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NRL Memorandum Report 754

368420

**SUMMARY OF NAVY STUDY PROGRAM
FOR F4H-1 WEAPON SYSTEM
(Parameter Plots for Sparrow III Missile Attacks)**

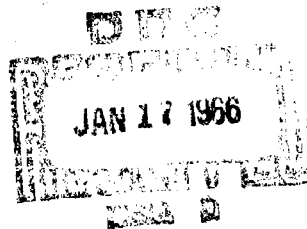
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VOLUME XV

I. Bellavin, R. Lister, C. Loughmiller,
M. Schmookler, and J. Ryon

EQUIPMENT RESEARCH BRANCH
RADAR DIVISION

October 1962



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TABLE OF CONTENTS

ABSTRACT	11
PROBLEM STATUS	11
AUTHORIZATION	11
LIST OF FIGURES	11
INTRODUCTION	1
INPUT DATA	2
GEOMETRY	6
MISSILE PARAMETER INVESTIGATION	8
CO-ALTITUDE ATTACKS - UNIMPROVED MISSILE	10
PULL-UP ATTACK - UNIMPROVED MISSILE	15
PULL-UP ATTACK - IMPROVED MISSILE	18
ERROR IN V_0	19
ACKNOWLEDGMENTS	23
REFERENCES	24

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ABSTRACT

The Naval Research Laboratory is serving as technical director of the Navy's Air-to-Air Missile Study. The results are presented in a series of volumes under NRL Memorandum Report 754. This volume is the fifteenth in this series. The study to date has been primarily concerned with the system employing the F4H-1 aircraft, the AN/APQ-72 radar and the Sparrow III6a missile. This volume represents a continuation of the study results presented in preceding volumes. Examples of missile parameter variations, missile limits encountered and missile miss distance results are presented.

PROBLEM STATUS

This is an interim report; work on the problem is continuing.

AUTHORIZATION

NRL Problem 53R05-04
BUWEPS Problem EL-42001

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LIST OF FIGURES

- Figure 1. Sparrow III Autopilot and Seeker Block Diagram.
- Figure 2. Attack Geometry.
- Figure 3. Typical Missile Guidance Geometry.
- Figure 4a. Sparrow III Miss Distance; Co-Altitude Attacks;
X-Y Miss Distance at the Target ($\gamma_0 = 15^\circ$) -
Unimproved Missile.
- 4b. Sparrow III Miss Distance; Co-Altitude Attacks;
X-Z Miss Distance at the Target ($\gamma_0 = 15^\circ$) -
Unimproved Missile.
- 4c. Sparrow III Miss Distance; Co-Altitude Attacks;
Y-Z Miss Distance at the Target ($\gamma_0 = 15^\circ$) -
Unimproved Missile.
- 4d. Fighter to Missile Range Vs Time.
- 4e. Missile to Target Range Vs Time.
- 4f. Fighter to Target Range Vs Time.
- 4g. Fighter to Missile Range Rate Vs Time.
- 4h. Missile to Target Range Rate Vs Time.
- 4i. Fighter to Target Range Rate Vs Time.
- 4j. Antenna Azimuth Gimbal Angle of Missile Vs Time.
- 4k. Antenna Elevation Gimbal Angle of Missile Vs Time.
- 4l. Missile Lead Angle Vs Time.
- 4m. Azimuth Line of Sight Rate of Missile Vs Time.
- 4n. Elevation Line of Sight Rate of Missile Vs Time.
- 4o. Missile Velocity Vs Time.
- 4p. Azimuth Look-Angle Error for Missile Seeker Vs Time.
- 4q. Elevation Look-Angle Error for Missile Seeker Vs Time.

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Figure 4r. Missile Angle of Attack Vs Time.

- 4s. Missile and Fighter Roll Angles Vs Time.
- 4t. Commanded Elevation G's Vs Time.
- 4u. Commanded Azimuth G's Vs Time.
- 4v. Commanded Elevation Wing Deflection Vs Time.
- 4w. Commanded Azimuth Wing Deflection Vs Time.
- 4x. Deflection of Missile Pitch Wings Vs Time.
- 4y. Deflection of Missile Yaw Wings Vs Time.
- 4z. Total Wing Movement Vs Time.

Figure 5a. Sparrow III Miss Distance; Co-Altitude Attacks;
X-Y Miss Distance at the Target ($\gamma_0 = 15^\circ$) -
Unimproved Missile.

- 5b. Sparrow III Miss Distance; Co-Altitude Attacks;
X-Z Miss Distance at the Target ($\gamma_0 = 15^\circ$) -
Unimproved Missile.
- 5c. Sparrow III Miss Distance; Co-Altitude Attacks;
Y-Z Miss Distance at the Target ($\gamma_0 = 15^\circ$) -
Unimproved Missile.
- 5d. Fighter to Missile Range Vs Time.
- 5e. Missile to Target Range Vs Time.
- 5f. Fighter to Target Range Vs Time.
- 5g. Fighter to Missile Range Rate Vs Time.
- 5h. Missile to Target Range Rate Vs Time.
- 5i. Fighter to Target Range Rate Vs Time.
- 5j. Antenna Azimuth Gimbal Angle of Missile Vs Time.
- 5k. Antenna Elevation Gimbal Angle of Missile Vs Time.
- 5l. Missile Lead Angle Vs Time.

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Figure 5m. Azimuth Line of Sight Rate of Missile Vs Time.

- 5n. Elevation Line of Sight Rate of Missile Vs Time.
- 5o. Missile Velocity Vs Time.
- 5p. Azimuth Look-Angle Error for Missile Seeker Vs Time.
- 5q. Elevation Look-Angle Error for Missile Seeker Vs Time.
- 5r. Missile Angle of Attack Vs Time.
- 5s. Missile and Fighter Roll Angles Vs Time.
- 5t. Commanded Elevation G's Vs Time.
- 5u. Commanded Azimuth G's Vs Time.
- 5v. Commanded Elevation Wing Deflection Vs Time.
- 5w. Commanded Azimuth Wing Deflection Vs Time.
- 5x. Deflection of Missile Pitch Wings Vs Time.
- 5y. Deflection of Missile Yaw Wings Vs Time.
- 5z. Total Wing Movement Vs Time.

Figure 6a. Sparrow III Miss Distance; Co-Altitude Attacks;
X-Y Miss Distance at the Target ($\tau_0 = 1$) -
Unimproved Missile.

- 6b. Sparrow III Miss Distance; Co-Altitude Attacks;
X-Z Miss Distance at the Target ($\tau_0 = 15^\circ$) -
Unimproved Missile.
- 6c. Sparrow III Miss Distance; Co-Altitude Attacks;
Y-Z Miss Distance at the Target ($\tau_0 = 15^\circ$) -
Unimproved Missile.
- 6d. Fighter to Missile Range Vs Time.
- 6e. Missile to Target Range Vs Time.
- 6f. Fighter to Target Range Vs Time.
- 6g. Fighter to Missile Range Rate Vs Time.

CONFIDENTIAL

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Figure 6h. Missile to Target Range Rate Vs Time.

- 6i. Fighter to Target Range Rate Vs Time.
- 6j. Antenna Azimuth Gimbal Angle of Missile Vs Time.
- 6k. Antenna Elevation Gimbal Angle of Missile Vs Time.
- 6l. Missile Lead Angle Vs Time.
- 6m. Azimuth Line of Sight Rate of Missile Vs Time.
- 6n. Elevation Line of Sight Rate of Missile Vs Time.
- 6o. Missile Velocity Vs Time.
- 6p. Azimuth Look-Angle Error for Missile Seeker Vs Time.
- 6q. Elevation Look-Angle Error for Missile Seeker Vs Time.
- 6r. Missile Angle of Attack Vs Time.
- 6s. Missile and Fighter Roll Angles Vs Time.
- 6t. Commanded Elevation G's Vs Time.
- 6u. Commanded Azimuth G's Vs Time.
- 6v. Commanded Elevation Wing Deflection Vs Time.
- 6w. Commanded Azimuth Wing Deflection Vs Time.
- 6x. Deflection of Missile Pitch Wings Vs Time.
- 6y. Deflection of Missile Yaw Wings Vs Time.
- 6z. Total Wing Movement Vs Time.
- 6zz. Missile Altitude Vs Time

Figure 7a. Sparrow III Miss Distance; Co-Altitude Attacks;
X-Y Miss Distance at the Target ($\gamma_0 = 15^\circ$) -
Unimproved Missile.

7b. Sparrow III Miss Distance; Co-Altitude Attacks;
X-Z Miss Distance at the Target ($\gamma_0 = 15^\circ$) -
Unimproved Missile.

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Figure 7c. Sparrow III Miss Distance; Co-Altitude Attacks;
Y-Z Miss Distance at the Target ($\gamma_0 = 15^\circ$) -
Unimproved Missile.

- 7d. Fighter to Missile Range Vs Time.
- 7e. Missile to Target Range Vs Time.
- 7f. Fighter to Target Range Vs Time.
- 7g. Fighter to Missile Range Rate Vs Time.
- 7h. Missile to Target Range Rate Vs Time.
- 7i. Fighter to Target Range Rate Vs Time.
- 7j. Antenna Azimuth Gimbal Angle of Missile Vs Time.
- 7k. Antenna Elevation Gimbal Angle of Missile Vs Time.
- 7l. Missile Lead Angle Vs Time.
- 7m. Azimuth Line of Sight Rate of Missile Vs Time.
- 7n. Elevation Line of Sight Rate of Missile Vs Time.
- 7o. Missile Velocity Vs Time.
- 7p. Azimuth Look-Angle Error for Missile Seeker Vs Time.
- 7q. Elevation Look-Angle Error for Missile Seeker Vs Time.
- 7r. Missile Angle of Attack Vs Time.
- 7s. Missile and Fighter Roll Angles Vs Time.
- 7t. Commanded Elevation G's Vs Time.
- 7u. Commanded Azimuth G's Vs Time.
- 7v. Commanded Elevation Wing Deflection Vs Time.
- 7w. Commanded Azimuth Wing Deflection Vs Time.
- 7x. Deflection of Missile Pitch Wings Vs Time.
- 7y. Deflection of Missile Yaw Wings Vs Time.
- 7z. Total Wing Movement Vs Time.

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Figure 7zz. Missile Altitude Vs Time.

- 8a. Sparrow III Miss Distance; Co-Altitude Attacks;
X-Y Miss Distance at the Target ($\gamma_0 = 15^\circ$) -
Improved Missile.
- 8b. Sparrow III Miss Distance; Co-Altitude Attacks;
X-Z Miss Distance at the Target ($\gamma_0 = 15^\circ$) -
Improved Missile.
- 8c. Sparrow III Miss Distance; Co-Altitude Attacks;
Y-Z Miss Distance at the Target ($\gamma_0 = 15^\circ$) -
Improved Missile.
- 8d. Fighter to Missile Range Vs Time.
- 8e. Missile to Target Range Vs Time.
- 8f. Fighter to Target Range Vs Time.
- 8g. Fighter to Missile Range Rate Vs Time.
- 8h. Missile to Target Range Rate Vs Time.
- 8i. Fighter to Target Range Rate Vs Time.
- 8j. Antenna Azimuth Gimbal Angle of Missile Vs Time.
- 8k. Antenna Elevation Gimbal Angle of Missile Vs Time.
- 8l. Missile Lead Angle Vs Time.
- 8m. Azimuth Line of Sight Rate of Missile Vs Time.
- 8n. Elevation Line of Sight Rate of Missile Vs Time.
- 8o. Missile Velocity Vs Time.
- 8p. Azimuth Look-Angle Error for Missile Seeker Vs Time.
- 8q. Elevation Look-Angle Error for Missile Seeker Vs Time.
- 8r. Missile Angle of Attack Vs Time.
- 8s. Missile and Fighter Roll Angles Vs Time.
- 8t. Commanded Elevation G's Vs Time.
- 8u. Commanded Azimuth G's Vs Time.

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Figure 8v. Commanded Elevation Wing Deflection Vs Time.

8w. Commanded Azimuth Wing Deflection Vs Time.

8x. Deflection of Missile Pitch Wings Vs Time.

8y. Deflection of Missile Yaw Wings Vs Time.

8z. Total Wing Movement Vs Time.

8zz. Missile Altitude Vs Time.

Figure 9a. Sparrow III Miss Distance; Co-Altitude Attacks;
X-Y Miss Distance at the Target ($\gamma_0 = 15^\circ$) -
Improved Missile.

9b. Sparrow III Miss Distance; Co-Altitude Attacks;
X-Z Miss Distance at the Target ($\gamma_0 = 15^\circ$) -
Improved Missile.

9c. Sparrow III Miss Distance; Co-Altitude Attacks;
Y-Z Miss Distance at the Target ($\gamma_0 = 15^\circ$) -
Improved Missile.

9d. Fighter to Missile Range Vs Time.

9e. Missile to Target Range Vs Time.

9f. Fighter to Target Range Vs Time.

9g. Fighter to Missile Range Rate Vs Time.

9h. Missile to Target Range Rate Vs Time.

9i. Fighter to Target Range Rate Vs Time.

9j. Antenna Azimuth Gimbal Angle of Missile Vs Time.

9k. Antenna Elevation Gimbal Angle of Missile Vs Time.

9l. Missile Lead Angle Vs Time.

9m. Azimuth Line of Sight Rate of Missile Vs Time.

9n. Elevation Line of Sight Rate of Missile Vs Time.

9o. Missile Velocity Vs Time.

9p. Azimuth Look-Angle Error for Missile Seeker Vs Time.

9q. Elevation Look-Angle Error for Missile Seeker Vs Time.

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SUMMARY OF NAVY STUDY PROGRAM FOR F4H-1 WEAPON SYSTEM

INTRODUCTION

The Bureau of Naval Weapons has a project with the Naval Research Laboratory to conduct system studies directed toward establishing the tactical use capability of the Navy's Air-to-Air Missile Systems. These studies are conducted under the technical direction of the Naval Research Laboratory with all inputs derived from Navy sources. To date, study effort has been primarily directed toward revealing the tactical use capability of the F4H-1 Weapon System. In support of this effort, NRL has contracted with Westinghouse Air Arm Division for analytical services. Recommendations and conclusions to be drawn from analytical results are a Navy responsibility, and in particular the responsibility of the technical director (NRL). This report is the fifteenth in a series directed toward revealing the tactical effectiveness of the F4H-1 Weapon System.

The Navy study has been, and will continue to be, a cooperative effort. Wherever possible duplication has been avoided. Input data for the study has been obtained from the government facilities which most logically would cover the particular field. For example, radar test data was obtained from NATC, Patuxent; Sidewinder performance data was obtained from NOTS, Inyokern; and Sparrow III seeker performance data was obtained from NMC, Pt. Mugu. In addition, the facilities of the various activities have been, in effect, pooled so that special talents and equipments can be employed. The results of NMC, Pt. Mugu simulator studies to ascertain the allowable launch error for Sparrow III, and the effects of hydraulic oil limits have been incorporated in the overall study. In addition, NMC has conducted tests to verify the vectoring accuracies and to determine if the field degradation applied to AI radar detection range in this study is valid. It is very important that everyone concerned recognize that a study such as this must be a team effort. It is just as important to continue this team effort on future studies under the Sparrow III-6b and other programs.

The study results, to date, have been presented in Vols. I through XIV of this series (references 1 thru 12). The study effort covered by Volumes I thru X carries the system through to Sparrow III-6a missile launch. At this point it is assumed that, if the initial aircraft heading errors can be reduced to an acceptable launch error, the missile will fly perfectly to impact with the target. The probability of arrival to missile launch results presented in these preceding volumes are based upon this assumption.

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The study effort covered by Volumes XI thru XV is primarily concerned with the launch and missile guidance phases of the attack. The investigation of these phases of the attack has been divided into three parts and have been reported on in the same fashion. These three parts are:

1. Investigation of the tactical effectiveness of the F4H-1 system when employing the Sp III 6a missile as defined at the start of the Navy's Study. This missile is referred to throughout the text as the unimproved Sp III 6a.
2. Investigation of the sensitivity of system performance to Sp III 6a parameter variations.
3. Investigation of the tactical effectiveness of the F4H-1 system when employing the Sp III 6a missile as defined today. This missile will be referred to as the improved Sp III 6a. Miss distance results for the missile associated with the investigation of each of the above three phases are given in Vols. XI, XIII and XIV. This volume presents tables of initial conditions for a selection of the runs investigated; repeats miss distance results for this selected group of runs; presents tables of limits encountered during the missile flights on these runs; and presents selected samples of tables and plots of missile parameter variations during the missile flight for co-altitude and pull-up attacks.

INPUT DATA

The input conditions related to the subsystem performance and to the tactical situation have been detailed in preceding volumes. Only those items pertinent to the results presented in this volume will be repeated here.

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Sp III 6a Missile

The Unimproved Sparrow III missile which has been used in the simulation program of the Navy's Air-to-Air Missile Study is detailed in the Appendix to Volume XI. For the most part, this information is also valid for the latest version (improved) of the Sparrow III 6a. There are areas which have changed and these changes were included in the Navy Study of the improved missile (Volume XIII). When the Sp III 6a is referred to in this text as the improved Sp III 6a the basic differences from the unimproved Sp III 6a are as follows:

Equation 4 in the Appendix to Volume XI gives the average incremental missile velocity as

$$V_b = 800 \left[1 + 0.41 (1 - P/P_{SL}) \right]$$

P = pressure at altitude

P_{SL} = pressure at sea level

For the improved missile this equation is changed to

$$V_b = 1000 \left[1 + 0.3 (1 - P/P_{SL}) \right]$$

Equations 5 and 6 of the Appendix to Volume XI give the azimuth and elevation steering error equations as

$$\epsilon_a = \frac{57.3 \left[V_0 \sin \lambda_a + R \frac{W_k}{175} \right]}{2300}$$

ϵ_a = azimuth steering error

λ_a = azimuth gimbal angle

R = range

W_k = azimuth line of sight rate

$$\epsilon_e = \frac{57.3 \left[-V_0 \sin \lambda_e \cos \lambda_a - R \frac{W_l}{175} \right] - 0.48 \alpha}{2300}$$

ϵ_e = elevation steering error

λ_e = elevation gimbal angle

W_l = elevation line of sight rate

α = angle of attack

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For the improved missile these equations are changed to

$$E_a = \frac{57.3 [v_o \sin \lambda_a + \frac{R_{M1}}{178}]}{3400}$$

$$E_e = \frac{57.3 [-v_o \sin \lambda_e \cos \lambda_a - \frac{R_{M1}}{178}]}{3400} - 0.48$$

Table I gives the Sparrow III autopilot gains used in the Navy's Study of the unimproved Sp III 6a. In the latest version of the Sparrow III 6a, T_B is changed to 0.3 secs for altitude bands C and D.

The Sparrow III autopilot and seeker block diagram is given by Fig. 1. On this block diagram, Block A is shown to have a transfer equation having the form of

$$\frac{50}{170.5s}$$

In the latest version (improved) of the Sparrow III 6a, this block is changed to include a shaping network and the resulting transfer equations take the form of

$$\begin{array}{cc} 45 \left[\frac{P}{50} + 1 \right] & \left[\frac{P}{266} + 1 \right] \\ \hline \left[\frac{P}{18.62} + 1 \right] & \left[\frac{P}{5.81} + 1 \right] \\ 45 \left[\frac{P}{60.7} + 1 \right] & \left[\frac{P}{292} + 1 \right] \\ \hline \left[\frac{P}{19.9} + 1 \right] & \left[\frac{P}{5.8} + 1 \right] \end{array} \begin{array}{l} \text{(pitch channel)} \\ \text{(yaw channel)} \end{array}$$

The block labeled B on the diagram of Fig. 1 represents a limit and has the value of $\pm 80^\circ/\text{sec}$. In the latest version of the Sparrow III 6a this limit is changed to $\pm 100^\circ/\text{sec}$. The block labeled E also represents a limit and has the value $1.0^\circ \pm 1.25^\circ$. This is changed to $0^\circ \pm 2.25^\circ$.

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TABLE I

SPARROW III AUTOPILOT PARAMETERS

$t \triangleq$ TIME FROM LAUNCH (TIME FROM END OF STROKE)

$t_1 \triangleq$ UNLOCK TIME = (0.4 - 0.08) SEC

$t_2 \triangleq$ END-OF-BOOST TIME = (2.22 - 0.08) SEC

$t \triangleq$ MISSILE SEEKER LOCK-ON TIME = (2.22 - 0.08) SEC

ALTITUDE CONDITION	A	B	C	D
ALTITUDE	SL-17K	17-32K	32-46	>46K
T_3 (SEC)	.15	.15	0.4	0.4
T_5 (SEC)	YAW 4.93 PITCH 3.87	3.17 2.49	1.70 1.33	1.09 .857
K_5 (°/g SEC)	3.57	5.56	10.5	16.3
T_8 (SEC)	0.0063	0.0063	0.008	0.008
G_2 (°/°/SEC)	$\frac{1.14}{1/25S}$	$\frac{1.14}{1/12.5S}$	$\frac{3.43}{1/25S}$	$\frac{3.43}{1/12.5S}$
K_8 (°/°/SEC)	0.054	0.110	0.21	0.43

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Radar Analyses

The AI radar performance used in this phase of the study corresponds to that predicted for the AN/APQ-72 (XN-3). The 85% probability of detection range for this radar against a B-47 size target flying at M 1.6 at 50,000 ft. where $V_T/V_F = 0.8$ is shown by Fig. 1 of ref. 9. Head-on, this radar has an 85% probability of detection at approximately 19 n. mi. when the expected 10 db of field degradation is used. The radar has gimbal limits of $\pm 57^\circ$ in azimuth and elevation. It is currently estimated that these gimbal limits will actually be $\pm 60^\circ$. This change has not been incorporated in the study to date. A B-47 size target is used throughout this study.

Aircraft Analyses

The basic performance of the F4H-1 aircraft has been detailed in Vol. II of this series. Changes in this performance have occurred during the study period covered by this report. However, these changes have not resulted in significant changes in system analyses results. Details of the performance changes which have occurred and which are now being used in the simulation program are given in Volume XII of this series (reference 10).

GEOMETRY

The attack geometry for the fighter aircraft is shown on figure 2. The defined quantities will be used later in describing the conditions at missile launch.

Typical missile guidance geometry is shown by figure 3. Parameters shown on this chart which will be subject of investigation are:

- R_{F-M} = Fighter to missile range
- R_{M-T} = Missile to target range
- R_{F-T} = Fighter to target range
- H_M = Missile altitude
- H_F = Fighter altitude
- V_M = Missile velocity
- V_F = Fighter velocity
- V_T = Target velocity
- λ_m = Missile lead angle

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In addition the following parameters are of interest:

- $\dot{R}_{F-M}$ = Fighter to missile range rate
- $\dot{R}_{M-T}$ = Missile to target range rate
- $\dot{R}_{F-T}$ = Fighter to target range rate
- λ_a = Missile antenna azimuth gimbal angle
- λ_e = Missile antenna elevation gimbal angle
- ω_k = Missile azimuth line of sight rate
- ω_j = Missile elevation line of sight rate
- ϵ_a = Missile seeker azimuth look-angle error
- ϵ_e = Missile seeker elevation look-angle error
- α = Missile angle of attack
- ϕ' = Missile roll angle
- ϕ'' = Fighter roll angle
- $\Delta\tau$ = Total missile wing movement
- Δy = Deflection of missile yaw wings
- Δp = Deflection of missile pitch wings

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MISSILE PARAMETER INVESTIGATION

The results of missile miss distance analyses have been detailed in preceeding volumes (ref. 7, 9, and 11). Particular missile runs (flights) which have been selected from the many used to get these miss distances, will be investigated in terms of missile parameter variations. These parameters are discussed in detail in the following sections.

Table II gives the conditions at missile launch for the fighter courses to be used in this investigation. Two fighter courses were selected for co-altitude attack with the unimproved Sp III 6a missile, two for pull-up attacks with the unimproved Sp III 6a missile and two for pull-up attacks with the improved Sp III 6a missile. The first column of Table II gives the box in the detection and probability grid (see fig. 2 of Vol. XI) from which the intercept runs originated. For the co-altitude samples boxes G-3 and D-1 were used. For the other two cases boxes E-1 and C-5 were used. The second column of this table gives the launch range condition. For the samples presented here all launches were at maximum aerodynamic range (R_{max}). The next three columns give the X, Y, Z components of range to the target at launch. The next column gives the launch altitude of the interceptor aircraft. Columns 7 and 8 give the azimuth (E_{az}) and elevation (E_{el}) components of the steering error at missile launch. The final two columns give interceptor and target velocities at missile launch.

The following sections will discuss each of the two groups of runs for the three tactical situations given on Table II separately starting with the co-altitude attacks. Missile miss distances will be described first. This will be followed by a discussion of missile limits encountered during the flight. Finally a set of typical parameter plots will be presented.

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TABLE II INITIAL CONDITIONS AT MISSILE LAUNCH

CO-ALTITUDE ATTACKS UNIMPROVED SP III 6a MISSILE

Fighter Course	Launch Range Ft	Rx Ft	Ry Ft	Rz Ft	Launch Alt. Ft	Steering Error		Vf Ft/Sec	Vt Ft/Sec
						EAZ Deg	EEL Deg		
G-3	Rmax 32,744	31,340	-9,022	0	50,000	-3.40	9.97	1784	2005
D-1	Rmax 32,850	3,818	32,640	0	50,000	-0.014	0.241	1921	2005

INITIAL CONDITIONS AT MISSILE LAUNCH

PULL-UP ATTACKS UNIMPROVED SP III 6a MISSILE

Fighter Course	Launch Range Ft	Rx Ft	Ry Ft	Rz Ft	Launch Alt. Ft	Steering Error		Vf Ft/Sec	Vt Ft/Sec
						EAZ Deg	EEL Deg		
E-1	Rmax 30,702	20,140	16,980	-15,760	49,236	-6.058	8.747	1776	1937
C-5	Rmax 37,179	34,540	10,650	-8,699	56,301	-0.011	0.074	1658	1937

INITIAL CONDITIONS AT MISSILE LAUNCH

PULL-UP ATTACKS IMPROVED SP III 6a MISSILE

Fighter Course	Launch Range Ft	Rx Ft	Ry Ft	Rz Ft	Launch Alt. Ft.	Steering Error		Vf Ft/Sec	Vt Ft/Sec
						EAZ Deg	EEL Deg		
E-1	Rmax 30,554	19,890	16,980	-15,800	49,200	-4.743	7.064	1777	1937
C-5	Rmax 37,142	34,490	10,680	-8,722	56,278	-0.008	0.505	1667	1937

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Co-Altitude Attacks - Unimproved Missile

The missile miss distance results for the first co-altitude attack, given in Table II are shown on figures 4a thru 4c. For this case (79) the initial target aspect angle (angle with respect to the targets nose at the beginning of the interceptor run) is 15° . The box in the detection probability grid from which the run started is G-3. The fighter to target speed ratio, $V_F/V_T = 1.0$ and $V_T = M 2.0$. The altitude of the attack is 50,000 feet. These three figures present X - Y; X - Z and Y - Z projections of miss distance with respect to the geometrical center of the B-47 size target. On these figures the miss distances for 10 noise samples (shown by numbered circles) were investigated. The simulation was instrumented such that each of the 10 points on the same noise distribution could be selected as starting points for the missile launch and guidance investigation. As an example of how to interpret these figures referring to figure 4a the closest point of missile approach to the target in the X - Y phase for the run of noise sample 9 is approximately 6 feet in the X direction and 48 feet in the Y direction. The mean miss distance for the 10 noise samples examined is given by the solid square.

The missile limits encountered for this same situation are given on Table III. The first column on this table gives the noise sample involved. The second column gives the radial miss distance at the target. As an example, see noise sample 2. Radial missile miss distance was 70.57 ft. The third column gives missile time of flight. This is the time from launch to the time when the missile impacts with or passes the target. The times that the missile encountered "g" limits; (fixed limit in the autopilot - see Fig. 1) are given by the next column. The limiting value for the missile is 13.8 g's as an example referring to noise sample 8, it is seen that "g" limits were encountered at 2.8 seconds after launch. From this time until 6.8 seconds the missile flight path demanded less than the limiting "g's", at 6.8 seconds after launch "g" limits were encountered again and the missile rode the limit until the end of the flight. In those cases when an asterisk is used, it denotes the end of the missile flight.

The next column on Table III gives the times that missile seeker antenna gimbal limits were encountered. Gimbal limits of $\pm 46^\circ$ are mechanized. As shown on Table III, missile gimbal limits were not a problem.

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TABLE III
MISSILE LIMITS ENCOUNTERED
CO-ALTITUDE ATTACKS - R_{MAX} LAUNCH

V_T = 2005
V_F = 1783.8
T₀ = 15°
H_T = 50,000
H_F = 50,000
Box No. - G-3

Noise Sample	Miss (Ft)	(Sec)	TIME OF MISSILE LIMIT OCCURRENCE (SEC)		
			"g" Limit	Missile Gimbal Limit	Wing Deflection Limit
1	44.46	7.134	(4.4) (6.8-*)		(0.4-0.6) (7.0-*)
2	70.57	7.165	(3.0) (5.6-5.8) (6.2) (7.0-*)		(0.4-0.6) (5.6)
3	33.65	7.137	(2.8) (7.0-*)		(0.4-0.6) (7.0-*)
4	21.63	7.128	(6.0) (*)		(0.4-0.6) (7.0-*)
5	58.52	7.141	(5.0)		(0.4-0.6) (*)
6	5.90	7.134	(3.6) ((4.8) (5.2) (6.4) (7.0-*)		(0.4-0.6)
7	12.16	7.136	(6.6)		(0.4-0.6) (2.6) (*)
8	59.77	7.141	(2.8) (6.8-*)		(0.4-0.6) (7.0-*)
9	49.21	7.134	(5.8) (7.0-*)		(0.4-0.6)
10	10.03	7.139	(7.0-*)		(0.4-0.6)

*End of Missile Flight

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As shown on figure 1, the missile mechanization includes a $\pm 20^\circ$ wing (control surface) deflection limit. Thus it is of interest to investigate how often this limit was encountered on the simulated flights. The final column on Table III lists the times that these limits were encountered. It is interesting to note that on each case, limits were encountered at launch. Also in most cases the limits were encountered near the end of the run indicating that maximum maneuver was demanded.

From the runs associated with the miss distances described above, one run (noise sample 8) was selected and pertinent parameter variations were plotted. Figures 4d thru 4z give these parameter plots. The geometrical quantities plotted have been defined previously. A short discussion of each plot follows. Figure 4d shows the fighter to missile range (R_{F-M}) as a function of time. As is shown, after the initial missile acceleration period of approximately 2 seconds, the range variation is linear. The missile to target range (R_{M-T}) as a function of time is shown on figure 4e. Except for the slight curvature at the start of the missile flight (missile acceleration) the result is a straight line variation. Fighter to target range (R_{F-T}) is shown on figure 4f. The corresponding range rates are shown on figures 4g through 4i. Referring to 4g and 4h we see that the fighter to missile range rate ($\dot{R}_{F-M}$) and the missile to target range rate ($\dot{R}_{M-T}$) build up rapidly during the acceleration period of the missile and then gradual decay during the glide phase of the missile flight. The gradual change in fighter to target range rate ($\dot{R}_{F-T}$) shown on figure 4i is that associated with the lead pursuit course flown by the fighter.

The azimuth (λ_a) and elevation (λ_e) gimbal angles as a function of time are shown on figures 4j and 4k. The perturbations in the curves are due to system noises (launching transients, target noise, radome noise). As stated in the discussion of Table III, gimbal angle limits ($\pm 45^\circ$) are not encountered. The missile lead angle (λ_m) as a function of time is shown on figure 4l. Again the random variation is caused by noise. The azimuth (ω_a) and elevation (ω_e) missile antenna line of sight rates are shown on figure 4m and 4r. The same random variation occurs.

Missile velocity (V_m) as a function of time is shown on figure 4v. During the acceleration period of the missile flight, this velocity builds up from the launch velocity (interceptor velocity) and then gradually decays during the glide phase. The azimuth and elevation look-angle errors (ξ_a and ξ_e) for the missile are shown by the curves of figures 4p and 4q. Again, the perturbations are due to system noise. The missile angle of attack (α) as a function of time is shown on figure 4r. The angle of attack decays immediately after launch and then builds up rapidly to a peak of approximately 13° in the vicinity of one second. During the major portion of the flight, angle of attack

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is influenced by system noise as shown by the oscillations. Near the end of the flight, angle of attack builds up rapidly again.

Missile (ϕ') and fighter (ϕ'') roll angles versus time are shown on figure 4s. At launch the roll angles, as expected, are the same. After launch the missile is rolled through 45° . This is reflected in the curves.

The g's commanded in the plane of the pitch and azimuth wings are given by figures 4f and 4u. In the early phases of the study of the unimproved missile mechanization the missile was limited to 13.8 g's or less. Referring to figure 4t it is seen that g limits are encountered at 2.8 seconds and again at 6.8 seconds to the end of the run.

Figures 4v and 4w show the commanded wing deflections on the pitch and azimuth wings. Mechanized wing deflection limits are $\pm 20^\circ$. Referring to these figures we see that limits are encountered at 0.4 to 0.6 seconds and again at 7.0 seconds to the end of the run.

The actual wing deflections are shown on figures 4x and 4y. Comparing these figures to figures 4t thru 4w one can get a complete history of commands, limits and responses. For example, we would expect the actual wing deflections to be high from 7 seconds to the end of the run since limiting deflections ($\pm 20^\circ$) are commanded. However at this time the missile is also g limited. Thus limiting wing deflections are not encountered.

Total wing movement ($\Delta\tau$) is shown on figure 4z. For this particular flight the plot of wing movement is essentially a linear function. This summation of wing movement can now be translated directly into oil consumption.

Another sample of co-altitude data resulting from use of the unimproved missile, is given by figures 5a, b, and c, Table IV and figures 5d through 5z. This group of data corresponds to the second family on Table II. The initial conditions are:

$$H_F = 50,000 \text{ ft.}$$

$$V_T = M 2.0$$

$$\frac{V_F}{V_T} = 1.0$$

$$\gamma_0 = 15^\circ$$

$$\text{Box} = G-3$$

$$R_{\text{max Launch}}$$

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TABLE IV

MISSILE LIMITS ENCOUNTERED

CO-ALTITUDE ATTACKS - R_{MAX} LAUNCH

$V_T = 2005 \text{ Ft/Sec}$ $H_T = 50,000$
 $V_F = 1920.9 \text{ Ft/Sec}$ $H_F = 50,000$
 $\gamma = 60^\circ$ Box No. - D-1

Noise Sample	Miss (Ft)	t_f (Sec)	TIME OF MISSILE LIMIT OCCURRENCE (SEC)		
			"g" Limit	Missile Gimbal Limit	Wing Deflection Limit
1	26.88	14.136	(13.0) (13.8)	(13.0) (13.8)	(0.6) (*)
2	73.61	14.206	(13.8-*)	(11.6) (12.2) (13.6)	(0.6) (12.8) (14.2-*)
3	15.72	14.166	(14.0-*)	(13.2) (13.6-13.8) (*)	(0.6)
4	46.89	14.134	(13.8-*)		(0.6)
5	31.47	14.178	(13.4-13.6) (14.0-*)	(13.2) (13.6)	(0.6) (14.0-*)
6	29.92	14.131	(13.4) (14.0-*)	(12.2) (13.2) (13.6) (14.0)	(0.6) (14.0-*)
7	39.24	14.237	(14.0) (*)	(12.6) (13.6-13.8)	(0.6) (14-*)
8	53.67	14.225	(12.8-13.0) (13.6) (14.2-*)	(12.8) (13.4) (13.8)	(0.5) (13.2) (14.2-*)
9	23.68	14.167	(*)	(13.2) (13.6) (14.0)	(0.6)
10	38.37	14.187	(14.0-*)	(13.6)	(0.6) (*)
No Noise	2.17	14.066	(*)	(14.0)	(0.6)
					*End of Missile Flight

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One difference in results from those presented for the previous case is that a no noise sample was also run. This is shown by the black circle on figures 5a through 5c. The term "no noise" applies only to the missile flight portion of the run. Target noise only is neglected.

Pull-up Attack - Unimproved Missile

The second group of runs given on Table II are those resulting from using the unimproved Sp III missile in pull-up attacks. Miss distance results, limits encountered and parameter plots for these pull-up attacks are given by figures 6a through 6zz, Table V, figures 7a through 7zz, and Table VI. A brief description of the first of these two groups of results is given in the following sections.

The miss distance results for the tan noise samples are plotted on figures 6a through 6c. The mean miss distance is shown by a "■". The no noise results are shown by the "●". The initial aspect angle (θ_0) at AI radar detection is 0° . The fighter course started in box C-5 of the probability grid. $\frac{V_F}{V_T} = 1.0$ where $V_T = M 2.0$. Target altitude is 65,000 feet. $\frac{V_F}{V_T}$ Fighter altitude at the beginning of the pull-up maneuver is 50,000 feet. The missile is launched at R_{max} .

Missile limits encountered are given on Table V. As in the case of the co-altitude flights described previously, gimbal limits are not a problem. Wing deflection limits and g limits are encountered in most of the runs. Referring to the second column on this table, it is seen that in general, miss distances are large.

The range relationships between fighter, target and missile vary linearly with time after the boost phase of the missile is completed as shown on figures 6d, 6e and 6f. The fighter to missile range rate is shown by figure 6g. After missile boost the range rate stays constant. This is due to the fact that the missile is gradually slowing down and so is the fighter while in the pull-up maneuver. Missile to target range rate is shown by figure 6h. As expected the range rate peaks up at end of boost and gradually decays as the missile slows down. The curve for fighter to target range rate given on figure 6i is the result of the pull-up; lead pursuit maneuver.

The antenna gimbal angles are shown by figures 6j and 6k. Missile lead angle is shown by figure 6l. The line of sight rates are shown by figures 6m and 6r. The perturbations are due to system noise.

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TABLE V
MISSILE LIMITS ENCOUNTERED

PULL-UP ATTACKS - R_{MAX} LAUNCH

$V_T = 1937$ Ft./Sec $H_T = 65,000$ Ft.
 $V_F = 2005$ Ft. $H_F = 50,000$ Ft.
 $\tau_0 = 0.0$ Box No. = C-5

Noise Sample	Miss (Ft)	τ_f (Sec)	TIME OF MISSILE LIMIT OCCURRENCE (SEC)		
			"g" Limit	Missile Gimbal Limit	Wing Deflection Limit
1	44.5	8.508	(7.0) (7.4-*)		(8.2-*)
2	50.3	8.540	(6.6-7.6) (8.0-*)		(7.2-7.6) (8.4-*)
3	162.8	8.500	(6.4) (7.2) (7.6-*)		(7.8-*)
4	81.7	8.508	(7.2-7.4) (8.2-*)		(8.4-*)
5	102.3	8.500	(7.6-*)		(7.6-*)
6	47.1	8.515	(6.8-7.0) (7.4-*)		(7.0) (*)
7	120.7	8.535	(7.2-*)		(7.2-7.6)
8	37.1	8.525	(5.4) (7.4-*)		
9	44.7	8.491	(6.4) (7.2) (7.8-*)		(8.2-*)
10	18.7	8.516	(7.4-7.8) (8.4-*)		(7.4-7.8)
No Noise	4.7	8.490	(8.2-*)		(8.2-*)
*End of Missile Flight					

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TABLE VI
MISSILE LIMITS ENCOUNTERED
PULL-UP ATTACKS - R_{MAX} LAUNCH

$V_T = 1937 \text{ Ft/Sec}$ $H_T = 65,000 \text{ Ft.}$
 $V_F = 2034 \text{ Ft/Sec}$ $H_F = 40,000 \text{ Ft.}$
 $T_o = 450$ BOX NO. = E-1

Noise Sample	Miss (Ft)	t_f (Sec)	TIME OF MISSILE LIMIT OCCURANCE (SEC)		
			"g" Limit	Missile Gimbal Limit	Wing Deflection Limit
1	60.1	8.723	(7.6), (8.0-*)		(0.6), (7.8), (8.2-*)
2	94.1	8.776	(7.4), (8.0)		(0.6)
3	101.5	8.708	(7.6-*)		(0.6)
4	101.3	8.722	(7.6-*)		(0.6), (7.8)
5	77.2	8.718	(8.0-*)		(0.6), (8.6-*)
6	52.6	8.720	(8.0-*)		(0.6), (7.8), (8.2-*)
7	83.6	8.732	(7.0), (7.4), (7.8-*)		(0.6), (7.4-*)
8	52.4	8.724	(2.8), (8.4-*)		(0.6), (8.6-*)
9	69.4	8.725	(7.8-*)		(0.6), (8.2-*)
10	42.9	8.724	(7.8-*)		(0.6), (7.8)
No Noise	38.1	8.720	(8.2-*)		(0.6), (8.6-*) *End of Missile Flight

CONFIDENTIAL

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Missile velocity as a function of time is shown by the curve of figure 6o. The velocity history is as expected. It peaks up at end of missile boost and gradually decays during the rest of the flight.

Azimuth and elevation look-angle errors for the missile seeker are shown on figures 6p and 6q. These errors are essentially zero until the end of the run. The missile angle of attack time history of figure 6r shows many perturbations. These are due to systems noise. Missile and fighter roll angles are shown on figure 6s. The missile rolls the programmed (approx. 45°) roll angle during the early stages of the flight and continues at that angle. The fighter roll angle is that required by the pull-up; lead pursuit course.

Figures 6t thru 6y give commanded pitch and yaw g's; commanded pitch and yaw wing deflections; and actual pitch and yaw wing deflections.

Total wing movement as a function of time is shown by figure 6z. This is essentially a linear function.

Missile altitude versus time is shown on figure 6zz. For this particular case the missile rate of climb is essentially constant throughout the run.

Figures 7a through 7zz give another group of runs for the unimproved Sp III missile when used in pull-up attacks. Uses of the parameter plots and the tables are the same as described above for figures 6a through 6zz.

PULL-UP ATTACKS - IMPROVED MISSILE

The third "groups" of runs listed on Table II are those resulting from using the improved Sp III missile in pull-up attacks. The differences between the unimproved and improved missiles are detailed in the section of inputs as shown on page 3.

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Table II lists the initial conditions for the two families of pull-up runs investigated for the improved Sp III missile. The same two sets of initial conditions were used as described previously for the unimproved situation in order that a comparison of results could be made. Such a comparison has been described in detail in ref. 12. In general, referring to figures 8a thru 8c, 9a thru 9c and Tables VII and VIII, it is seen that the miss distances achieved for the improved missile are smaller than those realized for the unimproved missile. However, for the two cases given here there isn't a major improvement. The parameter plots given by figures 8d thru 8zz and 9j thru 9zz follow the same order as described for the preceding cases. The use of each is the same as that described previously.

ERROR IN V_o

Table IX gives the results of an investigation conducted to determine the error in computed V_o (average incremental missile velocity). Since V_o is used directly or indirectly in launch equation and steering computation, accuracy is important. On Table IX the launch conditions are repeated for each of the six families investigated. Under the heading of "Missile Simulation Results", there are four columns. The next column gives (V_o) the actual average incremental velocity between missile and launching aircraft. The next column gives the computed value of V_o . The error between actual and computed in percent is given by the last column. In general, for the cases presented here, the error is small.

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MISSILE LIMITS ENCOUNTERED
PULL-UP AT ACKC IMPROVED MISSILE) P MAX LAUNCH

TABLE VII

$V_T = 1937 \text{ Ft/Sec}$ $H_T = 65,000 \text{ Ft.}$
 $V_F = 2005 \text{ Ft/Sec}$ $H_F = 10,000 \text{ Ft.}$
 $\gamma = 0^\circ$ BOX NO. = 0-5

Noise Sample	Miss (Ft)	t_f (Sec)	TIME OF MISSILE LIMIT OCCURRENCE (SEC)		
			"g" Limit	Missile Gmbal Limit	Wing Deflection Limit
1	13.7	8.165	(2.8), (3.8-4.0), (4.4), (5.8), (6.8-7.0), (7.4-*)		(7.7), (7.5-7.8)
2	32.5	8.193	(2.6), (3.4), (5.0), (5.6-5.8), (6.4-6.8), (7.2-*)		(7.8), (7.4-7.6)
3	103.9	8.152	(6.0), (6.4), (7.2-*)		(7.8-*)
4	84.1	8.160	(2.8), (3.2-3.4), (6.2), (7.0-7.2), (7.6-*)		(7.8-*)
5	31.2	8.163	(5.8), (6.2), (6.6), (7.4-*)		(5.8), (7.4-7.6)
6	13.3	8.183	(2.6), (3.8-4.0), (6.4-7.0), (7.4-*)		(6.6-7.0)
7	46.1	8.191	(4.0-4.2), (5.8), (7.0-*)		(7.2) (*)
8	43.7	8.181	(2.8-3.0), (3.6), (4.0-4.2), (5.4), (7.4-*)		(4.2), (8.0)
9	27.6	8.151	(4.0), (4.8), (5.4), (6.2-6.4), (7.2), (7.6-*)		(4.2)
10	7.3	8.180	(4.2-4.4), (6.2), (7.4-*)		(4.4), (5.4), (6.2), (7.4-7.6)
No Noise	20.7	8.147	(8.0-*)		(7.8-*)

*End of Missile Flight

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MISSILE LIMITS ENCOUNTERED
PULL-UP ATTACKS - (IMPROVED MISSILE) R_{MAX} LAUNCHED

TABLE VIII

$V_T = 1937$ Ft/Sec $H_T = 65,000$ Ft.
 $V_F = 2034$ Ft/Sec $H_F = 40,000$ Ft.
 $\gamma_0 = 450$ BOX NO. = E-1

Noise Sample	Miss (Ft)	t_f (Sec)	TIME OF MISSILE LIMIT OCCURRENCE (SEC)		
			"g" Limit	Missile Gimbal Limit	Wing Deflection Limit
1	62.2	8.255	(4.0), (5.8), (7.0), (7.4-*)		(7.0), (7.6-*)
2	96.8	8.314	(2.6), (5.0), (6.4-6.8) (7.4-*)		(5.4), (5.8)
3	95.9	8.240	(7.0), (7.4-*)		(8.0)
4	88.7	8.252	(4.0), (6.8), (7.4-*)		(6.8)
5	95.1	8.252	(4.0), (5.0), (5.8), (7.2-*)		(7.4), (7.8)
6	43.5	8.250	(2.6), (3.8), (7.0), (7.4-*)		(8.0-*)
7	73.9	8.262	(3.2), (7.0-*)		(7.2-*)
8	51.4	8.251	(2.8), (4.4), (5.4), (6.8-7.0), (8.0-*)		(6.8), (8.0)
9	94.5	8.247	(3.2), (4.2), (6.2-6.4), (7.4-*)		(8.2-*)
10	43.2	8.257	(4.2), (4.6), (7.6-*)		(7.6-7.8), (8.2-*)
No Noise	38.7	8.243	(8.0-*)		(*) *End of Missile Flight

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TABLE IX CO-ALTITUDE ATTACKS

LAUNCH CONDITIONS				MISSILE SIMULATION RESULTS						
Target Altitude H_T ($\text{ft} \times 10^3$)	Target Speed V_T (ft/sec)	Fighter Altitude H_F (ft)	Fighter Speed V_F (ft/sec)	Range R (ft)	Target Aspect Angle (deg)	Range Interlock Condition	Time of Flight t_f (sec)	Average Speed Relative to fighter (ft/sec)	Computed V_o (ft/sec)	Error in V_o (%)
50	2005	50,000	1920.9	32,860	83.33	R_{max}	14.166	1064.24	1090.25	-2.44
50	2005	50,000	1783.0	32,610	16.06	R_{max}	7.138	978.43	1090.25	-21.19

PULL-UP ATTACKS (UNIMPROVED MISSILE)

LAUNCH CONDITIONS				MISSILE SIMULATION RESULTS						
Target Altitude H_T (ft $\times 10^3$)	Target Speed V_T (ft/sec)	Fighter Altitude H_F (ft)	Fighter Speed V_F (ft/sec)	Range R (ft)	Target Aspect Angle (deg)	Range Interlock Condition	Time of Flight t_f (sec)	Average Speed Relative to fighter (ft/sec)	Computed V_o (ft/sec)	Error in V_o (%)
65	1937	49,236	1776.0	30,702	48.998	R_{max}	8.726	1136.74	1088.84	4.21
65	1937	56,301	1657.7	37,179	21.71	R_{max}	8.511	1112.50	1100.06	1.11

PULL-UP ATTACKS (IMPROVED MISSILE)

LAUNCH CONDITIONS				MISSILE SIMULATION RESULTS						
Target Altitude H_T (ftX10 ³)	Target Speed V_T (ft/sec)	Fighter Altitude H_F (ft)	Fighter Speed V_F (ft/sec)	Range R (ft)	Target Aspect Angle (deg)	Range Interlock Condition	Time of Flight t_f (sec)	Average Speed Relative to fighter (ft/sec)	Computed V_o (ft/sec)	Error in V_o (%)
65	1937	49,199	1776.9	30,554	49.381	R_{max}	8.256	1287.4	1264.12	1.81
65	1937	56,278	1667.3	37141.6	21.789	R_{max}	8.169	1270.0	1274.42	-0.35

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12. "Summary of Navy Study Program for F4H-1 Weapons System, Volume XIV", NRL Memo Report 754, Confidential.

