

AD-A065 356

AD A065 356

MEMORANDUM REPORT ARBRL-MR-02881

(Supersedes IMR No. 586)

YAWSONDE FLIGHTS OF 155MM NON-CONICAL
BOATTAIL PROJECTILES AND THE 155MM M549
PROJECTILE AT TONOPAH TEST RANGE--OCTOBER 1977

Anders S. Platou

TECHNICAL
LIBRARY

November 1978



US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
BALLISTIC RESEARCH LABORATORY
ABERDEEN PROVING GROUND, MARYLAND

Approved for public release; distribution unlimited.

DTIC QUALITY INSPECTED 3

Destroy this report when it is no longer needed.
Do not return it to the originator.

Secondary distribution of this report by originating
or sponsoring activity is prohibited.

Additional copies of this report may be obtained
from the National Technical Information Service,
U.S. Department of Commerce, Springfield, Virginia
22161.

7.32

The findings in this report are not to be construed as
an official Department of the Army position, unless
so designated by other authorized documents.

*The use of trade names or manufacturers' names in this report
does not constitute endorsement of any commercial product.*

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|-----------------------|---|
| 1. REPORT NUMBER MEMORANDUM REPORT ARBRL-MR-02881 | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle) YAWSONDE FLIGHTS OF 155MM NON-CONICAL BOATTAIL PROJECTILES AND THE 155MM M549 PROJECTILE AT TONOPAH TEST RANGE--OCTOBER 1977 | | 5. TYPE OF REPORT & PERIOD COVERED Final |
| 7. AUTHOR(s) Anders S. Platou | | 6. PERFORMING ORG. REPORT NUMBER |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Ballistic Research Laboratory (ATTN: DRDAR-BLL) Aberdeen Proving Ground, Maryland 21005 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS RDT&E 1L161102AH80 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Armament Research & Development Command U.S. Army Ballistic Research Laboratory (ATTN: DRDAR-BL) Aberdeen Proving Ground, MD 21005 | | 12. REPORT DATE NOVEMBER 1978 |
| | | 13. NUMBER OF PAGES 59 |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) | | 15. SECURITY CLASS. (of this report) Unclassified |
| | | 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |
| 16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited. | | |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) | | |
| 18. SUPPLEMENTARY NOTES This BRL Memorandum Report supersedes BRL Interim Memorandum Report No. 586 dated December 1977. | | |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Projectiles Non-Conical Boattails Aeroballistic Characteristics | | |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number) (1cb) As part of the BRL program to develop the non-conical boattail projectile, twenty 155mm projectiles were fired from an M185 gun tube on 18 and 21 October 1977 at the Sandia Corporation, Tonopah Test Range, Nevada. This is the second phase of a planned three phase test program at Tonopah on the non-conical boattail projectiles. The report describes the experimental plans and presents the data records and some of the results obtained during the projectile flights. | | |

TABLE OF CONTENTS

| | <u>Page</u> |
|--|-------------|
| LIST OF ILLUSTRATIONS | 5 |
| LIST OF TABLES | 7 |
| I. INTRODUCTION | 9 |
| II. TEST SITE AND FACILITIES | 9 |
| III. CONFIGURATIONS, TEST PROGRAM, AND INSTRUMENTATION | 9 |
| IV. RESULTS AND CONCLUSIONS | 10 |
| REFERENCES | 56 |
| DISTRIBUTION LIST | 57 |

LIST OF ILLUSTRATIONS

| <u>Figure</u> | <u>Page</u> |
|--|-------------|
| 1. The 155mm M549 Projectile | 12 |
| 2. The M549 and the NCB-A Projectiles | 13 |
| 3. The Non-Conical Boattail Projectile--NCB-A | 14 |
| 4. The NCB-B Projectile Without the Discarding Rotating Band | 15 |
| 5. The NCB-B Projectile With the Discarding Rotating Band . . | 16 |
| 6. The Non-Conical Boattail Projectile--NCB-B | 17 |
| 7. The External Dimensions of the Plastic Discarding Rotating Band | 18 |
| 8. The Yawing Motion of the NCB-A Projectile Round No. 1 . . | 19 |
| 9. The Spin Motion of the NCB-A Projectile Round No. 1 . . . | 20 |
| 10. The Yawing Motion of the NCB-A Projectile Round No. 2 . . | 21 |
| 11. The Spin Motion of the NCB-A Projectile Round No. 2 . . . | 22 |
| 12. The Yawing Motion of the NCB-A Projectile Round No. 3 . . | 23 |
| 13. The Spin Motion of the NCB-A Projectile Round No. 3 . . . | 24 |
| 14. The Yawing Motion of the NCB-A Projectile Round No. 4 . . | 25 |
| 15. The Spin Motion of the NCB-A Projectile Round No. 4 . . . | 26 |
| 16. The Yawing Motion of the NCB-A Projectile Round No. 5 . . | 27 |
| 17. The Spin Motion of the NCB-A Projectile Round No. 5 . . . | 28 |
| 18. The Yawing Motion of the NCB-A Projectile Round No. 6 . . | 29 |
| 19. The Spin Motion of the NCB-A Projectile Round No. 6 . . . | 30 |
| 20. The Yawing Motion of the NCB-A Projectile Round No. 7 . . | 31 |
| 21. The Spin Motion of the NCB-A Projectile Round No. 7 . . . | 32 |
| 22. The Yawing Motion of the NCB-A Projectile Round No. 8 . . | 33 |

LIST OF ILLUSTRATIONS (Continued)

| <u>Figure</u> | | <u>Page</u> |
|---------------|--|-------------|
| 23. | The Spin Motion of the NCB-A Projectile Round No. 8 . . . | 34 |
| 24. | The Yawing Motion of the M549 RAP Projectile, Rocket Off, Round No. 10 | 35 |
| 25. | The Spin Motion of the M549 RAP Projectile, Rocket Off, Round No. 10 | 36 |
| 26. | The Yawing Motion of the M549 RAP Projectile, Rocket Off, Round No. 11 | 37 |
| 27. | The Spin Motion of the M549 RAP Projectile, Rocket Off, Round No. 11 | 38 |
| 28. | The Yawing Motion of the M549 RAP Projectile, Rocket Off, Round No. 13 | 39 |
| 29. | The Spin Motion of the M549 RAP Projectile, Rocket Off, Round No. 13 | 40 |
| 30. | The Yawing Motion of the M549 RAP Projectile, Rocket On, Round No. 15 | 41 |
| 31. | The Spin Motion of the M549 RAP Projectile, Rocket On, Round No. 15 | 42 |
| 32. | The Yawing Motion of the M549 RAP Projectile, Rocket On, Round No. 16 | 43 |
| 33. | The Spin Motion of the M549 RAP Projectile, Rocket On, Round No. 16 | 44 |
| 34. | The Yawing Motion of the NCB-B Projectile Round No. 17 . . | 45 |
| 35. | The Spin Motion of the NCB-B Projectile Round No. 17 . . | 46 |
| 36. | The Yawing Motion of the NCB-B Projectile Round No. 18 . . | 47 |
| 37. | The Spin Motion of the NCB-B Projectile Round No. 18 . . | 48 |
| 38. | The Yawing Motion of the NCB-B Projectile Round No. 19 . . | 49 |
| 39. | The Spin Motion of the NCB-B Projectile Round No. 19 . . | 50 |

LIST OF TABLES

| <u>Table</u> | <u>Page</u> |
|---|-------------|
| I. The Physical Characteristics of the 155mm Projectiles Fired at Tonopah Test Range, Nevada, on 18-21 October 1977 | 51 |
| II. Program for the Second Phase Shoot of the NCB-A and NCB-B Projectiles at Tonopah During the Week of 17 October 1977 | 52 |
| III. Log of Second Phase Non-Conical Boattail Projectile Flights, Tonopah Test Range, Nevada, 18 and 21 October 1977 | 53 |
| IV. The Impact Data From the Phase 2 Flights | 55 |

I. INTRODUCTION

The BRL program to develop the non-conical boattail projectile requires the firing of approximately one hundred 155 mm projectiles and twenty-two 105 mm projectiles under various flight conditions. During each flight various aeroballistic information is recorded for later analysis. So far, thirteen 155 mm projectiles and twenty-two 105 mm projectiles have been fired at APG for charge assessment, mechanical integrity, and aerodynamic characteristics, six 155 mm projectiles have been fired at Nicolet, Canada, under minimum stability conditions and thirty-three 155 mm projectiles have been fired at the Tonopah Test Range, Nevada, at various flight conditions. All of these firings have been reported^{1,2,3} except for the last thirteen fired at Tonopah on 18 and 21 October 1977. This report presents the experimental plans, and the in-flight data records on these thirteen projectiles plus seven additional 155 mm M549 projectiles used as reference projectiles. These twenty projectile flights are the second phase of three to be flown at Tonopah.

II. TEST SITE AND FACILITIES

The Tonopah Test Range and facilities are the same used during the Phase I firings and are described in detail in reference 3.

III. CONFIGURATIONS, TEST PROGRAM, AND INSTRUMENTATION

During the week of 16 October 1977, twenty 155 mm projectiles were fired from an M185 gun tube. Three projectile configurations were flown as listed below.

1. M549 RAP Projectile with rocket on or off (Figures 1 and 2).
2. Non-Conical Boattail Projectile A (NCB-A) (Figures 2 and 3).

-
1. Anders S. Platou, "An Improved Projectile Boattail. Part IV.," ARBRL-MR-02826, April 1978, U.S. Army Ballistic Research Laboratory, Aberdeen Proving Ground, Maryland. AD BB027520L.
 2. John H. Whiteside, "Transonic Tests of the 155mm Non-Conical Boat-tail Projectile A and the 8-Inch XM650E4 and EBVP Projectiles at Nicolet, Canada, During January-February 1977," ARBRL-MR-02809, January 1978, U.S. Army Ballistic Research Laboratory, Aberdeen Proving Ground, Maryland. AD B027297L.
 3. Vural Oskay and Anders S. Platou, "Yawsonde Tests of 155mm M549 Non-Conical Boattail Projectile at Tonopah Test Range," BRL Memorandum Report in preparation.

3. Non-Conical Boattail Projectile B (NCB-B) (Figures 4, 5, and 6).

The model physical characteristics are given in Table I, and the test program is given in Table II. Each projectile was instrumented with a yawsonde just prior to the launch so that the angular yawing motion of the projectile during the flight was recorded. Radar was used to track each projectile to provide trajectory and velocity records. Impact coordinates were obtained from ground surveys.

The projectiles NCB-A and M549 were launched using standard copper rotating bands and required no preliminary tests. The NCB-B projectiles used a plastic discarding rotating band which required some development of the design. The final design used on the NCB-B projectile is shown in Figure 5. The plastic Eurethane was molded onto the triangular boattail with three (one on each triangular surface) aluminum keys used to keep the projectile from sliding axially with respect to the plastic during the projectile ramming process. The exterior of the plastic was then machined to the dimensions shown in Figure 7. At propellant ignition the plastic moves forward with respect to the projectile, breaking into small pieces as it becomes compacted between the projectile and the gun tube rifling grooves. This action brings the projectile spin up to the gun twist value, thereby stabilizing the projectile in flight. After leaving the muzzle the small pieces of plastic fall to the ground and the aluminum keys are thrown away by centrifugal force.

IV. RESULTS AND CONCLUSIONS

1. The log of the twenty flights of the Phase II firings is given in Table III.

2. Muzzle velocity variations (642.5 to 659.3 m/s) for the nine NCB-A projectiles is reduced from those observed during the corresponding Phase I firings (625.1 to 658.4) but is still higher than desired. Muzzle velocity variations during the firing of the five M549 RAP projectiles is much less (245.3 to 247.5 m/s). This is apparently due to use of a plastic obturator ring to create a better gas seal for the propelling gases. It is understood that this seal is used on most 155 mm projectile firings and it should be used with the NCB-A projectiles.

3. The first maximum yaw values ($2\frac{1}{2}^\circ$ to 5°) had less variation and were lower than during the corresponding Phase I tests (1.6° to 9°). This is probably due to increasing the rear portion of the boattail diameter to within .25 mm of the gun bore. During the manufacture of the NCB-A and NCB-B projectiles, the main boattail diameter had been undercut by .76 mm, but has been corrected on all non-conical boattailed projectiles fired since Phase I (Figures 3 and 6) by welding aluminum pads on the rear portion of the boattail and machining to within .25 mm

of the gun bore diameter. Machining the whole boattail diameter to tighter tolerances should lower the first maximum yaw values even further.

4. The yawsonde records show all of the projectiles had stable flights (Figures 8 to 39). The first maximum yaw of the NCB-A projectiles was slightly higher ($2\frac{1}{2}^{\circ}$ to 5°) than the M549 RAP (rocket off), but it is not believed that this small yaw will deter the flight performance. Only the first portion of the yawsonde records for the 18 October 1977 flights have been processed so far. Unless the need arises, the later portion of these flights will not be processed for the aerodynamic characteristics of the NCB-A and M549 are known (references 1 and 4).

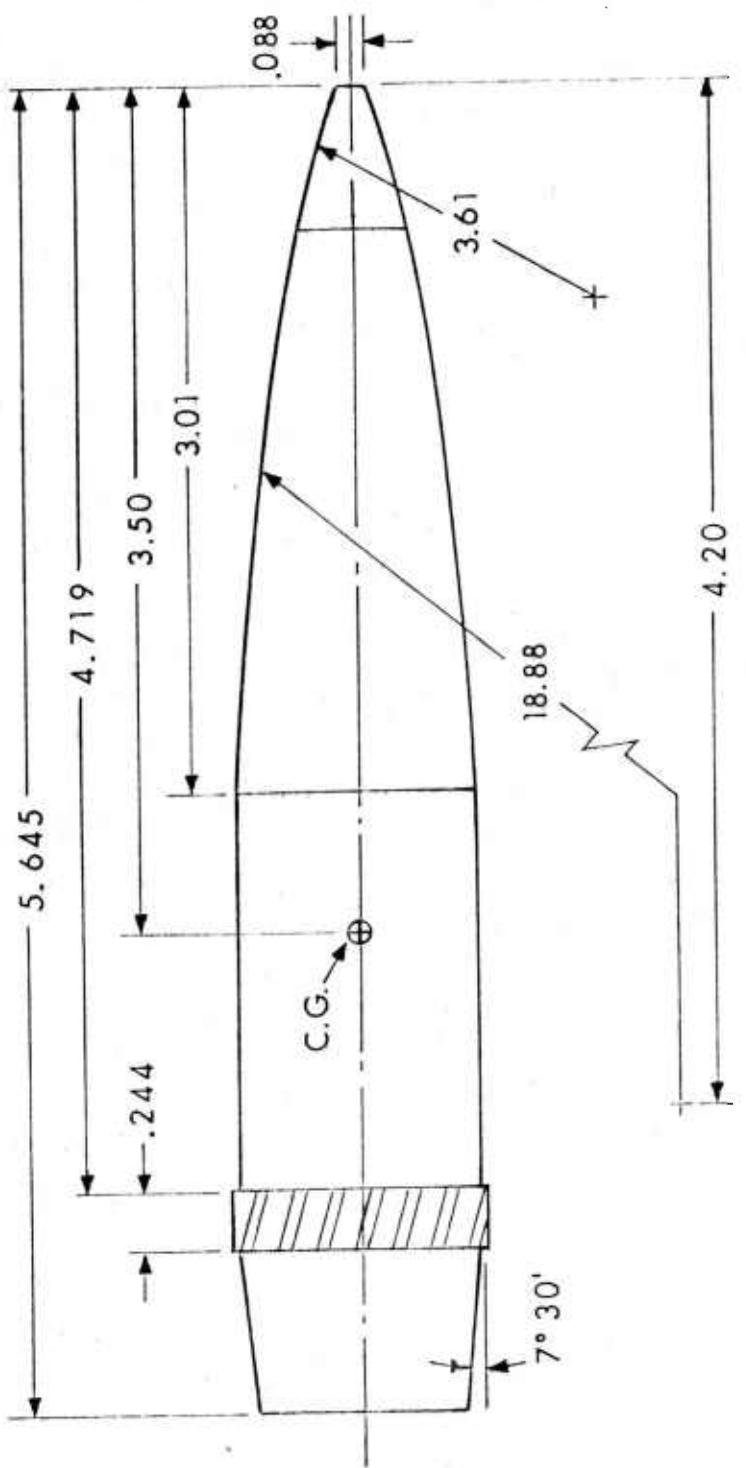
5. The two M549 RAP projectiles with rocket on were fired for general interest and are not directly associated with the non-conical boattail testing. Their yawsonde records (Figures 31 to 34) show stable flight; however, the spin increase (in spite of the uncantered axial nozzle) during the rocket on portion of the flight ($t = 7$ seconds to 10 seconds) is not clearly understood. This phenomena has been observed before on other large caliber rocket assisted flights. The blanking of the telemetered yawsonde signal during the rocket on portion of the flight has also been observed before.

6. The four NCB-B projectiles which were launched at transonic speeds ($M \approx 1.05$) flew with a 5° limit cycle (Figures 35 to 39) similar to those observed during the NCB-A transonic launch flights (references 2 and 3). Also, the NCB-B angular motion recovered from large artificially induced first maximum yaw (Figure 39) similar to the NCB-A projectile. The aerodynamic characteristics of the NCB-B projectile will be computed from these yawsonde records as soon as possible.

7. Impact, deflection, and muzzle velocity are given in Table IV. Table IV also gives the impact data for the NCB-A and the M549 projectiles corrected to the listed muzzle velocities and the resulting dispersion values.

8. On all of the spin plots PHI DOT is the Eulerian spin of the projectile and the spin about the principle body axis at any given time is essentially the average of PHI DOT.

4. R. W. Kline, W. R. Herrmann, and V. Oskay, "A Determination of the Aerodynamic Coefficients of the 155mm, M549 Projectile," Picatinny Arsenal Technical Report No. 4764, November 1974. AD B002073L.



