NAVY DEPARTMENT

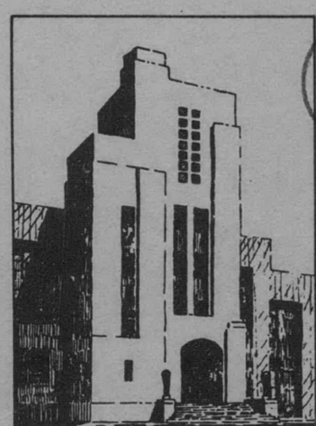
THE DAVID W. TAYLOR MODEL BASIN

WASHINGTON 7, D.C.

THE MEASUREMENT OF PERFORMANCE OF THE GUN-ELEVATING SYSTEM OF THE 8-INCH 55-CALIBER PILOT TURRET

by

William D. Hunter



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FOREWORD

The new main-battery turret for the CA139-Class cruisers incorporated many novel structural and mechanical features which rendered it capable of firing its three 8-inch 55-caliber guns more rapidly than any of its predecessors. To check its operation, perhaps the most extensive structural investigation ever conducted on turrets was performed. A 1/10-scale structural model was fabricated and tested at the David Taylor Model Basin, and a full-scale pilot turret was tested at the Naval Proving Ground. The results have subsequently been checked by structural firing trials conducted on the USS DES MOINES (CA134), the first naval vessel to carry these new turrets. As its part of the over-all program, the David Taylor Model Basin was given the responsibility of measuring (a) the performance of the turret structure and roller track, (b) the behavior of the recoil-counterrecoil system, (c) the operation of the training buffer, and (d) the motion of the guns and turret during elevating and training exercises.

Apart from the primary objective of confirming the safety and the satisfactory performance of the new turret in advance of construction of the ships themselves, secondary objectives were established to derive experimentally information which could be employed to confirm or invalidate design criteria for guns and turrets, and for structural assemblies which are similarly loaded.

The results of tests of the gun-elevating system are given in this report. The other results are given in additional reports and memoranda, as follows:

1. "Description of Test of Hydraulic Training Buffer of CA139-Class Pilot Turret," TMB RESTRICTED Report C-38, February 1948.

2. "An Elastic-Tube Gage for Measuring Static and Dynamic Pressures," TMB Report 627, May 1948.

3. "Description of Instruments Employed in the Operational Tests of the Gun-Elevating Systems of the CA139-Class Pilot Turret," TMB RESTRICTED Report C-29, October 1947.

4. "The Measurement of Performance of the Training System of the 8-Inch 55-Caliber Pilot Turret," TMB RESTRICTED Report C-164, May 1950.

5. "Experimental Analysis of the Recoil System of the 8-Inch 55-Caliber Guns Mark 20, Mod 1," TMB RESTRICTED Report C-165, March 1950.

6. "The Elastic Behavior of the Rotating Structure of the CA139-Class Pilot Turret under Static Loading," TMB RESTRICTED Report C-166, March 1950.

7. "The Dynamical Response of the Rotating Structure of Turrets with Particular Reference to the 8-Inch 55-Caliber 3-Gun Turret," TMB RESTRICTED Report C-81, June 1950.

8. "Structural Design Studies of a 1/10-Scale Model of the 8-Inch Gun Girder on the CA139-Class Cruisers," Thesis, Department of Naval Architecture and Marine Engineering, Massachusetts Institute of Technology, 1949.

9. "Schedule of Measurements to be Made by the David Taylor Model Basin during Tests of the CA139 Pilot Turret," TMB Memo 2, CA139 Class/S72-1 of 13 November 1945 (revised 25 April 1947).

10. "Experimental Analysis of Stress and Deformation of a 1/10-Scale Model 8-Inch Gun Turret for the CA139-Class Cruisers," TMB RESTRICTED Report 571, February 1948.

11. "The TMB Tension Dynamometer," TMB Report 605 (in preparation).

12. "The Elastic Behavior of the CA139-Class Pilot Turret with Gunfire Loading," TMB RESTRICTED Report C-231, October 1950.

13. "Natural Frequencies Measured on the CA139-Class Pilot Turret," TMB RESTRICTED Report C-82, December 1948.

Whereas the experimental and theoretical analyses were conducted for this turret investigation to obtain specific data regarding performance, a vast amount of general information was obtained pertaining to the behavior of hydraulic energy-absorbing systems and to the elastic behavior of complex structures subjected to dynamic loading. It is now planned to present these more general results in two separate reports:

1. Considerations for the Design of Complex Structures subjected to Dynamic Loads, as derived from Experimental Analysis.
2. New Considerations for the Design of Hydraulic Buffers as derived from Experimental Analysis.

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ABSTRACT

The torque transmitted by the elevating-pinion shaft and the angular acceleration of the guns were measured by the Taylor Model Basin during proof tests of the gun-elevating system of the 8-inch 55-caliber pilot turret. At the same time measurements of the electrical power input and pressure in the hydraulic units were made by the Naval Proving Ground.

The maximum torque of 390 kip-in. was recorded in tests in which the guns were pointed at an elevation of 10°, given a stationary order of 5°, and released without firing; the maximum acceleration of 215 degrees/sec^2 was developed when the gun was run into the buffer stops at a maximum velocity of 8 degrees/sec.

INTRODUCTION

Heavy cruisers of the CA139 Class differ from ships of the CA68 Class primarily in the use of rapid-firing guns which can be loaded at any elevation. Among the novel mechanical features incorporated in the CA139 turret is an arc-and-pinion drive located in the final gearing of the elevating system of the guns. To determine the operating characteristics of this system and the performance of all its components, full-scale field tests were deemed necessary. Accordingly, the Bureau of Ordnance directed[1] that proof tests of the elevating gear be conducted on a pilot turret installed at the Naval Proving Ground, Dahlgren, Virginia. The Proving Ground was requested to study the driving elements through measurements of the electrical power input and of pressures in the hydraulic units. The David Taylor Model Basin was requested to determine the response of the system to specific signals from a dummy director by measuring the torque transmitted by the elevating-pinion shaft and the angular acceleration developed by the moving gun. A schedule of the tests in which the Taylor Model Basin participated, and a list of instruments furnished during these tests is given in Reference 2.

This report contains a brief description of the elevating system under study, a description of the tests conducted and the results obtained, and an analysis of these results indicating how they may be related to check operation as well as design criteria. A description of the gages and instruments used by the Model Basin for these tests has been previously given in Reference 3 and therefore has not been included here. The performance of these instruments during the tests appeared satisfactory and records obtained are considered reliable.

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*References are listed on page 28.

The general arrangement of the instruments and of the auxiliary equipment provided for the complete test program of the turret is shown in Figure 1.

DESCRIPTION OF ELEVATING SYSTEM

The elevating gear induces and controls the elevation and depression of the guns. This angular motion is accomplished through a Waterbury hydraulic speed gear driven by a 25-hp electric motor. The electric motor drives a hydraulic pump—the A-end—which is the source of fluid under high pressure for driving the hydraulic motor—the B-end. The B-end is coupled directly with a worm gear which engages a worm wheel at one end of the pinion shaft. The elevating pinion gear on the other end meshes with an arc which is rigidly attached to the gun housing.

Changes in the elevation of the gun are the results of changes in the direction or rate of flow of the fluid in the motor of the hydraulic system. This variation in flow, except for the very slight change in the speed of the electric motor, is produced entirely by a controlling device—the tilting box—in the A-end. The tilting box provides a means of changing the length of the piston stroke in the A-end from zero to maximum, in either direction, thus varying the pumping capacity and direction of flow of fluid from the A-end as required for gun motion. Figure 2 is a sectional view of the worm gear, worm wheel, pinion shaft, and pinion gear.

TEST MEASUREMENTS

Although the elevating-gear tests were primarily proof tests, and the instrumentation was desired mainly to detect malfunctioning, the quantities measured also had intrinsic value as data for use in future design of elevating systems. For example, the torque transmitted by the pinion shaft is useful knowledge for design of the strength of the shaft, strength of the gear teeth, strength of stiffeners of machinery foundations, etc. The angular acceleration of the gun is useful in determining the power requirements of the elevating system and the shock to instruments located on the guns.

The exercises to which the elevating gearing was subjected during the proof tests were designed to be at least as severe as those ordinarily encountered in normal operation of the turret.