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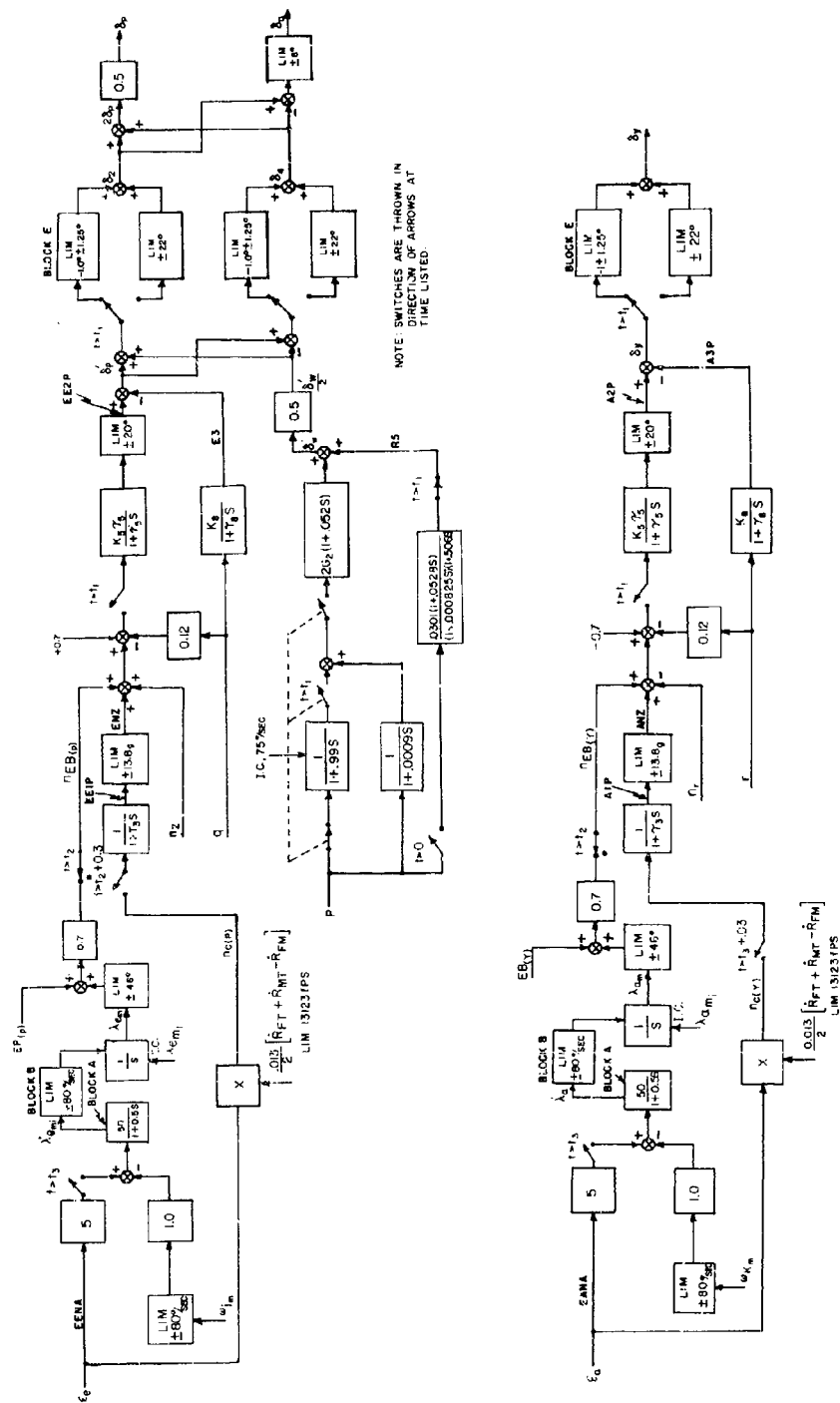
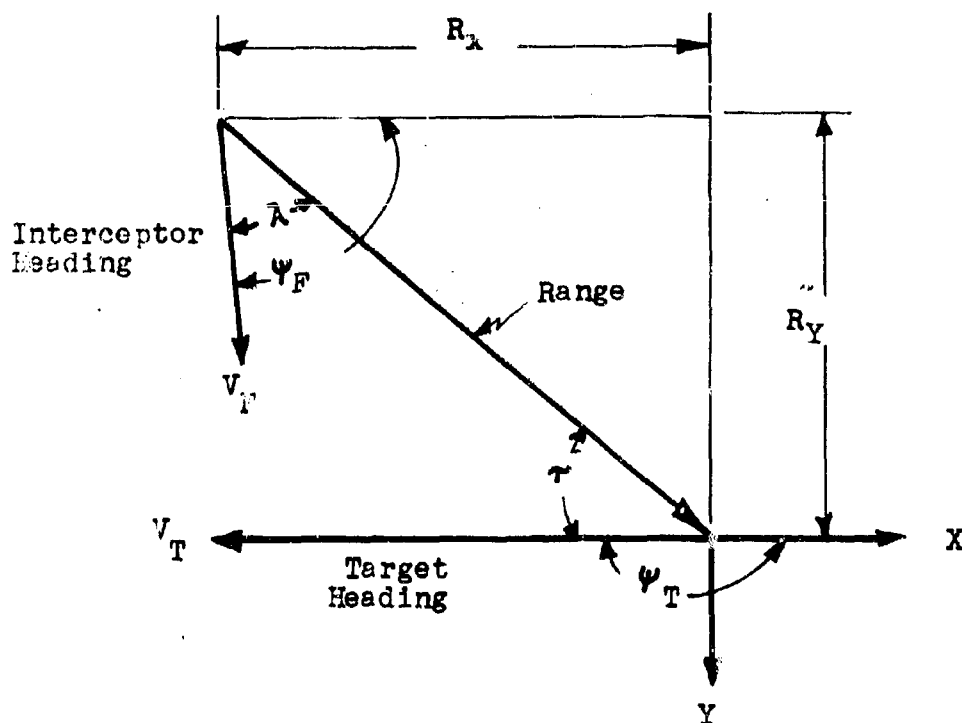


Figure 1 - Sparrow III Autopilot and Seeker Block Diagram



R = Range Vector
 X, Y, Z = Reference Axes
 R_X, R_Y, R_Z = Components of Range Along X, Y, Z
 (Z -Axis Positive Downward)
 τ = Angle off the Target Nose
 ψ_F = Eulerian Angle of Fighter Velocity
 Vector in Azimuth
 V_F = Fighter Velocity Vector
 V_T = Target Velocity Vector
 λ = Lead Angle

Fig. 2- Attack Geometry

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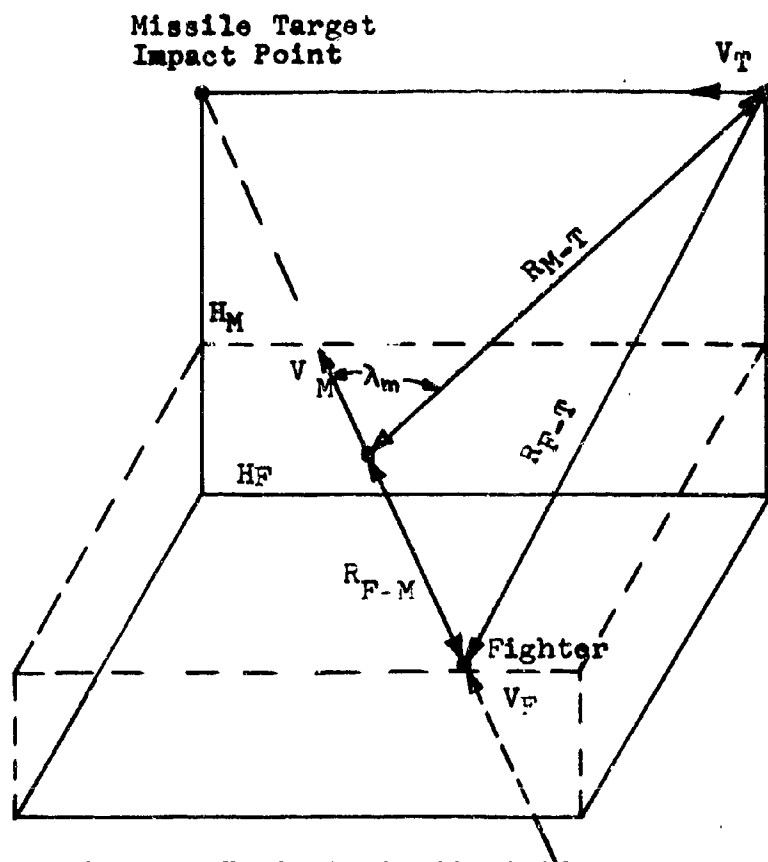
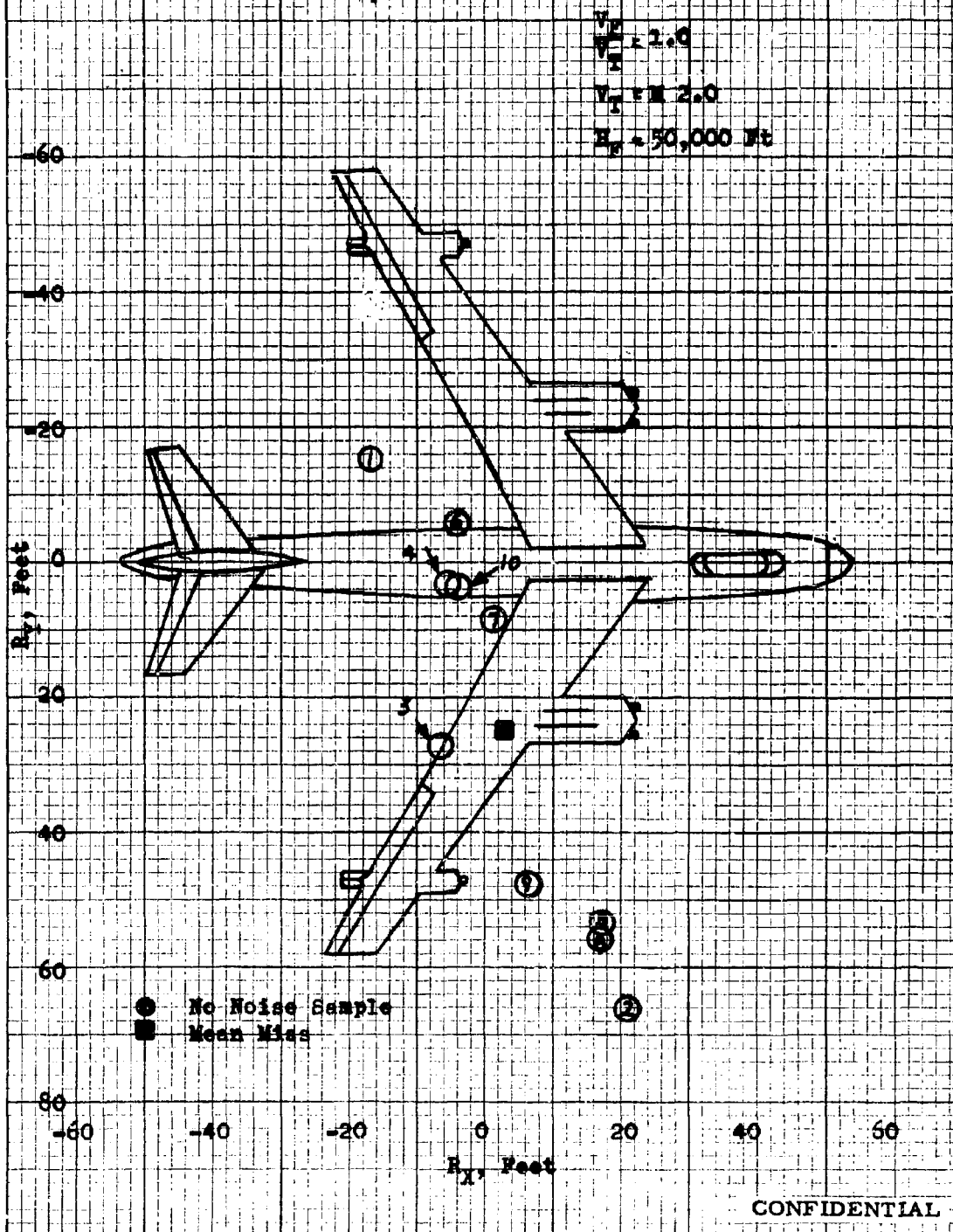


Figure 3-Typical Missile Guidance Geometry

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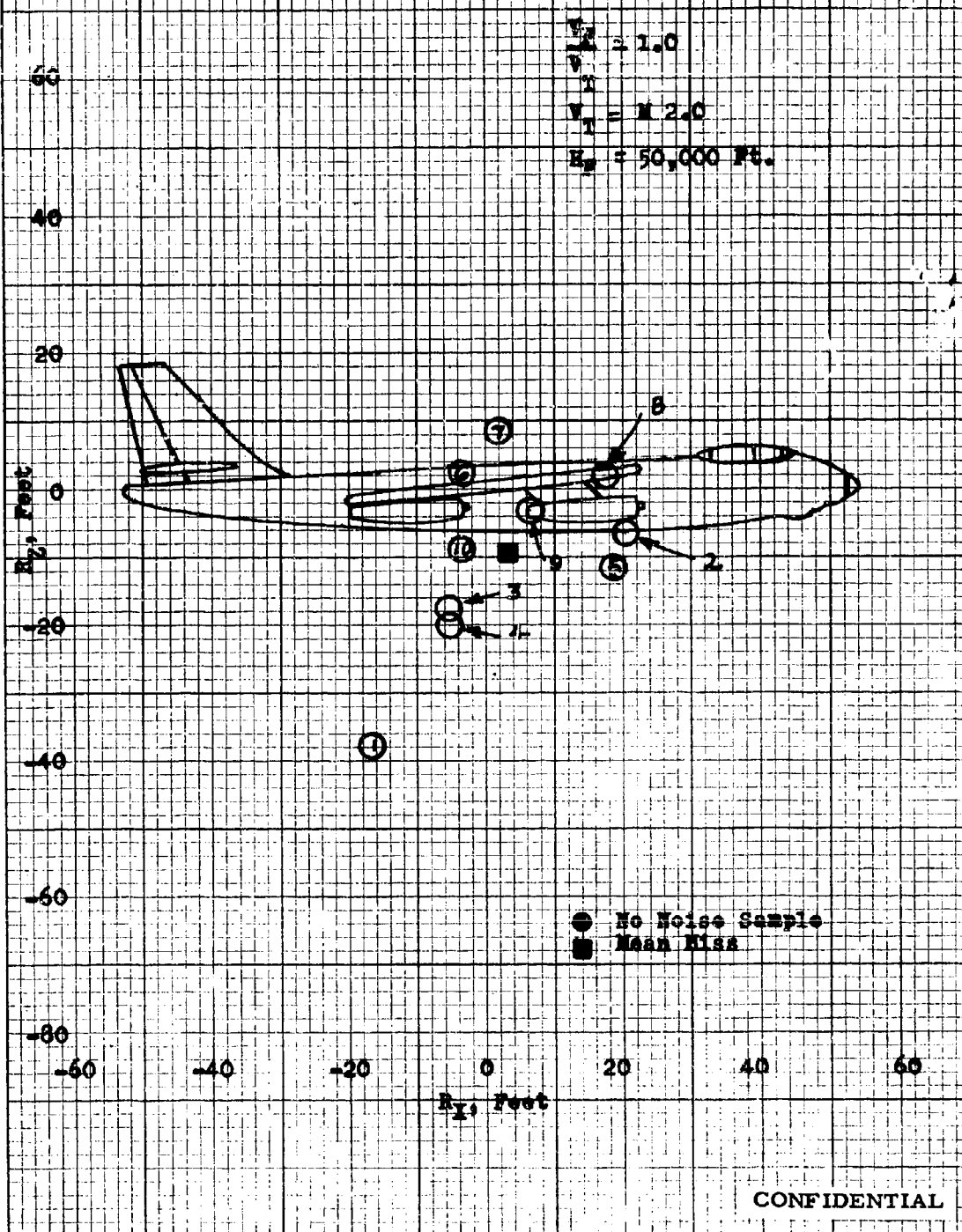
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Fig. 4a Sparrow III Miss Distance - Co-altitude Attacks
 X-Y Miss Distance at the Target
 $\gamma_0 = 15^\circ$, R_{max} Launch, Fighter Course - 8-3
 Unimproved Missile



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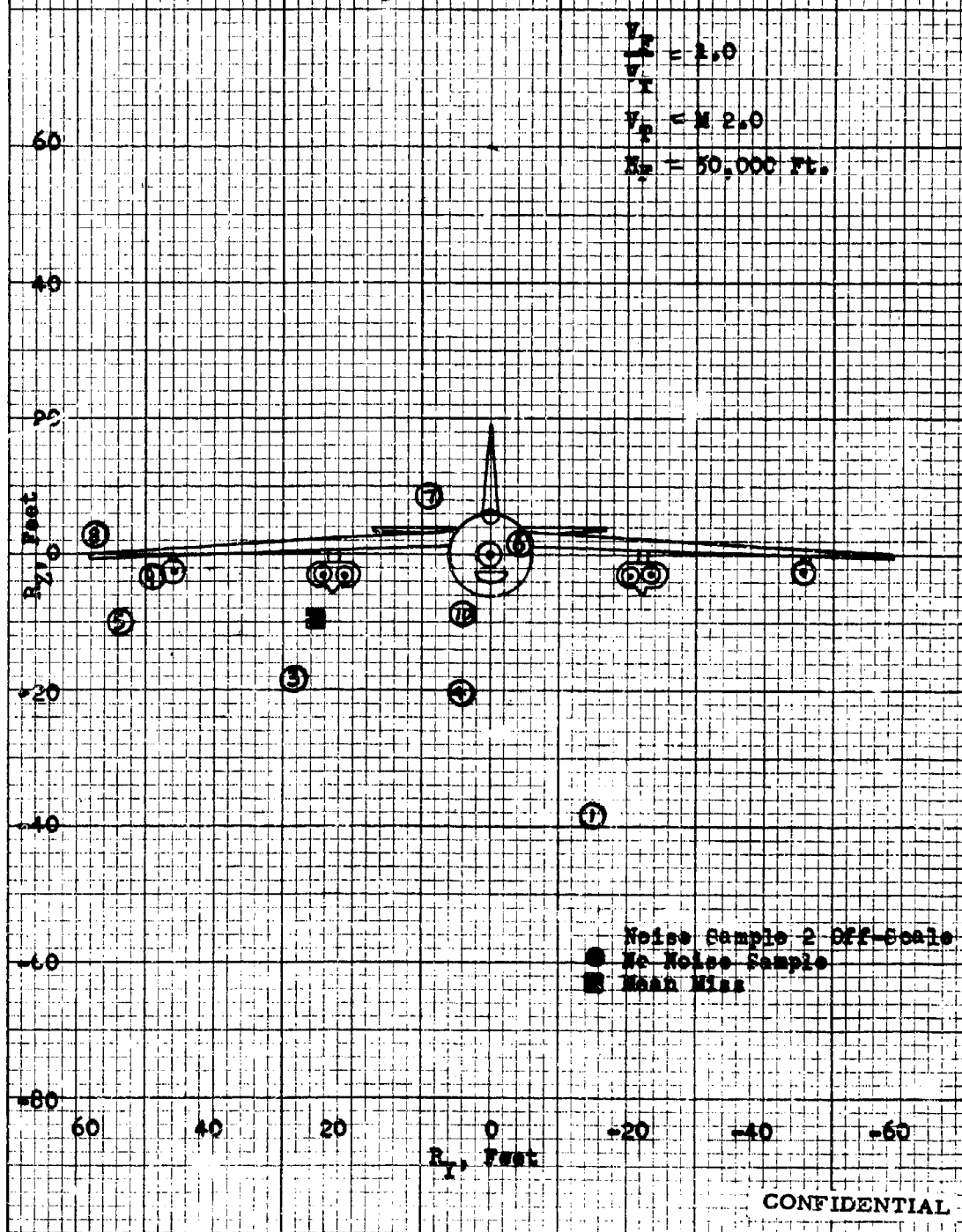
Fig. 4b Sparrow III Miss Distance - Co-altitude Attacks
X-2 Miss Distance at the Target
1-15, Rear Launch, Fighter Course - G-3
Unimproved Missile



K⁰² 10 X 10 TO THE INCH 359-50G
KEUFFEL & ESSER CO. BOSTON, U.S.A.

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Fig. 4 c- Sparrow III Miss Distance - Co altitude Attack
 X-Z Miss Distance at the Target
 $\theta_0 = 15^\circ$, R_{max} Launch, Fighter Course - G-3
 Unimproved Missile





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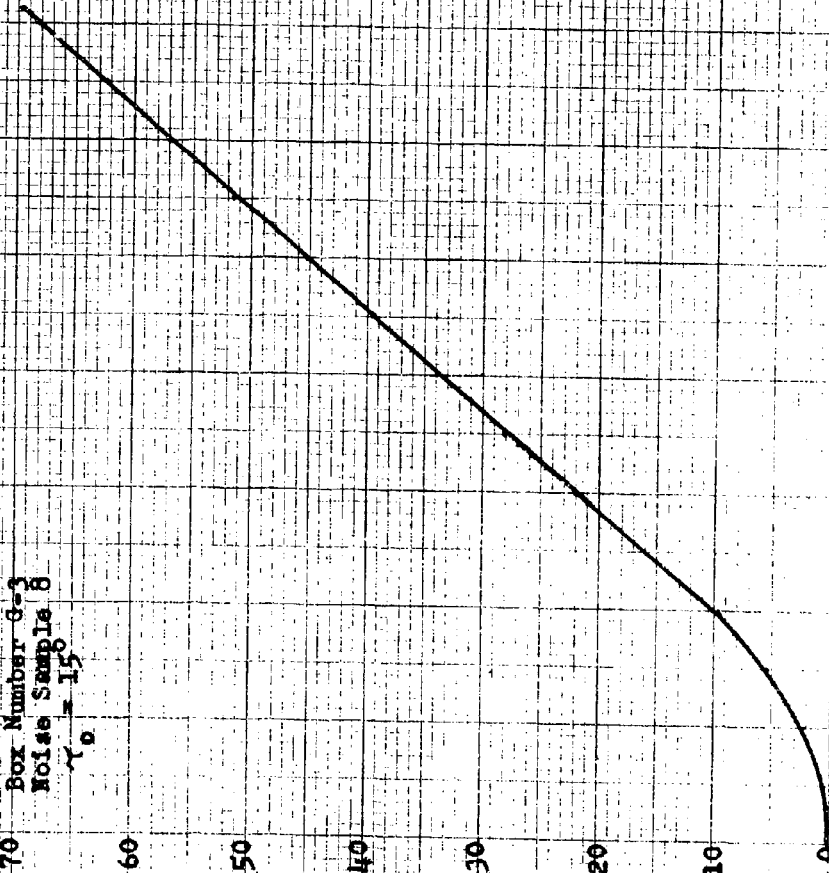
Fig. 14-Fighter to Missile Range vs Time
Go=Altitude Attacks-Unimproved Missile

Altitude 50,000 Ft.
Target Speed 2005 Ft/Sec
Fighter Speed at Launch 1783.8 Ft/Sec
Missile Launch Max

Box Number G-3
Noise Sample 8

$\gamma_0 = 15^\circ$

Fighter to Missile Range (Ft/Sec)



Time from Launch in Seconds

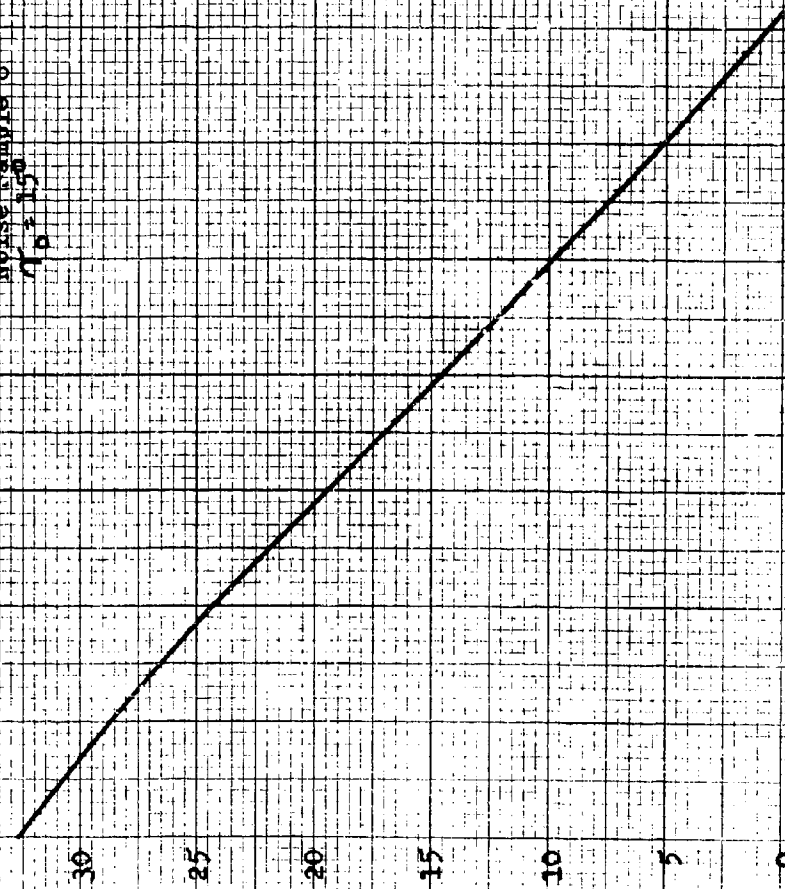
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Fig. 1a - Missile to Target Range vs Time
Co-Altitude Attacks - Unimproved Missile

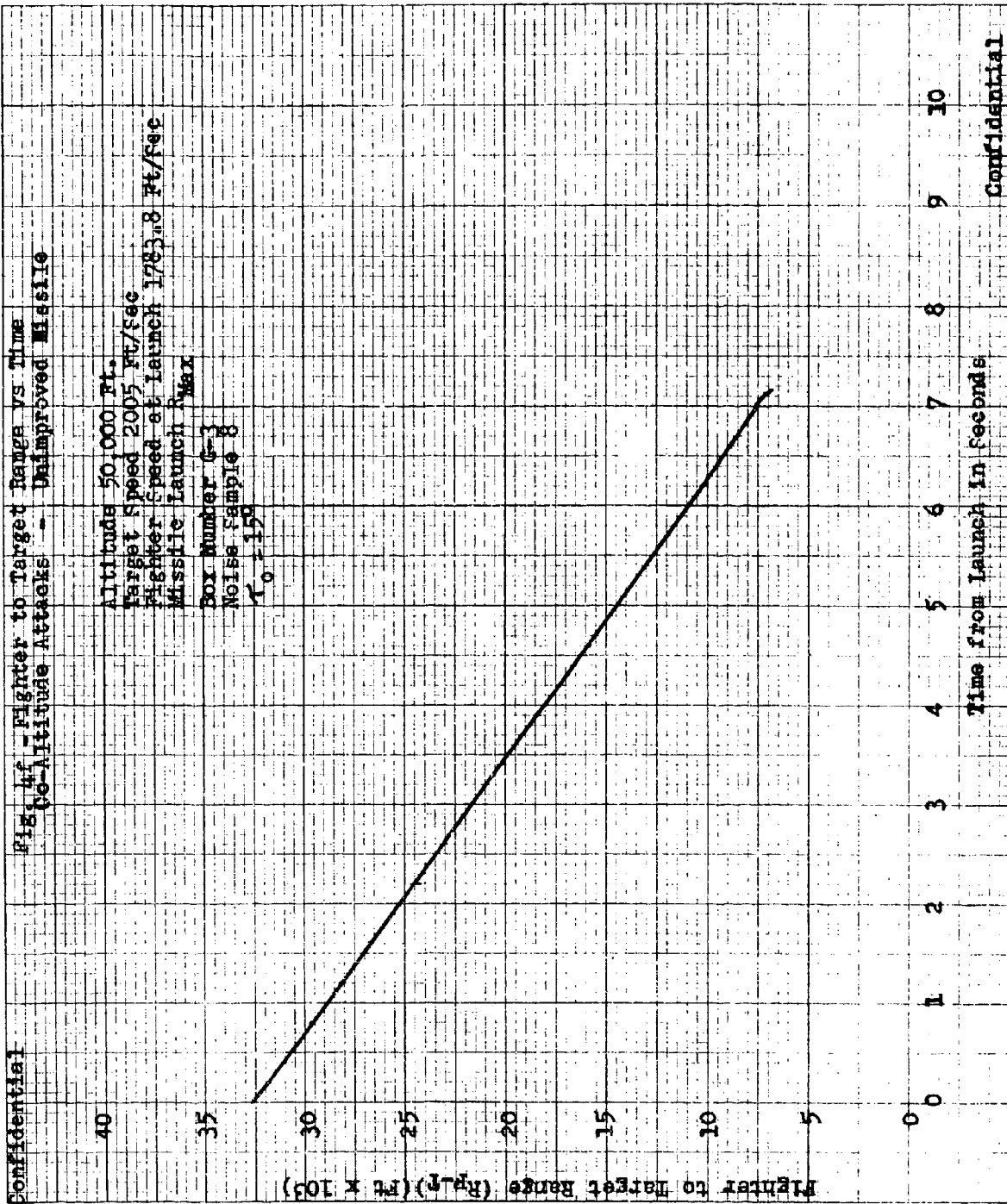
Altitude 30,000 ft.
Target Speed 2805 ft/sec
Fighter Speed at launch 1783.8 ft/sec
Missile launch Max
Box Number 0-3
Noise Sample 8
 $\Delta t = 1.5$

Missile to Target Range (R_{T-2}) (ft $\times 10^3$)



Time from Launch in Seconds

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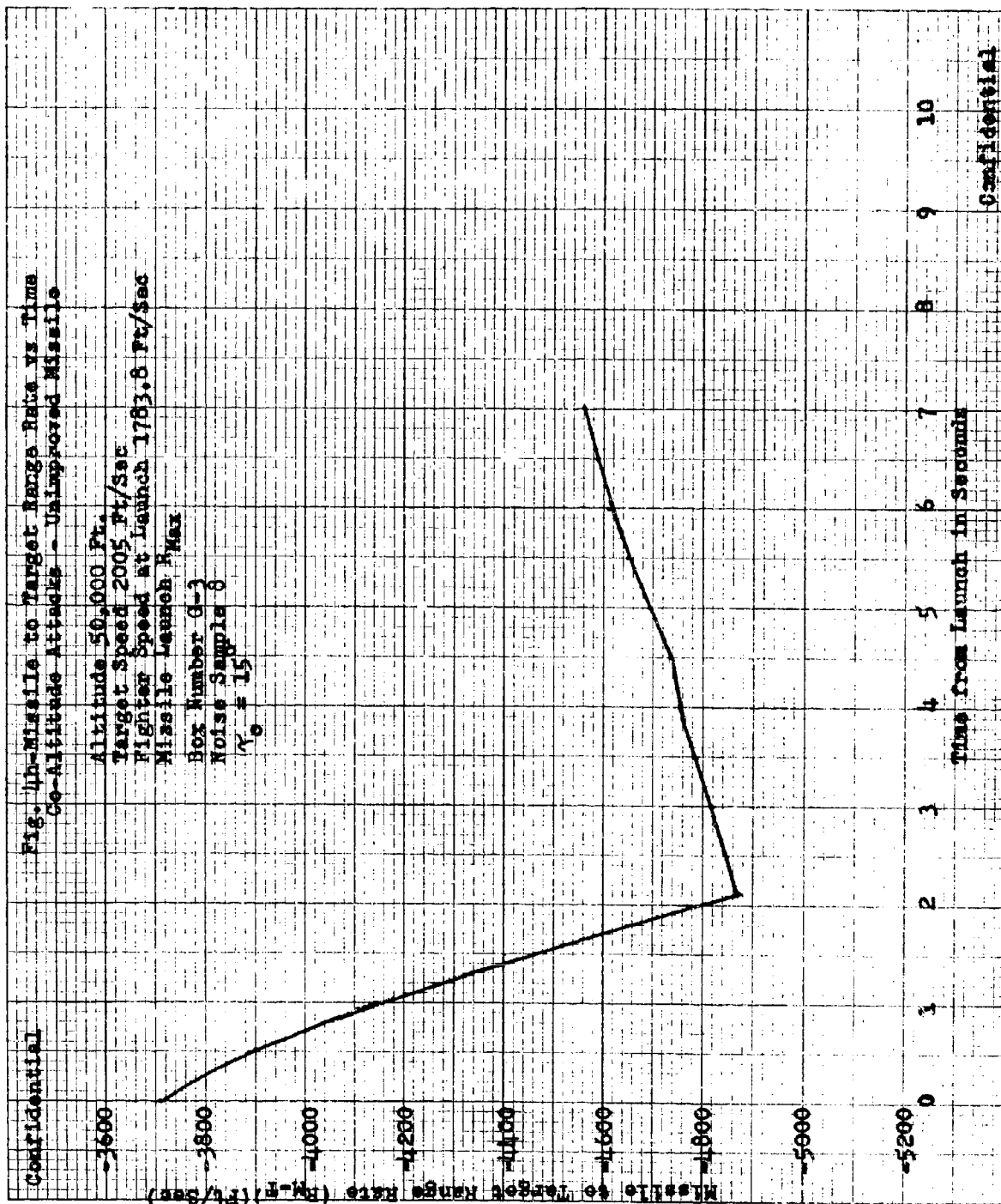
Fig. 10. Fighter to Missile Range Rate vs Time
Co-Altitude Attacks - Unimproved Missile

Altitude 50,000 Ft.
Target Speed 2005 Ft/Sec
Fighter Speed at Launch 1783.8 Ft/Sec
Missile Launch Box
Box Number 6-3
Noise Sample 8
70-1150

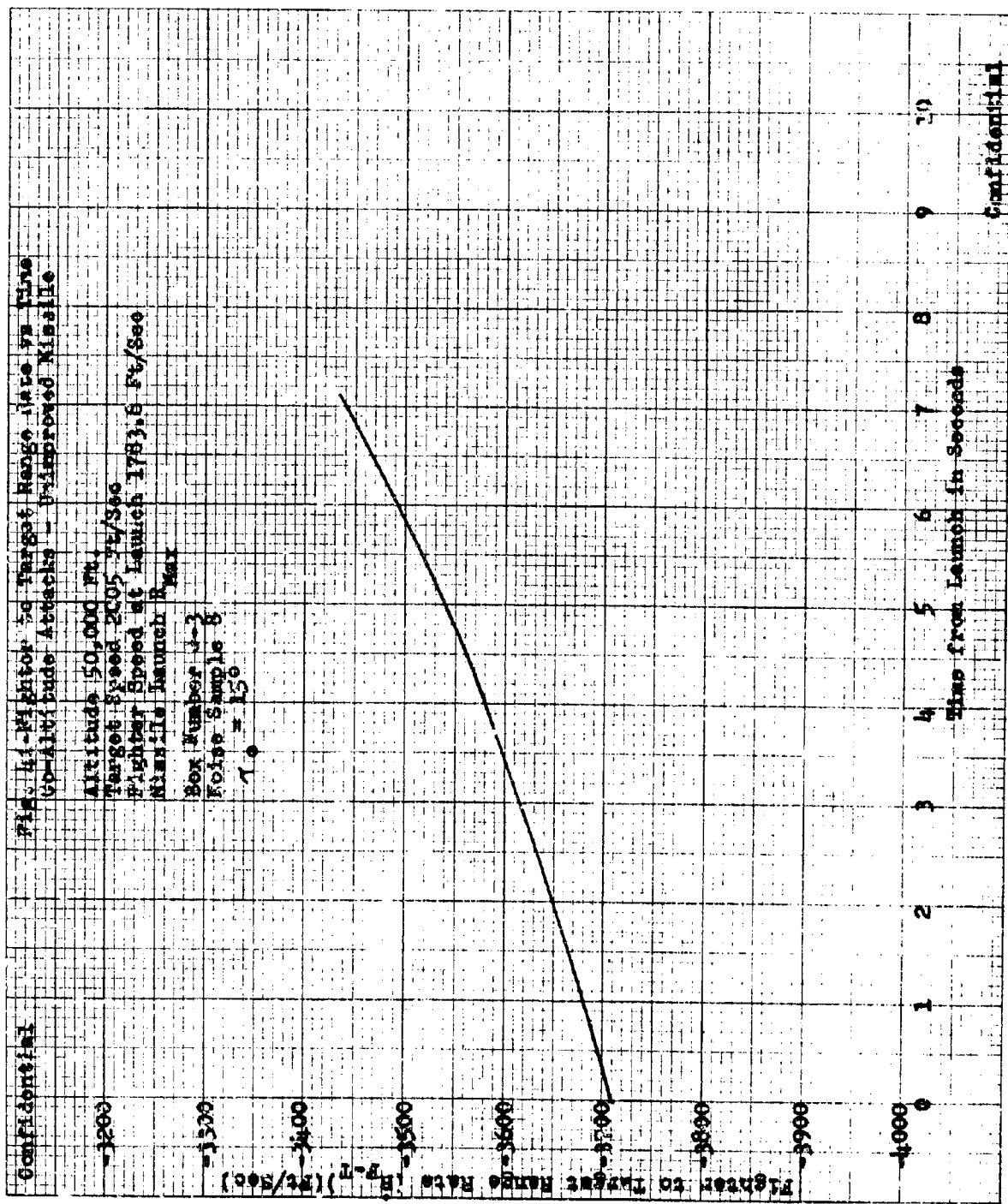
Fighter to Missile Range Rate (Ft/Sec)

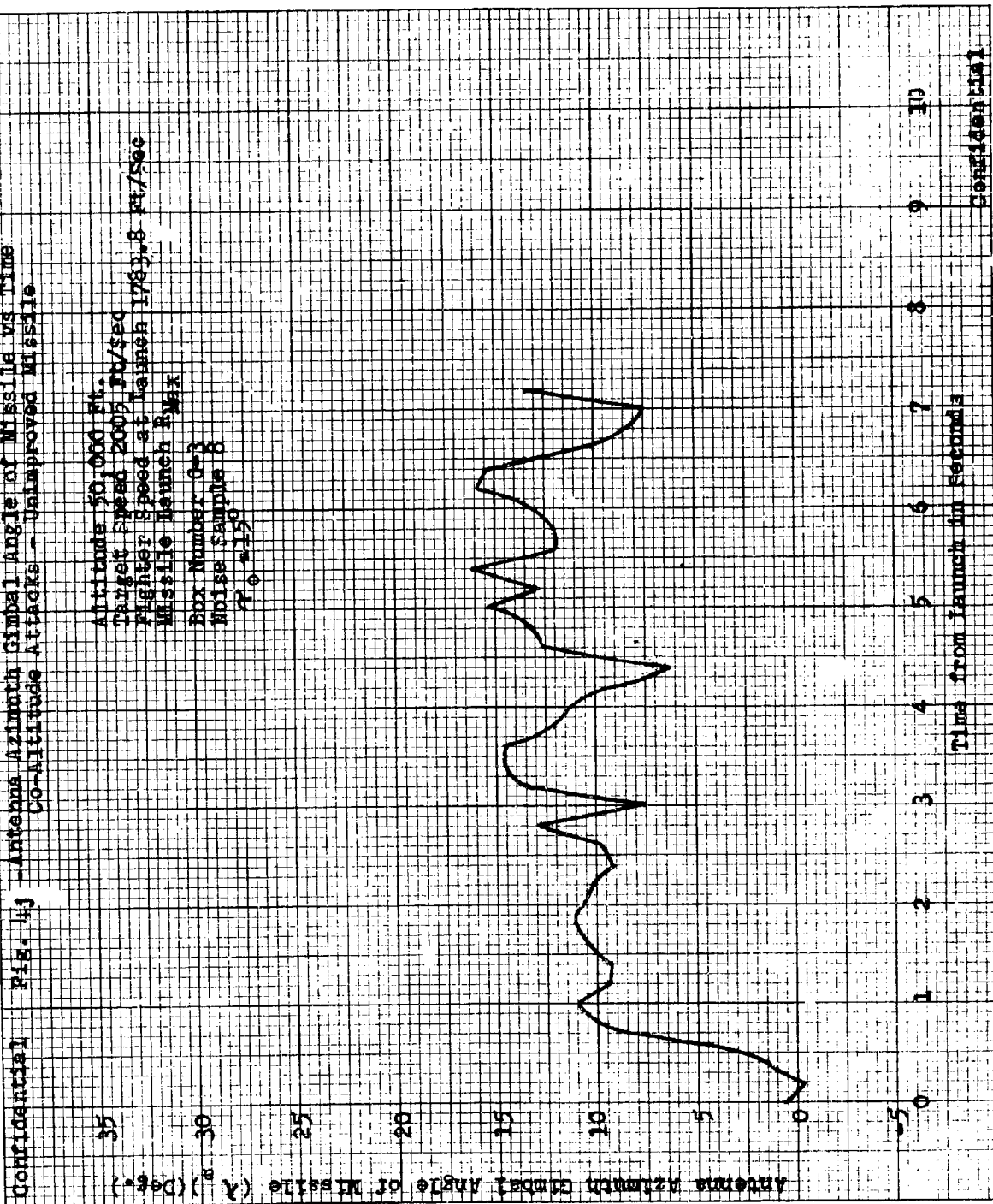
Time from Launch in Seconds

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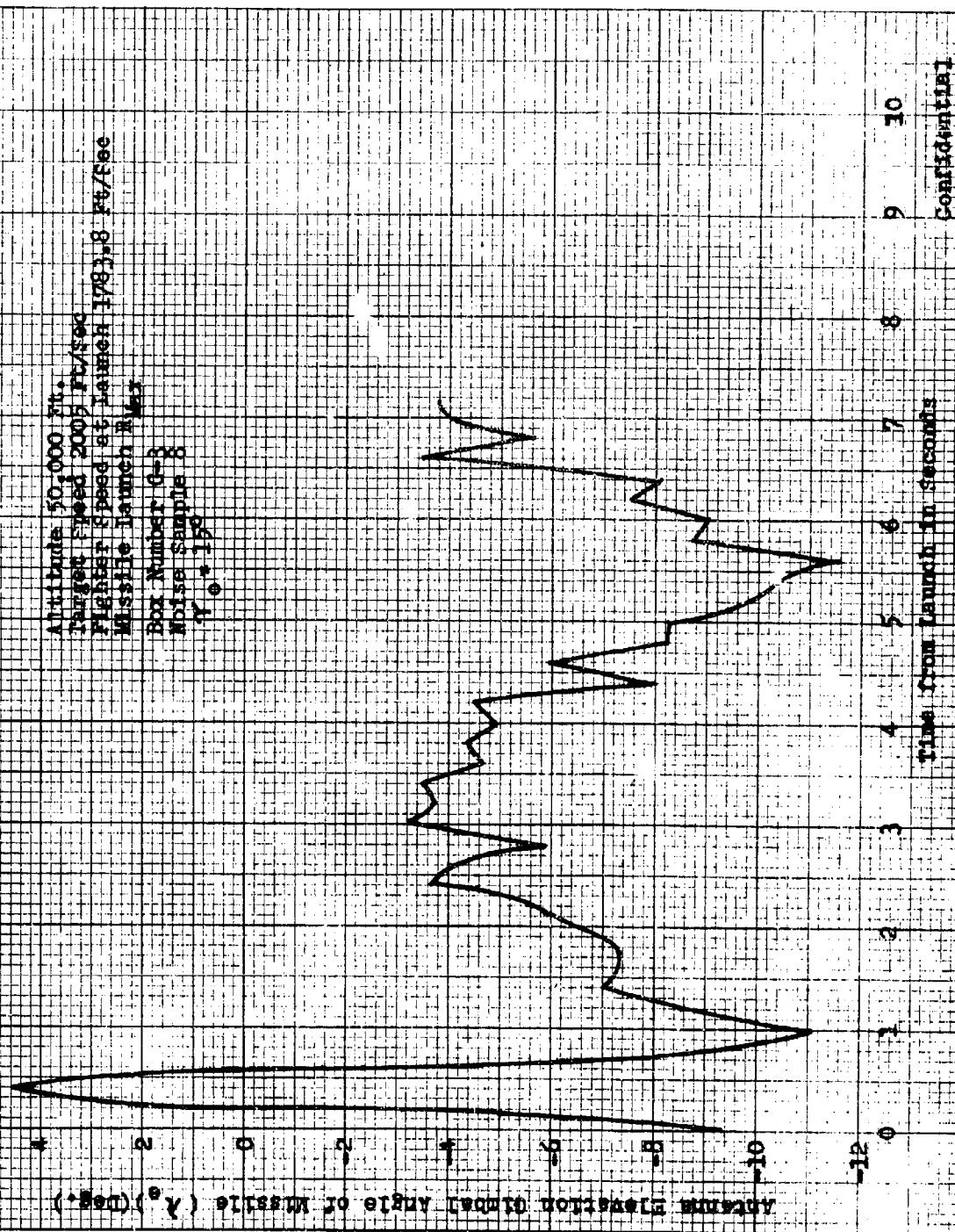
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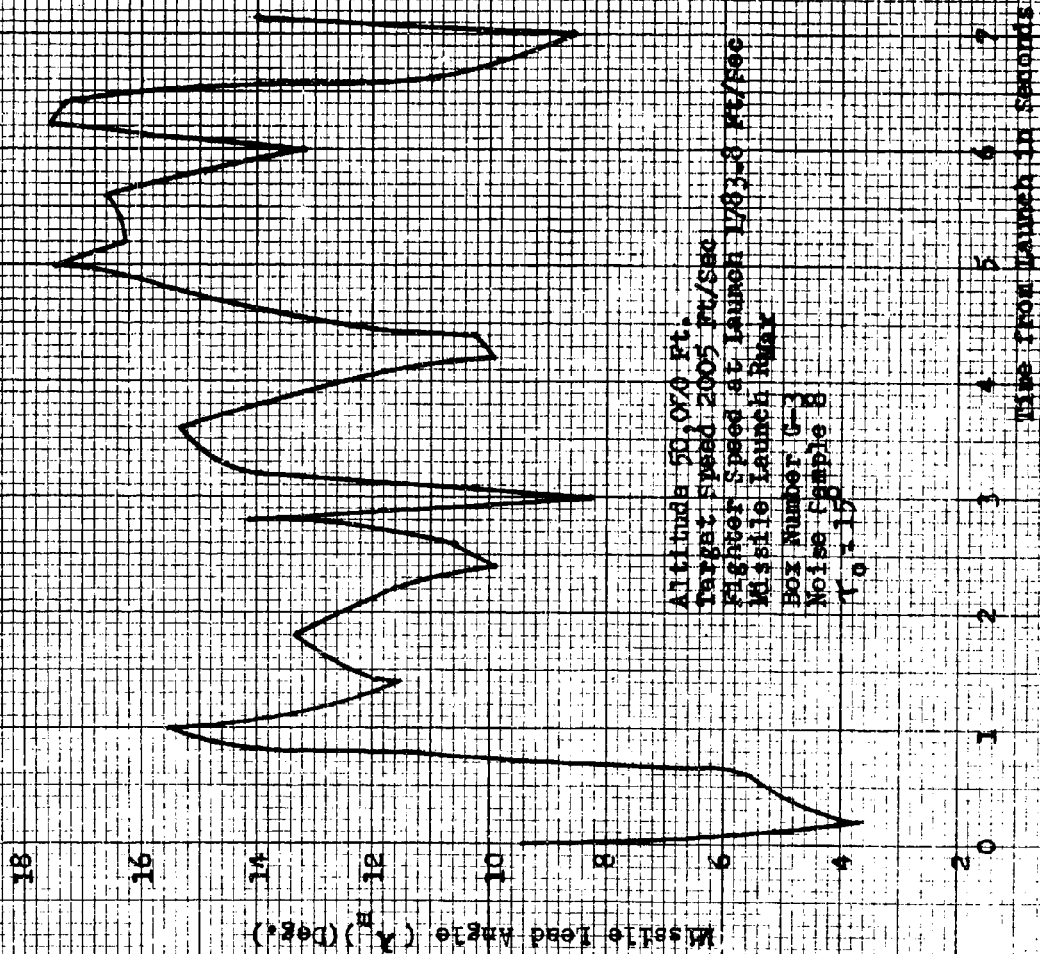
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Fig. 44 - Antenna Elevation Gimbal Angle of Missile vs Time
Co-Altitude Attacks - Unimproved Missile



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Fig. 41 - Missile Lead Angle vs Time
Co-Altitude Attacks - Unimproved Missile

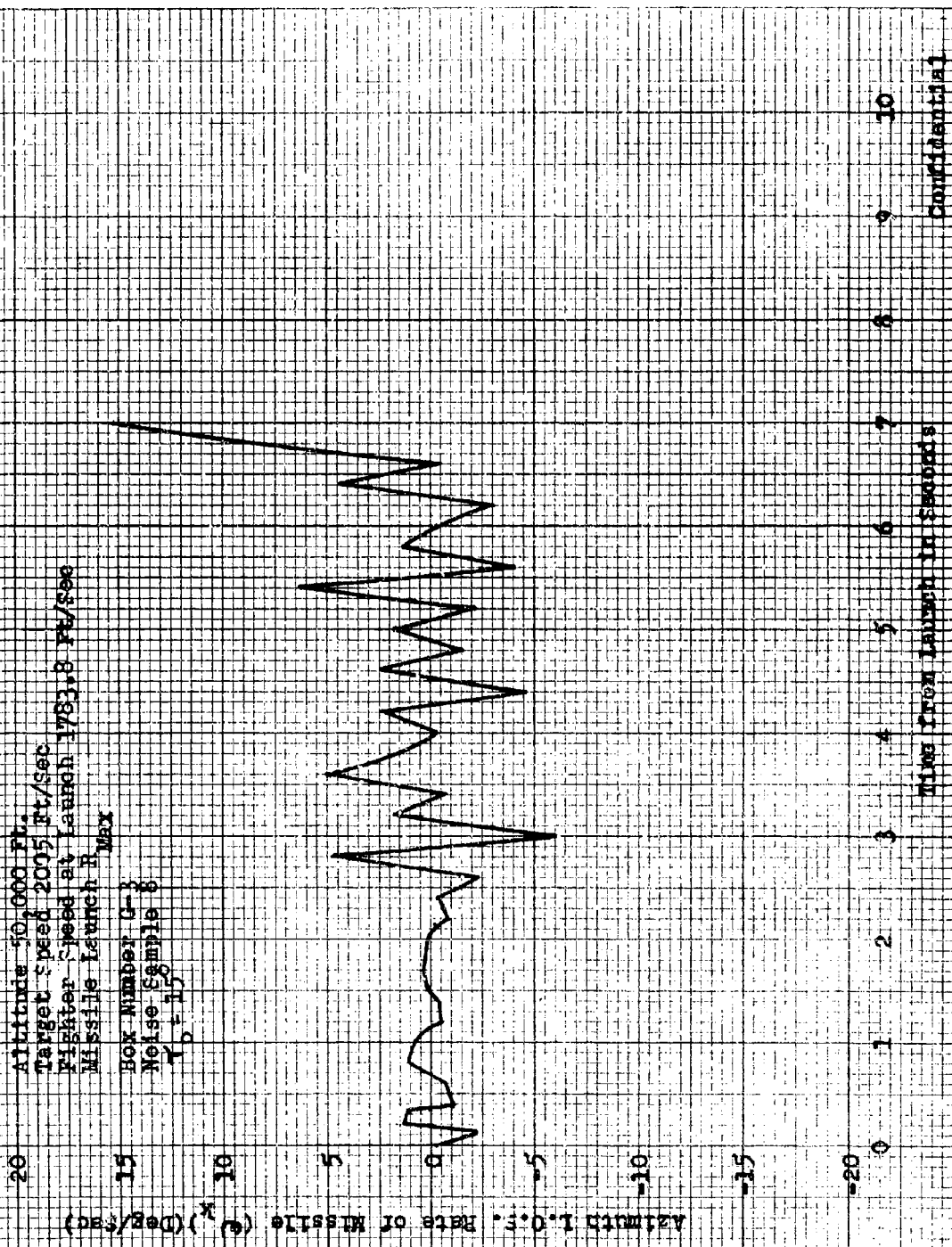


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Fig. 4a - Azimuth Rate of Sight Rate of Missile vs Time
Co-Altitude Attacks - Unimproved Missile

Altitude 50,000 Ft.
Target Speed 2005 Ft/sec
Fighter Speed at Launch 1781.8 Ft/sec
Missile Launch R_{max}
Box Number C-1
Noise Sample 8
T₀ = 1.5



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Fig. 10 - Elevation Line of Flight Rate of Missile vs Time
Co-Altitude Attacks - Improved Missile

Altitude 50,000 ft.
Target Speed 2000 ft/sec
Fighter Speed at Launch 1763.6 ft/sec
Missile Launch Angle
Box Number 0-3
Noise Sample 8
Co-Altitude

