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RESEARCH MEMORANDUM

LANDING AND TAXIING TESTS OVER VARIOUS TYPES OF RUNWAY LIGHTS

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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LANDING AND TAXIING TESTS OVER VARIOUS TYPES OF RUNWAY LIGHTS[1]

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SUMMARY

An investigation was made at the Langley landing-loads track to obtain data on the landing-gear loads developed during landing and taxiing tests over various types of runway lights. The tests were made at forward speeds of 112 to 167 feet per second with a fighter nose landing gear and of 13.8 to 143 feet per second with a larger main landing gear. The results show the increase in loads caused by striking the lights.

INTRODUCTION

For the past several years a great deal of effort has been devoted to the improvement of runway lighting in order to reduce the minimum visibility requirements which currently impose a severe limit on flight operations in poor weather. The results of some recent flight tests have indicated that, when lights are installed along the runway center line in the landing area, most aircraft are capable of landing safely under conditions that approach zero ceiling and zero visibility. Because of the favorable results obtained during these tests, the operators of both military and civil aircraft are now very anxious to have this type of lighting installed on all major runways. These lights, in order to provide adequate illumination, must protrude above the runway surface because a flush light cannot transmit light parallel to the surface and, in addition, is difficult to see at the very low angles which are characteristic of aircraft approaches. Since the lights must be installed in the landing areas, airplanes will land and taxi over them many times. At the present time there are no data available regarding the effect that striking these protruding lights will have on the loads developed on the aircraft.

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[1]The information presented herein was previously given limited distribution.

In order to obtain information on this problem, the National Advisory Committee for Aeronautics has conducted a series of landing and taxi tests over some of the proposed lights at the Langley landing-loads track. Also included were tests of several types of runway edge lights. It is the purpose of this paper to present the results of this investigation.

Most of the tests were made with a small fighter nose gear at forward speeds of 112 to 167 feet per second; however, some tests were made with a larger landing gear at forward speeds of 13.8 to 143 feet per second.

The experimental data are presented in tabular and time-history form with no attempt at detailed analysis.

DESCRIPTION OF LIGHTS USED FOR TESTS

This investigation was carried out with five different lights (figs. 1 to 5). Figures 1 and 2 are the Elfaka and Westinghouse lights which are proposed for installation in the runway landing areas. Figures 3 to 5 show the edge lights.

Figure 6 is a drawing of the Elfaka light (Structural Concrete Products Corp., New York 16, N. Y.) and shows the pertinent dimensions. The light source is located under the flat steel plate and shines out through the grating. The front of the grating is level with the runway surface and the grating rises 1/2 inch from front to rear. The surface of the flat metal plate lies 1/2 inch above the runway. When installed, the concrete surrounding the light on the sides as well as in the rear is sloped down to the runway at an angle of about 1°. In order to simplify changing the orientation of the light in the runway, the unit tested was a casting made with the actual light as a pattern but with some modifications to the under side. In addition, the length of the 6-inch-wide steel plate at the end of the grating was reduced from approximately 4 feet to 2 feet. Figure 7 is a drawing of the unit used for these tests.

The Westinghouse light (Westinghouse Electric Corp., Pittsburgh 30, Pa.), shown in figure 2, is 12 inches in diameter and protrudes 7/8 inch above the runway surface. Light from a source located directly beneath the cover is transmitted along the runway by a system of lenses which are built into the glass top. Since raising the light improves its illumination characteristics, tests were also made with this light raised 5/8 inch. Figure 8 is a photograph of the Westinghouse light raised 5/8 inch.

The AGA expendable-top light (AGA, Div. of Elastic Stop Nut Corp. of America, Elizabeth, N. J.), shown in figure 3, derives its light from a source located beneath the runway surface and the light is reflected along the runway in each direction by the two reflectors supported in the plastic top. The top is approximately $5\frac{1}{8}$ inches high and $7\frac{1}{8}$ inches in diameter; it is very light and merely shatters when it is struck by the landing gear wheel.

The C-1 light (Westinghouse Electric Corp. and Revere Electric Mfg. Co., Chicago 40, Ill.), shown in figure 4, is approximately $12\frac{1}{2}$ inches high and is mounted on a frangible coupling. The coupling is made to fracture approximately 1/4 inch above ground level upon collision.

The ANL-9 light (Revere Electric Mfg. Co.), shown in figure 5, is approximately $9\frac{1}{4}$ inches in diameter and protrudes 3 inches above the runway surface. The light source is located below the runway and reflected in the desired direction through a system of lenses in the glass portion of the top.

APPARATUS, TEST PROCEDURE, AND INSTRUMENTATION

Method of Testing

The tests were made by simulating actual landings and taxi runs during which the landing gear wheel ran over the lights. The landing gear was mounted on the carriage at the Langley landing-loads track which was brought up to the desired horizontal velocity by means of a hydraulic jet catapult. (See ref. 1.) Figure 9 is a photograph of the carriage, which is 60 feet long, 30 feet wide, and weighs approximately 100,000 pounds. The carriage straddles a concrete runway having surface characteristics which are representative of most presently used runways. All the lights tested were mounted in this runway. In the landing-impact tests initial touchdown occurred on and in the vicinity ahead of the light. During the taxi tests initial touchdown was made well ahead of the light. Two landing gears were used during the test, an F-94C nose landing gear and a B-57 main gear.

F-94C Nose-Landing-Gear Tests

Figure 10 is a schematic drawing of the F-94C nose-landing-gear test apparatus which was used to attach the landing gear to the carriage. The nose landing gear was mounted rigidly near the end of an arm which pivoted in a vertical plane about a bearing attached to the main carriage. The steel plate attached to the arm added sufficient weight to simulate the maximum static load condition. The landing gear was normal to the arm and was supported at its two trunnion points and at the drag link attachment. This method of support held the yaw attitude of the upper part of the landing gear fixed rigidly at 0°. The only restraints to yawing of the wheel were the shimmy damper and wheel trail angle. Figure 11 is a photograph of the F-94C nose landing gear mounted for testing.

The landing gear was equipped with a 20×4.4, type VII, 10-ply-rating tire. The tire inflation pressure was 150 pounds per square inch, and the pressure in the oleo-pneumatic shock absorber was 202 pounds per square inch, when fully extended. This pressure corresponds to the heavily loaded condition. The static load between the tire and runway surface was 2,150 pounds, and the weight of the lower or unsprung portion of the strut, which includes the wheel, tire, and fork, was 60 pounds.

Prior to each test the landing gear was raised so that the tire was $6\frac{1}{8}$ inches above the runway. It was held in this position by a bomb shackle mounted on the main carriage. During the test, the bomb-shackle release was actuated at a predetermined point along the track allowing the landing gear to fall freely. No provision was made for simulating wing lift forces during these tests. The vertical velocity at the instant of touchdown for all tests was 5.7 feet per second and the horizontal velocity covered a range between 112 and 167 feet per second. The test apparatus was positioned so that the landing gear was essentially vertical throughout the entire impact. Most of the tests were made with the wheel set at a yaw angle of 0°. Some tests, however, were made with the wheel yawed $8\frac{1}{3}^{\circ}$ (clockwise rotation when viewed from above). This was accomplished by rotating only the lower portion of the gear. The wheel was held in this position against the restraint of the shimmy damper by a cable which was released just before the wheel touched down on the runway.

Tests were made on the Elfaka light mounted in three different positions in the runway. The positions will be referred to as A, B, and C. Figure 1 shows the light mounted in position A. In this position, the longitudinal center line of the light coincided with the center line of the runway, and the landing gear wheel traveled in the trough directly down the center of the grating. Position B was obtained by shifting the entire light 1 inch transversely so that the tire rolled along the top of one of the ribs in the grating. For position C the light was rotated $8\frac{1}{3}^{\circ}$ (clockwise when viewed from above) to obtain a diagonal traverse of the grating. In this position, the wheel entered midway between the first two ribs on the right side of the grating (right side as viewed from an airplane approaching the light). Figure 12 is a photograph of the light in position C. In all the positions concrete was placed around the light so that the wheel experienced the same changes in elevation while traveling over the light and adjacent concrete as occur on an actual installation.

Instrumentation was provided to measure the vertical and drag loads developed upon striking the lights. Strain-gage accelerometers were mounted on the apparatus in the locations shown in figure 13. Also shown in this figure is the load cell used to measure the load in the drag strut. The vertical load developed between the tire and the lights on the runway was obtained by summing the vertical inertia reactions of the upper and lower masses at the desired instant of time. Drag loads applied to the tire were obtained by summing the horizontal component of load measured by the drag strut and the inertia reaction of an effective lower mass in the drag direction. An effective lower mass must be used for determining drag loads since in this direction there is no clearly defined boundary between the upper and lower masses as exists in the vertical direction. The value obtained for the lower mass was 1.39 slugs. The method used for determining the effective lower mass is described in the appendix. A correction was applied to the drag strut load to eliminate the effect of the moment caused by the vertical load acting 2 inches behind the strut vertical axis. (See fig. 10.)

Although wire resistance strain gages were mounted on the nose landing gear in the locations shown in figure 13, they were not used during a large part of the investigation. About midway in the test program the connections to these gages were destroyed during an impact with one of the lights. Since only low values of unit stress had been recorded up to this point, these gages were not put back into service.

B-57 Main-Landing-Gear Tests

A limited investigation, consisting only of taxi tests, was made with the B-57 main landing gear. Figure 14 is a photograph of this gear mounted on the carriage. The static weight on the tire was 20,000 pounds, and the weight of the lower or unsprung portion of the gear was 534 pounds. The landing gear was equipped with a 44x13, type VII, 26-ply-rating tire. The tire pressure was 140 pounds per square inch, and the pressure in the oleo-pneumatic shock strut when fully extended was 292 pounds per square inch. All runs were made with this landing gear arbitrarily inclined forward at a fixed angle of 15° to the vertical. The horizontal and vertical loads between the tire and the lights were measured by a dynamometer built into the main carriage. Appropriate inertia corrections were made through the use of accelerometers mounted on the landing gear.

RESULTS AND DISCUSSION

F-94C Nose-Landing-Gear Tests

The effects of striking the various types of lights during landing impact and taxiing are shown in figures 15 to 25. The test conditions and the maximum loads and accelerations for landings made on plain concrete are listed in table I. Table II contains similar values for the landing impacts and taxi runs made on the lights. It is important to note that the values appearing in table II are a direct result of striking the light, and most of them were obtained while the wheel was in actual contact with the light. The values of vertical acceleration appearing in the figures and tables are increments above the 1 g datum.

Elfaka light unit.- In tables I and II and in figure 15, it can be seen that, in general, larger values of maximum vertical load were obtained during landings on the Elfaka light than on plain concrete. This was caused primarily by the tire, which had been forced down into the grating, being forced to climb out onto the flat metal plate. (See fig. 7.) The maximum drag loads listed in the tables show that smaller loads were developed on the light than on concrete. It was also found that for certain test conditions, the wheel developed marked yawing oscillations while negotiating the light.

The effect of the light on vertical load is illustrated in figure 16 where the maximum incremental upper mass vertical acceleration is plotted against the distance between initial touchdown and the Elfaka light unit. Upper mass accelerations are presented rather than the actual vertical loads, because small irregularities in the runway cause appreciable distortions of the load data. Maximum acceleration occurred on the light only for the group of tests in which touchdown ranged between 12 and 34 feet in front of the light, and in each of these tests the maximum acceleration occurred at climbout. This figure and figure 17 shows that the acceleration caused by climbout was as much as 60 percent greater than the acceleration developed during landings on plain concrete. Furthermore, the largest accelerations were obtained during landings made on the yawed light. Figure 16 also indicates that the loads are independent of the lateral position of the wheel on the light, since the same load was obtained when the wheel traveled along the ridge of the grating and in the trough. A comparison of the two triangle points, for which touchdown occurred at 12.5 and 26 feet in front of the light, show that the maximum load is larger when climbout occurs late in the impact. This is illustrated in figure 18 which shows time histories of the vertical accelerations obtained during these two tests.

The effect of the light on drag load was apparent only during the period in which the wheel was being spun up to full rolling velocity. Figure 19 shows that with the exception of an initial high peak, caused by climbout, the drag load developed on the light was much smaller than on concrete. Since the vertical loads for both tests were substantially the same while the wheel was negotiating the light, the spin-up coefficient of friction developed on the light was smaller than on concrete.

High-speed moving pictures (1,000 frames per second) showed rather violent yawing oscillations of the wheel during the tests in which the light was yawed and initial touchdown occurred either on the grating or less than a foot in front of it. In this group of tests, the largest oscillations occurred during the yawed wheel landings. Figure 20 is a photograph of the track made by the wheel during one of these runs and shows that the landing gear experienced a considerable amount of side deflection while passing over the light.

Westinghouse light.- The values in table II and figure 21 show that the maximum vertical load developed during a landing impact on the normal Westinghouse light installation is approximately the same as those obtained for the unyawed Elfaka light. The tables also indicate that the maximum vertical loads developed during taxi tests over this light were almost as large as the maximum impact loads obtained during the landing tests made on plain concrete. Figure 22(a) shows the large lower mass vertical acceleration obtained during one of these tests and indicates that these loads are primarily caused by the rapid rise experienced by the wheel while rolling over the light. It can be seen in figure 22(b) that raising the light 5/8 inch caused some increase in the vertical and drag loads; however, the most significant result was the large increase in the upper mass vertical accelerations.

AGA expendable-top edge light.- One taxi test was made over the AGA expendable top light. The loads developed in the landing gear while rolling over this light were small, however, some tire damage occurred during this run. Figure 23 is a photograph of the tire taken immediately after the run and shows the cuts caused by rolling over this light. Figure 24 is a photograph of the light taken immediately after the test.

C-1 edge light.- One taxi test was made during which the landing gear struck the C-1 light. Table II shows that most of the instruments were driven off scale, indicating that the highest loads obtained from this investigation were developed during this test. Taxiing over this light also resulted in a considerable amount of tire cutting.

ANL-9 edge light.- One taxi test was made over the ANL-9 semiflush light. During this run the rim of the landing gear wheel was bent while passing over the light. Figure 25 is a photograph of the wheel damage which occurred during the run.

B-57 Main-Landing-Gear Tests

As stated previously, only taxi tests were made with the B-57 main landing gear. The maximum vertical and drag loads developed between the light and tire and the horizontal velocity of the gear are listed in table III. The maximum vertical load was obtained during a test over the ANL-9 light; however, tests with all the lights gave comparable loads. This load was almost 40 percent greater than the static ground load for this landing gear. The maximum drag load was obtained during a test made with the C-1 light, and was approximately 60 percent of the static ground load. This is in contrast to the data obtained with the F-94C gear which indicated that vertical and drag loads obtained during tests of these same lights were very much larger than the static loads. This would indicate that the loads developed on a small landing gear while taxiing over these lights are relatively more severe than those developed on a larger gear.