ALL DIMENSIONS IN CALIBERS
1 caliber = 154.7 mm

Figure 1. The 155mm M549 Projectile

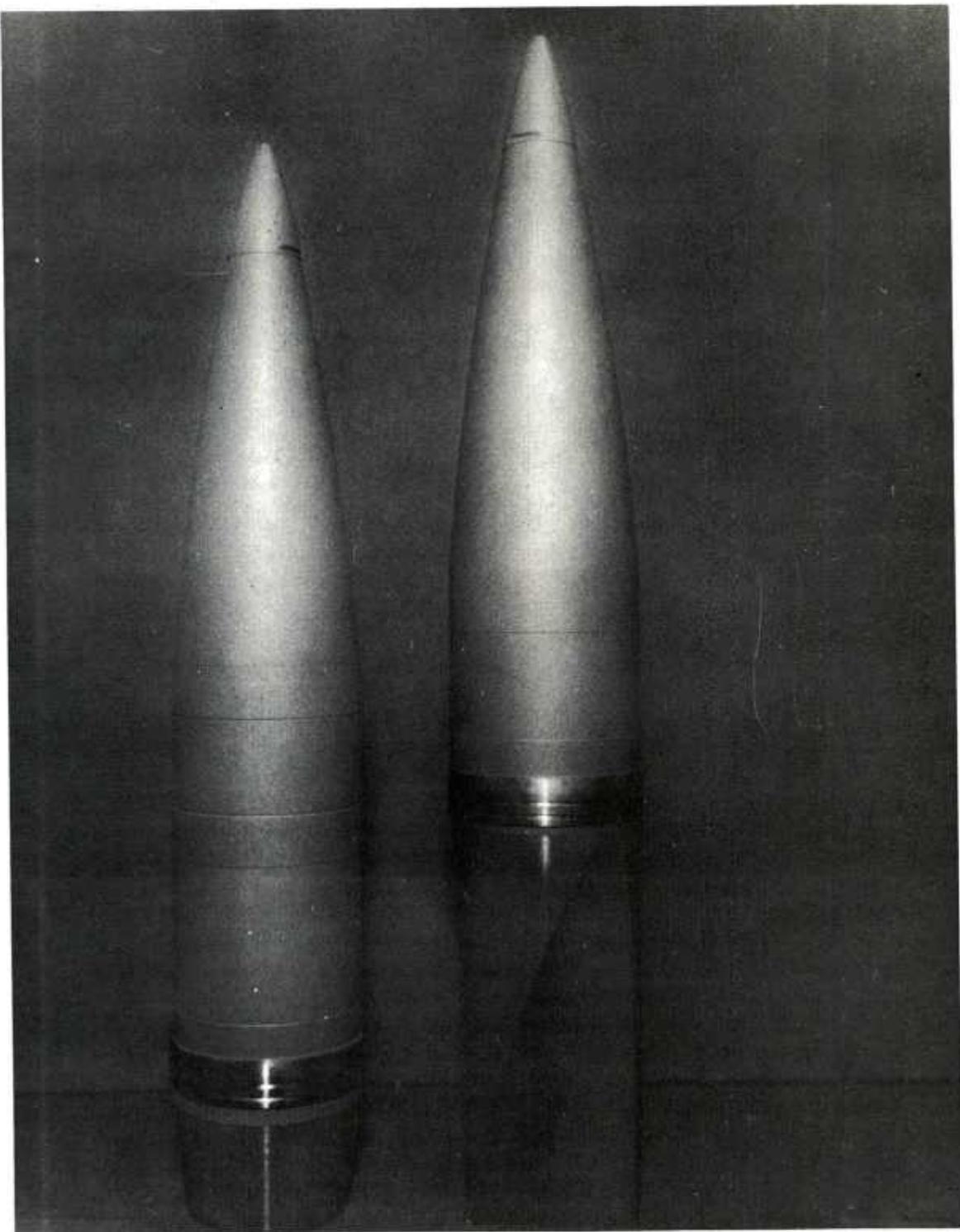


Figure 2. The M549 and the NCB-A Projectiles

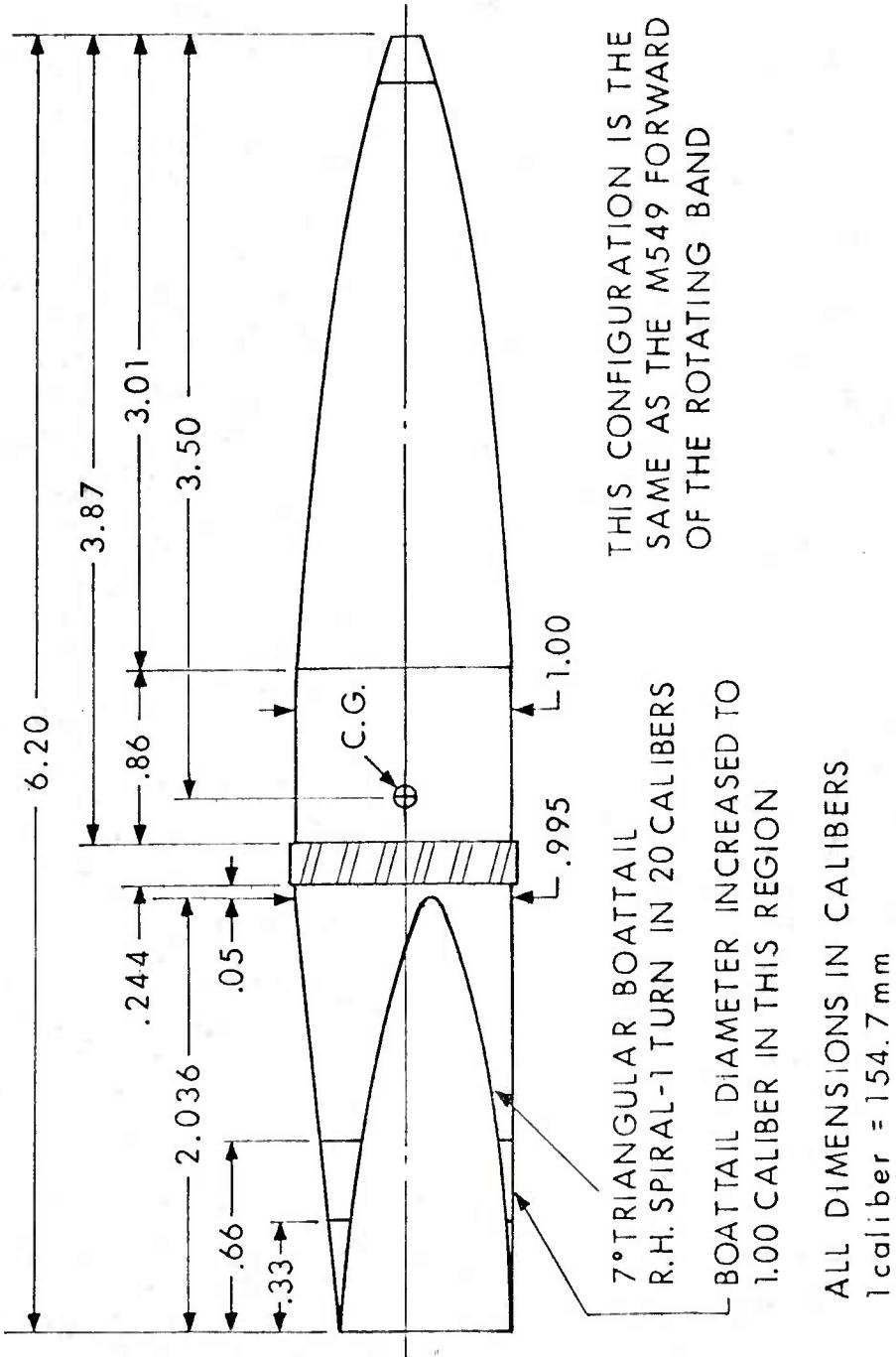


Figure 3. The Non-Conical Boattail Projectile--NCB-A

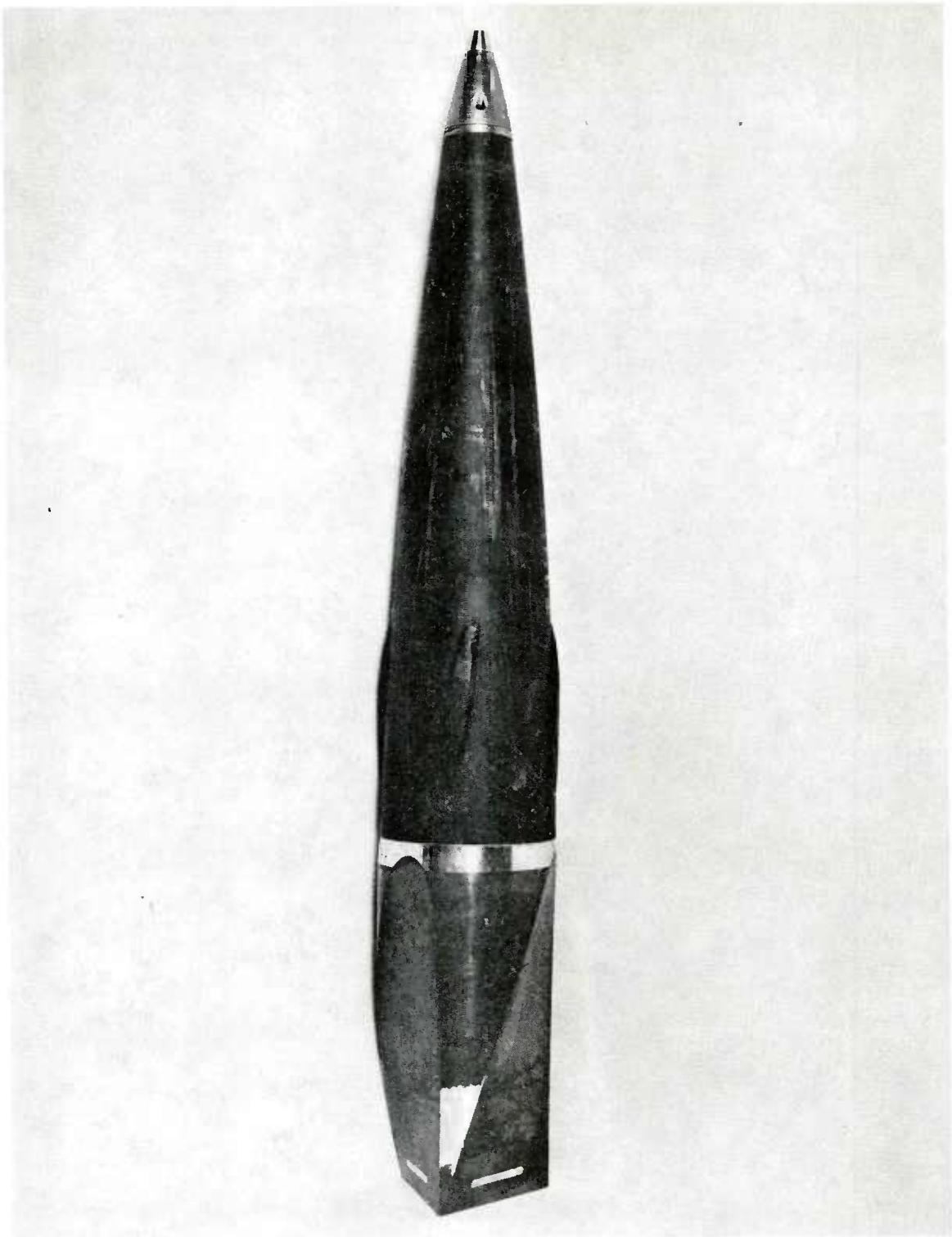


Figure 4. The NCB-B Projectile Without the Discarding Rotating Band

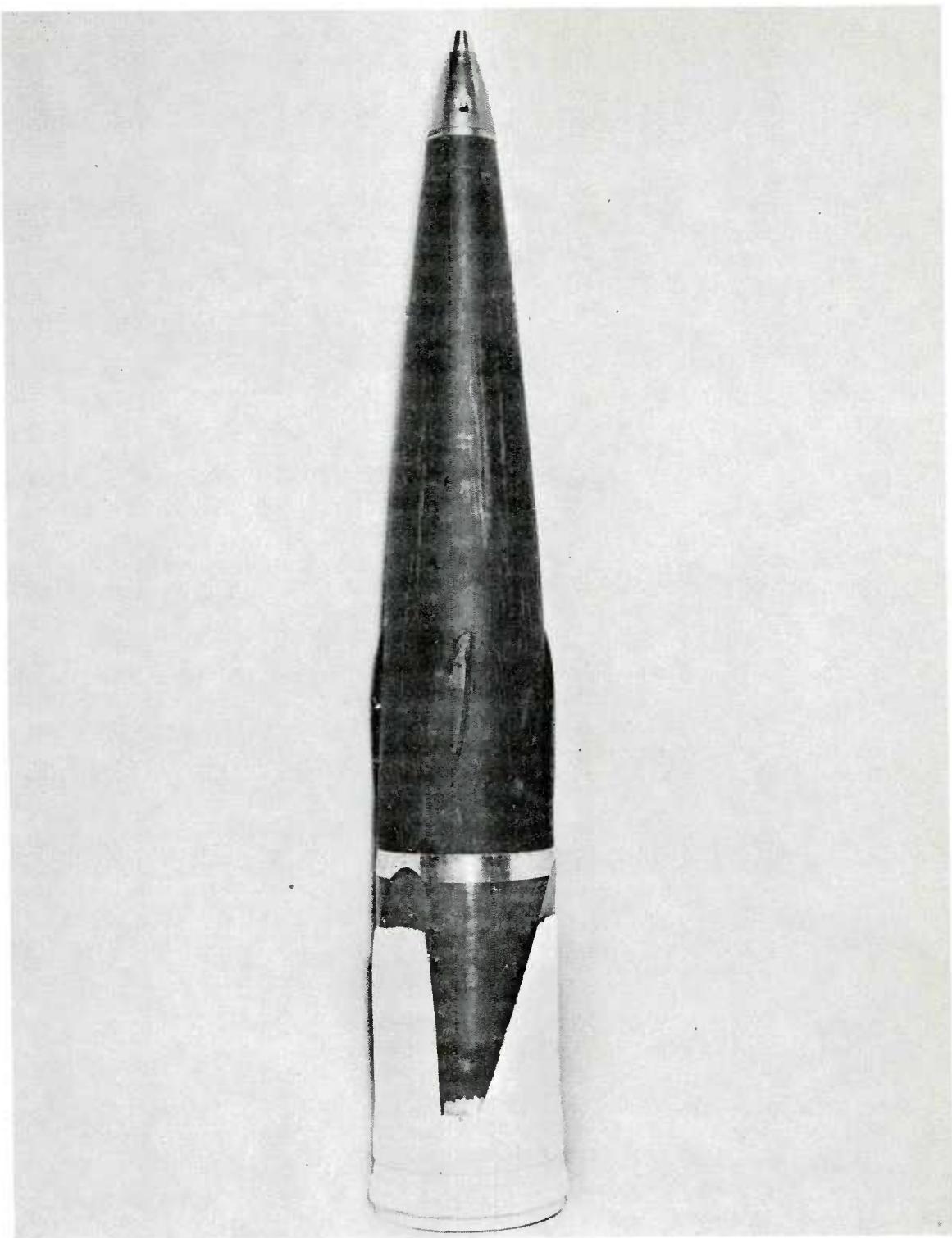


Figure 5. The NCB-B Projectile With the Discarding Rotating Band

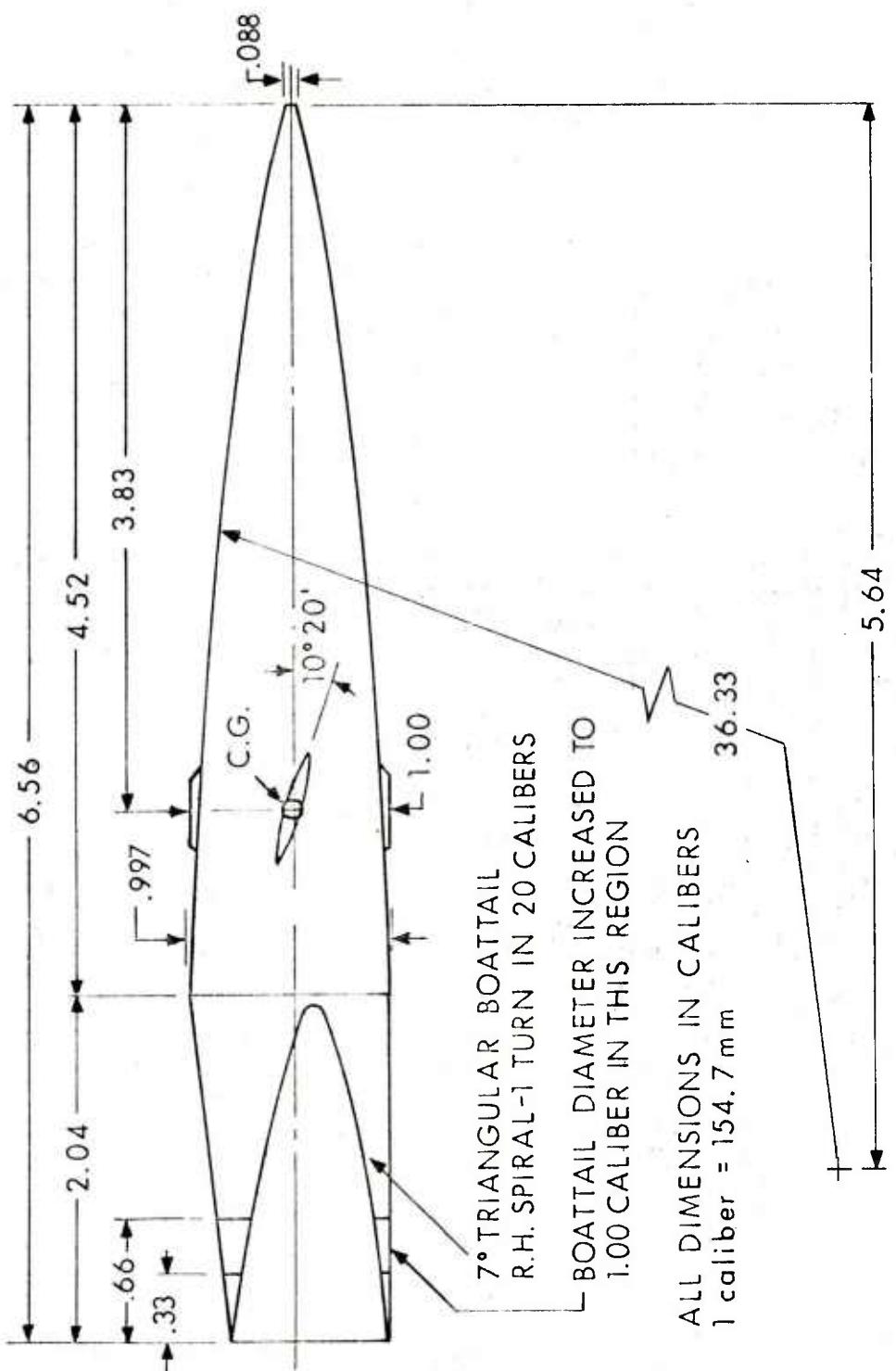


Figure 6. The Non-Conical Boat-tail Projectile--NCB-B

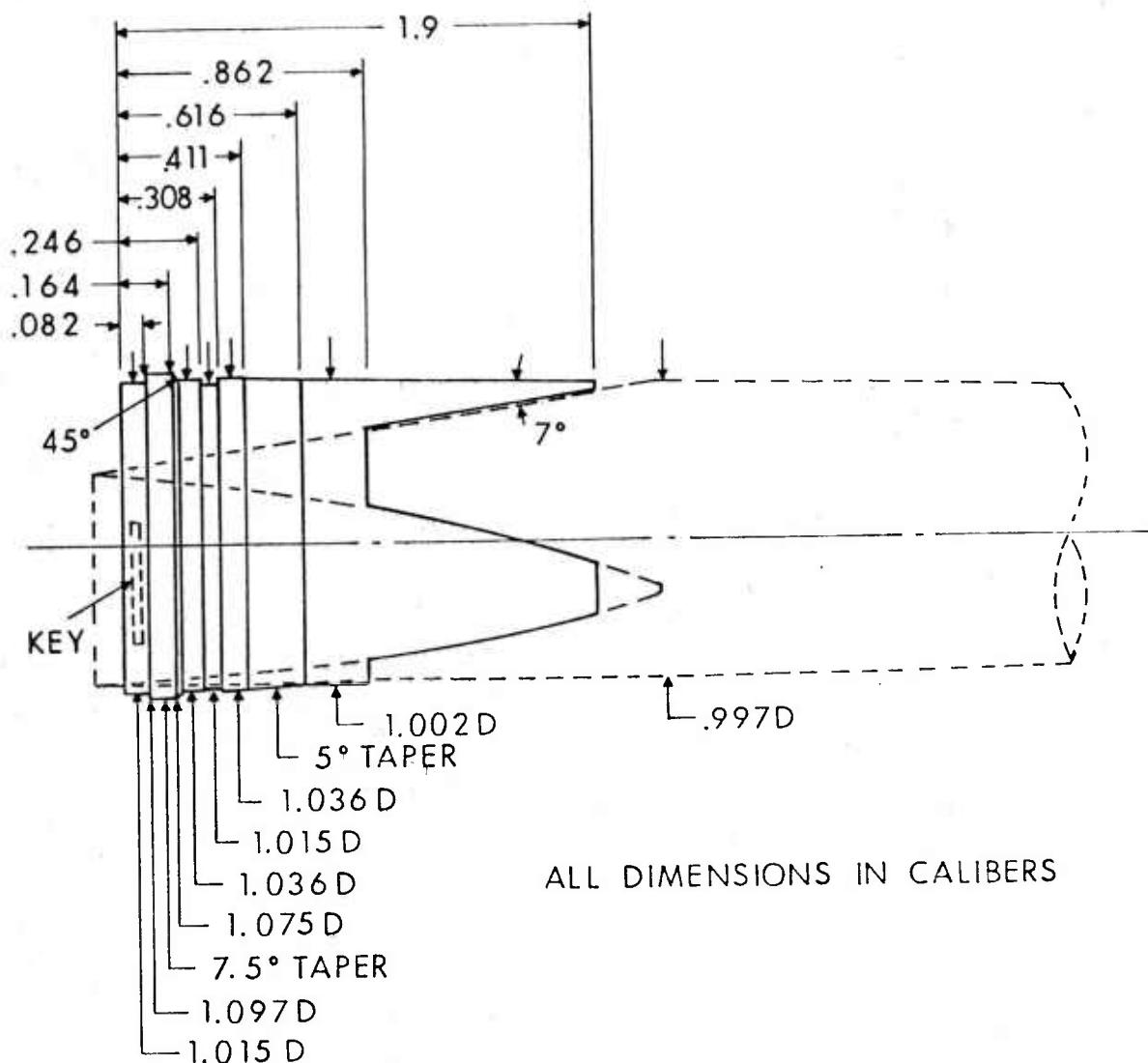


Figure 7. The External Dimensions of the Plastic Discarding Rotating Band