20

15

10

5

0

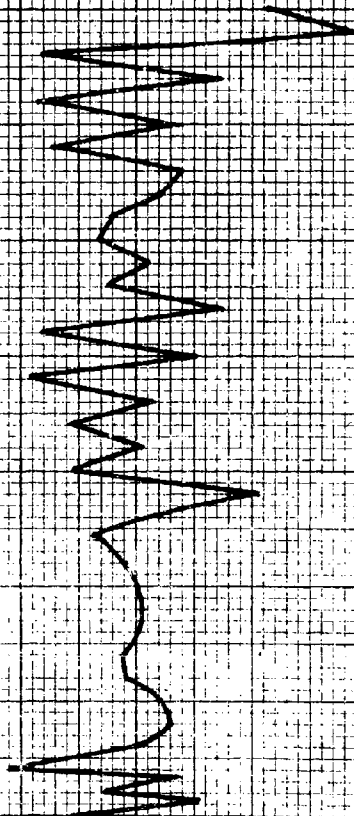
-5

-10

-15

-20

Elevation L.O.F. Rate of Missile (ft./sec)



0

1

2

3

4

5

6

7

8

9

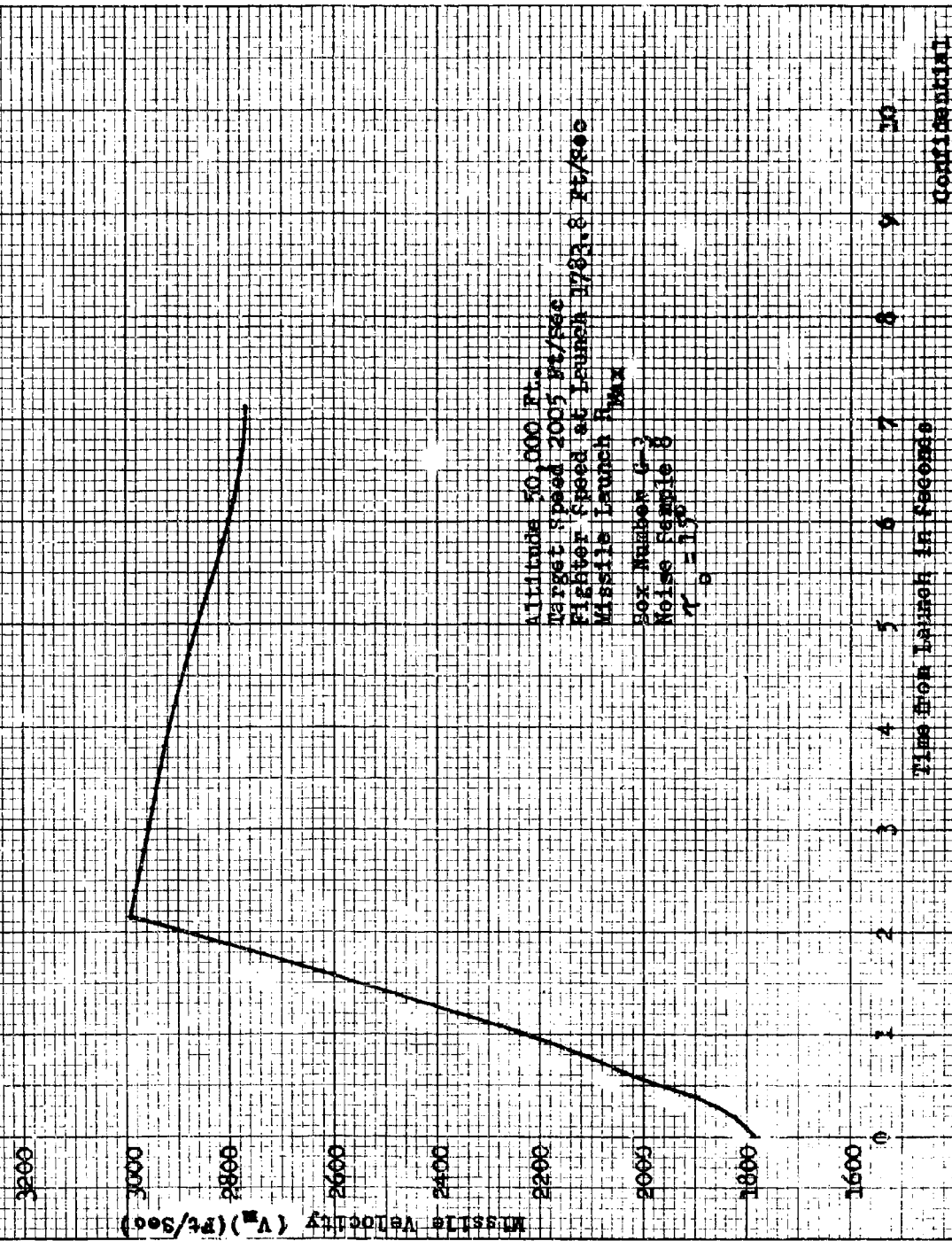
10

Time from Launch in Seconds

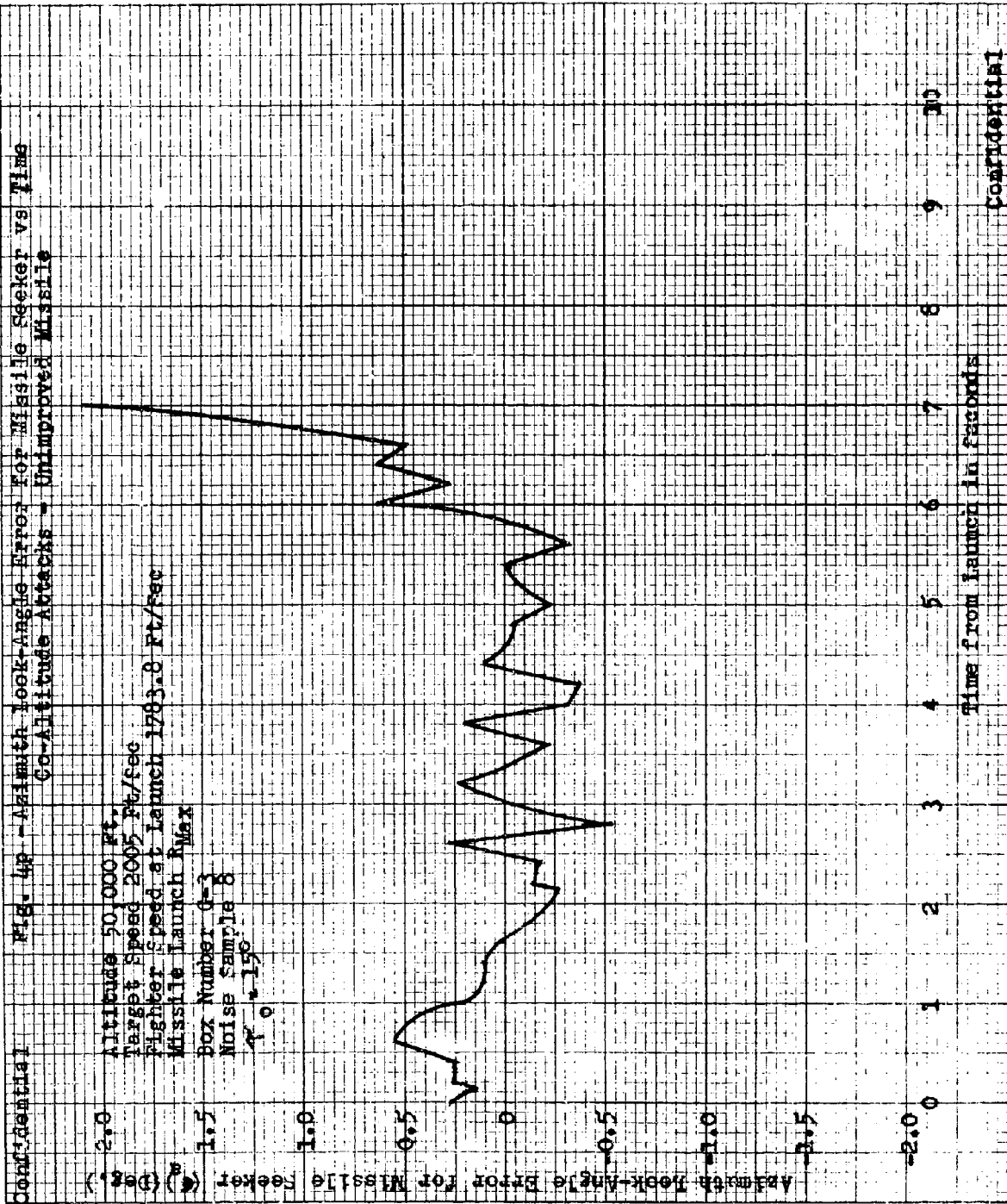
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Fig. 40 - Missile Velocity vs. Time
Co-A Altitude Attacks - Unimproved Missile



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Fig. 14 - Elevation Look-Angle Error for Missile Seeker vs Time
Co-Altitude Attacks - Unimproved Missile

Altitude 50,000 Ft.
Target Speed 2005 Ft/Sec
Fighter Speed at Launch 1783.8 Ft/Sec
Missile Launch R Max
Box Number 6-3
Noise Sample 8
 $\sigma = 1.2$

Elevation Look-Angle Error for Missile Seeker (°) (Dev)

2.0

1.5

1.0

0.5

0

-0.5

-1.0

-1.5

-2.0

0

1

2

3

4

5

6

7

8

9

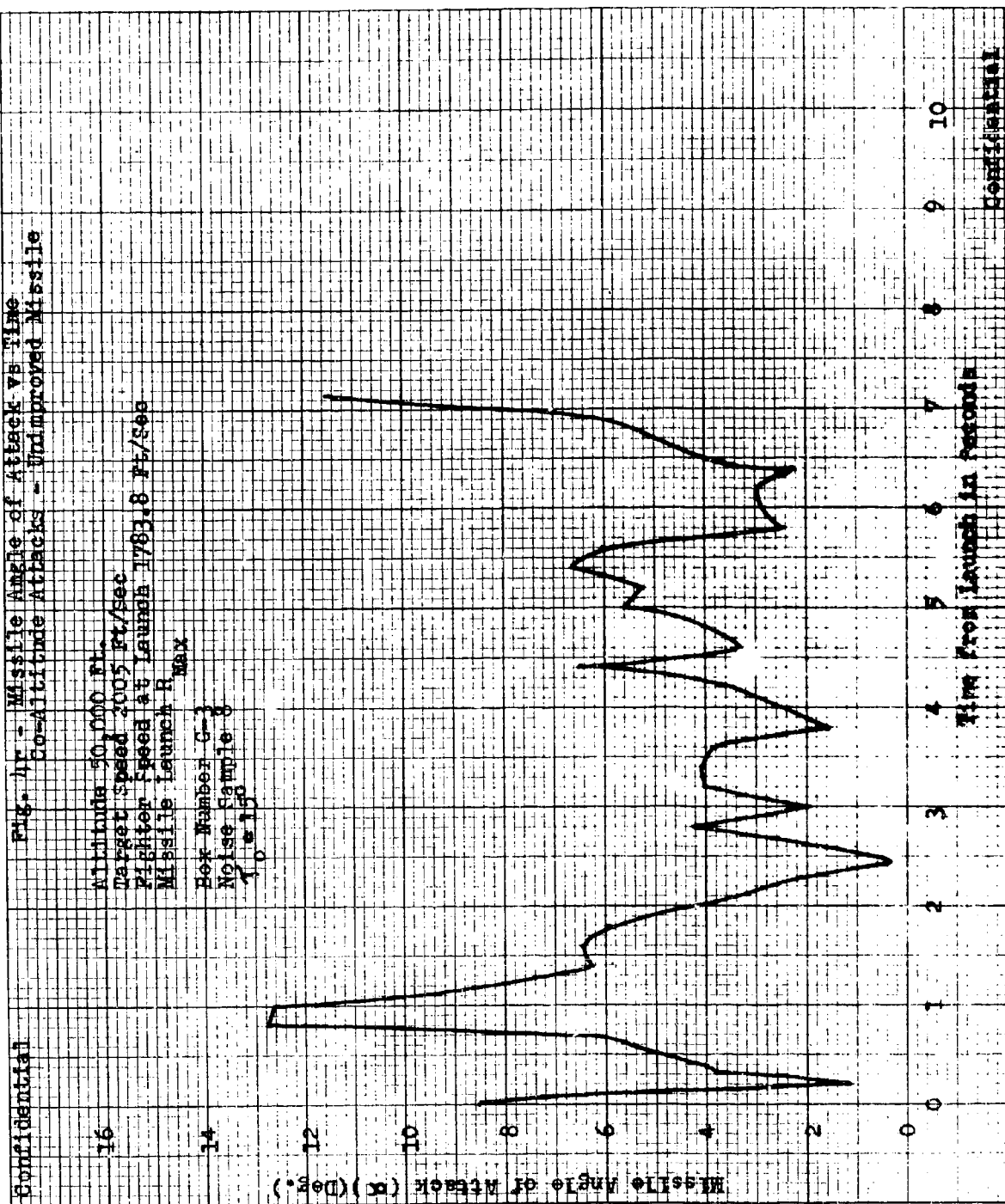
10

Time from Launch in Seconds

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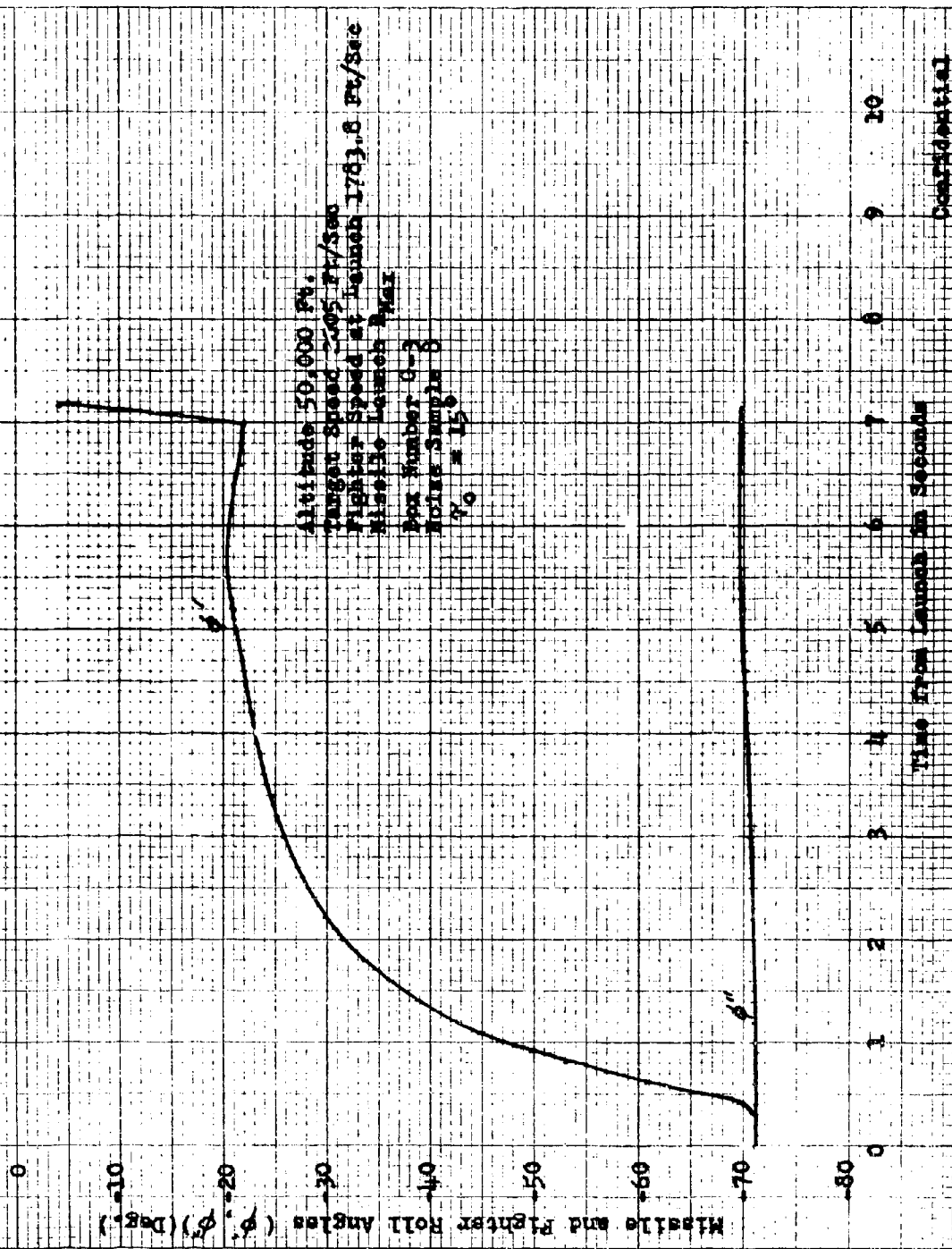
Fig. 4r - Missile Angle of Attack vs Time
Co-Altitude Attacks - Unimproved Missile



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Fig. 14-Missile and Fighter Roll Angles vs Time
Geekitunda Attack-Enimproved Missile

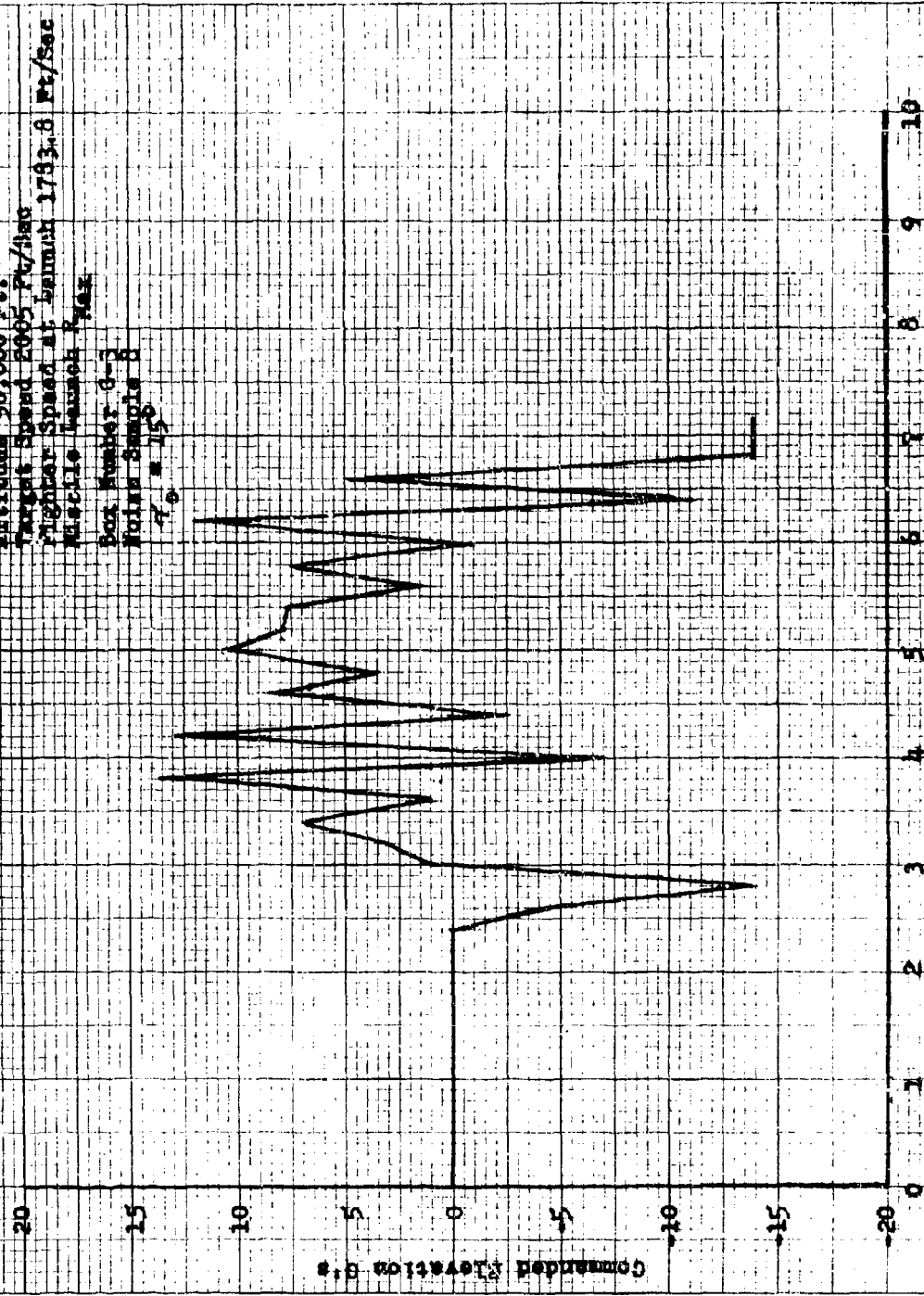


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Fig. 18-Commanded Elevation G's vs Time
Co-Airplane Attitude-Unimproved Missile

Altitude 50,000 Ft.
Target Speed 2005 Ft./Sec
Pilot's Speed at Launch 1783.8 Ft./Sec
Missile Launch Angle
Box Number 0-3
Roller Sample 8
 $\sigma = 15^\circ$



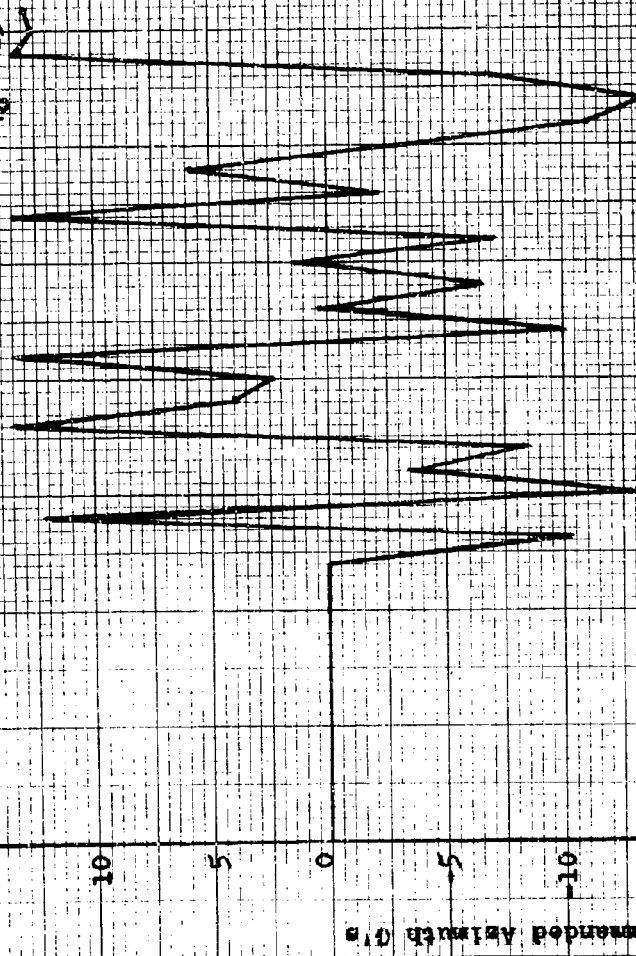
Time from Launch in Seconds

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Fig. 11-Commanded Azimuth G's vs Time
Co-Altitude Attacks-Unimproved Missiles

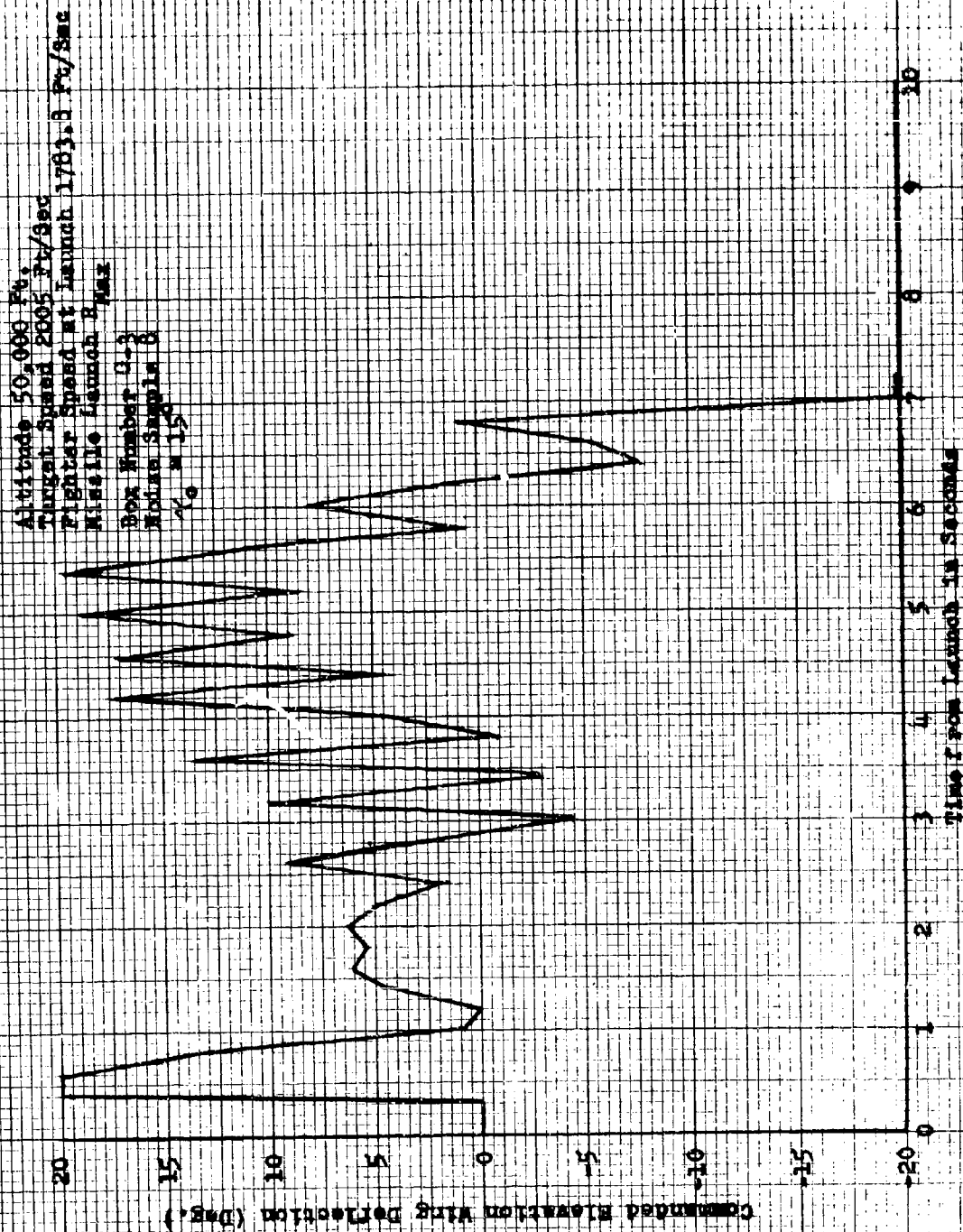
Altitude 50,000 Ft.
Target Speed 2005 Ft./Sec.
Fighter Speed at Launch 1783.8 Ft./Sec.
Missile Launch E Max
Box Number G-3
Voice Sample 8
 $\tau_0 = 150$



Time from Launch in Seconds

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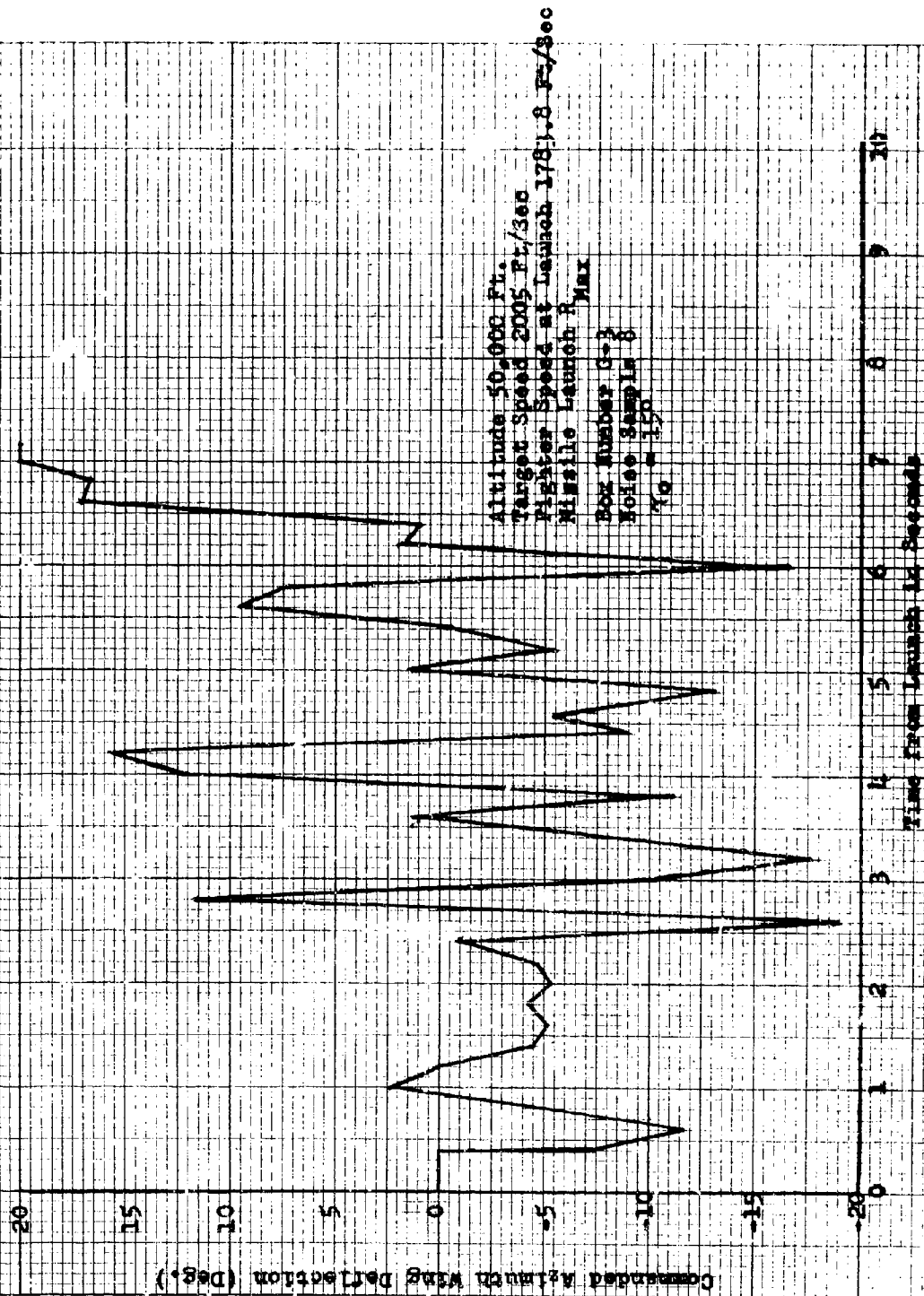
Fig. 17-Commanded Klevation v'ing Deflection vs Time



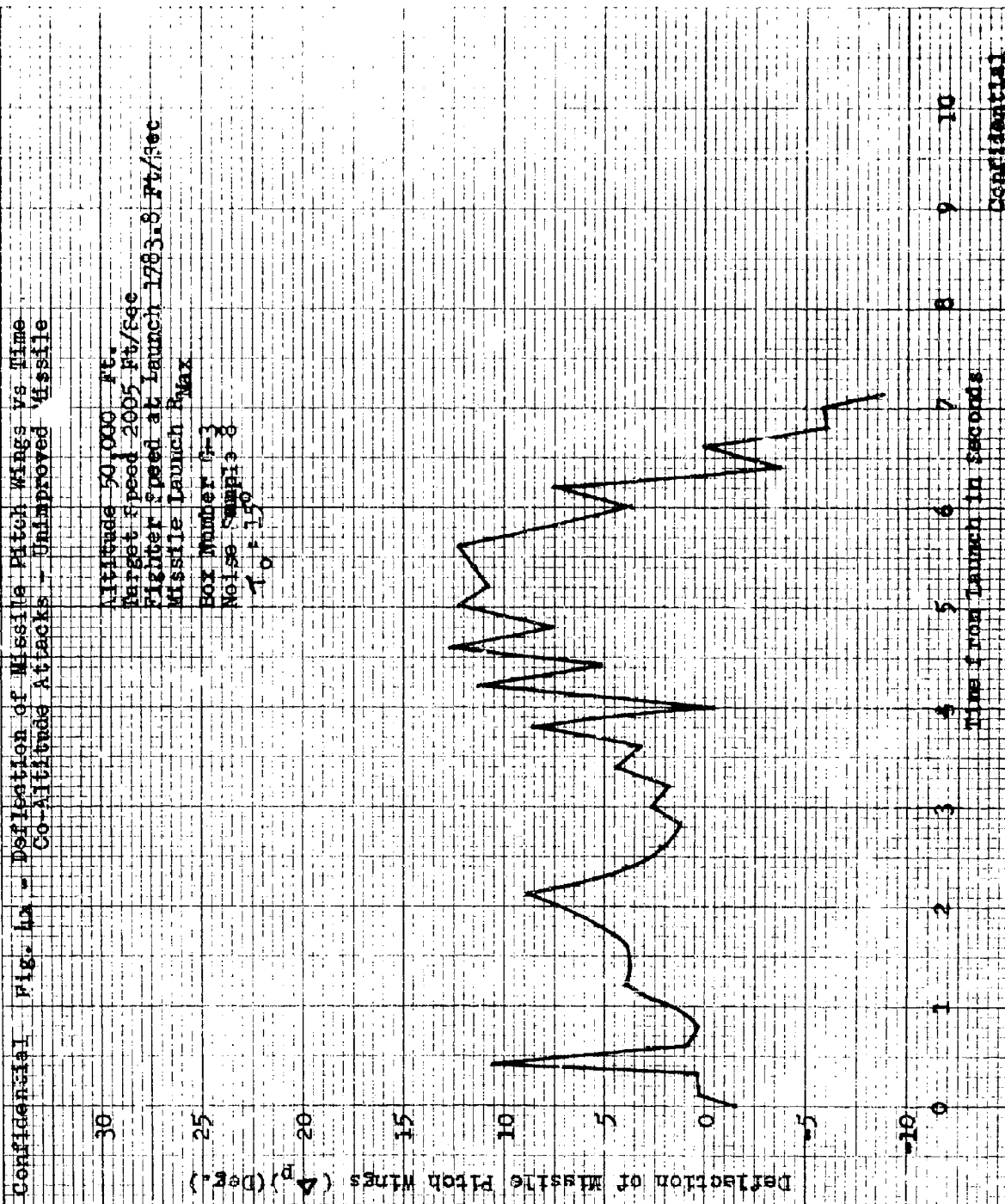
Don't forget!

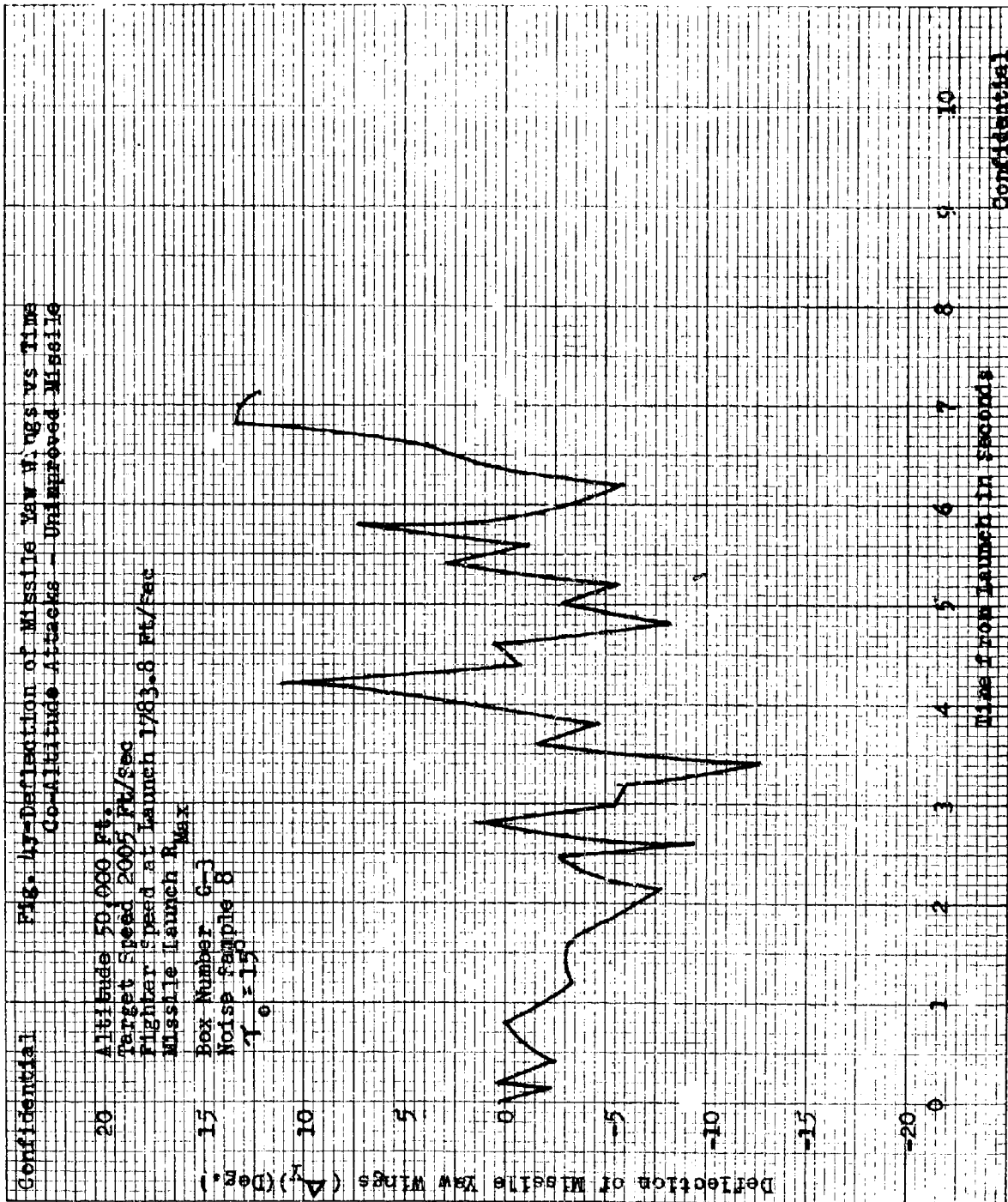
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Fig. 4a- Commanded Azimuth Wing Deflection vs Time
Co-Altitude Attacks - Unimproved Missile



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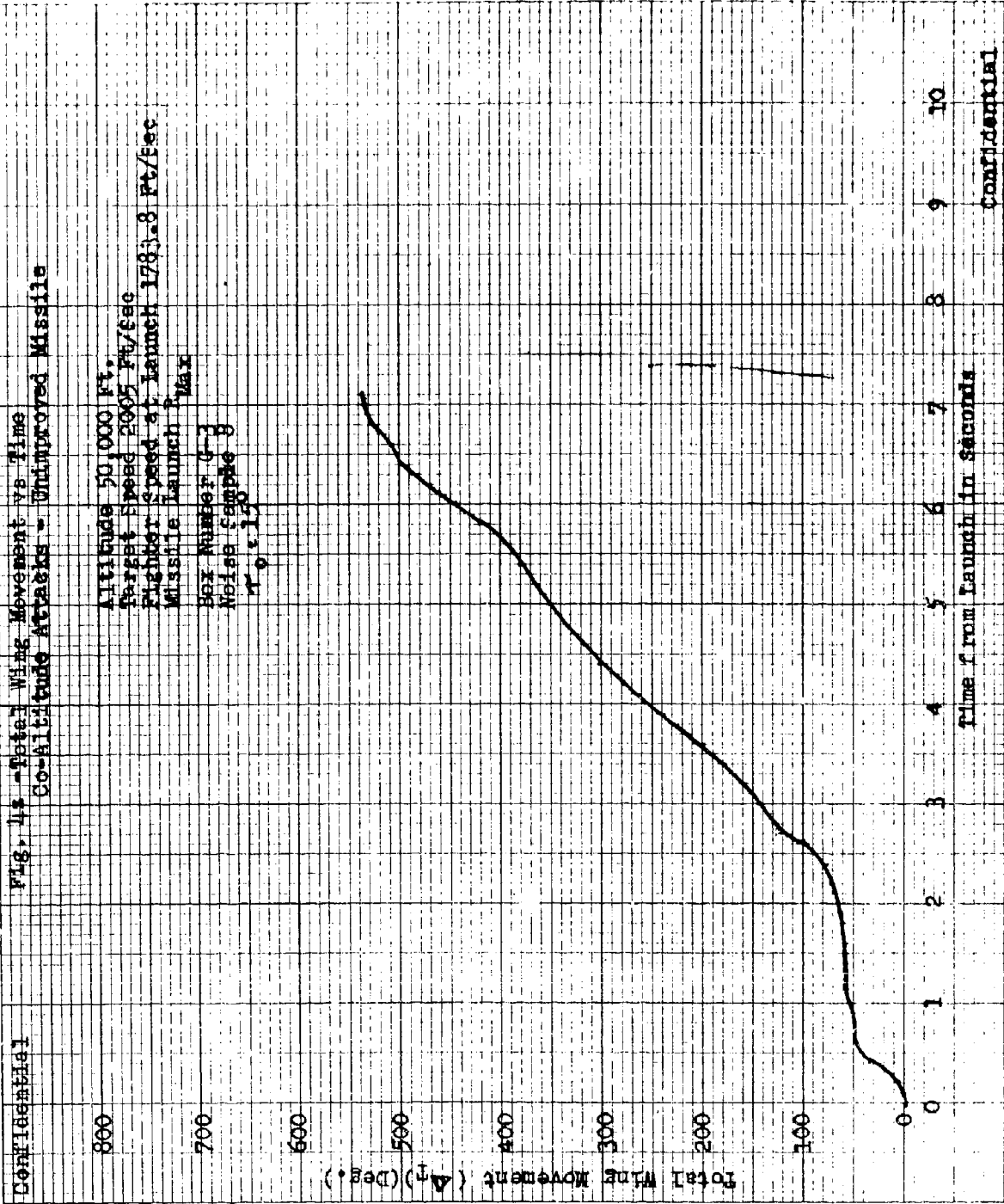
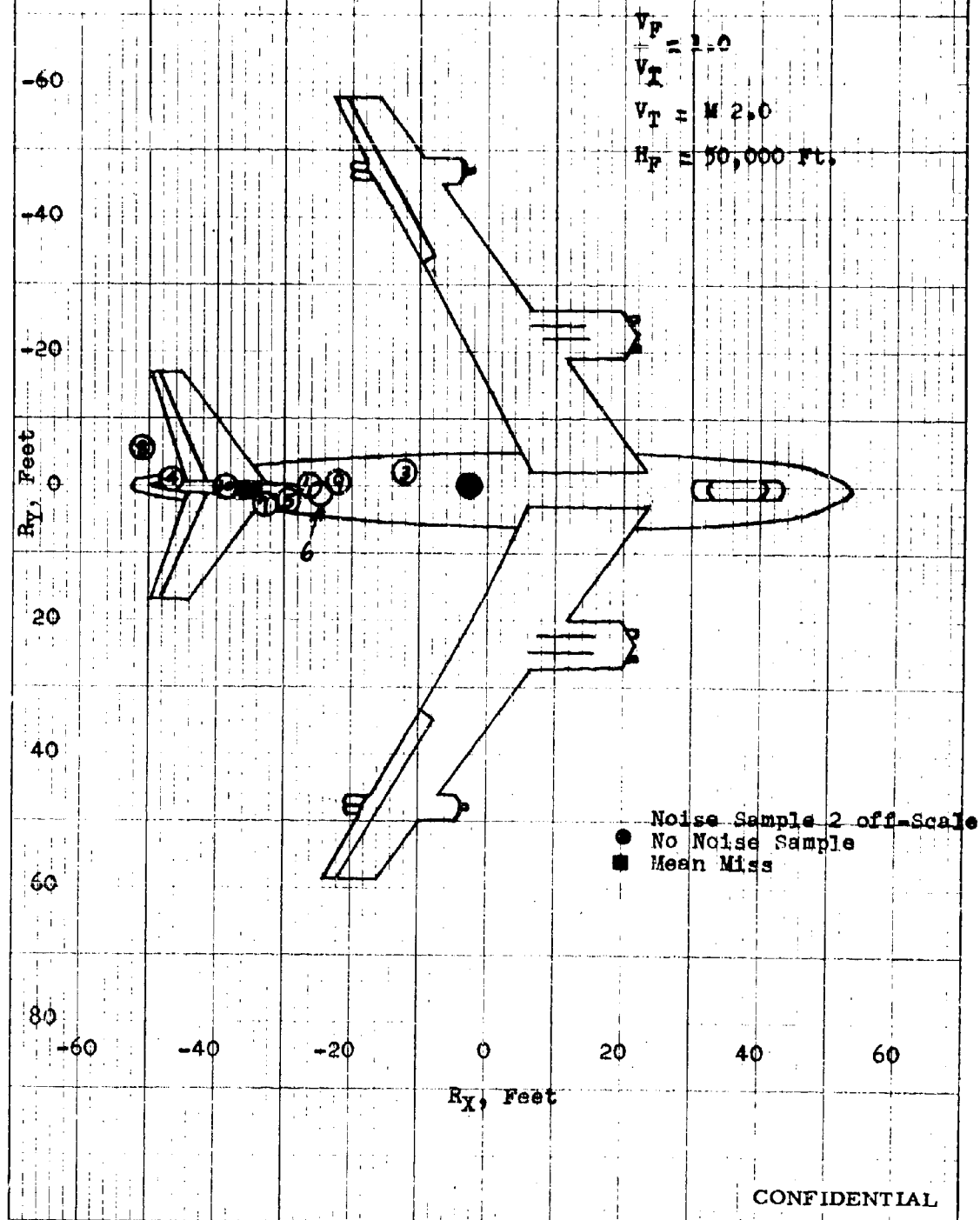
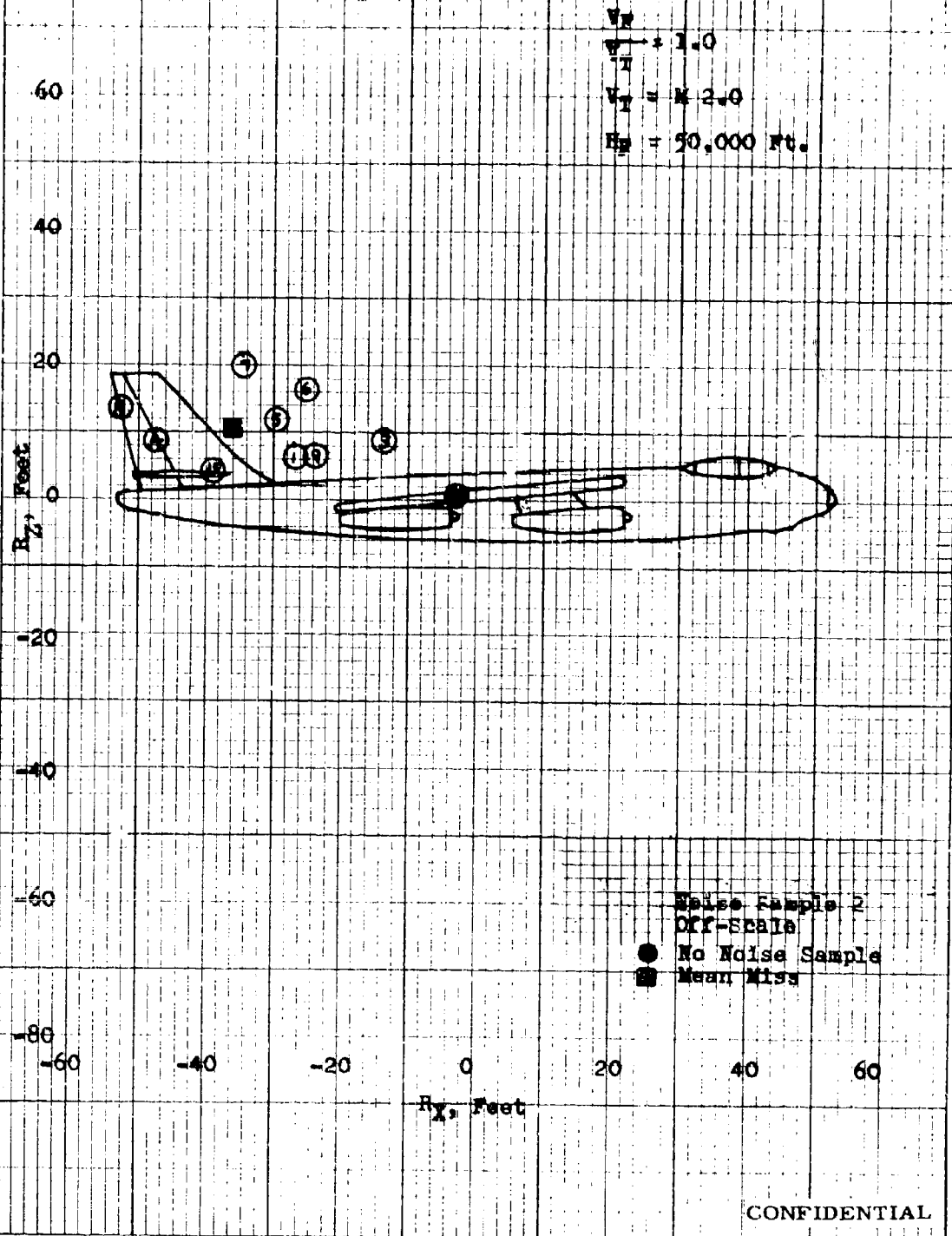


Fig. 5a - Sparrow III Miss Distance-Co-Altitude Attack
 X-Y Miss Distance at the Target
 $\gamma_0 = 60^\circ$, R_{MX} Launch, Fighter Course - D-1
 Unimproved Missile