During the series of four tests which were made over the ANL-9 light (table III), the horizontal velocity was different for each test, varying from 13.8 to 143 feet per second. It is interesting to note that the maximum drag loads developed during taxiing over the light occurred during the tests made at the intermediate velocities. This indicates that the dynamic response characteristics of the landing gear have an effect on the value of the drag load over the range of velocities covered during this series of tests.

SUMMARY OF RESULTS

The principal results indicated by these tests are as follows:

1. Larger vertical loads were obtained during landings of the F-94C nose landing gear on the Elfaka and Westinghouse light than on plain concrete.

2. Yawing oscillations of the F-94C nose landing gear wheel were developed during landings on the yawed Elfaka light when initial touchdown occurred on the grating, or less than a foot in front of it.

3. The loads developed on the small nose landing gear while taxiing over the lights were relatively more severe than those developed on the larger main gear.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., March 21, 1958.

APPENDIX

METHOD USED TO DETERMINE EFFECTIVE LOWER MASS ACTING IN DRAG DIRECTION

The apparatus shown in figure 10 was set up with the tire clear of the ground and the landing gear vertical. A drag load was applied to the wheel axle and suddenly released. During the ensuing vibration, measurements were obtained of the lower mass acceleration and the load in the drag strut. The values of the horizontal component of load in the drag strut were plotted against axle accelerations obtained at the same time. These data are shown in figure 26. The slope of the line indicates the value of the effective lower mass acting in the drag direction. Figure 26 shows that this value was, for all practical purposes, independent of shock strut displacement.

REFERENCE

1. Joyner, Upshur T. and Horne, Walter B.: Considerations on a Large Hydraulic Jet Catapult. NACA TN 3203, 1954. (Supersedes NACA RM L51B27.)

TABLE I

TEST CONDITIONS AND MAXIMUM LOADS AND ACCELERATIONS OBTAINED DURING

LANDING IMPACTS ON CONCRETE (F-94C NOSE LANDING GEAR)

Test number	Landing gear yaw angle, deg	Vertical load, lb	Drag load, lb	Hori-zontal speed, fps	Drag strut load, lb	Upper mass vertical acceleration, g units (a)	Lower mass vertical acceleration, g units (a)	Lower mass drag acceleration, g units	Lower mass side acceleration, g units
1	0	6,230	2,400	160	10,905	2.00	17	32.1	9.2
2	0	6,540	2,300	145	10,655	2.13	13	30.6	11.3
3	$8\frac{1}{3}$	6,090	2,495	162	11,555	1.77	13	30.8	15.7
4	$8\frac{1}{3}$	6,270	2,070	158	9,560	1.97	14	29.3	18.2

[a]Acceleration values are increments above 1 g datum.

TABLE II

TEST CONDITIONS AND MAXIMUM LOADS AND ACCELERATIONS OBTAINED

DURING CONTACT WITH LIGHT (F-94C NOSE LANDING GEAR)

Light	Test number	Vertical load, lb	Drag load, lb	Horizontal speed, fps	Drag strut load, lb	Upper mass vertical acceleration, g units (a)	Lower mass vertical acceleration, g units (a)	Lower mass drag acceleration, g units	Lower mass side acceleration, g units	Distance from touchdown to light, ft	Remarks
Elfaka light in position A; nose-wheel yaw angle 0°	5	4,870	2,040	166	11,710	1.45	20	24.3	----	-3.0	Touchdown on light
	6	4,890	-----	159	9,680	1.01	25	----	----	1.0	
	7	3,590	290	157	1,385	.56	18	5.2	----	226	Taxi test
	8	3,440	175	143	1,240	.45	15	4.4	----	252	Taxi test
	9	2,760	70	138	1,190	.38	7	6.1	----	234	Taxi test
	10	3,100	75	112	1,470	.46	14	5.4	----	240	Taxi test
	11	3,750	80	155	940	.58	15	3.3	----	41.8	Maximum vertical load occurred 11 feet ahead of light
	12	7,320	125	166	1,675	2.50	33	5.9	----	33.6	Maximum vertical load occurred on light
	13	7,790	0	166	1,295	2.62	29	8.1	----	27.7	Maximum vertical load occurred on light
	14	7,430	395	160	1,860	2.63	27	5.3	----	27.1	Maximum vertical load occurred on light
	15	7,490	110	155	2,770	2.63	16	15.2	----	21.8	Maximum vertical load occurred on light
	16	7,270	-----	153	3,880	2.57	11	----	----	17.5	Maximum vertical load occurred on light
	17	5,180	-----	157	5,325	1.27	12	----	----	6.0	Maximum vertical load occurred 15 feet past front of light
Elfaka light in position B; nose-wheel yaw angle 0°	18	4,270	1,810	160	7,815	1.39	33	34.3	11.3	-1.3	Touchdown on light
	19	7,870	65	162	1,320	2.52	20	6.8	16.6	28.8	Maximum vertical load occurred on light
	20	5,370	60	156	1,490	1.36	18	5.4	22.3	36.5	Maximum vertical load occurred 8 feet ahead of light
Elfaka light in position C; nose-wheel yaw angle 0°	21	5,820	1,350	160	7,145	1.41	49	29.3	58.6	.7	
	22	3,590	40	154	1,545	.36	14	10.5	6.4	254	Taxi test
	23	8,290	125	164	2,490	2.97	21	10.2	18.2	24.0	Maximum vertical load occurred on light
	24	8,350	40	164	2,520	3.15	21	13.7	24.3	24.5	Maximum vertical load occurred on light
	25	8,730	140	161	1,645	3.26	22	5.8	20.4	25.0	Maximum vertical load occurred on light
	26	5,720	0	160	1,085	1.83	17	3.7	16.1	37.8	Maximum vertical load occurred 5.6 feet ahead of light
Elfaka light in position C; nose-wheel yaw angle $8\frac{1}{3}°$	27	6,460	1,630	162	8,940	1.27	51	50.9	42.9	-.8	Touchdown on light
	28	-----	-----	167	8,575	----	42	20.4	53.5	-1.5	Touchdown on light
	29	7,370	1,690	149	5,130	2.19	17	16.9	31.4	12.5	Maximum vertical load occurred on light
	30	10,170	970	159	5,030	3.22	31	5.7	----	26.0	Maximum vertical load occurred on light
Westinghouse semiflush light	31	4,930	870	143	2,630	.40	44	25.9	9.6	576	Taxi test
	32	5,027	830	154	2,365	.37	49	27.8	13.2	357	Taxi test
	33	4,830	820	143	1,610	.20	51	19.5	----	370	Taxi test
	34	5,470	1,060	154	2,450	.42	54	21.4	----	355	Taxi test
	35	7,150	910	143	2,300	1.50	37	36.5	----	15.9	Maximum vertical load occurred 1.5 feet past light
	36	7,950	760	154	2,250	2.38	40	39.1	----	21.8	Maximum vertical load occurred on light
Westinghouse semiflush light raised $\frac{5}{8}$ inch	37	5,670	1,570	154	4,480	1.27	58	53.8	16.4	274	Taxi test
	38	5,830	1,440	143	4,720	1.55	56	58.2	16.6	313	Taxi test
	39	5,400	1,740	154	5,170	1.40	56	56.9	15.2	366	Taxi test
AGA expendable-top	40	4,940	1,730	143	2,860	.25	56	47.5	26.9	282	Taxi test
C-1 runway marker	41	[b]11,000	[b]6,390	154	25,610	[b]5.95	57	[b]60.0	53.5	352	Taxi test
AN-L-9	42	7,520	[b]4,945	160	14,005	4.22	54	[b]60.7	64.5	352	Taxi test

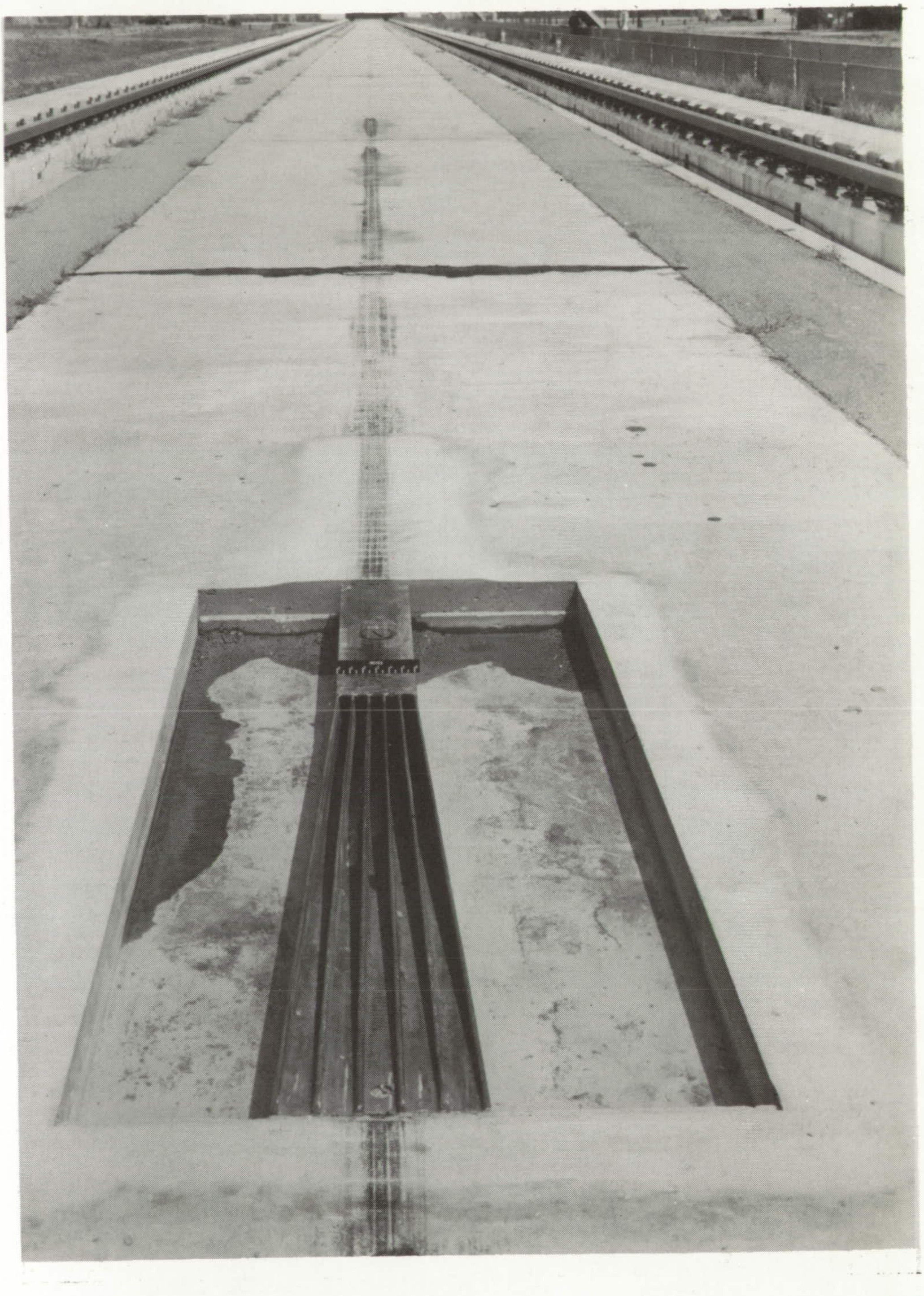
[a]Acceleration values are increments above 1 g datum.

[b]Accelerometer hit stop.

TABLE III

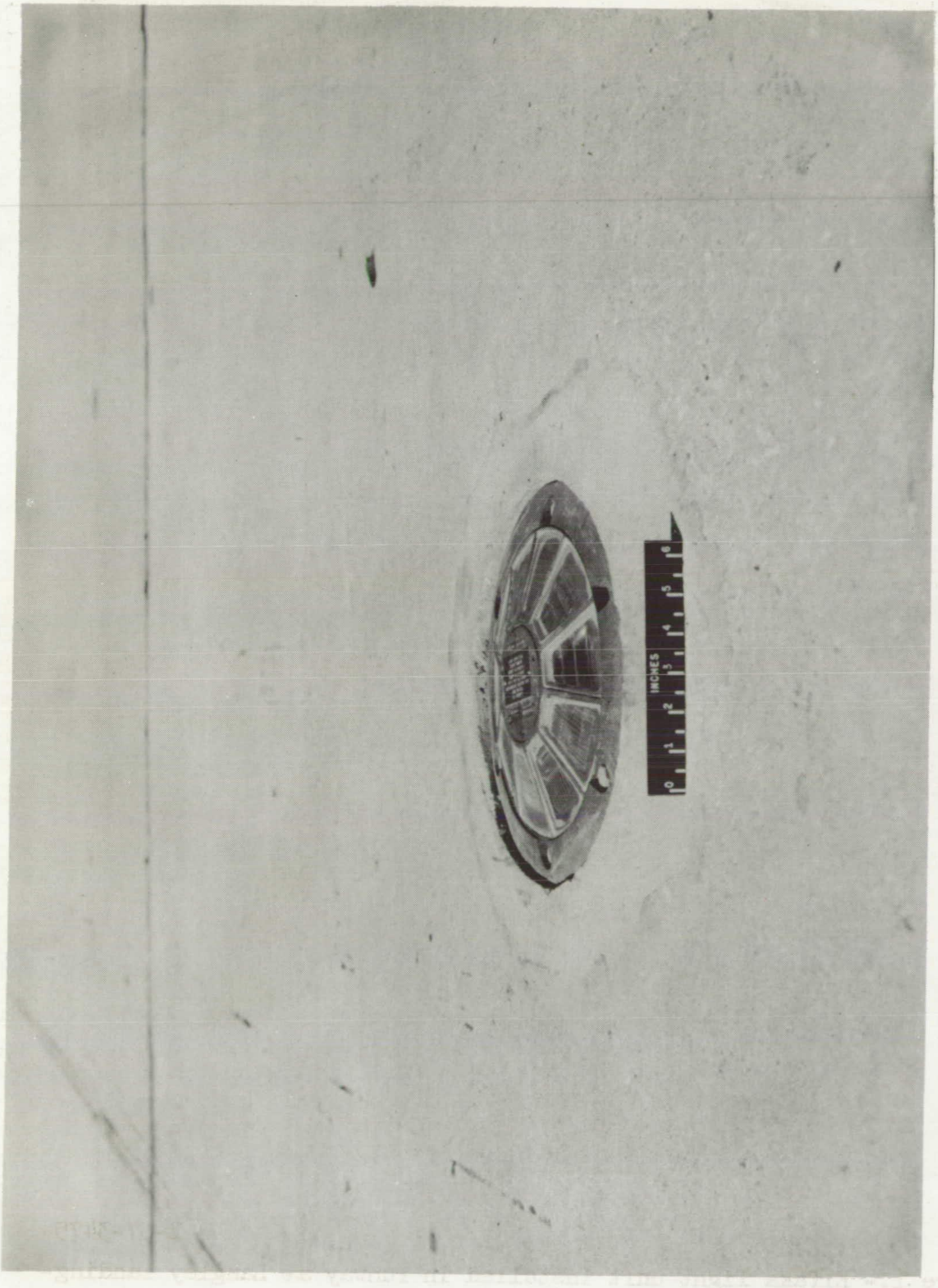
MAXIMUM LOADS AND FORWARD SPEEDS FOR B-57 MAIN LANDING GEAR

Light	Maximum vertical load, lb	Maximum drag load, lb	Horizontal velocity, fps
C-1	26,610 26,939	8,841 11,919	32.2 132.0
Westinghouse semiflush	27,101	1,578	133.0
AN-L-9	25,619 27,236 25,777 28,206	3,167 7,256 7,208 5,873	13.8 54.0 78.5 143.0



L-57-3475

Figure 1.- Elfaka light unit installed in runway at Langley landing-loads track (position A).



