.62
	6.06	1.55	4,856	2.05	5.83	1.75	4,214	2.26	5.77	2.02	3,469	2.53	5.59	2.50	2,645	3.04
	6.78	1.79	5,435	2.29	6.54	2.06	4,796	2.57	6.42	2.43	4,041	2.95	6.12	2.94	3,050	3.29
	7.91	2.28	6,604	2.79	7.73	2.69	6,000	3.21	7.55	3.05	4,922	3.59	7.37	3.74	3,776	4.35
	9.04	2.76	7,773	3.28	8.86	3.22	7,009	3.75	8.68	3.66	5,777	4.22	8.41	4.50	4,469	5.14
	9.87	3.42	9,365	3.95	9.81	3.74	8,016	4.29	9.63	4.33	6,722	4.91	9.39	5.10	5,019	5.78
.75	4.54	1.02	2,953	1.25	4.40	1.13	2,528	1.35	4.16	1.37	2,170	1.58	3.80	1.75	1,714	1.97
	5.35	1.31	3,652	1.54	5.23	1.49	3,206	1.72	4.99	1.71	2,657	1.94	4.64	2.21	2,132	2.45
	6.06	1.57	4,279	1.81	5.83	1.74	3,694	1.98	5.71	2.08	3,179	2.32	5.35	2.63	2,510	2.89
	7.37	2.09	5,521	2.33	7.31	2.39	4,936	2.64	7.08	2.75	4,117	3.01	6.78	3.36	3,175	3.63
	8.92	2.73	7,064	2.98	8.86	3.14	6,370	3.41	8.62	3.70	5,457	3.98	8.44	4.49	4,204	4.84
	11.41	4.76	11,970	5.05	11.24	4.94	9,800	5.24	11.12	5.20	7,581	5.53	10.94	6.42	5,968	6.87
1.00	3.37	.82	1,846	.78	3.09	.84	1,465	.78	2.97	.99	1,266	.92	2.50	1.31	1,062	1.22
	4.35	1.16	2,654	1.12	4.40	1.22	2,191	1.17	4.04	1.41	1,851	1.35	3.63	1.76	1,472	1.69
	5.29	1.41	3,256	1.37	5.11	1.50	2,726	1.46	4.99	1.80	2,401	1.75	4.52	2.25	1,919	2.21
	6.64	1.90	4,438	1.87	6.54	2.14	3,949	2.11	6.54	2.45	3,326	2.43	6.12	2.98	2,584	2.97
	8.29	2.66	6,283	2.65	8.26	2.94	5,478	2.93	8.03	3.39	4,645	3.39	7.85	4.11	3,608	4.15
	11.00	3.97	9,441	3.99	11.00	4.43	8,325	4.45	10.82	4.99	6,909	5.04	10.46	6.25	5,558	6.40
1.25					3.45	1.05	1,366	.73	2.97	1.16	1,131	.83	2.26	1.29	790	.91
					4.40	1.38	1,997	1.07	4.16	1.54	1,659	1.21	3.69	1.79	1,245	1.43
					5.29	1.70	2,608	1.40	5.11	1.87	2,125	1.55	4.40	2.22	1,641	1.89
					6.78	2.23	3,631	1.94	6.42	2.50	3,015	2.20	6.00	3.03	2,379	2.74
					8.32	2.98	5,064	2.71	8.03	3.44	4,347	3.17	7.73	4.04	3,294	3.79
					10.64	4.14	7,271	3.89	10.58	4.73	6,161	4.50	10.17	5.92	5,016	5.77
1.50									2.97	1.31	963	.70	2.32	1.33	581	.67
									4.16	1.69	1,498	1.09	3.39	1.89	1,091	1.26
									5.23	1.95	1,866	1.36	4.40	2.30	1,468	1.69
									6.54	2.61	2,806	2.05	6.09	3.13	2,217	2.55
									8.09	3.52	4,079	2.98	7.67	3.99	3,007	3.46
									9.99	4.50	5,474	4.00	9.99	5.68	4,540	5.22
1.75													1.73	1.20	214	.25
													3.45	2.00	936	1.08
													4.46	2.41	1,316	1.51
													5.26	2.87	1,732	1.99
													7.12	3.80	2,580	2.93
													9.16	5.18	3,839	4.42
2.00													2.25	1.59	315	.36
													3.40	2.05	733	.84
													4.58	2.64	1,271	1.46
													6.54	3.73	2,268	2.61
													8.68	4.92	3,353	3.86

NACA

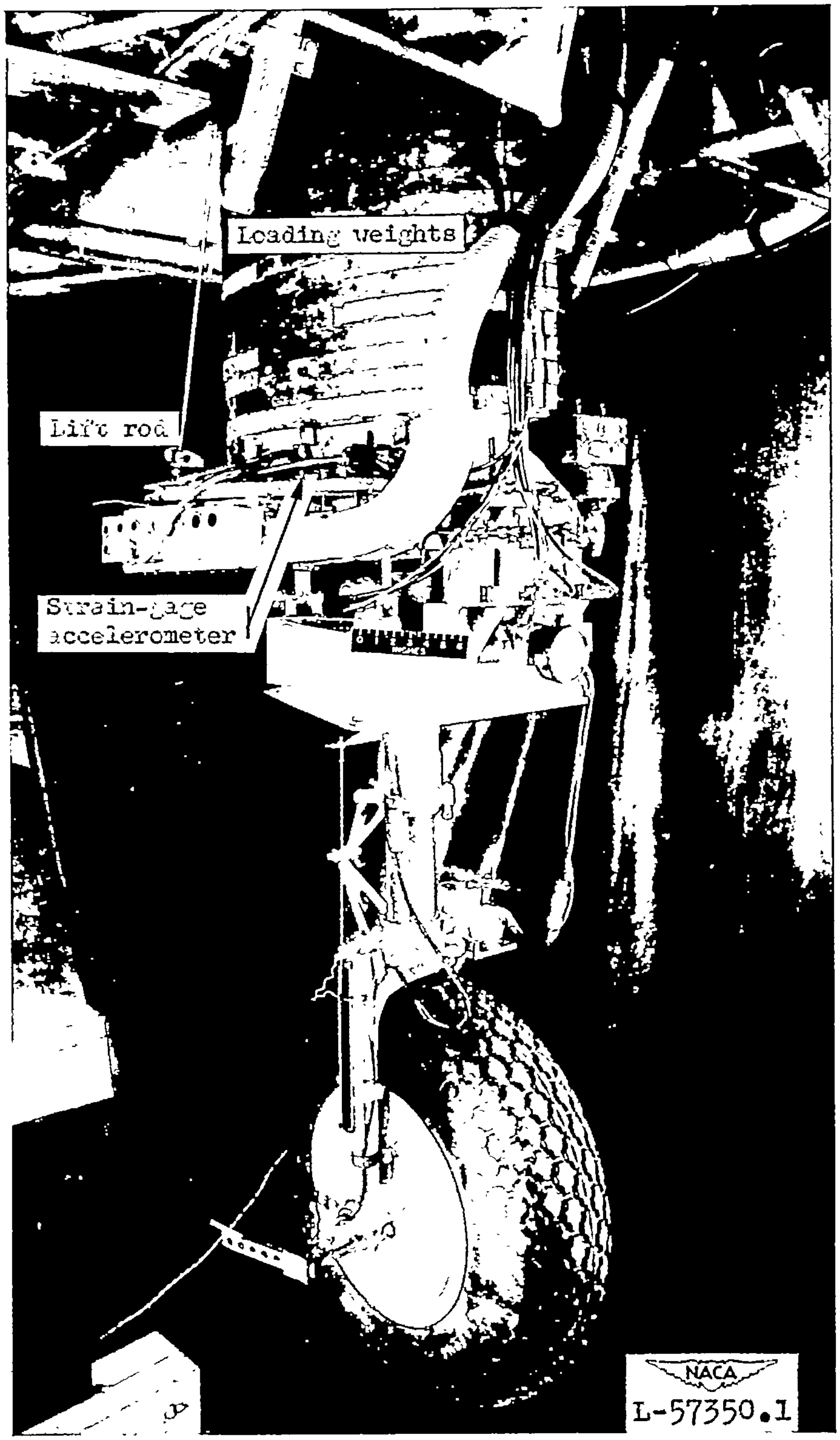
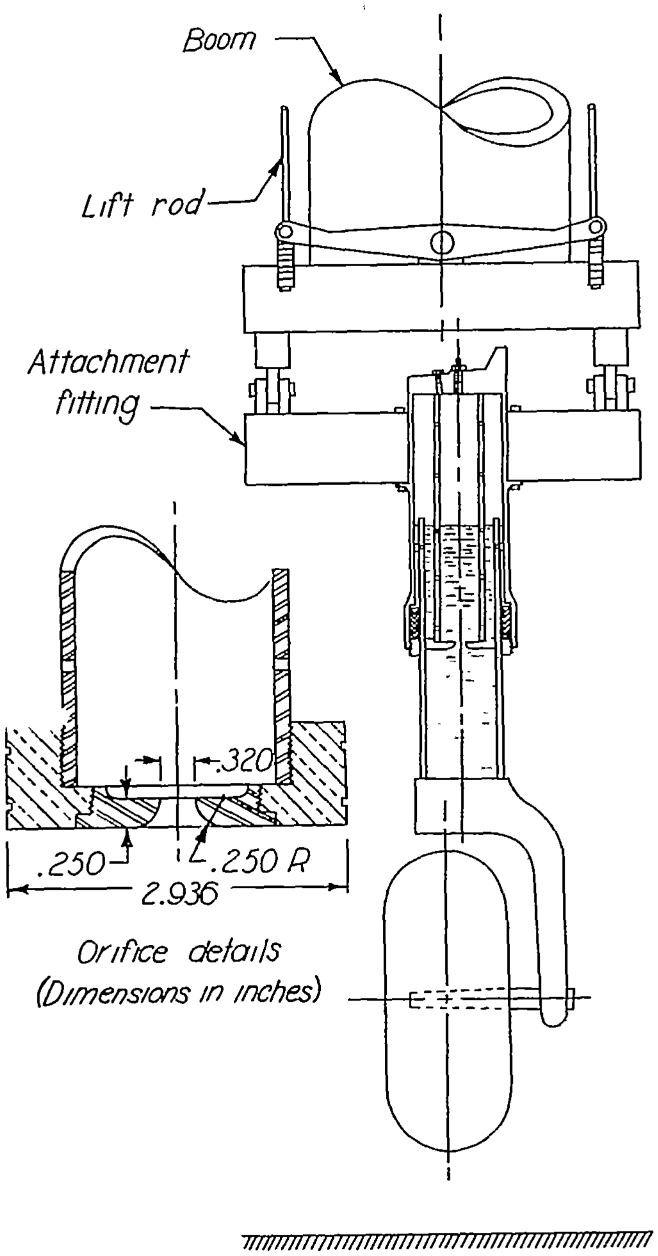


Figure 1.- View of landing gear and instrumentation.

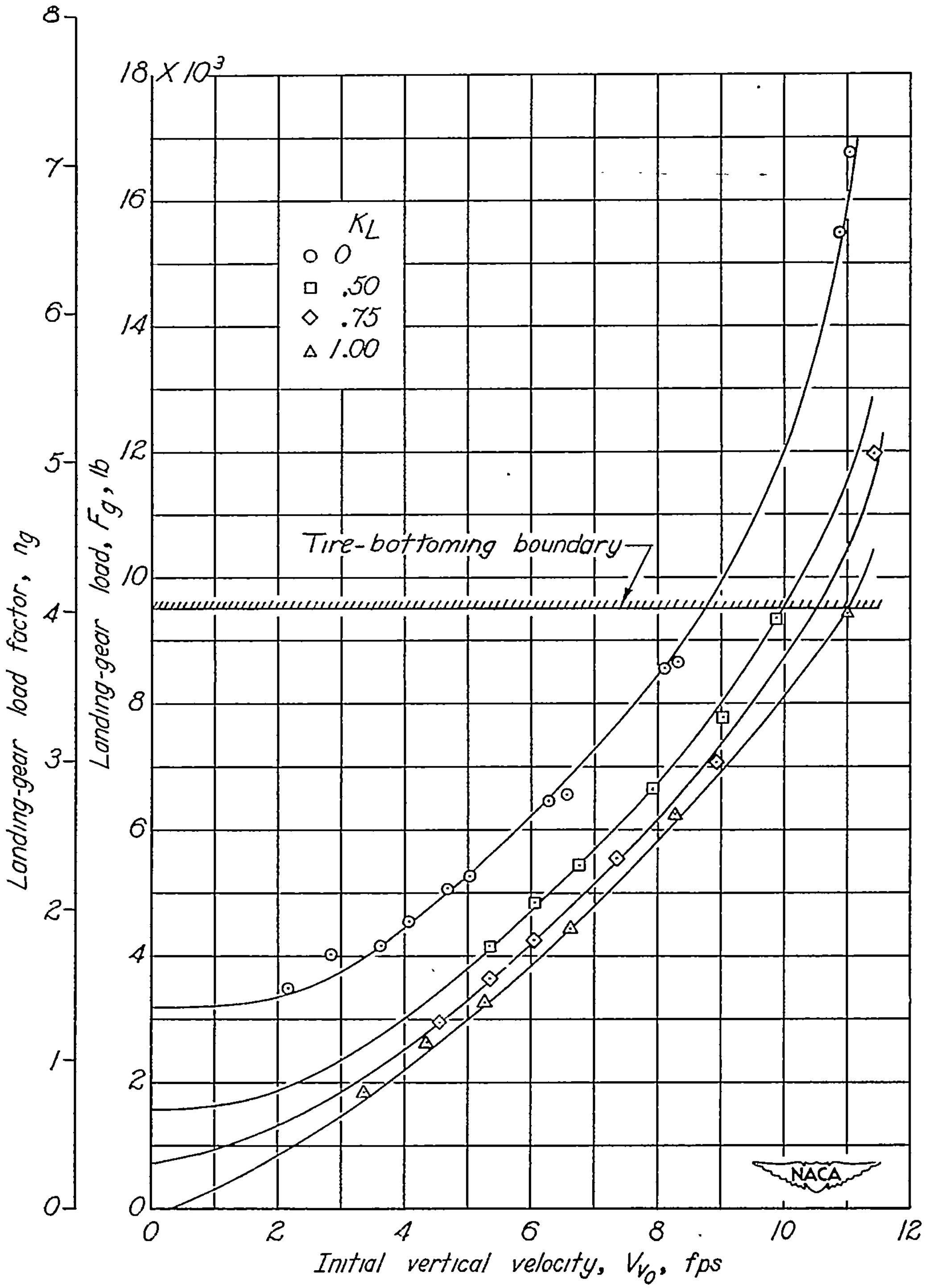


LANDING-GEAR SPECIFICATIONS

Air-supporting area, sq in.	8.30
Oil-supporting area, sq in.	6.78
Air volume - extended, cu in.	61.26
Stroke, maximum, in.	$7\frac{3}{8}$
Static extension, in.	$1\frac{1}{8}$
Fluid specification	AN-VV-O-336B
Fluid volume, cu in.	123
Strut inclination to vertical, deg . .	0
Tire diameter, in.	27
Tire type	Smooth-contour (type I), nonskid tread
Tire pressure, lb/sq in.	32
Landing-gear weight, lb	150
Unsprung weight, lb	131
Strut air pressure, P, lb/sq in. . .	