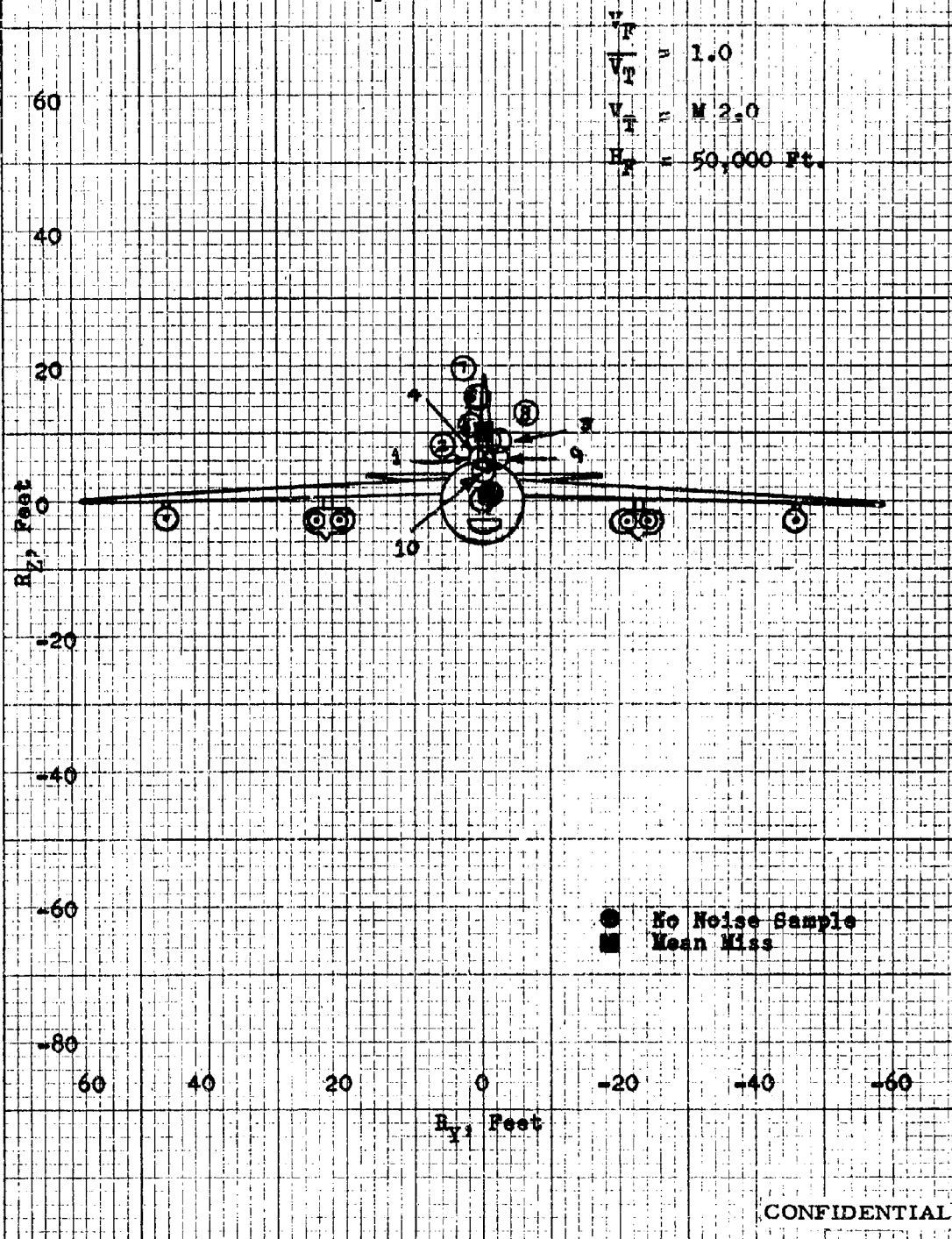


CONFIDENTIAL Fig. 5b Sparrow III Miss Distance - Co-altitude Attacks
 X-Z Miss Distance at the Target
 $\gamma_0 = 60^\circ$, Max Launch, Fighter Course - B-1
 Unimproved Missile



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Fig. 5 - Sparrow III Miss Distance - Co-altitude Attacks
Y-Z Miss Distance at the Target
 $T_0 = 60^\circ$, R_{Max} Launch, Fighter Course - D-1
Unimproved Missile





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Fig. 5d - Fighter to Missile Range vs Time
60-Altitude Attacks - Unimproved Missile

Altitude 50,000 Ft.
Target Speed 2005 Ft/sec
Fighter Speed at Launch 1920.9 Ft/sec
Missile Launch R_{max}
Box Number D-1
Noise Sample 3
T₀ = 600

Fighter to Missile Range (R_{F-M}) (Ft x 10³)

Time from Launch in Seconds

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Fig. 5a - Missile to Target Range vs Time
Co-Altitude Attacks - Unimproved Missile

Altitude 50,000 Ft.
Target Speed 2005 Ft/Sec
Fighter Speed at Launch 1920.9 Ft/Sec
Missile Launch Angle
Box Number D-1
Noise Sample 3
 $T_0 = 600$

Missile to Target Range (R_{M-T}) (Ft x 10^3)

Time from Launch in Seconds

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Fig. 57 - Fighter to Target Range vs Time
00-Altitude Attacks - Unimproved Missile

Altitude 50,000 Ft.
Target Speed 2005 Ft/Sec
Fighter Speed at launch 1920 Ft/Sec
Missile's Launch Range
Box Number D-1
Noise Sample 3
2600

Fighter to Target Range (R_{F-T}) (Ft x 10³)

Time from Launch in Seconds

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Fig. 56. Fighter to Missile Range Rate vs Time
Co-Altitude Attacks - Unimproved Missile

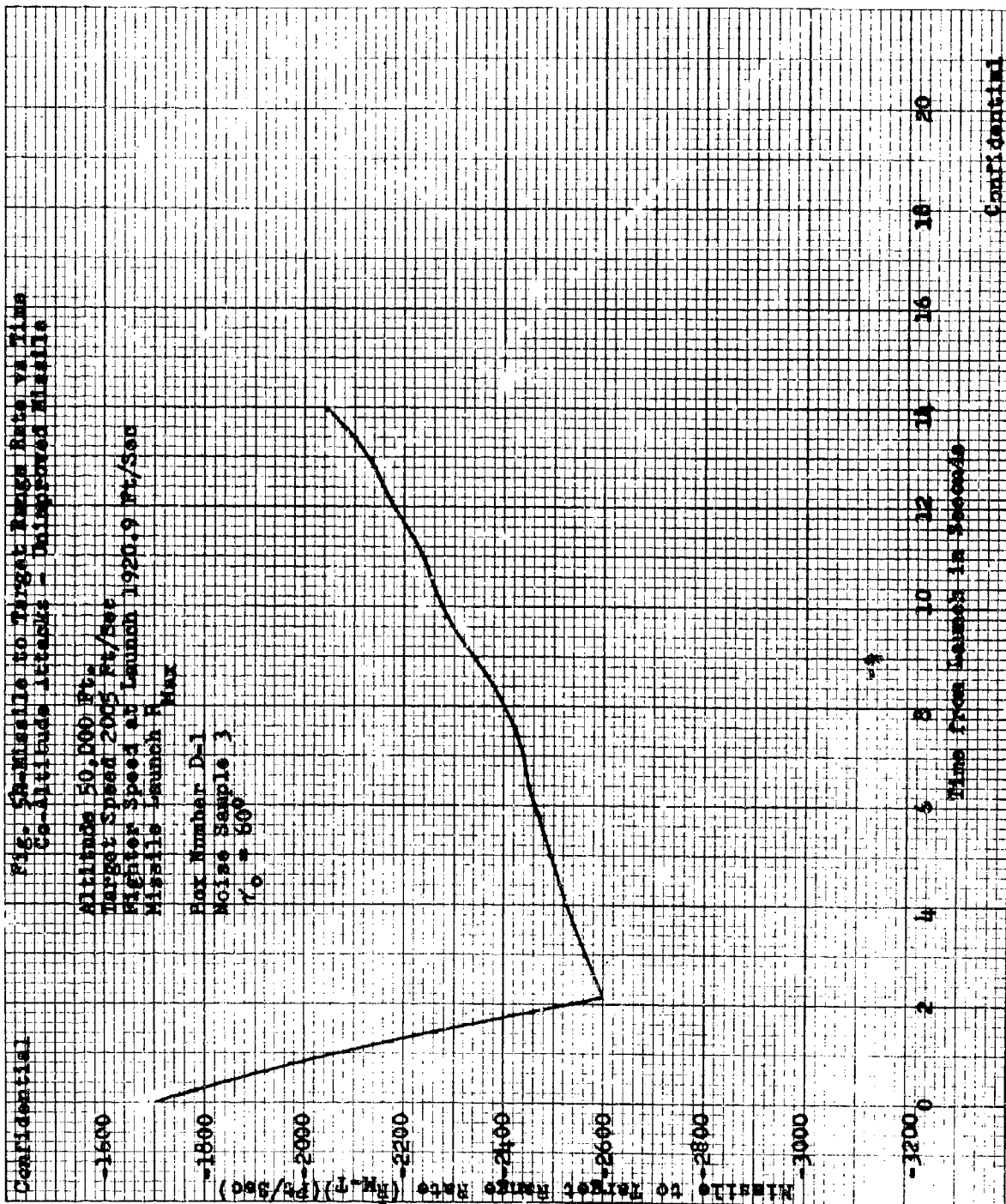
Altitude 50,000 Ft.
Target speed 2005 Ft/sec
Fighter speed at launch 1920.9 Ft/sec
Missile launch Rate
Box Number D-1
Noise Sample 3
 $V_0 = 600$

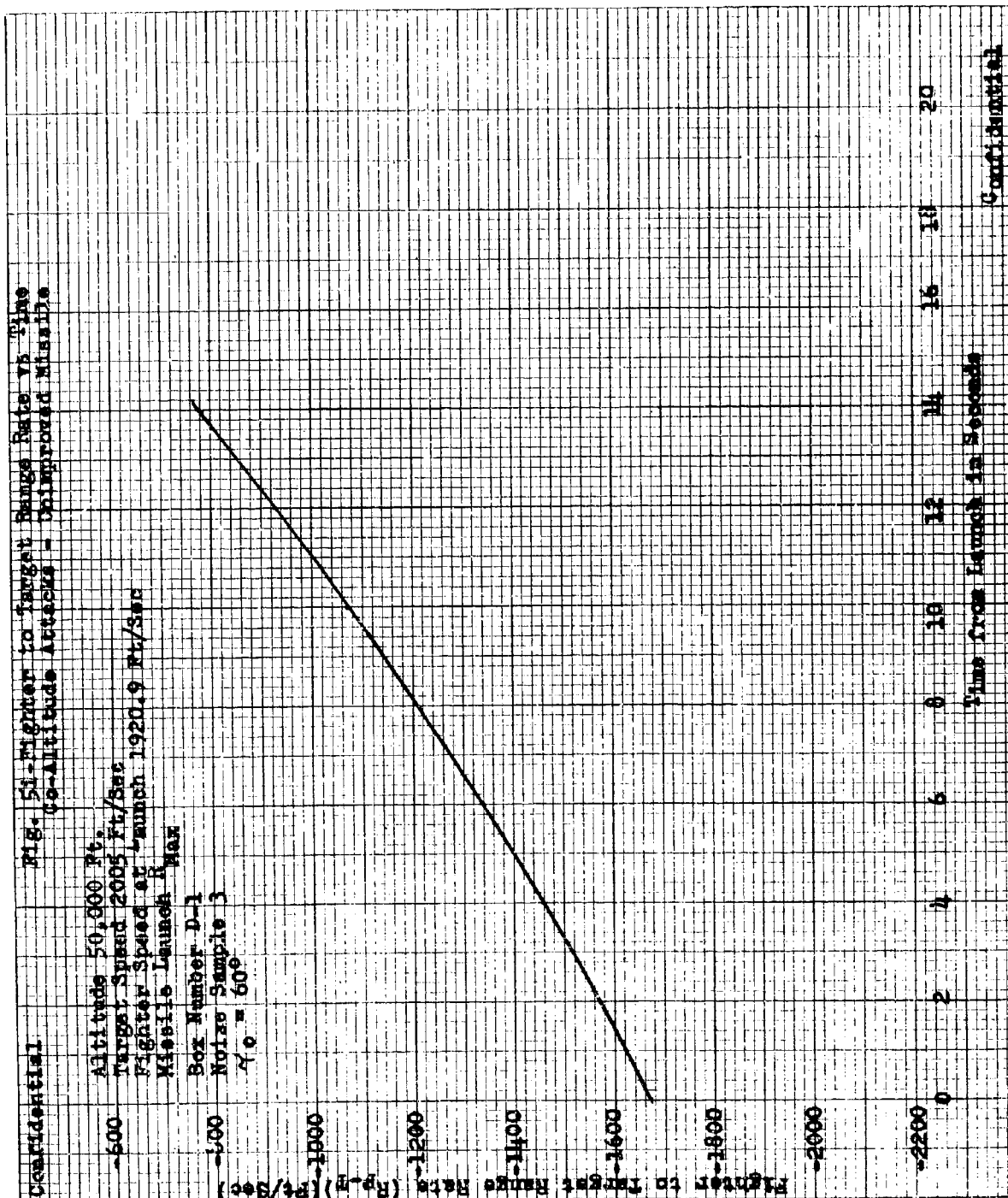
Fighter to Missile Range Rate (R_{F-M}) (Ft/sec)



Time from launch in seconds

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Fig. 51 - Antenna Azimuth Global Angle of Missile vs Time
CS-Antitude Attacks - Unimproved Missile

Altitude 50,000 Ft.
Target Speed 2005 Ft/Sec
Fighter Speed at launch 1920.9 Ft/Sec
Missile launch Max
Box Number D-1
Moire Sample 3
40 ± 60°



Time from Launch in seconds

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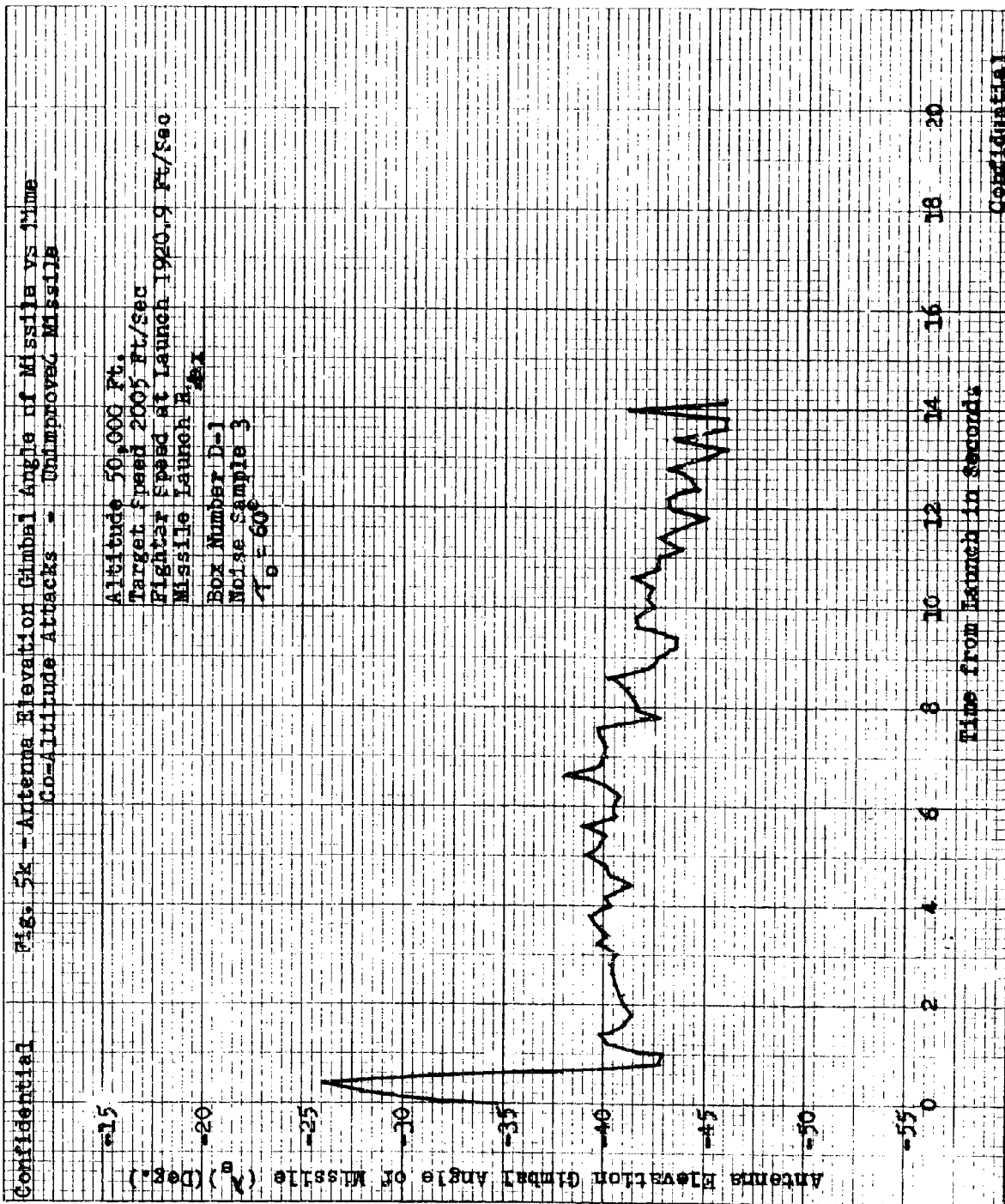




Fig. 51 - Missile Lead Angle vs Time
Co-Altitude Attacks - Unimproved Missile

Altitude 50,000 Ft.
Target Speed 2005 Ft/Sec
Fighter Speed at Launch 1920.9 Ft/Sec
Missile Launch Range

Box Number D-1
Noise Sample 3
 $\gamma_0 = 600$

Missile Lead Angle (λ^H) (Deg.)

Time from Launch in Seconds

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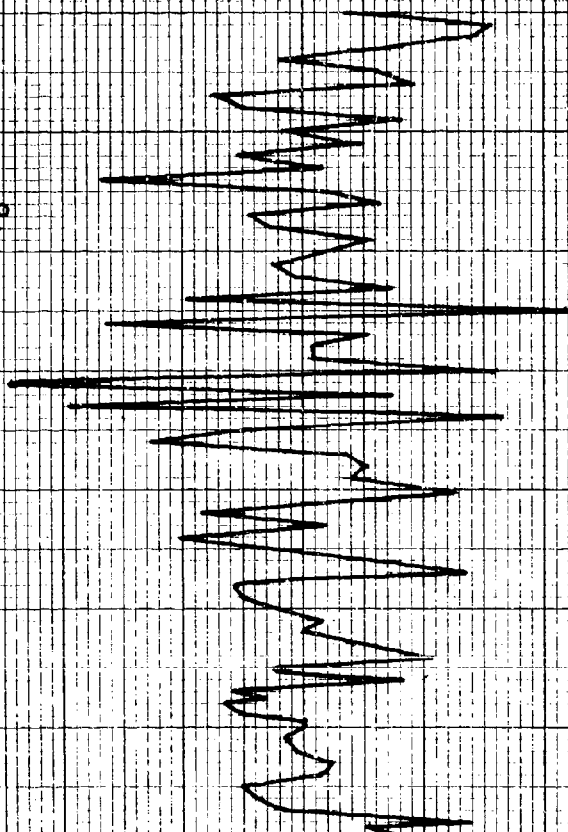
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Fig. 5a - Azimuth Line of Sight Rate of Missile vs Time
 Co-Azimuth Attacks - Unimproved Missile

Altitude 50,000 Ft.
 Target Speed 2005 ft/sec
 Fighter Speed at Launch 1920.9 ft/sec
 Missile Launch Range
 Box Number D-1
 Noise Sample 3
 $\tau_0 = 60^\circ$

Azimuth L.O.S. Rate of Missile (ω_k) (Deg/Sec)

8
 6
 4
 2
 0
 -2
 -4
 -6
 -8



Time from Launch in seconds

20
 18
 16
 14
 12
 10
 8
 6
 4
 2
 0

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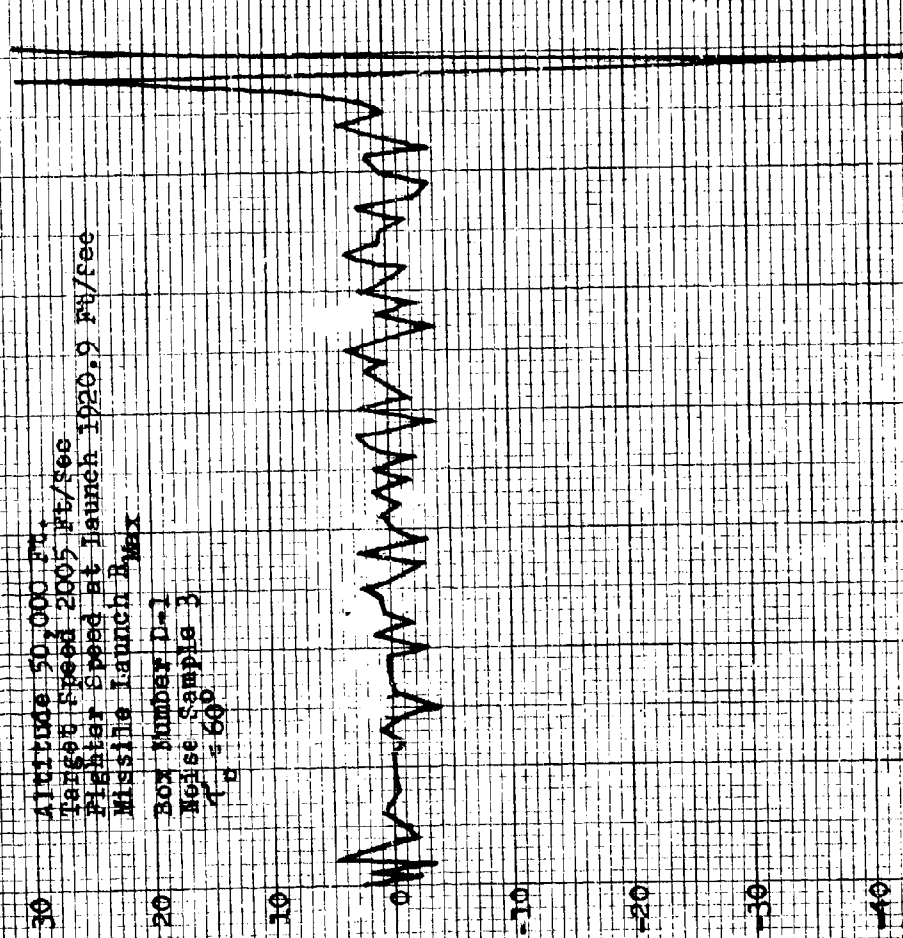


Fig. 5a-Elevation Line of Sight Rate of Missile vs. Time
Co-Altitude Attacks - Unimproved Missile

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Altitude 50,000 Ft.
Target Speed 2005 Ft/Sec
Fighter Speed at Launch 1920.9 Ft/Sec
Missile Launch D_{max}
Box Number D-1
Noise Sample 3
 $\alpha = 60^\circ$

Elevation L.O.S. Rate of Missile ($\dot{\alpha}$) (Deg/Sec)



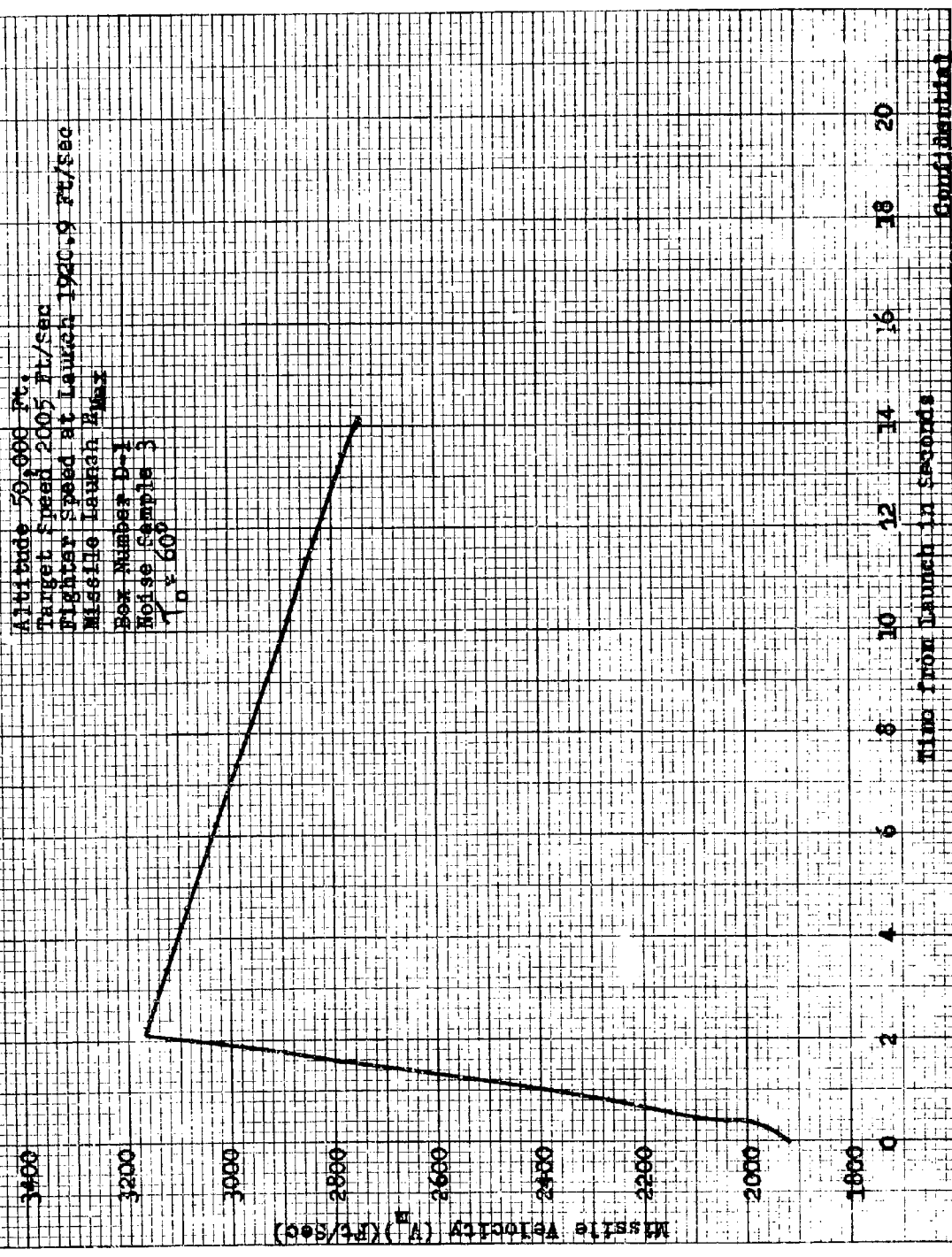
Time from Launch in Seconds

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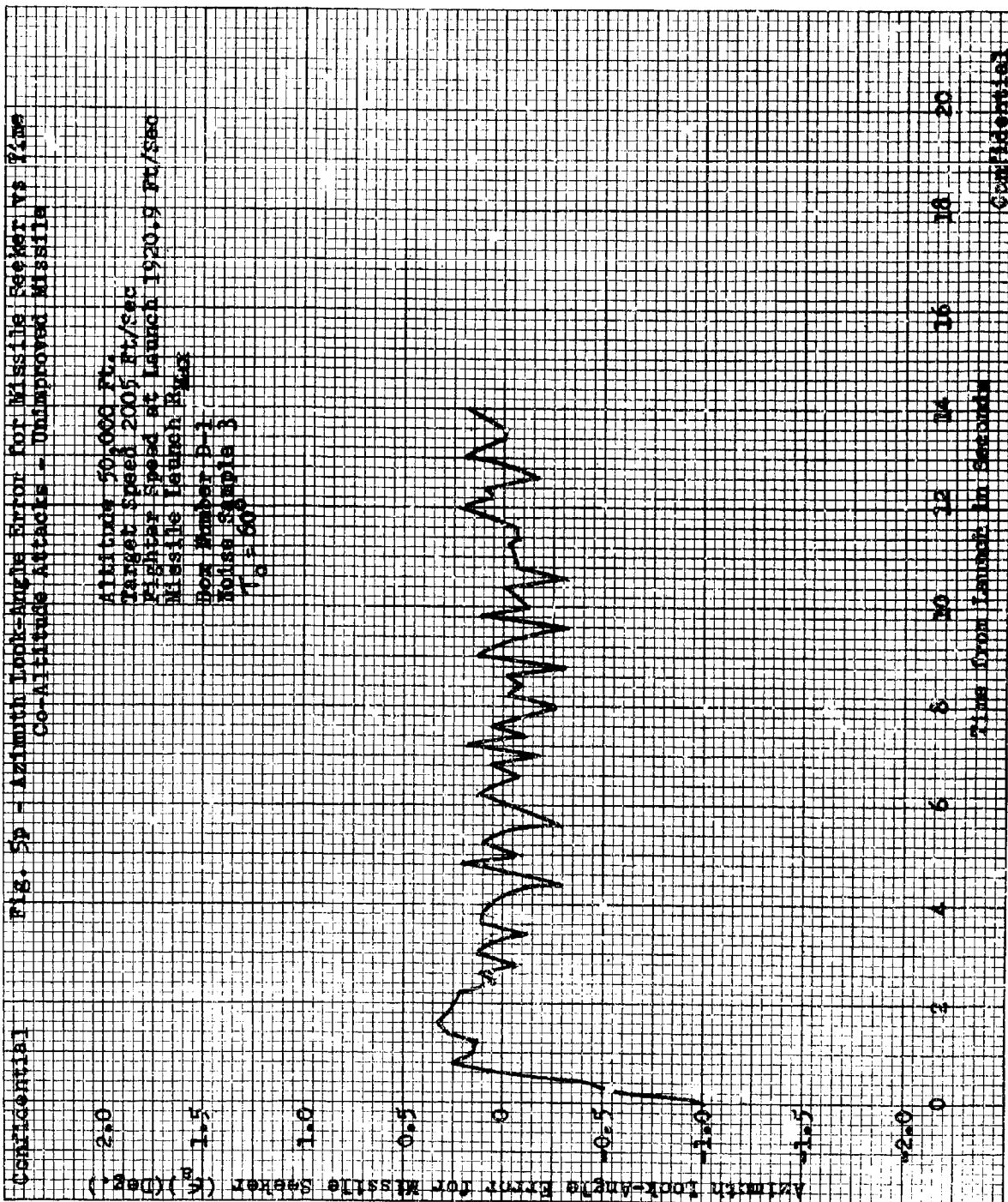
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Fig. 50- Missile Velocity vs Time
Co-Altitude Attacks - Unimproved Missile

Altitude 50,000 Ft.
Target Speed 2005 Ft/sec
Fighter Speed at Launch 1920.9 Ft/sec
Missile Launch Angle
Box Number D-1
Noise Sample 3
10 x 60



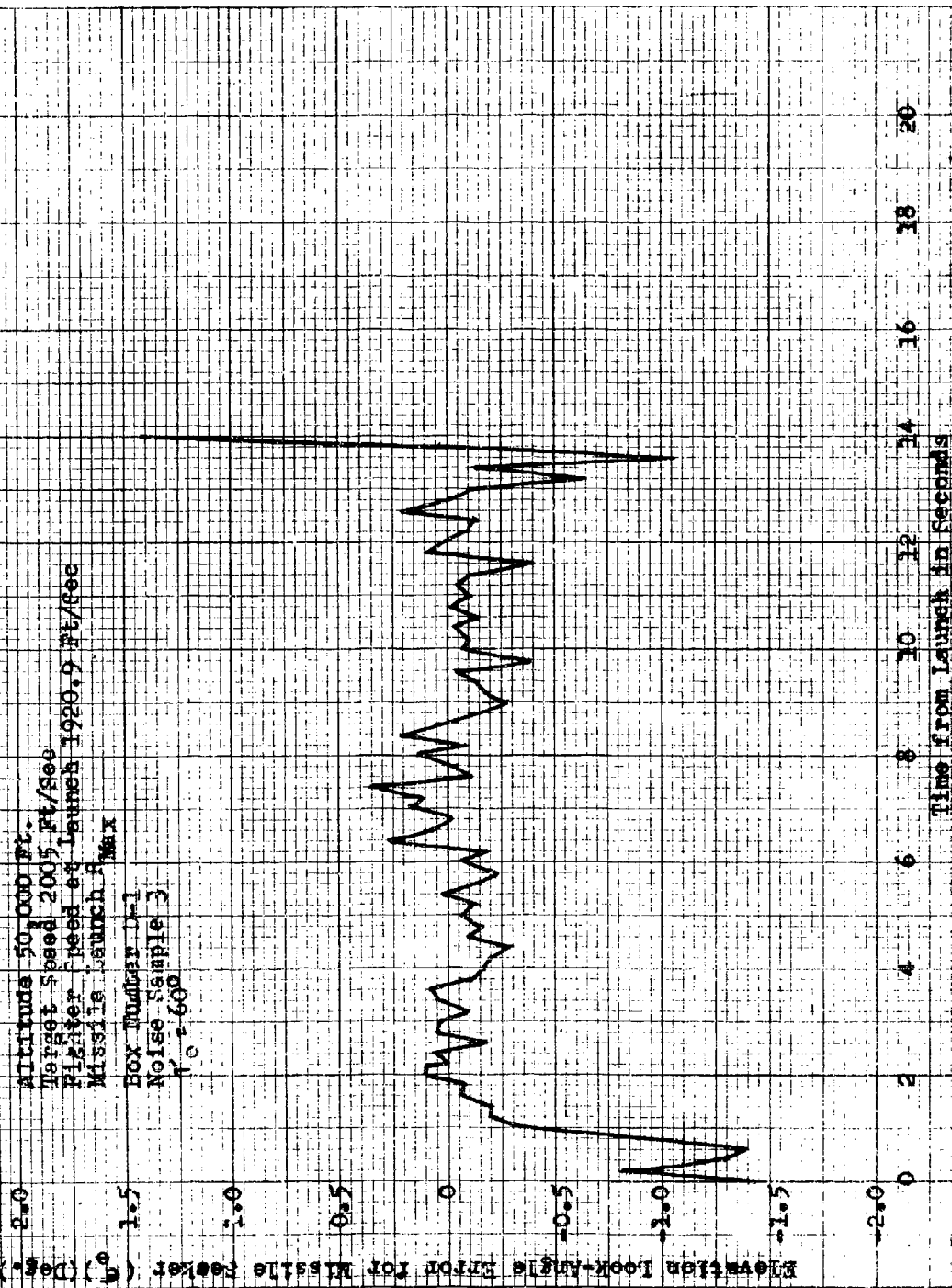
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Fig. 5a - Elevation Look-Angle Error for Missile Seeker vs Time
CB-Altitude Attacks - Unimproved Missile

Altitude 50,000 Ft.
Target Speed 2005 Ft/Sec
Fighter Speed at Launch 1920.9 Ft/Sec
Missile Launch R_{Max}
Fox Radar Del
Noise Sample 3
 $r_c = 60^\circ$



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Fig. 5a - Missile Angle of Attack vs Time
Co-Altitude Attacks - Unimproved Missile

Altitude 50,000 Ft.
Target Speed 2005 Ft/Sec
Fighter Speed at Launch 1920.9 Ft/Sec
Missile Launch R
Box Number D-1
Noise Sample 3
Tc = 600

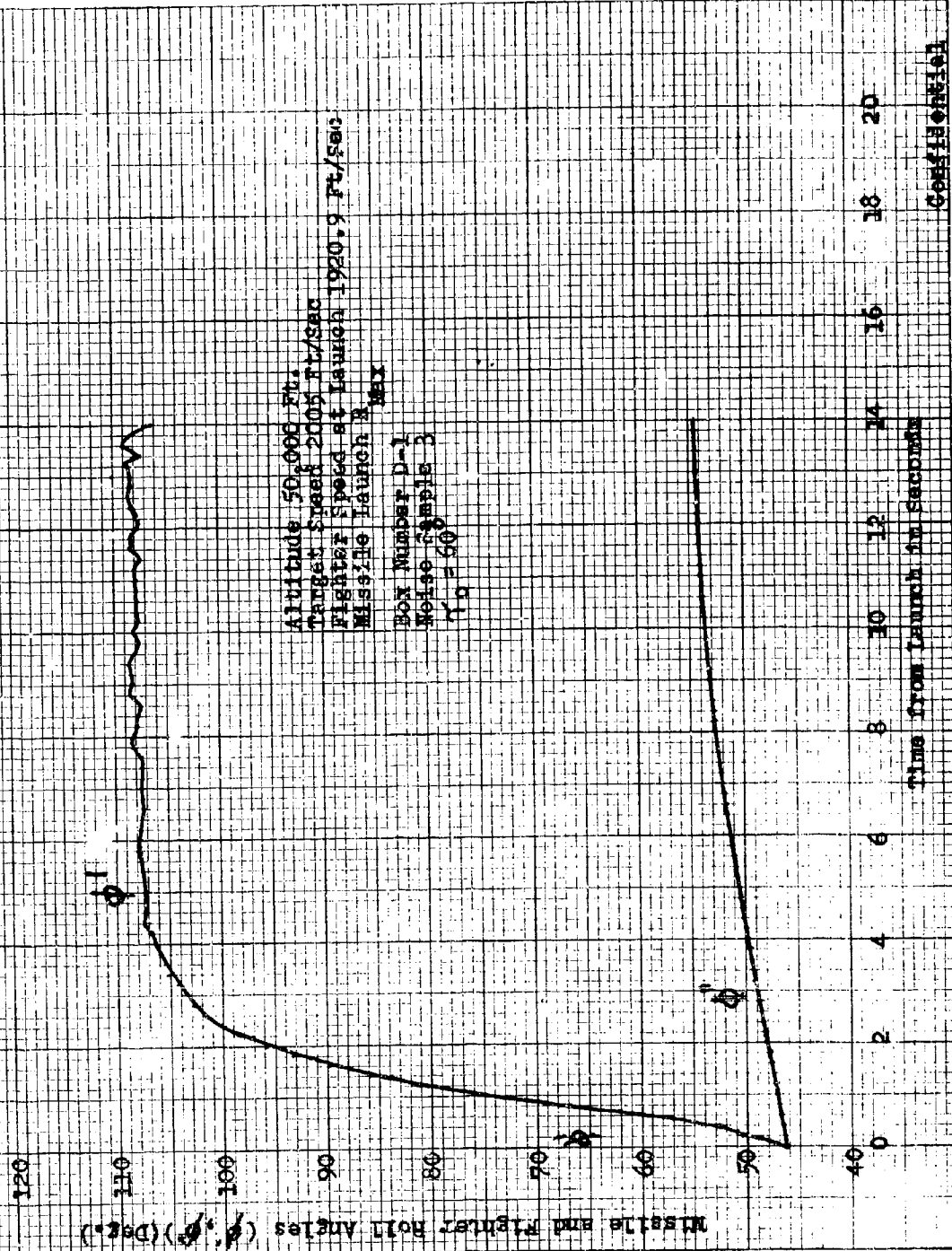
Missile Angle of Attack (α) (Deg.)

Time from Launch in Seconds

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Fig. 50 - Missile and Fighter Roll Angled vs Time
Co-Altitude Attacks - Unimproved Missiles



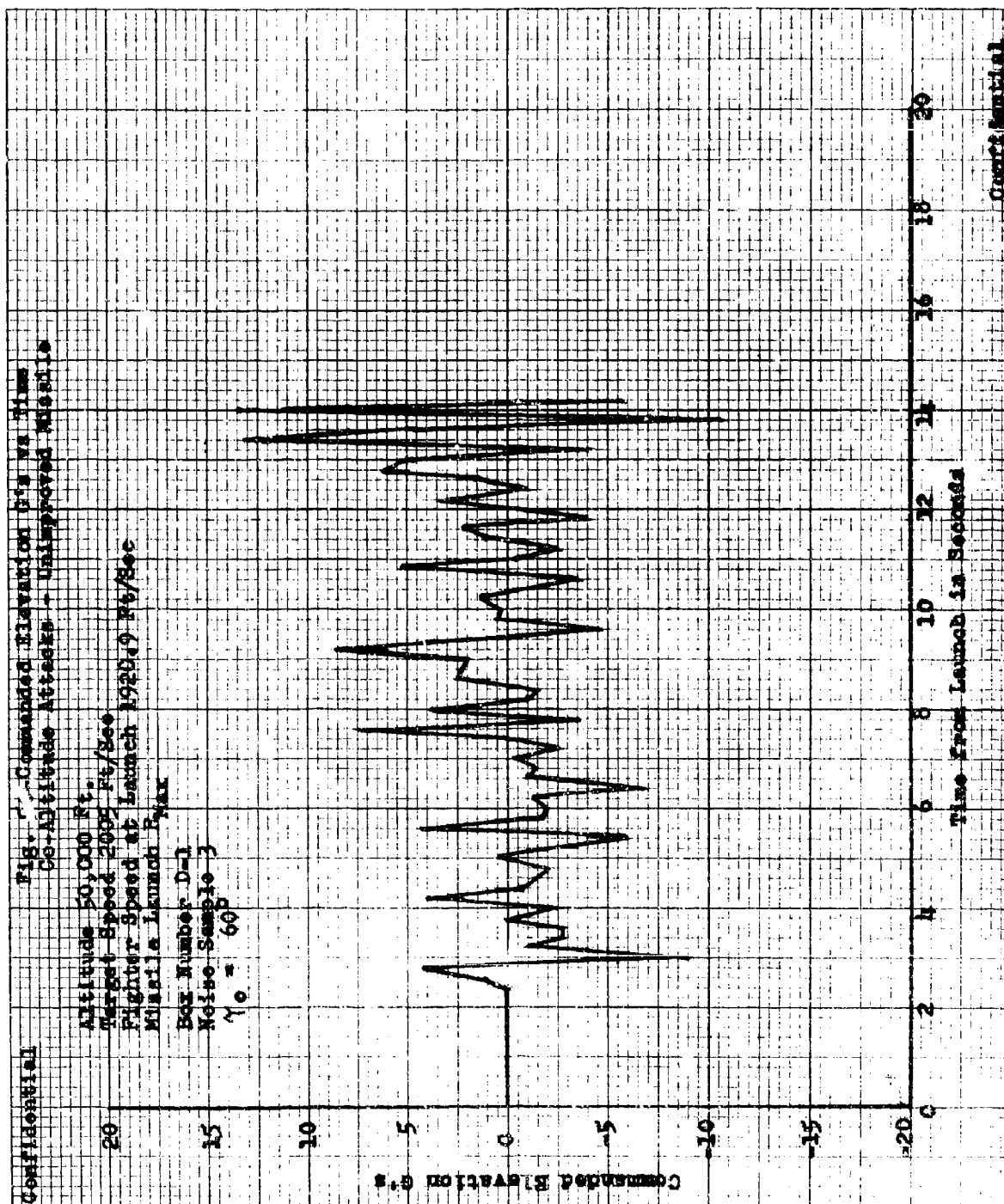
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Fig. 1. Commanded Elevation vs Time
Co-Altitude Attacks - Unimproved Missile

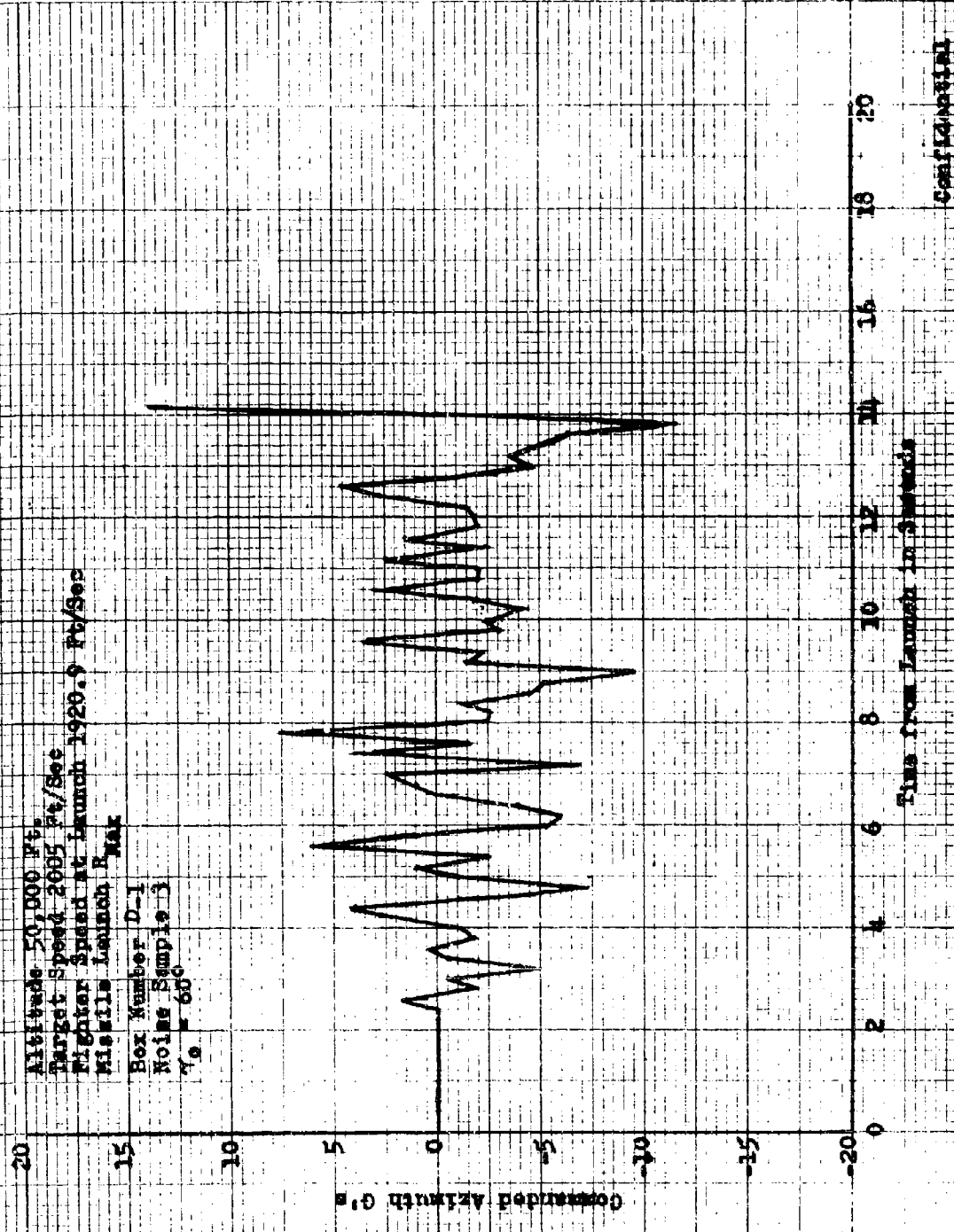
Altitude 50,000 Ft.
Target Speed 2000 Ft/Sec
Fighter Speed at Launch 1920.9 Ft/Sec
Missile Launch Range
Box Number D-1
Noise Sample 3
 $\gamma_0 = 60^\circ$



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Fig. 5a-Commanded Azimuth G's vs Time
Co-Altitude Attack-Unmanned Missile

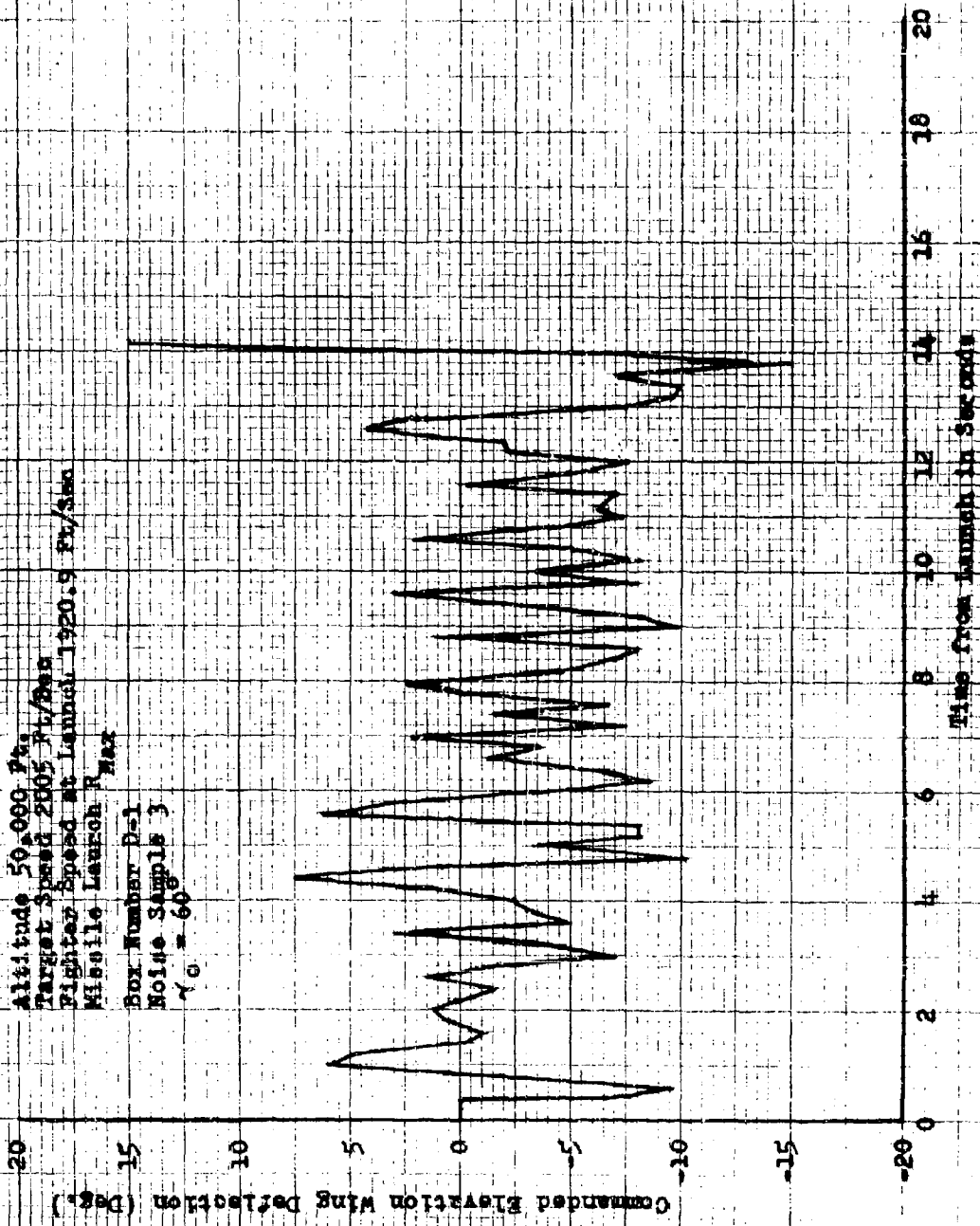


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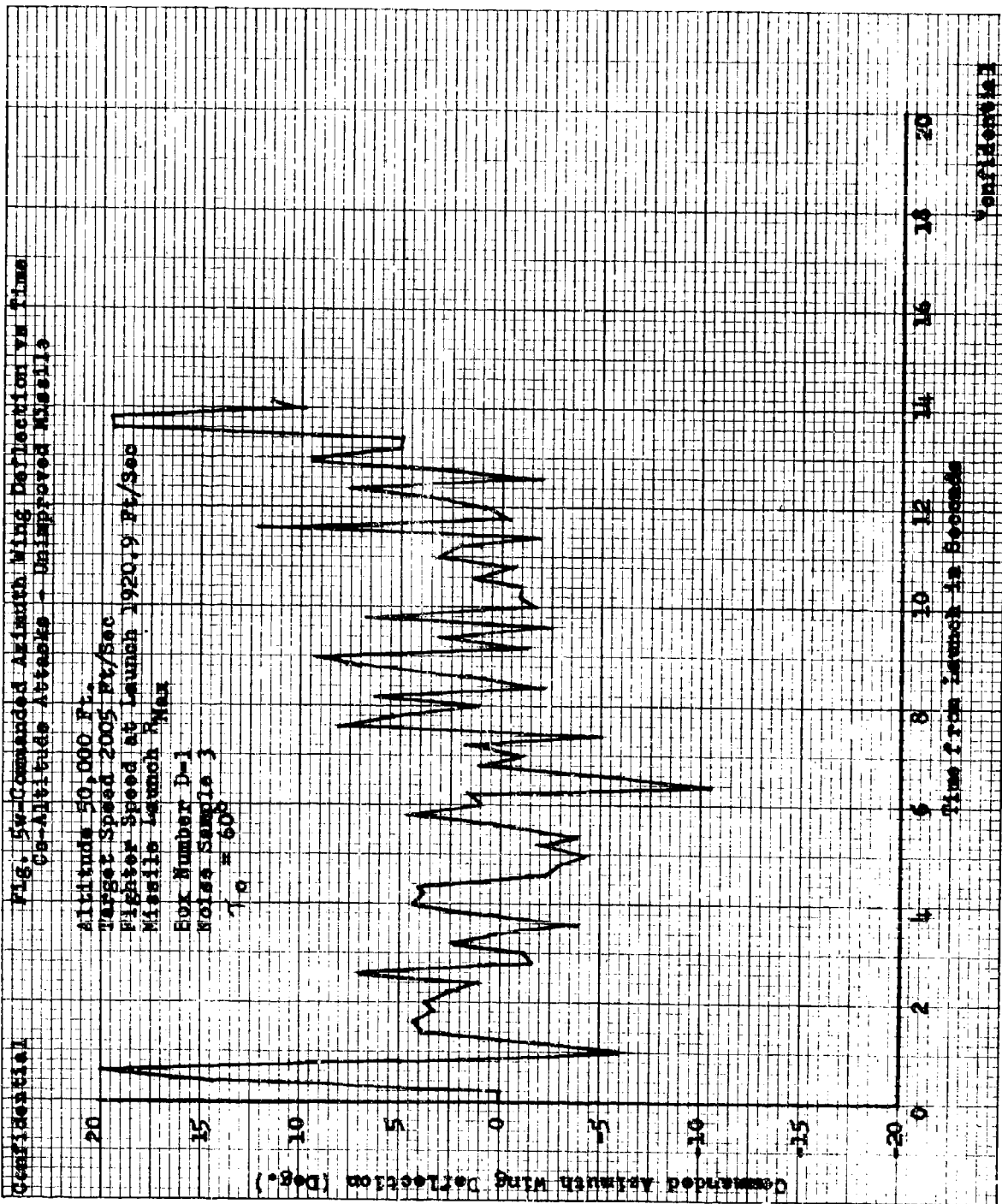
Fig. 5b-Commanded Elevation Wing Deflection vs Time
00-Altitude Attacks - Unimproved Missile