L-57-4070

Figure 2.- Westinghouse light unit installed in runway at Langley landing-loads track.

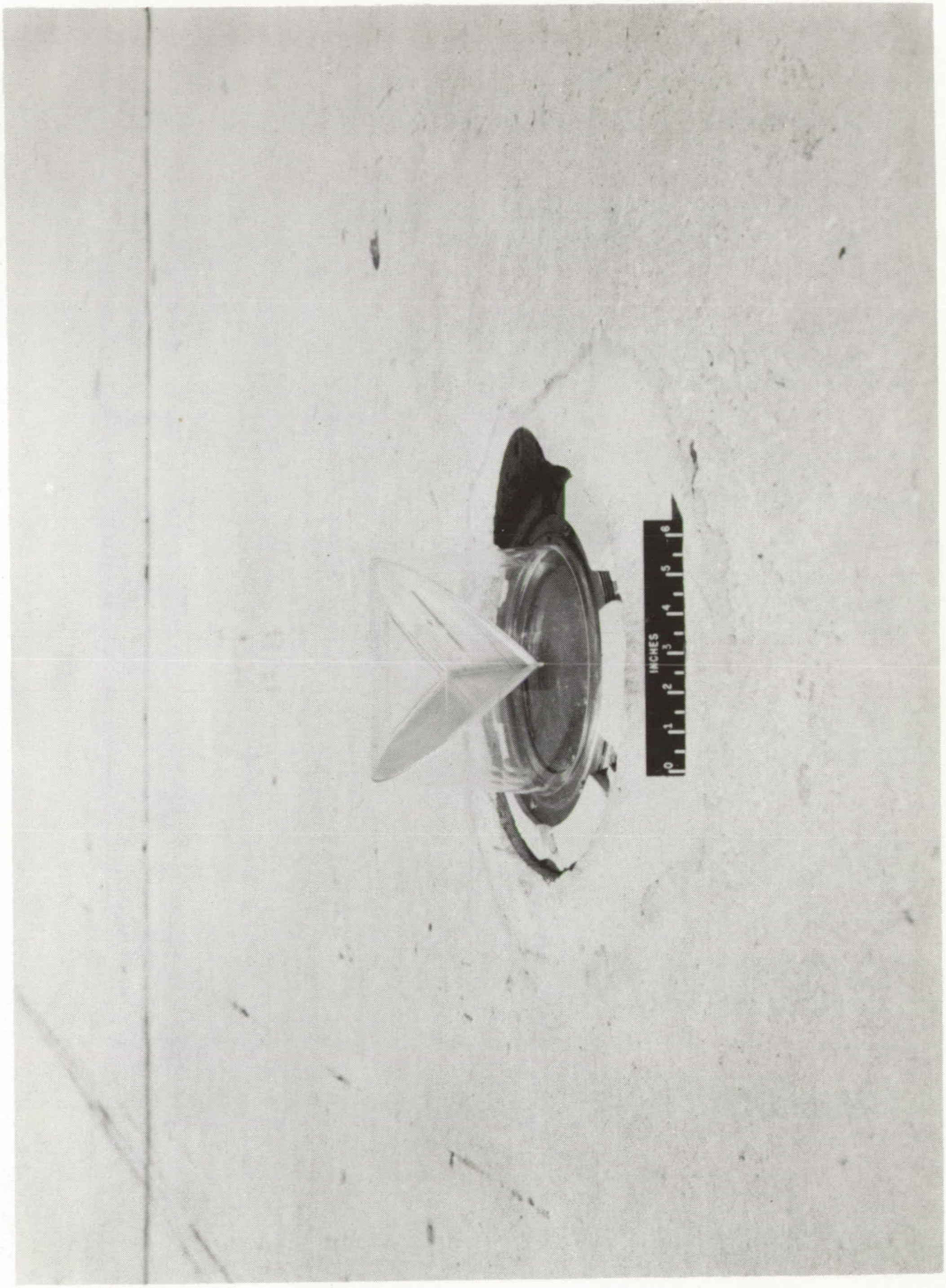


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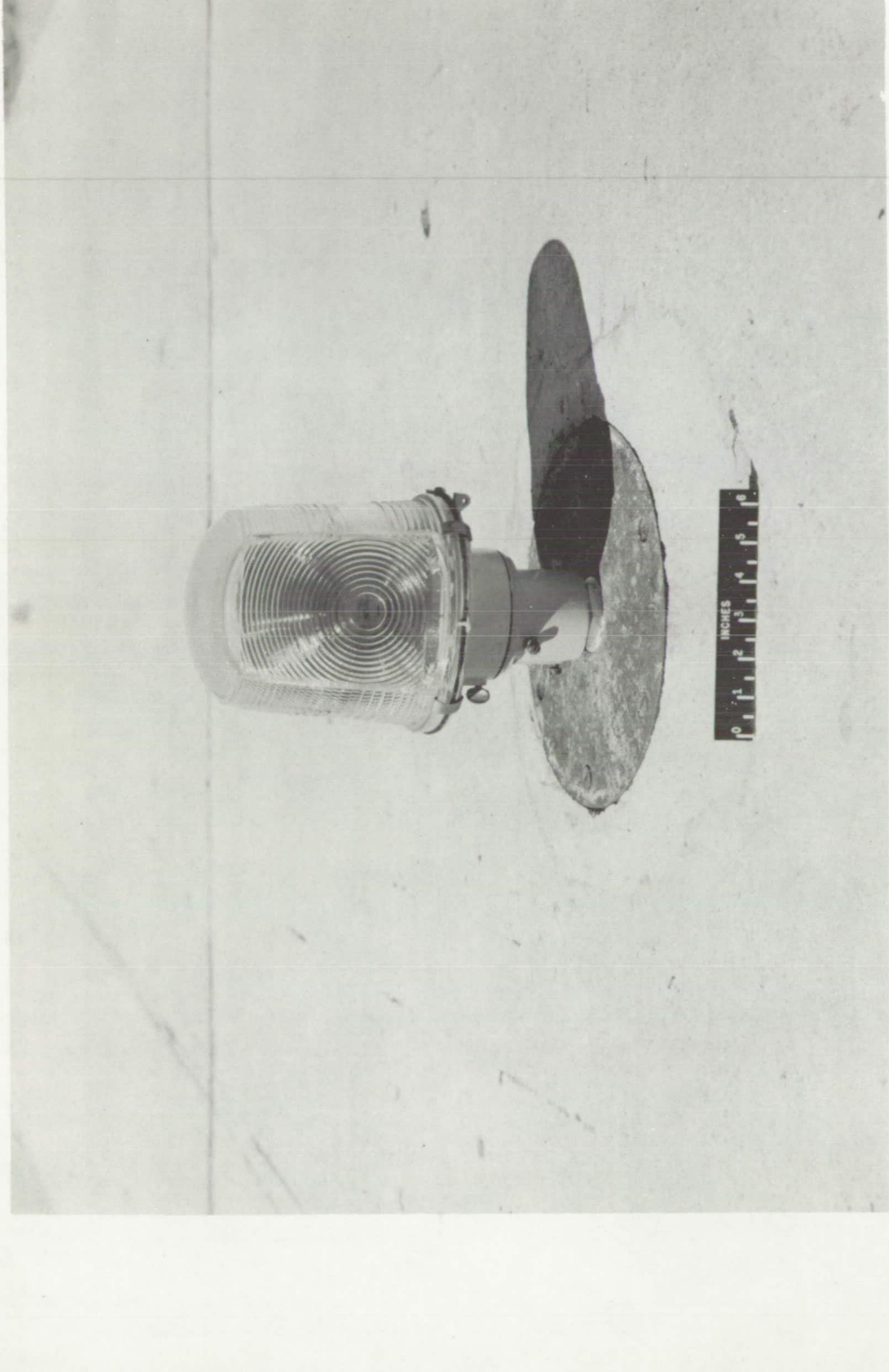
Figure 3.- AGA expendable-top light installed in runway at Langley landing-loads track.



L-57-4065

Figure 4.- C-1 elevated light installed in runway at Langley landing-loads track.

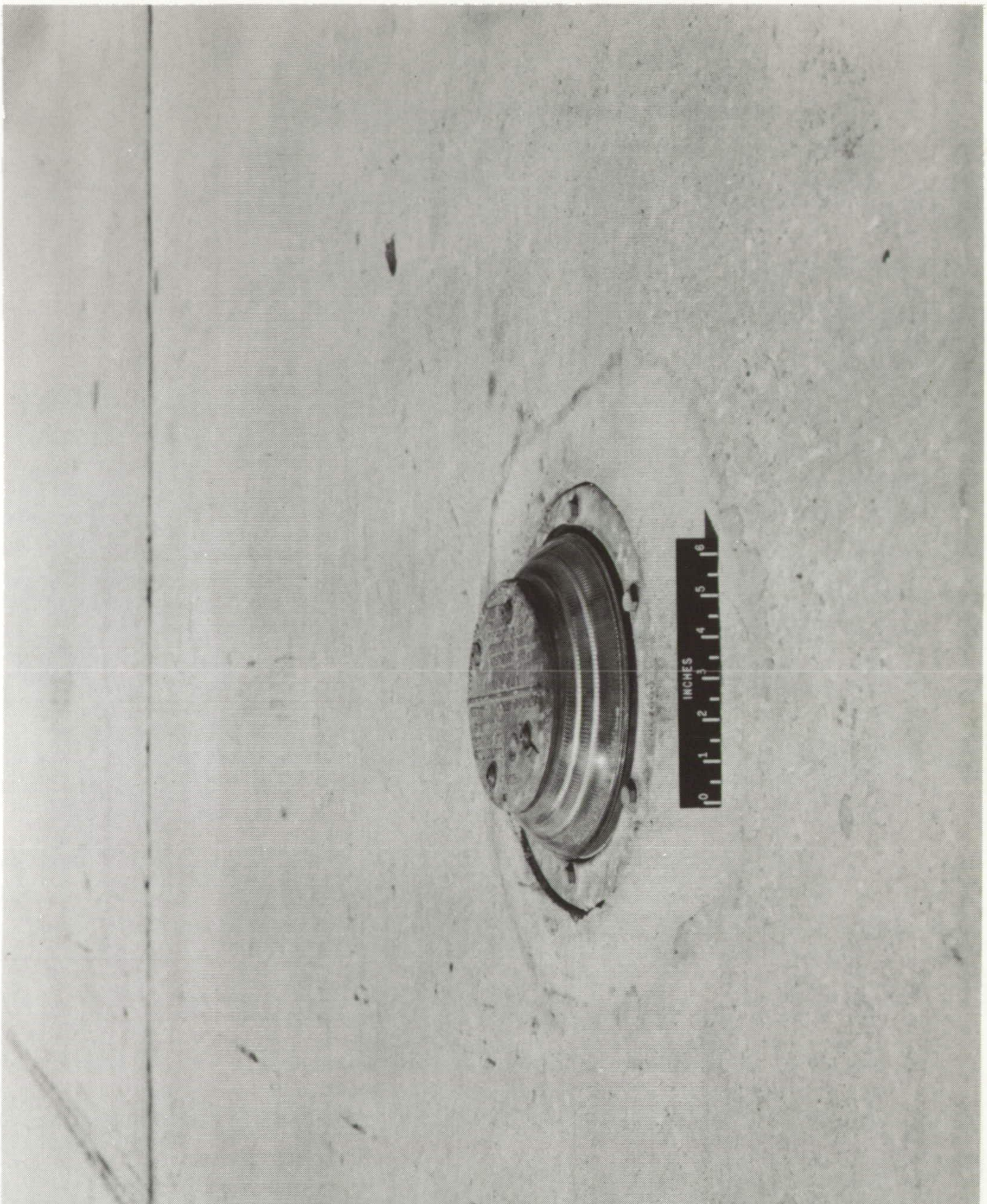


Figure 5.- ANL-9 light installed in runway at Langley landing-loads track. L-57-4068