Measurements made by the Taylor Model Basin during these tests included the following:

1. Torque in the pinion shaft.
2. Angular acceleration of the guns.

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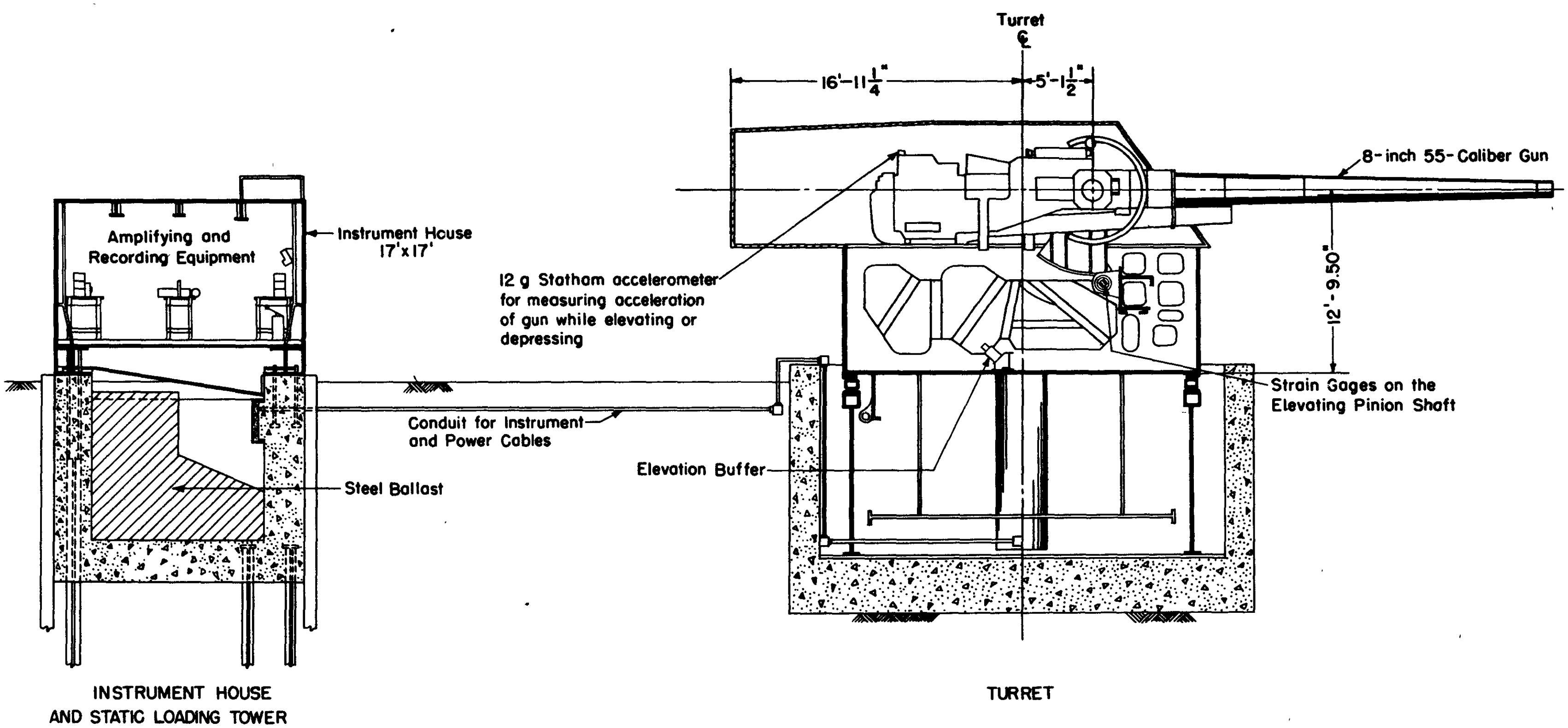

Figure 1 - General Arrangement of the Instruments in the Turret

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3. Gun position.

4. Firing time.

Measurements made by the Naval Proving Ground for the same tests included:

5. Pressure in the hydraulic lines between A-end and B-end.

6. Input power to the electric motor.

7. Speed of the electric motor.

8. Angular velocity of the gun.

9. Angle of tilt of the A-end tilt plate.

10. Error.

11. B-end speed.

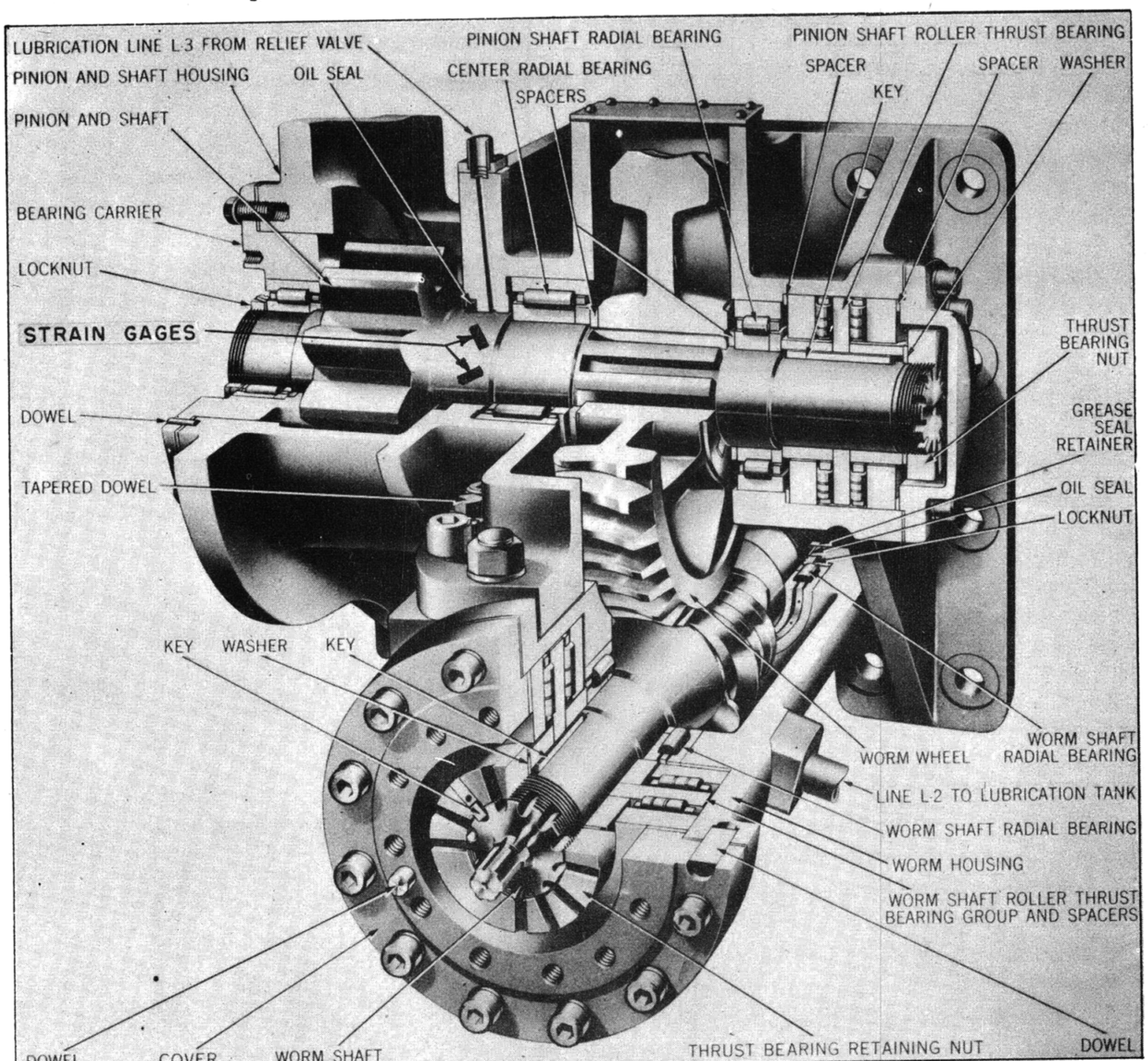
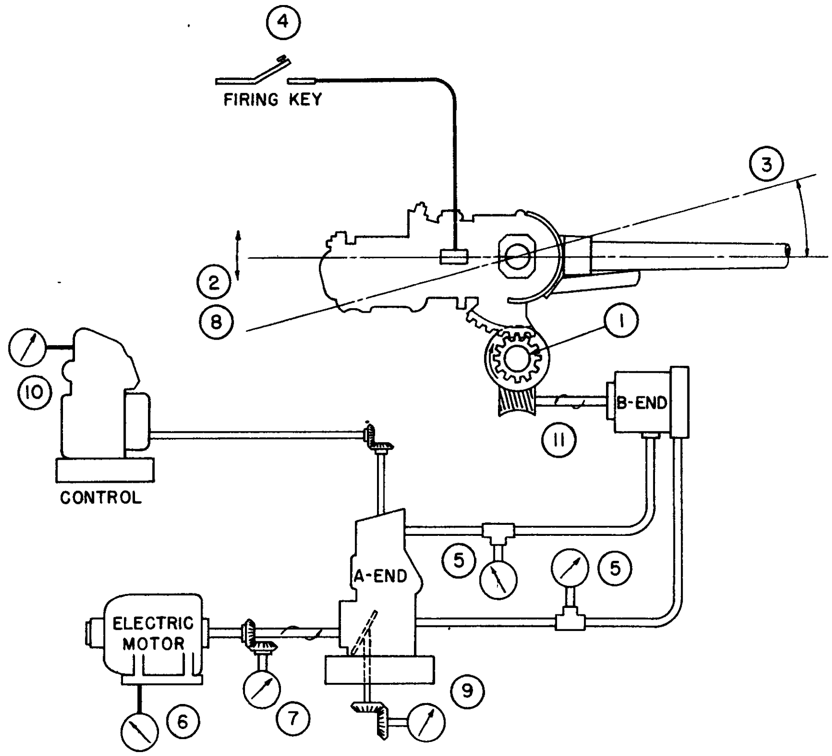


Figure 2 - Sectional View of Worm Gear, Worm Wheel, and Pinion Shaft

Instrumentation for these measurements is shown schematically in Figure 3. All measurements were recorded on string oscillographs. When more than one oscillograph was used, a 60-cps timing wave, interrupted once each second, was used to correlate the records.

The instruments and gages used by the Taylor Model Basin in the elevating-gear tests have been described in Reference 3.



1. Torque in pinion shaft
2. Angular acceleration of gun
3. Angular position
4. Firing time
5. Pressure in hydraulic lines between A- and B-end
6. Electrical input
7. Speed of electric motor
8. Angular velocity
9. Angle of tilt plate on A-end
10. Error indicator
11. B-end speed

Figure 3 - Arrangement of Instrumentation for Tests of Elevating Gear

As can be noted from the list of measurements made, a sufficient number of quantities were recorded to permit checking of most measurements against some other measurement. Among the relations by which such comparisons could be made are the following:

1. Torque transmitted by the B-end as determined by that measured directly by strain gages on the pinion shaft and torque derived from the measurement of B-end speed and B-end hydraulic pressure.