Altitude 50,000 Ft.
Target Speed 2805 Ft./Sec
Fighter Speed at Launch 1920.5 Ft./Sec
Missile Launch θ_{max}
Box Number D-1
Noise Sample 3
 $\gamma_0 = 60^\circ$



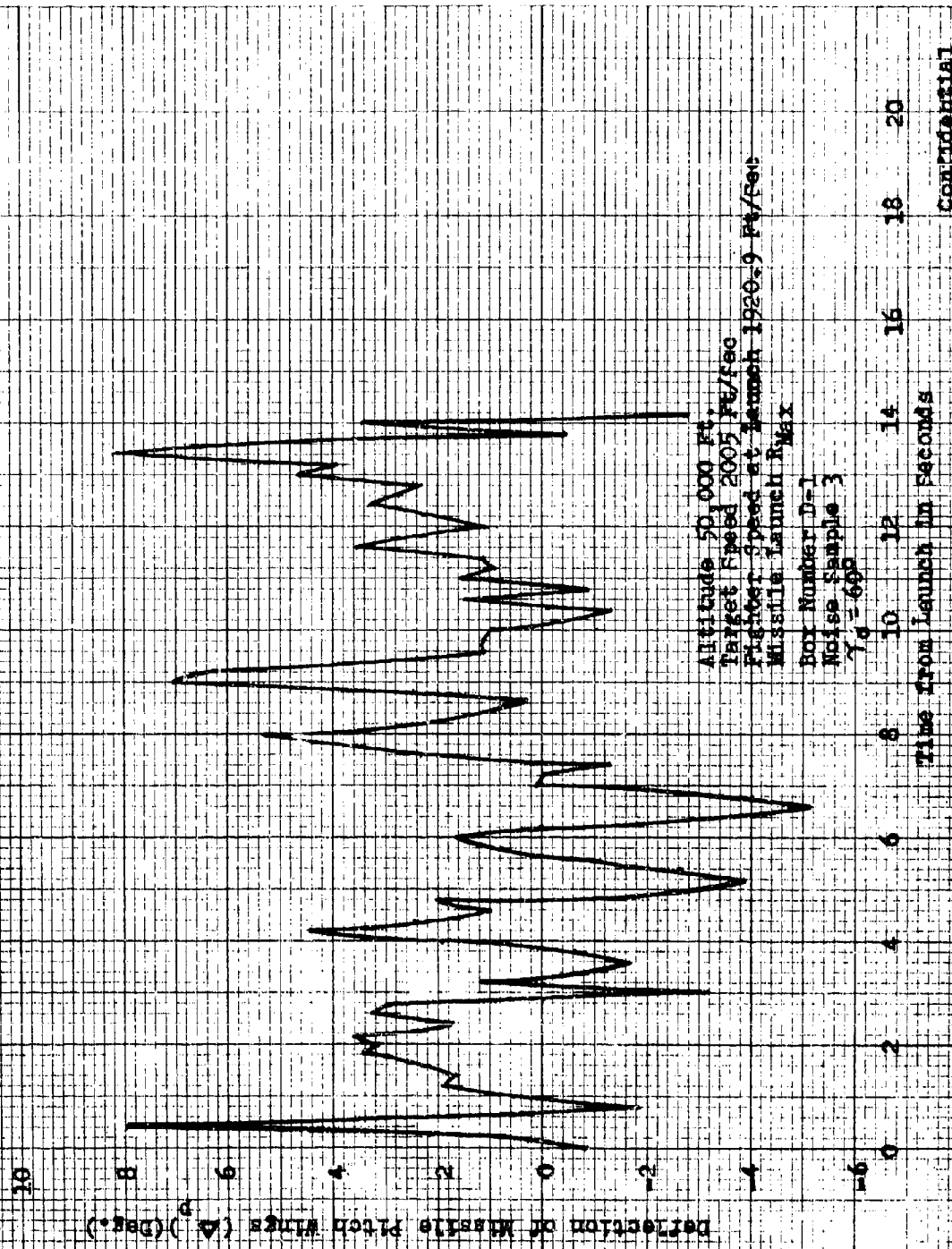
Time from Launch in Seconds

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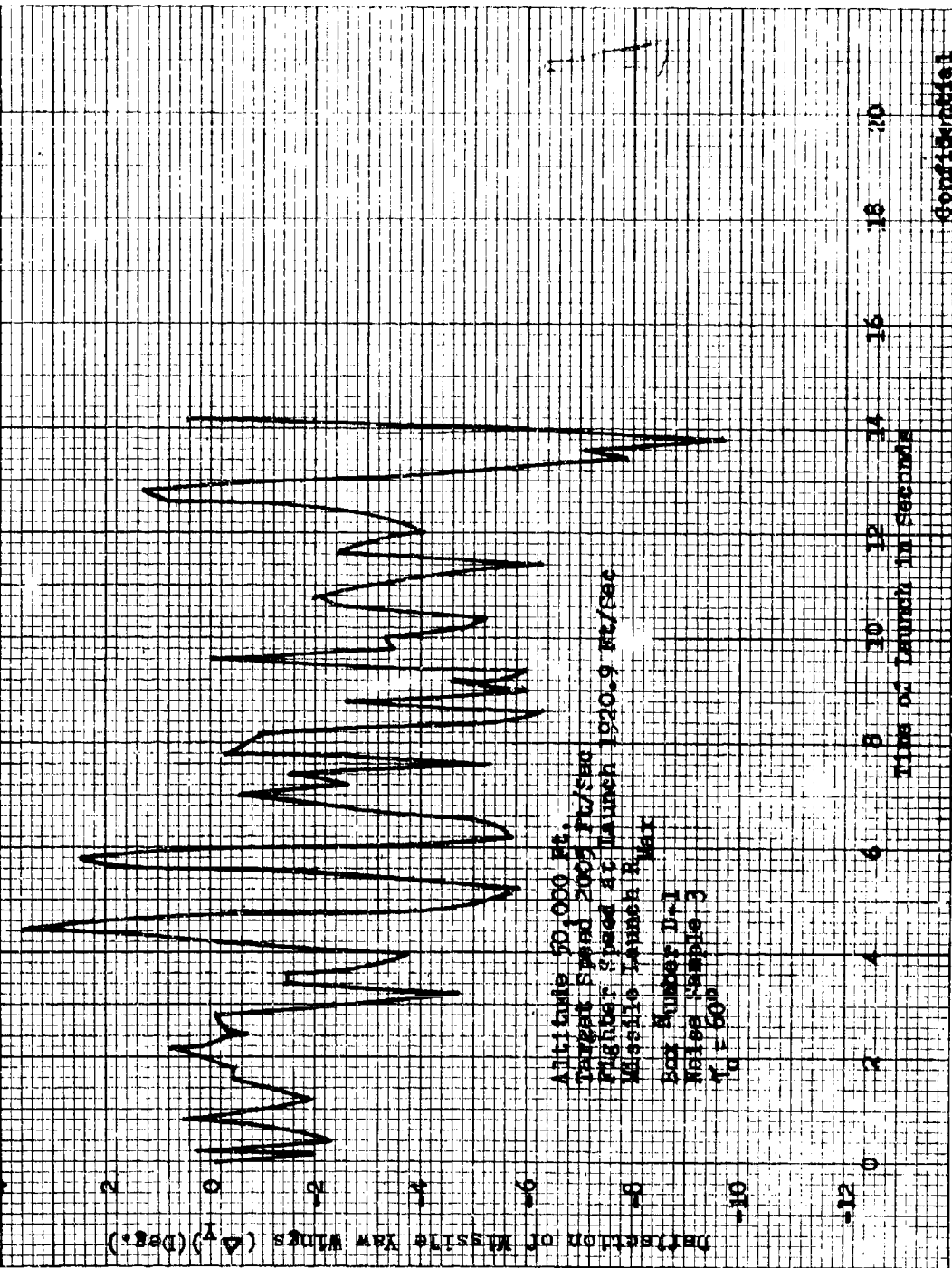
Fig. 5x - Deflection of Missile Pitch Wings vs Time
Co-Altitude Attacks - Unimproved Missile



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Fig. 57 - Deflection of Missile Yaw Wings vs Time
Go-Ahead Attack - Unapproved Missile



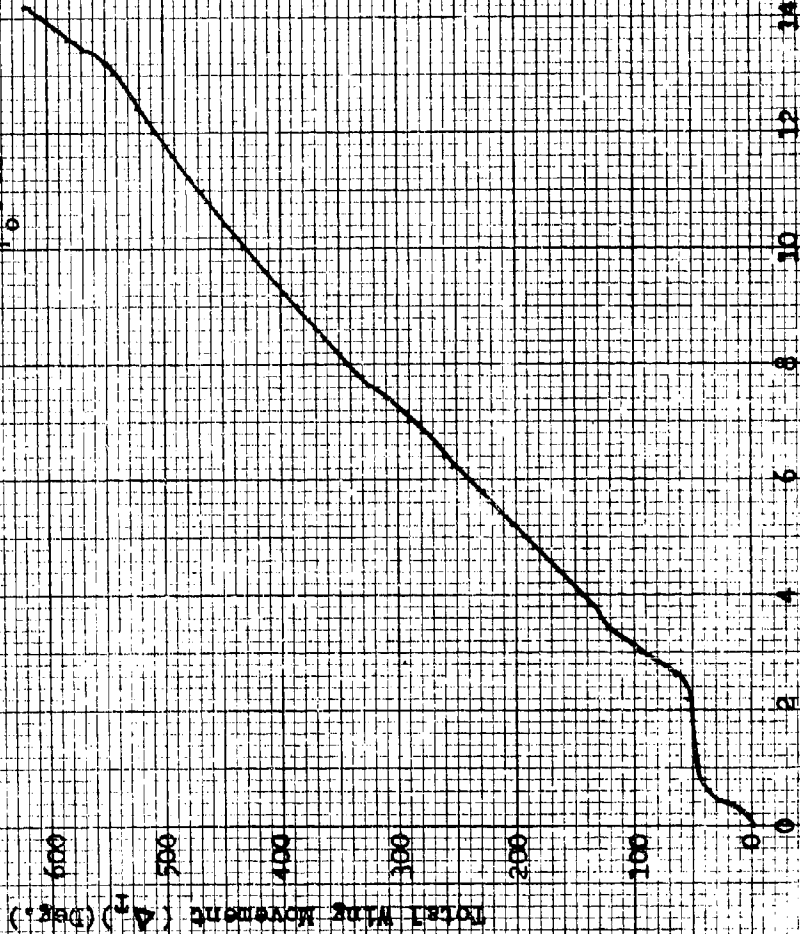
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Fig. 53 - Total Wing Movement vs Time
Coastal Air Attacks - Unimproved Missile

Altitude 50,000 Ft.
Target Speed 2005 Ft/Sec
Fighter Speed at Launch 1920.9 Ft/Sec
Missile Launch R Max
Box Number D-1
Noise Sample 3
 $r^2 = 600$

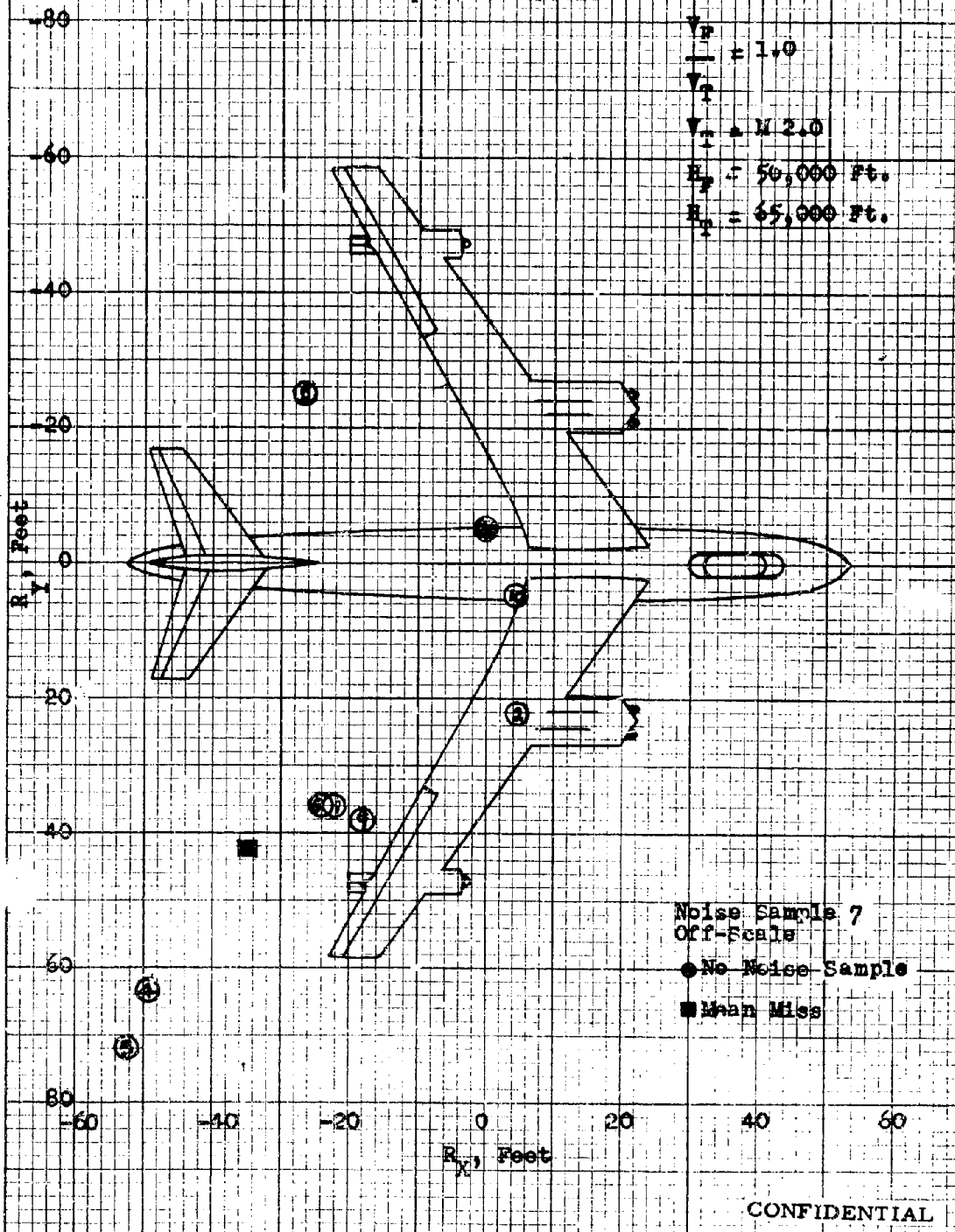


Time from Launch in Seconds

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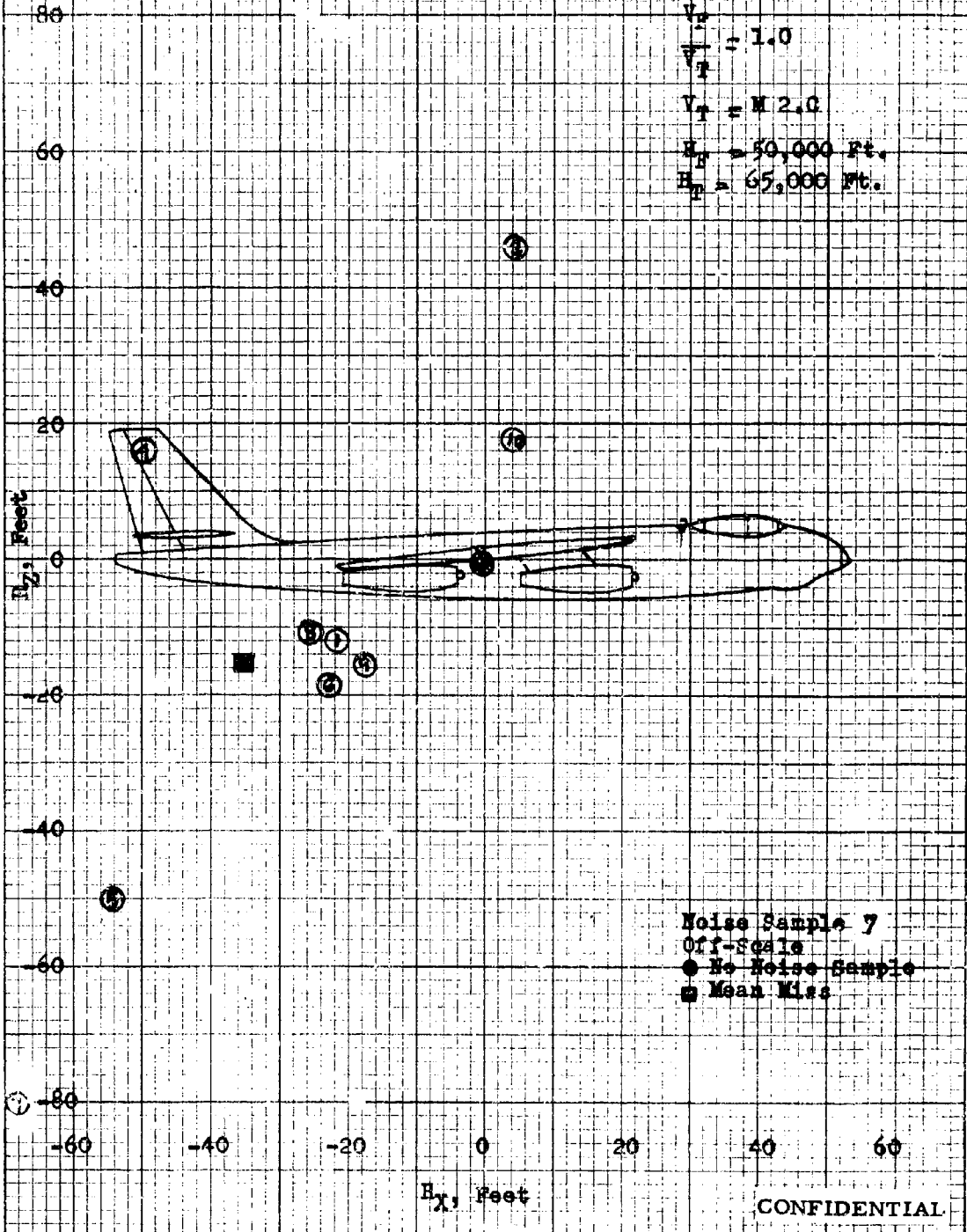
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Fig. 6a - Sparrow III Miss Distance - Pull-up Attacks
 X-Y Miss Distance at the Target
 $\gamma_0 = 0^\circ$, R_{LX} Launch, Fighter Course - C-5
 Unimproved Missile



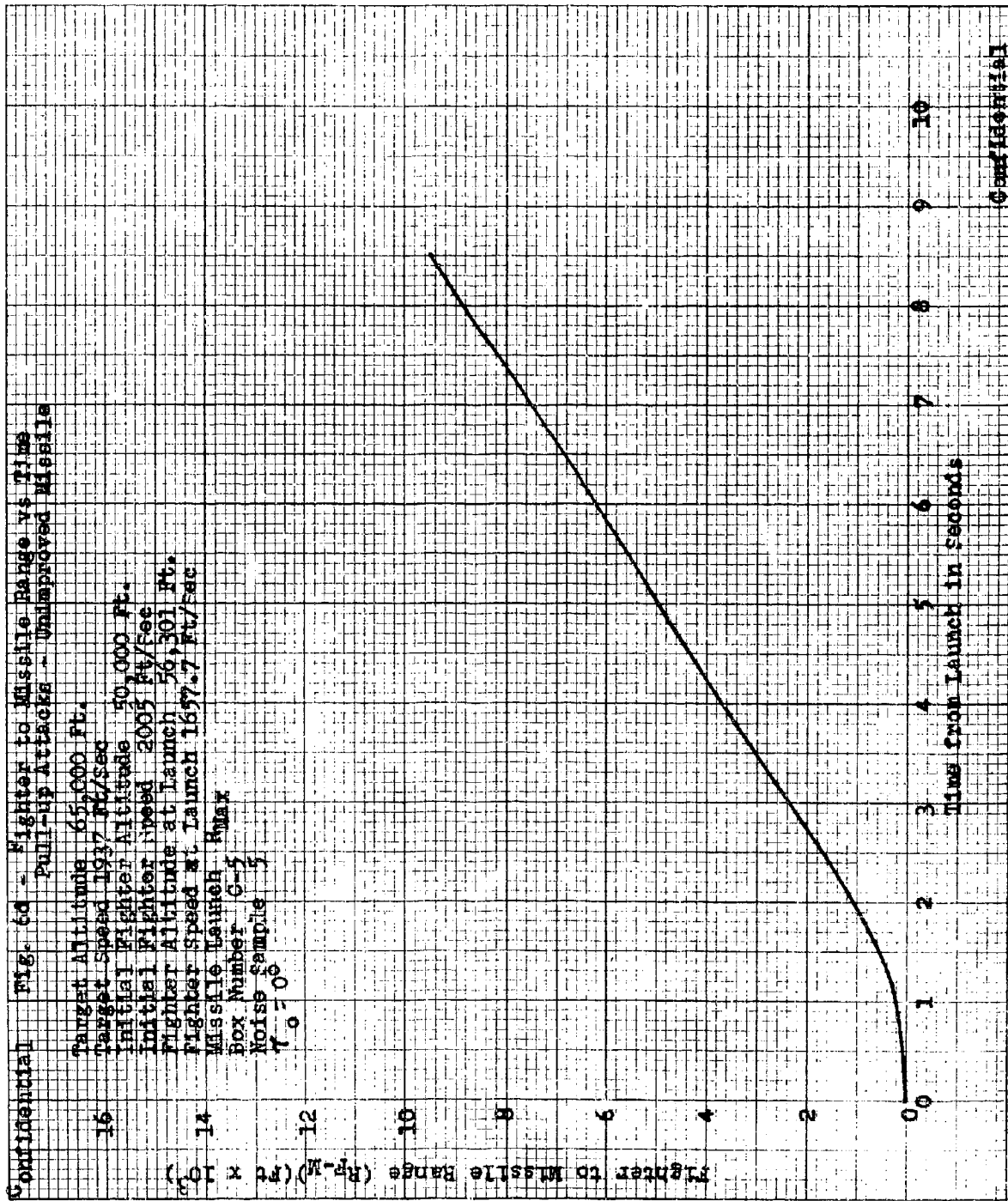
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Fig. 6b - Sparrow III Miss Distance - Pull-up Attacks
X-Z Miss Distance at the Target
 $\gamma_0 = 0^\circ$, R_{Max} Launch, Fighter Course - C-5
Unimproved Missile



K-E 10 X 10 TO THE INCH 359-5DG
KEUFFEL & ESSER CO. MADE IN U.S.A.

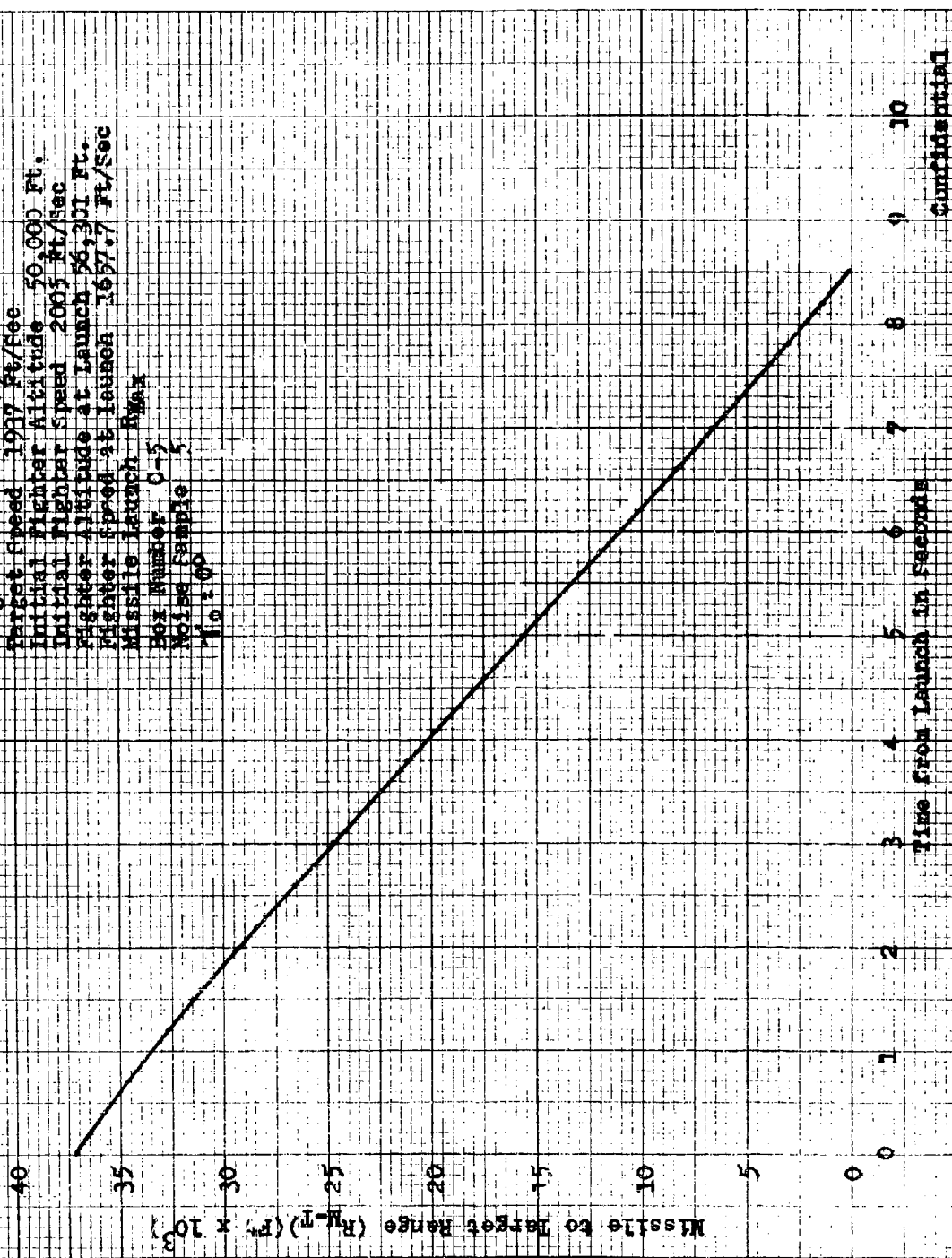
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Fig. 6a - Missile to Target Range vs Time
Full-on Attacks - Unimproved Missile

Target Altitude 65,000 Ft.
Target Speed 1937 Ft/Sec
Initial Fighter Altitude 50,000 Ft.
Initial Fighter Speed 2005 Ft/Sec
Fighter Altitude at Launch 56,351 Ft.
Fighter Speed at launch 1637.7 Ft/Sec
Missile launch Range
Box Number 0-5
Noise Sample 5
T₀:00



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Fig. 67. Fighter to Target Range vs Time
Pull-up Attacks - Unimproved Missile

Target Altitude 65,000 Ft.
Target Speed 1937 Ft./sec
Initial Fighter Altitude 50,000 Ft.
Initial Fighter Speed 2005 Ft./sec
Fighter Altitude at Launch 56,301 Ft.
Fighter Speed at Launch 1657.2 Ft./sec
Missile Launch Angle

Box Number C-5
House Sample 3
N 5-80

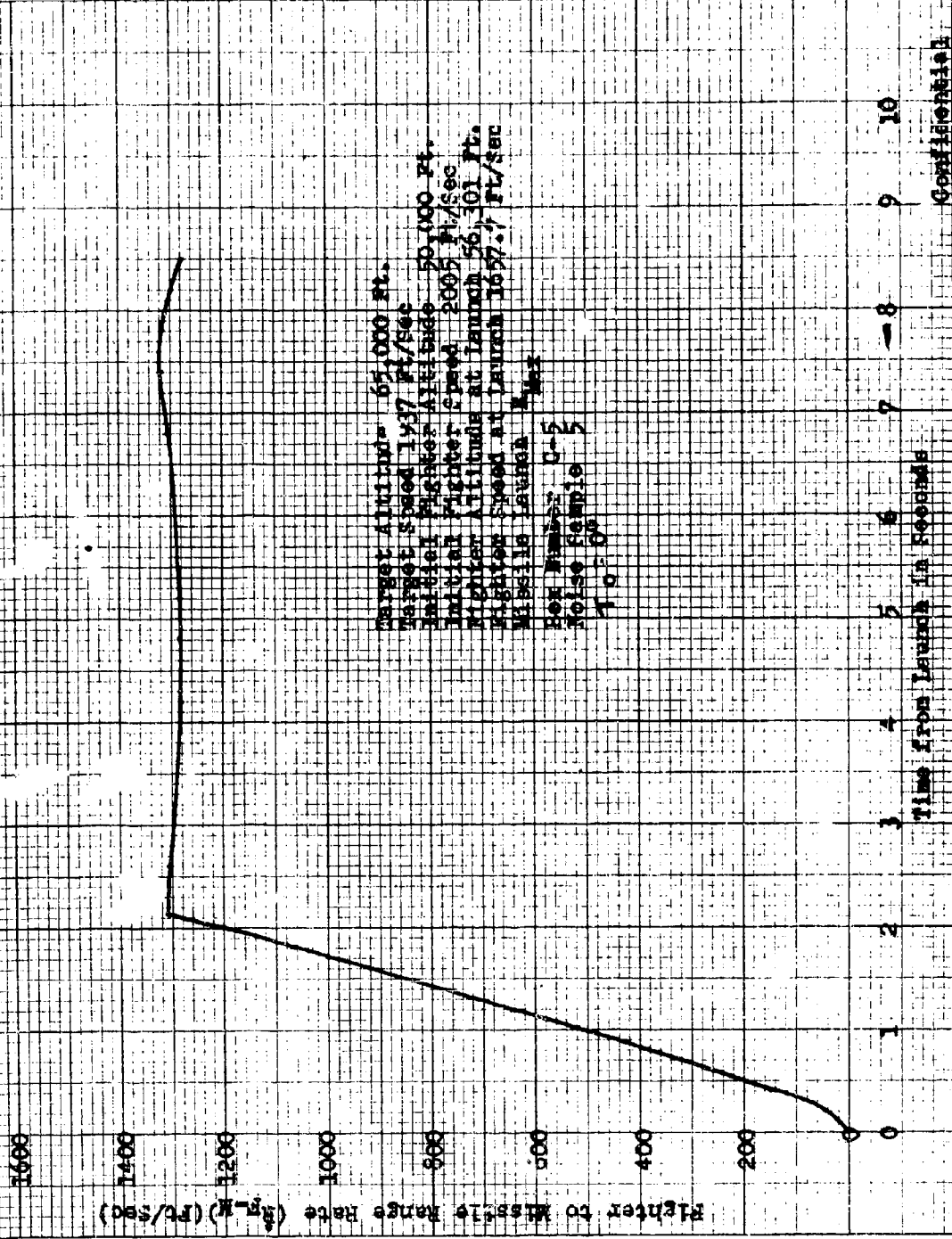
Fighter to Target Range (R_{F-T}) (Ft x 10^3)

Time from Launch in Seconds

Confidential

Confidential

Fig. 68- Fighter to Missile Range Rate vs Time
Pull-up Attack - Unpowered Missile



Confidential



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Fig. 6h- Missile to Target Range Rate vs Time
Pull-up Attacks - Unimproved Missile

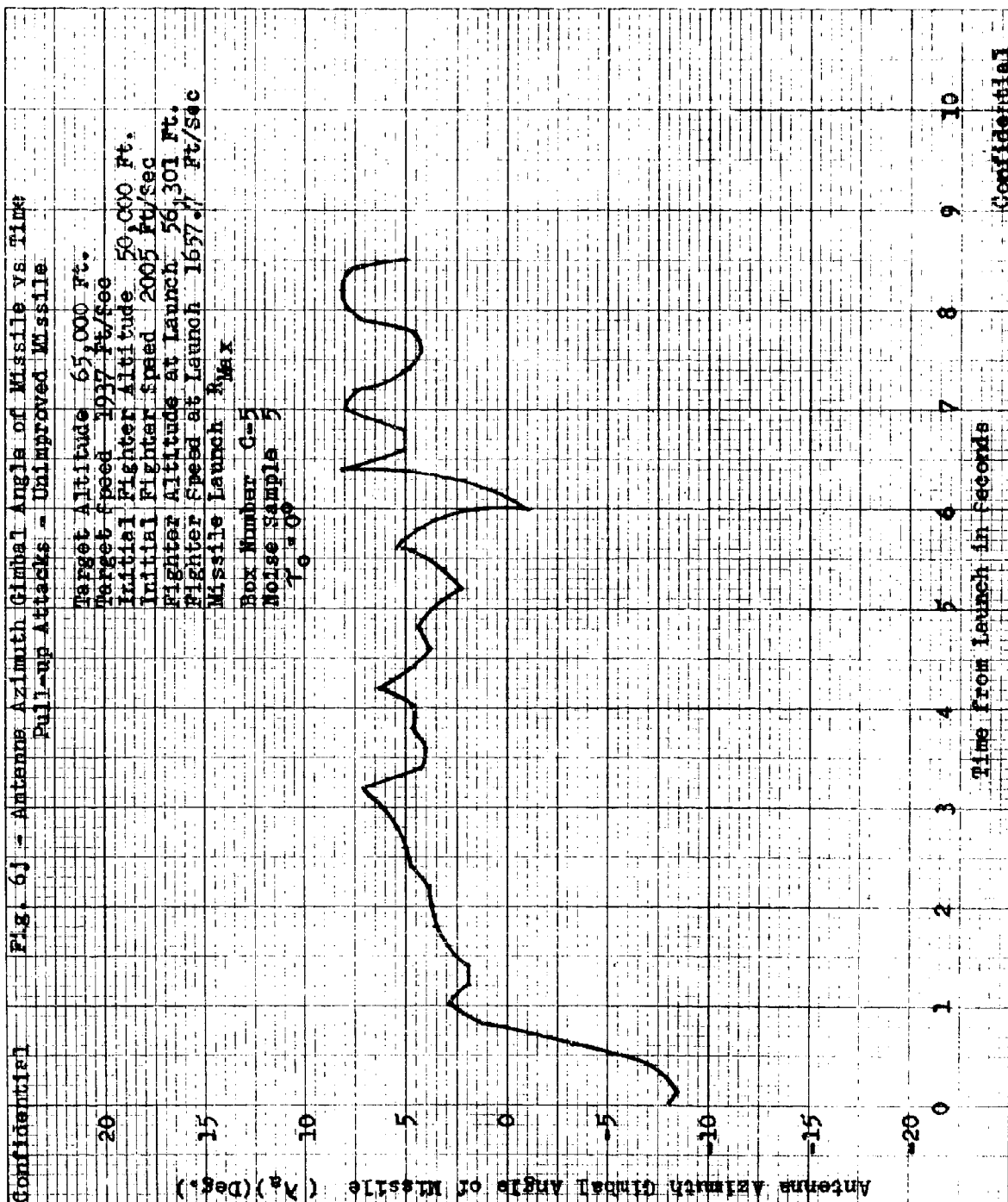
Target Altitude 65,000 Ft.
Target Speed 1337 Ft/Sec
Initial Fighter Altitude 50,000 Ft.
Initial Fighter Speed 2005 Ft/Sec
Fighter Altitude at Launch 56,201 Ft.
Fighter Speed at Launch 1557.1 Ft/Sec
Missile Launch Box

Box Number C-5
Noise Sample 5
 $\gamma_0 = 0$

Missile to Target Range Rate (ft/sec)
-3200
-3600
-4000
-4400
-4800

Time from Launch in Seconds
0 1 2 3 4 5 6 7 8 9 10

Confidential



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Fig. 6x - Antenna Elevation Gimbal Angle of Missile vs Time
Full-up Attacks - Unimproved Missile

Target Altitude 65,000 Ft.
Target Speed 1937 Ft/sec
Initial Fighter Altitude 50,000 Ft.
Initial Fighter Speed 2005 Ft/sec
Fighter Altitude at launch 36,301 Ft.
Fighter Speed at launch 1657.7 Ft/sec
Missile launch Max

Box Number C-5
Noise Sample
40

Antenna Elevation Gimbal Angle of Missile ($^{\circ}$)

10
5
0
-5
-10
-15
-20
-25
-30

Time from Launch in Seconds

10

9

8

7

6

5

4

3

2

1

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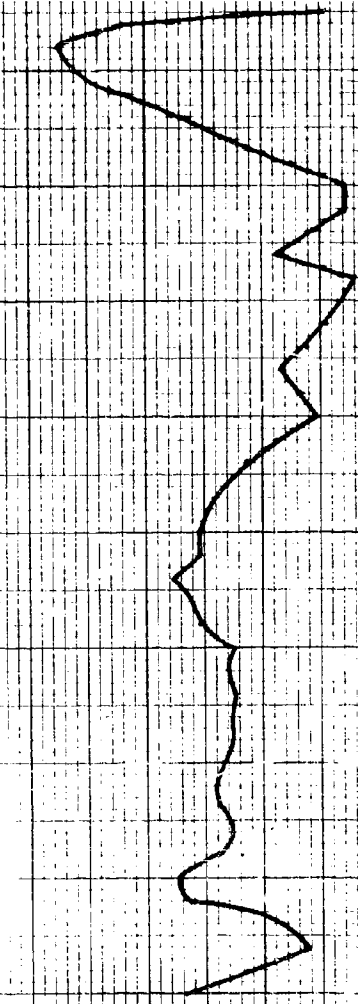
Confidential

Fig. 6-1 - Missile Lead Angle vs Time
Pull-up Attacks - Unimproved Missile

Target Altitude 65,000 Ft.
Target Speed 1937 Ft/Sec
Initial Fighter Altitude 50,000 Ft.
Initial Fighter Speed 2005 Ft/Sec
Fighter Altitude at Launch 56,301 Ft.
Fighter Speed at Launch 1657.7 Ft/Sec
Missile Launch Max
Box Number C-5
Noise Sample 5
7 0 - 0 0

Missile Lead Angle (°) (Deg.)