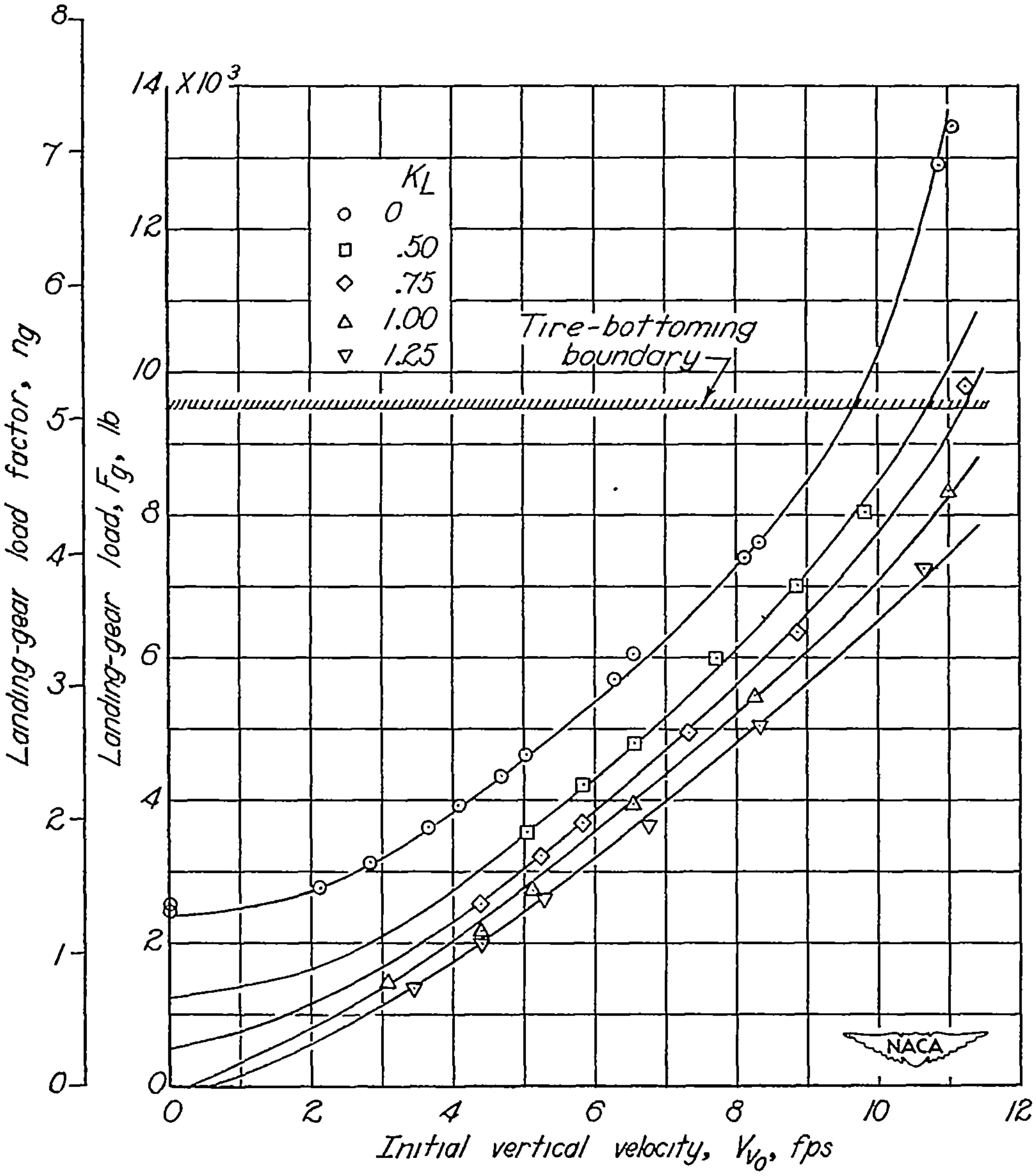
W_T	$P_{extended}$	P_{static}
2500	43.5	285.3
2000	34.3	225.3
1500	25.1	165.0
1000	16.0	104.8

Figure 2.- Landing gear tested in Langley impact basin.



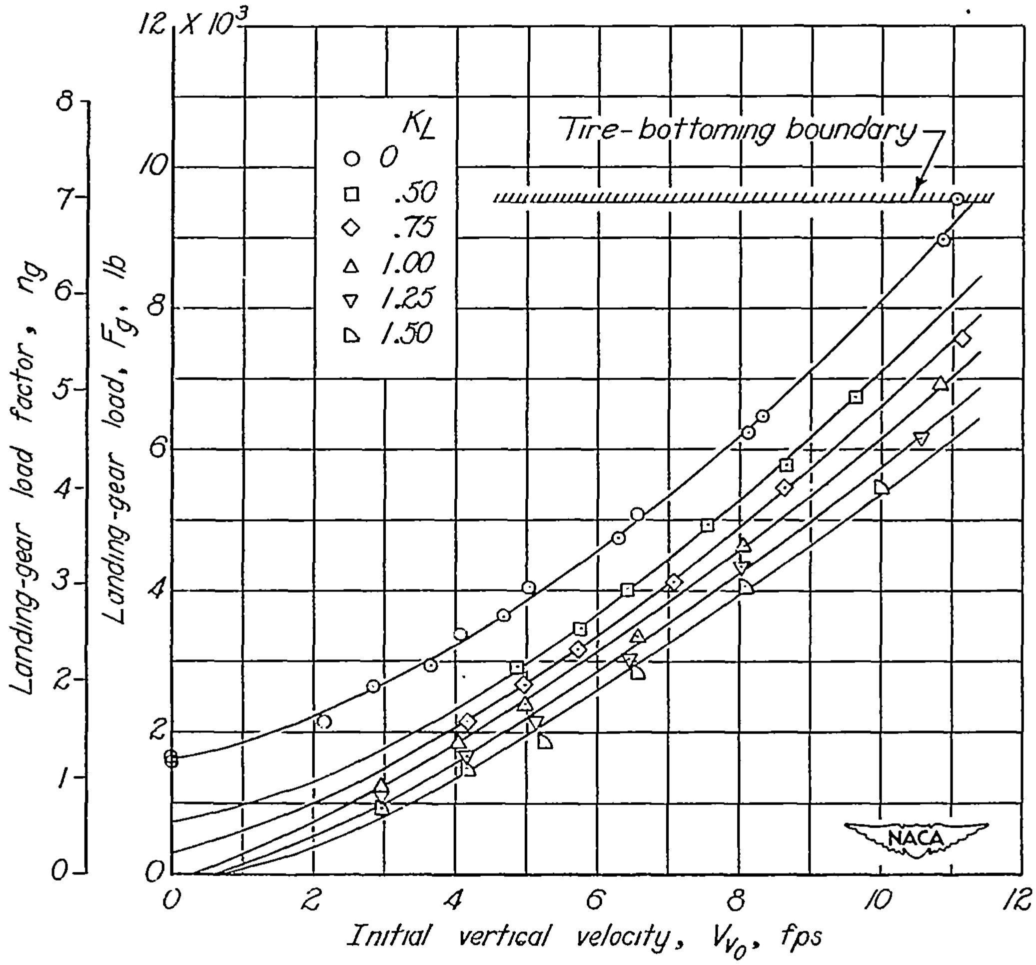
(a) W_T = 2500 pounds.

Figure 3.- Variation of landing-gear load and landing-gear load factor with vertical velocity.



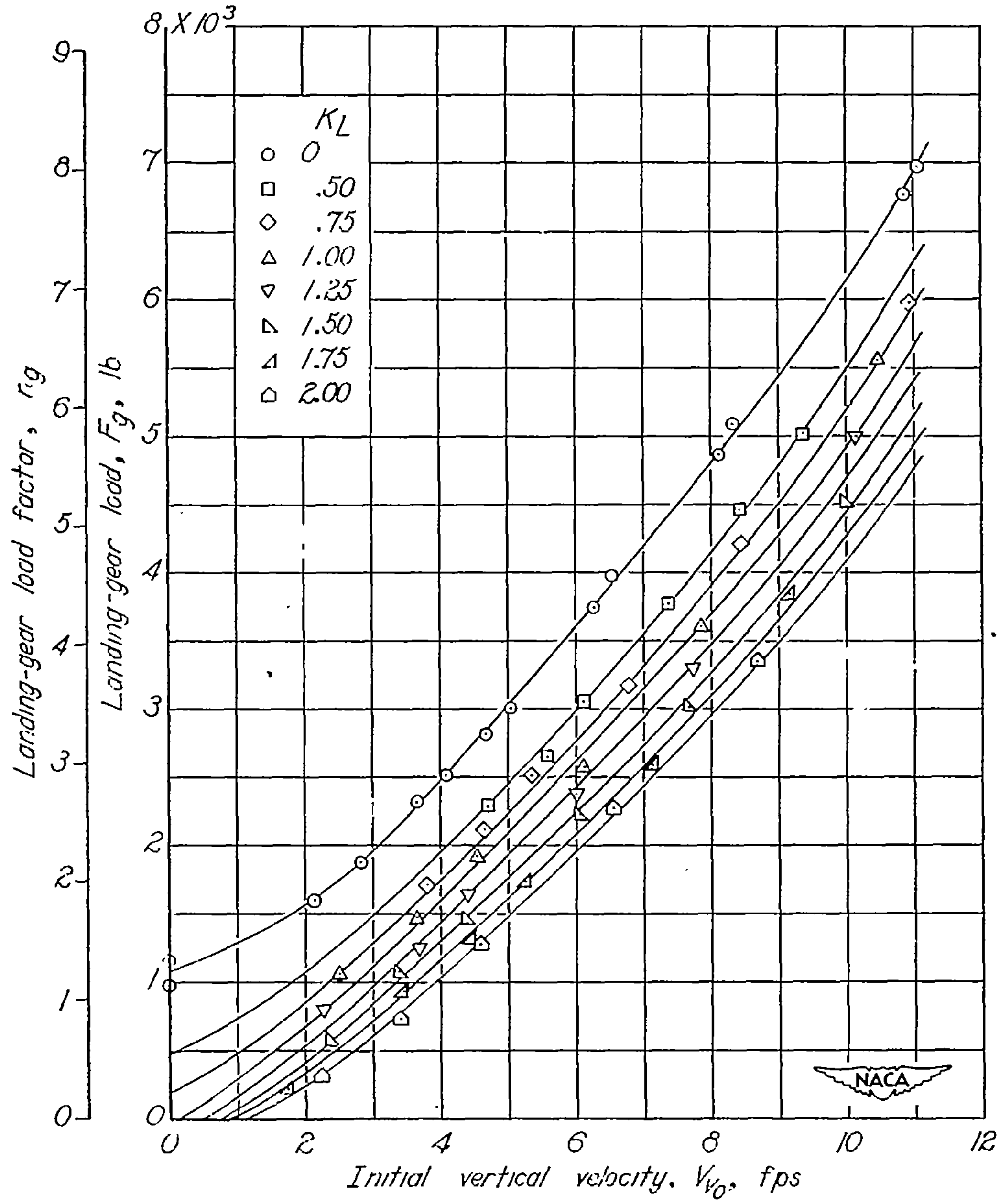
(b) W_T = 2000 pounds.

Figure 3.- Continued.



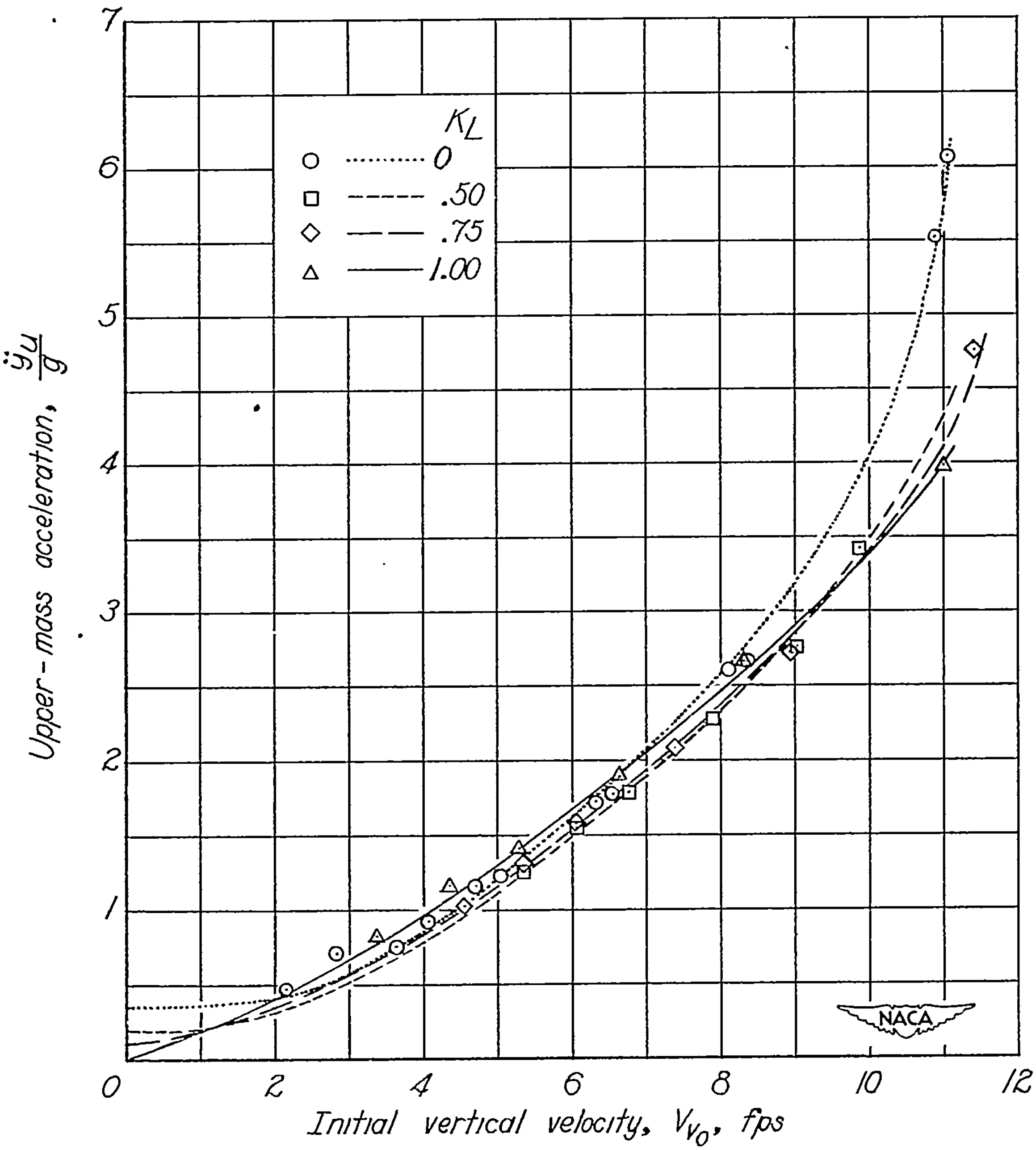
(c) W_T = 1500 pounds.

Figure 3.- Continued.