2. Electrical power input to the electric motor compared with power output of the A-end, which can be determined from the pressure in the hydraulic lines, the size characteristics of the A-end, the speed of the A-end, and the ratio of angle of tilt-plate to maximum angle of tilt.

3. Power transmitted by the B-end (from the measurement of pressures in the hydraulic line, size of the B-end, and speed of the B-end) as compared with power transmitted by the pinion shaft (which may be derived from the measurement of torque by the strain gages on the shaft, together with speed of the shaft).

4. Relationship between torque measured at the pinion shaft and angular acceleration of the gun.

5. Angular acceleration of the gun as measured by the accelerometer compared with that derived from the velocity of the B-end.

The mathematical expressions for these relations are:

For torque T_B transmitted by the B-end:

$$T_B = \frac{63\ P_M S_B}{1200}\ (T_B \text{ in lb-ft}) \qquad [1a]$$

$$T_B = \frac{T_S}{15} \qquad [1b]$$

where S_B is the size characteristic of the B-end,
T_S is the torque transmitted by the pinion shaft in lb-ft,
P_M is the main line pressure in psi, and
15 is the ratio of worm to worm wheel.

For horsepower H_A transmitted by A-end:

$$H_A = 0.75\ K \qquad [2a]$$

or

$$H_A = \frac{P_M S_A N_A}{100{,}000} \times \frac{\sin\theta}{\sin 15°} \qquad [2b]$$

where K is the power input to the electric motor in kilowatts,
S_A is the size characteristic of the A-end,

N_A is the speed of the A-end in rpm, and
θ is the angle of tilt of the tilt-plate in degrees (15° maximum).

For horsepower H_B at B-end;

$$H_B = \frac{P_M S_B N_B}{100,000} \qquad [3a]$$

where S_B is the size characteristic of the B-end and N_B is the speed of the B-end in rpm.

For horsepower transmitted by pinion shaft;

$$H_S = \frac{T_S \times 2\pi N_S}{33,000} \qquad [3b]$$

where N_S is the speed of the pinion shaft in rpm.

$$T_S = \frac{I\alpha}{14.4} \qquad [4]$$

where I is the mass moment of inertia of the rotating gun in $lb\text{-}ft/sec^2$,
α is the angular acceleration in $radians/sec^2$, and
14.4 is the ratio of the pitch radius of the elevating arc to that of the pinion gear.

Formulas [1a], [2b], and [3a] are taken from Reference 4.

TEST RESULTS

The quantities recorded by the Taylor Model Basin for all tests were torque in the elevating pinion shaft,* angular acceleration of the gun, gun position, a 60-cps timing signal, and—when the guns were fired—the closing of the firing circuit.**

The peak values of the measured quantities and the time to reach these values are summarized in Tables 1 through 5.

A complete set of the oscillograms taken by the Model Basin has been forwarded to the Bureau of Ordnance.[5] The original oscillograms are on file at the Taylor Model Basin.

*To measure the torque in the elevating pinion shaft, pairs of wire resistance strain gages were mounted on opposite sides of the shaft. These gages are sensitive to strains developed by bending as well as by torque in the shaft but by virtue of the opposite direction of strains on the two sides of the shaft in bending, the bending effect may be eliminated simply by averaging strains. This could have been accomplished electrically, but the failure of a single gage would have endangered all data. Consequently, records were obtained separately of strains on both sides of the shaft; and the torque at any instant may be computed as an average of the two measurements.

**In correlating TMB and NPG oscillograph records it should be noted that the Model Basin indicated the time of closing of the firing circuit, whereas the Proving Ground indicated the time when the circuit was opened by the burning out of the electrical element in the powder case.

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TABLE 1

Peak Values of Torque and Acceleration from TMB Test 1

Run	Stationary Order degrees	Gun Position at Release	Gun Position at First Peak	First Peak		Gun Position at Beginning of Second Peak	Gun Position at Second Peak	Second Peak		Gun Position at Beginning of Third Peak	Gun Position at Third Peak	Third Peak	
				Torque kip-in.	Acceleration deg/sec²			Torque kip-in.	Acceleration deg/sec²			Torque kip-in.	Acceleration deg/sec²
1	30	29°	29° 50'	-200	43								
2	30	28°	28° 10'	-225	26	30°	30° 30'	350	-63	30° 10'	29° 50'	-220	47
3	30	27°	27° 20'	-232	43	30°	30° 10'	185	-32	30° 05'	30°	-120	15.
4	30	25°	25° 15'	-218	26	30° 45'	31° 15'	285	-41	30° 20'	29° 43'	-185	25
5	30	18° 20'	18° 40'	-208	29	30° 20'	31°	285	-31	30° 30'	29° 30'	-265	50
6	30	13° 20'	14°	-245	42	30° 20'	31° 10'	282	-30	30° 35'	29° 50'	-240	56
7	30	8° 20'	8° 40'	-205	31	30° 20'	31° 10'	295	-36	30° 30'	29° 50'	-242	62
8	30	3° 20'	4° 20'	-210	53	30° 20'	31° 05'	282	-32	30° 30'	29° 40'	-252	52
9	30	-1° 40'	-1° 25'	-215	36	30°	30° 50'	290	-40	30° 25'	29° 30'	-300	48
10	5	10°	10°	225	-32	6°	5°	-280	42	5°	5° 30'	390	-55
11	5	15°	15°	257	-44	5°	4°	-315	70	5°	5° 40'	308	-48
12	5	20°	20°	220	-37	5°	4° 05'	-325	46	5°	5° 50'	330	-72
13	5	25°	25°	215	-45	5°	4°	-305	50	5°	5° 40'	315	-45
14	5	30°	30°	210	-40	5°	4° 10'	-315	45	5°	5° 40'	330	-63

TABLE 2

Peak Values of Torque from TMB Test 3

Run	Motion of the Gun	Velocity deg/sec	Time Interval from Gunfire to Peak Torque sec	Gun Position When Fired	Torque kip-in
1	Elevating	2	0.27	4° 30'	210
2	Depressing	2	0.24	4° 30'	200
3	Elevating	4	0.24	5° 45'	225
4	Depressing	4	0.36	6°	195
5	Elevating	6	0.23	8°	190
7	Elevating	8	0.28	-	200
8	Depressing	8	0.35	-	160
9	Elevating	2	0.24	-	210
10	Depressing	2	0.34	19° 11'	230
11	Elevating	4	0.29	21° 12'	190
12	Depressing	4	0.33	20° 48'	190
13	Elevating	6	0.30	20° 54'	190
14	Depressing	6	0.32	20° 11'	190
15	Elevating	8	0.35	19° 26'	185
16	Depressing	8	0.34	20° 44'	190

The test schedule followed by the Taylor Model Basin is given in the Appendix. An explanatory note on the oscillograms is included.

TMB TEST 1

Test 1 was designed to determine the accuracy and speed with which the gun responds to changing signals.

Table 1 shows the results obtained from this test. The first peak indicates the amount of torque and acceleration which was developed in starting the gun to move after it was shifted into automatic control. The second peak is the decelerating torque and the deceleration produced as the gun first approached the stationary order. If the gun overran the stationary order, the third peak indicates the maximum torque required to bring the gun to a stop at the stationary order when it approached it the second time. The gun position at the beginning of the peak indicates the point at which there is evidence of a decelerating torque.

Figure 4 is a sample record of this test.

TMB TEST 2

Test 2 was conducted to determine the degree of accuracy with which the gun would follow a constant-velocity signal from the dummy director and to find the amount of torque required to keep the gun elevating or depressing at velocities of 2, 4, 6, and 8°/sec with the gun loaded and the cradles latched to the hoists.

A sample record is shown in Figure 5. Throughout this test the maximum torque was below 100 kip-in. and the acceleration was below 10°/sec/sec; therefore the results are not tabulated.

There is an oscillation in both torque and acceleration records in this test which is believed to have come from the oscillator on the control pressure in the regulator. The actual movement of the gun due to this oscillation was very small—of the order of $\pm$ 0.1 minute—and has no effect upon the action of the gun.