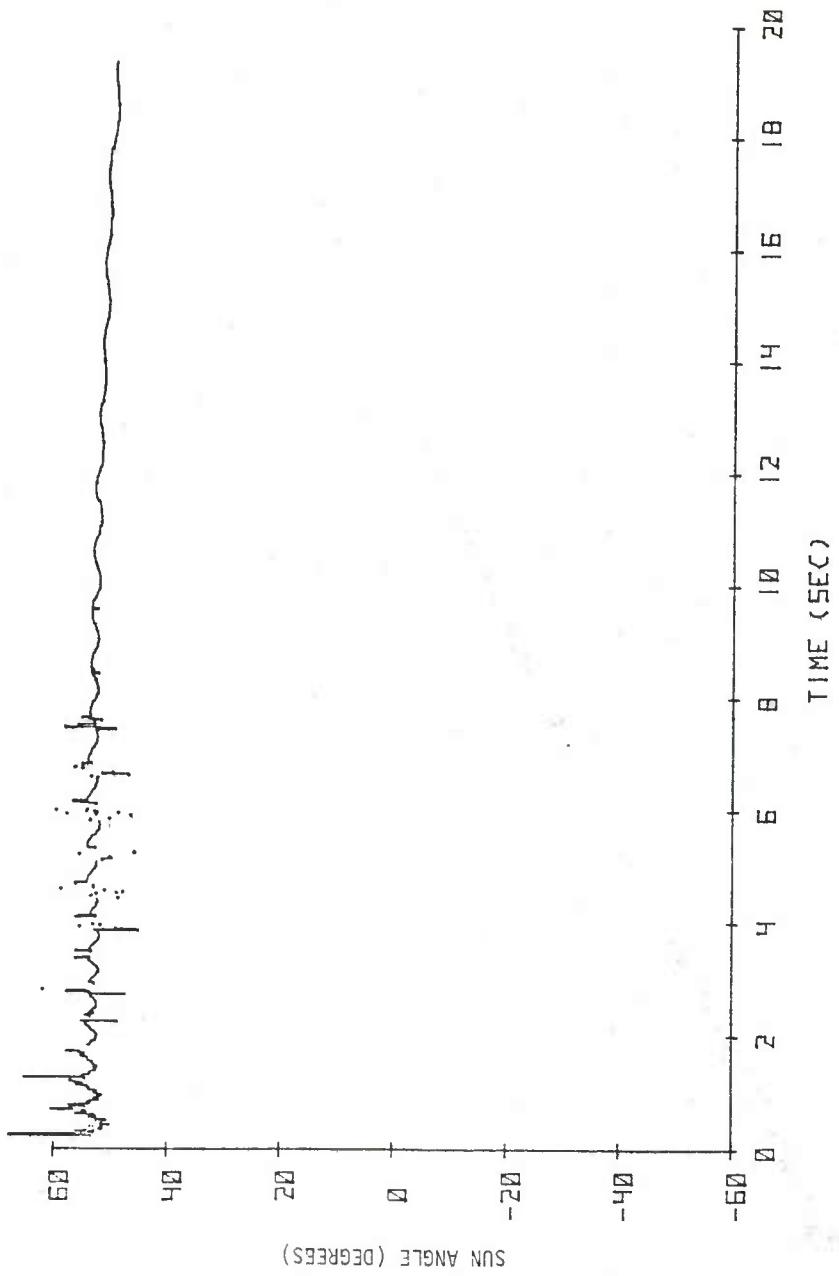


Figure 8. The Yawing Motion of the NCB-A Projectile Round No. 1

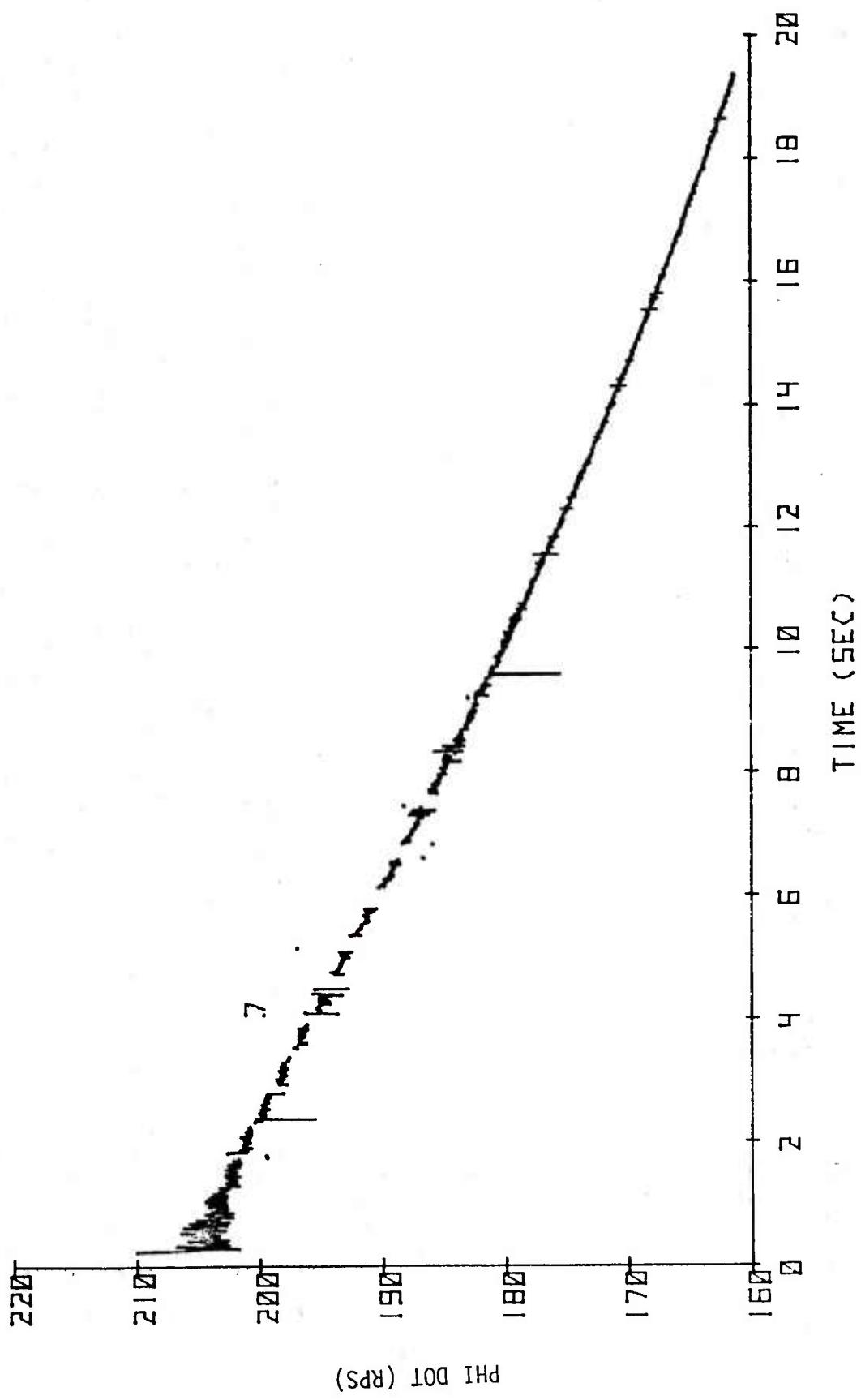


Figure 9. The Spin Motion of the NCB-A Projectile Round No. 1

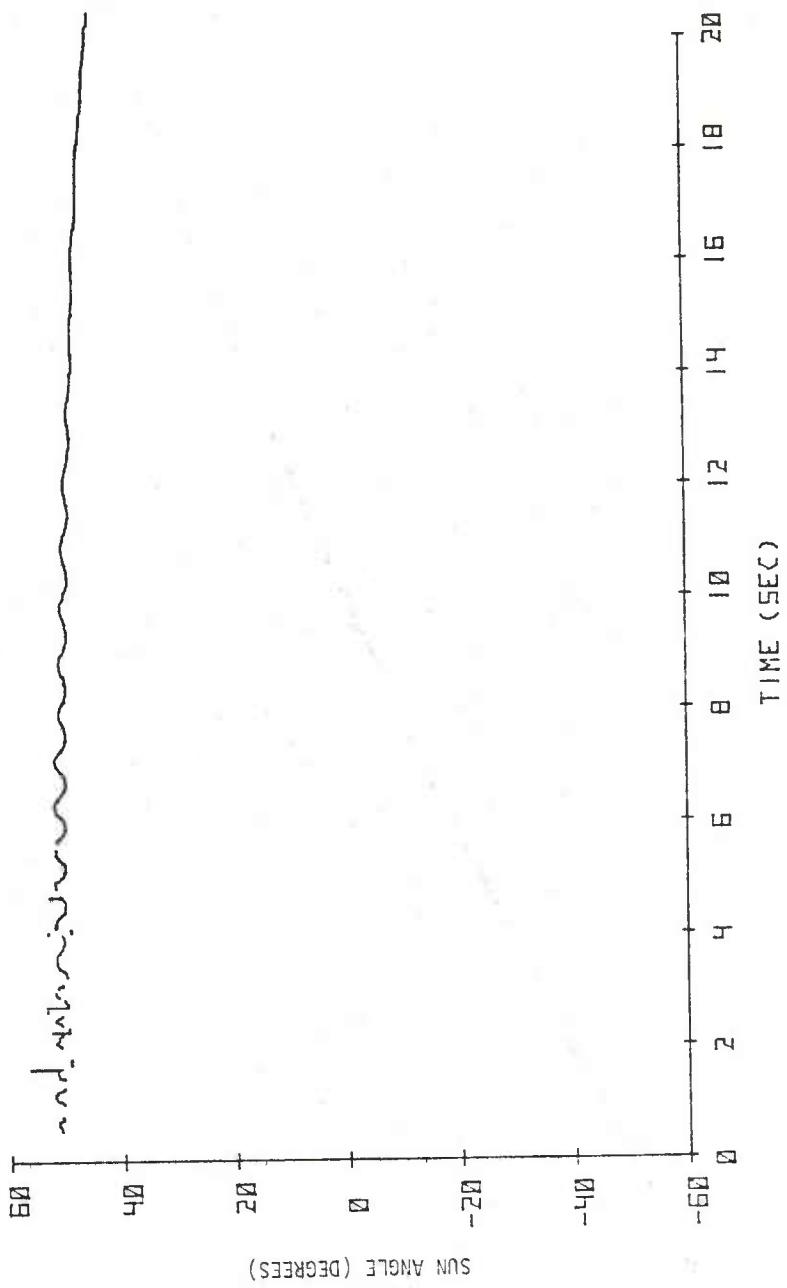


Figure 10. The Yawing Motion of the NCB-A Projectile Round No. 2

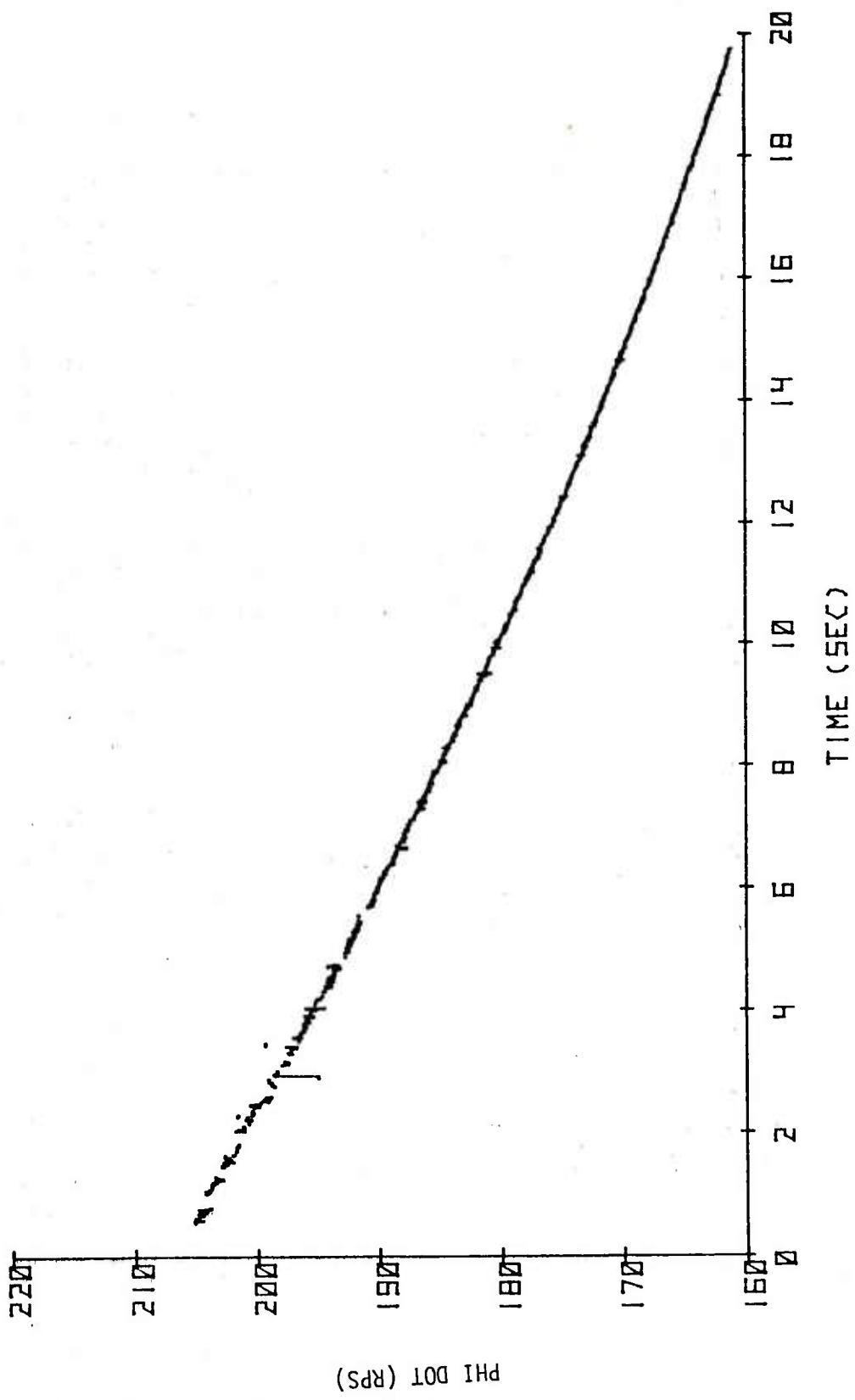


Figure 11. The Spin Motion of the NCB-A Projectile Round No. 2

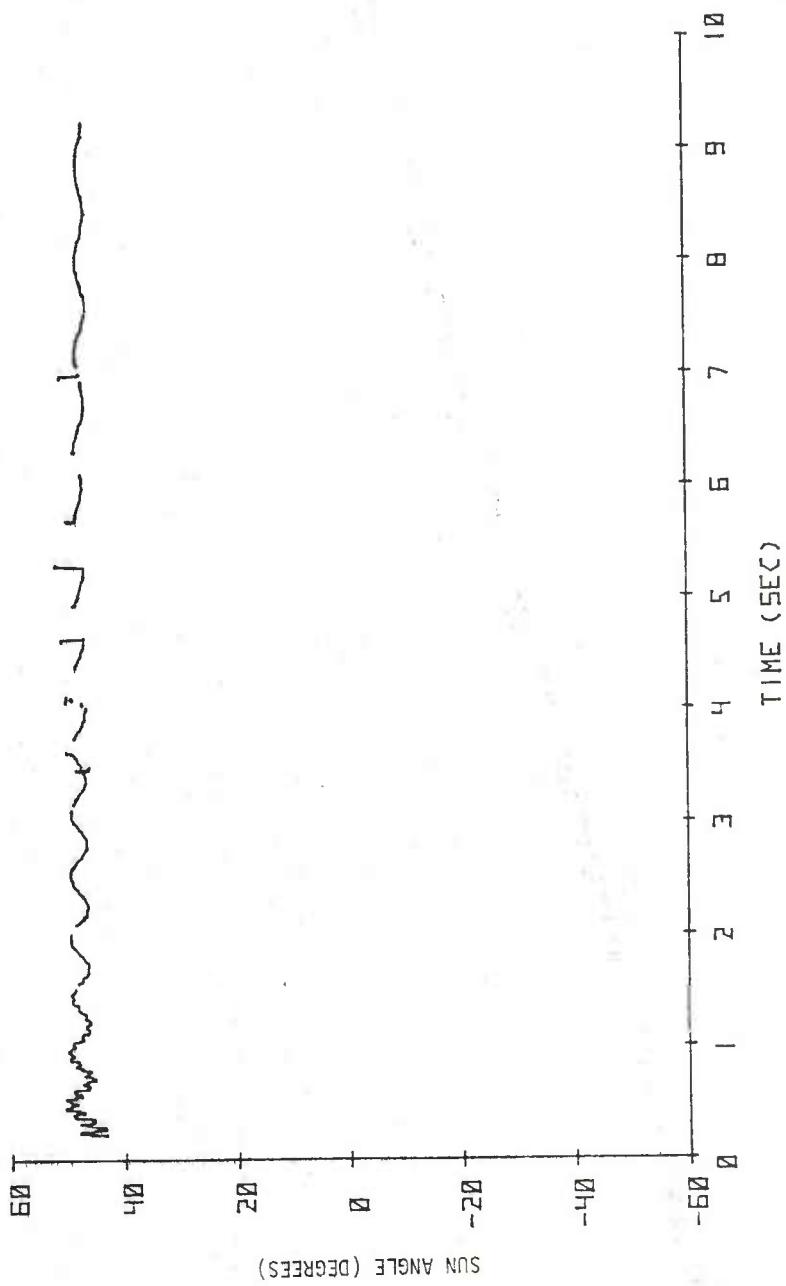


Figure 12. The Yawing Motion of the NCB-A Projectile Round No. 3

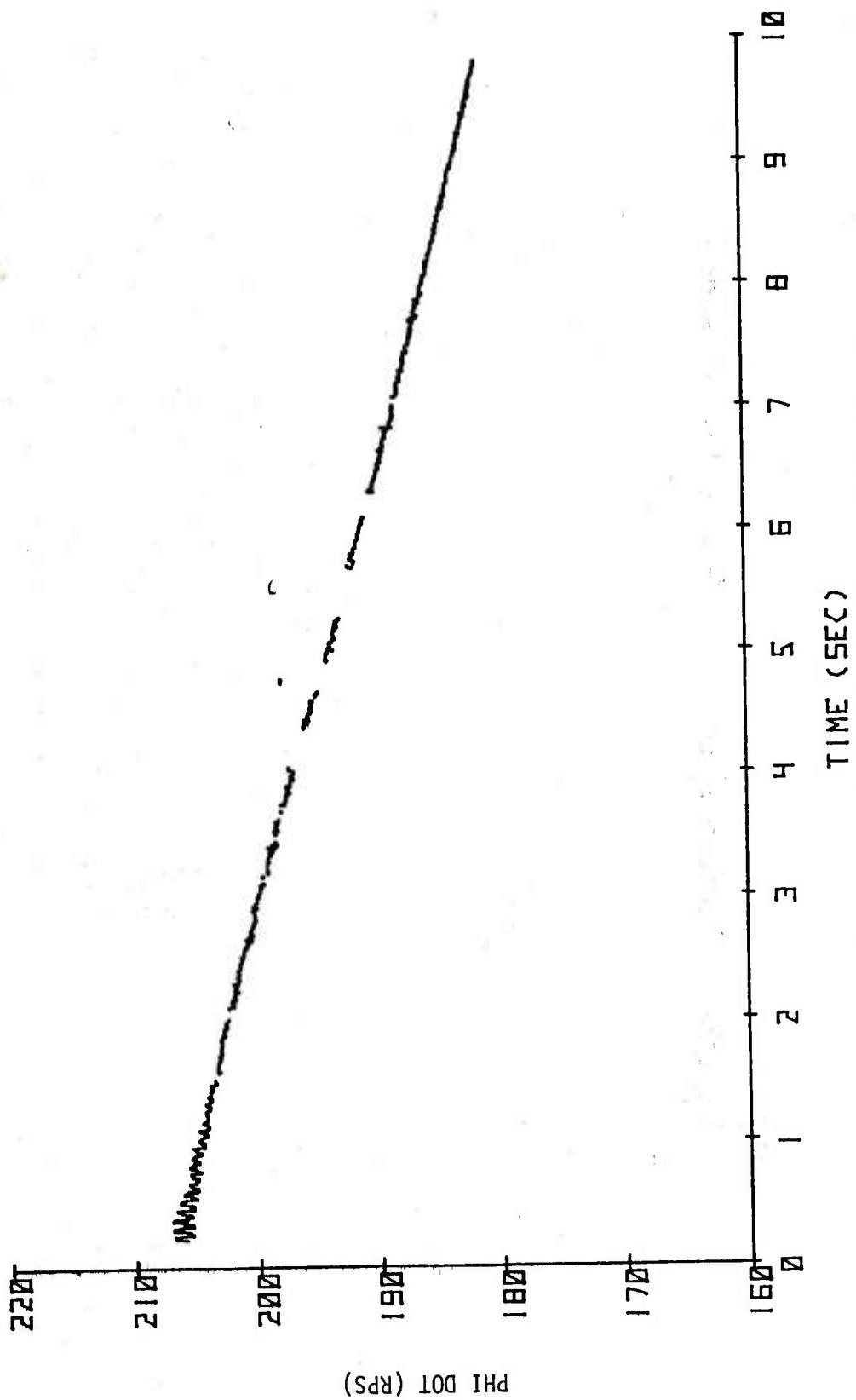


Figure 13. The Spin Motion of the NCB-A Projectile Round No. 3

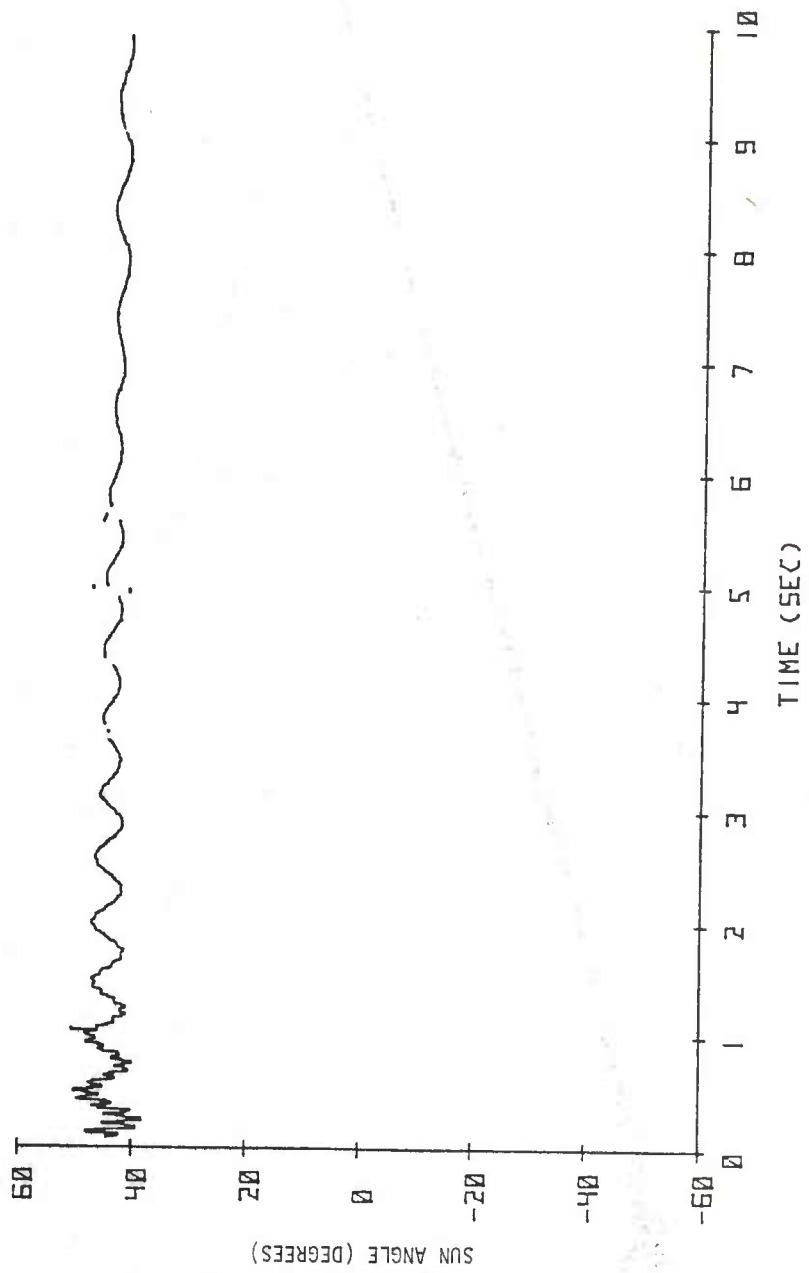