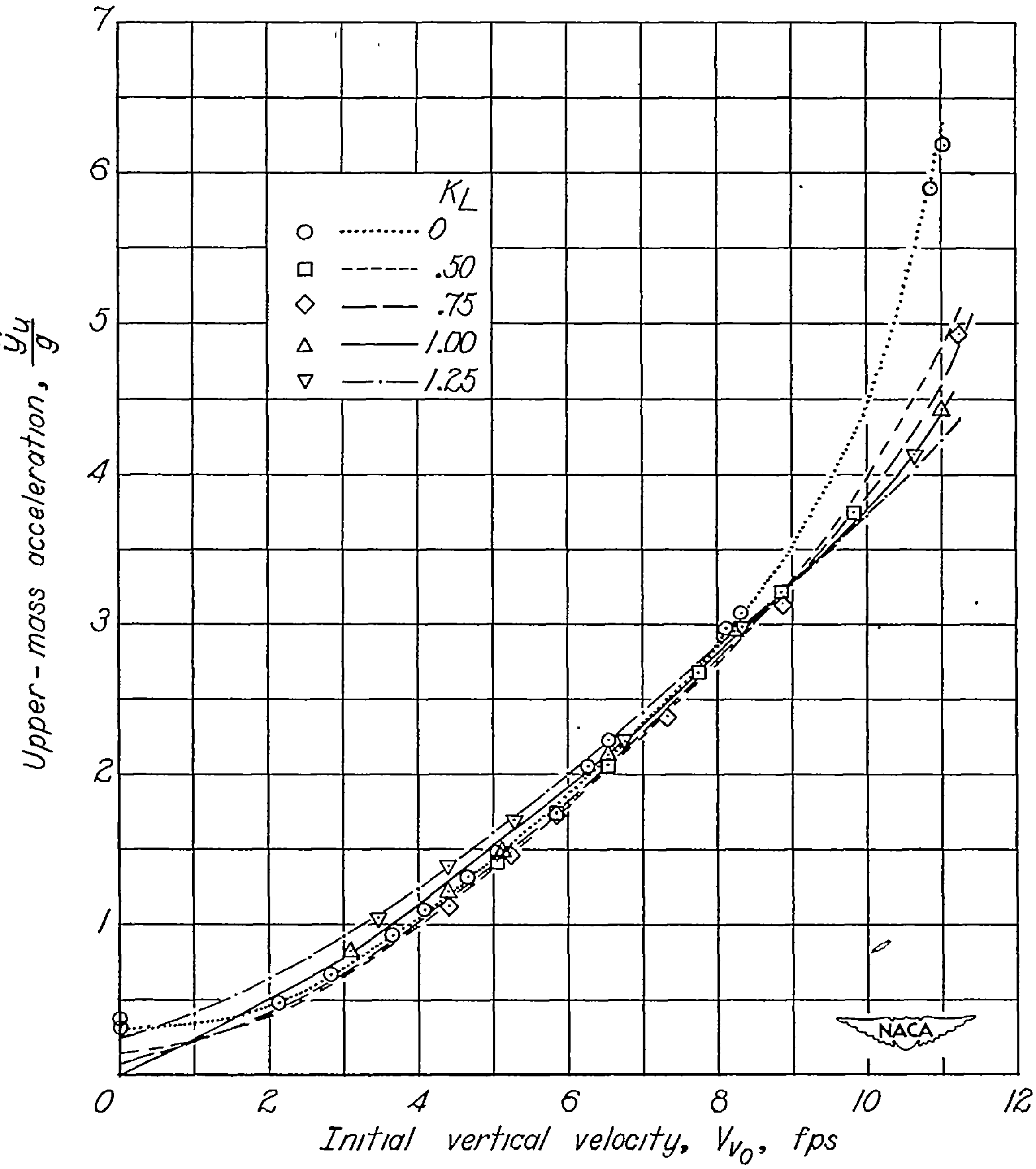
(d) W_T = 1000 pounds.

Figure 3.- Concluded.



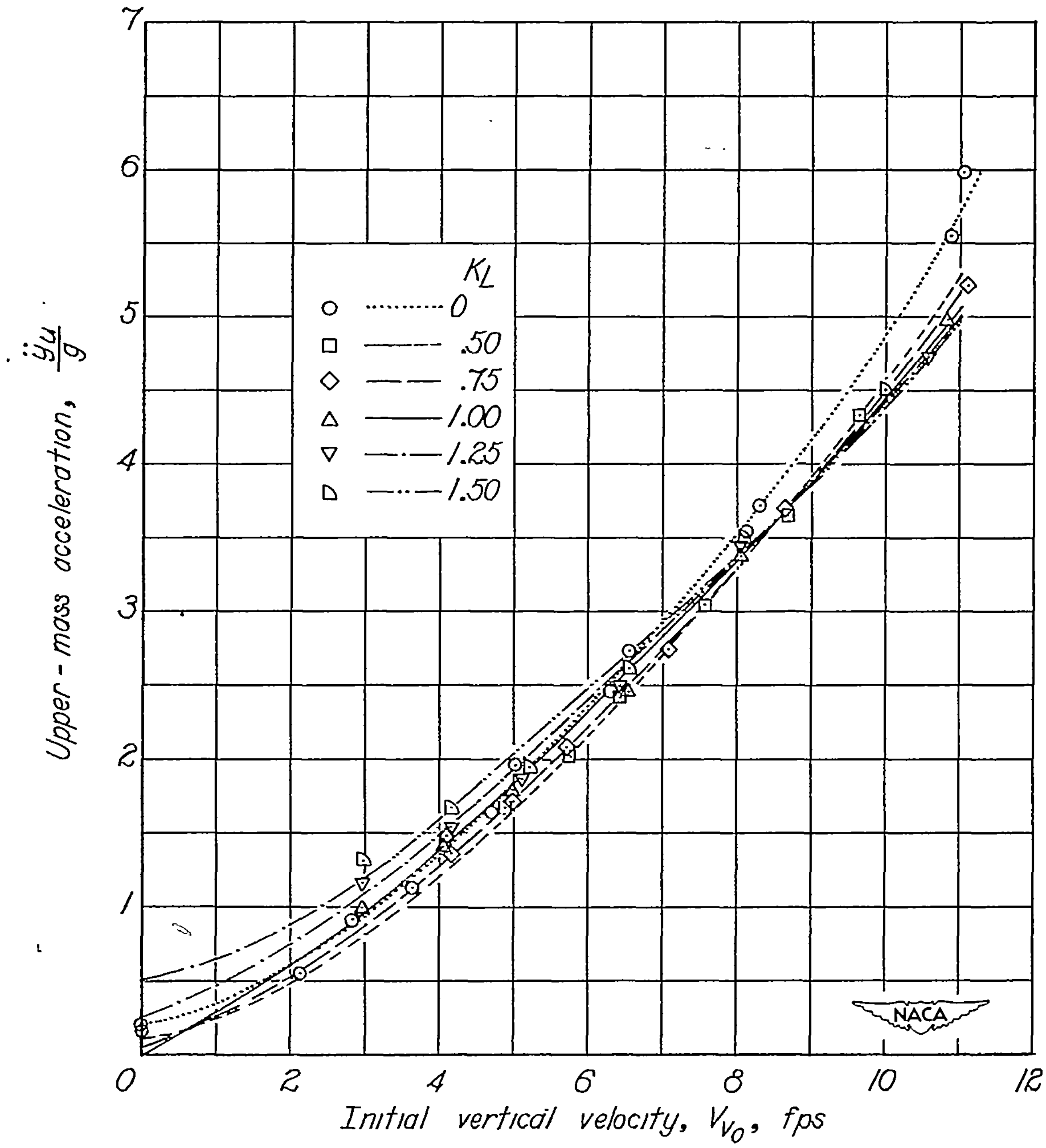
(a) W_T = 2500 pounds.

Figure 4.- Variation of upper-mass acceleration with vertical velocity.



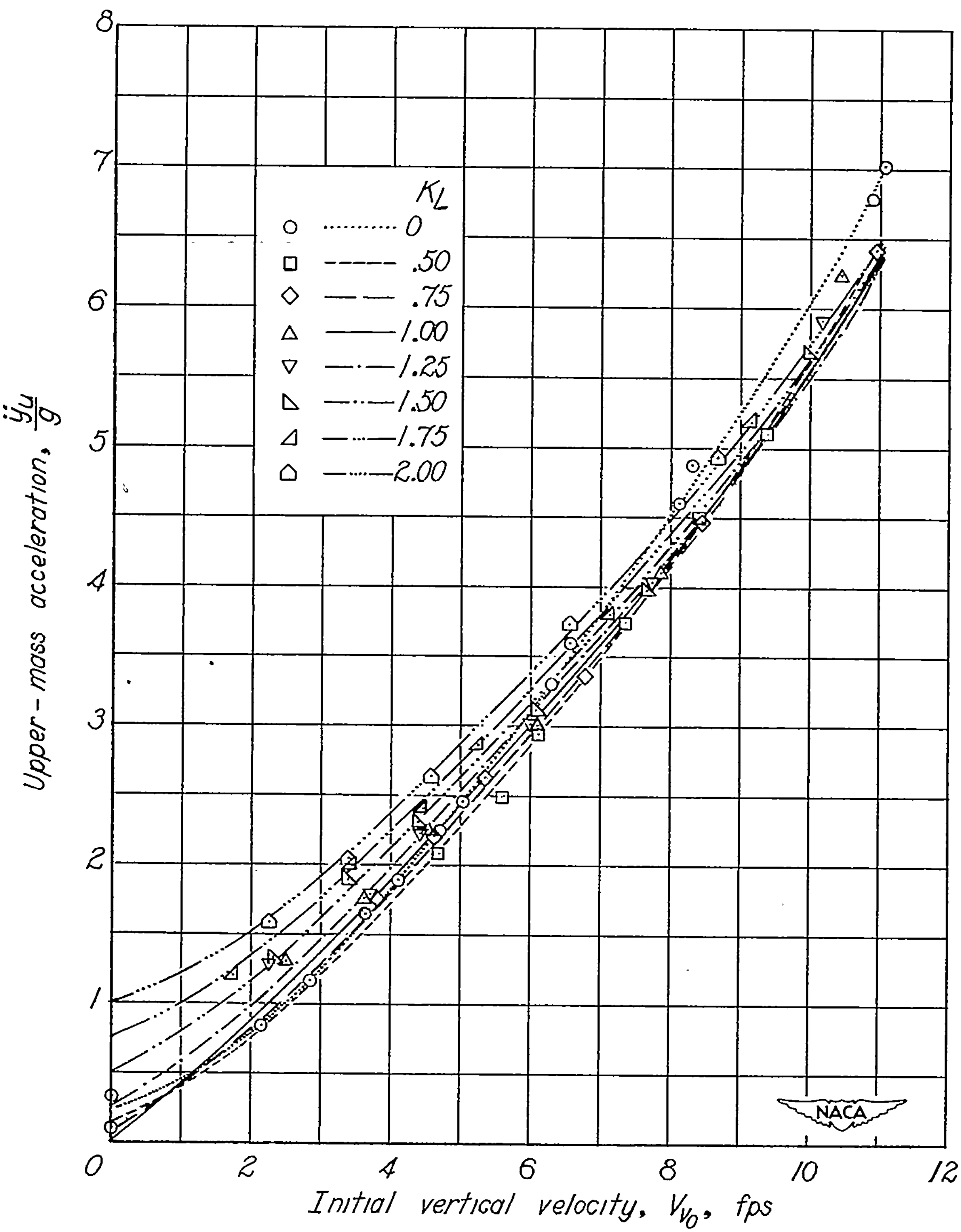
(b) W_T = 2000 pounds.

Figure 4.- Continued.



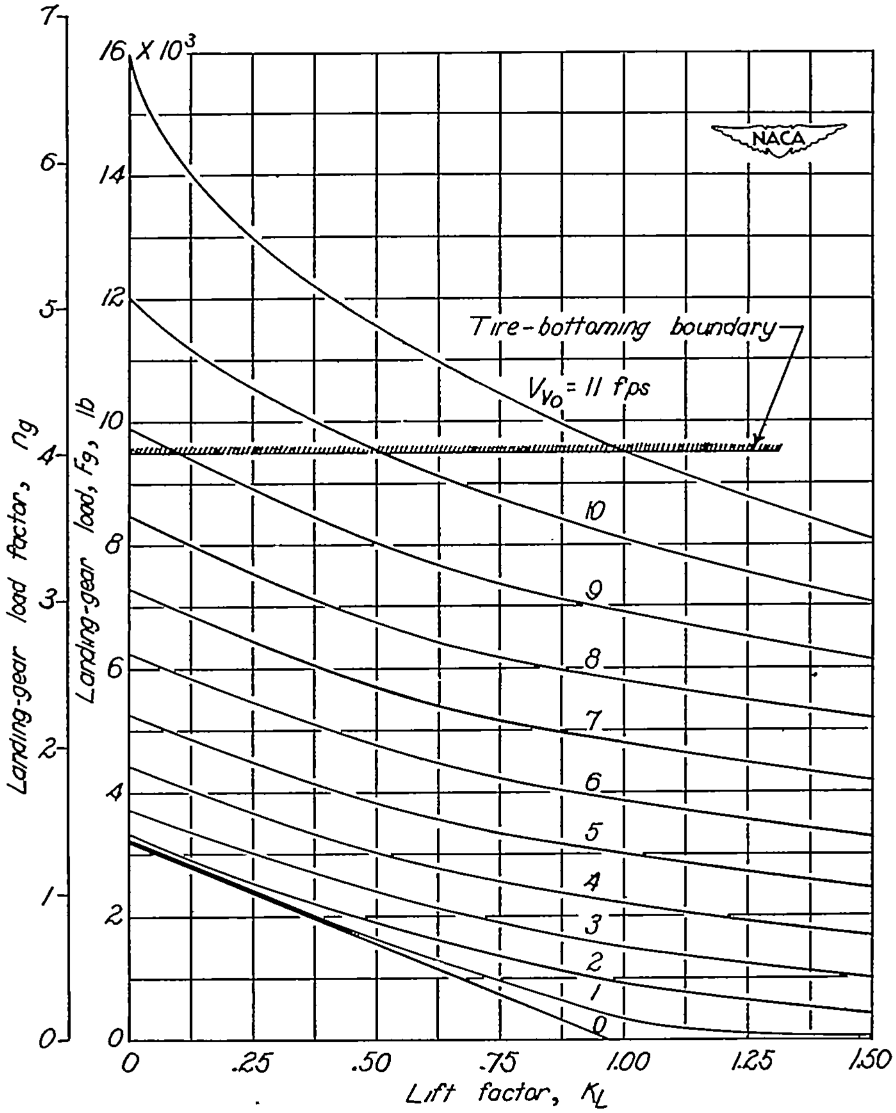
(c) W_T = 1500 pounds.

Figure 4.- Continued.