TMB TEST 3

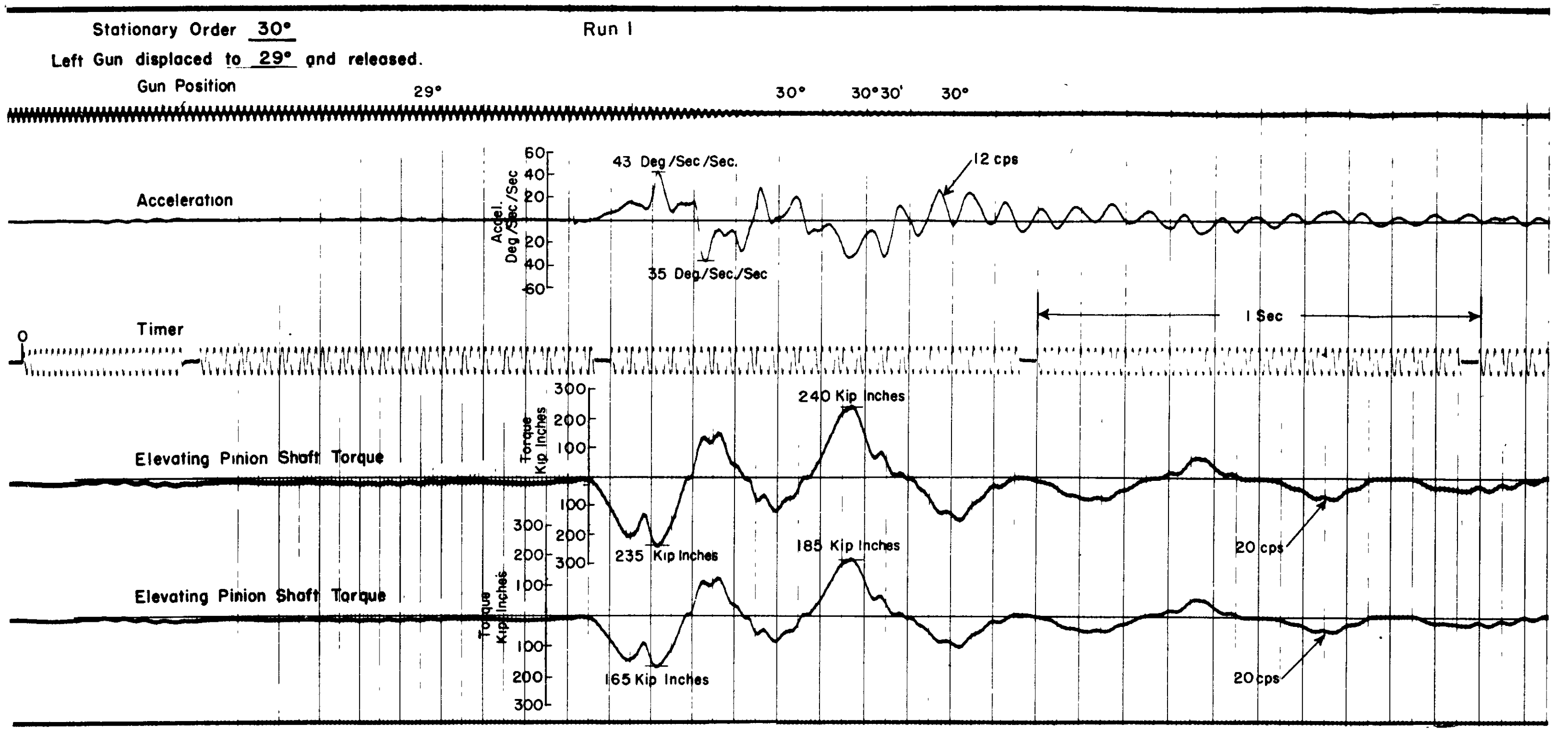
During Test 3 the gun was fired at 5° and 20° elevation while elevating and depressing at constant velocities of 2, 4, 6, and 8°/sec with all gun conditions being the same as in TMB Test 2. Peak values, and time to these values from time of fire, are tabulated in Table 2. The recorded acceleration is high as compared with the maximum acceleration expected. The frequency of 12.5 cps shown in the record indicates that the accelerometer was recording the vibration of the gun and not the change in angular velocity (considering the gun as a rigid body). These vibrations completely obscured the desired accelerometer response. Accelerations are therefore not tabulated.

Sample records from this test are shown in Figure 6.

TMB TEST 3a

TMB Test 2 was repeated in part except that the gun port seals and bucklers were made inoperative.

The pneumatic gun port seals installed in the pilot turret were considered inoperable by the Naval Gun Factory. At the time of their installation at the Gun Factory they were subjected to an air pressure in excess of the designed operating pressure without success in effecting a seal and were inoperative throughout the test. However, the bucklers were operative during all the tests except this one. There is no tabulation of peak results because of the low values observed.



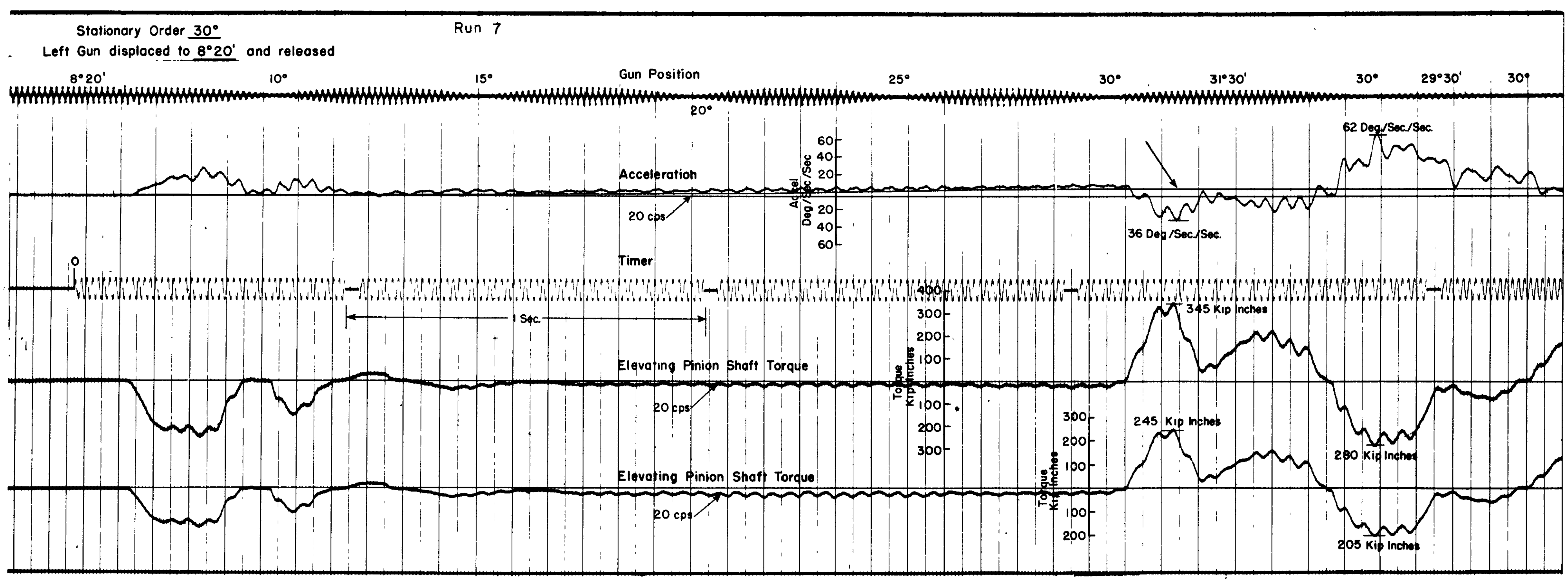


Figure 4 - Sample Record of TMB Test 1

TABLE 3

Peak Values of Torque from TMB Test 5

Run	Amplitude of Simple Harmonic Motion (12 second period) degrees	Motion of Gun at Firing	Gun Elevation at Firing	Torque kip-in.	Time Interval From Gunfire to Peak Torque seconds
1	5	Elevating	4° 30'	240	0.24
2	5	Depressing	5° 15'	215	0.34
3	10	Elevating	4° 20'	230	0.27
4	10	Depressing	6° 30'	185	0.28
5	15	Elevating	4° 15'	205	0.24
6	15	Depressing	6° 40'	180	0.32
7	5	Elevating	19°	205	0.23
8	5	Depressing	20° 30'	220	0.32
9	10	Elevating	18° 30'	200	0.26
10	10	Depressing	21°	190	0.32
11	15	Elevating	21°	170	0.30
12	15	Depressing	21° 30'	175	0.31

TMB TEST 4

Test 4 was conducted to determine how closely the position of the gun followed the director signal in response to a simple harmonic motion simulating rolls of 5°, 10°, and 15° with a 12-second period. A sample record is shown as Figure 7. As can be seen in this figure there was a small amount of hunting indicated in the torque records; however, the gun position record shows little or no evidence of this hunting.

There is no tabulation of peak results on this test because of the low values observed.

TMB TEST 5

During Test 5 the conditions of TMB Test 4 were repeated except that the guns were fired at approximately 5° elevation during elevating operations. A representative record is shown as Figure 8.

Table 3 shows the tabulated results from the records in this test.

TMB TEST 6

This test was conducted to determine the specific manner in which the gun, during elevating and depressing exercises, followed a constant velocity signal from the dummy director when it was loaded and both cradles were

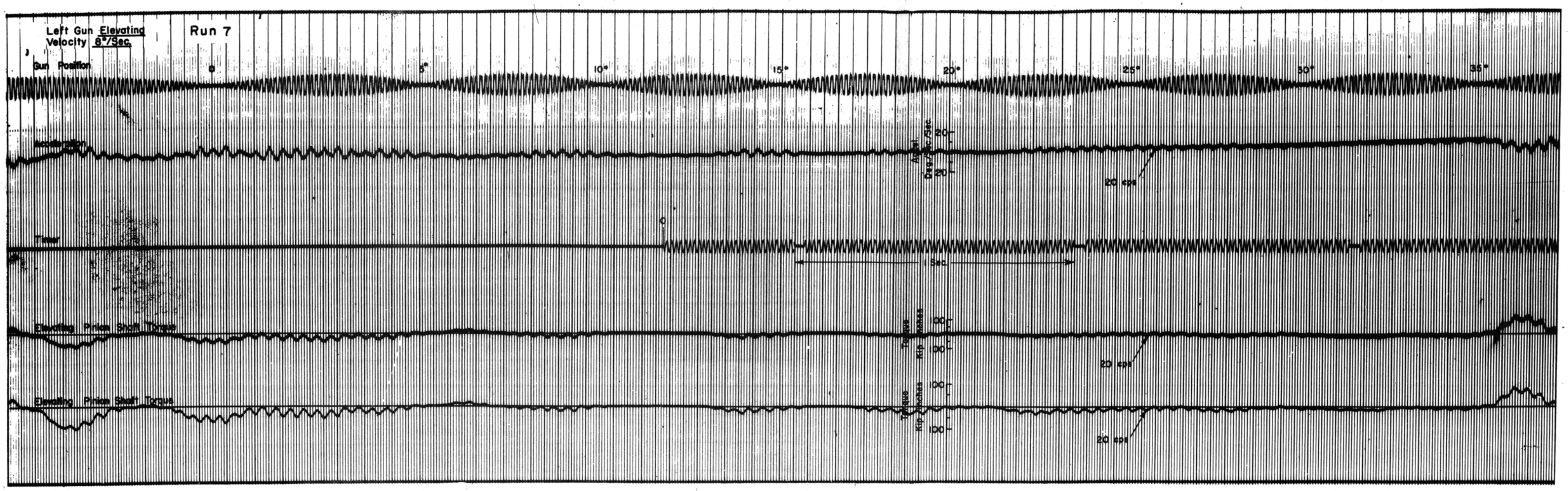


Figure 5 - Sample Record of TMB Test 2

This record was obtained while the left gun was elevating at a velocity of 8°/sec.