Figure 14. The Yawing Motion of the NCB-A Projectile Round No. 4

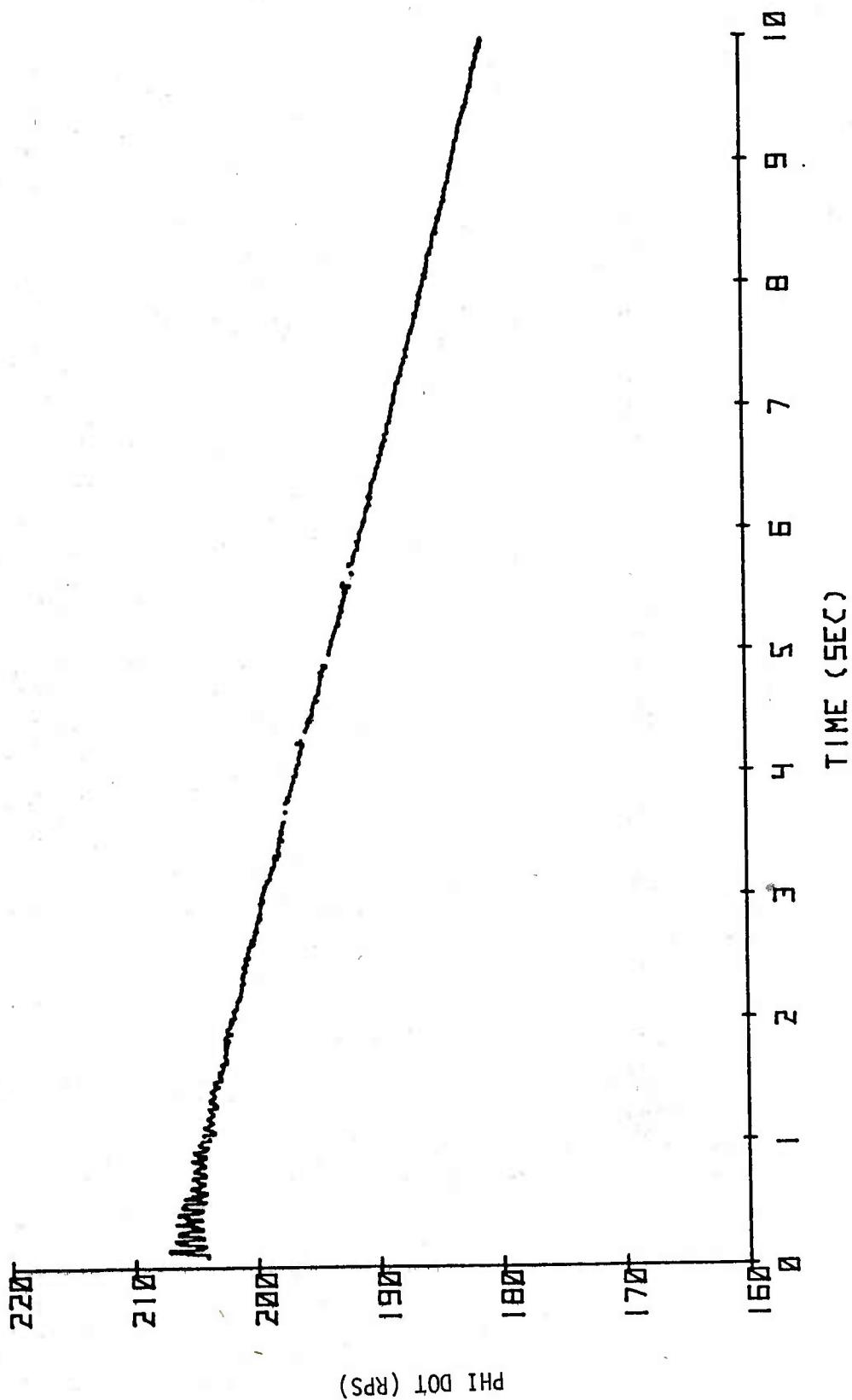


Figure 15. The Spin Motion of the NCB-A Projectile Round No. 4

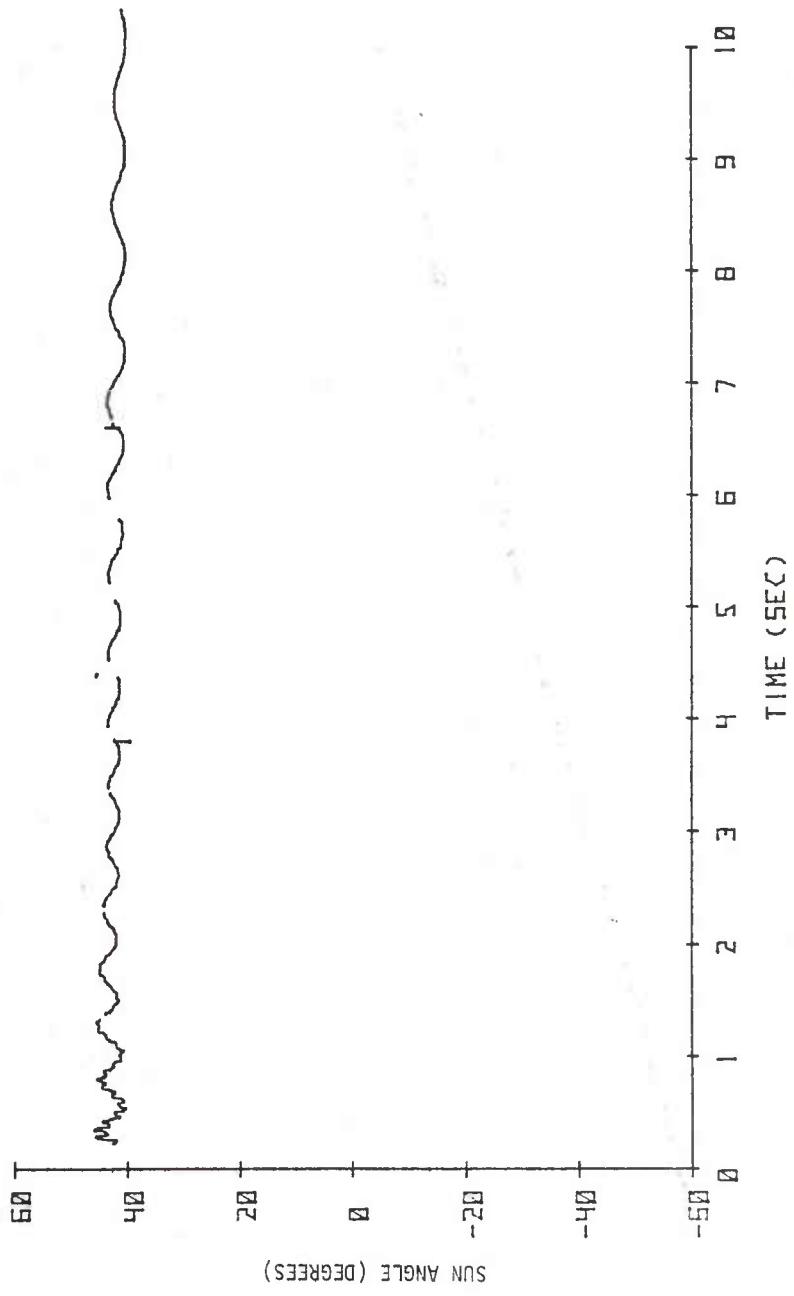


Figure 16. The Yawing Motion of the NCB-A Projectile Round No. 5

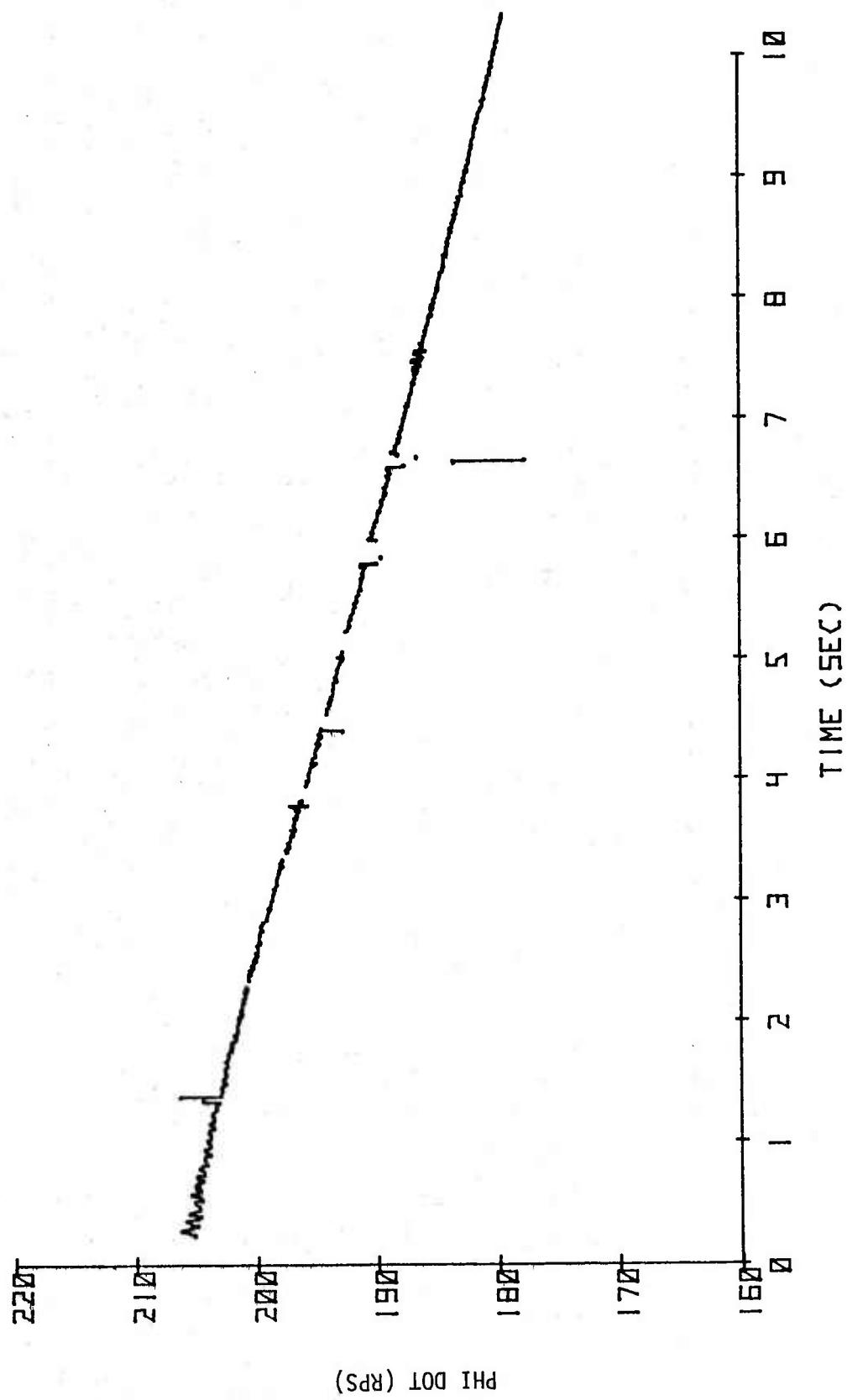


Figure 17. The Spin Motion of the NCB-A Projectile Round No. 5

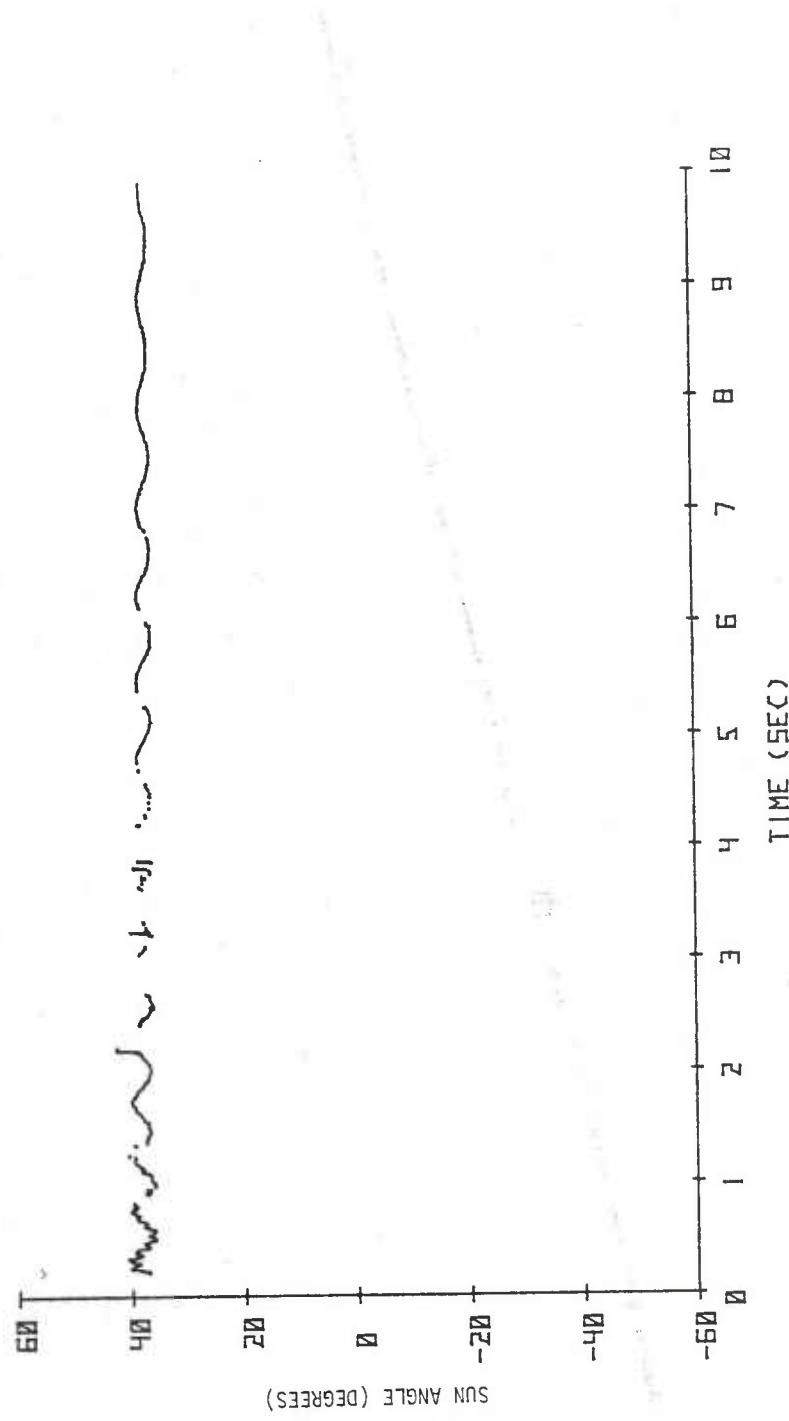


Figure 18. The Yawing Motion of the NCB-A Projectile Round No. 6

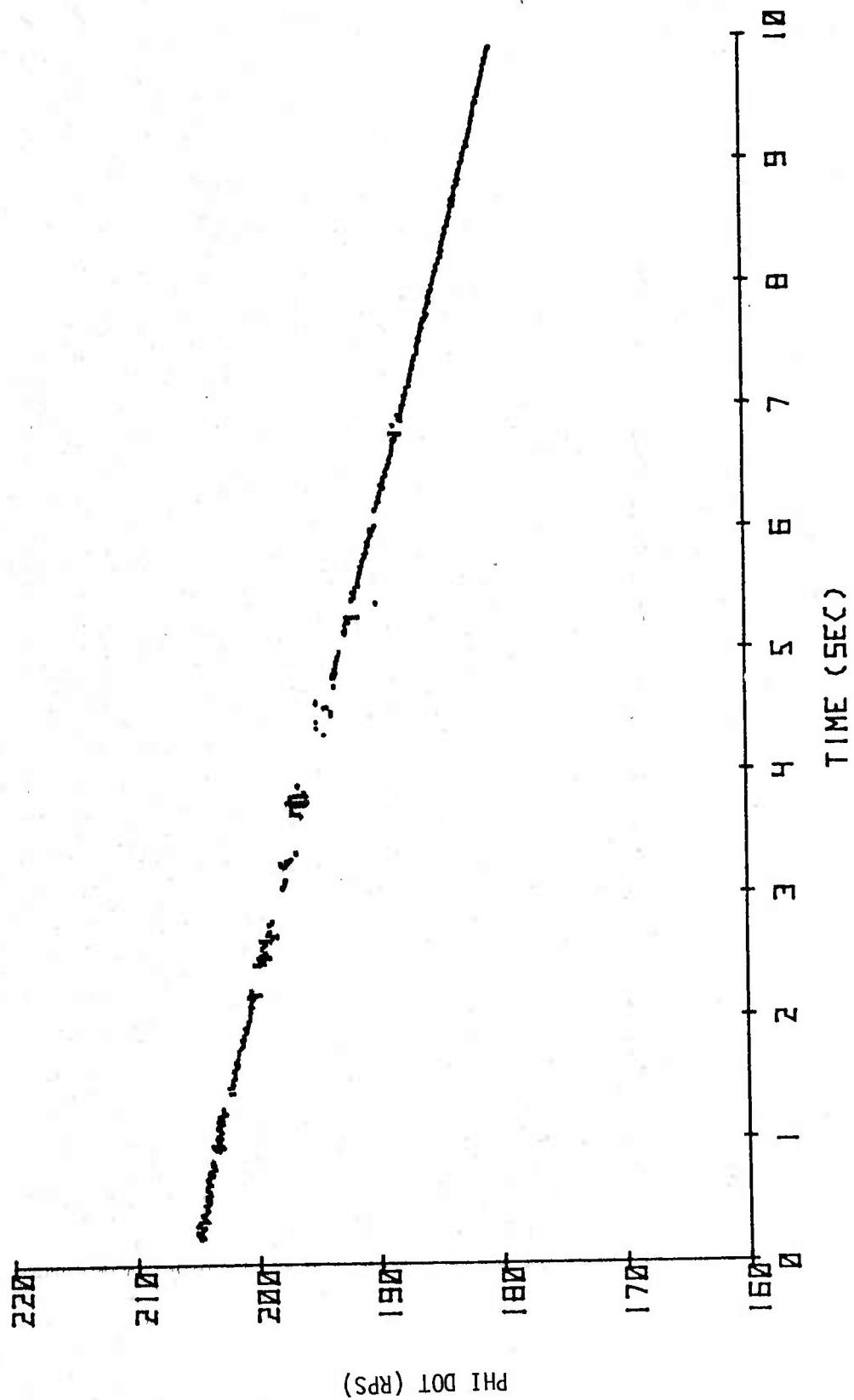


Figure 19. The Spin Motion of the NCB-A Projectile Round No. 6

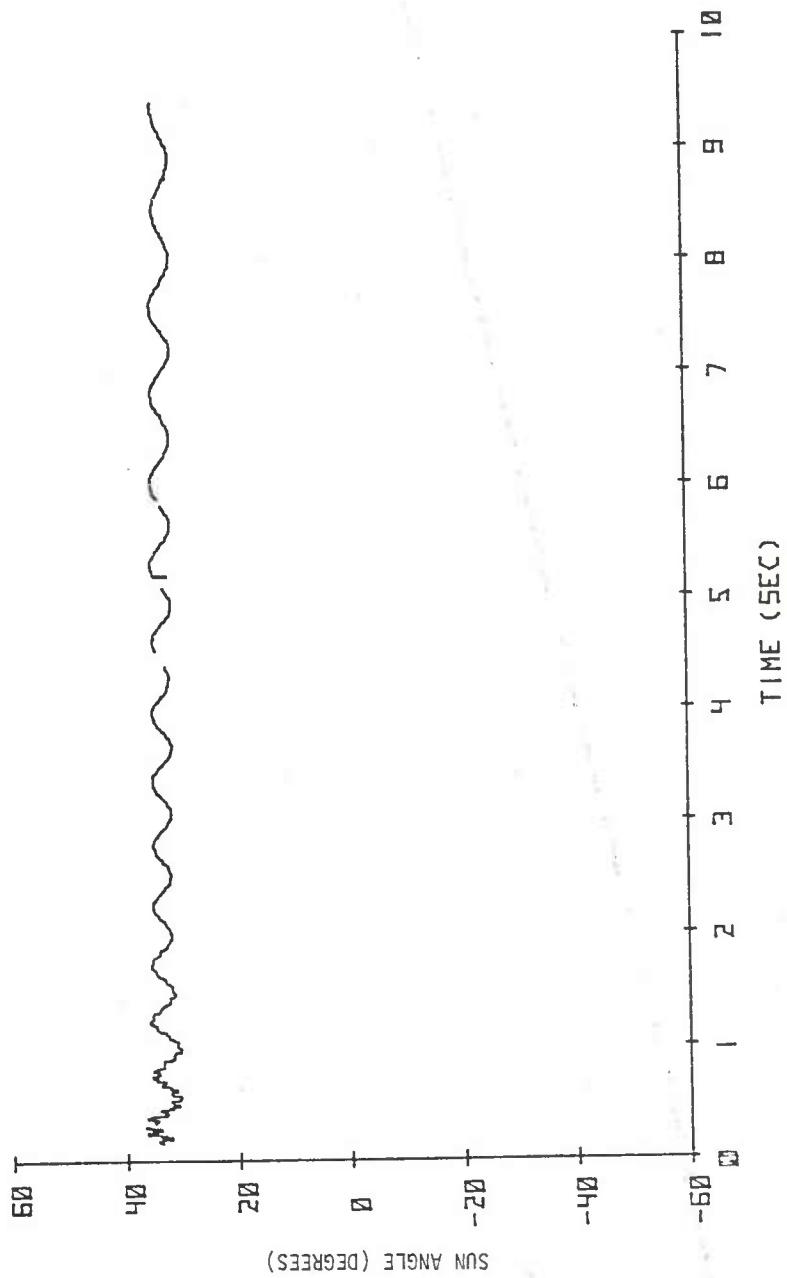


Figure 20. The Yawing Motion of the NCB-A Projectile Round No. 7