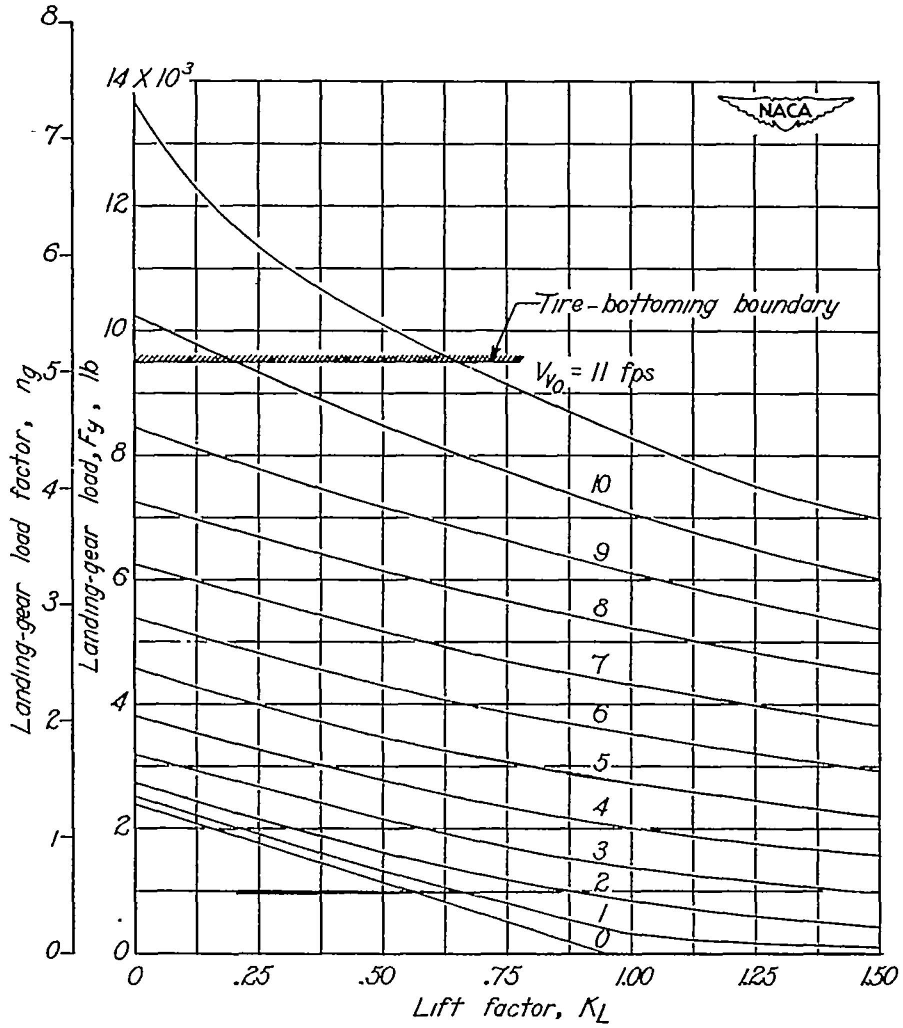
(d) W_T = 1000 pounds.

Figure 4.- Concluded.



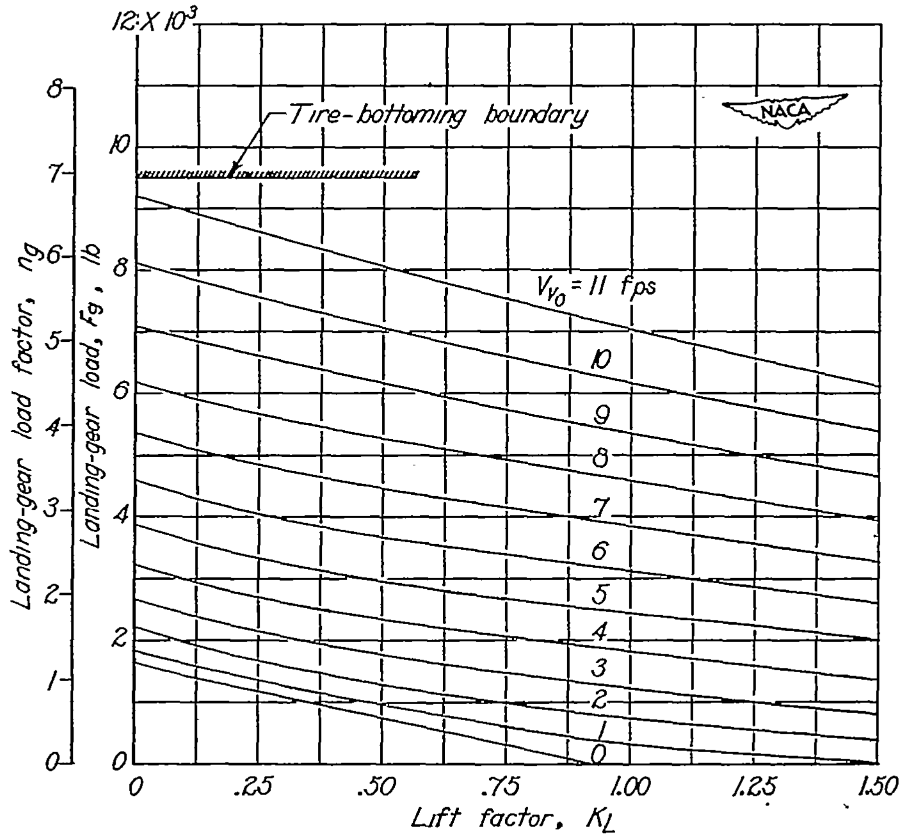
(a) W_T = 2500 pounds.

Figure 5.- Effects of wing lift on landing-gear load and landing-gear load factor.



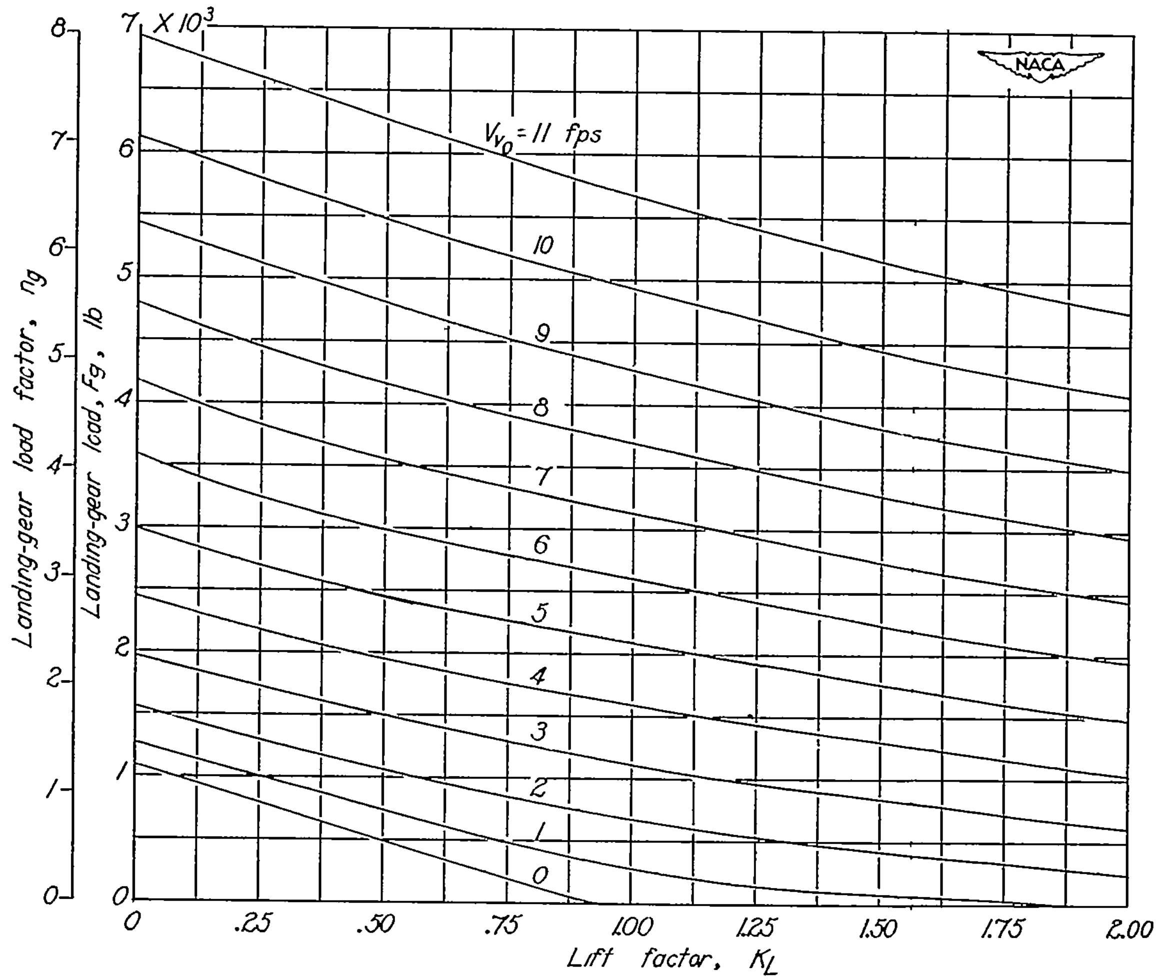
(b) W_T = 2000 pounds.

Figure 5.- Continued.



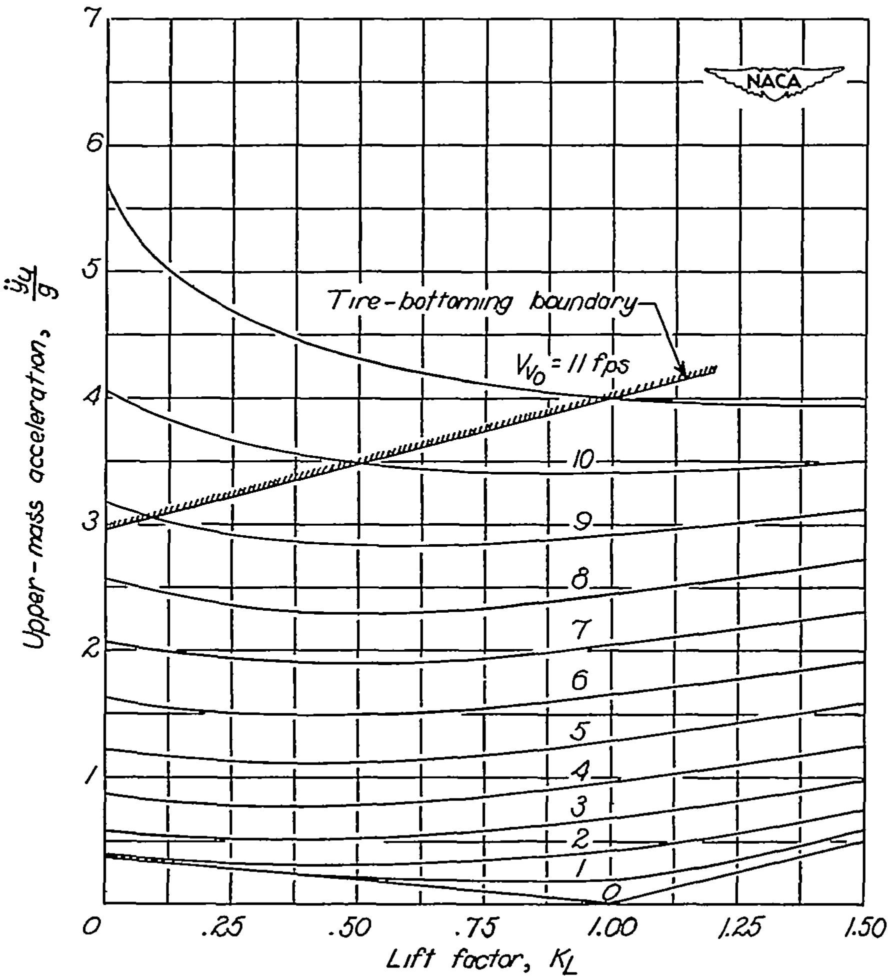
(c) W_T = 1500 pounds.

Figure 5.- Continued.



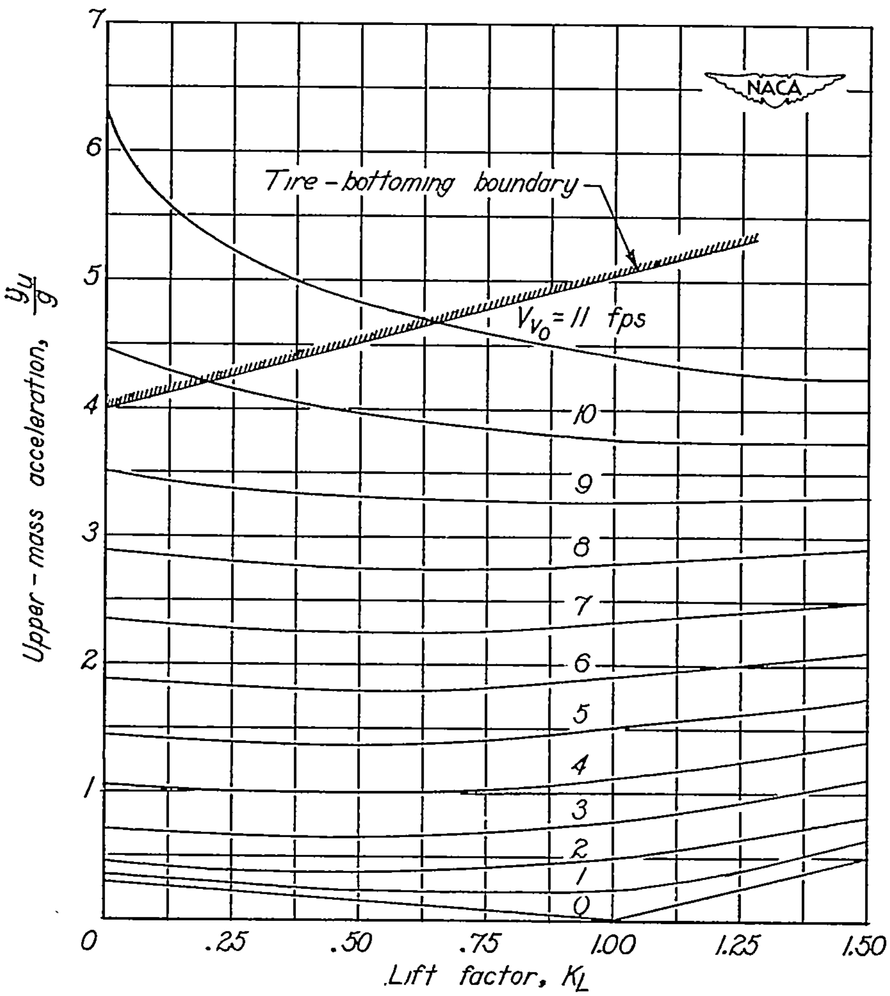
(d) W_T = 1000 pounds.

Figure 5.- Concluded.