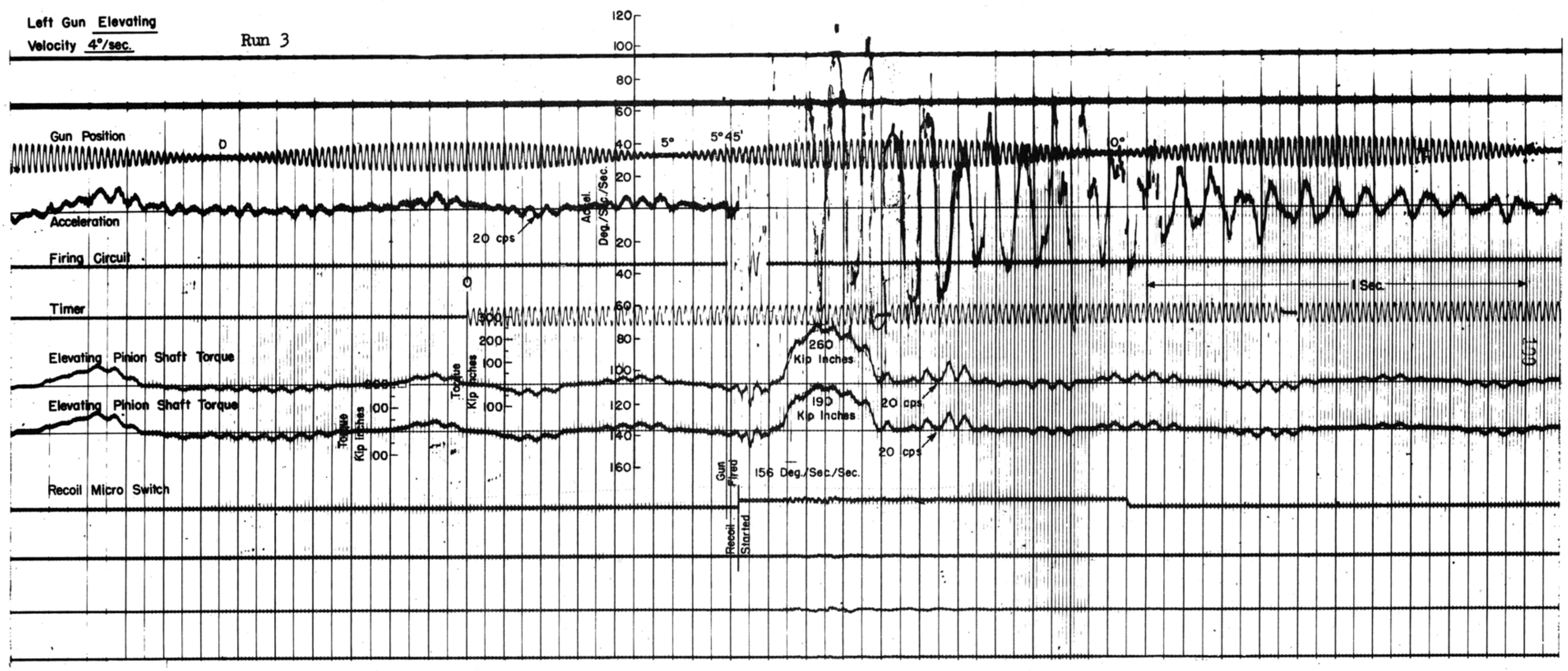


Figure 6 - Sample Record of TMB Test 3

This record was obtained while the left gun was elevating at a velocity of 4°/sec.

TABLE 4

Peak Values of Torque from TMB Test 8

Run	Amplitude of Simple Harmonic Motion (12 second period) degrees	Motion of Gun at Firing	Gun Elevation at Firing	Average Torque kip-in.	Time Interval From Gunfire to Peak Torque seconds
1	5	Elevating	4° 30'	240	0.26
2	5	Depressing	5° 40'	205	0.31
3	10	Elevating	3° 30'	230	0.29
4	10	Depressing	7°	195	0.31
5	15	Elevating	5° 15'	220	0.35
6	15	Depressing	7°	180	0.36
7	5	Elevating	20° 20'	200	0.27
8	5	Depressing	21°	210	0.36
9	10	Elevating	20°	200	0.28
10	10	Depressing	21° 15'	200	0.33
11	15	Elevating	18°	205	0.31
12	15	Depressing	17° 30'	220	0.35

TABLE 5

Peak Values of Torque and Acceleration from TMB Tests 9 and 10

Run	Velocity deg/sec (elevating)	Peak Torque kip-in.	Time to Peak Torque seconds	Peak Acceleration deg/sec^2	Time to Peak Acceleration seconds
TMB Test 9					
1	2	185	0.31	10	0.08
2	4	230	0.13	50	0.047
3	6	280	0.11	90	0.036
4	8	250	0.10	210	0.033
TMB Test 10					
1	2	200	0.33	10	0.07
2	4	250	0.12	50	0.05
3	6	270	0.12	110	0.037
4	8	250	0.08	215	0.033

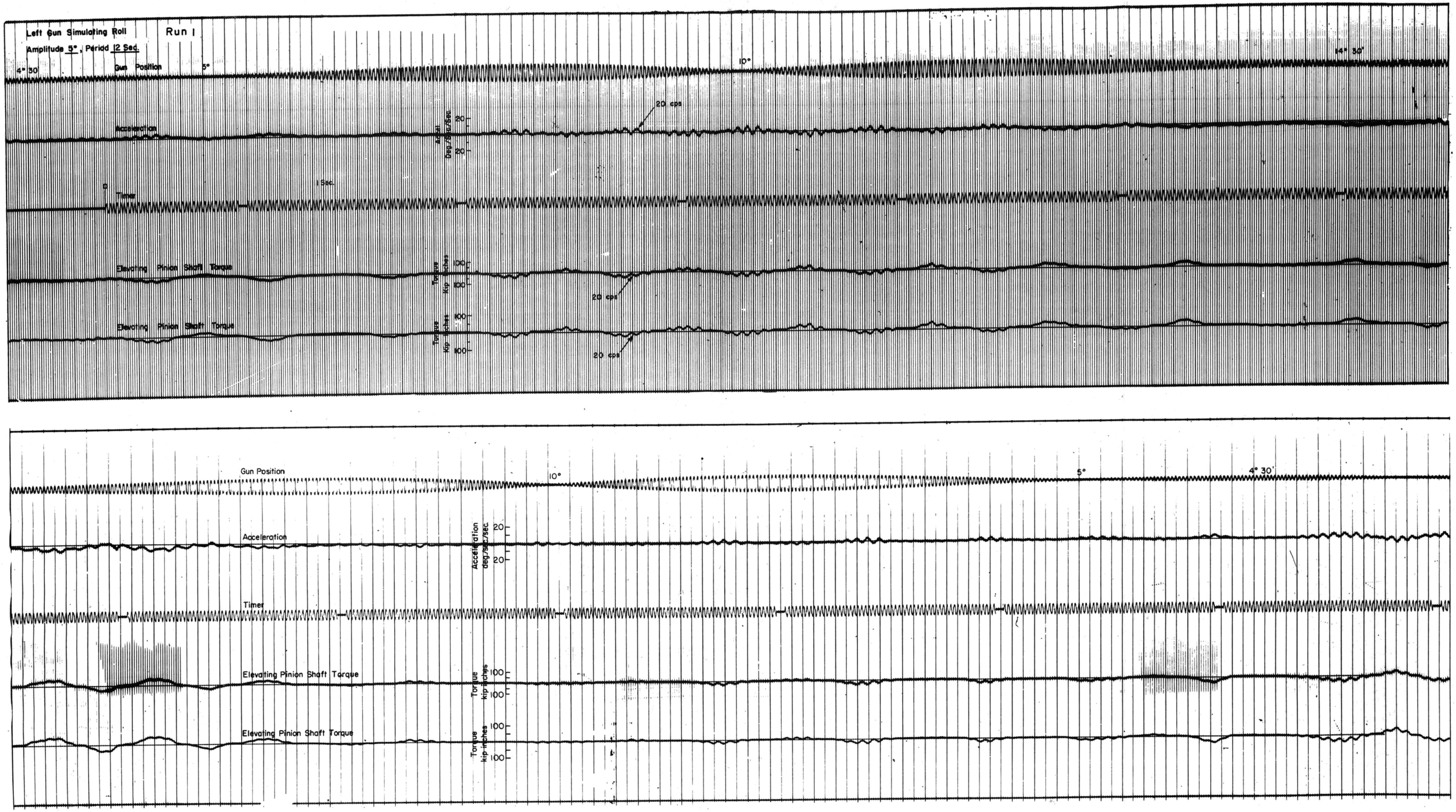
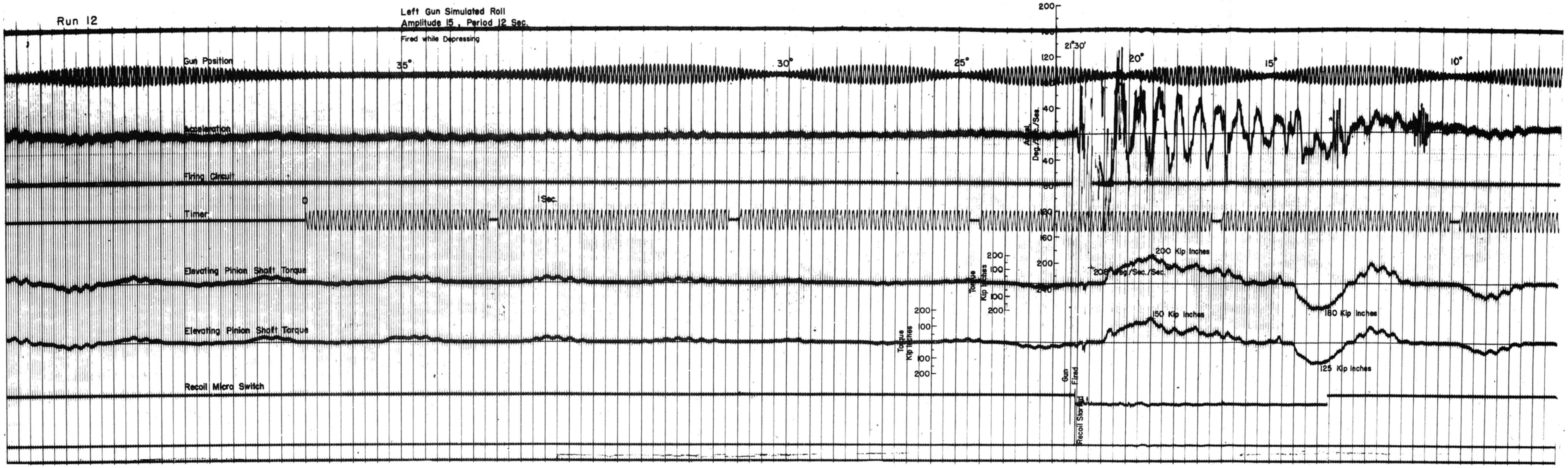