40
35
30
25
20
15
10
5
0



Time from Launch in seconds

10

9

8

7

6

5

4

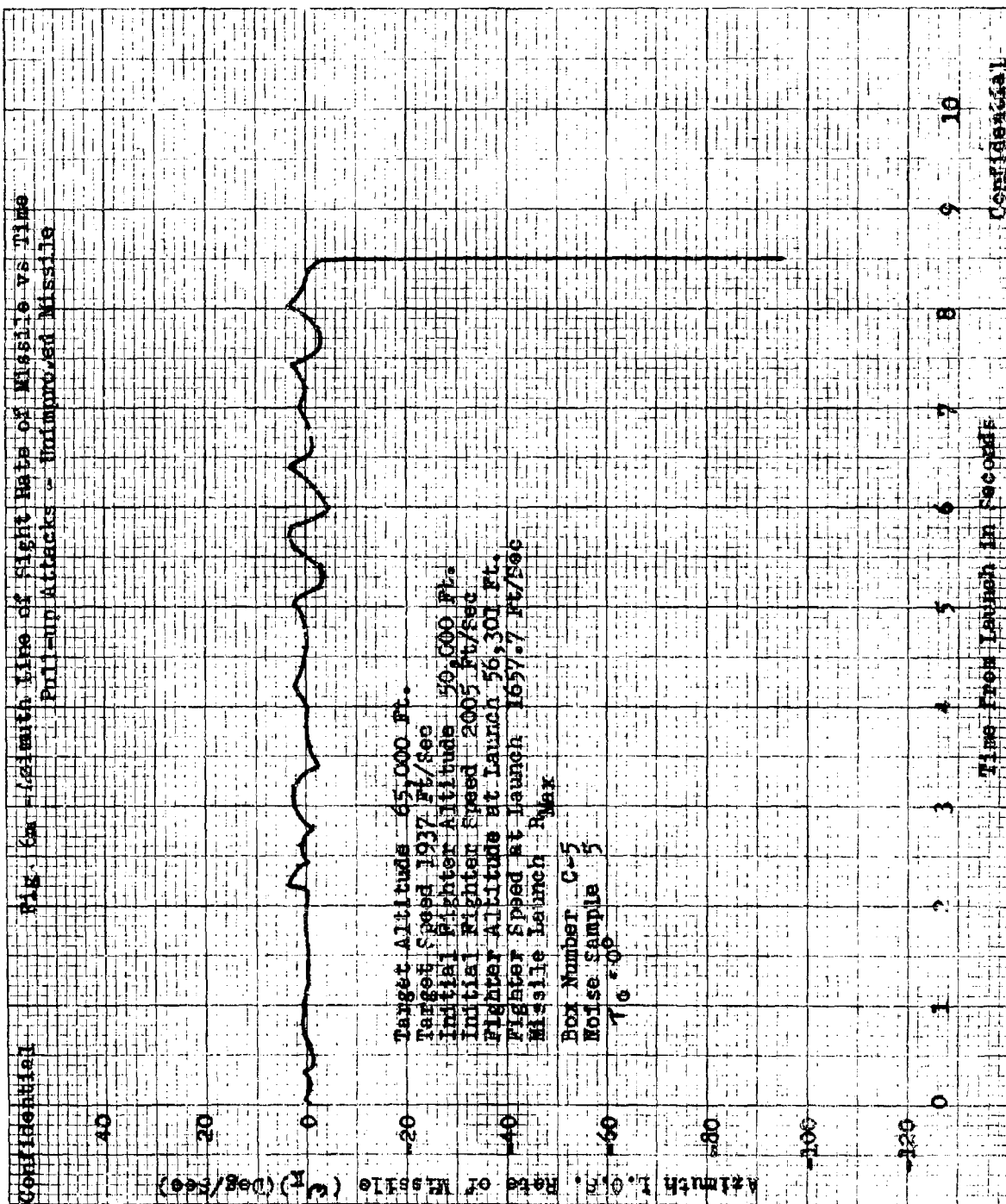
3

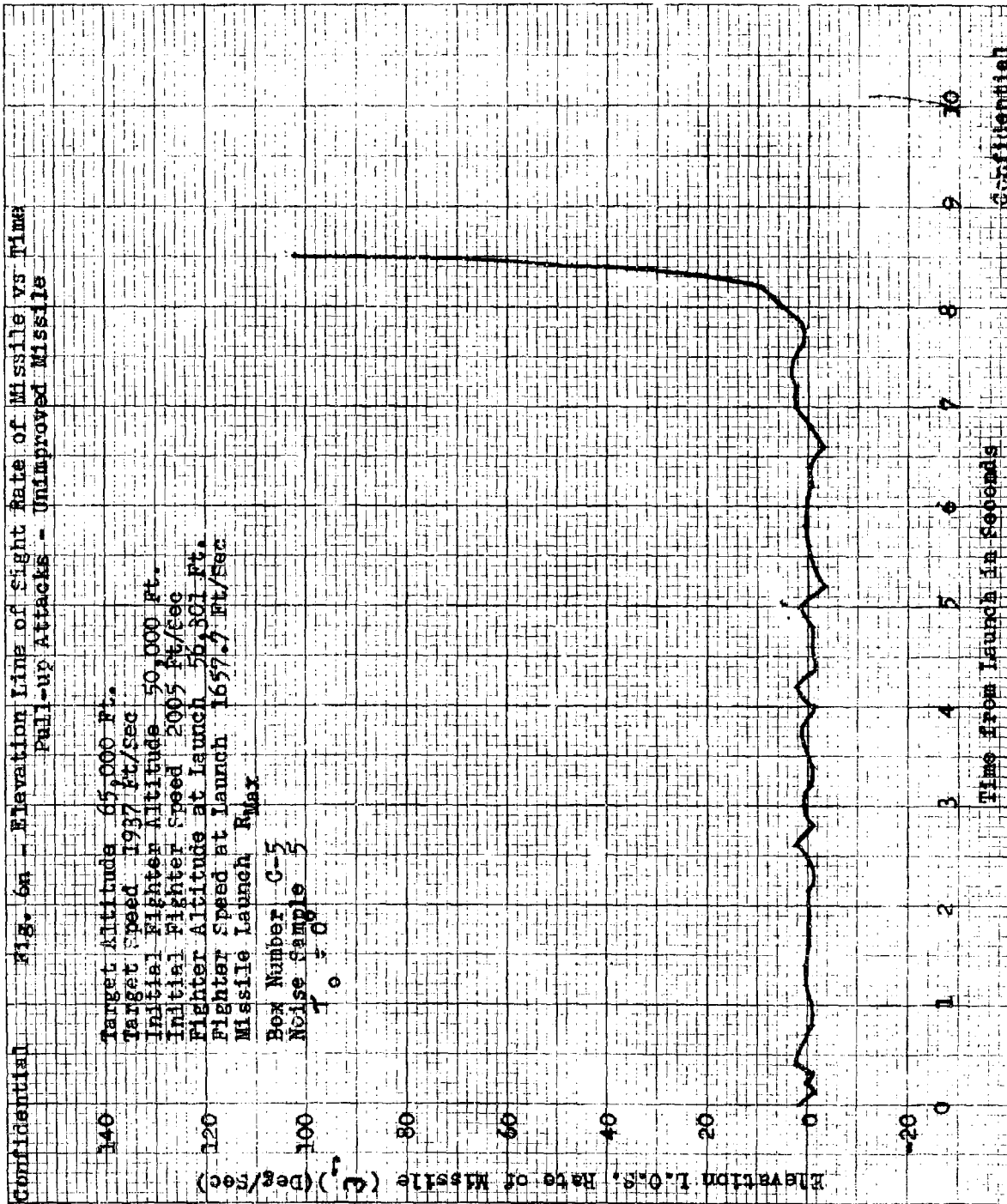
2

1

0

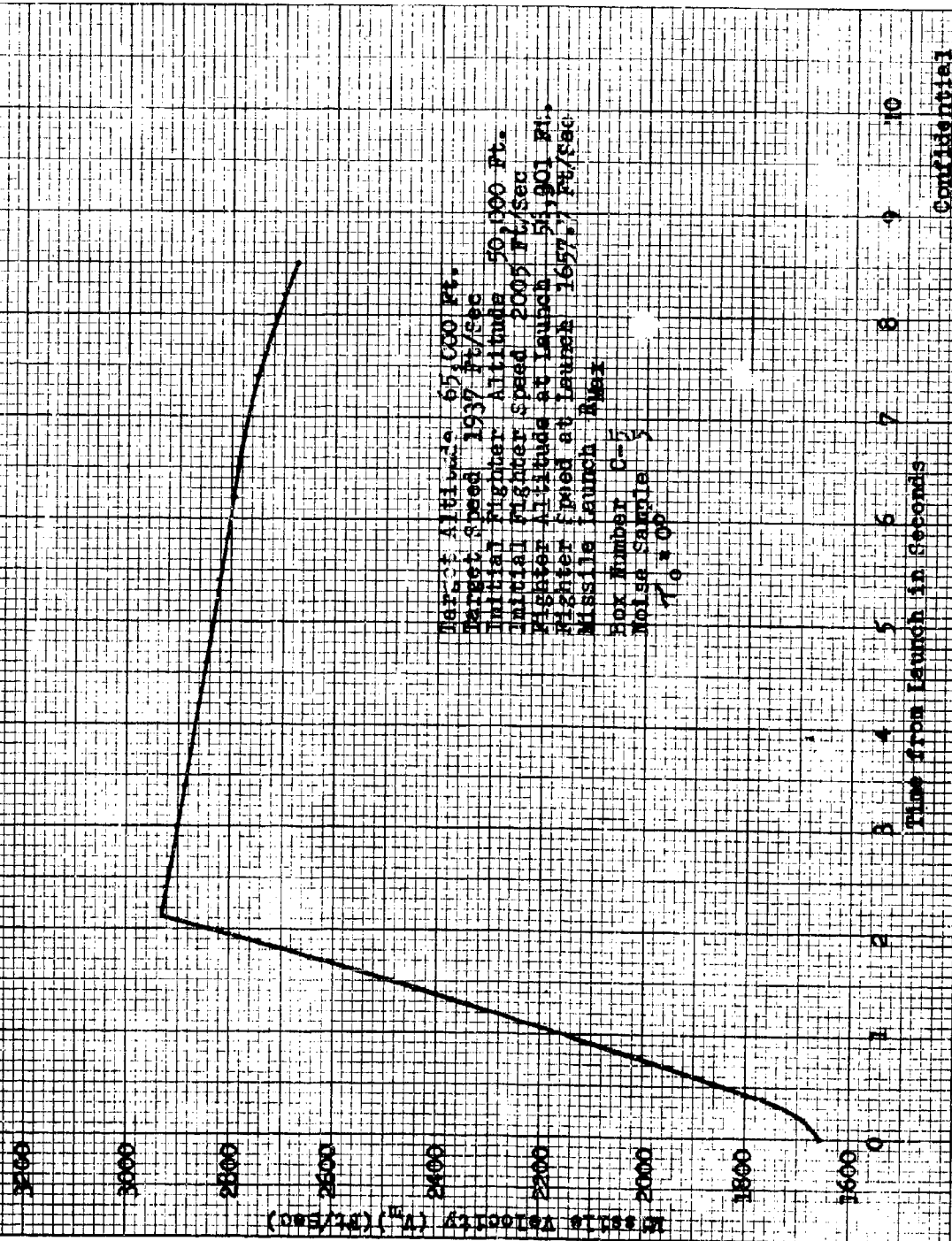
Confidential



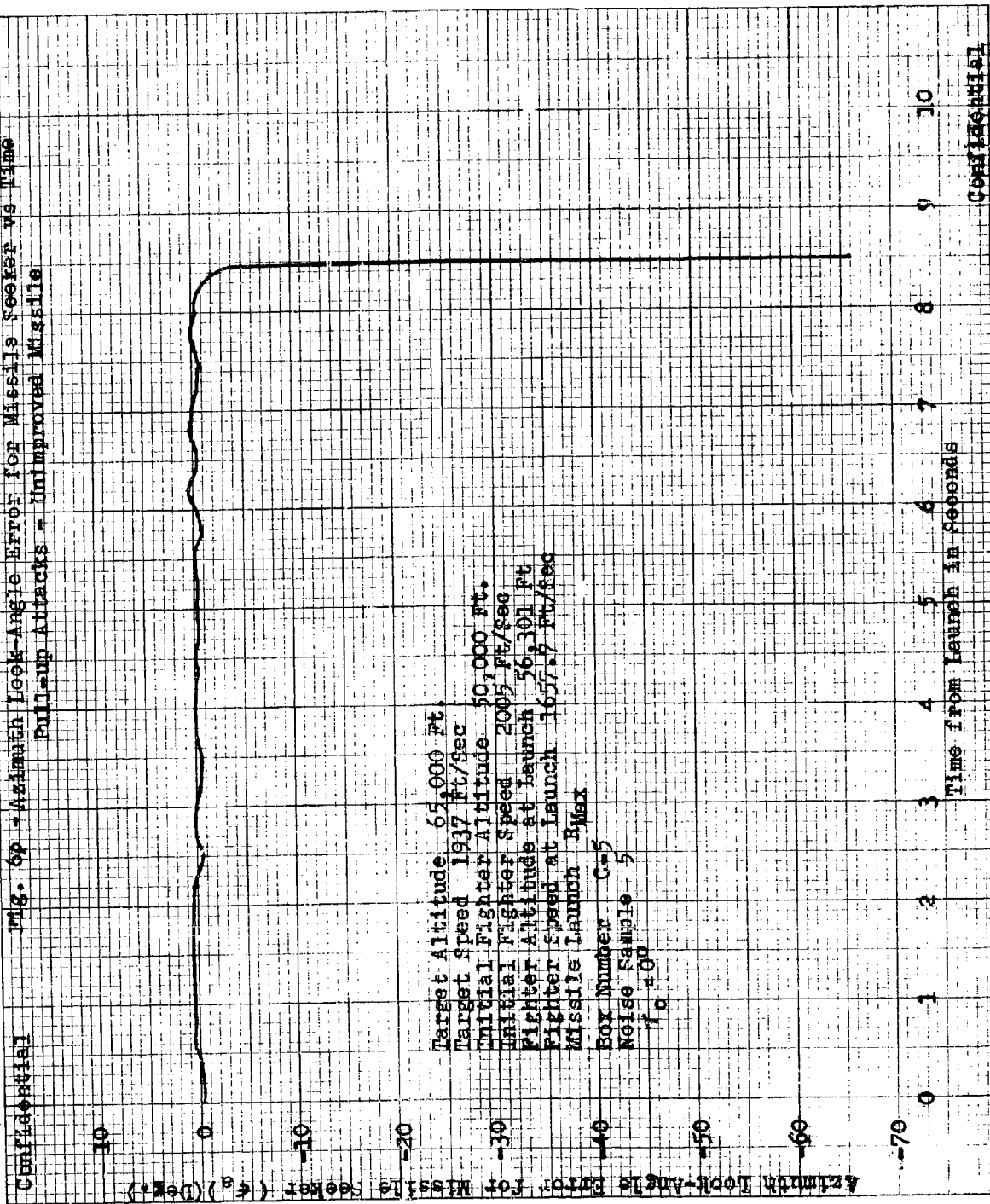


Confidential

Fig. 60 - Missile Velocity vs Time
Pull-up Attacks - Improved Missile



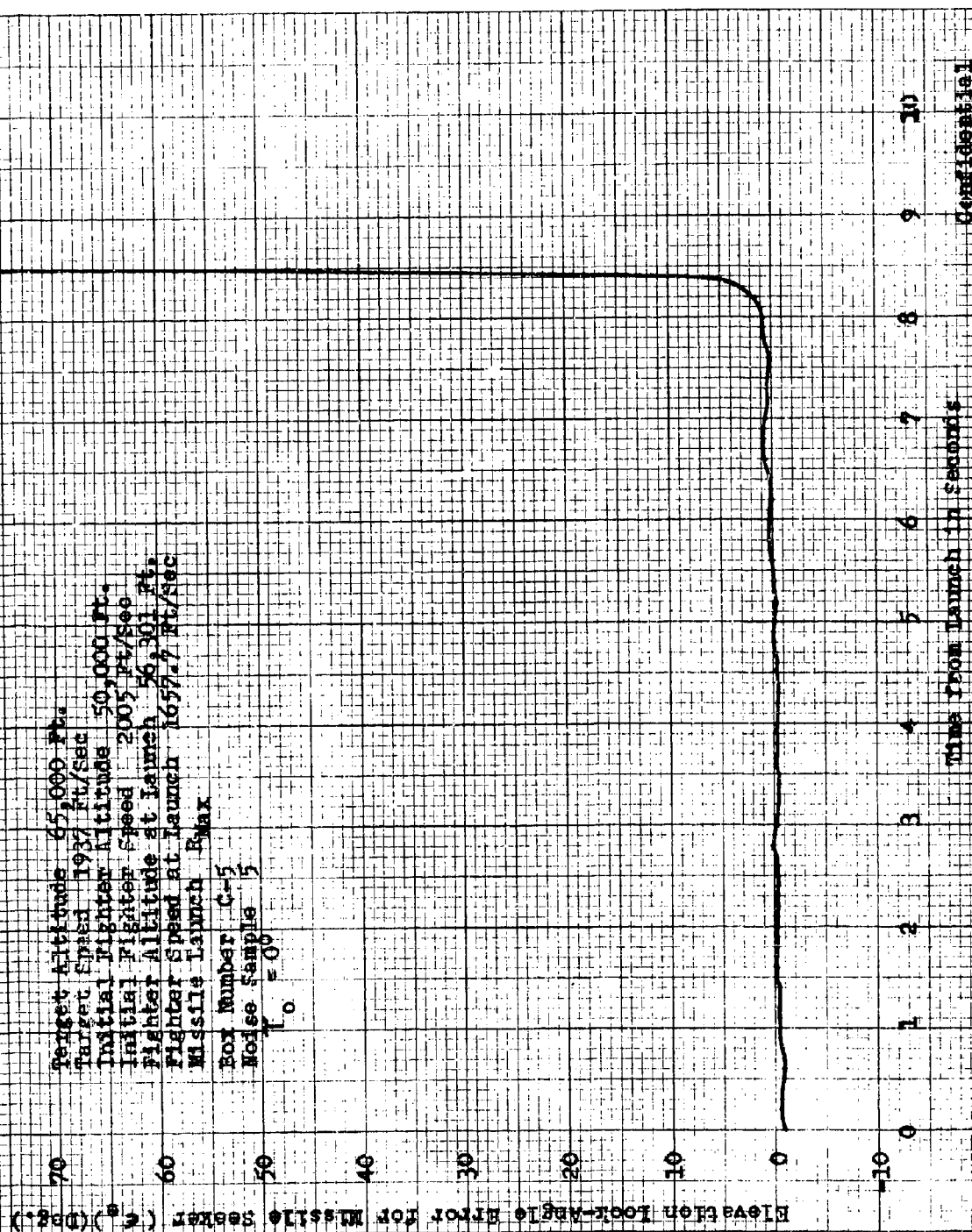
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Fig. 60 - Elevation Look-Angle Error for Missile Seeker vs Time
Pull-up Attacks - Improved Missile



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Fig. 6r - Missile Angle of Attack vs Time
Pull-up Attacks - Unimproved Missile

Target Altitude 65,000 Ft.
Target Speed 1937 Ft/sec
Initial Fighter Altitude 50,000 Ft.
Initial Fighter Speed 2005 Ft/sec
Fighter Altitude at Launch 56,301 Ft.
Fighter Speed at Launch 1657.7 Ft/sec
Missile Launch Error

Box Number C-5
Noise Sample 5
To

Missile Angle of Attack (α) (Deg.)

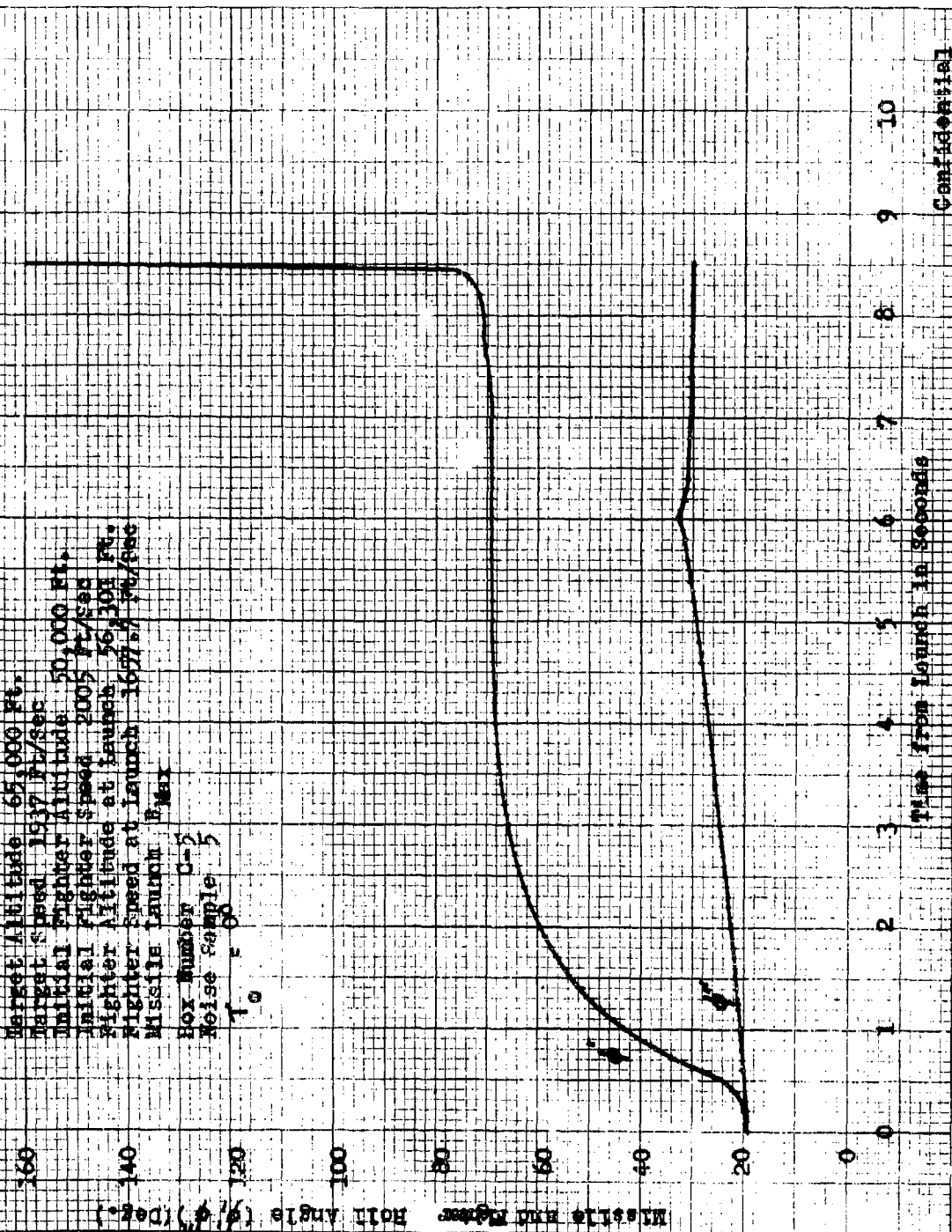
Time from Launch in seconds

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Fig. 5a. Missile and Fighter Roll Angle vs Time
Full-up Attack - Improved Missile

Target Altitude 65,000 Ft.
Target Speed 1937 Ft/Sec
Initial Fighter Altitude 50,000 Ft.
Initial Fighter Speed 2005 Ft/Sec
Fighter Altitude at Launch 56,101 Ft.
Fighter Speed at Launch 1677.4 Ft/Sec
Missile Launch E Max
Box Number C-2
Noise Sample 5
10

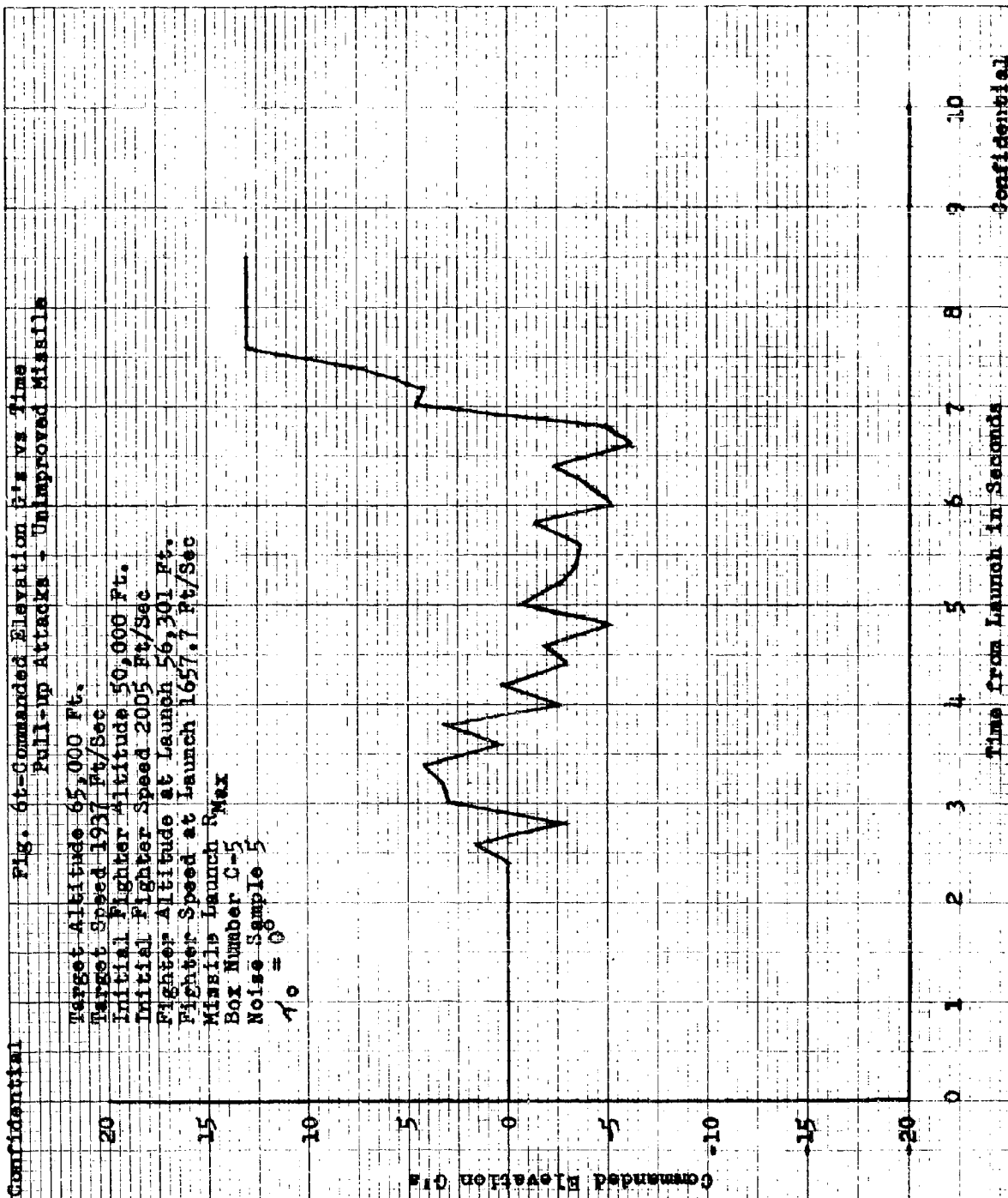


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Fig. 6t-Commanded Elevation 7's vs Time
Pull-up Attacks - Unimproved Missile

Target Altitude 65,000 Ft.
Target Speed 1937 Ft/Sec
Initial Fighter Altitude 50,000 Ft.
Initial Fighter Speed 2005 Ft/Sec
Fighter Altitude at Launch 56,301 Ft.
Fighter Speed at Launch 1657.7 Ft/Sec
Missile Launch 5 Max
Box Number C-5
Noise Sample 5
10 = 0



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Fig. 6a-Commanded Altitude G's vs Time
Pull-up Attack - Unimproved Missile

Targed Altitude 65,000 Ft.
Targed Speed 1937 Ft/Sec
Initial Fighter Altitude 50,000 Ft.
Initial Fighter Speed 2005 Ft/Sec
Fighter Altitude at Launch 56,101 Ft.
Fighter Speed at Launch 1657.7 Ft/Sec

Missile Launch Max

Box Number 3-5

Noise Sample 5

$\gamma = 0$

Commanded Altitude G's

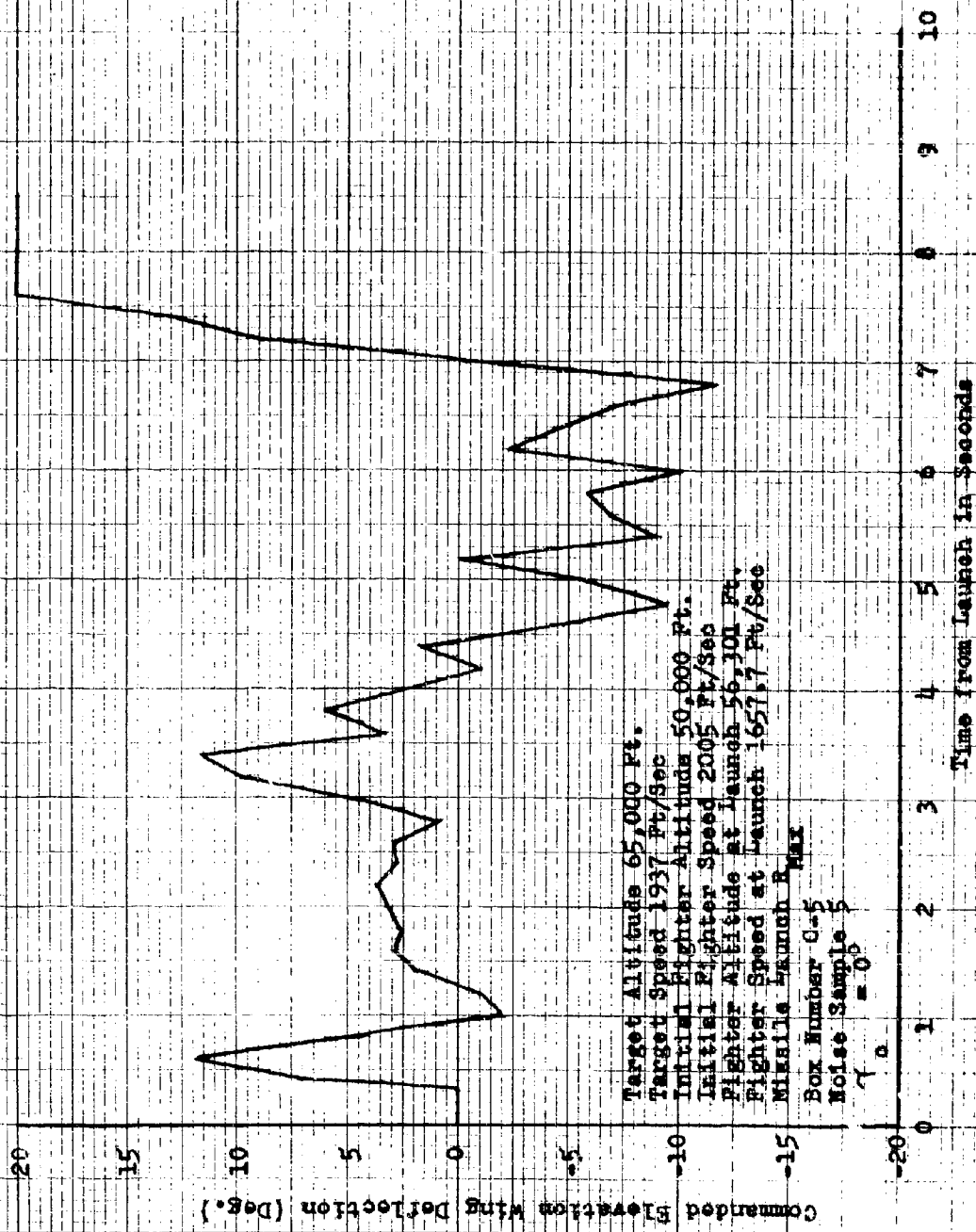
Time from Launch in Seconds

Confidential

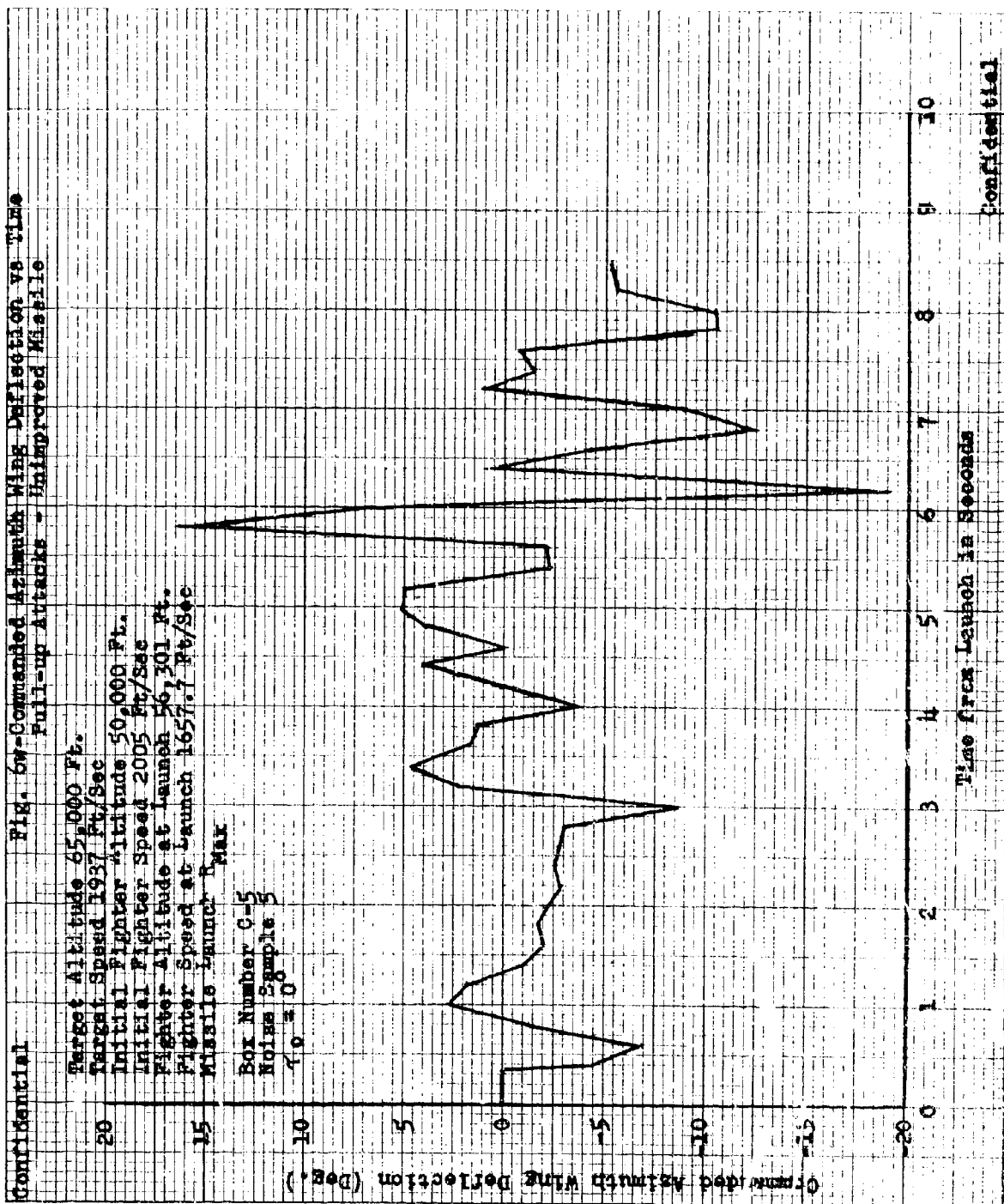


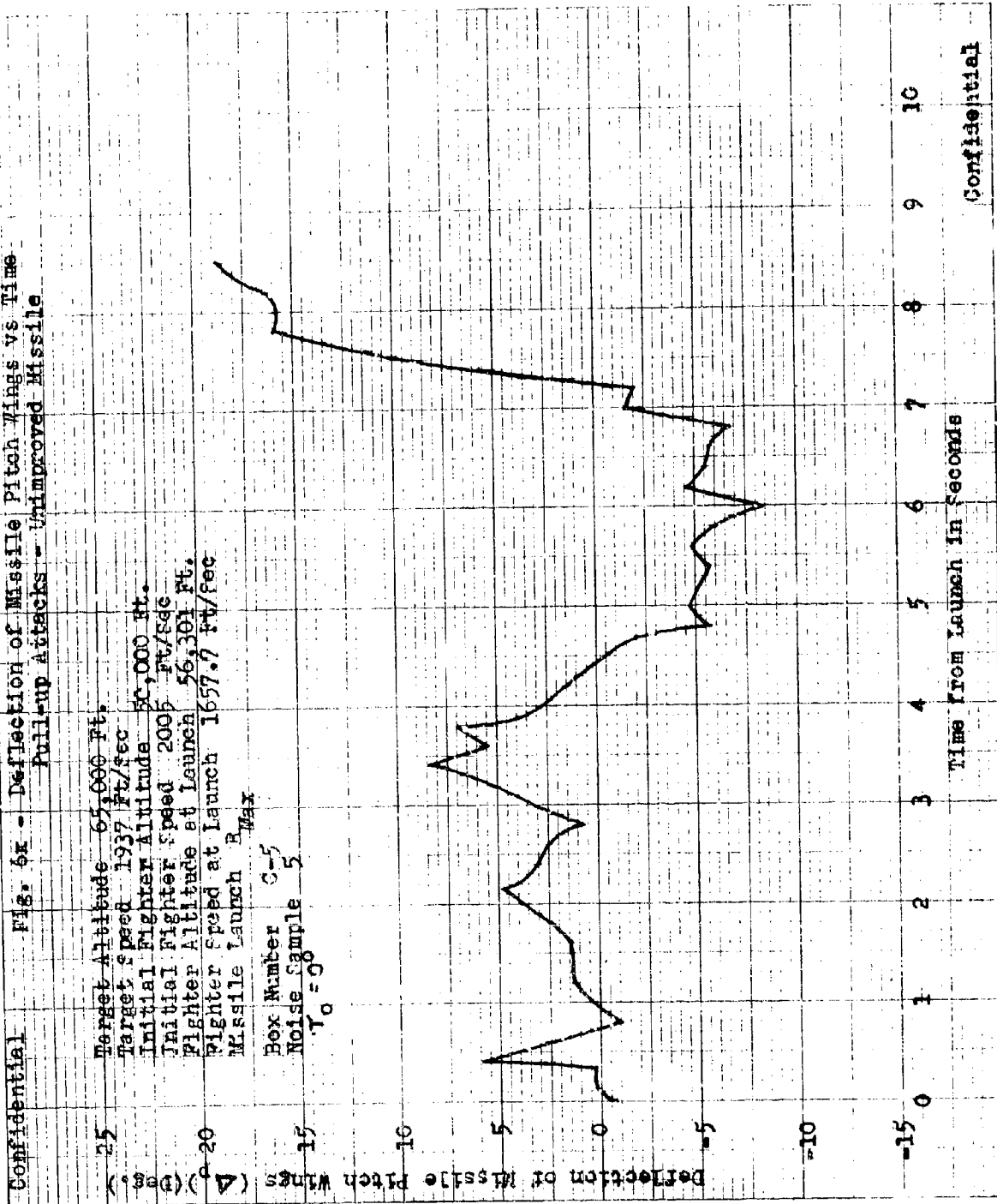
Confidential

Fig 6v-Commanded Elevation Wing Deflection vs Time
Pull-up Attacks - Unimproved Missile



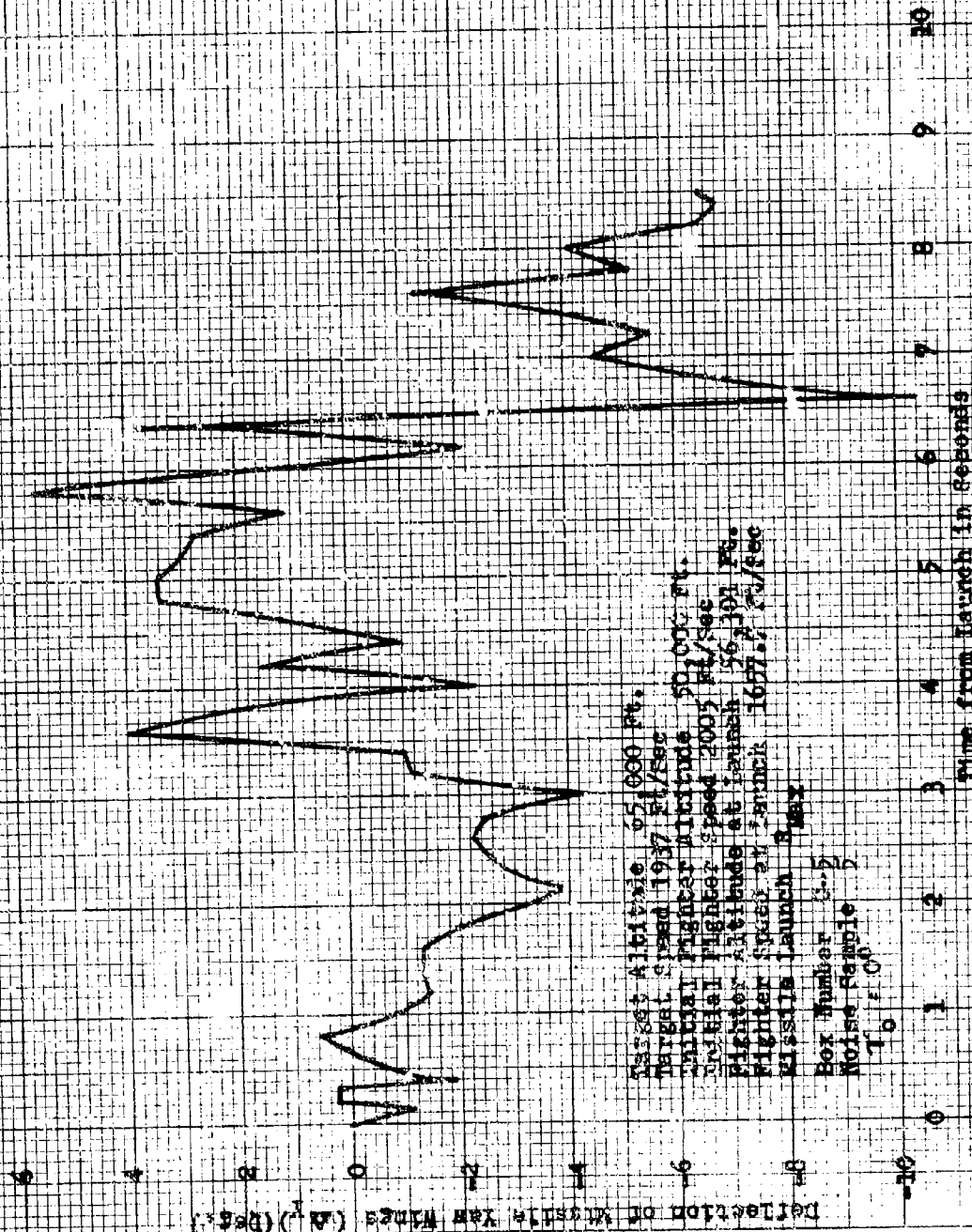
Confidential



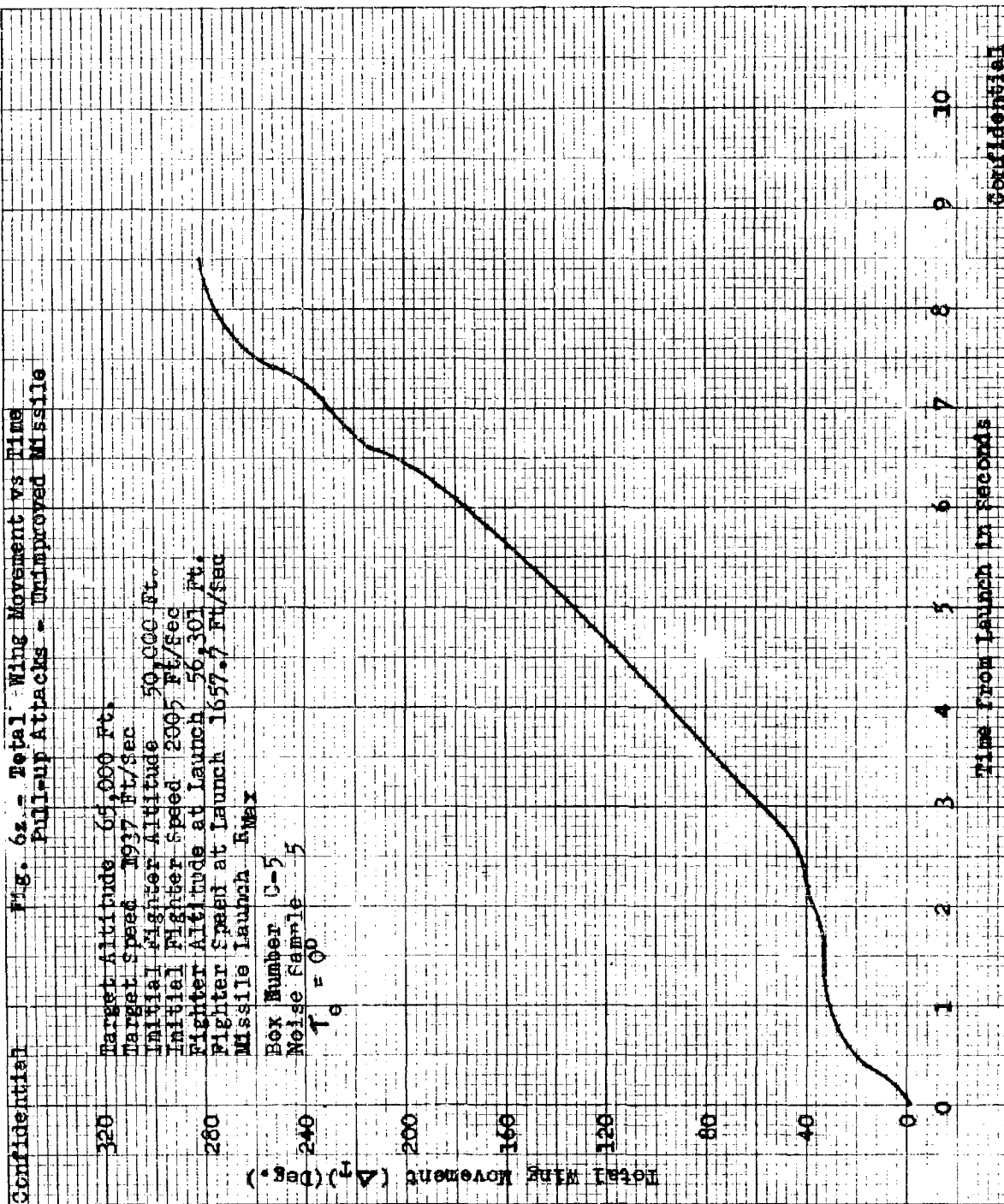


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Fig. 62 - Reflection of Missile from Wings vs. Time
Full-CP Attacks - Unimproved Missile



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Fig. 5a3 - Missile Altitude vs Time
Full-up Attacks - Unimproved Missile

Target Altitude 65,000 Ft.
Target Speed 1937 Ft./Sec
Initial Fighter Altitude 50,000 Ft.
Initial Fighter Speed 2005 Ft./Sec
Fighter Altitude at Launch 56,301 Ft.
Fighter Speed at Launch 1657.7 Ft./Sec
Missile Launch R_{Max}

Box Number C-5
Missile Sample 5

Missile Altitude (M) (ft x 10³)

Time from Launch in Seconds

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K&E 10X10 TO THE INCH 359-5DG
KEUFFEL & ESSER CO. MADE IN U.S.A.

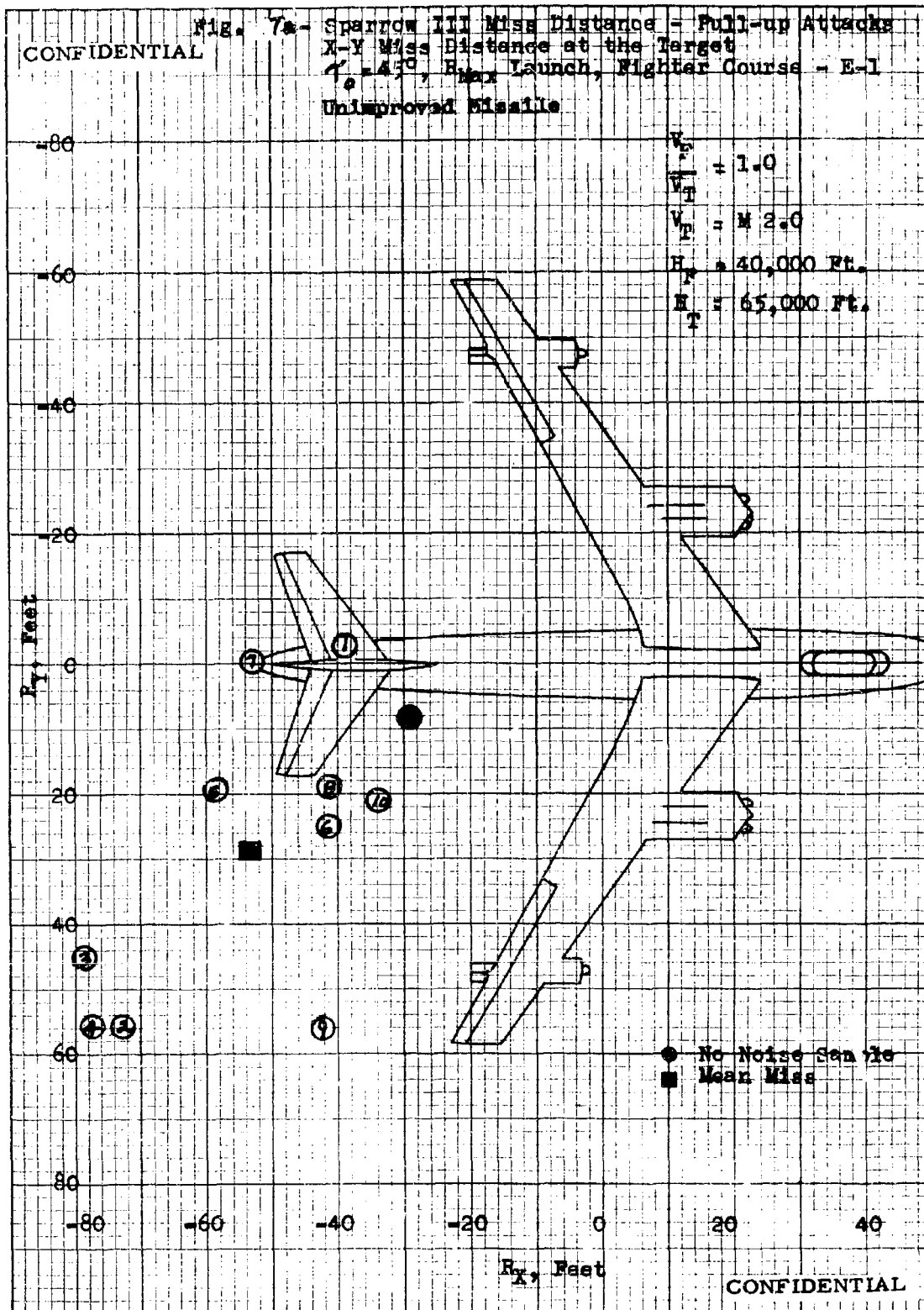
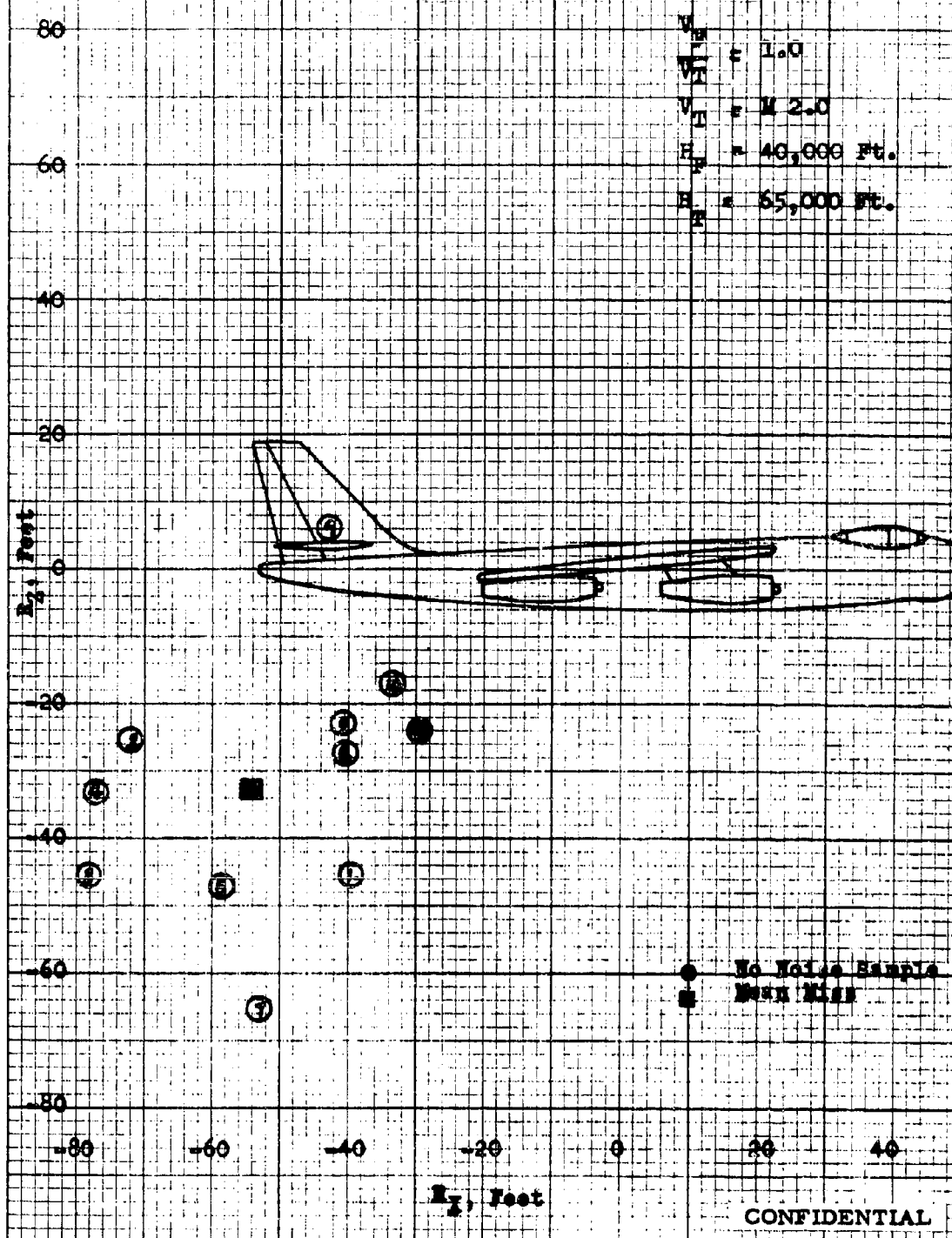
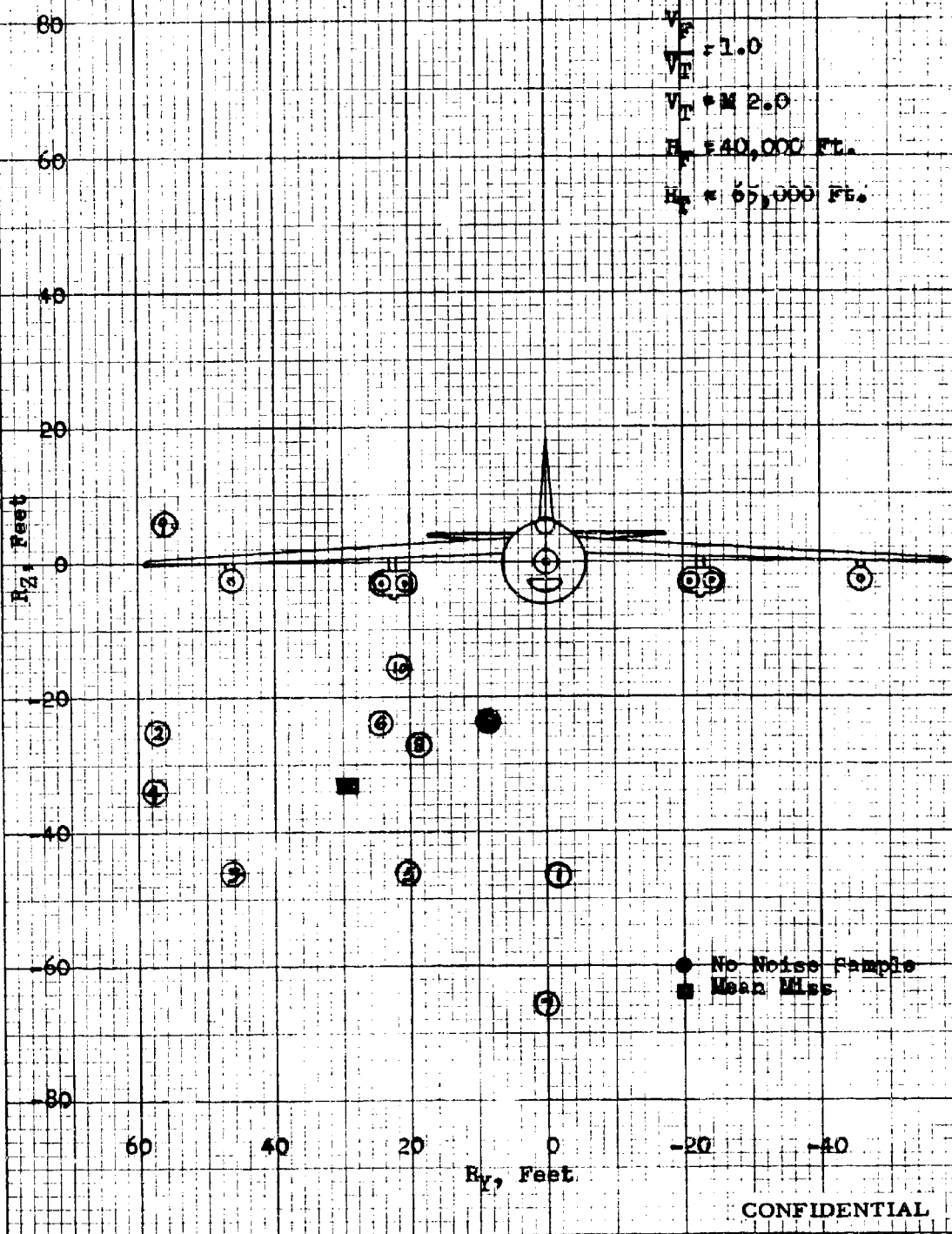


Fig. 7b - Sparrow III Miss Distance - Pull-up Attacks
X-Z Miss Distance at the Target
 $T_0 = 4.5^{\circ}$, R_{max} launch, Fighter Course - E-1
Unimproved Missile



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Fig. 7c - Sparrow III Miss Distance - Pull-up Attacks
Y-Z Miss Distance at the Target
 $T_0 = 45^\circ$, R_{max} Launch, Fighter Course - E-1
Unimproved Missile



K&E 10 X 10 TO THE INCH 359-5DG
KUPFFEL & ESSER CO. MAINTAIN S.A.