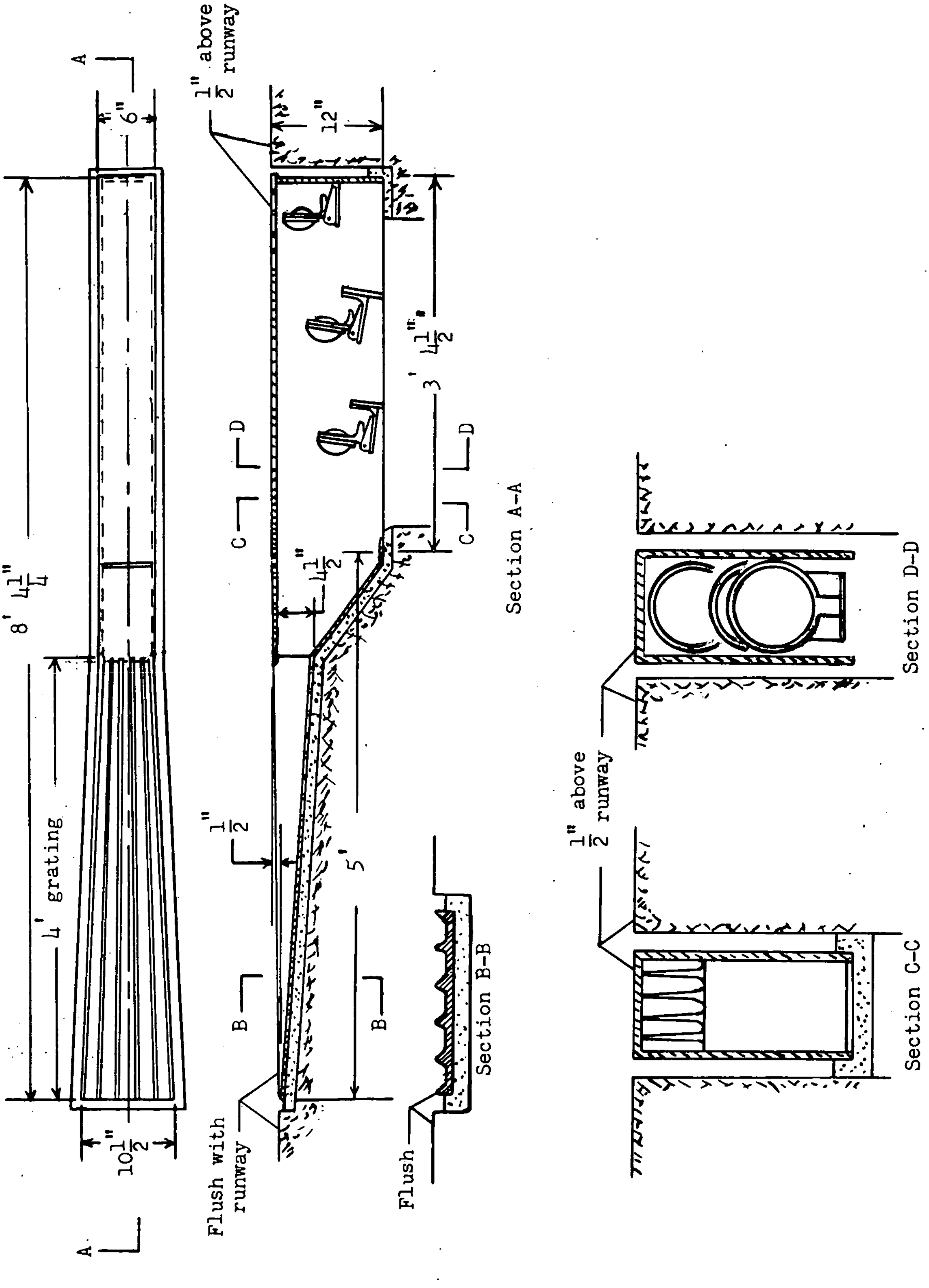


Figure 6.- Elfaka light unit.

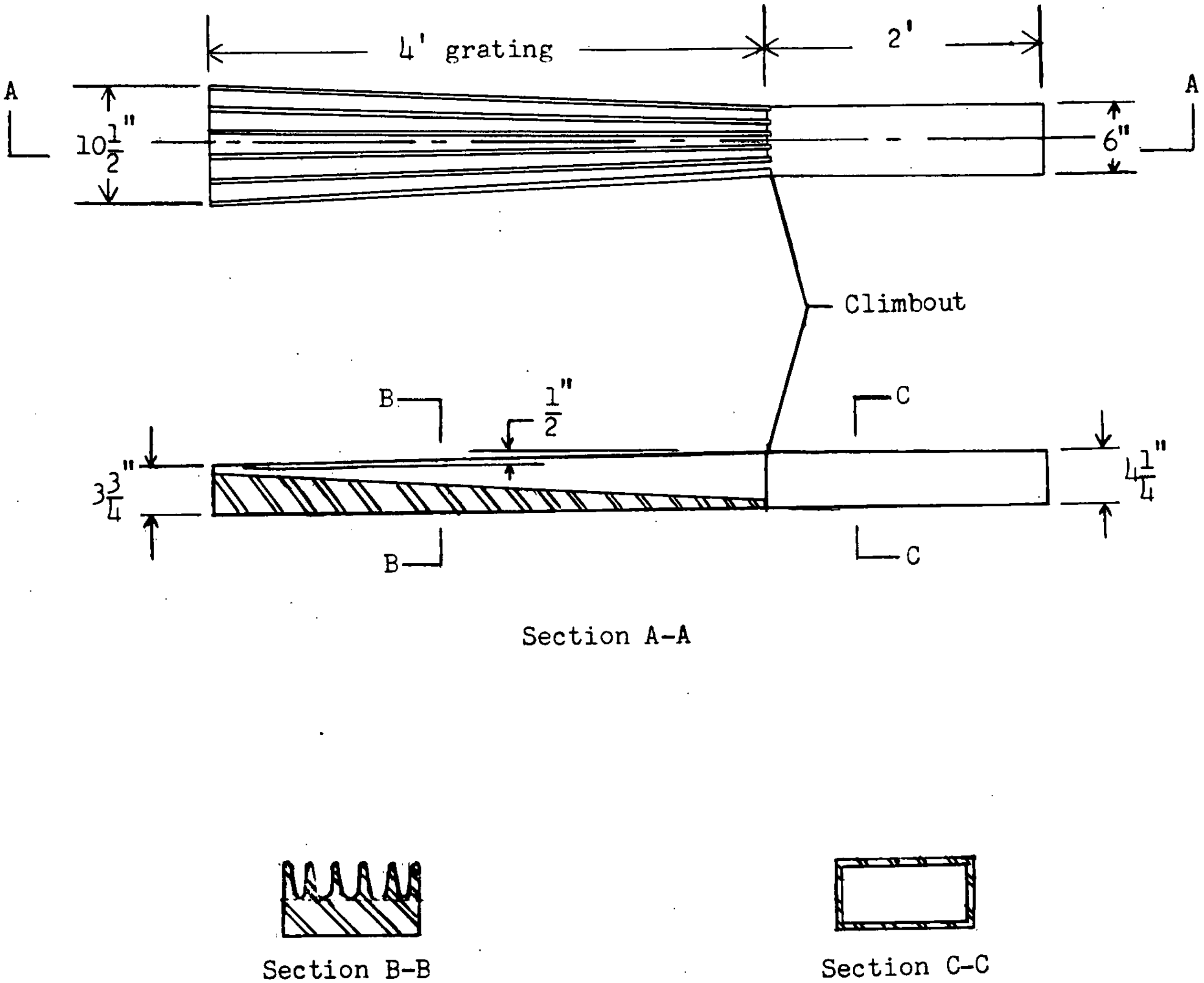
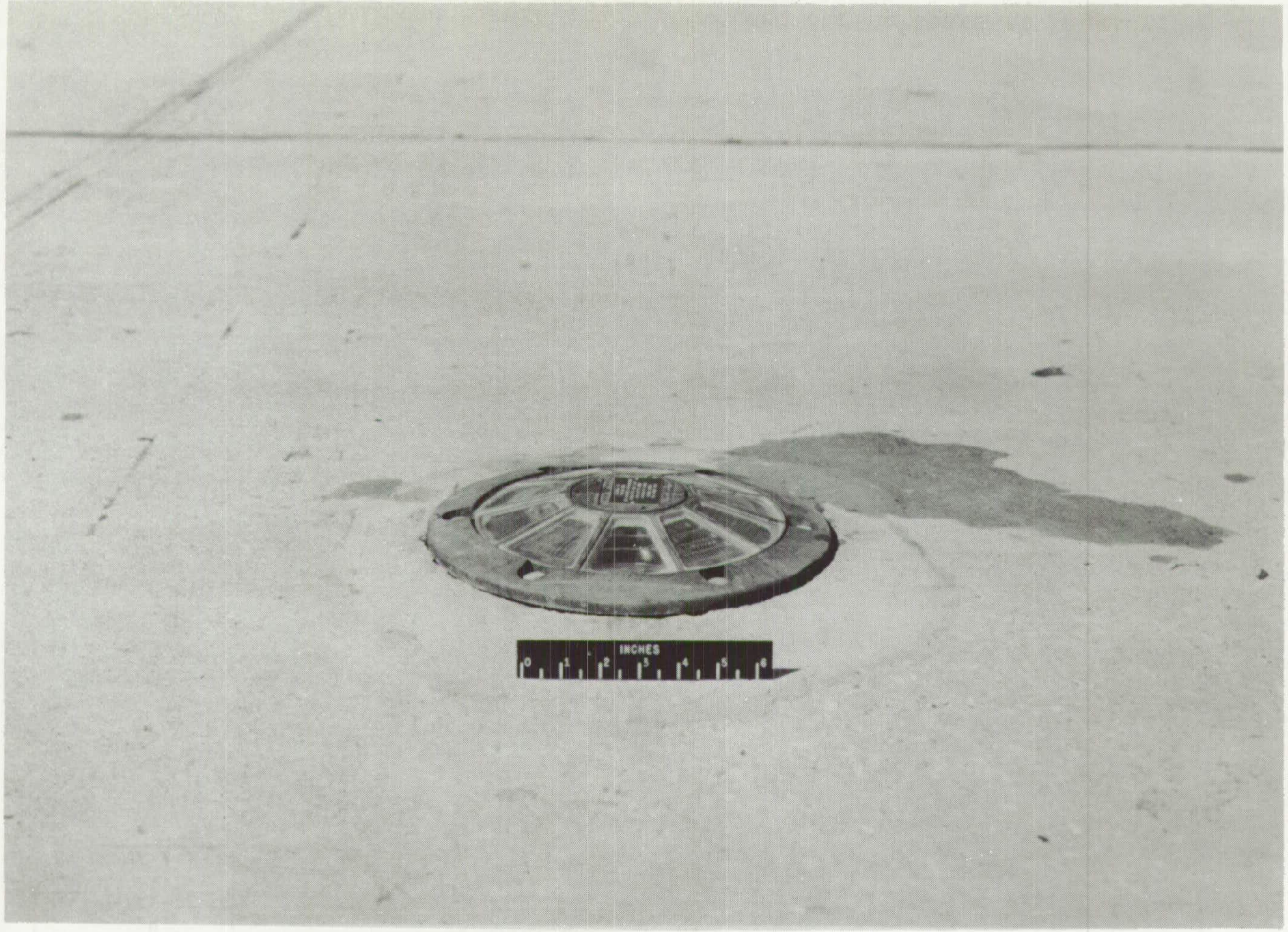


Figure 7.- Simulated Elfaka light unit used during tests at Langley landing-loads track.



L-57-4069

Figure 8.- Westinghouse light unit installed in runway at Langley landing-loads track raised 5/8 inch.