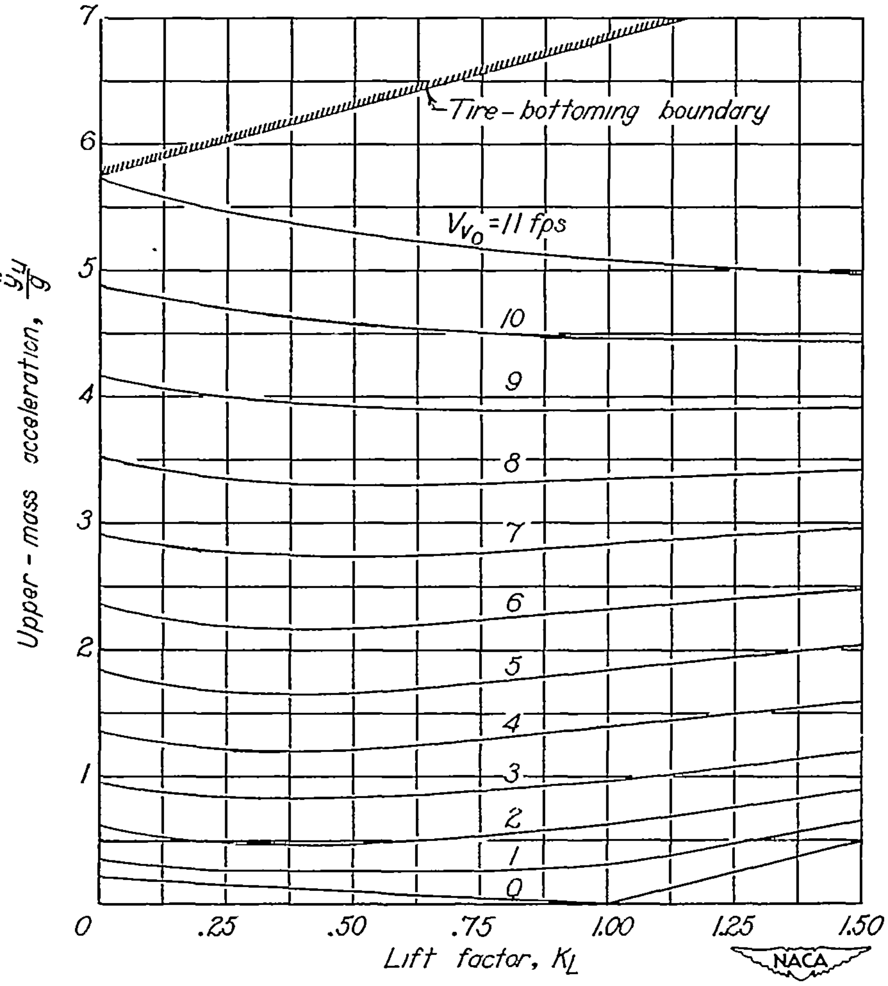
(a) W_T = 2500 pounds.

Figure 6.- Effects of wing lift on upper-mass acceleration.



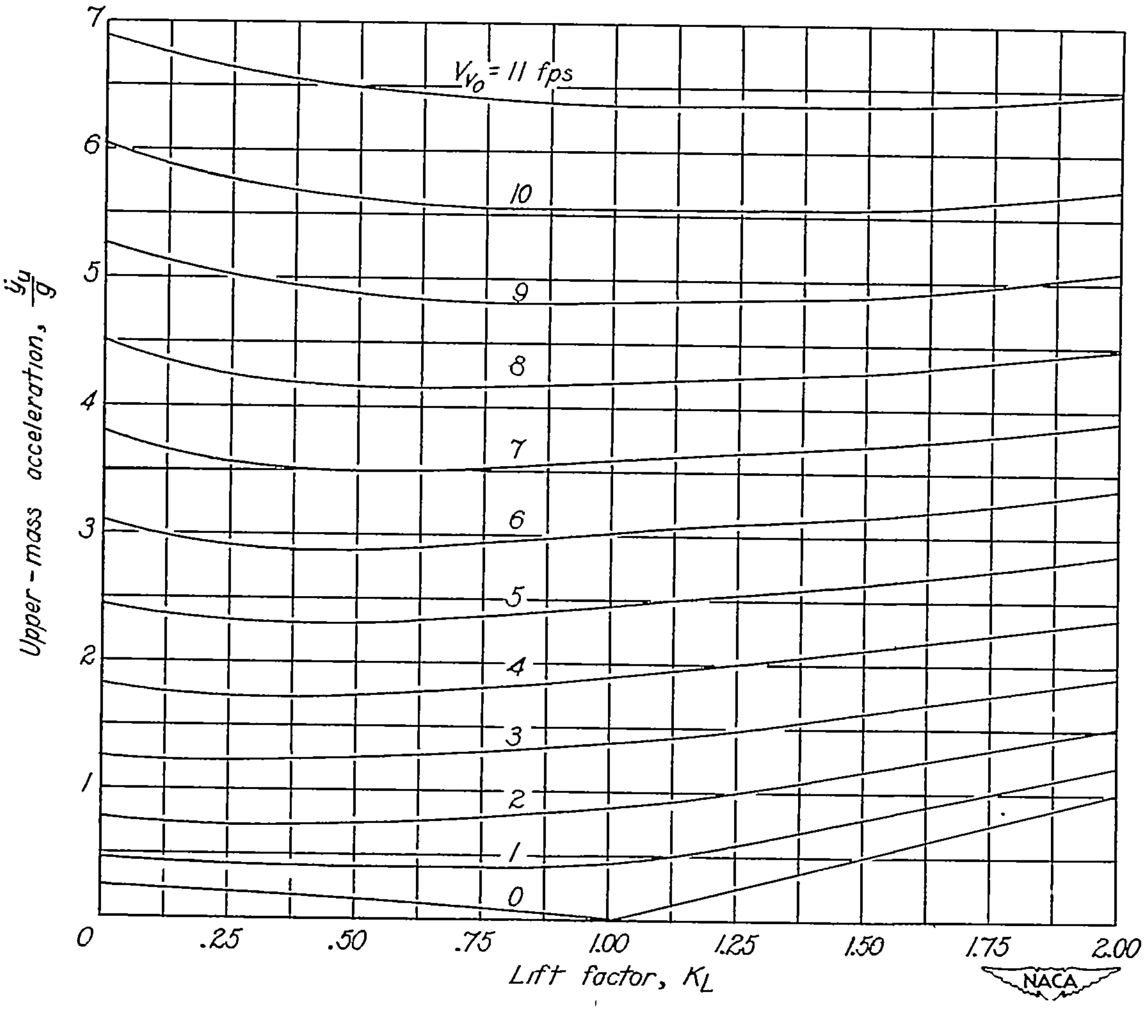
(b) W_T = 2000 pounds.

Figure 6.- Continued.



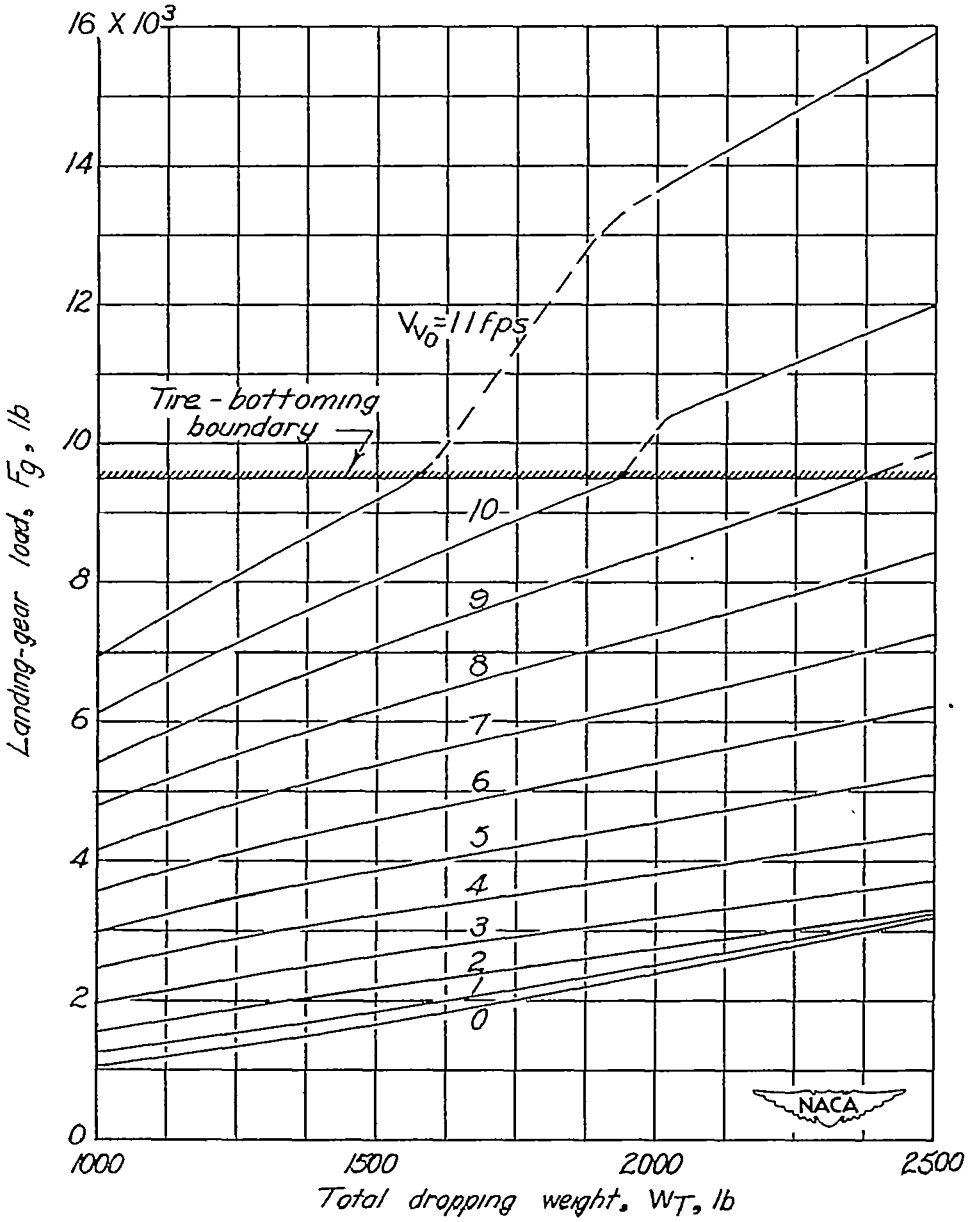
(c) W_T = 1500 pounds.

Figure 6.- Continued.



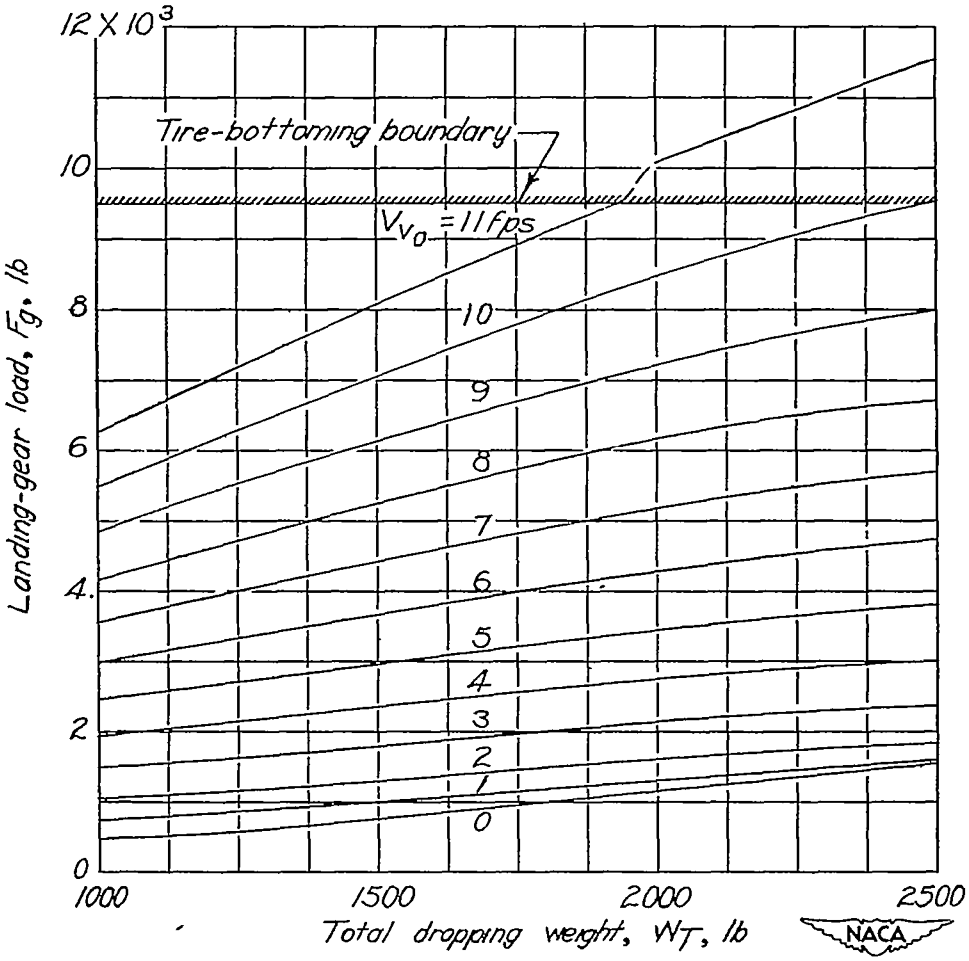
(d) W_T = 1000 pounds.

Figure 6.- Concluded.



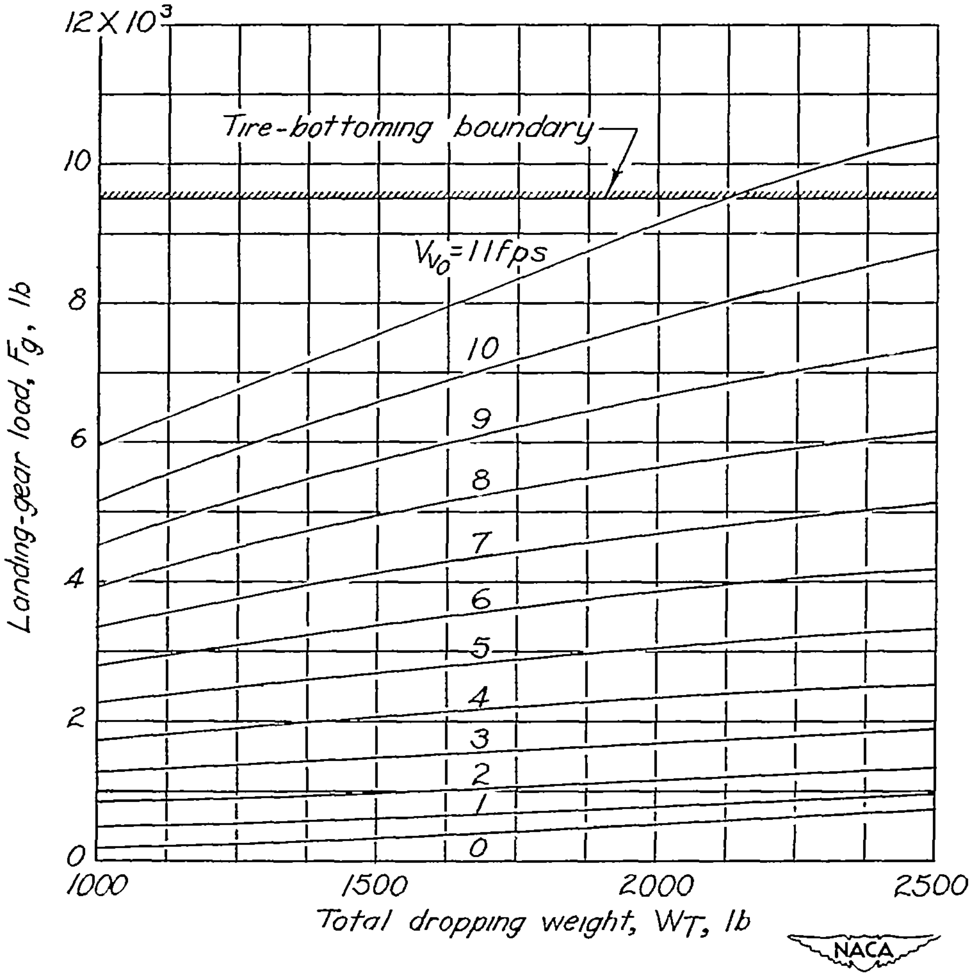
(a) $K_L = 0$.