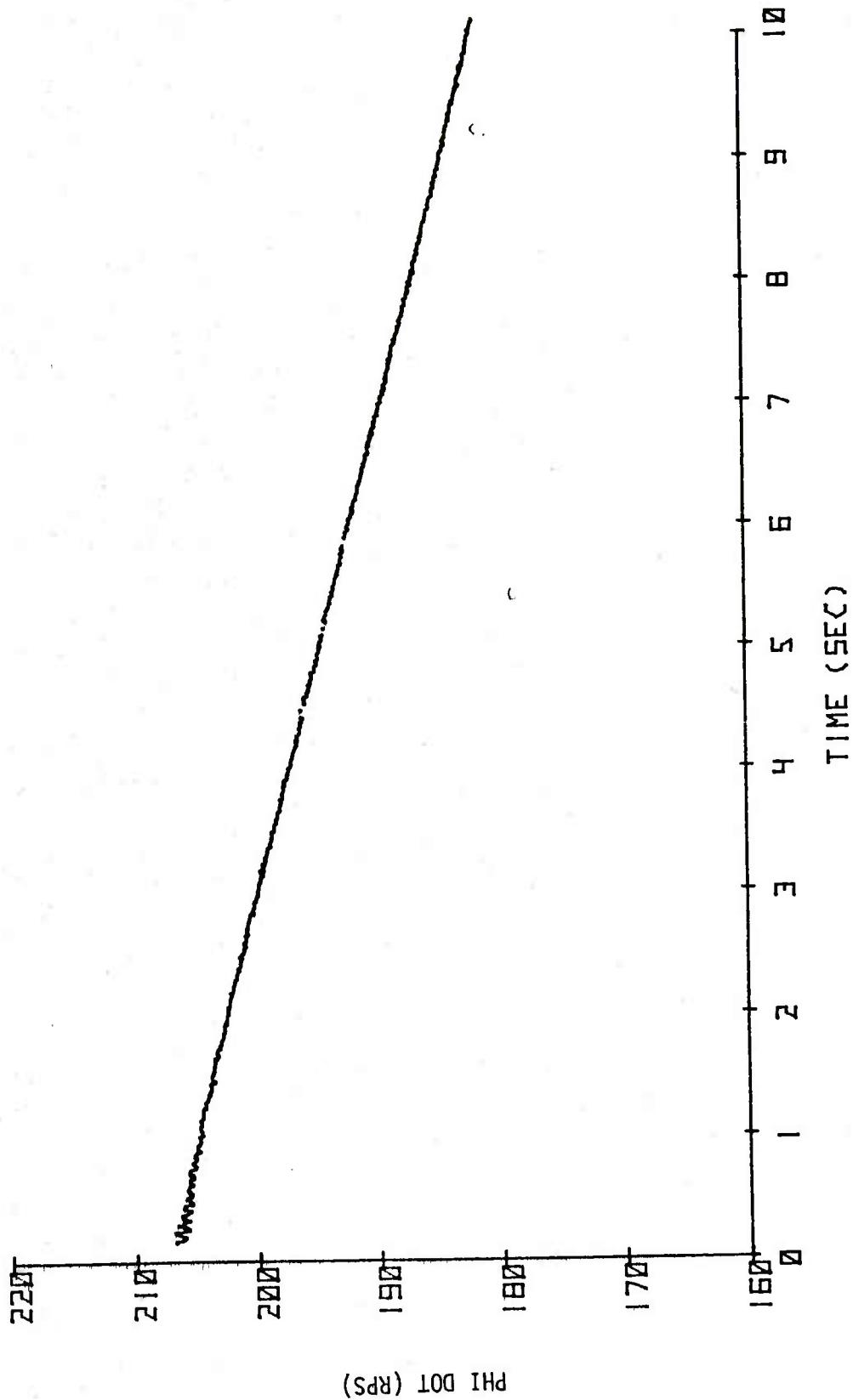


Figure 21. The Spin Motion of the NCB-A Projectile Round No. 7

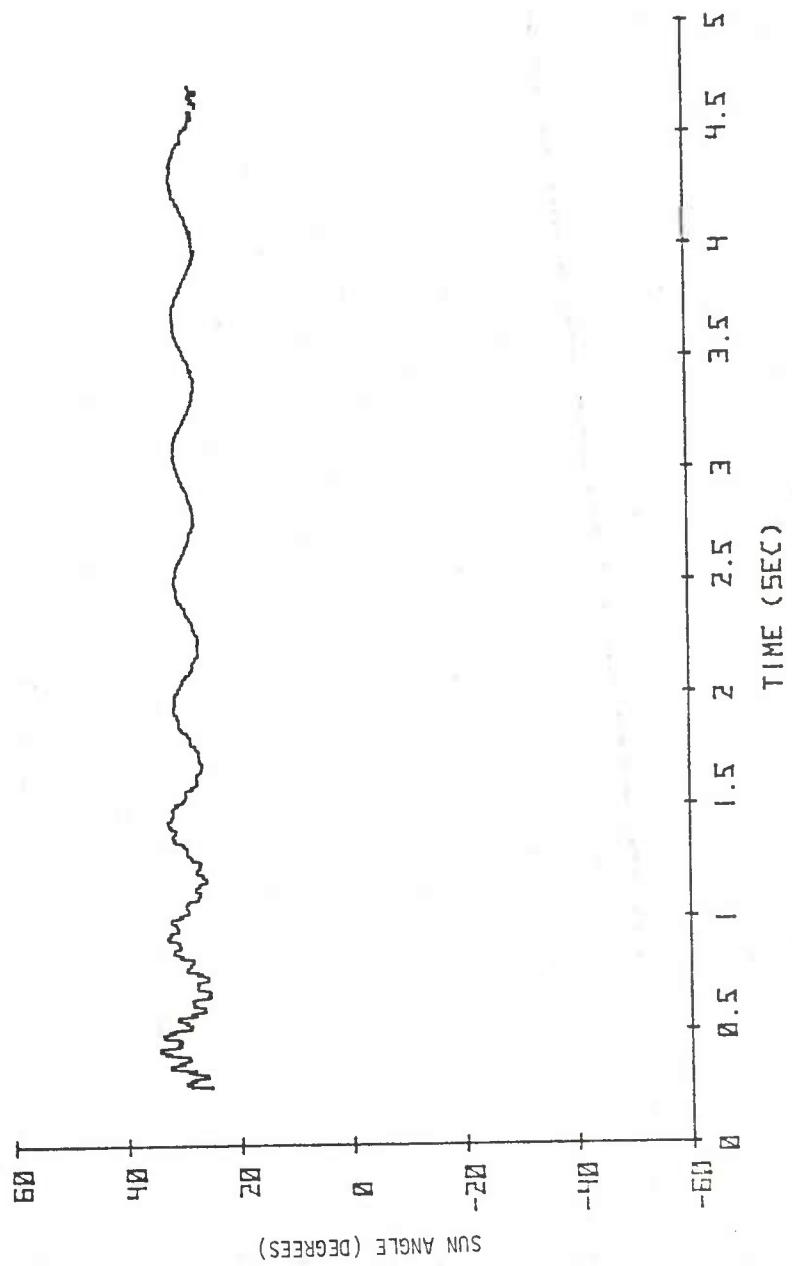


Figure 22. The Yawing Motion of the NCB-A Projectile Round No. 8

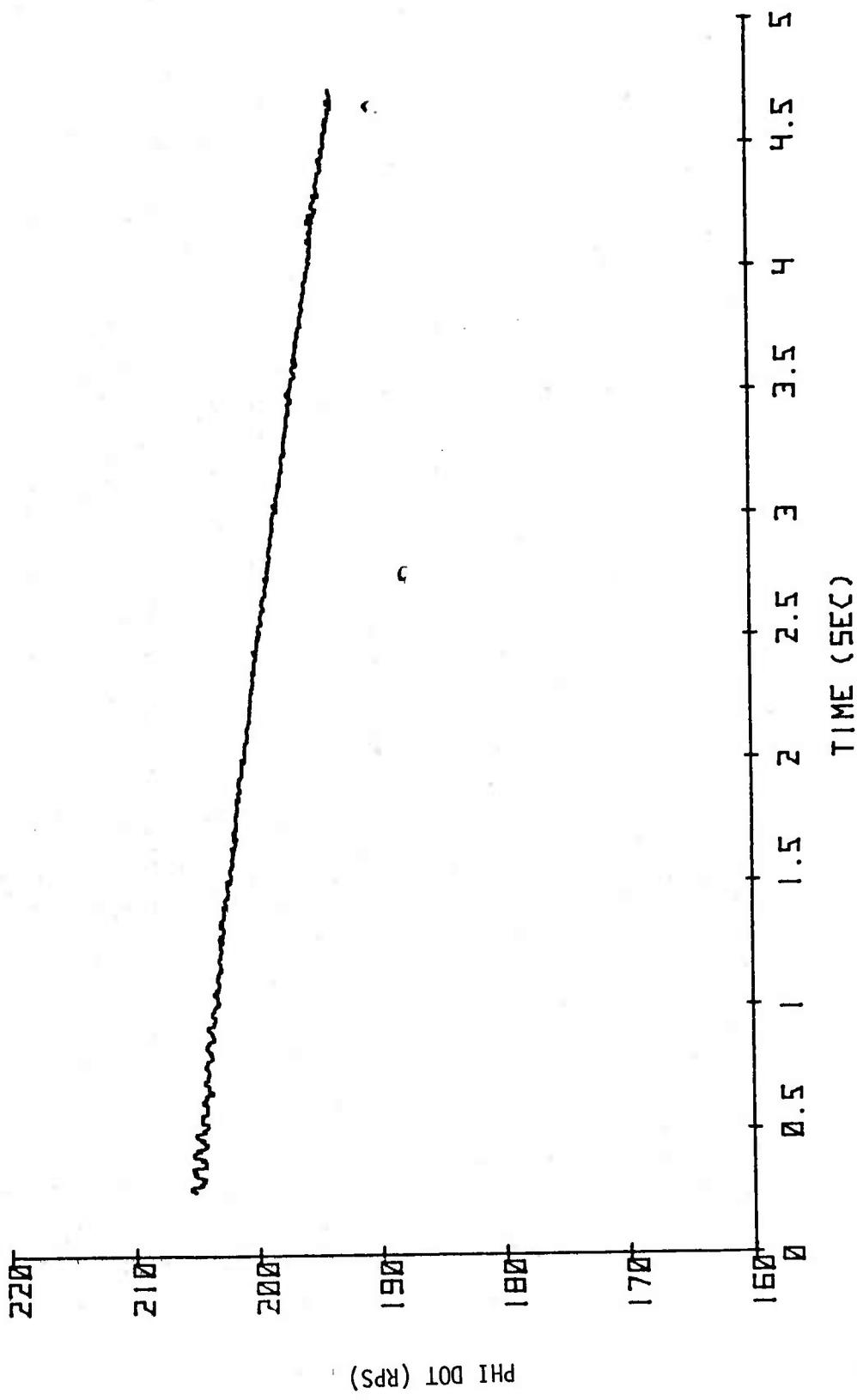


Figure 23. The Spin Motion of the NCB-A Projectile Round No. 8

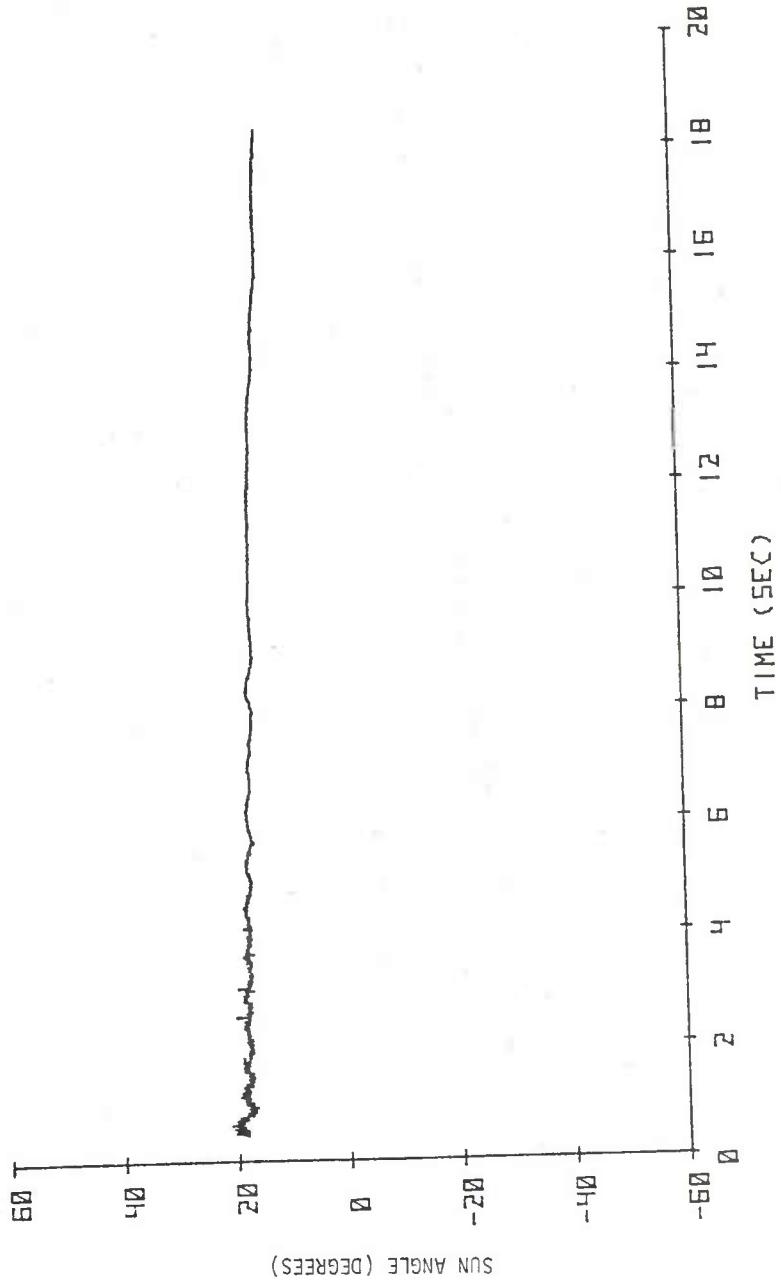


Figure 24. The Yawing Motion of the M549 RAP Projectile, Rocket Off, Round No. 10

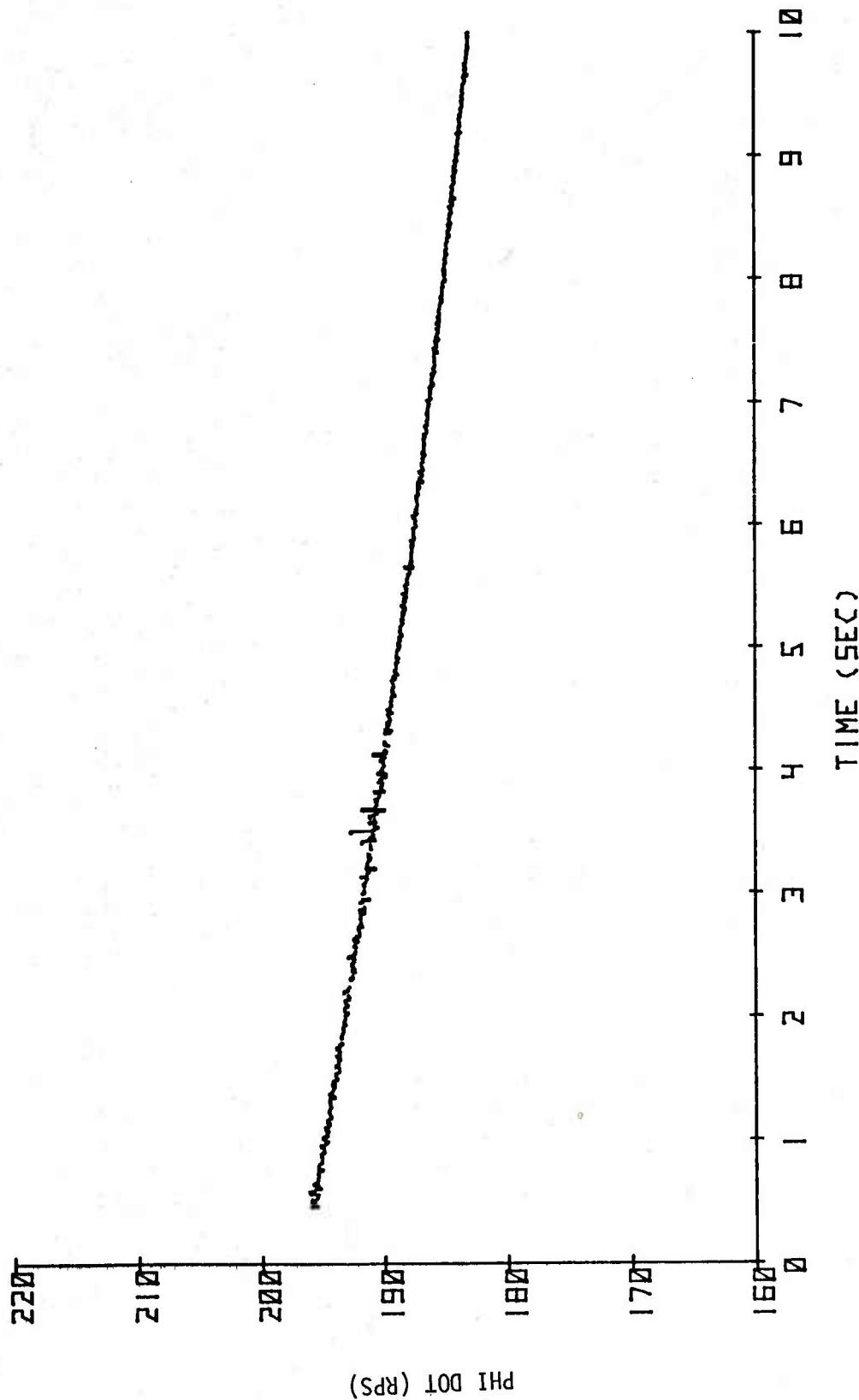


Figure 25. The Spin Motion of the M549 RAP Projectile, Rocket Off, Round No. 10

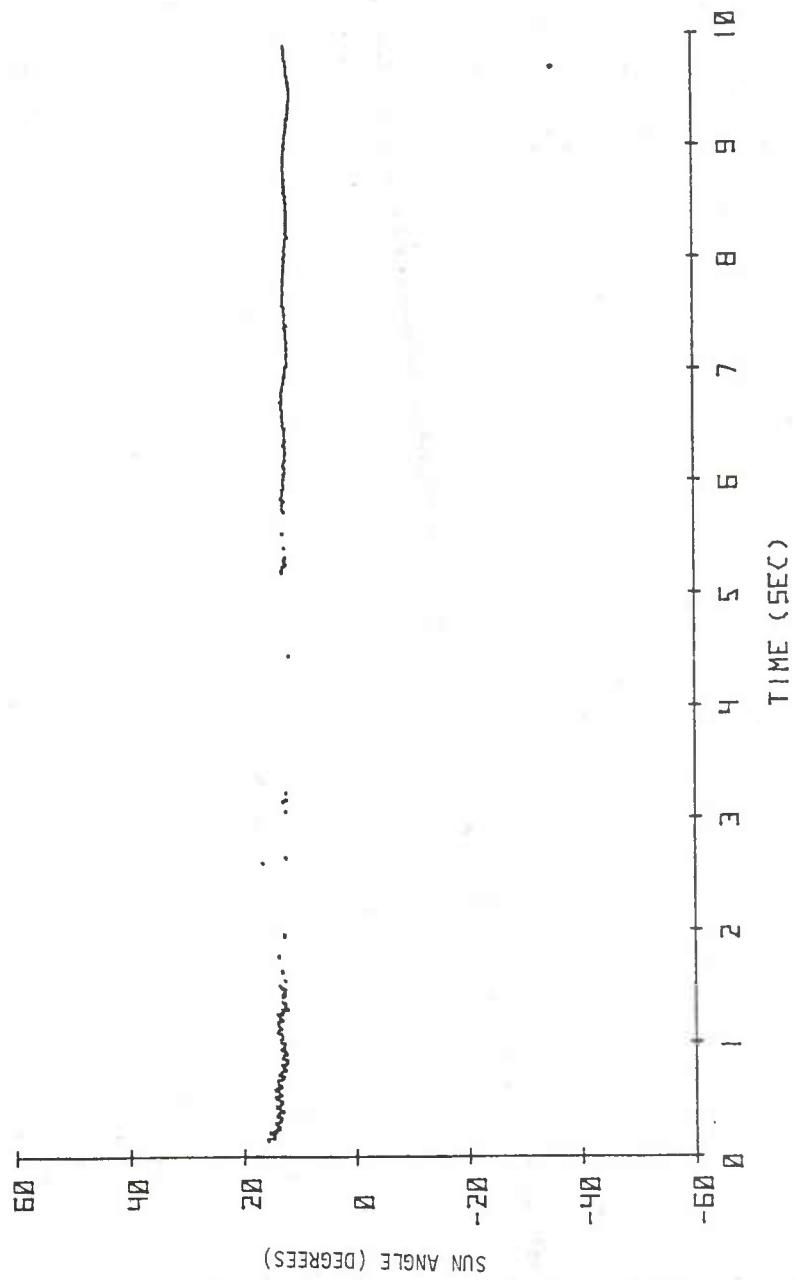


Figure 26. The Yawing Motion of the M549 RAP Projectile, Rocket Off, Round No. 11