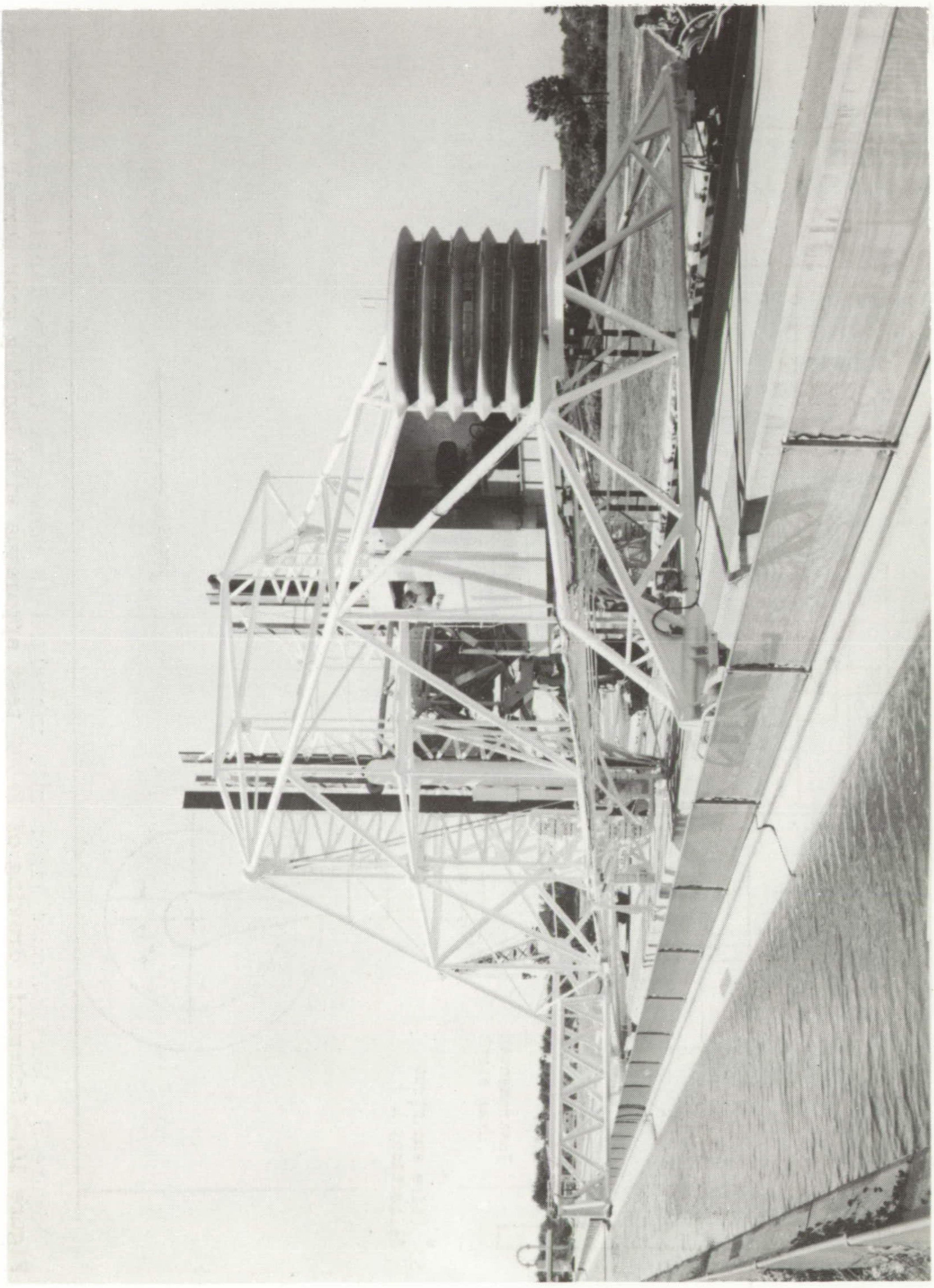


Figure 9.- Carriage of Langley landing-loads track. L-95476

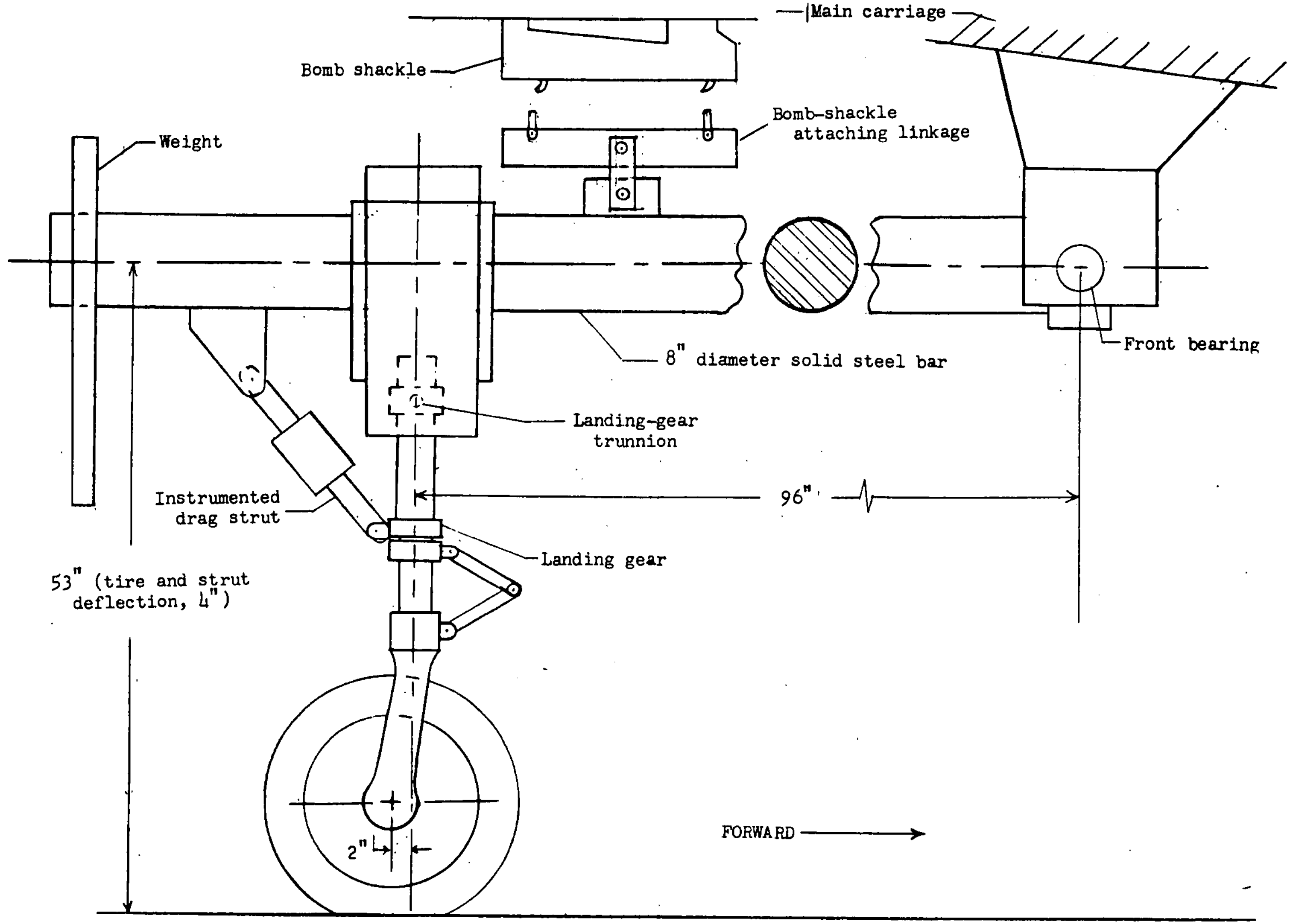
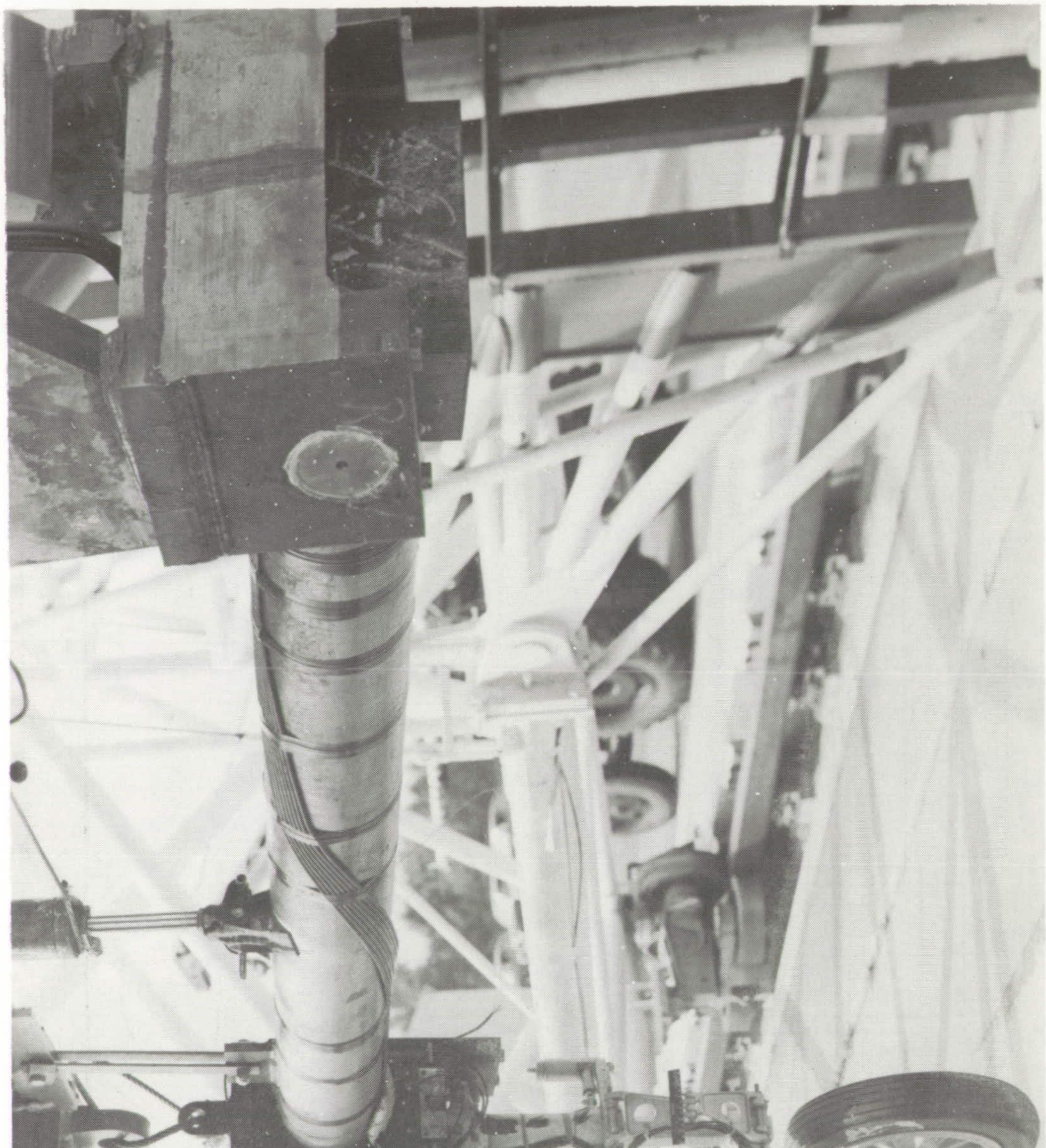
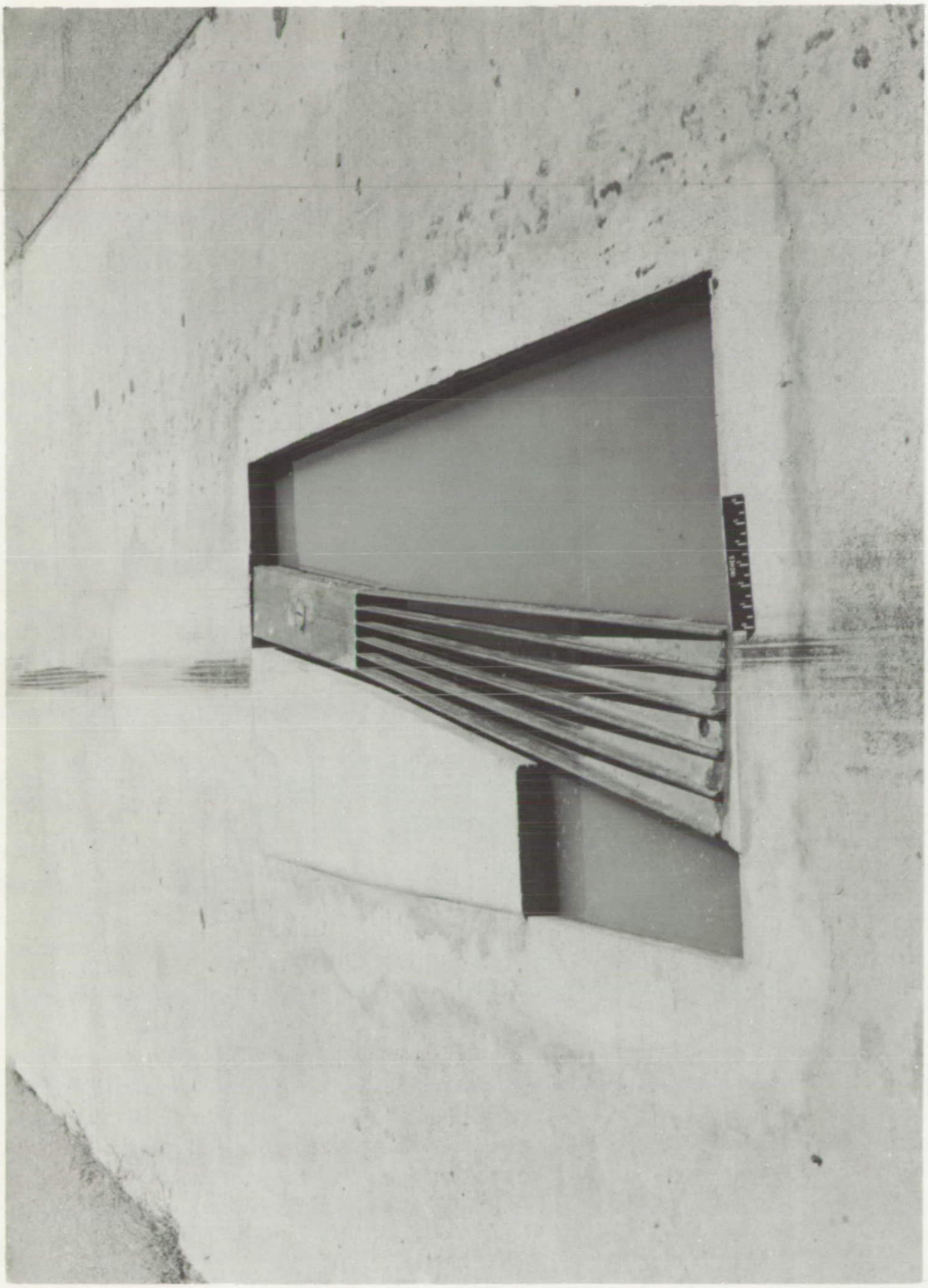


Figure 10.- Schematic drawing of F-94C test apparatus with landing gear normal to runway.



L-57-3477

Figure 11.- F-94C nose landing gear mounted for testing at Langley landing-loads track.



L-57-4062

Figure 12.- Installation of Elfaka light unit yawed $8\frac{1}{3}^{\circ}$ (position C).

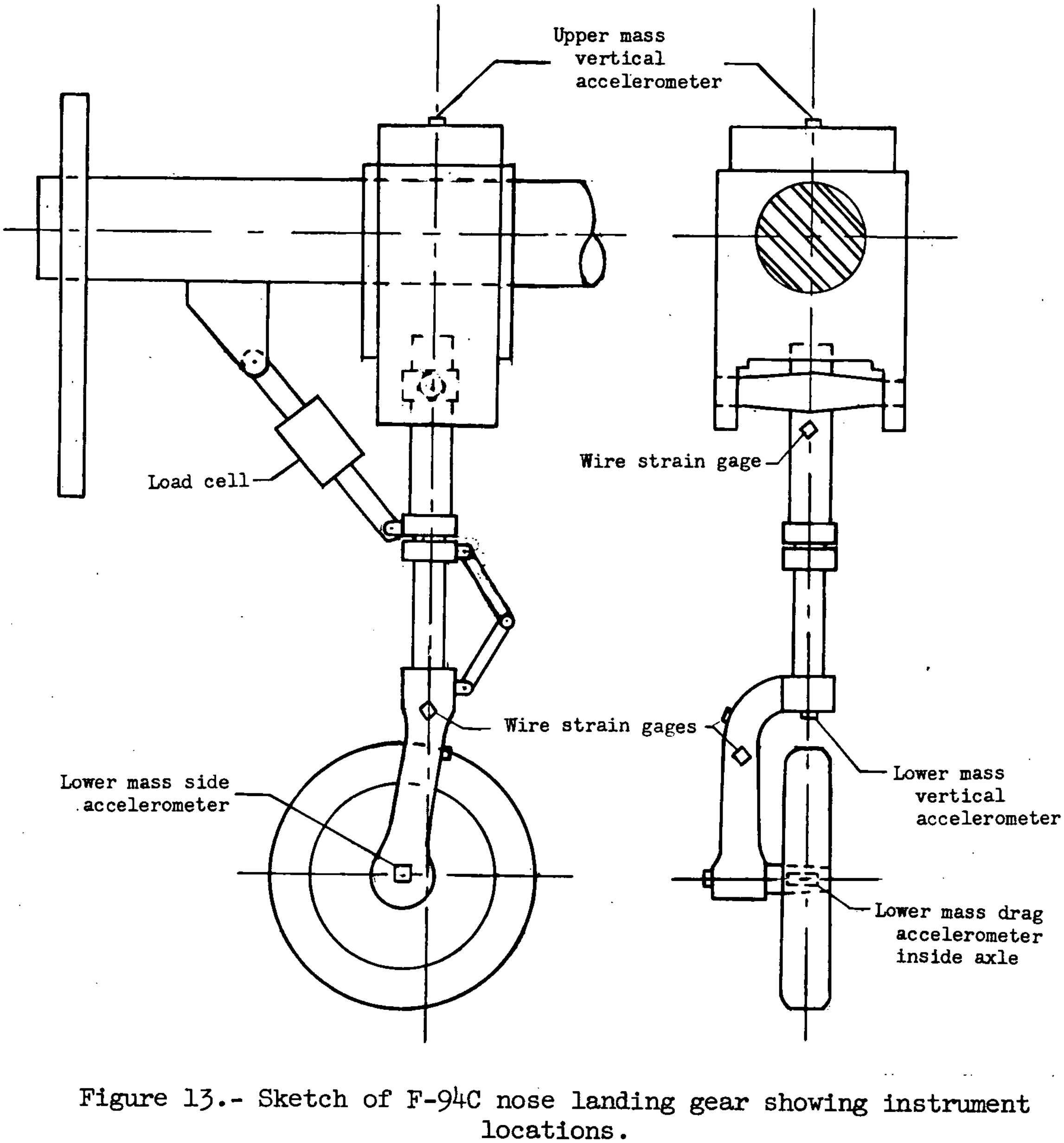


Figure 13.- Sketch of F-94C nose landing gear showing instrument locations.