Figure 7.- Effects of weight on landing-gear load.



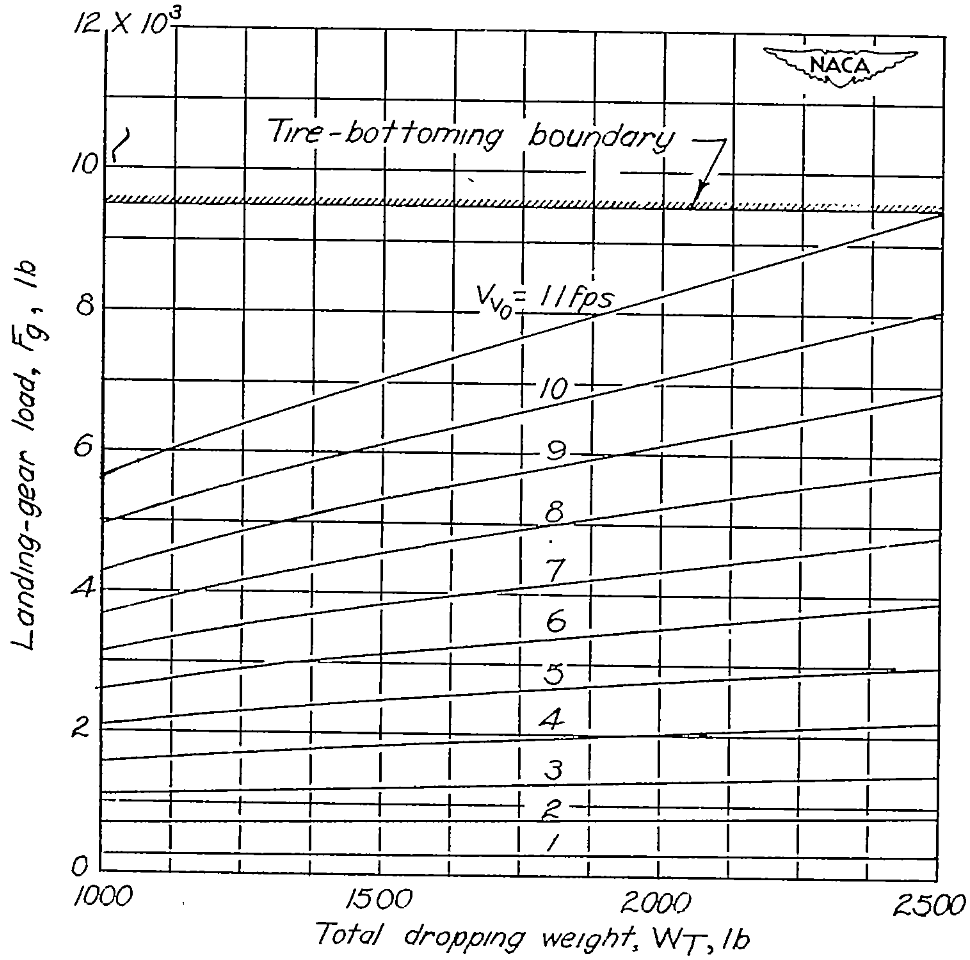
(b) $K_L = 0.50$.

Figure 7.- Continued.



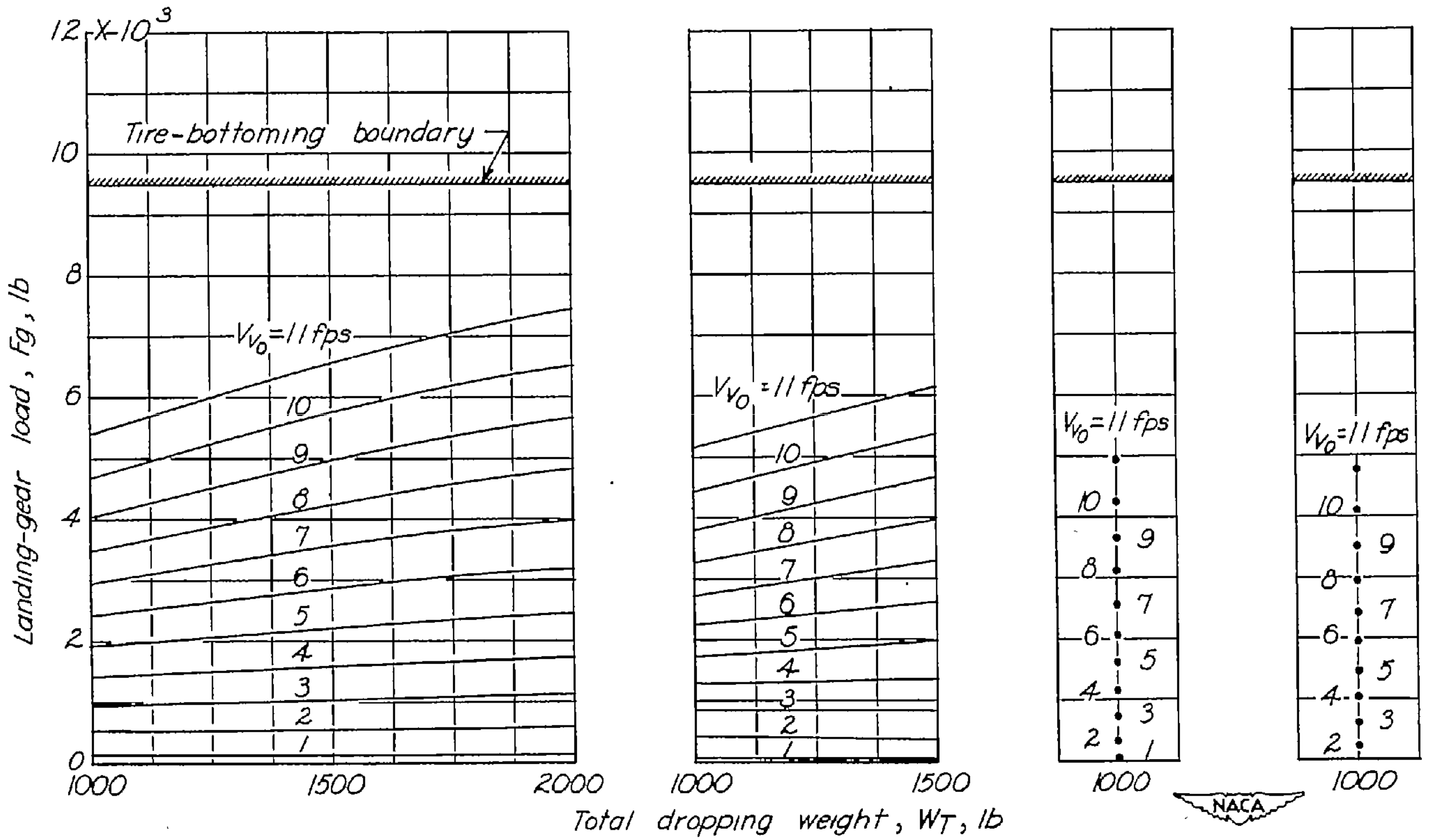
(c) $K_L = 0.75$.

Figure 7.- Continued.



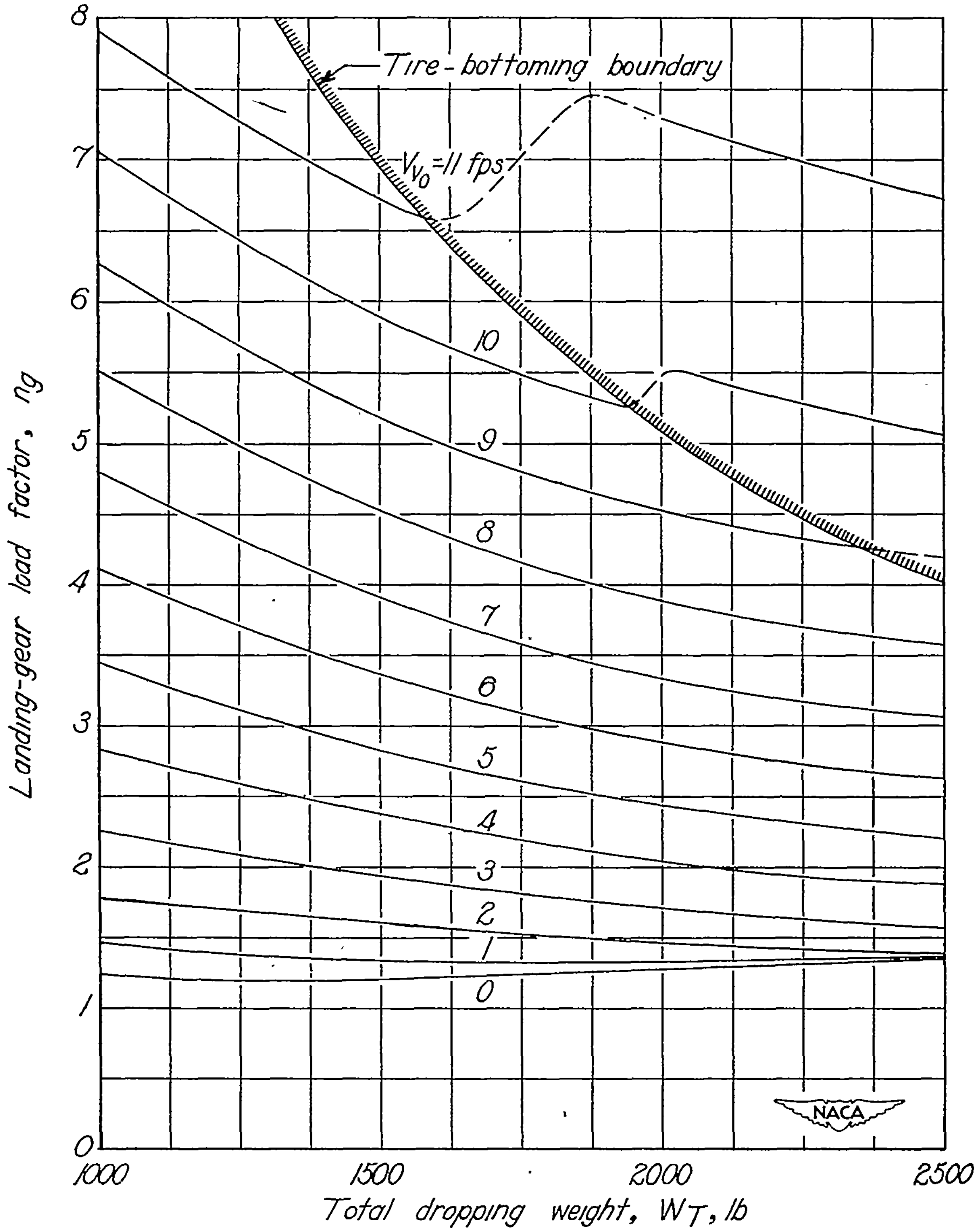
(d) $K_L = 1.00$.

Figure 7.- Continued.



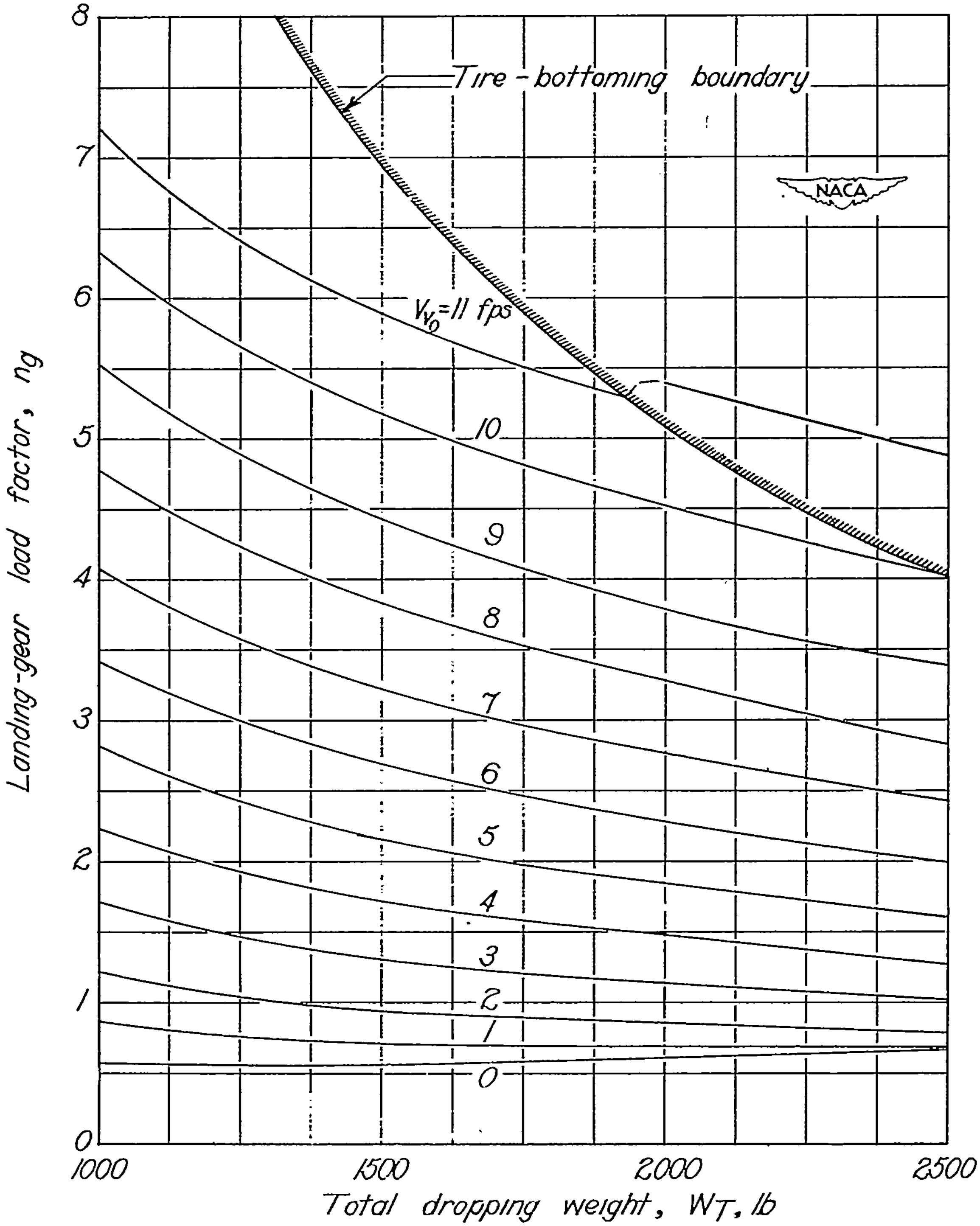
(e) $K_L = 1.25$. (f) $K_L = 1.50$. (g) $K_L = 1.75$. (h) $K_L = 2.00$.

Figure 7.- Concluded.