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Fig. 74 - Fighter to Missile Range vs Time
 Full-on Attacks - Unimproved Missile

Target Altitude 65,000 ft.
 Target Speed 1037 ft/sec
 Initial Fighter Altitude 40,000 ft.
 Initial Fighter Speed 2034 ft/sec
 Fighter Altitude at Launch 49,236 ft.
 Fighter Speed at Launch 1776 ft/sec
 Missile Launch Max

Box Number 1-1
 Missile Family 5
 $T_0 = 4.50$

Fighter to Missile Range (ft x 10³)

Time from Launch in Seconds

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Fig. 7a - Missile to Target Range vs Time
Pullman Attacks - Unimproved Missile

Target Altitude 65,000 ft.
Target Speed 1937 ft/sec
Initial Fighter Altitude 40,000 ft.
Initial Fighter Speed 2034 ft/sec
Fighter Altitude at launch 49,236 ft.
Fighter Speed at launch 1776 ft/sec
Missile Launch Max

Box Number E-1
Noise Sample 5
10 - 450

Missile to Target Range (R_{M-T}) (ft x 10³)

Time from Launch in Seconds

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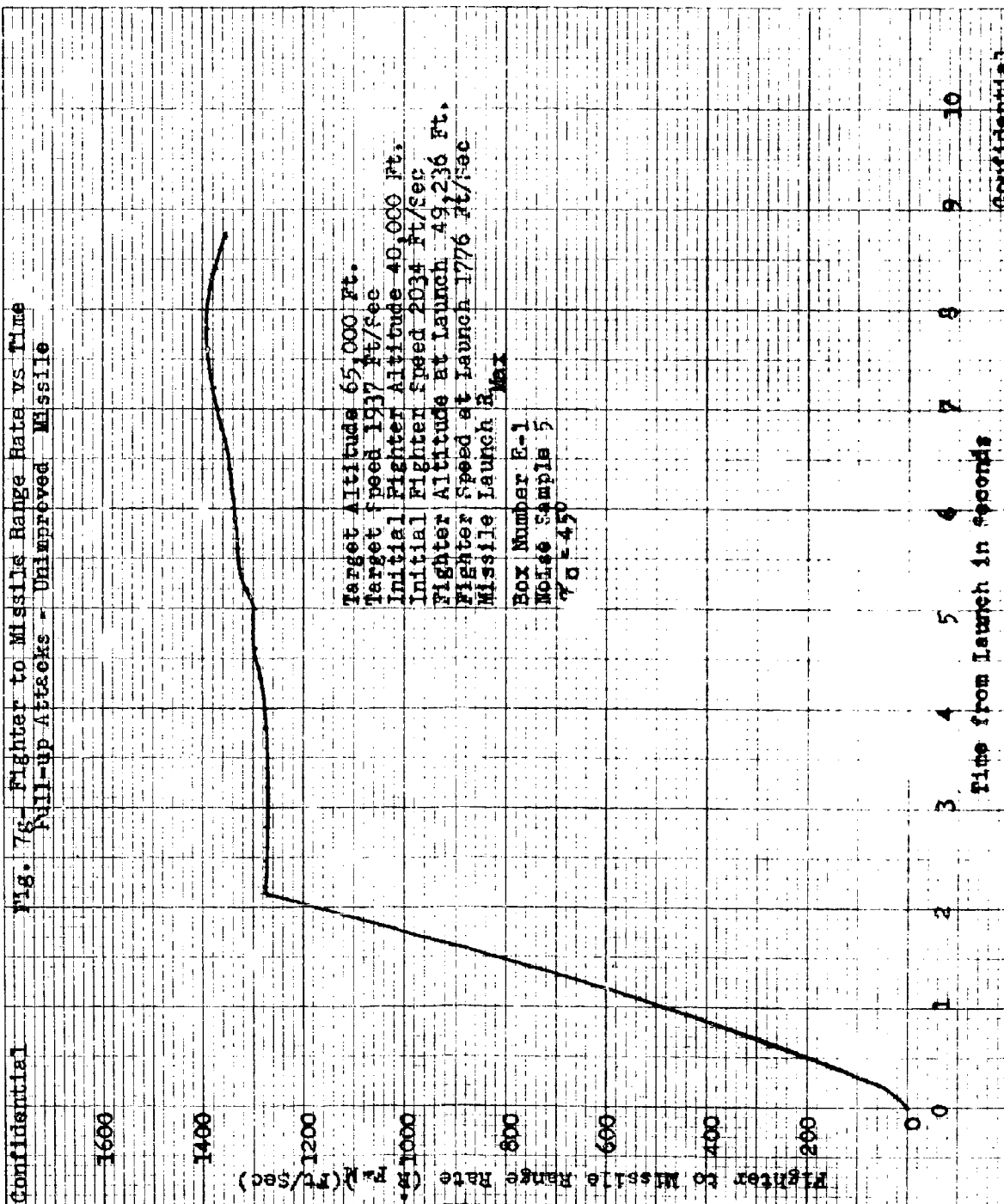
Fig. 71 - Fighter to Target Range vs Time
Full-up Attacks - Unimproved Missile

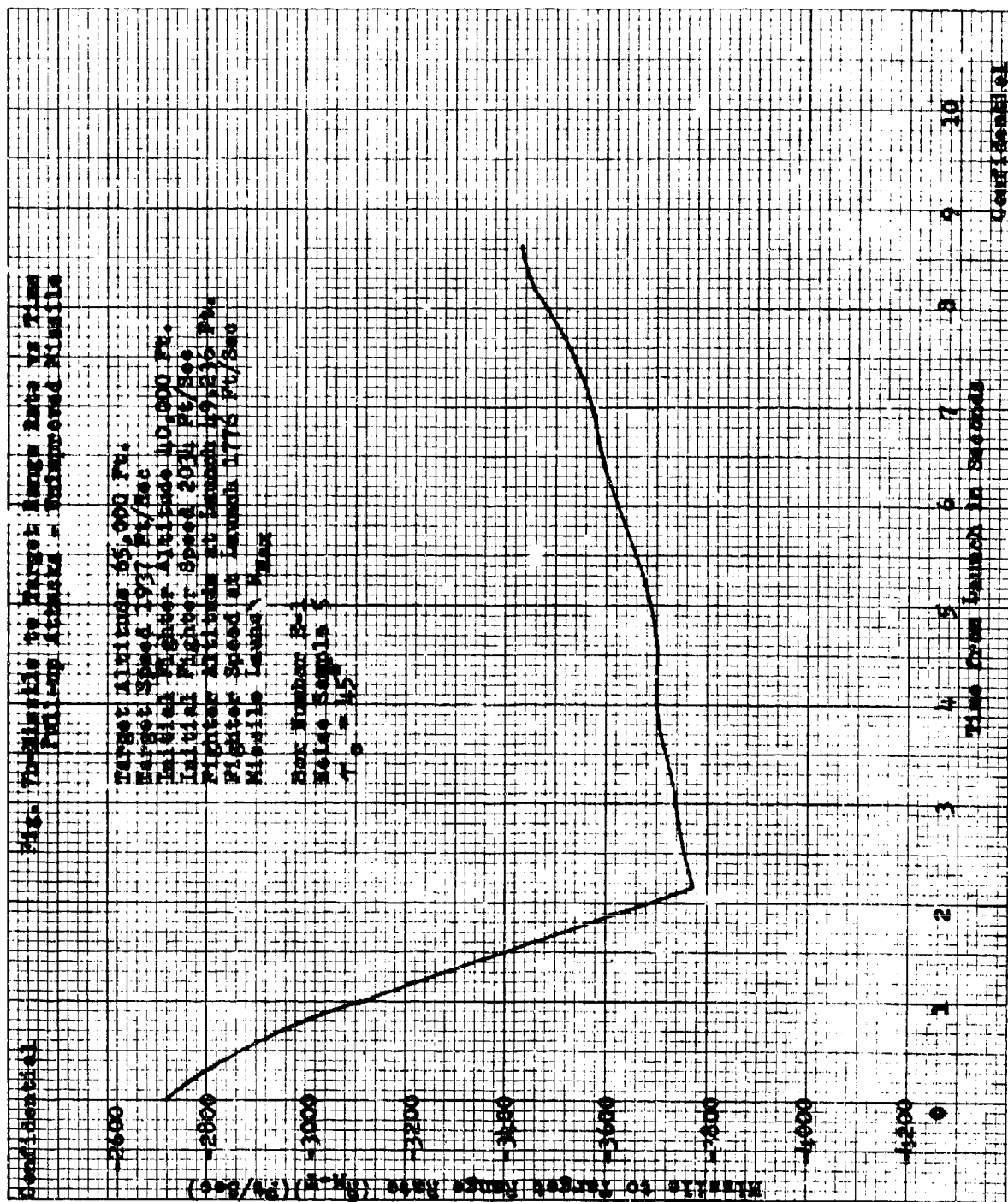
Target Altitude 65,000 Ft.
Target Speed 1937 Ft/Sec
Initial Fighter Altitude 40,000 Ft.
Initial Fighter Speed 2034 Ft/Sec
Fighter Altitude at Launch 49,236 Ft.
Fighter Speed at Launch 1776 Ft/Sec
Missile Launch Max
Box Number E-1
Noise Sample 5
 $r_0 = 450$

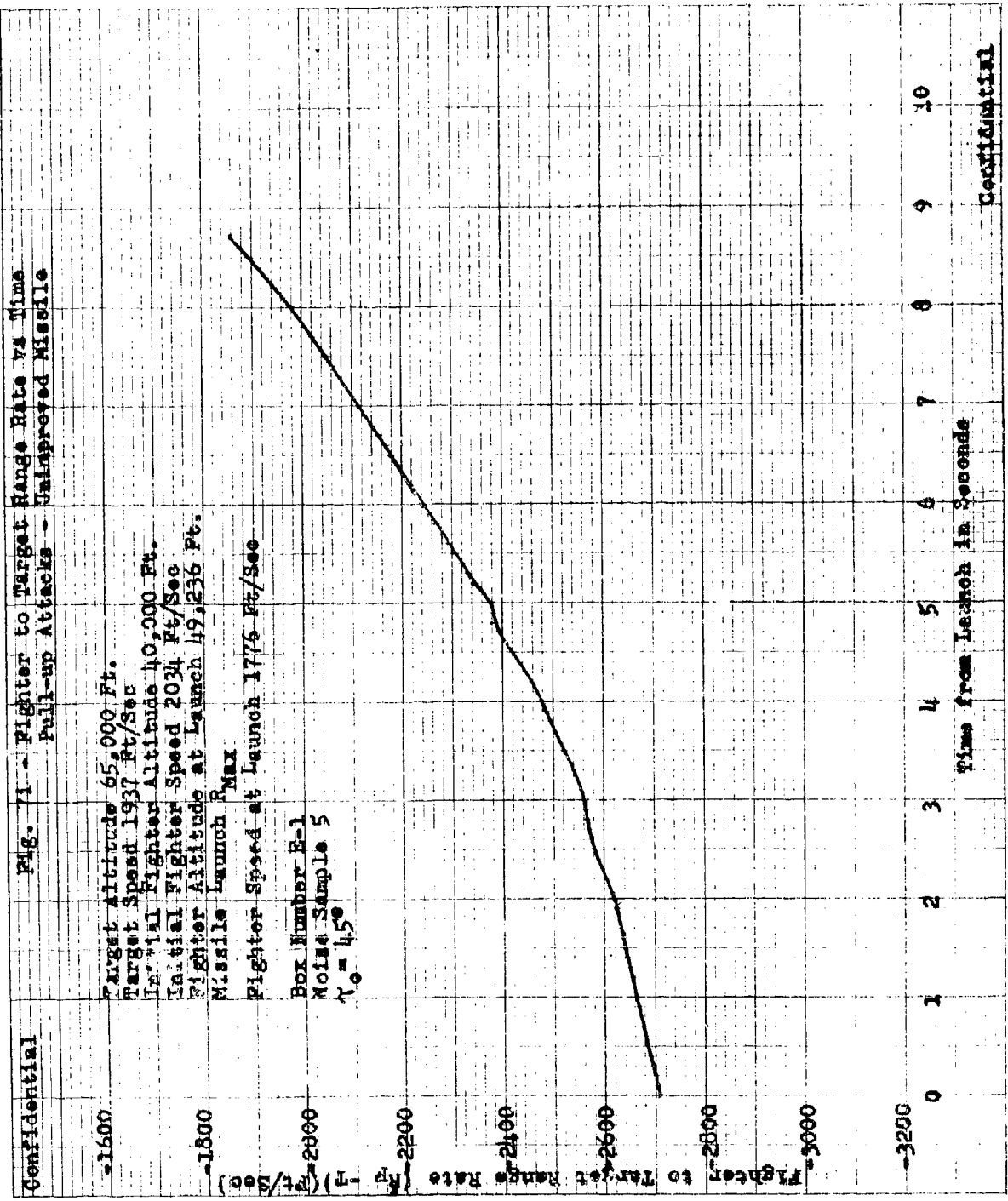
Fighter to Target Range (k.p.m) ($\text{ft} \times 10^3$)

Time from Launch, in Seconds

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Fig. Y j - Antenna Azimuth Control Angle of Missile vs Time
Pull-up Attacks - Unimproved Missile

Target Altitude 65,000 Ft.
Target Speed 1937 ft/sec
Initial Fighter Altitude 40,000 Ft.
Initial Fighter Speed 2034 ft/sec
Fighter Altitude at Launch 49,236 Ft.
Fighter Speed at Launch 1776 ft/sec
Missile Launch Angle
Box Number 8-1
Noise Sample 5
K = 150
0

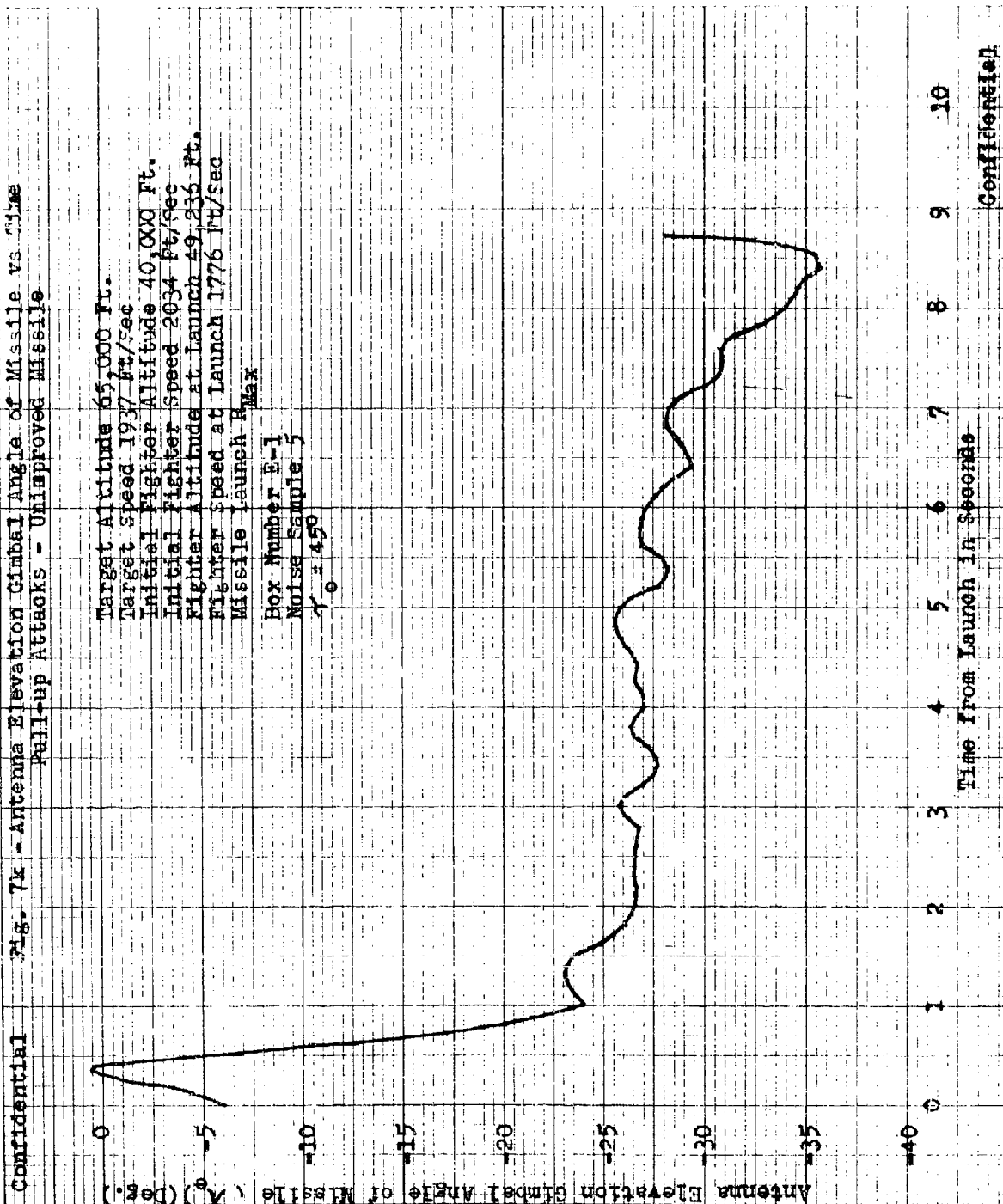
Antenna Azimuth Control Angle of Missile (Deg.)

0
-5
-10
-15
-20
-25
-30
-35
-40

Time from Launch in Seconds

10
5
0

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Fig. 71- Missile Lead Angle vs Time
Pull-up Attacks - Unimproved Missile

Target Altitude 65,000 Ft.
Target Speed 1937 Ft/Sec
Initial Fighter Altitude 40,000 Ft.
Initial Fighter Speed 2034 Ft/Sec
Fighter Altitude at launch 49,236 Ft.
Fighter Speed at launch 1776 Ft/Sec
Missile Launch R_{max}

Box Number E-1
Moist Sample 5
 $\sigma = 1.65$
2

Missile Lead Angle (λ) (Deg.)

Time from Launch in Seconds

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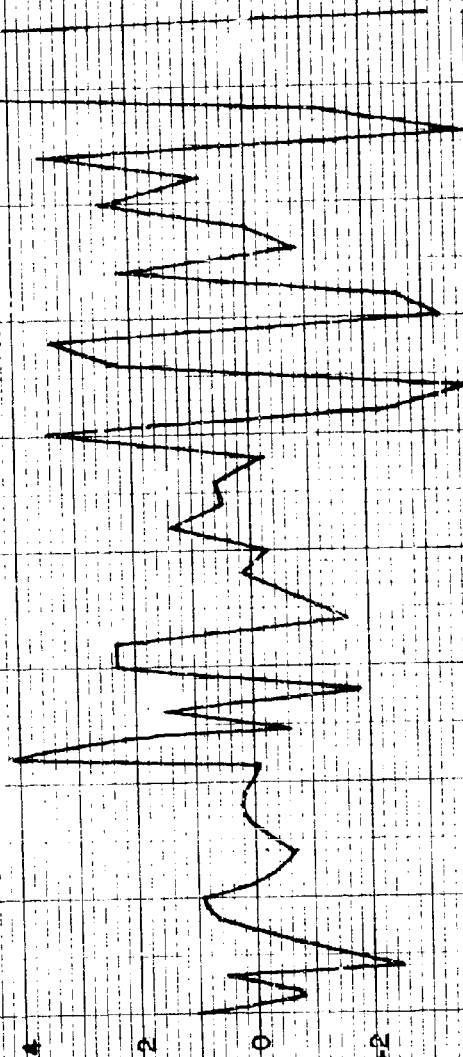
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Fig. 7a - Azimuth Line of Sight Rate of Missile vs Time
Pull-up Attacks - Unimproved Missile

Target Altitude 65,000 Ft.
Target Speed 1937 ft/sec
Initial Fighter Altitude 40,000 Ft.
Initial Fighter Speed 2034 ft/sec
Fighter Altitude at launch 49,236 Ft.
Fighter Speed at launch 1776 ft/sec
Missile launch 18.4 sec

Box Number 8-1
Noise Sample 5
10 = 45

Azimuth L.O.S. Rate of Missile ($^{\circ}$ /sec)

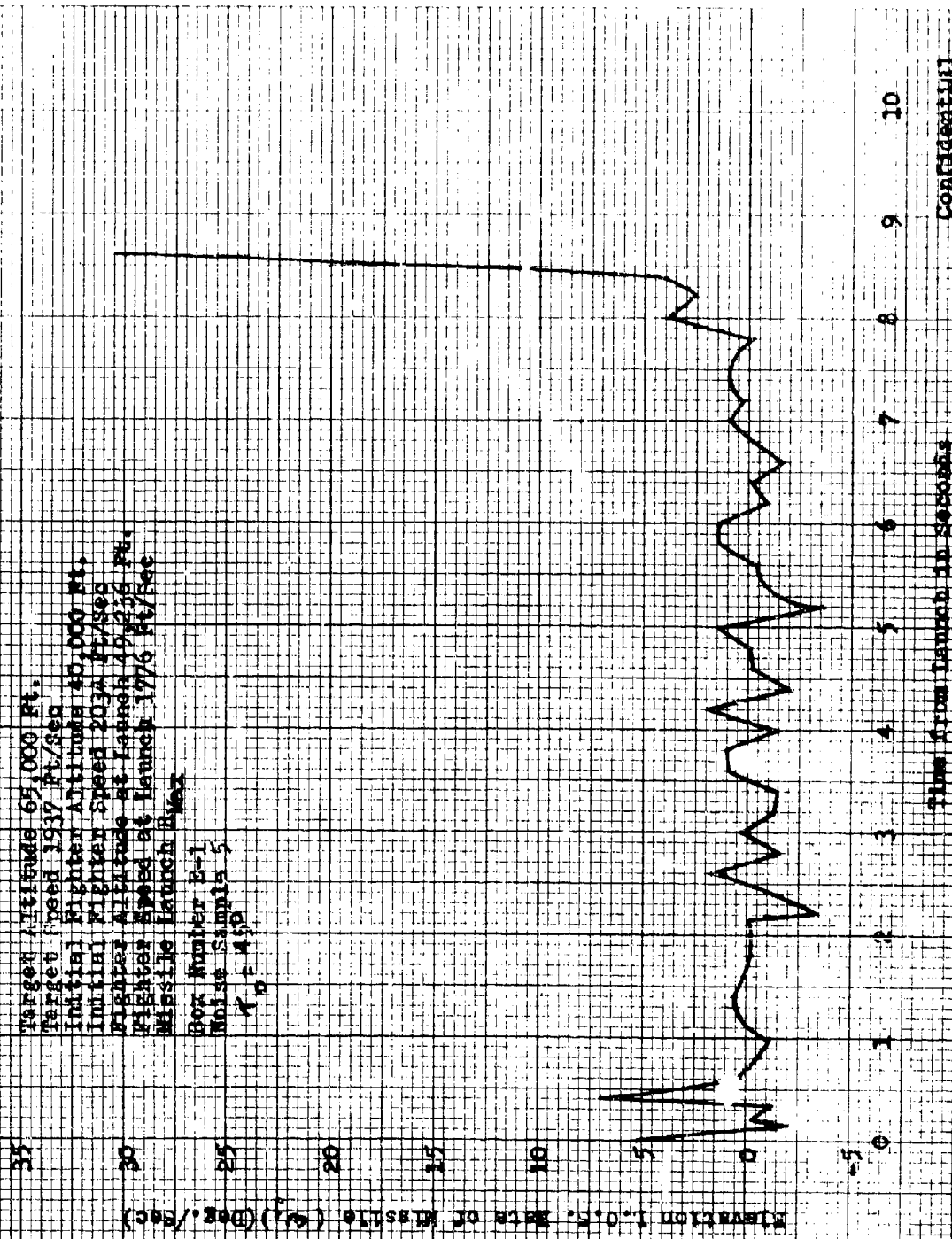


Time from launch in seconds

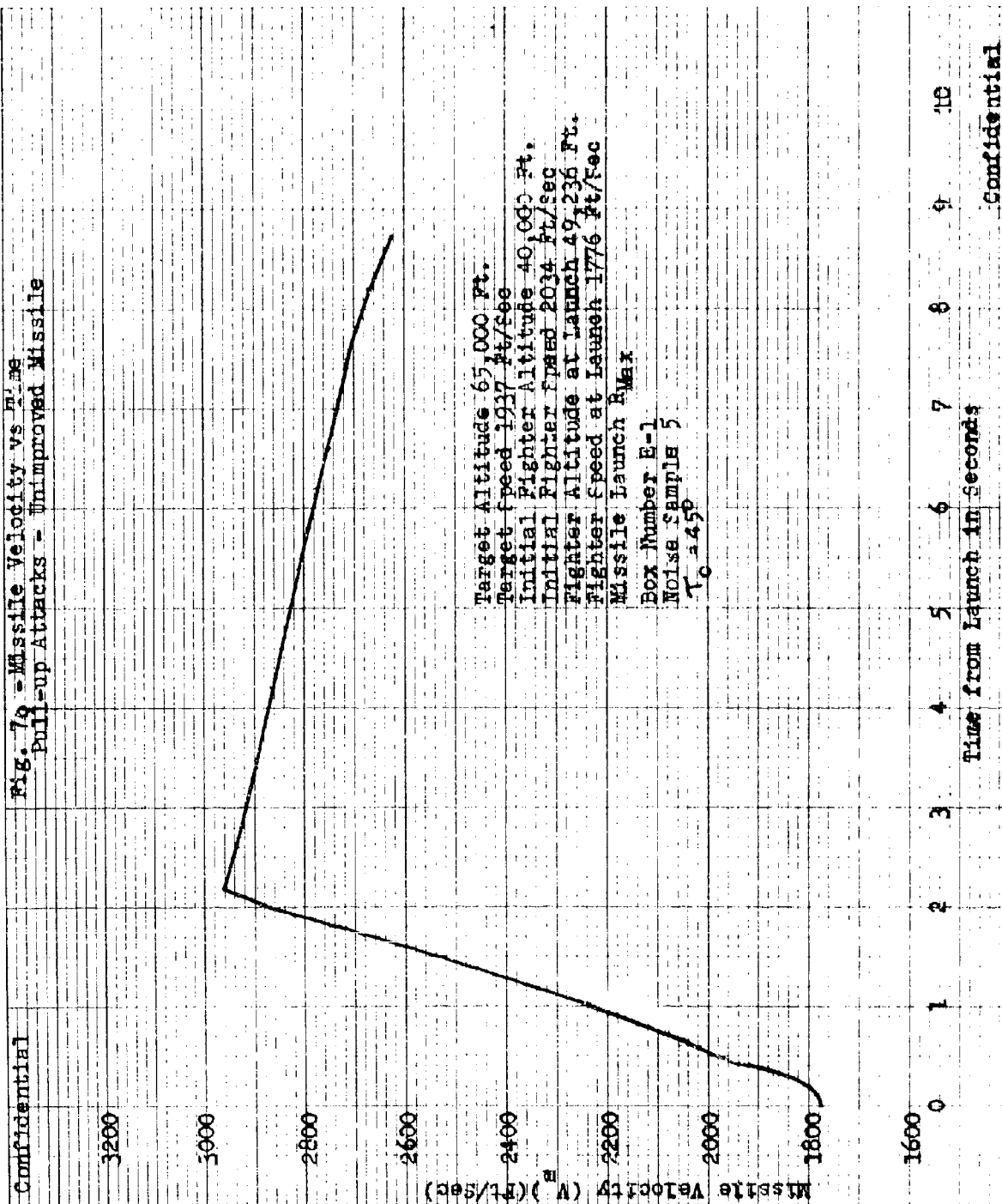
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Fig. 7h - Elevation Line of Sight Rate of Missile vs Time
Full-on Attacks - Unimproved Missile



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Fig. 7a - Azimuth Look-Angle Error for Missile Feeder vs Time
Pull-up Attacks - Unimpacted Missile

Target Altitude 67,000 ft.
Target Speed 1937 ft/sec
Initial Fighter Altitude 40,000 ft.
Initial Fighter Speed 2034 ft/sec
Fighter Altitude at launch 49,236 ft.
Fighter Speed at launch 1776 ft/sec
Missile Launch Box

Box Number B-1
Noise Sample 5
 $\tau_0 = 4.5$

3.0

2.5

2.0

1.5

1.0

0.5

0

-0.5

-1.0

0

1

2

3

4

5

6

7

8

9

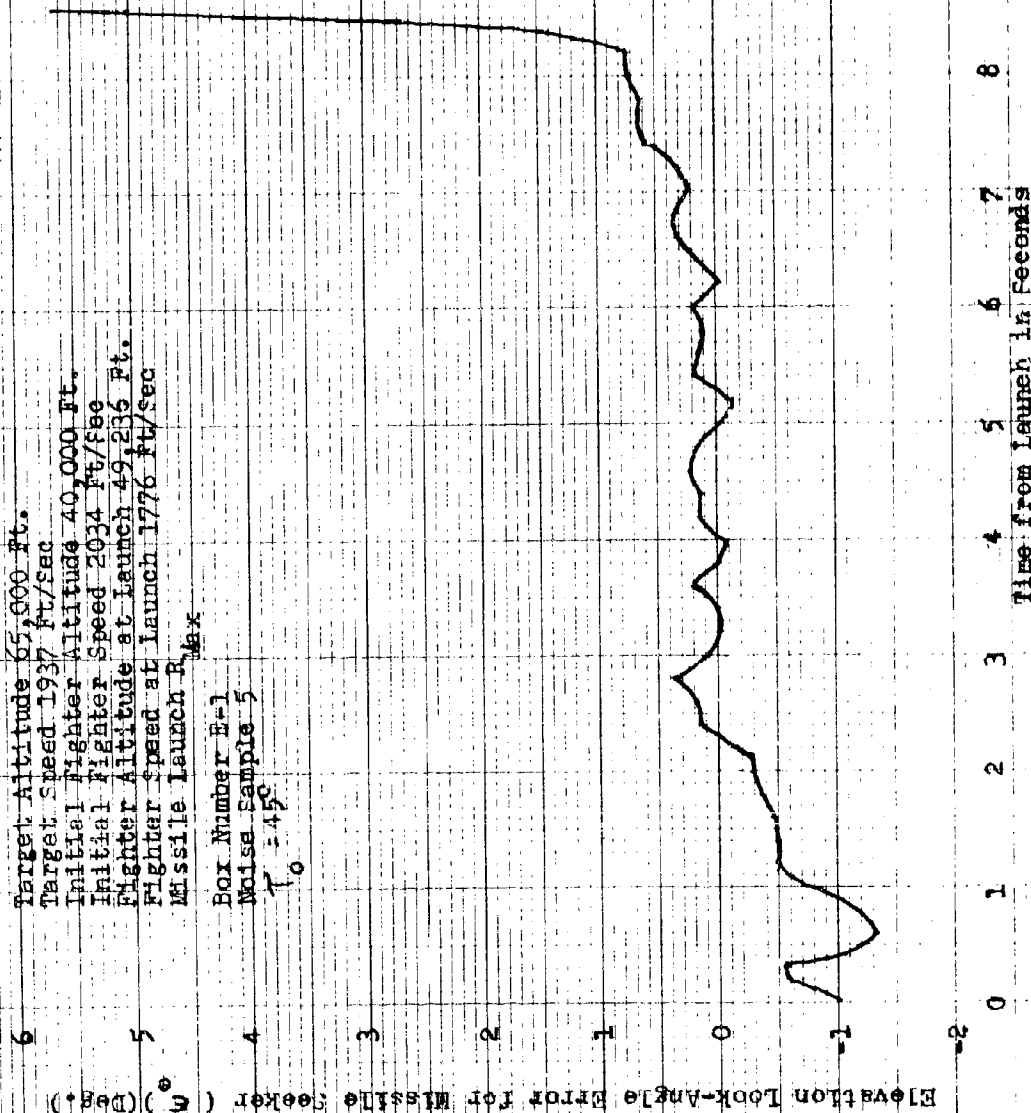
10

Time from Launch in Seconds

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Fig. 7q - Elevation Look-Angle Error for Missile Seeker vs Time
Pull-up Attacks - Unimproved Missile

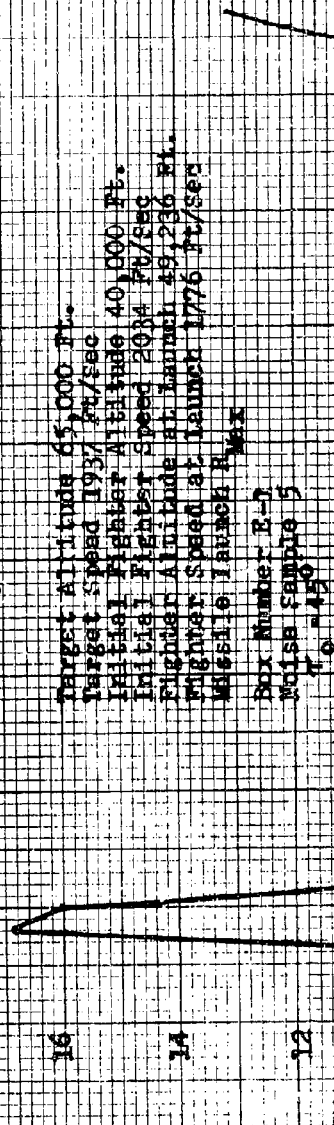


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Fig. 7r

Missile Angle of Attack vs Time
Full-Size Attacks - Unimproved Missile



Missile Angle of Attack (α) (Deg.)

Time from Launch in Seconds

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Fig. 7a-Missile and Fighter Roll Angle vs Time
Pull-up Attacks-Unimproved Missile

Target Altitude 65,000 Ft.
Target Speed 1937 Ft/Sec
Initial Fighter Altitude 40,000 Ft.
Initial Fighter Speed 2034 Ft/Sec
Fighter Altitude at Launch 49,236 Ft.
Fighter Speed at Launch 1776 Ft/Sec
Missile Launch - Max

Box Number E-1
Noise Sample 5
 $\gamma = 45^\circ$

120

100

80

60

40

20

0

-20

-40

-60

-80

-100

-120

-140

-160

-180

-200

-220

-240

-260

-280

-300

-320

-340

-360

-380

-400

-420

-440

-460

-480

-500

Missile and Fighter Roll Angle (ϕ) (Deg.)

Time from Launch in Seconds

0

1

2

3

4

5

6

7

8

9

10

11

12

13

14

15

16

17

18

19

20

21

22

23

24

25

26

27

28

29

30

31

32

33

34

35

36

37

38

39

40

41

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Fig. 7b-Commanded Elevation G's vs Time
Pull-up Attacks-Unimproved Missile

Target Altitude 65,000 Ft.
Target Speed 1937 Ft/Sec
Initial Fighter Altitude 40,000 Ft.
Initial Fighter Speed 2034 Ft/Sec
Fighter Altitude at Launch 19,236 Ft.
Fighter Speed at Launch 1776 Ft/Sec
Missile Launch R Max

Box Number 1-1
Noise Sample 5
7c #45

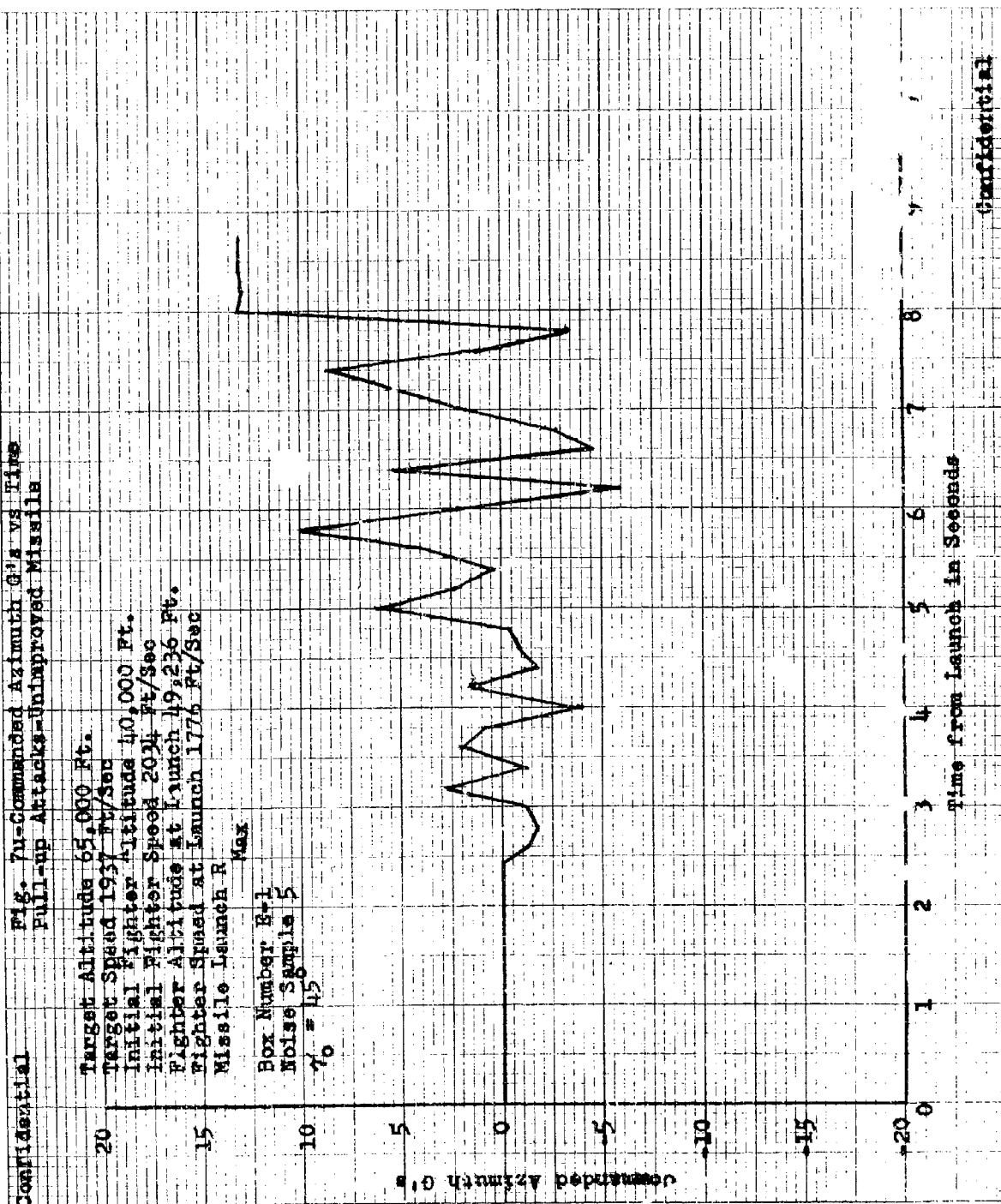
Commanded Elevation G's

Time from Launch in Seconds

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Fig. 7u-Commanded Azimuth G's vs Time
Full-up Attacks-Unimproved Missile



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Fig. 74-Commanded Elevation Wing Deflection vs Time
Pull-up Attacks - Unimproved Missiles

Target Altitude 65,000 Ft.
Target Speed 1937 Ft/Sec
Initial Fighter Altitude 40,000 Ft.
Initial Fighter Speed 2034 Ft/sec
Fighter Altitude at launch 49,236 ft.
Fighter Speed at launch 1776 Ft/Sec

Missile Launch θ_{Max}

Box Number E-1

Noise Sample 5

$\theta_0 = 45^\circ$

Commanded Elevation Wing Deflection (Deg.)

Time from Launch in Seconds

66-110811-1



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Fig. 7w-Demanded Azimuth Wing Deflection vs Time
Pull-up Attacks - Unimproved Missile

Target Altitude 65,000 Ft.
Target Speed 1937 Ft/Sec
Initial Fighter Altitude 40,000 Ft.
Initial Fighter Speed 2034 Ft/Sec
Fighter Altitude at Launch 49,216 Ft.
Fighter Speed at Launch 1776 Ft/Sec
Missile Launch Range
Box Number E-1
Noise Sample 5
 $T_0 = 45.0$

Commanded Azimuth Wing Deflection (Deg.)

Time from Launch in Seconds

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Fig. 7x - Deflection of Missile Pitch Wings vs Time
Pull-up Attacks - Unimproved Missile

Target Altitude 65,000 Ft.
Target Speed 1937 Ft/Sec
Initial Fighter Altitude 40,000 Ft.
Initial Fighter Speed 2034 Ft/Sec
Fighter Altitude at launch 49,236 Ft.
Fighter Speed at launch 1776 Ft/Sec
Missile Launch θ_{max}

Box Number F-1
Noise Sample 5
 $\tau_0 = 4.20$

Deflection of Missile Pitch Wings (Δ°) (Deg.)

Time from Launch in seconds

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Fig. 77 - Deflection of Missile Yaw Wings vs Time
Pull-up Attacks - Unimproved Missile

Target Altitude 65,000 Ft.

Target Speed 1937 Ft./sec

Initial Fighter Altitude 40,000 Ft.

Initial Fighter Speed 2034 ft/sec

Fighter Altitude at Launch 49,236 Ft.

Fighter Speed at Launch 1776 ft/sec

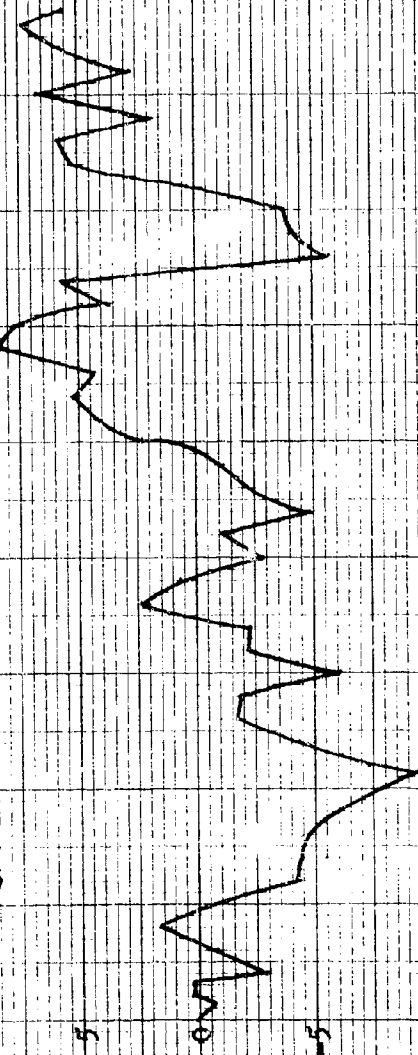
Missile Launch Range

Box Number E-1

Noise Sample 5

10.45

0



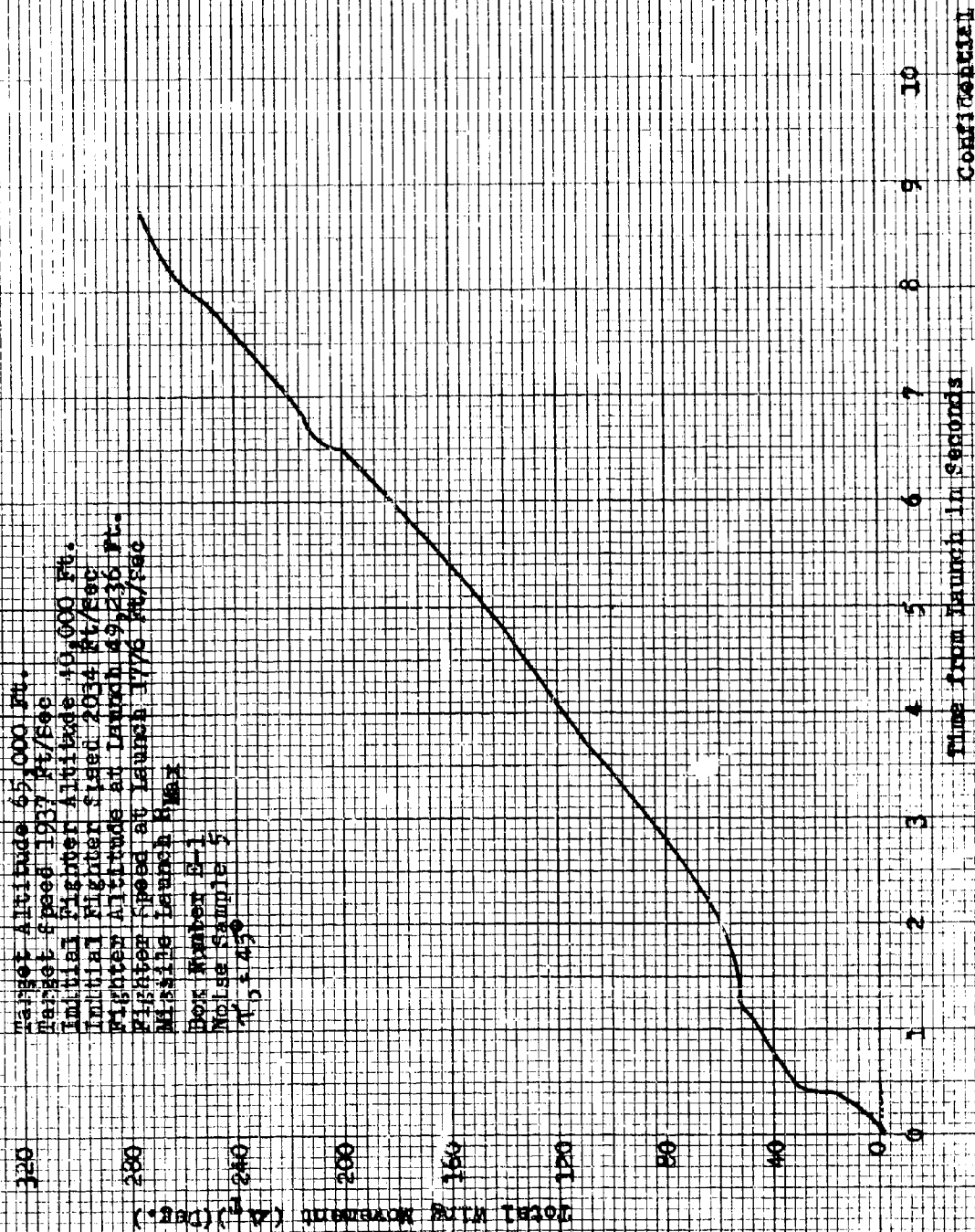
Time from Launch in Seconds

Confidential

Confidential

Fig. 7a - Total Wing Movement vs Time
Fall-up Attacks - Unimproved Missile

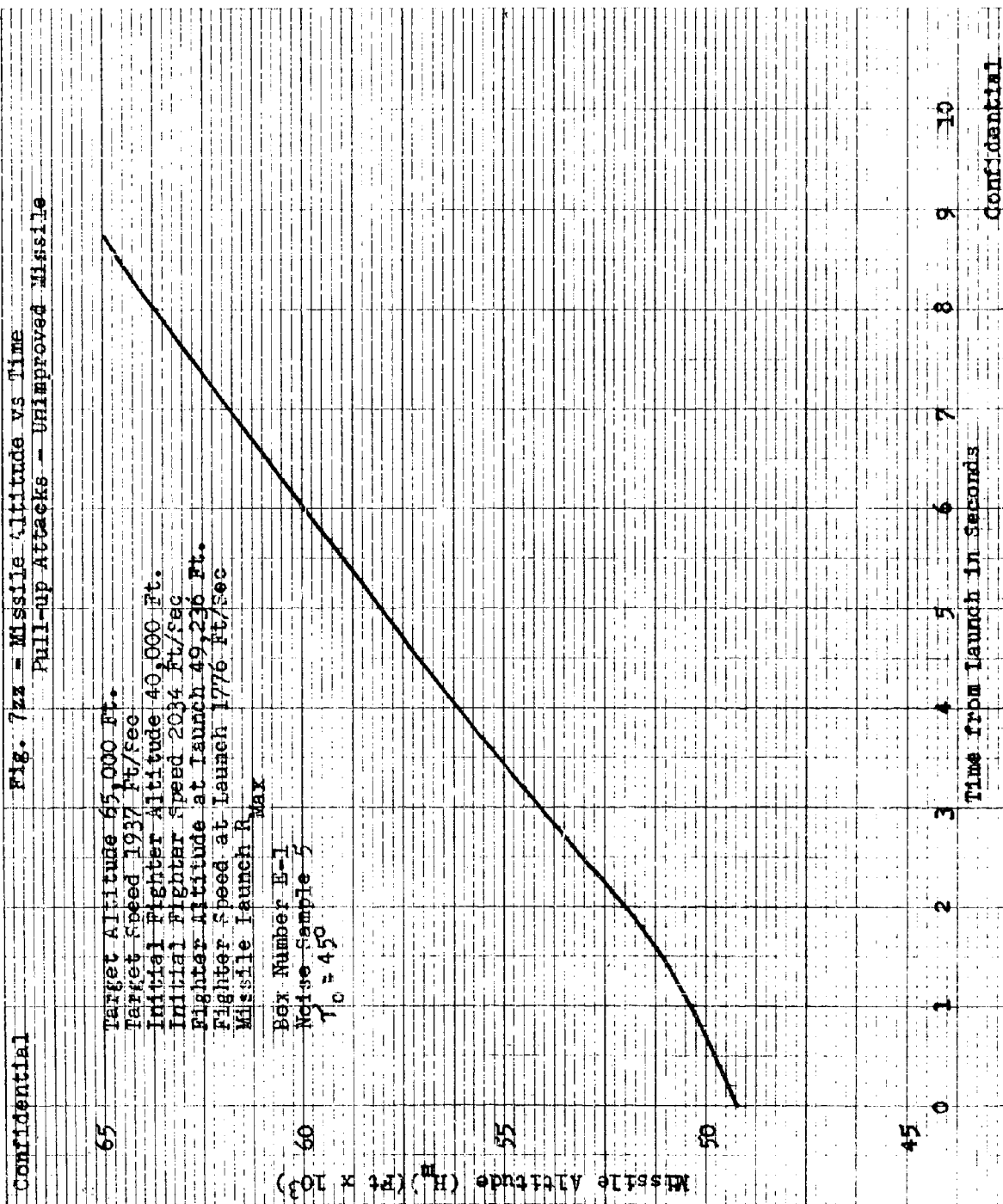
Target Altitude 65,000 ft.
Target Speed 1937 ft/sec
Initial Fighter Altitude 40,000 ft.
Initial Fighter Speed 2034 ft/sec
Fighter Altitude at Launch 49,236 ft.
Fighter Speed at Launch 1776 ft/sec
Missile Launch Angle
Box Number 3-1
Molise Sample 5
151430



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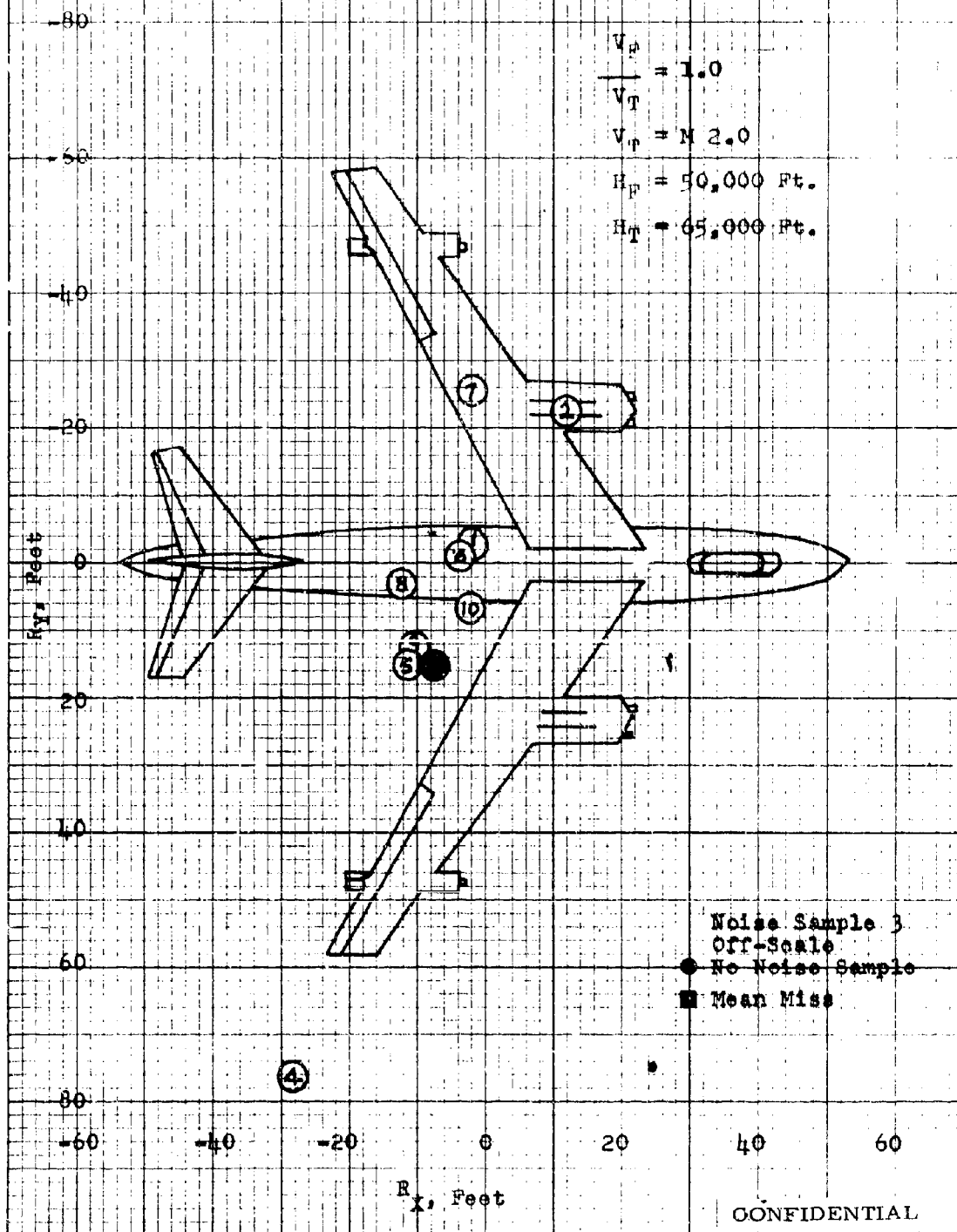