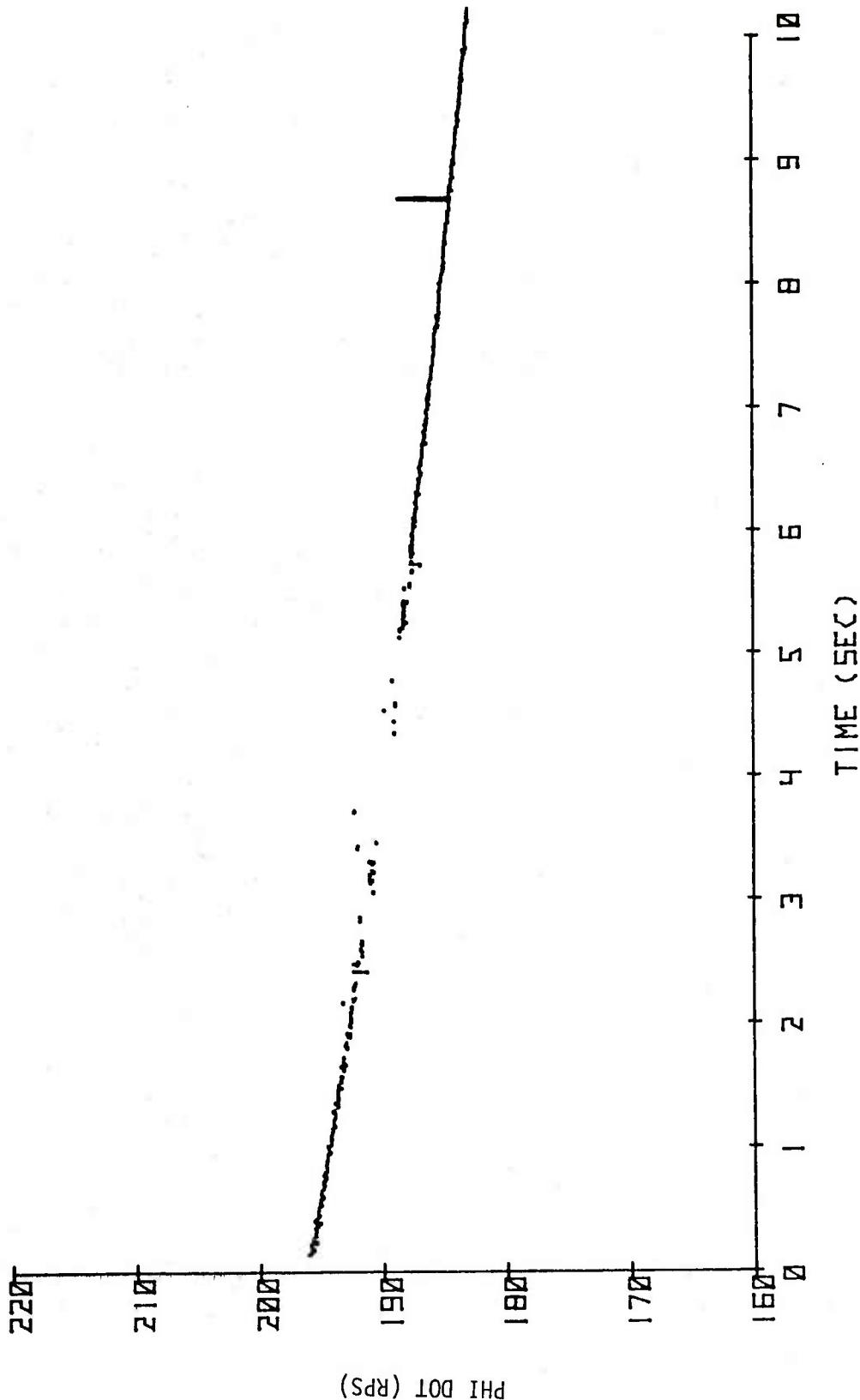


Figure 27. The Spin Motion of the M549 RAP Projectile, Rocket Off, Round No. 11

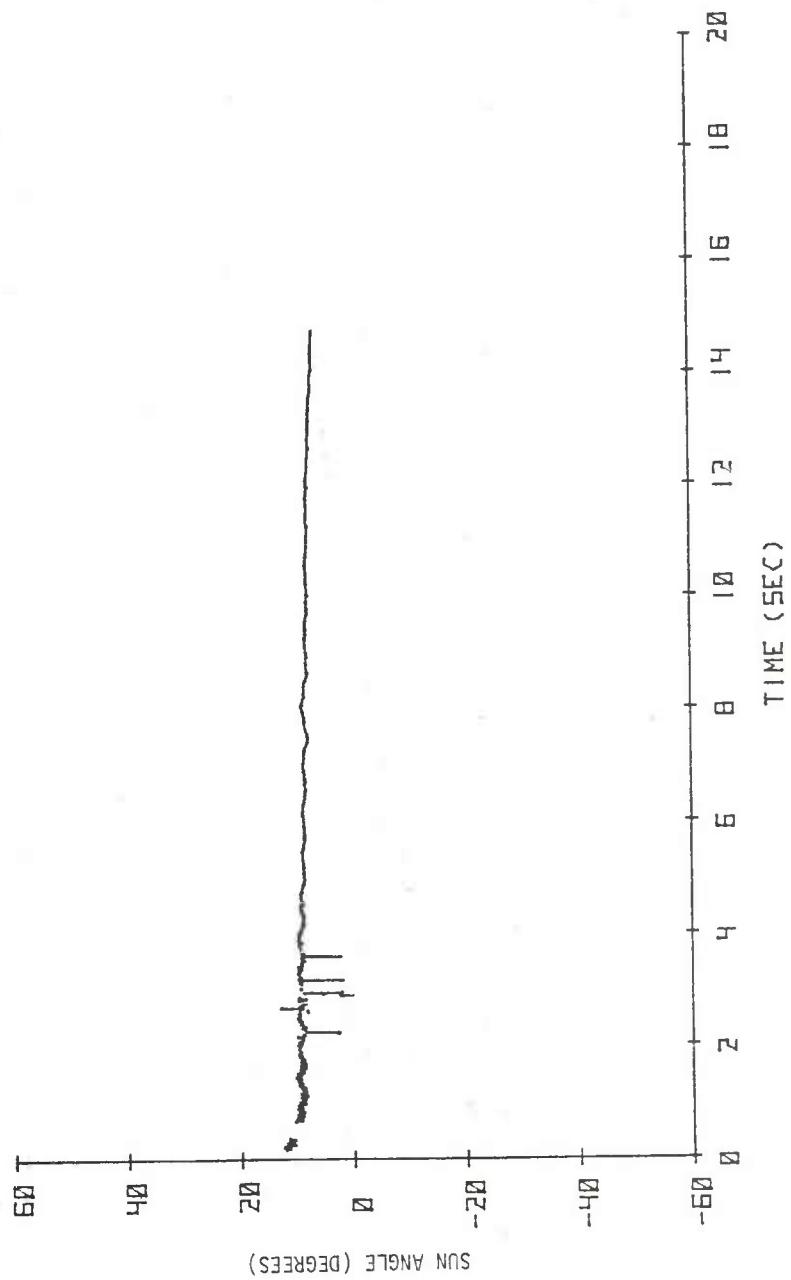


Figure 28. The Yawing Motion of the M549 RAP Projectile, Rocket Off, Round No. 13