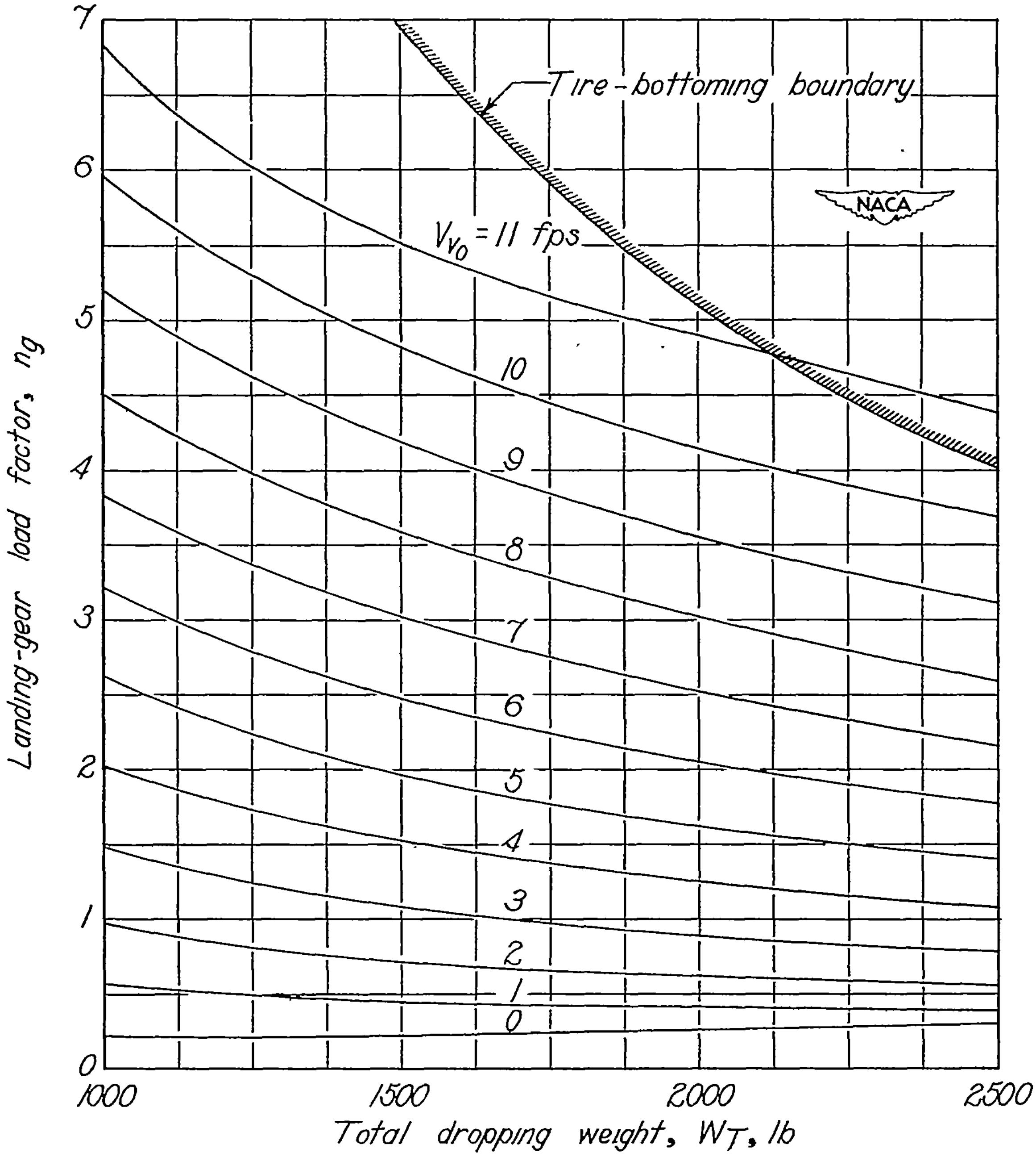
(a) $K_L = 0$.

Figure 8.- Effects of weight on landing-gear load factor.



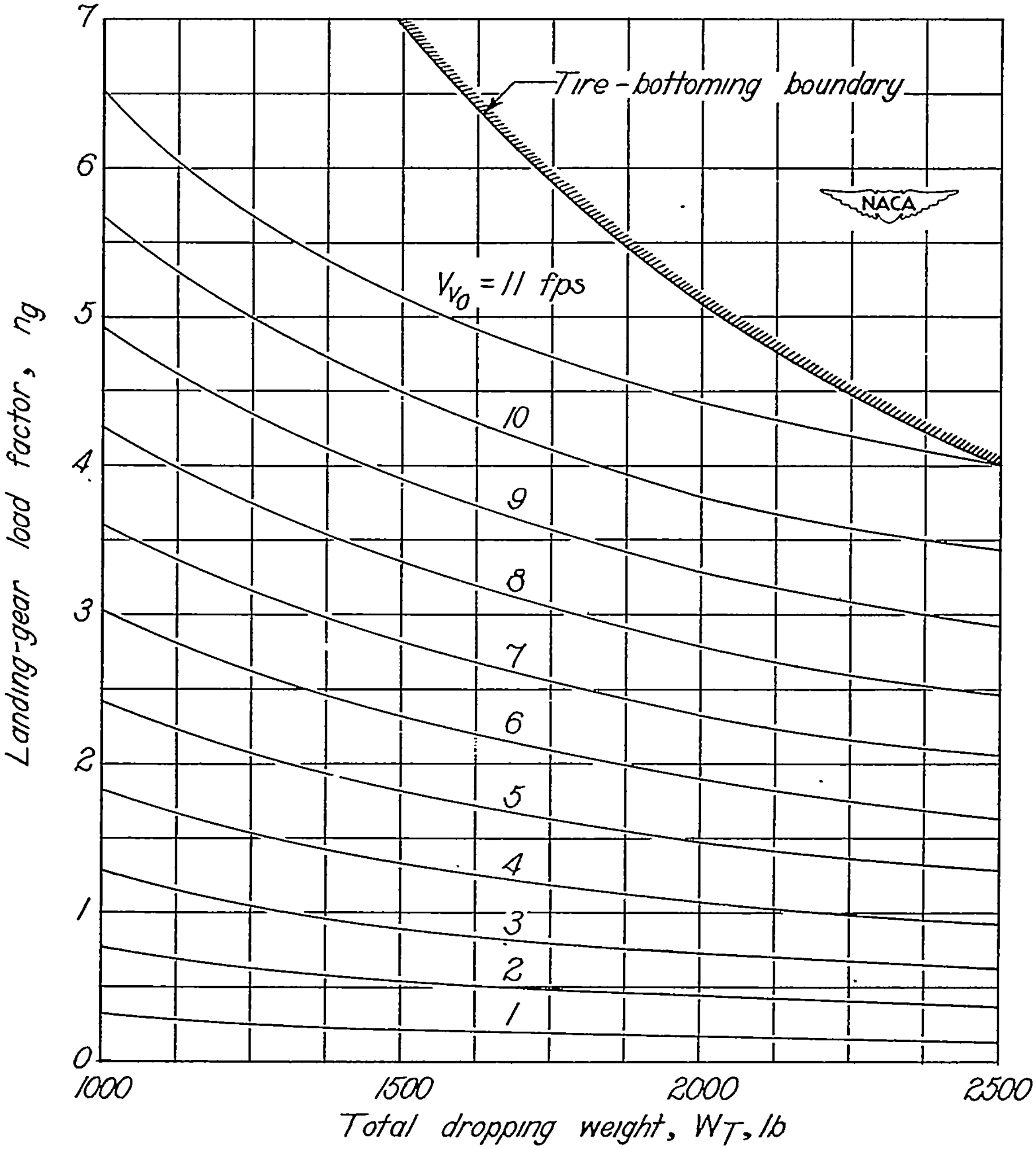
(b) $K_L = 0.50$.

Figure 8.- Continued.



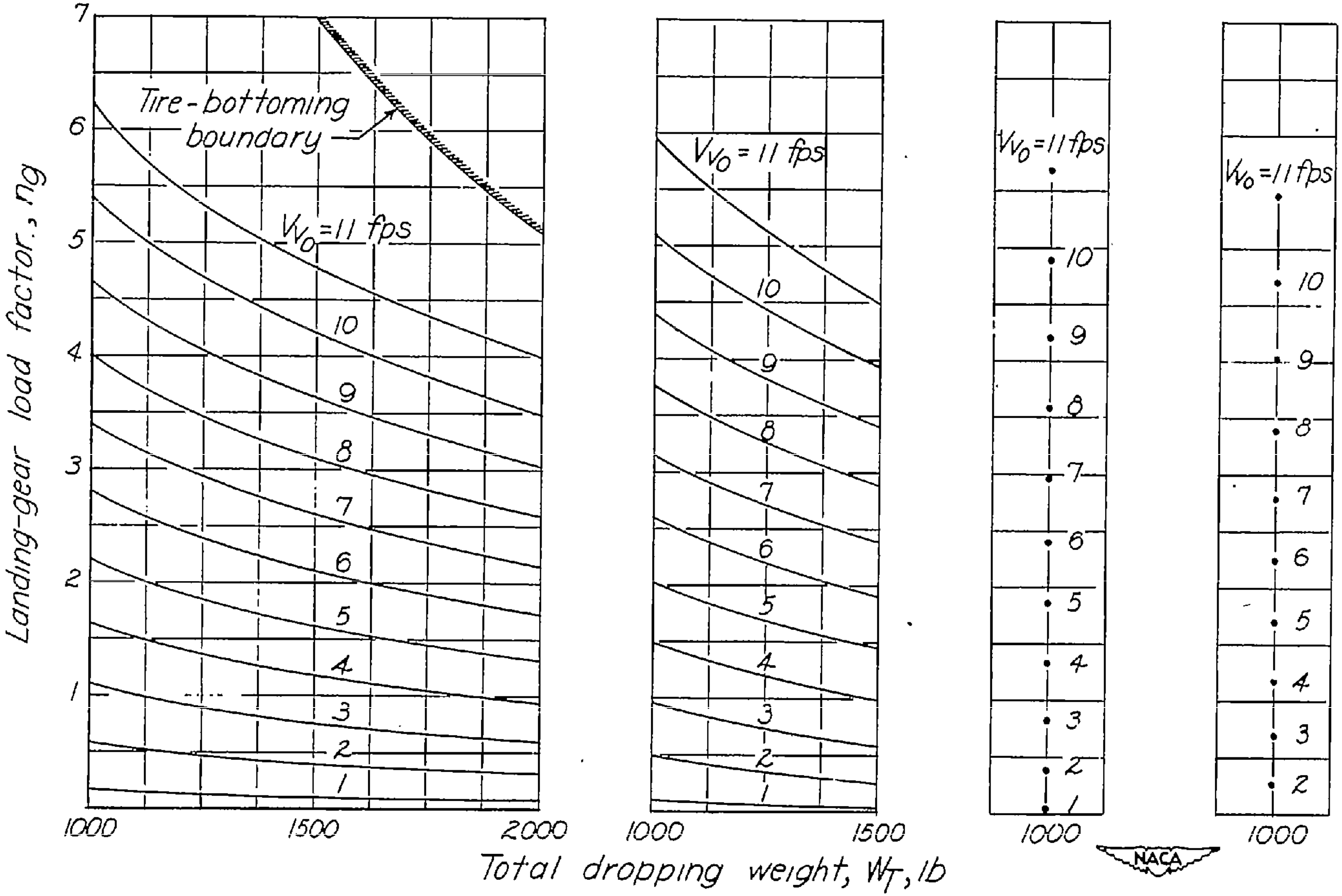
(c) $K_L = 0.75$.

Figure 8.- Continued.



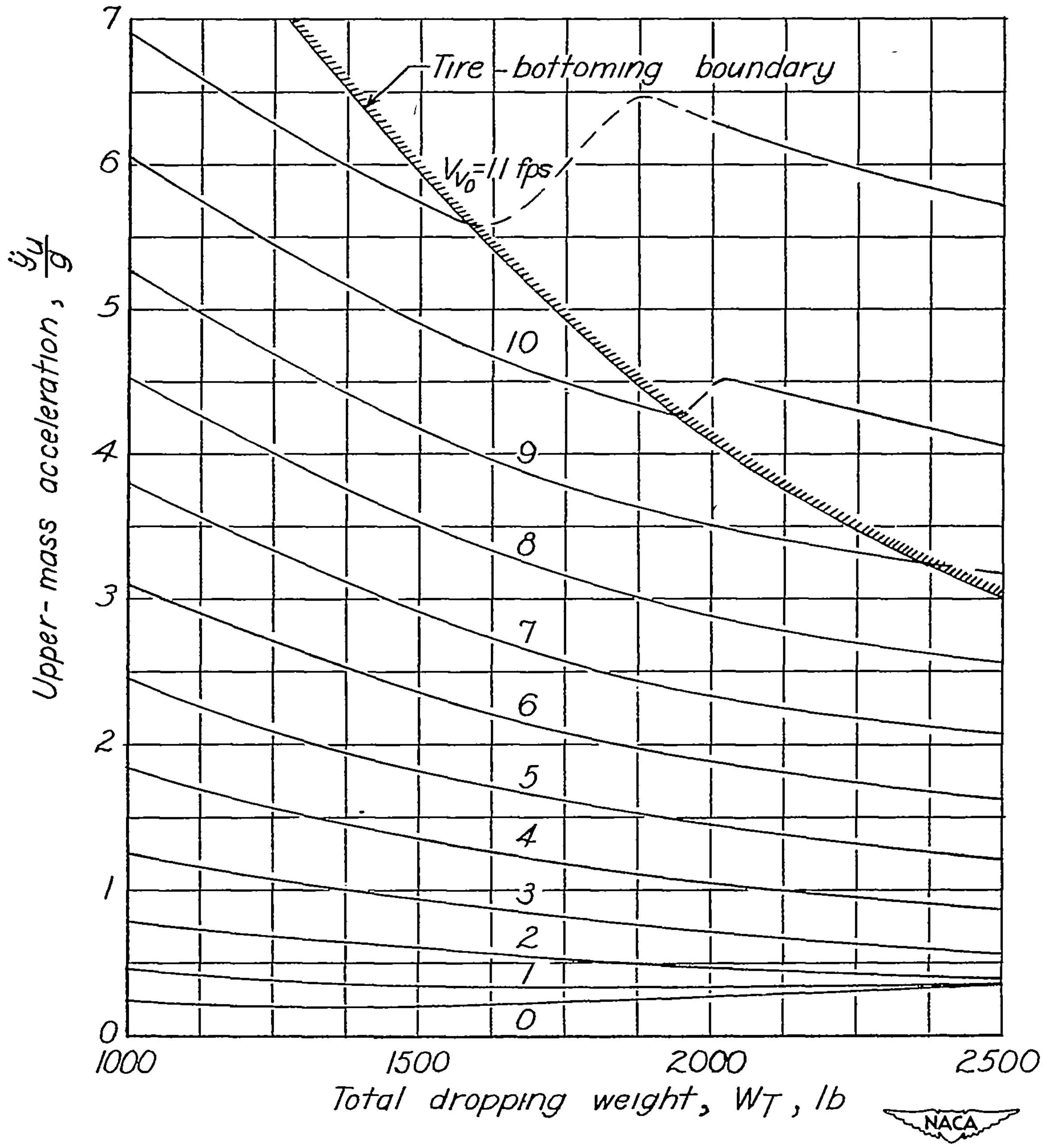
(d) $K_L = 1.00$.

Figure 8.- Continued.