Figure 14.- B-57 main landing gear mounted for test. L-57-1338

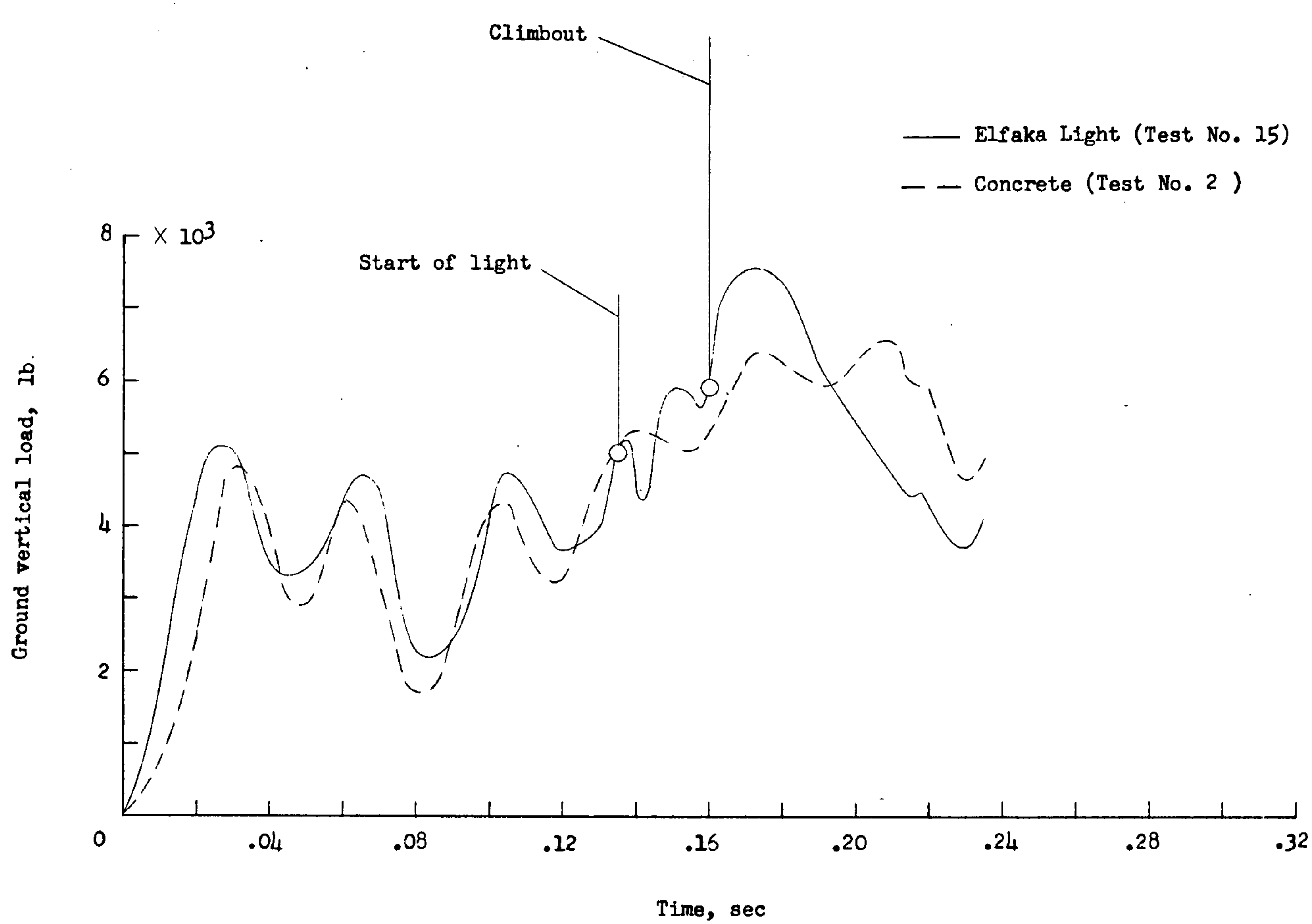


Figure 15.- Time histories of the vertical loads developed on the F-94C nose landing gear during landing impacts on plain concrete and on Elfaka light. Vertical velocity, 5.7 feet per second; horizontal velocity, approximately 150 feet per second.

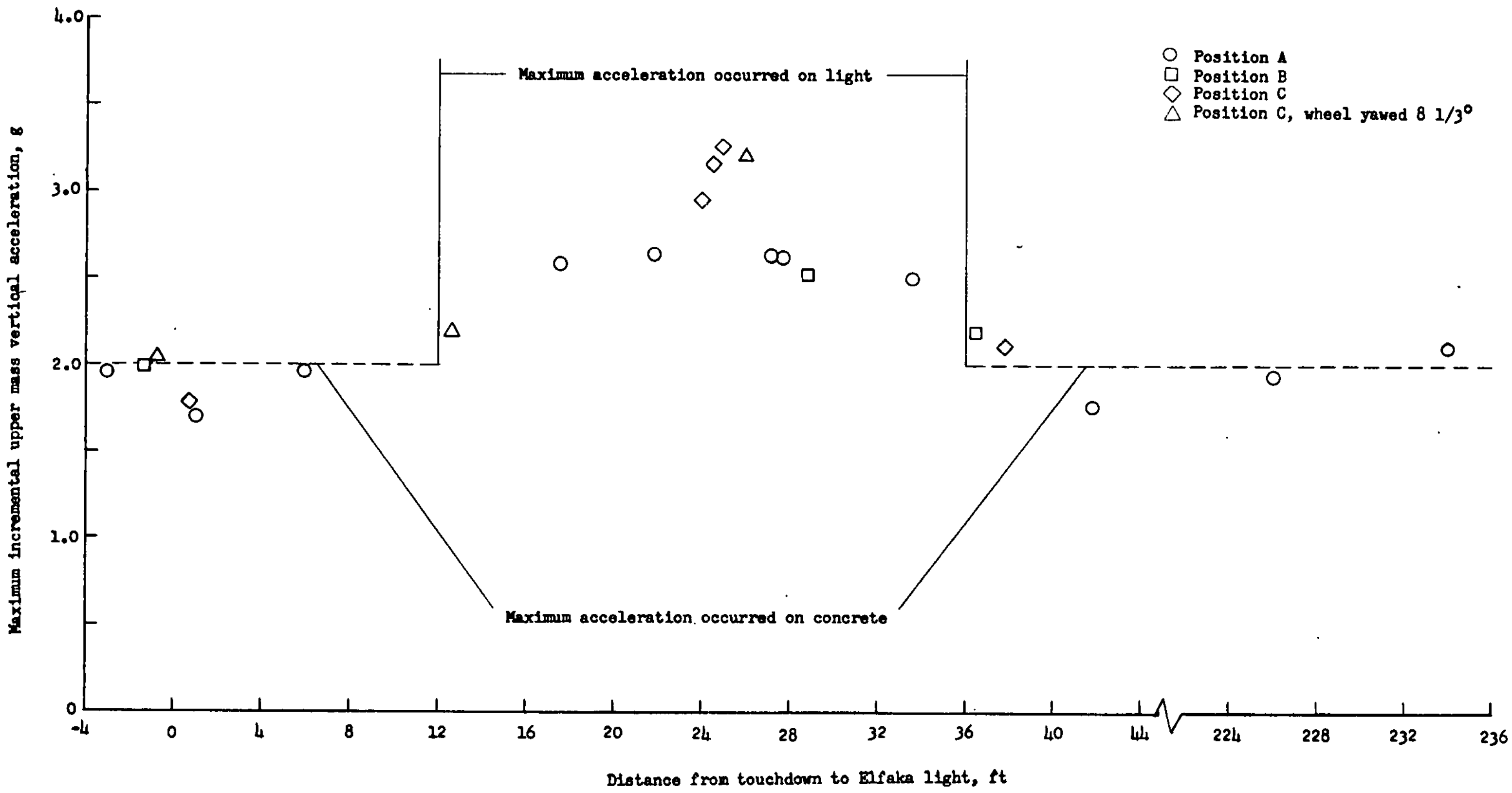


Figure 16.- Variation of maximum incremental upper mass vertical acceleration with distance from touchdown to Elfaka light during landing tests of F-94C nose landing gear. Horizontal velocity range 153 to 167 feet per second; vertical velocity 5.7 feet per second.

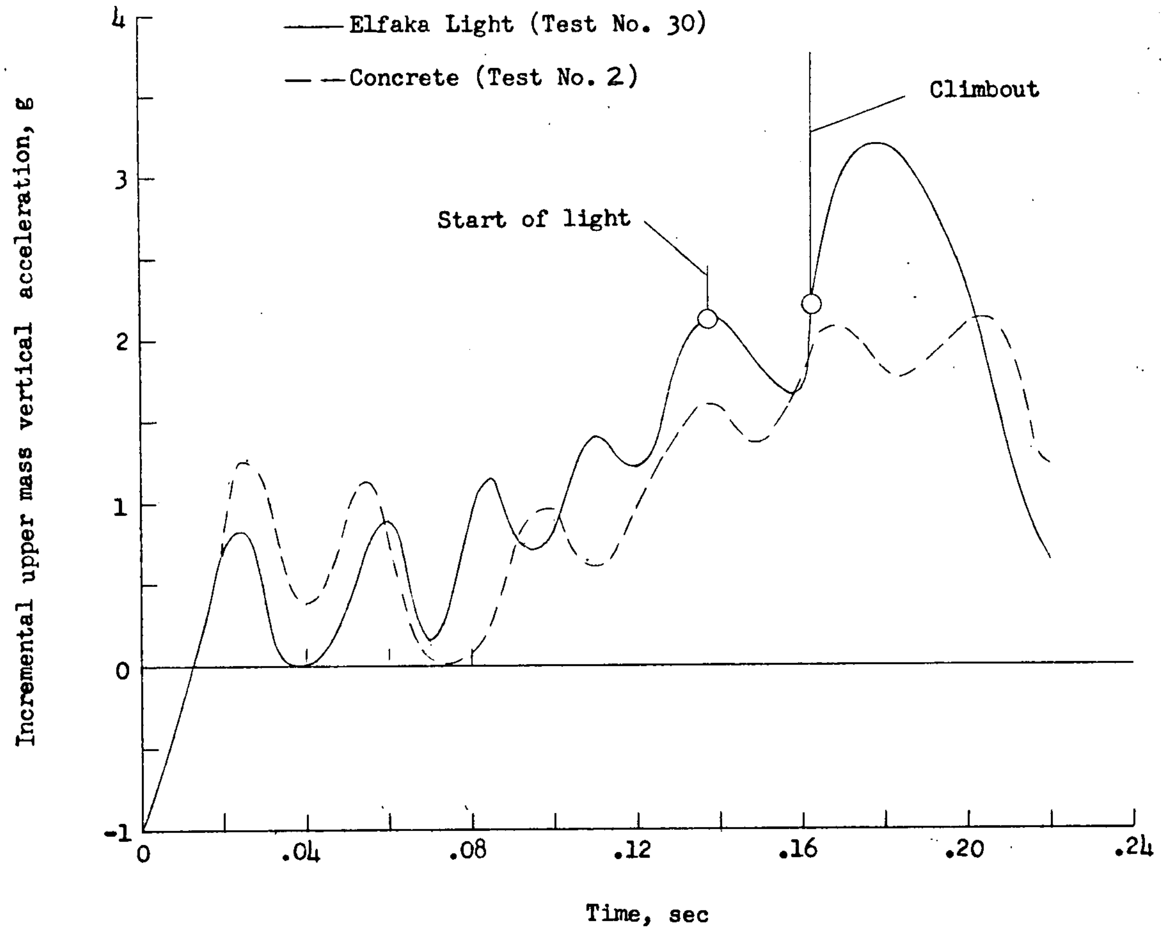


Figure 17.- Time histories of incremental upper mass vertical acceleration developed on F-94C nose landing gear during landing impacts on plain concrete and on Elfaka light. Vertical velocity, 5.7 feet per second; horizontal velocity, approximately 150 feet per second.

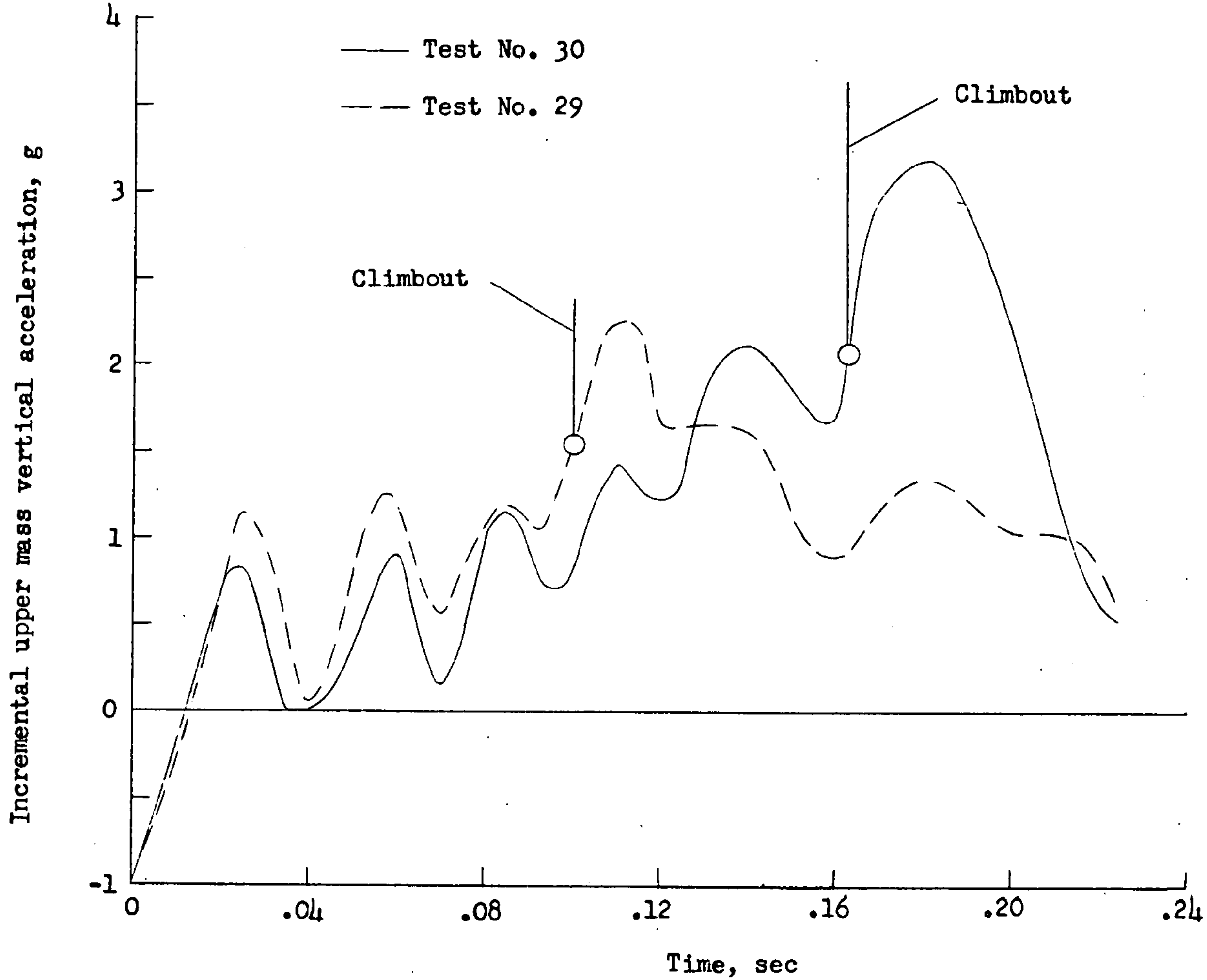


Figure 18.- Time histories of incremental upper mass vertical acceleration developed on F-94C nose landing gear during landing impacts on Elfaka light. Vertical velocity, 5.7 feet per second; horizontal velocity, approximately 150 feet per second.