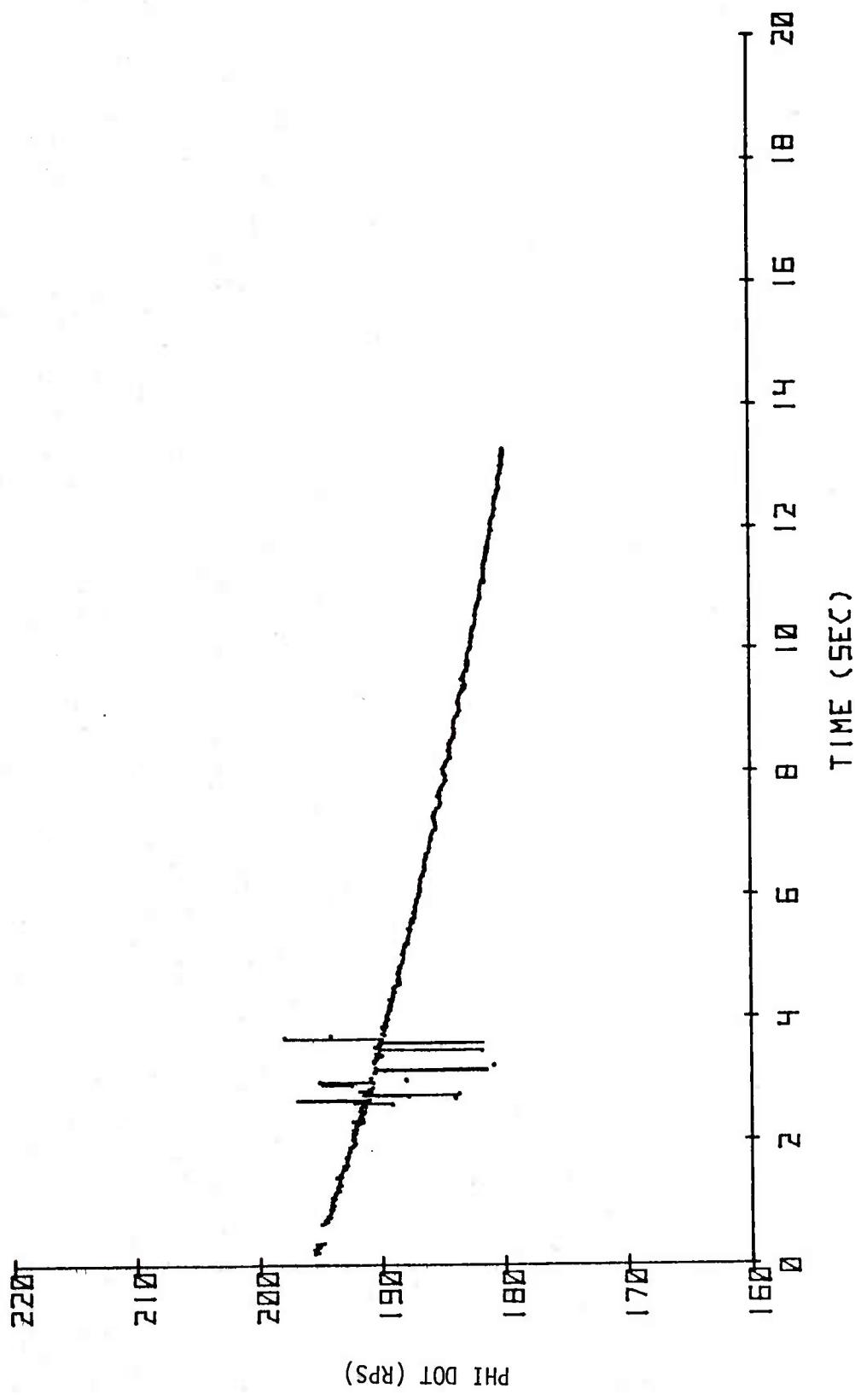


Figure 29. The Spin Motion of the M549 RAP Projectile, Rocket Off, Round No. 13

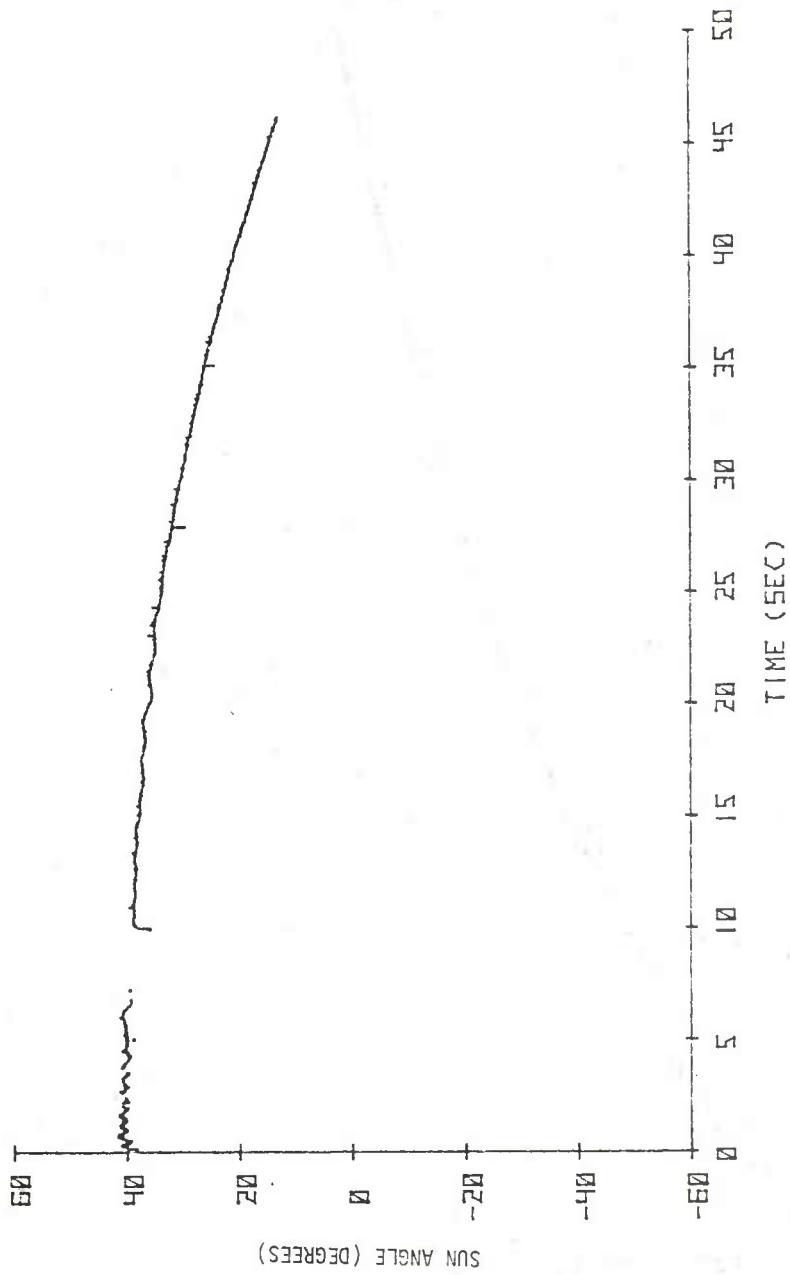


Figure 30. The Yawing Motion of the M549 RAP Projectile, Rocket On, Round No. 15

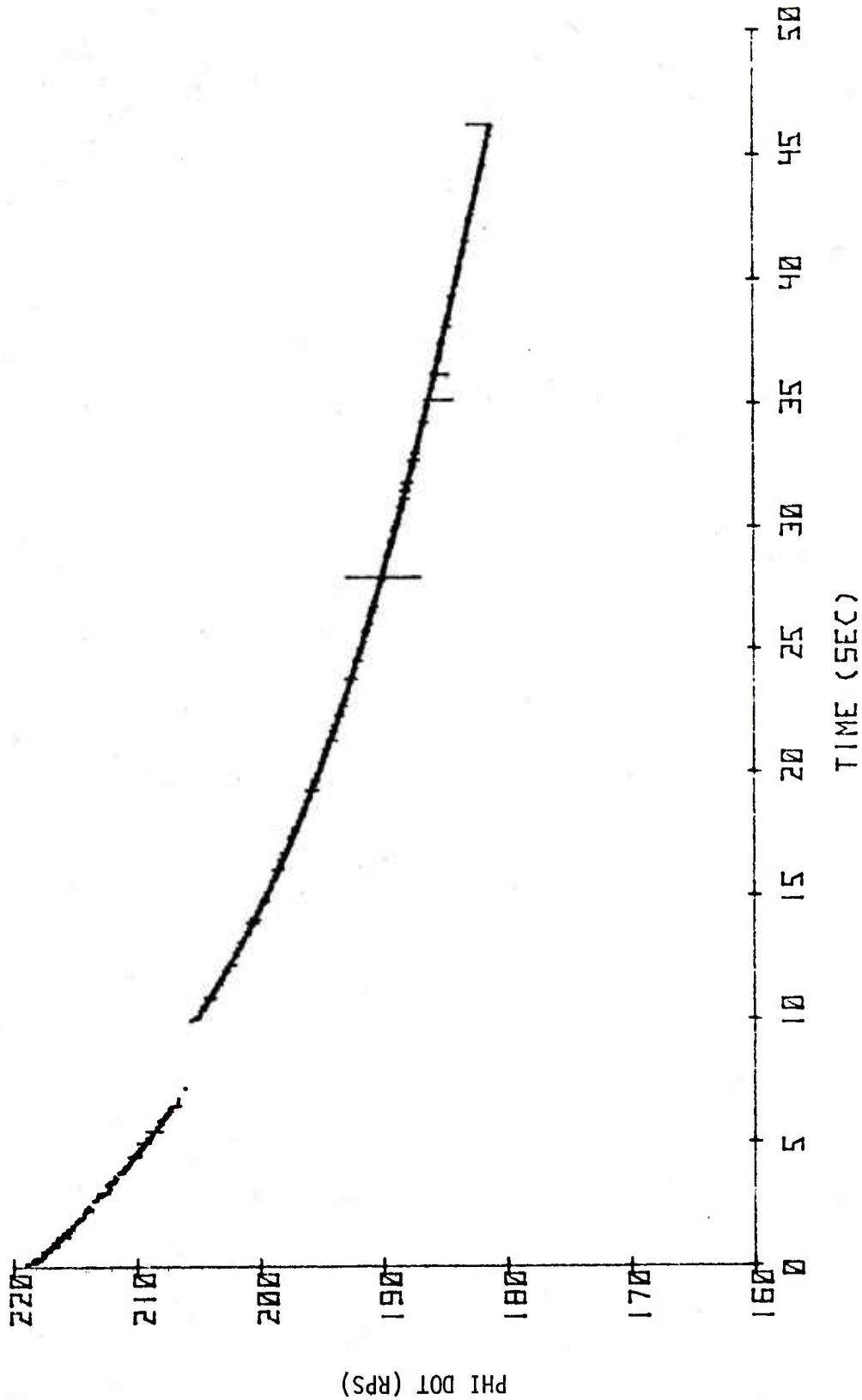


Figure 31. The Spin Motion of the M549 RAP Projectile, Rocket On, Round No. 15

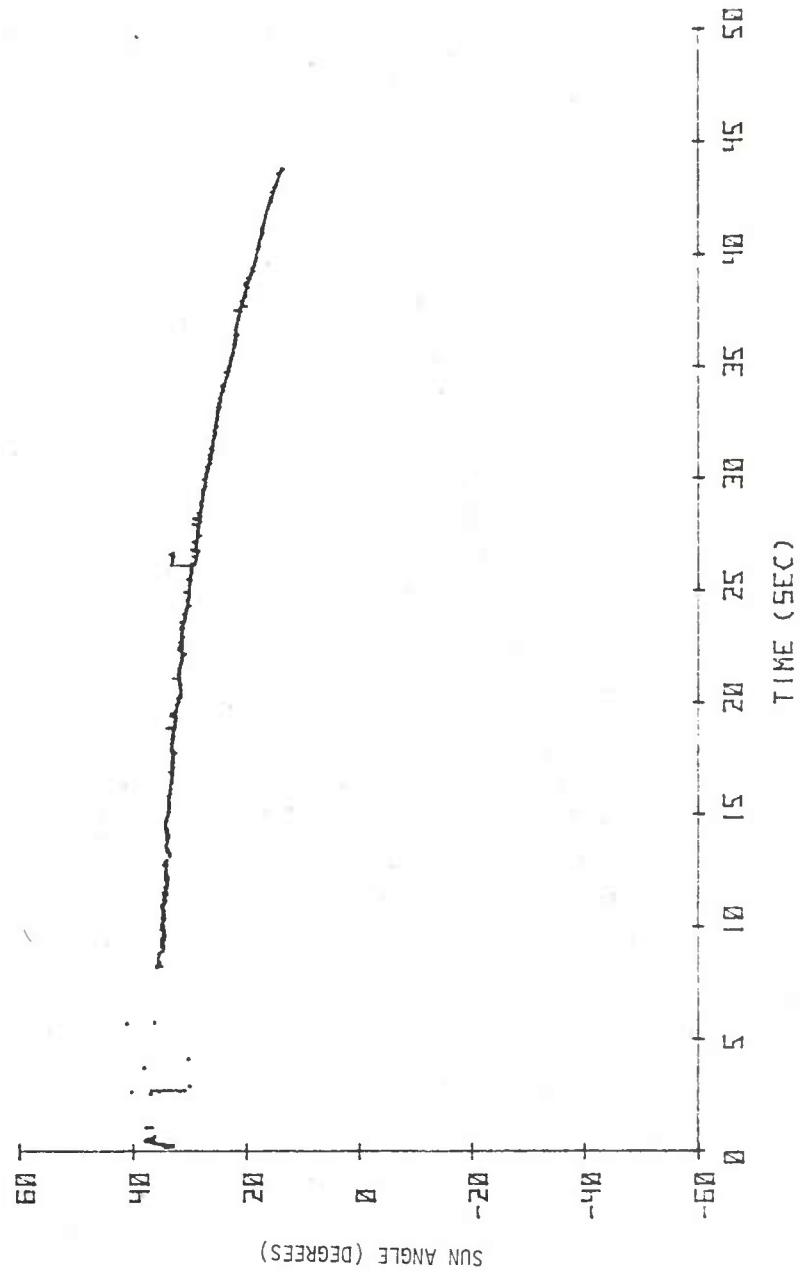


Figure 32. The Yawing Motion of the M549 RAP Projectile, Rocket On, Round No. 16

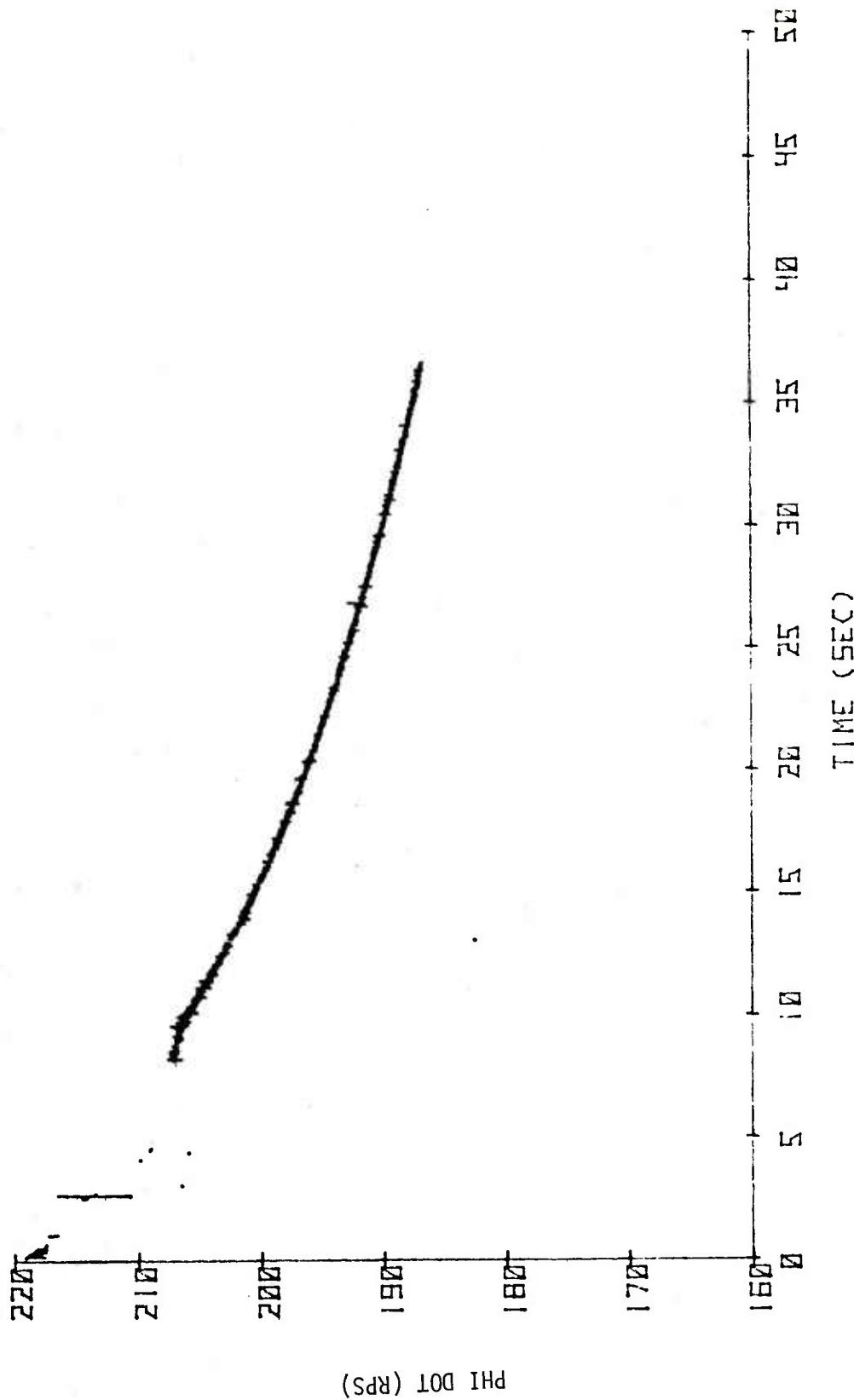


Figure 33. The Spin Motion of the M549 RAP Projectile, Rocket On, Round No. 16

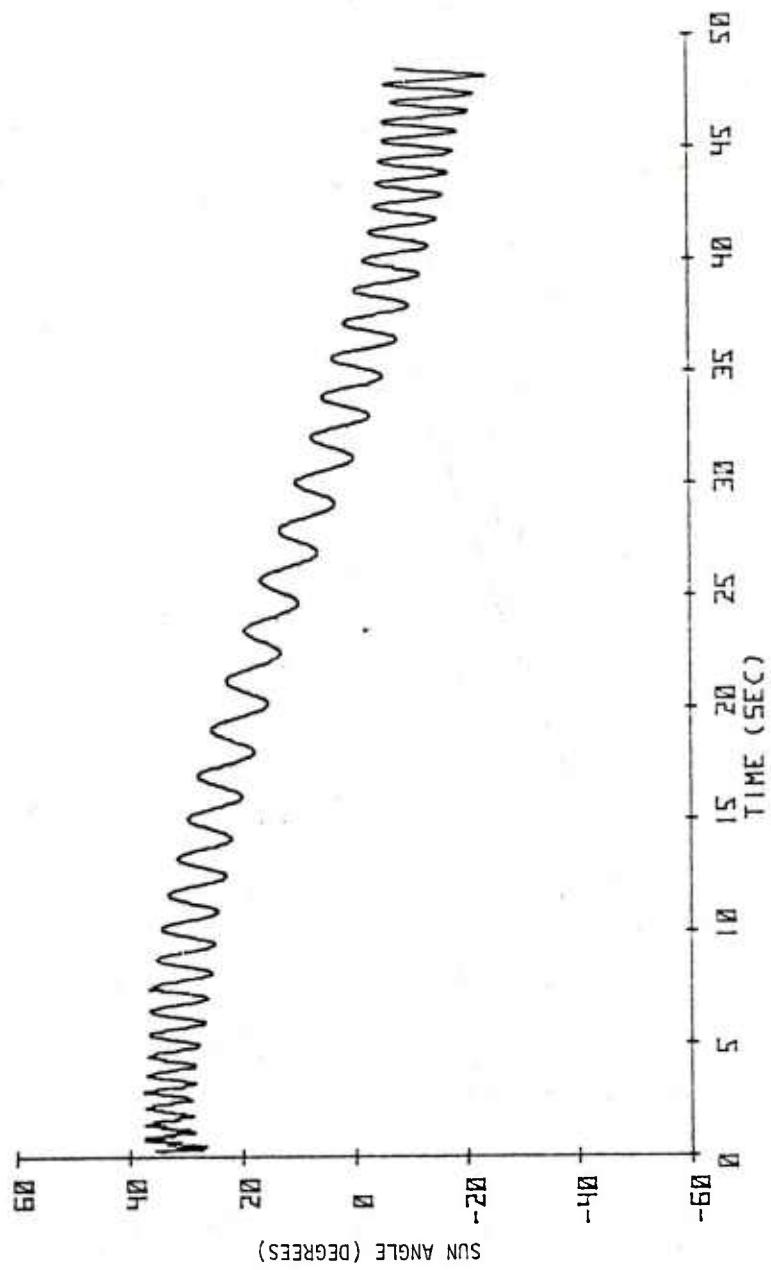


Figure 34. The Yawing Motion of the NCB-B Projectile Round No. 17

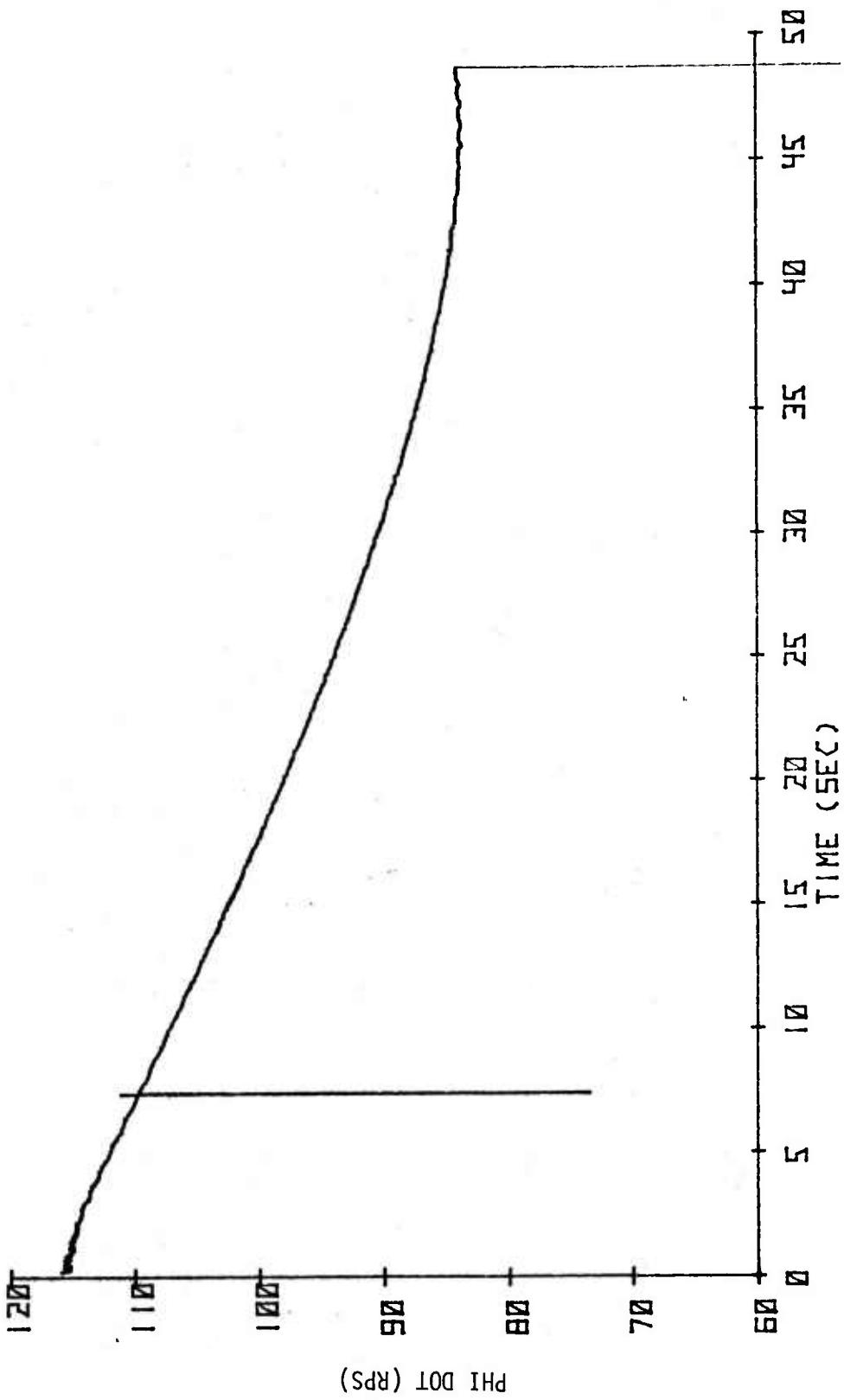


Figure 35. The Spin Motion of the NCB-B Projectile Round No. 17

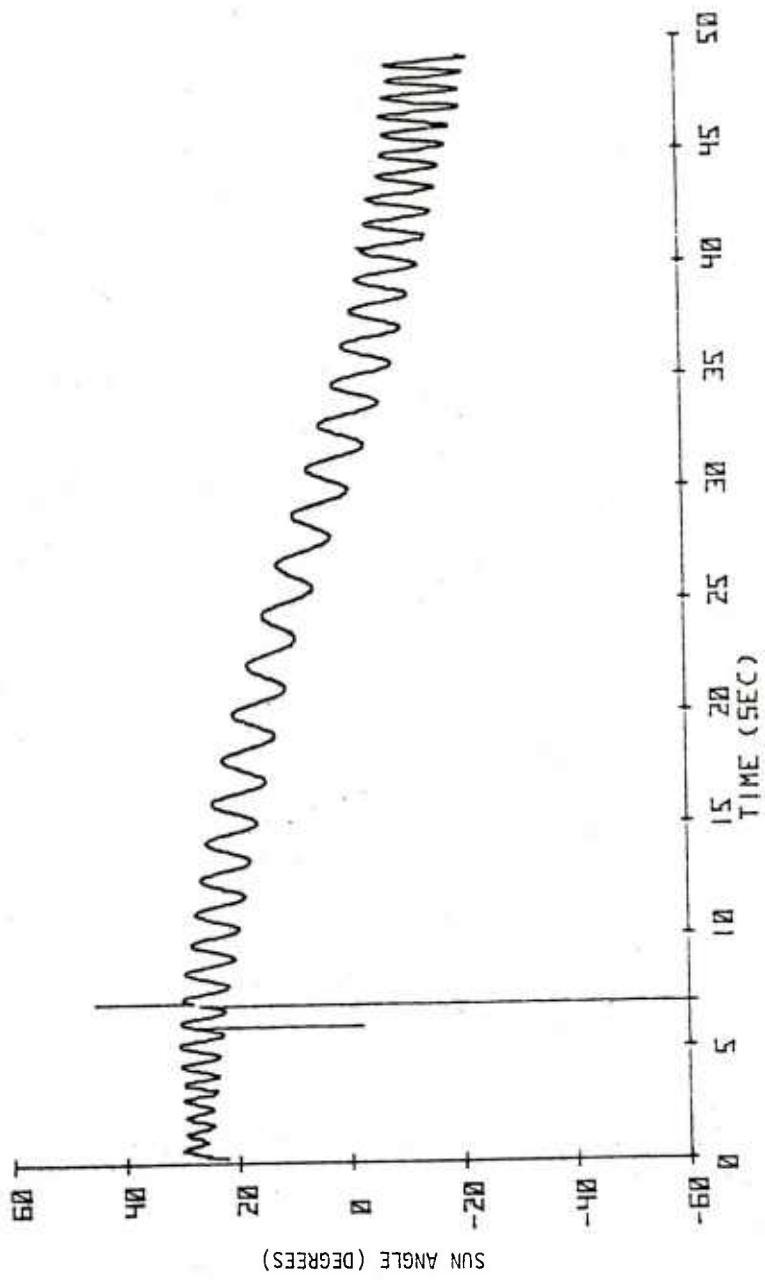


Figure 36. The Yawing Motion of the NCB-B Projectile Round No. 18

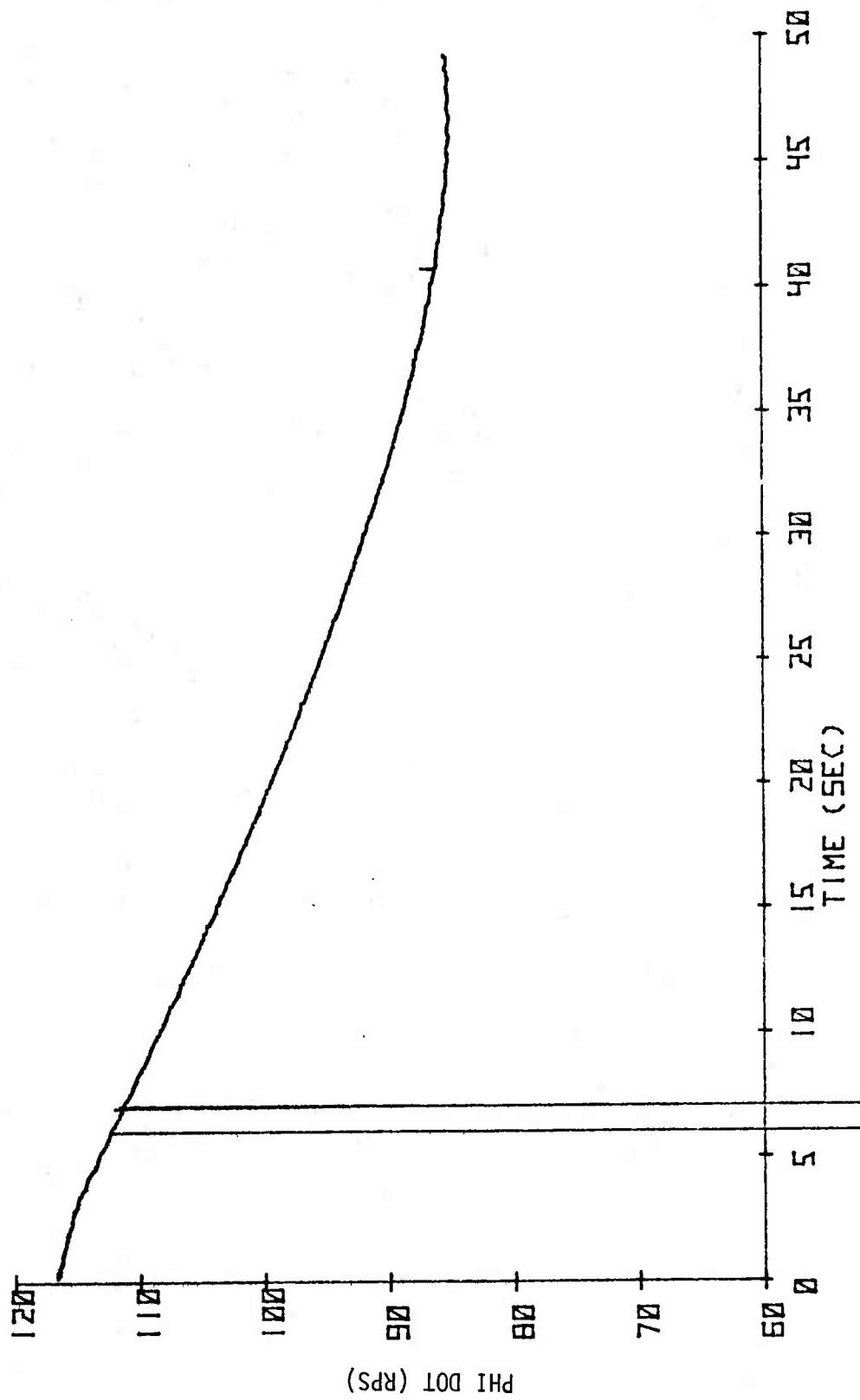


Figure 37. The Spin Motion of the NCB-B Projectile Round No. 18

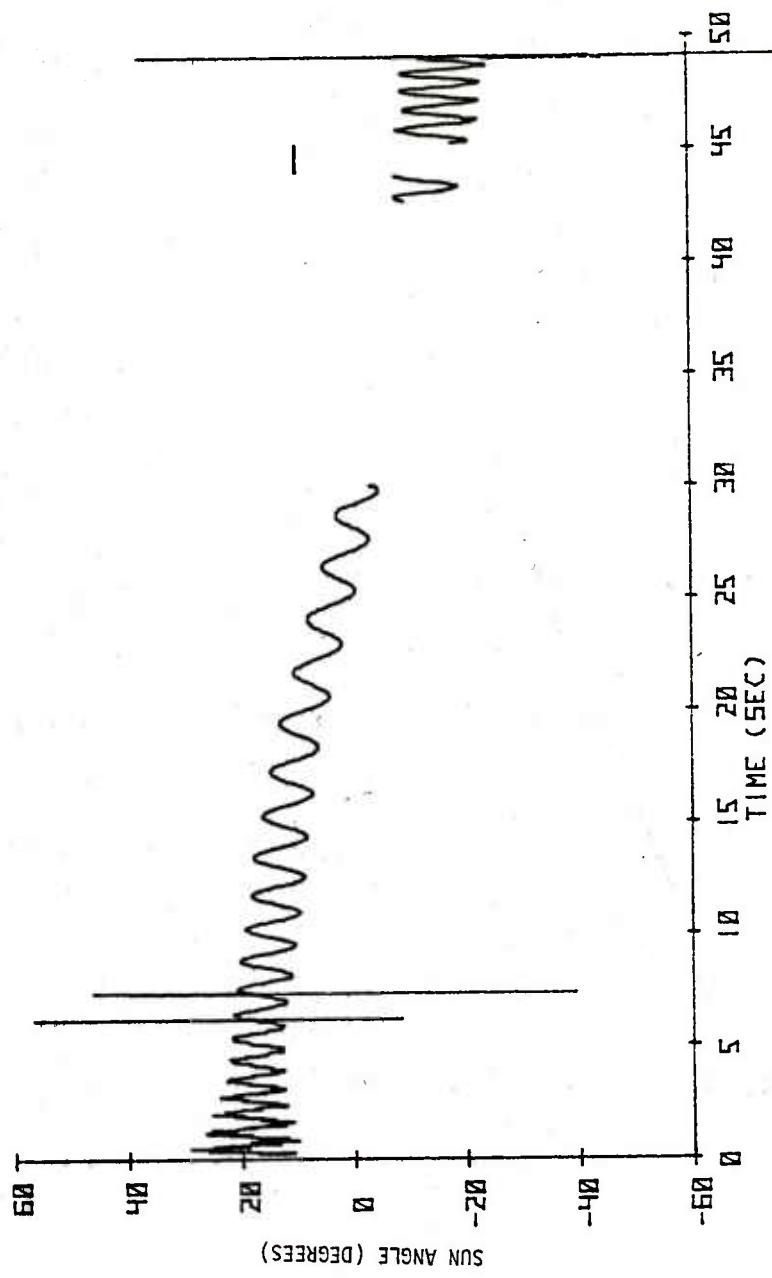


Figure 38. The Yawing Motion of the NCB-B Projectile Round No. 19

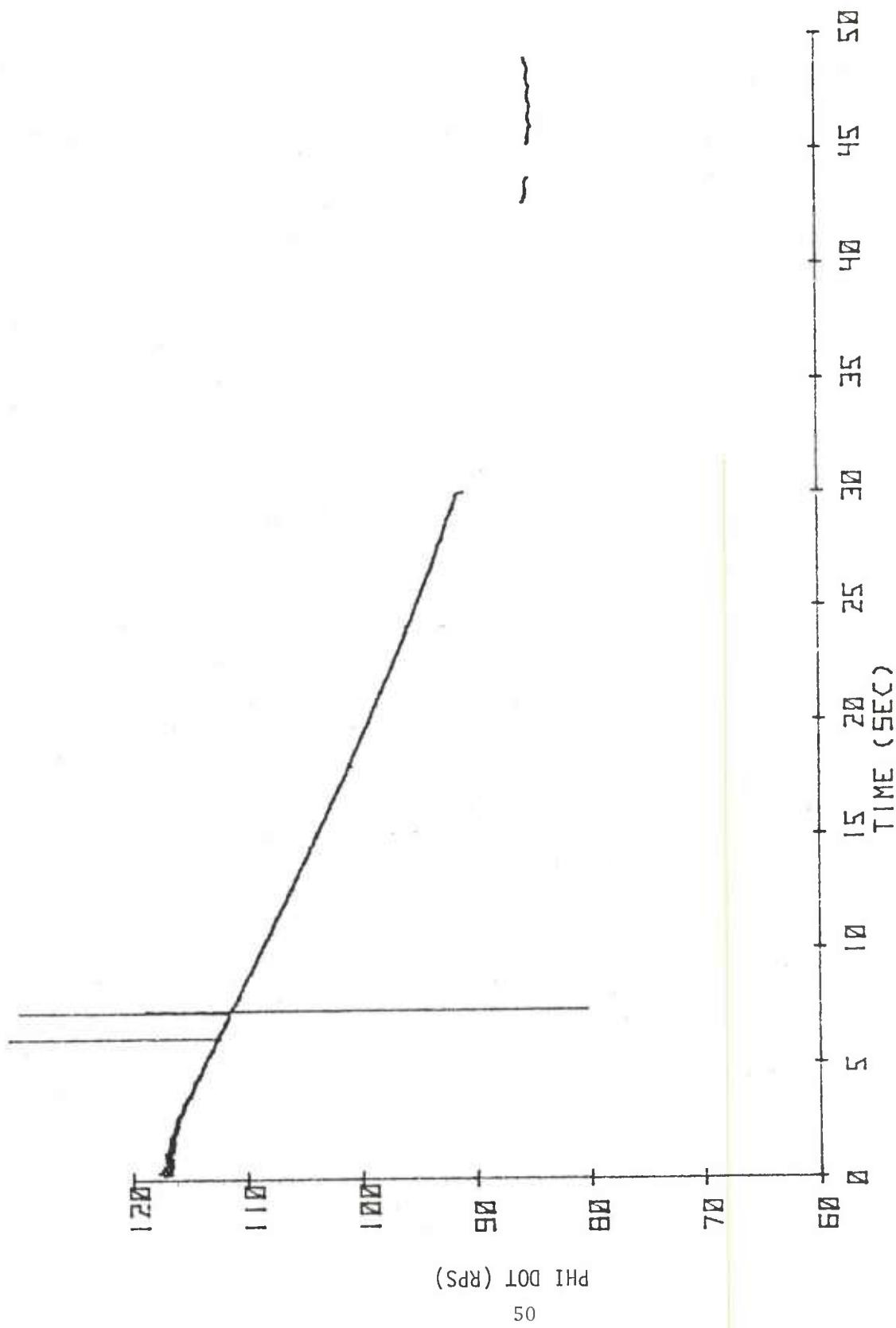


Figure 39. The Spin motion of the MCB-B Projectile Round No. 19

Table I. The Physical Characteristics of the 155 mm Projectiles
Fired at Tonopah Test Range, Nevada, on 18-21 October 1977

| <u>Configuration</u> | <u>W kg.</u> | <u>C.G. Cal. Aft Nose</u> | <u>I_x kg·m²</u> | <u>I_y kg·m²</u> |
|----------------------|------------------|-------------------------------|---|---|
| NCB-A | 43.0 | 3.5 | .130 | 1.710 |
| M549 | 43.5 | 3.5 | .150 | 1.930 |
| NCB-B | 46.1 | 3.9 | .122 | 1.695 |

Table II. Program for the Second Phase Shoot of the NCB-A and NCB-B Projectiles at Tonopah During the Week of 17 October 1977

| <u>Round</u> | <u>Number of Projectiles</u> | <u>Mach No. at Launch</u> | <u>Charge</u> | <u>Comments</u> |
|--------------|----------------------------------|-------------------------------|-------------------|---|
| NCB-A | 9 | 1.8 | XM201E2 (Z6) | Yawsonde Records and Flight Behavior |
| M549 | 5 | 1.8 | XM201E2 (Z6) | Yawsonde Records and Flight Behavior |
| M549 | 2 | Maximum Range RAP On | XM201E2 (Z7) | Yawsonde Records and Flight Behavior |
| NCB-B | 2 | 1.05 | M3A1 (25 and 50Z) | Yawsonde Records Boattail Pads |
| NCB-B | 2 | 1.05 | M3A1 (25 and 50Z) | Yawsonde Records No Boattail Pads Plus $\frac{1}{2}$ Muzzle Lip |

Table III. Log of Second Phase Non-Conical Boattail Projectile Flights
Tonopah Test Range, Nevada, 18 October 1977

| Tonopah Round Number | BRL Model Number | BRL Yawsonde Number | Yawsonde Frequency Hertz | Launch Time Hours | Muzzle Velocity m/sec | Breech Pressure kg/cm ² | Telemetry Status in Flight | Yawsonde Camera | Smear Camera | Loading ¹ Distance Meters |
|--|------------------|---------------------|--------------------------|-------------------|-----------------------|------------------------------------|----------------------------|-----------------|--------------|--------------------------------------|
| Two Warmer Rounds -- 155mm 107 Projectiles -- No Data Taken | | | | | | | | | | |
| <u>Non-Conical Boattail Projectile-A (No Plastic Obturator Ring)</u> | | | | | | | | | | |
| 53 | | | | | | | | | | |
| 422276-1 B4778 1302 241.0 1316 642.3 1900 Recorded No .756 | | | | | | | | | | |
| -2 B4776 1300 238.9 1331 659.3 2020 " " " " .759 | | | | | | | | | | |
| -3 B4777 1298 247.0 1344 648.3 1980 " " " " .762 | | | | | | | | | | |
| -4 B4779 1294 244.8 1357 645.6 1980 " " " " " | | | | | | | | | | |
| -5 B4783 1296 242.1 1408 646.2 1980 " " " " " | | | | | | | | | | |
| -6 B4780 1299 239.0 1429 644.3 1980 " " " " " | | | | | | | | | | |
| -7 B4784 1062 245.1 1439 648.7 1940 " " " " " | | | | | | | | | | |
| -8 B4781 974 242.8 1450 643.8 1900 Noisy " " " | | | | | | | | | | |
| -9 B4782 1279 239.1 1503 642.9 1880 No " " " | | | | | | | | | | |
| <u>M549 Projectile With RAP Off (Plastic Obturator Ring)</u> | | | | | | | | | | |
| 422276-10 3 1058 246.6 1556 615.3 1650 Recorded No .987 | | | | | | | | | | |
| -11 10 1059 244.3 1610 613.2 1640 " " " | | | | | | | | | | |
| -12 4 1060 247.5 1620 609.3 1640 No ² " " " | | | | | | | | | | |
| -13 9 1061 245.3 1634 613.5 1660 Recorded " " " | | | | | | | | | | |
| -14 11 965 246.0 1644 613.7 1640 No ² " " " | | | | | | | | | | |

All rounds fired from M185 gun tube mounted on Tonopah stationary mount with muzzle brake. Gun elevation 1630.4m above mean sealevel, Q.E. = 45°. All rounds fired with charge XM201E2 Zone 6-- flash reducer removed.

Table III. (Continued) Test Firings on 21 October 1977

| Tonopah Round Number | BRL Model Number | BRL Yawsonde Number | Yawsonde Frequency Hertz | Launch Time Hours | Muzzle Velocity km/sec | Breech Pressure kg/cm ² | Telemetry Status in Flight | Yawsonde Camera | Smear Camera | Loading ¹ Distance Meters |
|----------------------|------------------|---------------------|--------------------------|-------------------|------------------------|------------------------------------|----------------------------|-----------------|--------------|--------------------------------------|
| | | | | | | | | | | |

One Warmer Round -- 155mm 107 Projectile -- No Data Taken

M549 Projectile With RAP On (Plastic Obturator Ring)

| | | | | | | | | | |
|-----------|---|------|-------|------|-------|------|----------|-----|------|
| 422276-15 | 6 | 1207 | 235.1 | 1413 | 683.7 | 2540 | Recorded | Yes | .984 |
| -16 | 7 | 1209 | 237.2 | 1426 | 685.2 | 2570 | " | " | " |

Charge for above rounds XM201E2 Zone 7 -- RAP on from 7 seconds to 10 seconds.

Non-Conical Boattail Projectile-B With Boattail Pads--Full Muzzle Brake Plastic Discarding Rotating Band--Charge M3A1 Zone 5 + 5 Oz.

| | | | | | | | | | |
|-----------|-------|------|-------|------|-------|------|----------|-----|-------|
| 422276-17 | B4867 | 1301 | 243.7 | 1441 | 365.5 | 1090 | Recorded | Yes | 1.022 |
| -18 | B4869 | 1297 | 244.2 | 1501 | 367.4 | 1110 | " | " | " |

Non-Conical Boattail Projectile-B No Boattail Pads--½ Muzzle Brake Plastic Discarding Rotating Band--Charge M3A1 Zone 5 + 5 Oz.

| | | | | | | | | | |
|-----------|-------|------|-------|------|-------|------|----------|-----|-------|
| 422276-19 | B4870 | 1295 | 244.1 | 1534 | 364.0 | 1090 | Recorded | Yes | 1.026 |
| -20 | B4868 | 1032 | 239.1 | 1549 | 363.9 | 1080 | No | " | " |

All rounds fired from M185 gun tube mounted on Tonopah stationary mount. Gun elevation 1650.4m above mean sealevel, Q.E. = 45°.

1 -- Distance from projectile base to end of open breech.

2 -- Yawsonde fuze was tight fit in projectile cavity. Battery cap may have unscrewed so that battery power was lost.

Table IV. The Impact Data From the Phase 2 Flights

| Round | Range m | Deflection to Right m | Muzzle Velocity m/sec | Range Corrected to V = 650 m/sec m | Dispersion |