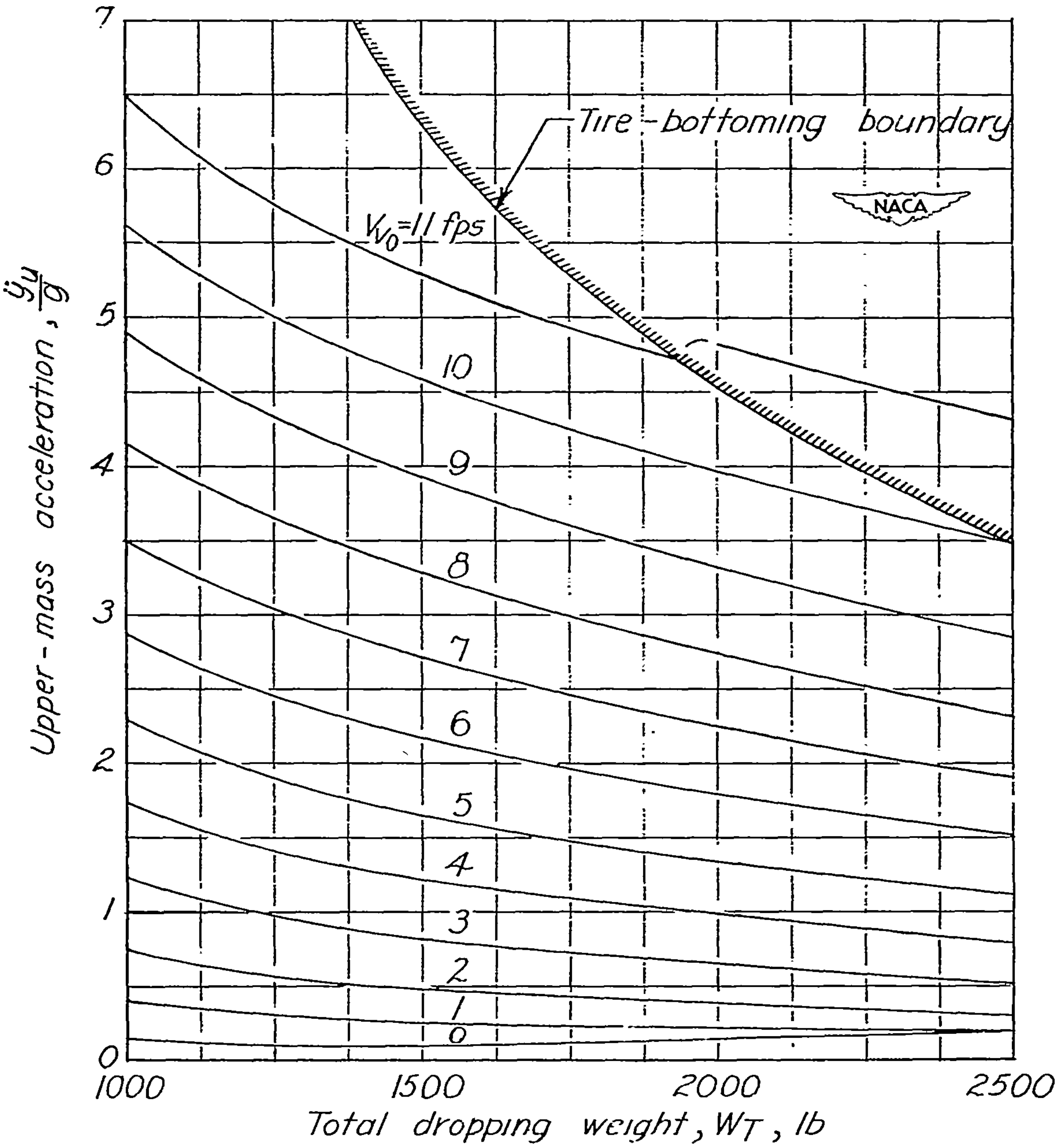
(e) $K_L = 1.25$. (f) $K_L = 1.50$. (g) $K_L = 1.75$. (h) $K_L = 2.00$.

Figure 8.- Concluded.



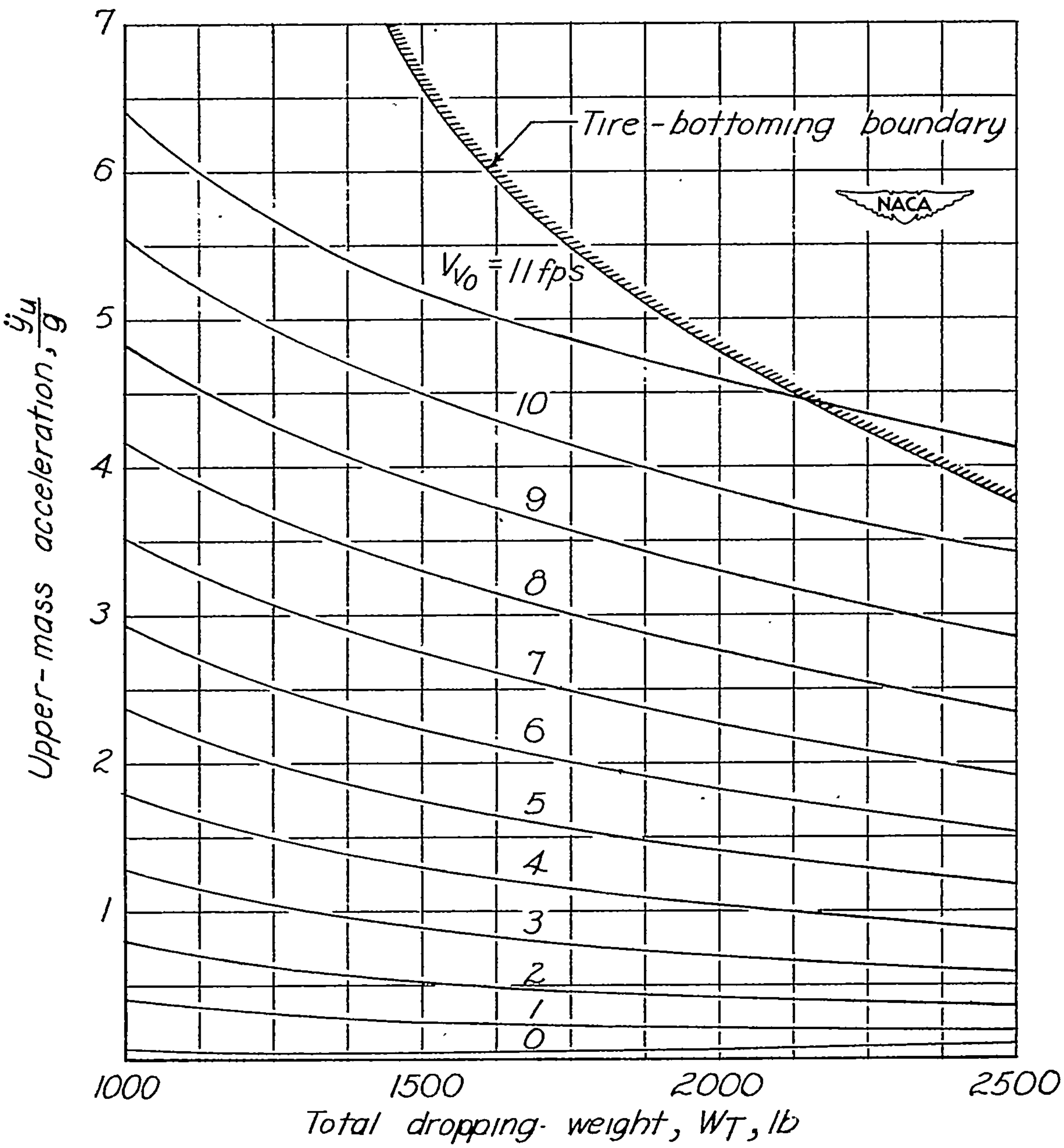
(a) $K_L = 0$.

Figure 9.- Effects of weight on upper-mass acceleration.



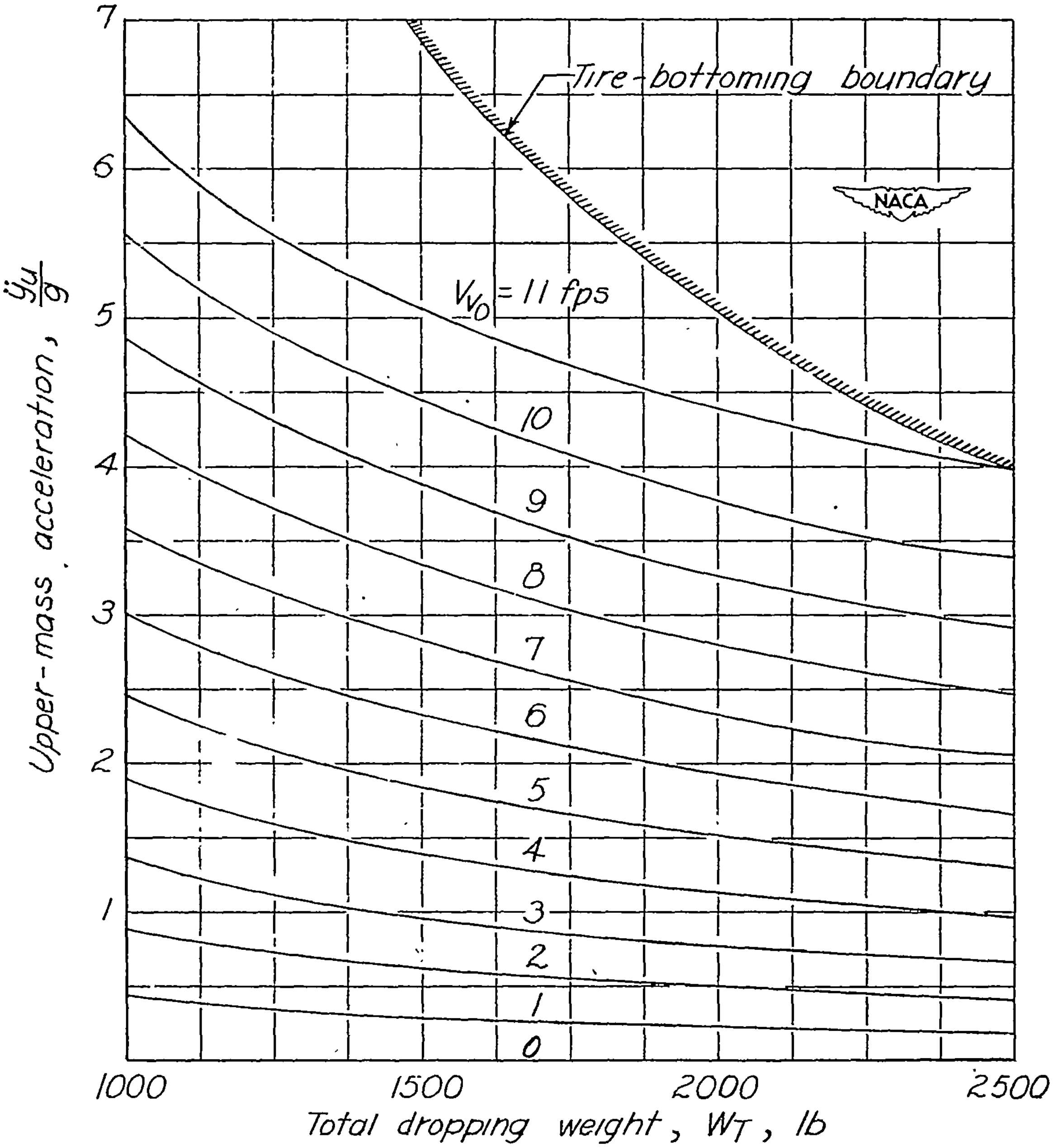
(b) $K_L = 0.50$.

Figure 9.- Continued.



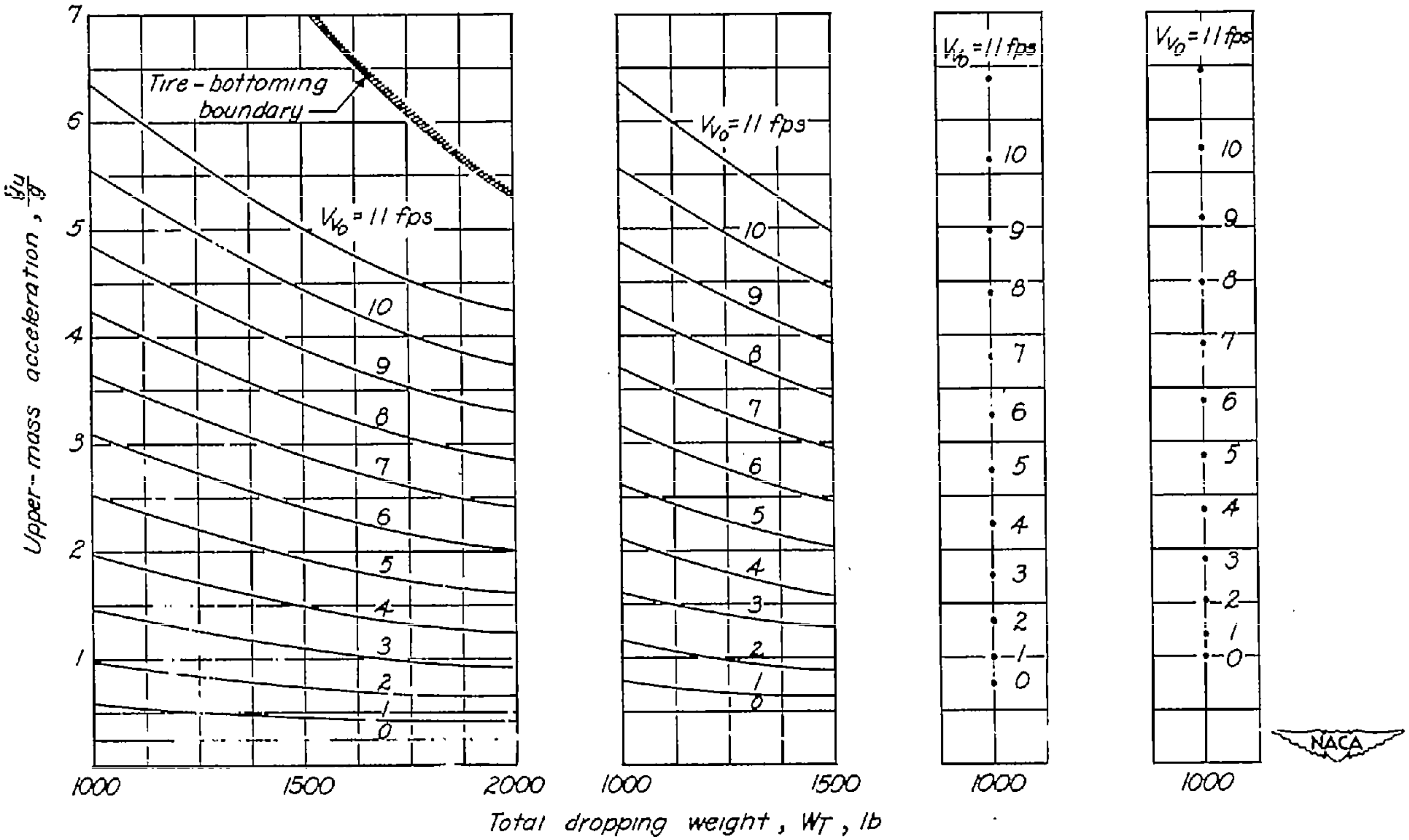
(c) $K_L = 0.75$.

Figure 9.- Continued.



(d) $K_L = 1.00$.

Figure 9.- Continued.



(e) $K_L = 1.25$. (f) $K_L = 1.50$. (g) $K_L = 1.75$. (h) $K_L = 2.00$.

Figure 9.- Concluded.

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