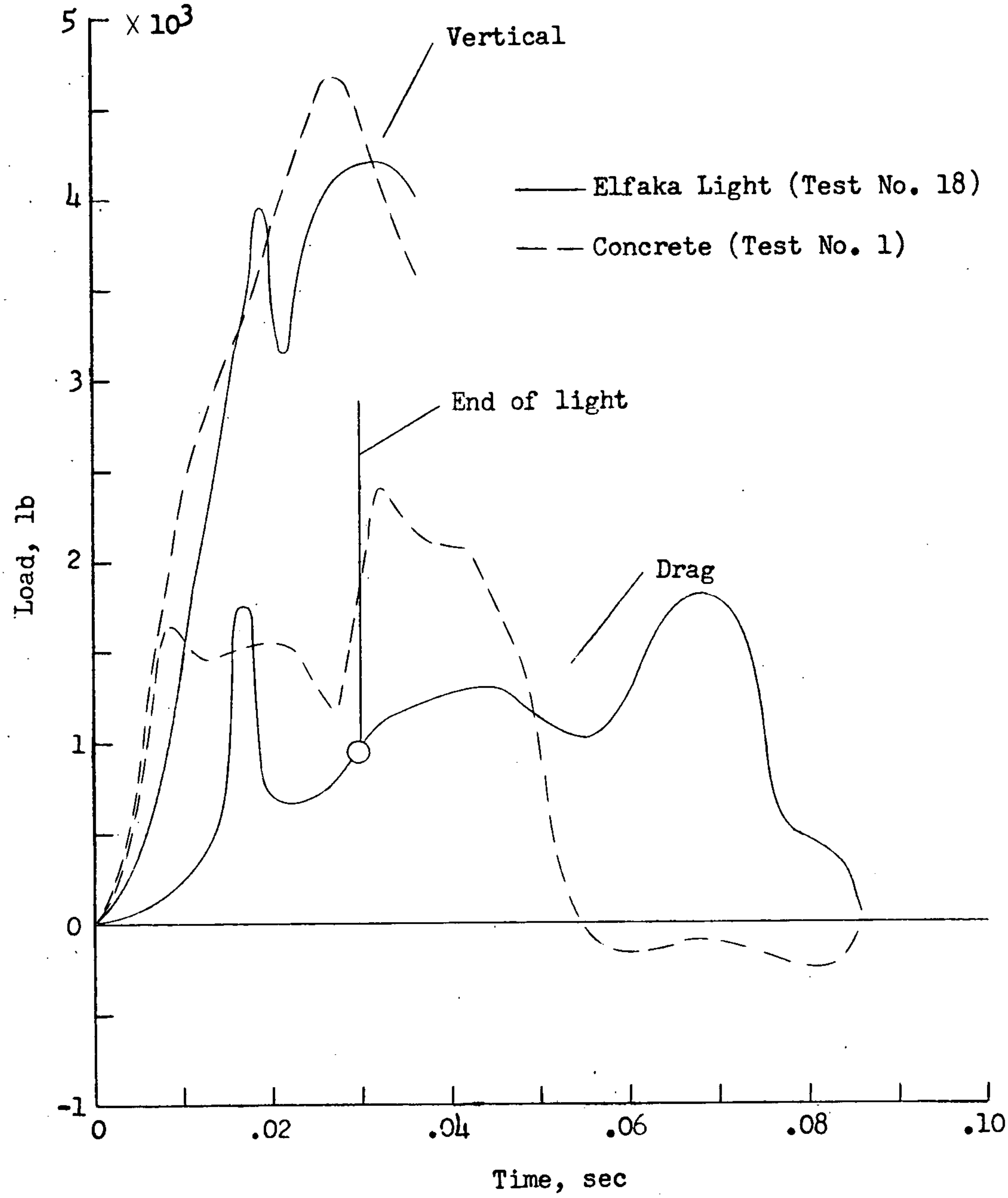
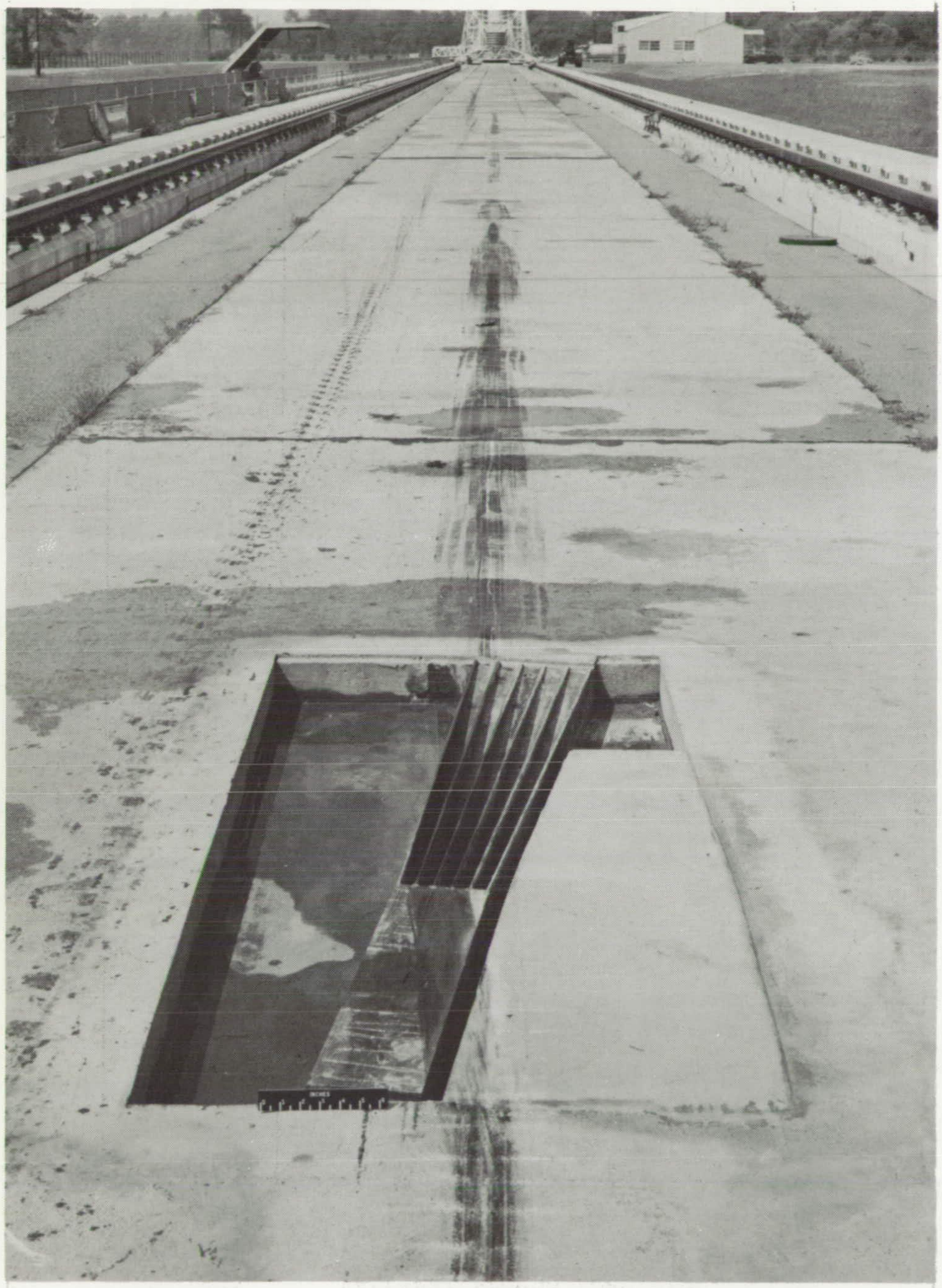


Figure 19.- Comparison of vertical and drag loads developed on F-94C nose gear during landing impacts on concrete and the Elfaka light.



L-57-3688

Figure 20.- Photograph of track left by F-94C nose-landing-gear wheel while negotiating yawed Elfaka light (position C). (Wheel entered light at grating.)