Figure 7 - Sample Record of TMB Test 4

Bottom record is a continuation of the top record.



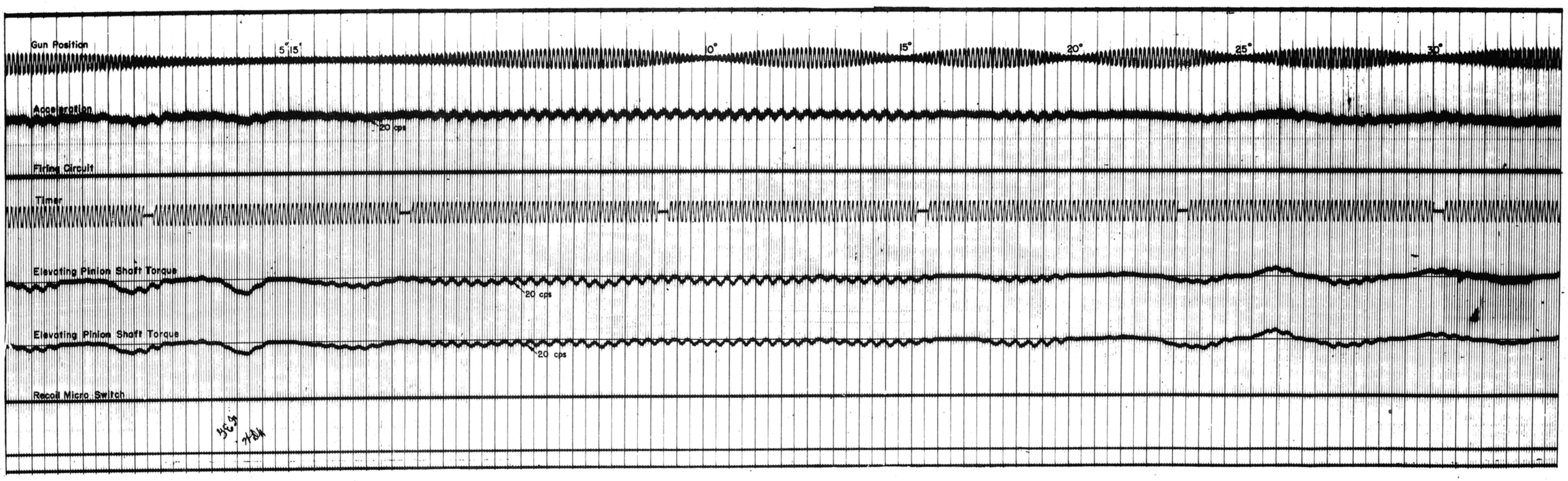


Figure 8 - Sample Record of TMB Test 5

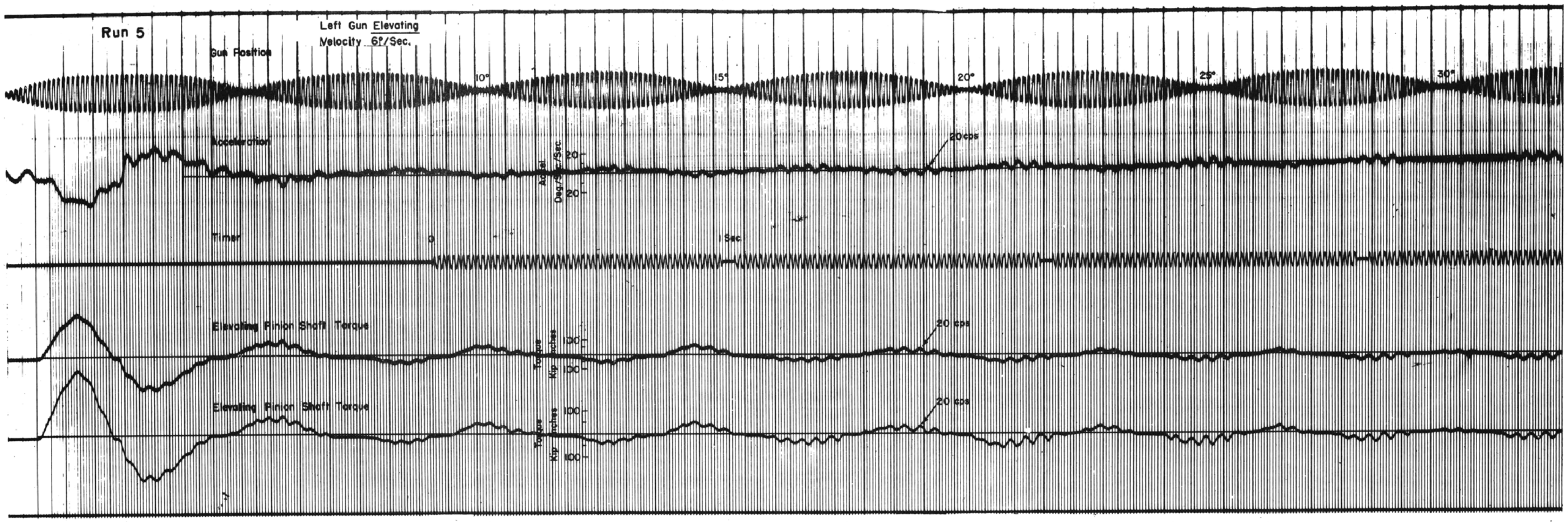


Figure 9 - Sample Record of TMB Test 6

latched to the slide. The exercises consisted of elevating and depressing the gun at 2, 4, 6, and 8°/sec.

A sample record is shown as Figure 9. A study of these records reveals that the gun did not operate smoothly during the first 2 seconds of its elevation or depression. This is the interval of time required for the gun to reach a constant velocity. The operation became uniform between 25 degrees and 20 degrees when the gun was depressing, after which there was little variation in velocity. There is no tabulation of peak results because of the low values observed.

TMB TEST 7

During Test 7 the guns were elevating and depressing in response to simple harmonic signals from the dummy director simulating 5° roll with 12-second period, 10° roll with 12-second period, and 15° roll with 12-second period. These were the same exercises as those in TMB Test 3 except that this time the guns were loaded, a powder case was in the transfer tray, the powder cradle was latched to the slide, and the projectile cradle was loaded and latched to the slide. All records in this test were similar to the sample record shown in Figure 5.

TMB TEST 8.

During Test 8 the conditions of the guns were identical with those in TMB Test 7 except that the guns were fired at approximately 5° and 20°. A sample record is shown as Figure 10.

The results of this test are recorded in Table 4 in the same manner which is followed in the previous tables. Again the acceleration readings indicate only the vibration of the gun.

TMB TESTS 9 AND 10

Because of the similarity between TMB Tests 9 and 10, the results are combined in this report. The only difference between the two is the type of fluid used in the buffer. In Test 9 the buffer was filled with fluid OS 2943, and during Test 10 the fluid was OS 1113..