|----------|--------------|-----------------------------|-----------------------------|--|-------------------------------------|
| 422276-1 | 20,137.5 | 383.1 | 642.3 | 20,388 | |
| -2 | 20,467.6 | 337.8 | <u>651.0-659.3*</u> | 20,151 | |
| -3 | 20,411.1 | 284.9 | <u>648.3</u> | 20,461 | |
| -4 | 20,296.5 | 311.3 | 645.6 | 20,435 | |
| -5 | 20,337.0 | 320.6 | 646.2 | 20,461 | |
| -6 | 20,306.5 | 350.0 | 644.3 | 20,492 | Without Rounds 2 and 7 |
| -7 | 20,386.4 | 345.0 | <u>644.8-648.7*</u> | 20,423 | Average Range = 20,444.3 m |
| -8 | 20,212.9 | 322.3 | <u>643.8</u> | 20,414 | Standard Deviation = 35.3 m |
| -9 | 20,250.0 | 303.4 | 642.9 | 20,480 | P.E. = .12% |
| | | | | | Range Corrected to V = 610 m/sec |
| | | | | | |
| -10 | 17,851.3 | 323.3 | 615.3 | 17,626 | |
| -11 | 17,826.3 | 358.2 | 613.2 | 17,691 | Average Range = 17,701.5 m |
| -12 | 17,831.2 | 367.4 | 609.3 | 17,856 | Standard Deviation = 89.5 m |
| -13 | 17,820.6 | 426.4 | 613.5 | 17,673 | P.E. = .34% |
| -14 | 17,817.7 | 426.8 | 613.7 | 17,662 | |
| -15 | Not Recorded | 683.7 | | | |
| -16 | Not Recorded | 685.2 | | | |
| -17 | 10,723.9 | 472.9 | 365.5 | | Two of these rounds were |
| -18 | 10,704.2 | 632.3 | 367.4 | | fired with induced yaw. |
| -19 | 10,739.5 | 410.1 | 364.0 | | Data was not good for |
| -20 | 10,734.6 | 355.6 | 363.9 | | dispersion. |

* Velocimeter data questionable--either velocity is possible. Underlined velocities maintain P.E. = .12%.

REFERENCES

1. Anders S. Platou, "An Improved Projectile Boattail. Part IV," Ballistic Research Laboratory Interim Memorandum Report No. 545, February 1977.
2. John H. Whiteside, "Transonic Tests of the 155mm Non-Conical Boat-tail Projectile A and 8-Inch XM650E4 and EBVP Projectiles at Nicolet, Danada, During January-February 1977," Ballistic Research Laboratory Memorandum Report (in preparation).
3. Vural Oskay and Anders S. Platou, "Yawsonde Tests of 155mm M549 Non-Conical Boattail Projectile at Tonopah Test Range," Ballistic Research Laboratory Interim Memorandum Report No. 580, November 1977.
4. R. W. Kline, W. R. Herrmann, and V. Oskay, "A Determination of the Aerodynamic Coefficients of the 155mm, M549 Projectile," Picatinny Arsenal Technical Report No. 4764, November 1974. AD B002073L.

DISTRIBUTION LIST

| <u>No. of Copies</u> | <u>Organization</u> | <u>No. of Copies</u> | <u>Organization</u> |
|----------------------|--|----------------------|---|
| 12 | Commander Defense Documentation Center ATTN: DDC-TCA Cameron Station Alexandria, VA 22314 | 3 | Commander US Army Missile Research and Development Command ATTN: DRDMI-R DRDMI-RDK Mr. R. Deep Mr. R. Becht Redstone Arsenal, AL 35809 |
| 1 | Commander US Army Materiel Development and Readiness Command ATTN: DRCDMD-ST, N. Klein 5001 Eisenhower Avenue Alexandria, VA 22333 | 1 | Commander US Army Missile Materiel Readiness Command ATTN: DRSMI-AOM Redstone Arsenal, AL 35809 |
| 1 | Commander US Army Aviation Research and Development Command ATTN: DRSAV-E P. O. Box 209 St. Louis, MO 63166 | 1 | Commander US Army Tank Automotive Research & Development Command ATTN: DRDTA-UL Warren, MI 48090 |
| 1 | Director US Army Air Mobility Research and Development Laboratory Ames Research Center Moffett Field, CA 94035 | 8 | Commander US Army Armament Research and Development Command ATTN: DRDAR-TSS (2 cys) DRDAR-LCA-F Mr. D. Mertz Mr. E. Falkowski Mr. A. Loeb Mr. R. Kline Mr. S. Kahn Mr. S. Wasserman Dover, NJ 07801 |
| 1 | Commander US Army Electronics Research and Development Command Technical Support Activity ATTN: DELSD-L Fort Monmouth, NJ 07703 | 1 | Commander US Army Armament Materiel Readiness Command ATTN: DRSAR-LEP-L, Tech Lib Rock Island, IL 61299 |
| 1 | Commander US Army Communications Research and Development Command ATTN: DRDCO-PPA-SA Fort Monmouth, NJ 07703 | 1 | Director US Army TRADOC Systems Analysis Activity ATTN: ATAA-SL, Tech Lib White Sands Missile Range NM 88002 |
| 1 | Commander US Army Jefferson Proving Ground ATTN: STEJP-TD-D Madison, IN 47250 | | |

DISTRIBUTION LIST

| <u>No. of Copies</u> | <u>Organization</u> | <u>No. of Copies</u> | <u>Organization</u> |
|----------------------|---|----------------------|--|
| 1 | Commander US Army Natick Research and Development Command ATTN: DRXRE, Dr. D. Sieling Natick, MA 01762 | 1 | Commander US Naval Weapons Center ATTN: Technical Library China Lake, CA 93555 |
| 1 | Commander US Army Research Office P. O. Box 12211 Research Triangle Park NC 27709 | 1 | AFATL (DLDL) Eglin AFB, FL 32542 |
| 3 | Commander US Naval Air Systems Command ATTN: AIR-604 Washington, D. C. 20360 | 1 | Director NASA Langley Research Center ATTN: MS-185, Tech Lib Langley Station Hampton, VA 23365 |
| 2 | Commander David W. Taylor Naval Ship Research and Development Center ATTN: Dr. S. de los Santos Mr. Stanley Gottlieb Bethesda, Maryland 20084 | 1 | Director NASA Ames Research Center ATTN: MS-202, Tech Lib Moffett Field, CA 94035 |
| 4 | Commander US Naval Surface Weapons Center ATTN: Dr. T. Clare, Code DK20 Dr. P. Daniels Mr. D. A. Jones III Mr. L. Mason Dahlgren, VA 22448 | 1 | Arnold Research Organization, Inc. von Karman Gas Dynamics Facility ATTN: Dr. John C. Adams, Jr. Aerodynamics Division Projects Branch Arnold AFS, TN 37389 |
| 4 | Commander US Naval Surface Weapons Center ATTN: Code 312 Mr. S. Hastings Mr. F. Regan Mr. J. Knott Mr. R. Schlie Silver Spring, MD 20910 | 1 | Calspan Corporation ATTN: Mr. J. Andes, Head Transonic Tunnel Dept. P. O. Box 235 Buffalo, NY 14221 |
| | | 1 | Honeywell, Inc. ATTN: Mr. George Stilley 600 Second Street, N. Hopkins, MN 55343 |
| | | 1 | Sandia Laboratories ATTN: Division No. 1331 Mr. H. R. Vaughn Albuquerque, NM 87115 |

DISTRIBUTION LIST

| <u>No. of Copies</u> | <u>Organization</u> | <u>No. of Copies</u> | <u>Organization</u> |
|----------------------|---|---|---|
| 2 | Space Research Corporation ATTN: Dr. G. V. Bull Dr. D. Lister North Jay Road P. O. Box 60 North Troy, VT 05859 | 1 | University of Virginia Department of Aerospace Engineering and Engineering Physics ATTN: Prof. I. Jacobson Charlottesville, VA 22904 |
| 2 | Massachusetts Institute of Technology ATTN: Prof. E. Covert Prof. C. Haldeman 77 Massachusetts Avenue Cambridge, MA 02139 | <u>Aberdeen Proving Ground</u> | |
| 1 | MIT/Lincoln Laboratories ATTN: Dr. Milan Vlajinac Mail Stop D-382 P. O. Box 73 Lexington, MA 02173 | Director, USAMSA Cdr, USATECOM ATTN: DRSTE-SG-H | |
| 1 | Rutgers University Mechanical, Industrial, and Aerospace Engineering Department ATTN: Dr. Robert H. Page New Brunswick, NJ 08903 | Cdr, USAARRADCOM, EA ATTN: DRDAR-ACW Mr. M. Miller Mr. A. Flatau | |
| 1 | University of Delaware Mechanical and Aerospace Engineering Department ATTN: Dr. J. E. Danberg Newark, DE 19711 | Biophysics Lab., EA ATTN: Mr. W. Sacco Bldg. 3160 | |