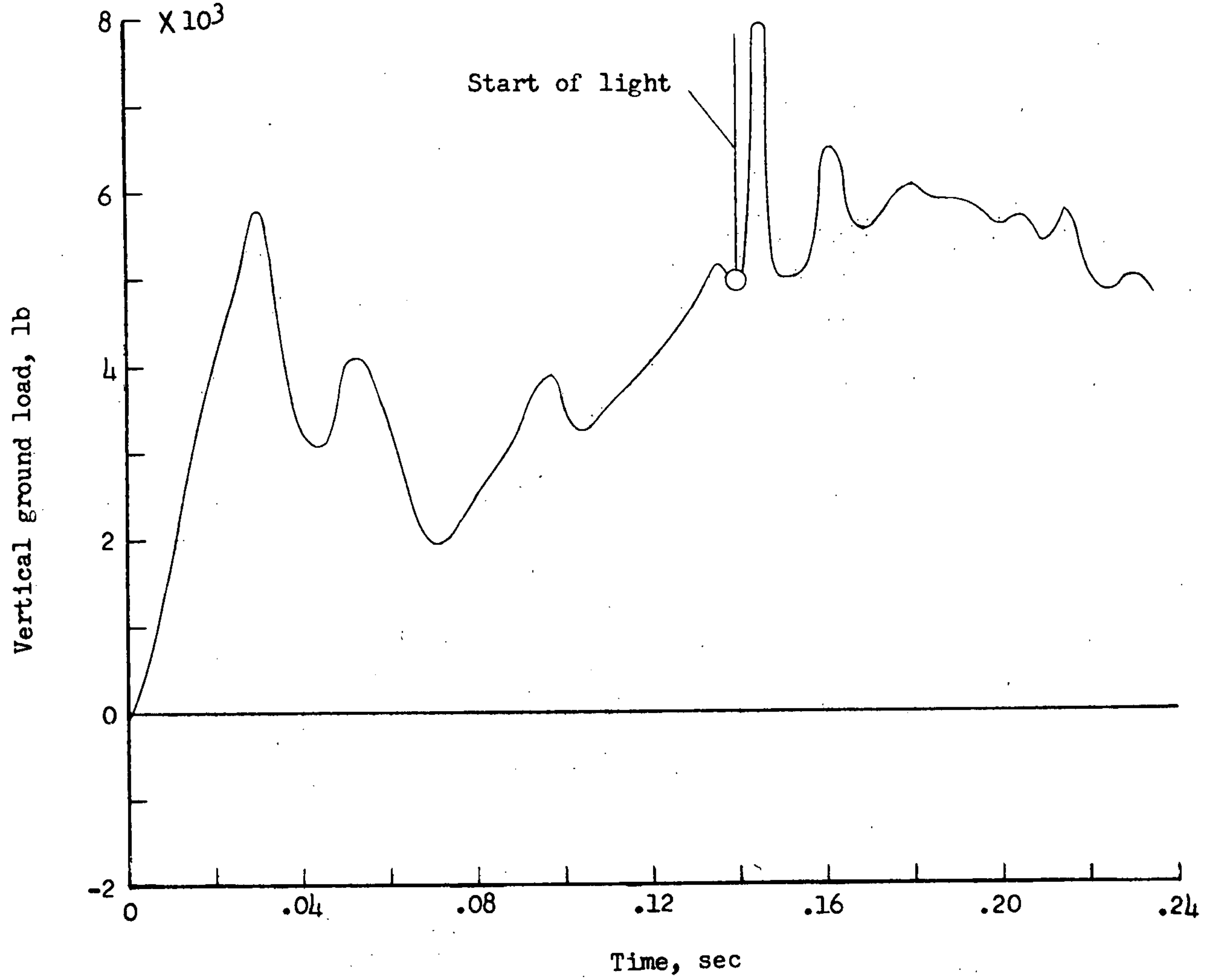
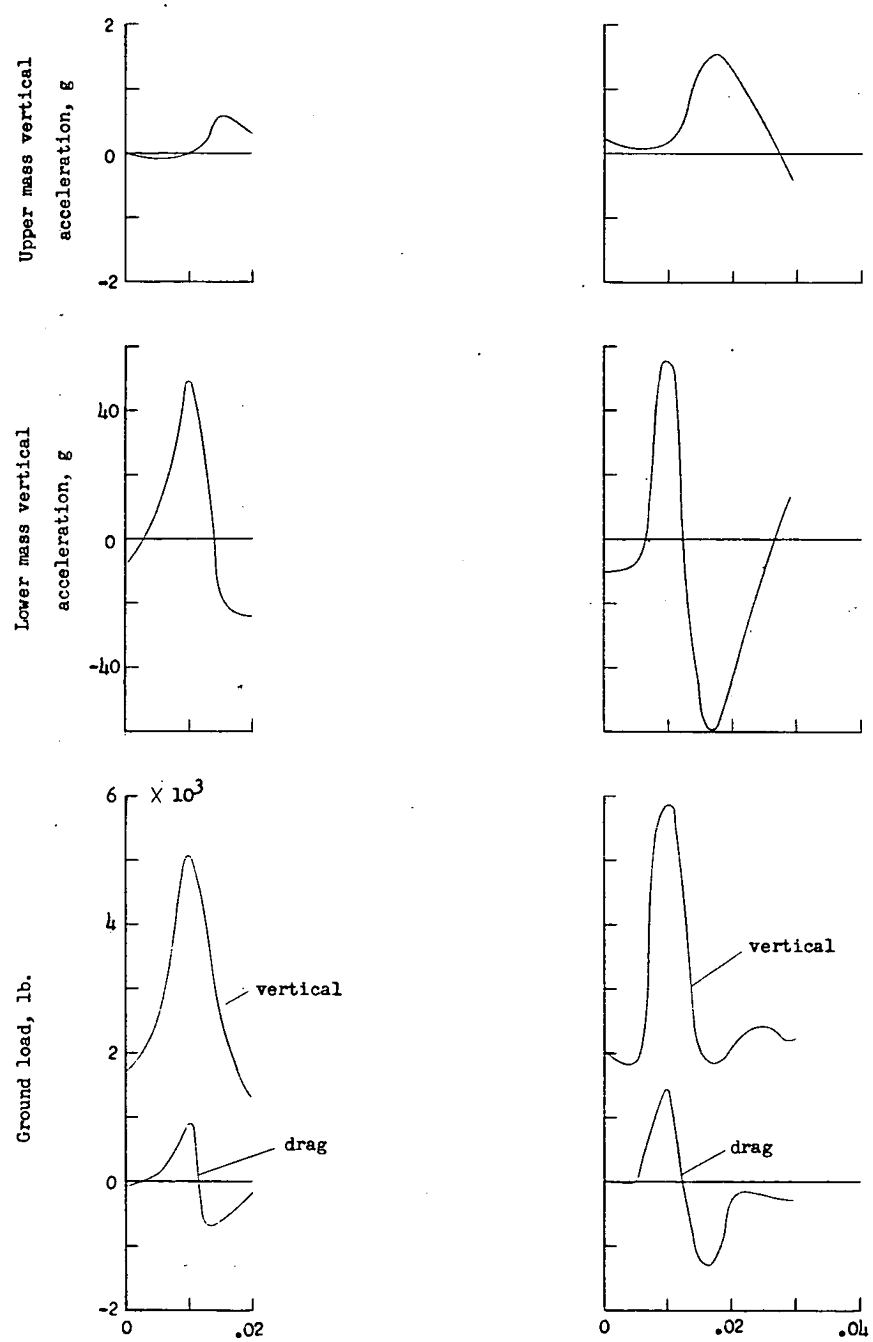
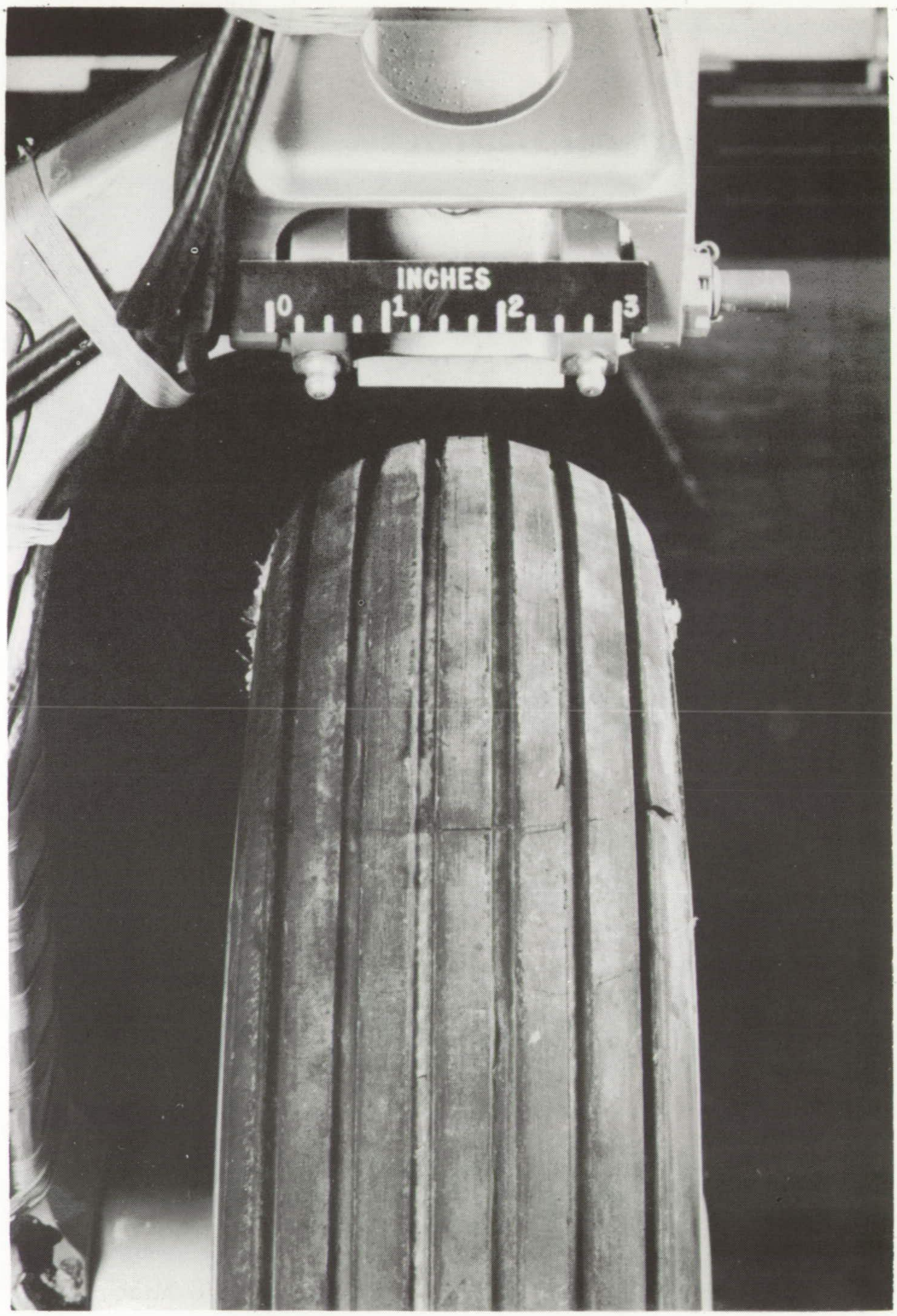


Figure 21.- Time history of vertical load obtained on F-94C nose landing gear during landing impact on Westinghouse light (test 36).

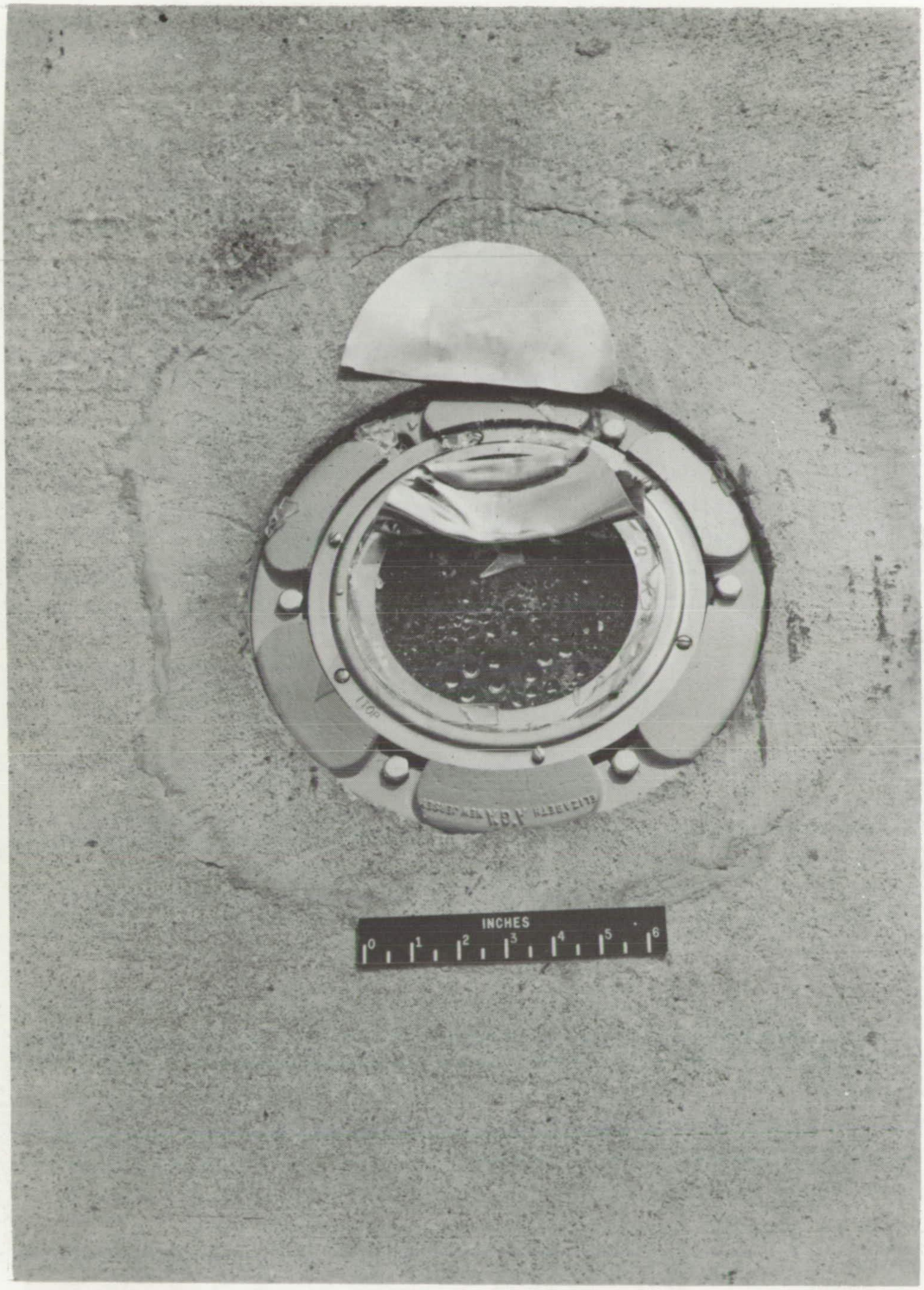


(a) Normal installation, test 32. (b) Raised 5/8 inch, test 38.

Figure 22.- Time histories of loads and vertical accelerations obtained on F-94C nose landing gear during taxi test over the normal and raised Westinghouse light installations.



L-57-3669
Figure 23.- Cut in F-94C nose gear tire caused by taxiing over AGA expendable-top light.



L-57-3672

Figure 24.- AGA expendable-top light after F-94C nose wheel roll-over test.

L-57-3717

Figure 25.- View of damage sustained by F-94C nose wheel after striking AN-L-9 light.

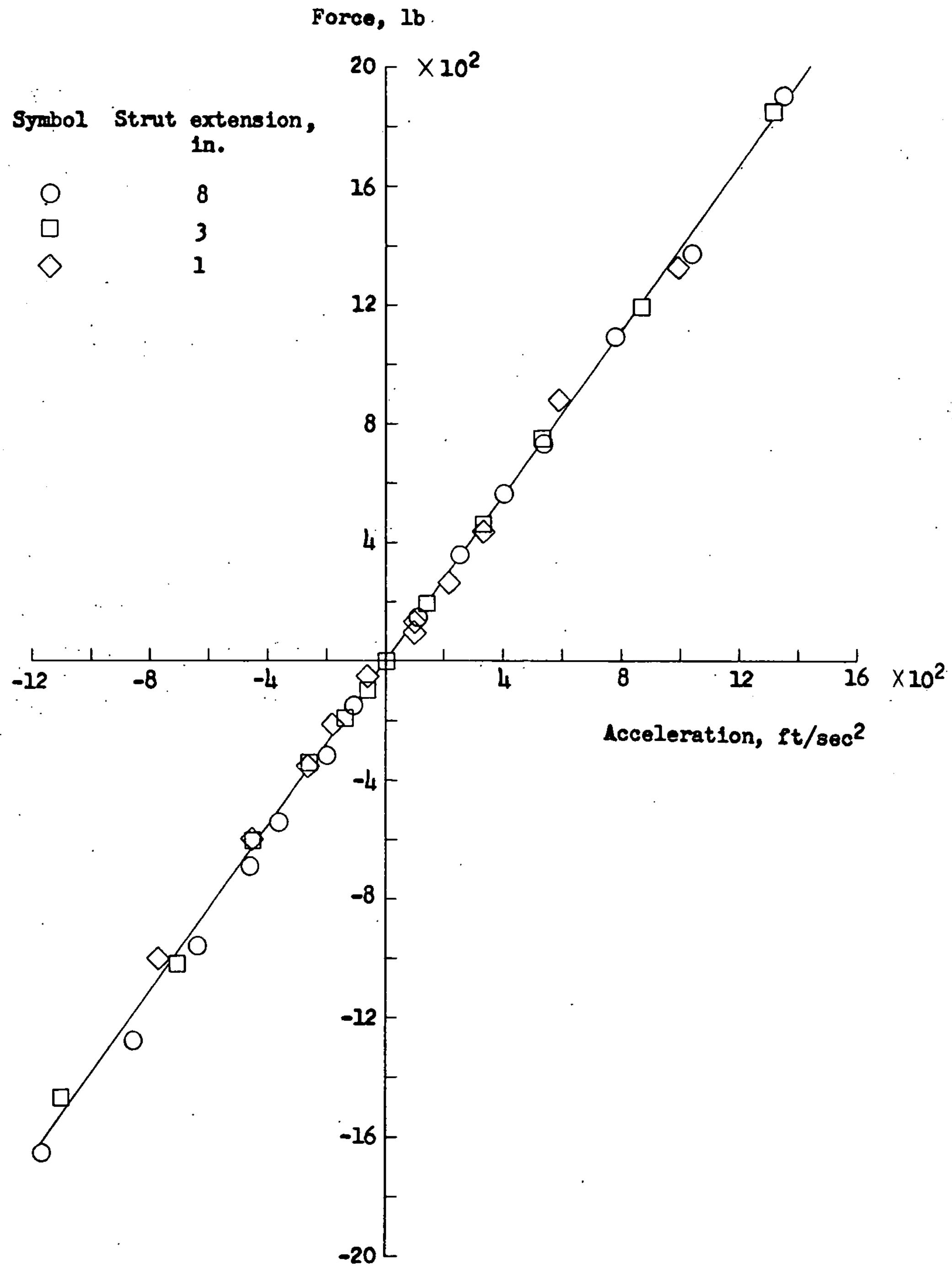


Figure 26.- Variation of horizontal component of force in drag strut with horizontal acceleration of axle during free vibration tests of F-94C nose landing gear.