The A-end limit stop of the elevating-speed gear was made inoperative, and the gun was elevated into the positive stop buffer at velocities of 2, 4, 6, and 8°/sec. During these exercises the Model Basin and the Naval Proving Ground recorded on one oscillograph the gun position, contact of buffer with slide, buffer displacement, pressure in buffer cylinder, pressure in

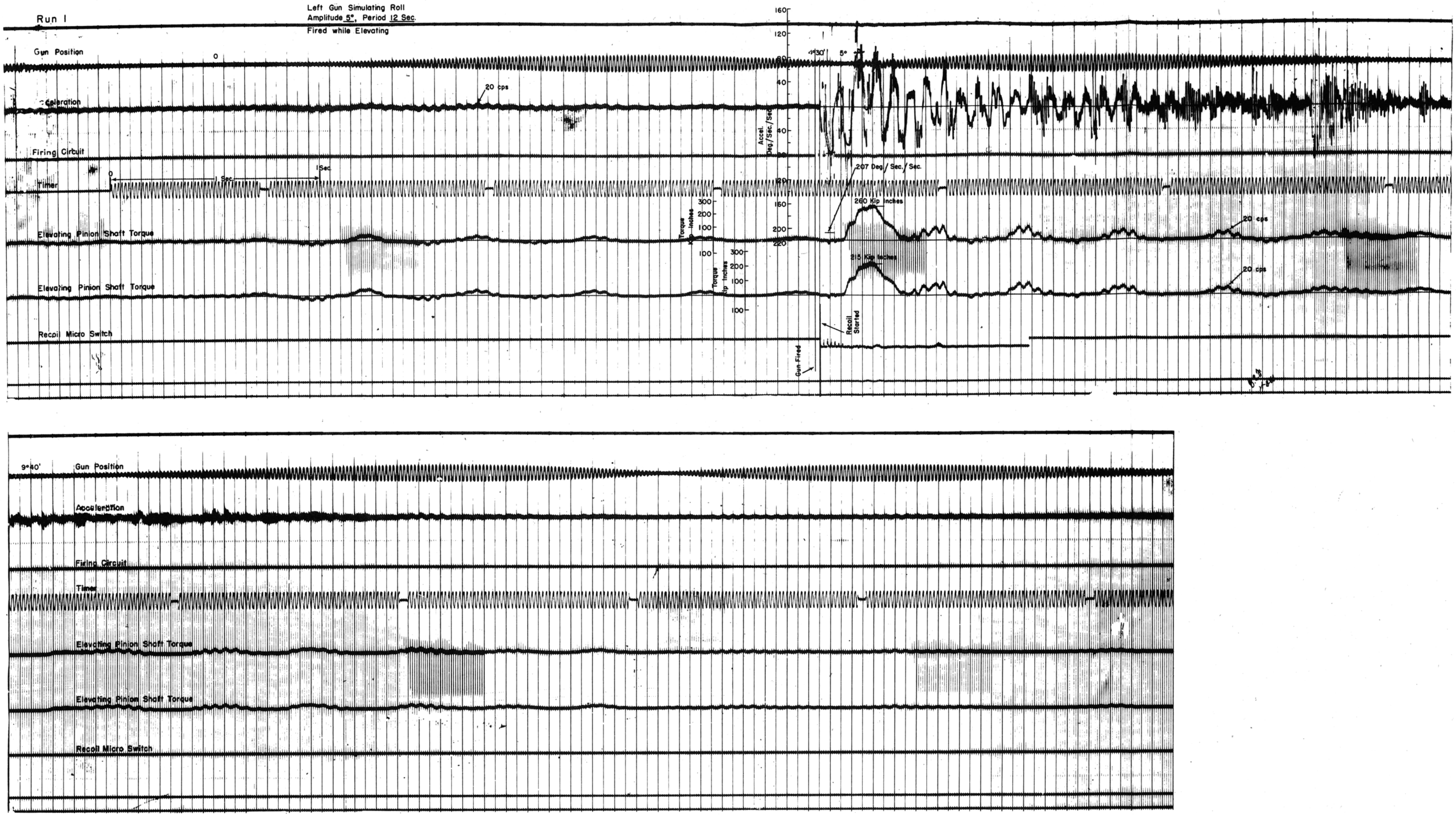
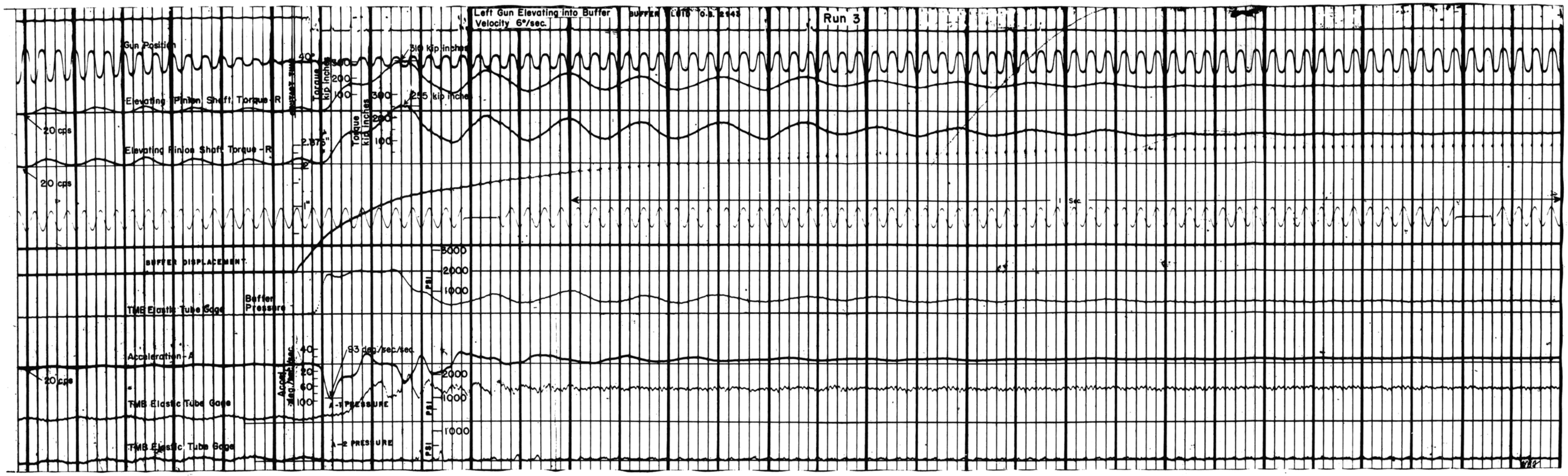


Figure 10 - Sample Record of TMB Test 8



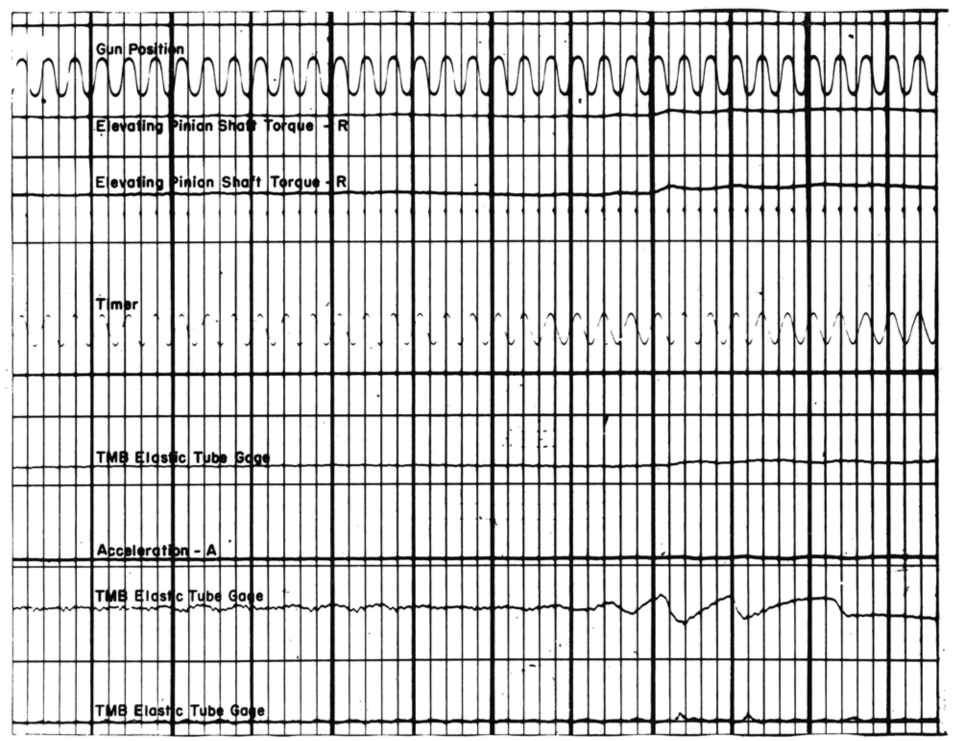


Figure 11 - Sample Record of TMB Test 9

main hydraulic lines, torque in pinion shaft, and angular acceleration of the gun.

The tabulated results are shown in Table 5, and a sample record is shown as Figure 11.

SUMMARY

The peak torque recorded was 390 kip-in. in TMB Test 1, Run 10. In this test the gun overran the stationary order; the peak torque occurred as the signal was approached for the second time.

The peak acceleration measured was 215°/sec^2 in TMB Test 10 when the gun was run into the buffer stops at the maximum velocity of 8°/sec.

Both the maximum torque and maximum acceleration were recorded in tests which did not include gunfire.

The angular acceleration of the gun recorded during tests which included gunfire appears to be, not the change in angular velocity of the gun acting as a rigid body, but acceleration of the gun due to its vibration. The vibration was apparently the result of gunfire. These vibrations obscure whatever rigid-body acceleration may be present. The peak values of such vibratory accelerations if of the same order as those observed during TMB Test 10 are about 200°/sec^2.

ACKNOWLEDGMENTS

In addition to the author of this report, personnel participating in these tests included J.F. Rhodes, C.A. Wagley, V.J. Mildenberg, M.E. Duke, and M. Dean under the supervision of L.M. DeLand. All tests of the pilot turret were made under the general guidance of Dr. E. Wenk.

APPENDIX

This appendix contains an explanatory note on the presentation of the oscillographic records which have already been forwarded to the Bureau of Ordnance,[5,6,7] and the test schedule followed in the elevating gear tests, which is in turn an index of the oscillograph data forwarded to the Bureau of Ordnance. Ordnance.[5,6,7]

The specifications[1] for conducting the tests of the CA139 Class pilot turret in general call for proof testing of the gun-elevating system by elevating or depressing both guns at constant velocity, or in response to simple harmonic signals from a dummy director, with and without simultaneous gunfire. Tests were run at gun velocities of 2, 4, 6, and 8°/sec and in response to signals which simulated 5°, 10° and 15° roll with a 12-second period.

Records of the measurements have been obtained with the instruments described in Reference 3. Each record for the respective elevating-gear test is identified according to the operation described in paragraph 14 of Reference 1.

All measurements obtained were recorded on a time base with timing lines of 0.01 sec marked throughout the complete record. A supplemental timing signal of 60 cps was also placed on one channel of each recording oscillograph. The start of the timing signal is marked "0" on each sheet and this point may be used to correlate records obtained by the David Taylor Model Basin with those obtained by the Naval Proving Ground, Dahlgren, Virginia.

Baselines with scales in appropriate units have been placed on each record. Peak values of torque and acceleration are labeled.

Torque records above the baseline accompany torques which tend to depress the gun whereas those below the baseline indicate elevating torques. The actual torque transmitted by the elevating pinion shaft is the average of the two records presented, as pointed out in Reference 3.

Accelerations while elevating or decelerations while depressing are indicated by records above the baseline. When two lines are drawn on the records of acceleration, the arrow points to the proper baseline, corrected as pointed out in Reference 3.

The position of the gun has been frequently designated to permit correlation of the variables measured.

On records of tests which involve gunfire, the time that the firing key is closed and the instant that recoil action starts are recorded.

Throughout the tests, the records show a superimposed frequency of 20 cps. This is caused by the 1200 rpm mechanical oscillator installed in the hydraulic system to reduce delays in valve operation.

ELEVATING GEAR TEST

TMB Test 1

NAVORD OS3873,[1] Paragraph 14a

The gun was displaced from stationary order and released from successively increasing angles of error.

Gun	Stationary Order degrees	Angle of Gun Release degrees	Measurements*	Sheet
Left	30	29	A, B, V	1
	30	28		2
	30	27		3
	30	25	Recorded	4
	30	18.3		5
	30	13.3		6
	30	8.3	On	7
	30	3.3		8
	30	-1.6		9
	5	10	All	10
	5	15		11
	5	20		12
	5	25	Sheets	13
	5	30		14

*A - Torque in elevating pinion shaft.
B - Elevation of gun.
V - Gun acceleration during elevation.

ELEVATING GEAR TEST

TMB Test 2

NAVORD OS3873,[1] Paragraph 14c-1

The gun was elevated and depressed at constant velocity. The cradles were latched to hoist.

Gun	Motion of the Gun	Velocity deg/sec	Measurements	Sheet
Left	Elevating	2	A, B, V	1
	Depressing	2		2
	Elevating	4	Recorded	3
	Depressing	4		4
	Elevating	6	On All	5
	Depressing	6		6
	Elevating	8	Sheets	7
	Depressing	8		8

ELEVATING GEAR TEST

TMB Test 3

NAVORD OS3873,[1] Paragraph 14c-2

The gun was elevated and depressed at constant velocity and was fired at selected elevations.

Gun	Motion of the Gun	Velocity deg/sec	Angle of Gunfire degrees	Measurements*	Sheet
Left	Elevating	2	5	A, B, J, V	1
	Depressing	2	5		2
	Elevating	4	5	Recorded	3
	Depressing	4	5		4
	Elevating	6	5		5
	Depressing	6	5		6
	Elevating	8	5	On	7
	Depressing	8	5		8
	Elevating	2	20		9
	Depressing	2	20		10
	Elevating	4	20	All	11
	Depressing	4	20		12
	Elevating	6	20		13
	Depressing	6	20		14
	Elevating	8	20	Sheets	15
	Depressing	8	20		16

*A - Torque in elevating pinion shaft.
B - Elevation of gun.
J - Closing of firing circuit.
V - Gun acceleration during elevation.

ELEVATING GEAR TEST

TMB Test 3a

NAVORD OS3873,[1] Paragraph 14c-2

The gun was elevated and depressed at constant velocity.
The gun port seals and bucklers were inoperative.

Gun	Motion of the Gun	Velocity deg/sec	Measurements	Sheet
Left	Elevating	2	A, B, V	1
	Depressing	2	Recorded	2
	Elevating	4	On All	3
	Depressing	4	Sheets	4

ELEVATING GEAR TEST

TMB Test 4

NAVORD OS3873,[1] Paragraph 14d-1

The gun was moving to simulate rolls with 12-second periods.

Gun	Amplitude degrees	Measurements	Sheet
Left	5	A, B, V	1
	10	Recorded	2
	15	On All Sheets	3

ELEVATING GEAR TEST

TMB Test 5

NAVORD OS3873,[1] Paragraph 14d-2

The gun was moving to simulate rolls with 12-second periods.

The gun was fired at selected elevations.

Gun	Motion of the Gun When Fired	Amplitude degrees	Angle of Gunfire degrees	Measurements	Sheet
Left	Elevating	5	5	A, B, J, V	1
	Depressing	5	5		2
	Elevating	10	5	Recorded	3
	Depressing	10	5		4
	Elevating	15	5		5
	Depressing	15	5	On	6
	Elevating	5	20		7
	Depressing	5	20		8
	Elevating	10	20	All	9
	Depressing	10	20		10
	Elevating	15	20		11
	Depressing	15	20	Sheets	12

ELEVATING GEAR TEST

TMB Test 6

NAVORD OS3873,[1] Paragraph 14e-1

The gun was elevated and depressed at constant velocity.

The cradles were latched to slide.

Gun	Motion of the Gun	Velocity deg/sec	Measurements	Sheet
Left	Elevating	2	A, B, V	1
	Depressing	2		2
	Elevating	4	Recorded	3
	Depressing	4		4
	Elevating	6	On All	5
	Depressing	6		6
	Elevating	8	Sheets	7
	Depressing	8		8

ELEVATING GEAR TEST

TMB Test 7

NAVORD OS3873,[1] Paragraph 14f-1

The gun was moving to simulate rolls with 12-second periods.

Same as 3 except that guns were loaded, powder case was in transfer tray, and cradles loaded and latched to slide.

Gun	Amplitude degrees	Measurements	Sheet
Left	5	A, B, V	1
	10	Recorded	2
	15	On All	3
		Sheets	

ELEVATING GEAR TEST

TMB Test 8

NAVORD OS3873,[1] Paragraph 14f-2

The gun was moving to simulate rolls with 12-second periods and was fired at given elevations.

Gun	Motion of the Gun When Fired	Amplitude degrees	Angle of Gunfire degrees	Measurements	Sheet
Left	Elevating	5	5	A, B, J, V	1
	Depressing	5	5		2
	Elevating	10	5	Recorded	3
	Depressing	10	5		4
	Elevating	15	5		5
	Depressing	15	5	On	6
	Elevating	5	20		7
	Depressing	5	20		8
	Elevating	10	20	All	9
	Depressing	10	20		10
	Elevating	15	20		11
	Depressing	15	20	Sheets	12

ELEVATING GEAR TEST

TMB Test 9

NAVORD OS3873,[1] Paragraph 15b-1

The gun was elevated at constant velocity and struck stop buffers. Buffer fluid OS2943 was used.

Gun	Motion of the Gun	Velocity deg/sec	Measurements	Sheet
Left	Elevating	2	A, B, V	1
	Elevating	4	Recorded	2
	Elevating	6	On All	3
	Elevating	8	Sheets	4

ELEVATING GEAR TEST

TMB Test 10

NAVORD OS3873,[1] Paragraph 15b-2

Buffer fluid OS 1113 was used in this test.

Gun	Motion of the Gun	Velocity deg/sec	Measurements	Sheet
Left	Elevating	2	A, B, V Recorded On All Sheets	1
	Elevating	4		2
	Elevating	6		3
	Elevating	8		4

REFERENCES

1. "General Specifications to Cover the Tests to be Conducted on the 8-Inch 55-Caliber Pilot Turret CA139 Class," NAVORD OS3873, dated 10 October 1945 (revised 25 September 1946).

2. "Schedule of Measurements to be Made by the David Taylor Model Basin during Tests of the CA139 Class Pilot Turret," TMB Memorandum 2, CA139 Class/S72-1 of 13 November 1945 (revised 25 April 1947).

3. DeLand, L. Mason, "Description of Instruments Employed in the Operational Tests of the Gun-Elevating Systems of the CA139 Class Pilot Turret," TMB RESTRICTED Report C-29, October 1947.

4. The Waterbury Hydraulic Speed Gear Catalog, Waterbury Tool Company, Waterbury, Conn.

5. TMB RESTRICTED ltr C-CA139 Class/S72 of 17 October 1947 to BuOrd.

6. TMB RESTRICTED ltr C-CA139 Class/S72-1 of 19 December 1947 to BuOrd.

7. TMB RESTRICTED ltr C-CA139 Class/S72-1 of 10 February 1948 to BuOrd.

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