Fig. 722 - Missile Altitude vs Time
Pull-up Attacks - Unimproved Missile



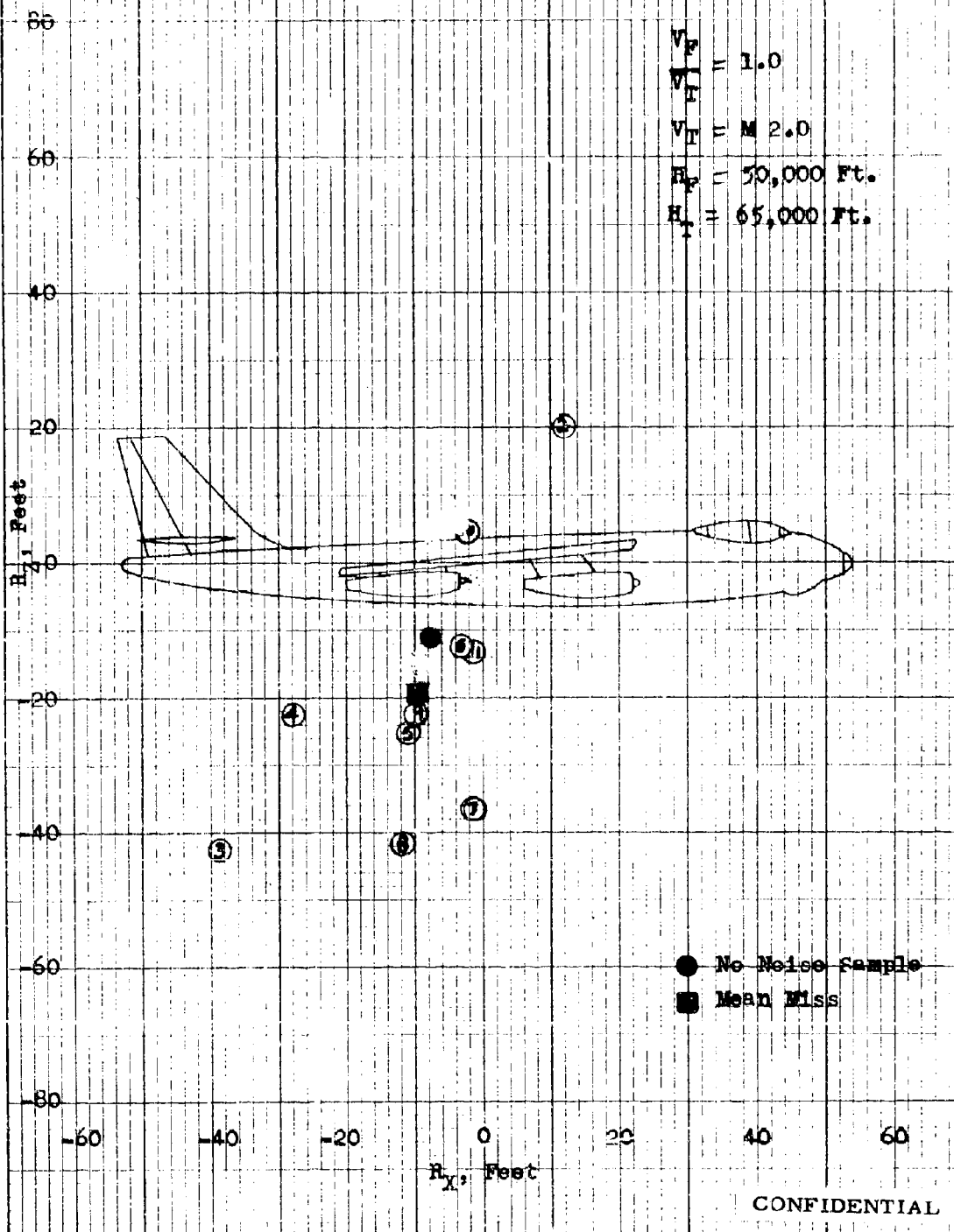
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Fig. 8a - Sparrow III Miss Distance (Improved Missile)
Pull-up Attacks
X-Y Miss Distance at the Target
 $\gamma_0 = 0^\circ$, R_{Max} Launch, Fighter Course - C-5



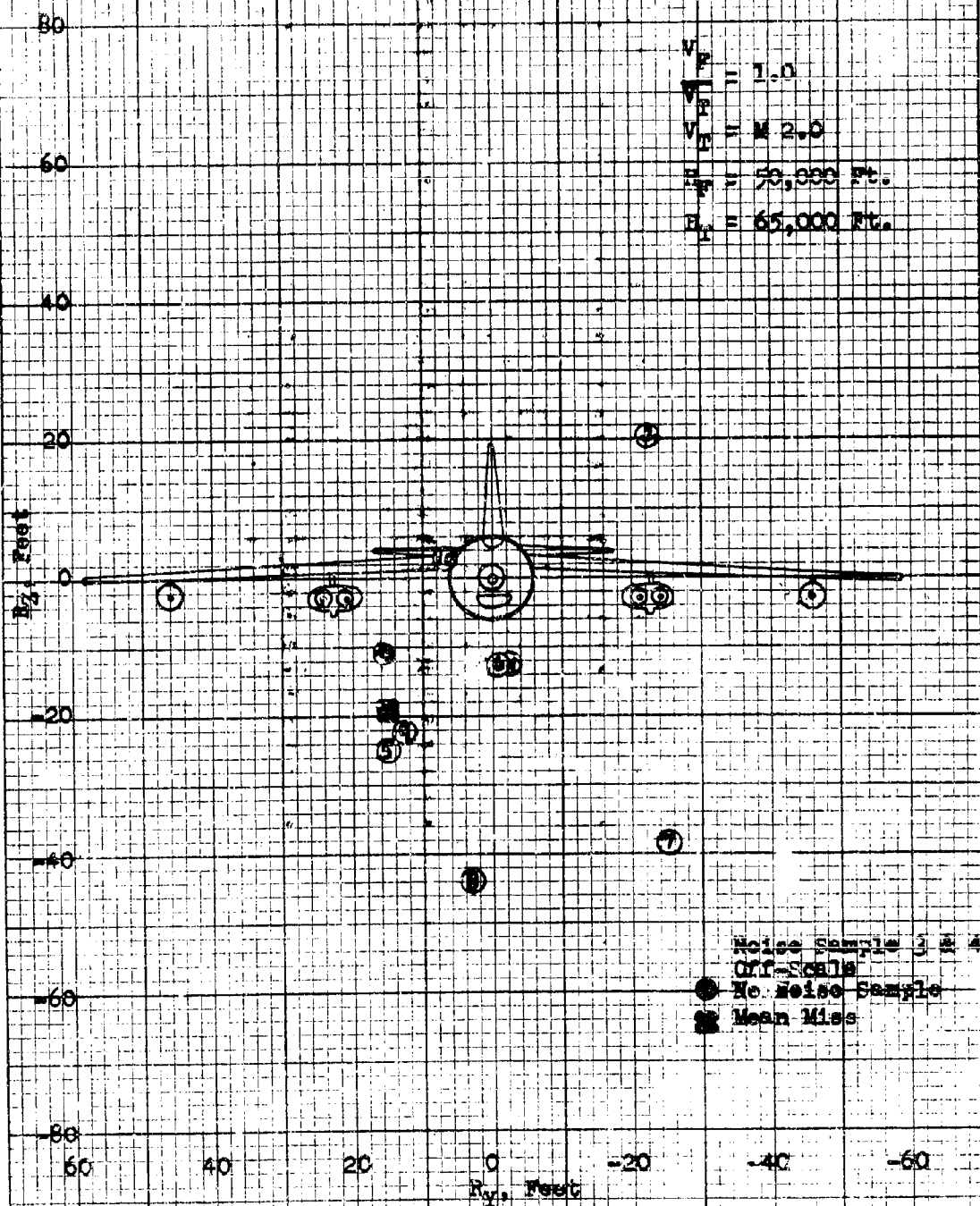
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Fig. 8b - Sparrow III Miss Distance (Improved Missile)
Pull-up Attacks
X-Z Miss Distance at the Target
 $\gamma_0 = 0^\circ$, R_{0x} Launch, Fighter Course - C-5



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Fig. 6 c- Sparrow III Miss Distance (Improved Missile)
Pull-up Attacks
Y-Z Miss Distance at the Target
 $T_0 = 0^\circ$, R_{max} Launch, Fighter Course - C-5



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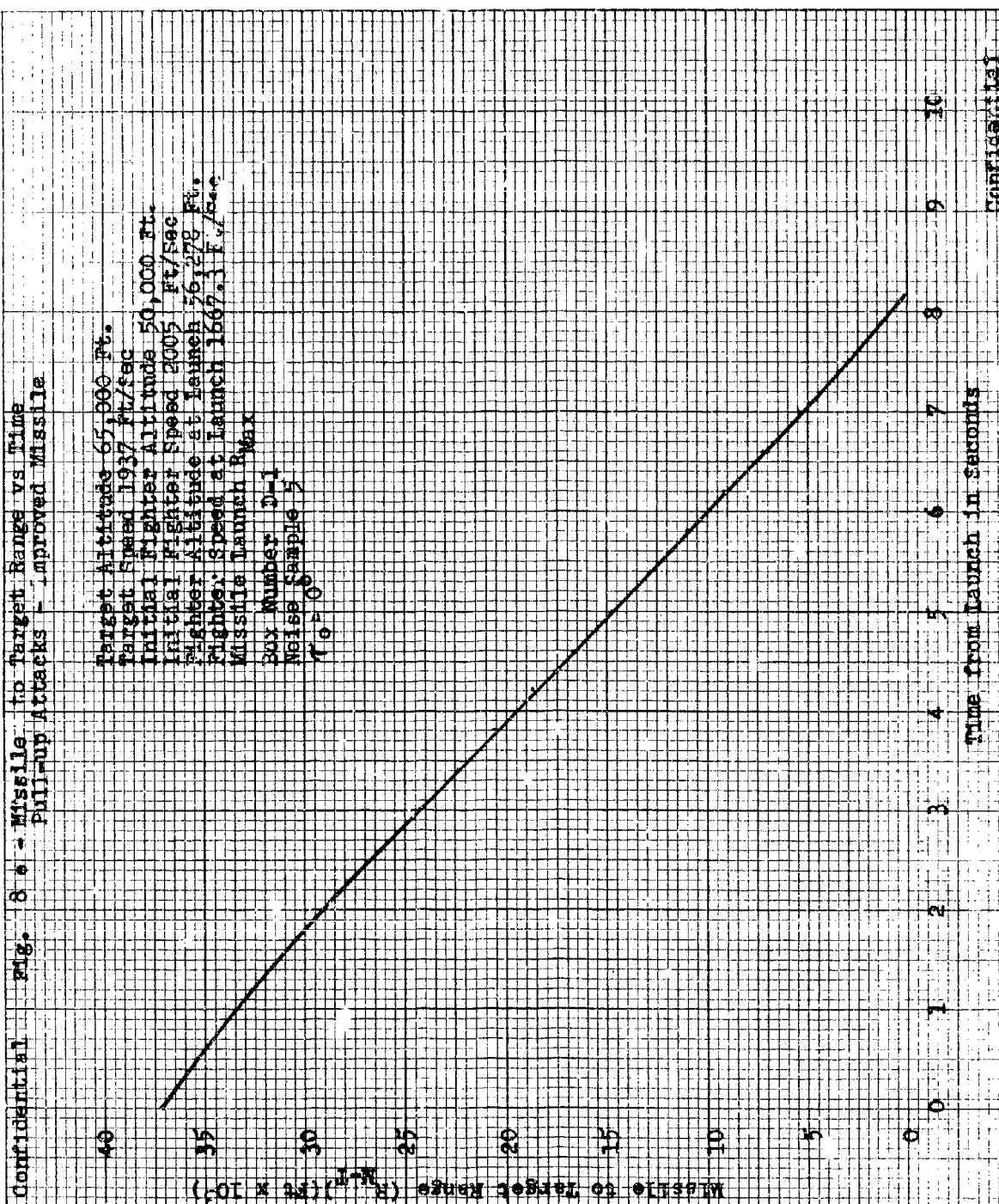
Fig. 8d - Fighter to Missile Range vs Time
Pull-up Attacks - Improved Missile

Target Altitude 65,000 Ft.
Target Speed 1977 ft/sec
Initial Fighter Altitude 50,000 Ft.
Initial Fighter Speed 2005 ft/sec
Fighter Altitude at launch 56,278 ft.
Fighter Speed at launch 1667.3 ft/sec
Missile Launch Angle
Box Number 0-1
Noise Sample 5
50 ± 10

Fighter to Missile Range (ft x 10³)

Time from Launch in seconds

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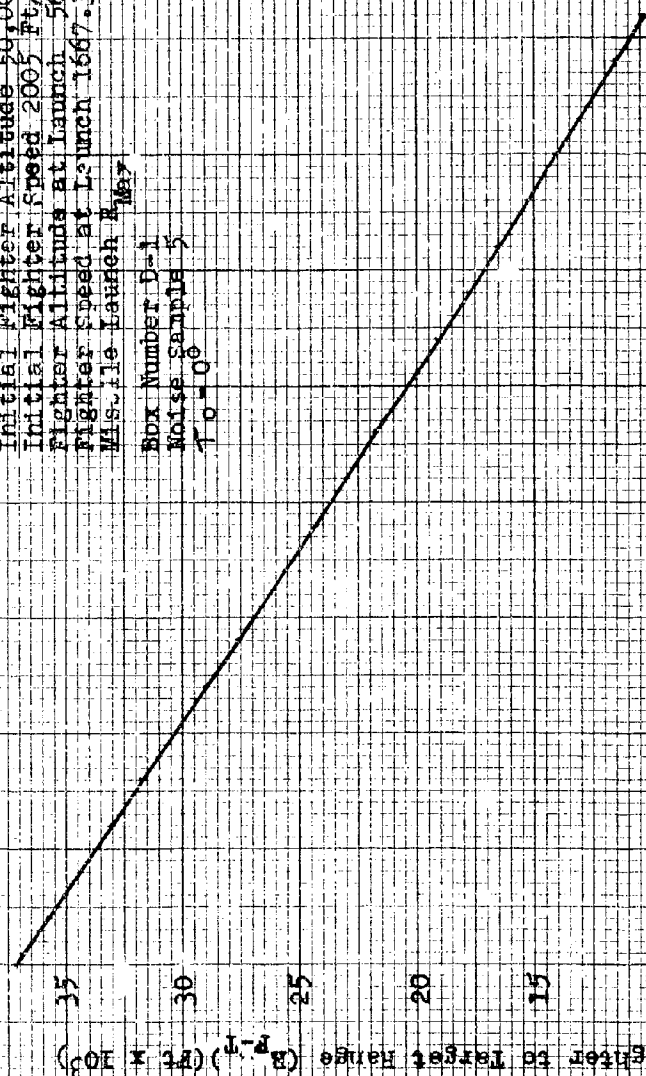


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Fig. 5f - Fighter c - Target Range vs Time
Pull-up Attacks - Improved Missile

Target Altitude 65,000 Ft.
Target Speed 1937 Ft./sec
Initial Fighter Altitude 56,000 Ft.
Initial Fighter Speed 2005 Ft./sec
Fighter Altitude at Launch 56,278 Ft.
Fighter Speed at Launch 1687.3 Ft./sec
Missile Launch 8.75 sec

Box Number D-1
Noise sample 5
T-0

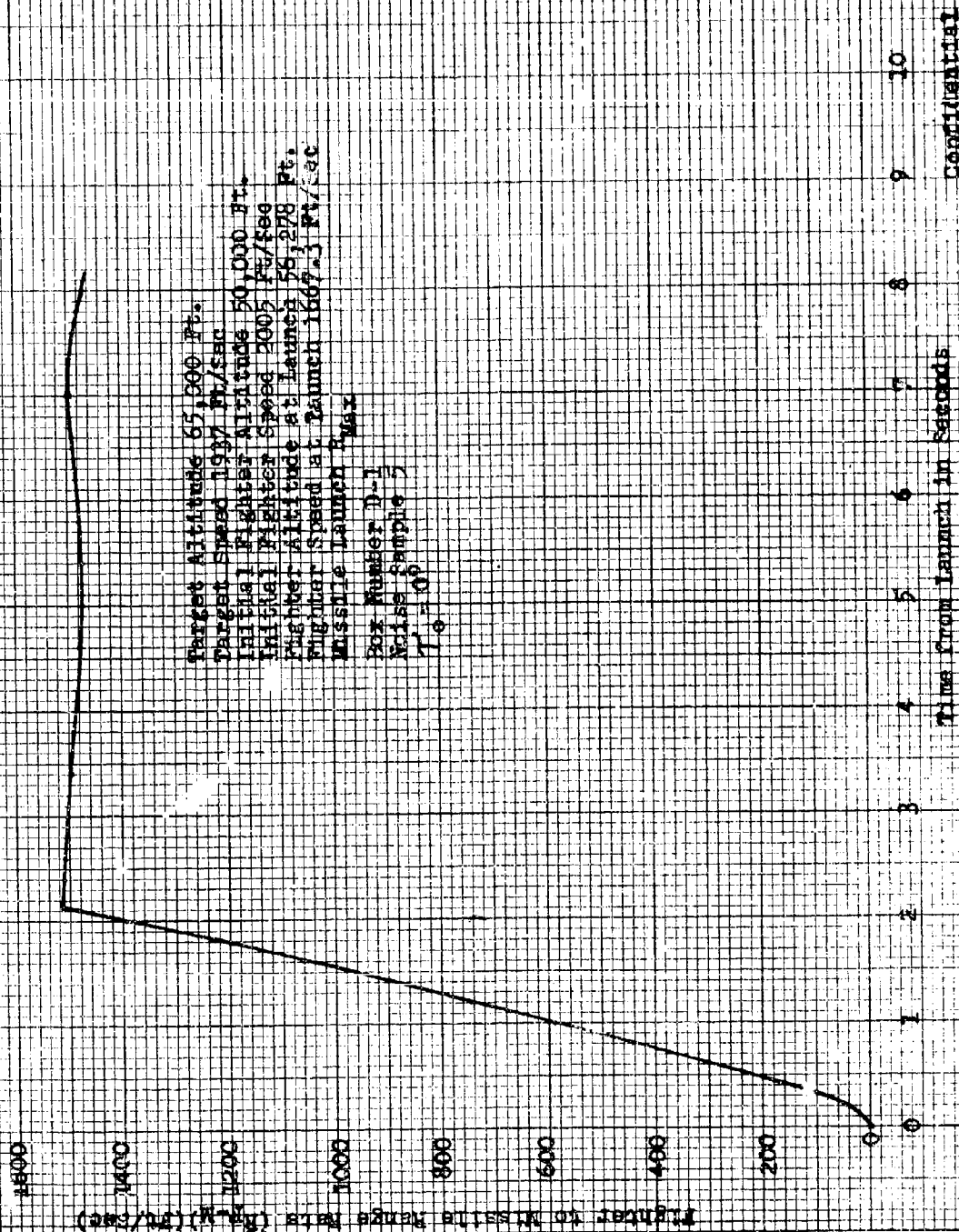


Time from Launch in seconds

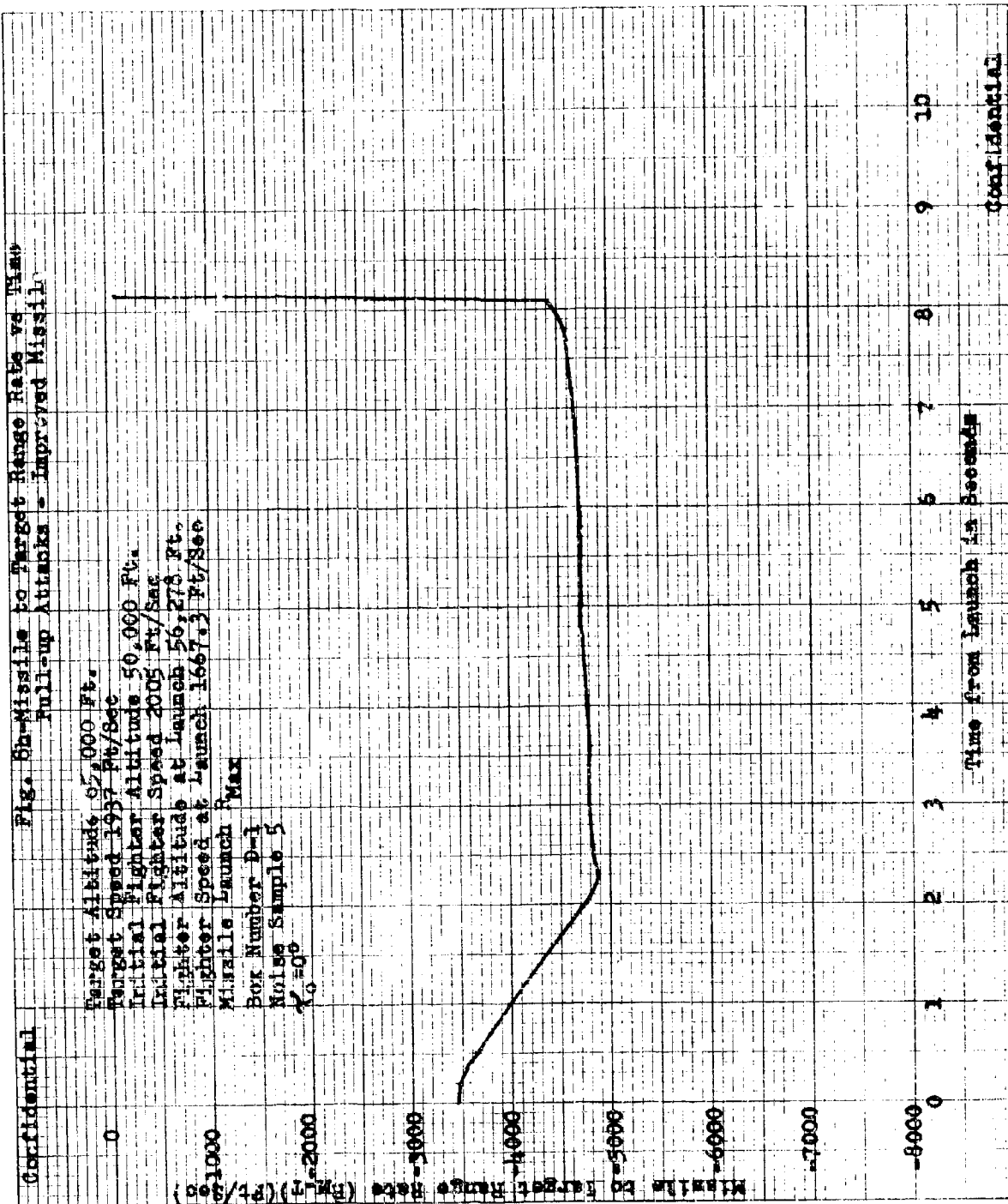
100-443886-100

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Fig. 8g. Fighter to Missile Range Rate vs Time Pull-up. 10000 - Improved Missile

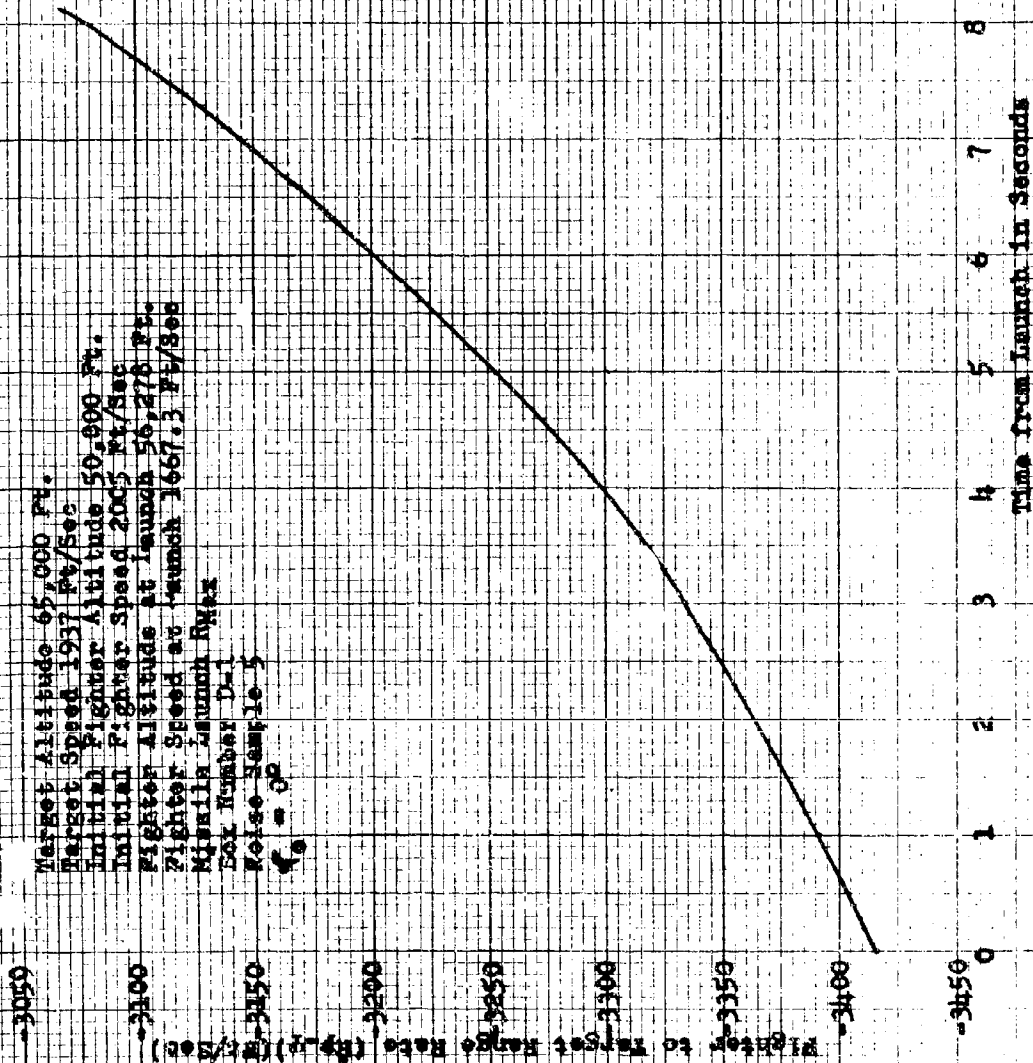


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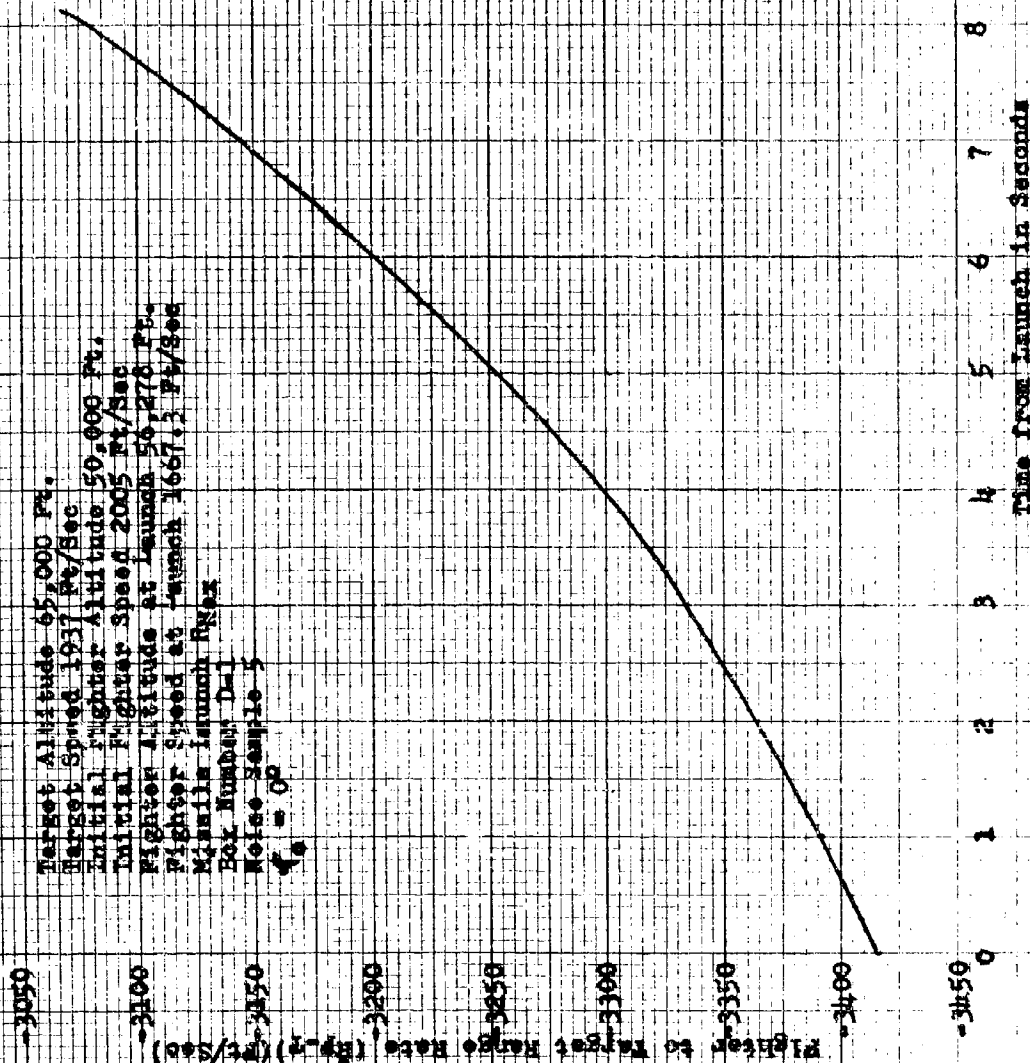
18. B1-Fighter's Target Range Rate vs Time
Pull-up Attacks - Impr 744 Missile



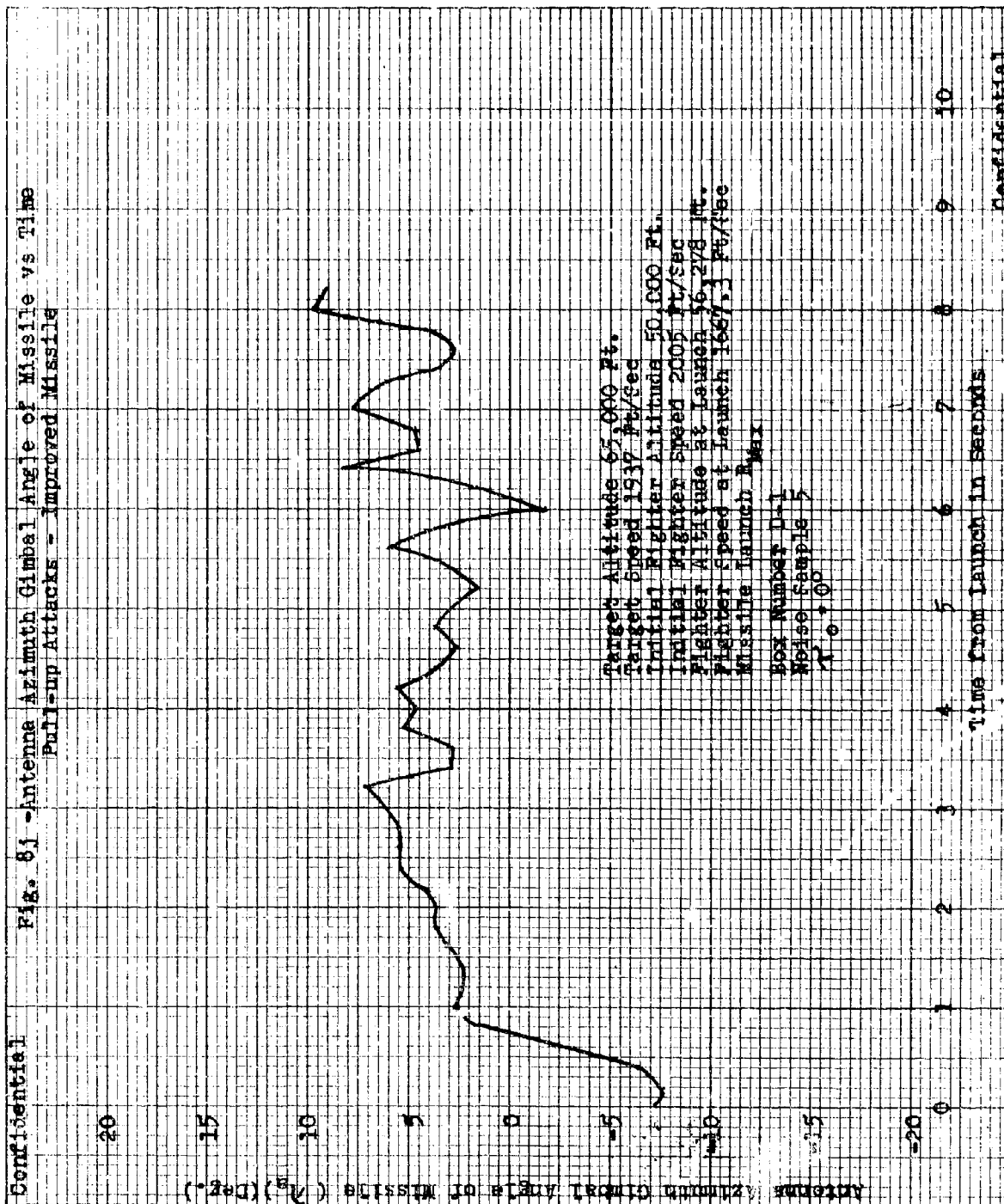
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Fig. 2i - Fighter to Target Range Rate vs Time
Full-up Attacks - Improved Missile



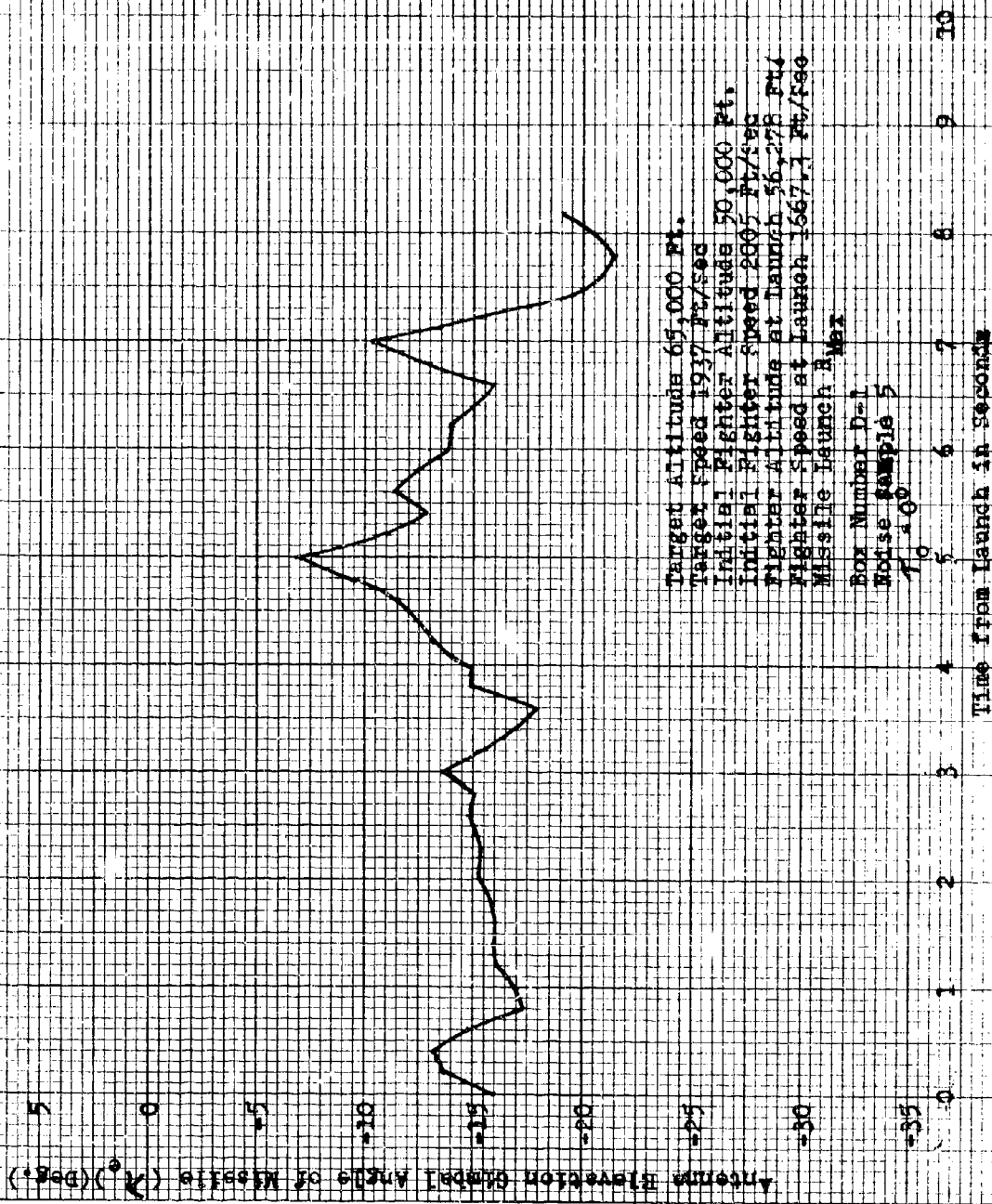
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Fig. 8k - Antenna Elevation Gimbal Angle of Missile vs Time
Pull-up Attacks - Improved Missile



Target Altitude 65,000 Ft.
Target Speed 1937 Ft/sec
Initial Fighter Altitude 50,000 Ft.
Initial Fighter Speed 2805 Ft/sec
Fighter Altitude at Launch 56,278 Ft.
Fighter Speed at Launch 1667.1 Ft/sec
Missile Launch Angle

Box Number D-1
Noise Sample 5
7.400

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Fig. 8-1 - Missile lead Angle vs Time
Pull-up Attacks - Improved Missile

Target Altitude 65,000 Ft.
Target Speed 1937 Ft/sec
Initial Fighter Altitude 50,000 Ft.
Initial Fighter Speed 2005 Ft/sec
Fighter Altitude at Launch 56,278 Ft
Fighter Speed at Launch 1667.3 Ft/sec
Missile launch K_{Max}

Box Number D-3
Noise Sample 5
 $\sigma_0 = 0$

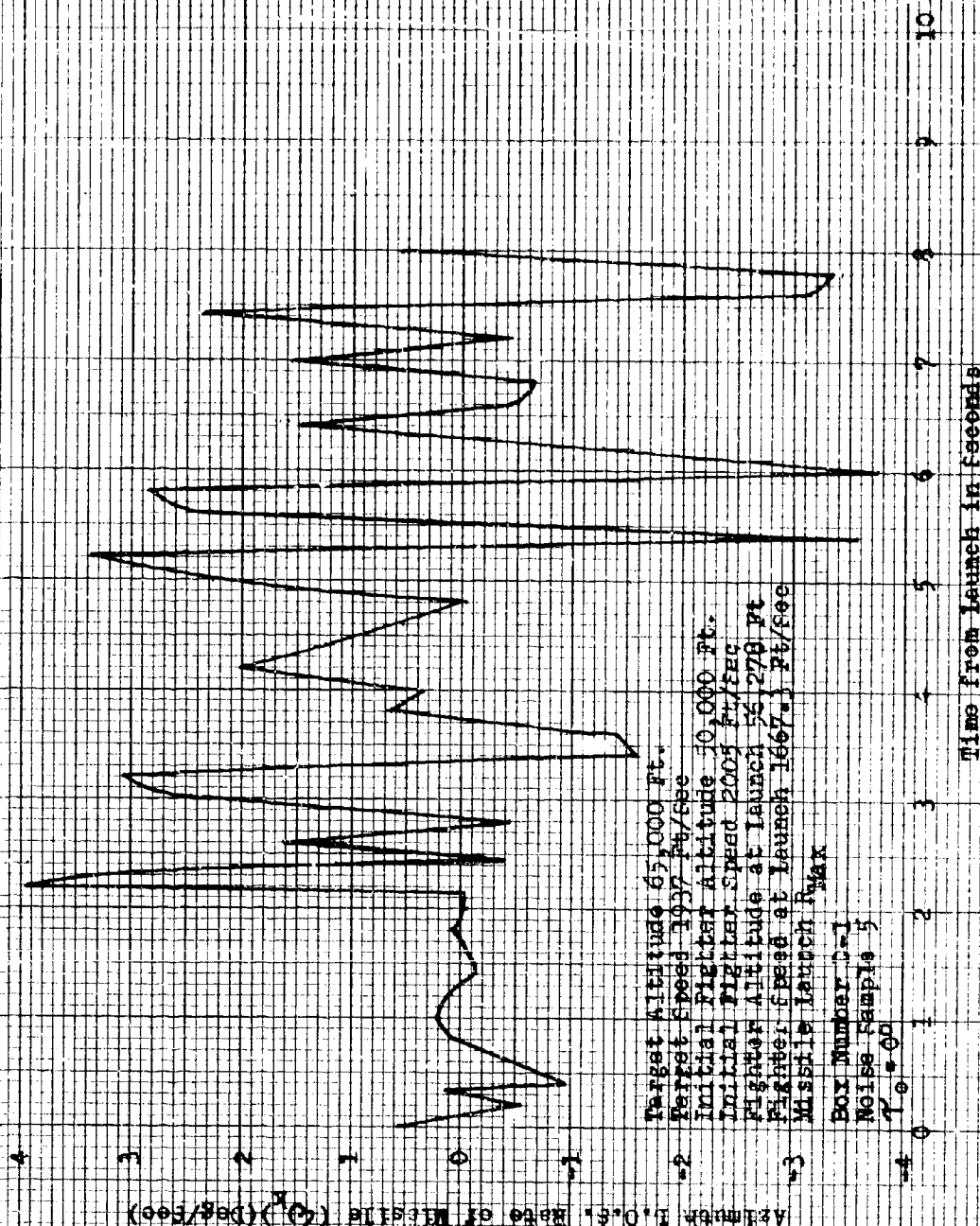
Missile Lead Angle (°) (Deg.)

Time from launch in seconds

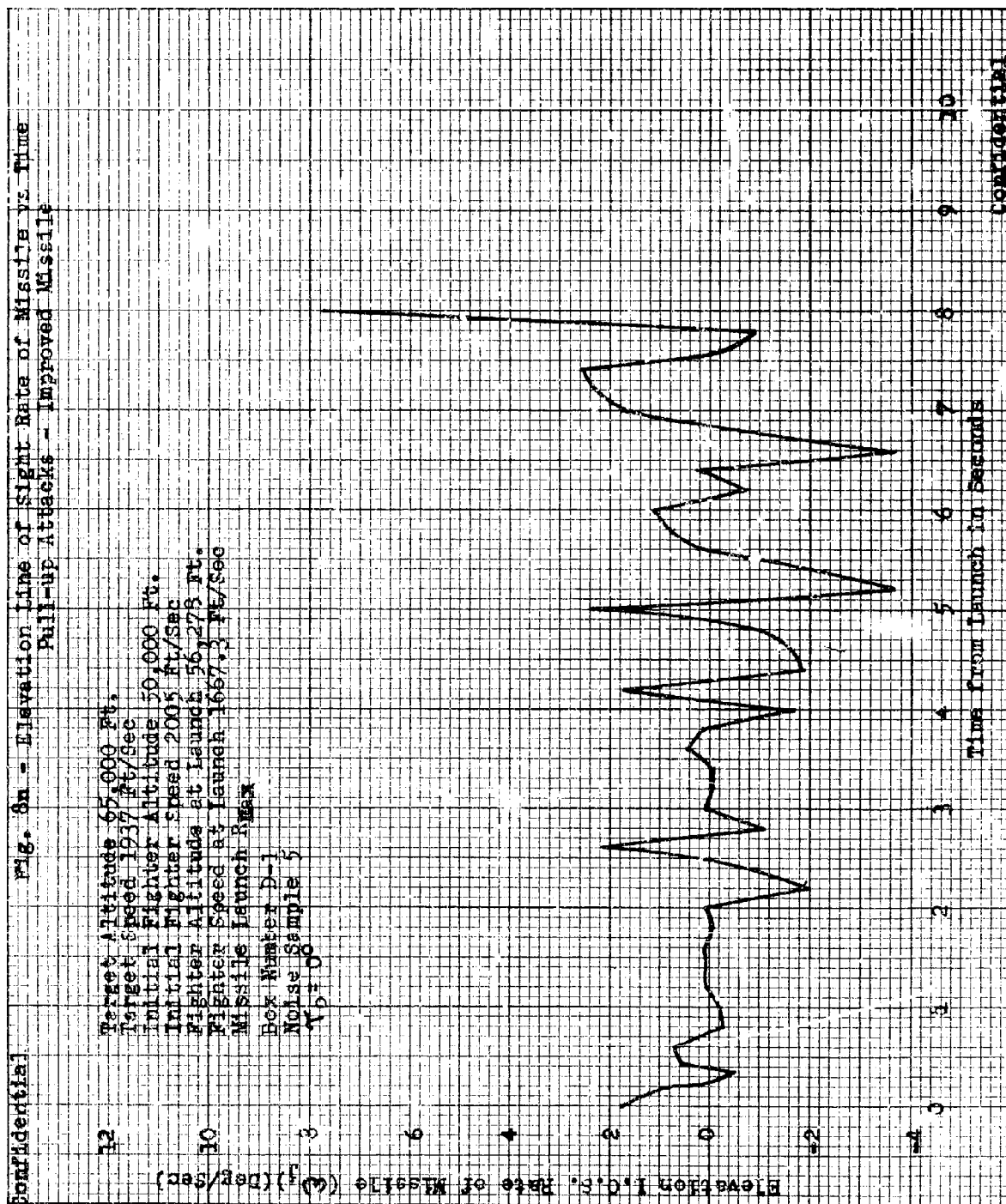
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Fig. 8a - Azimuth line of sight Rate of Missile vs Time
Pull-up Attacks - Improved Missile

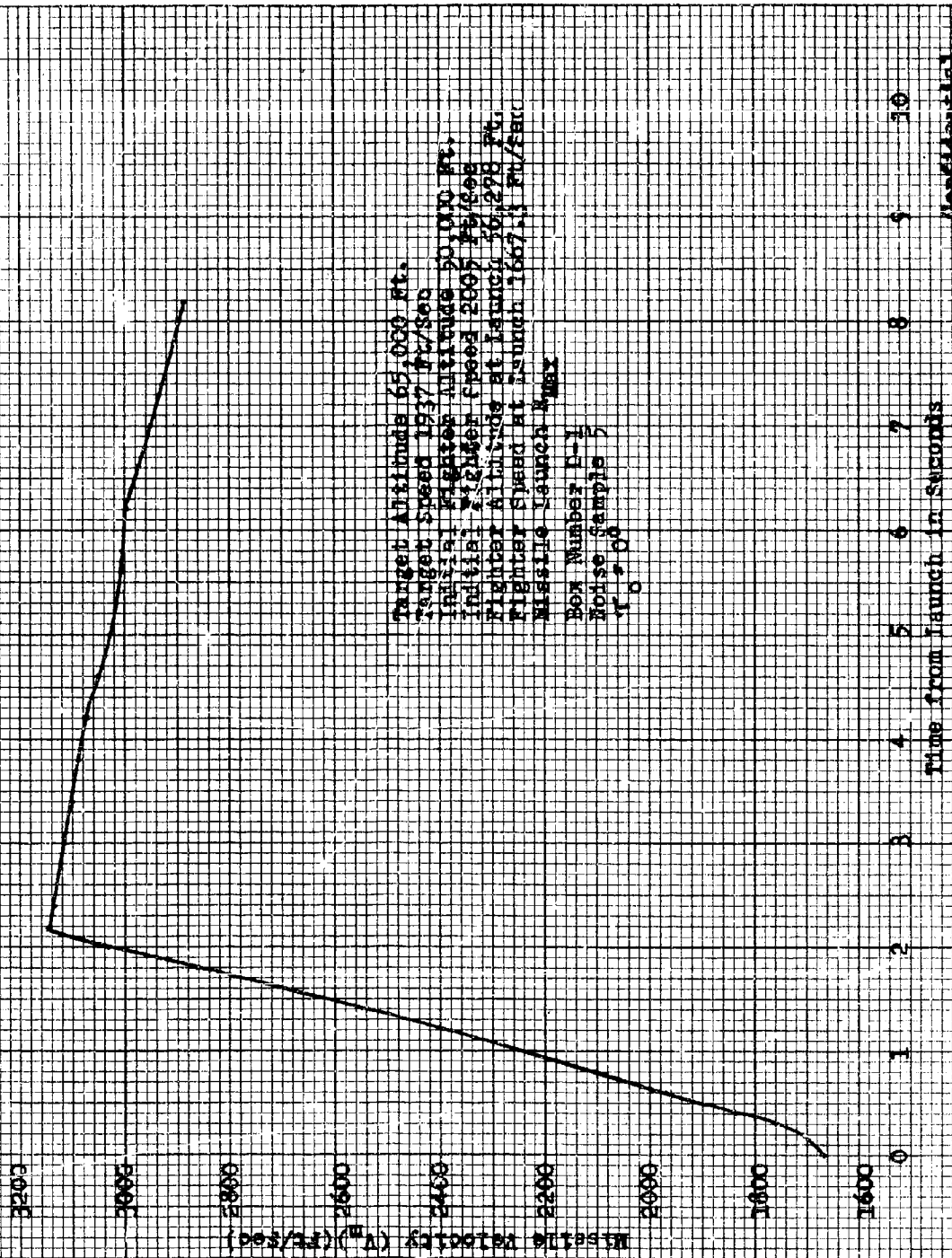


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Fig. 86 - Missile Velocity vs Time
Roll-up Attacks - Improved Missile

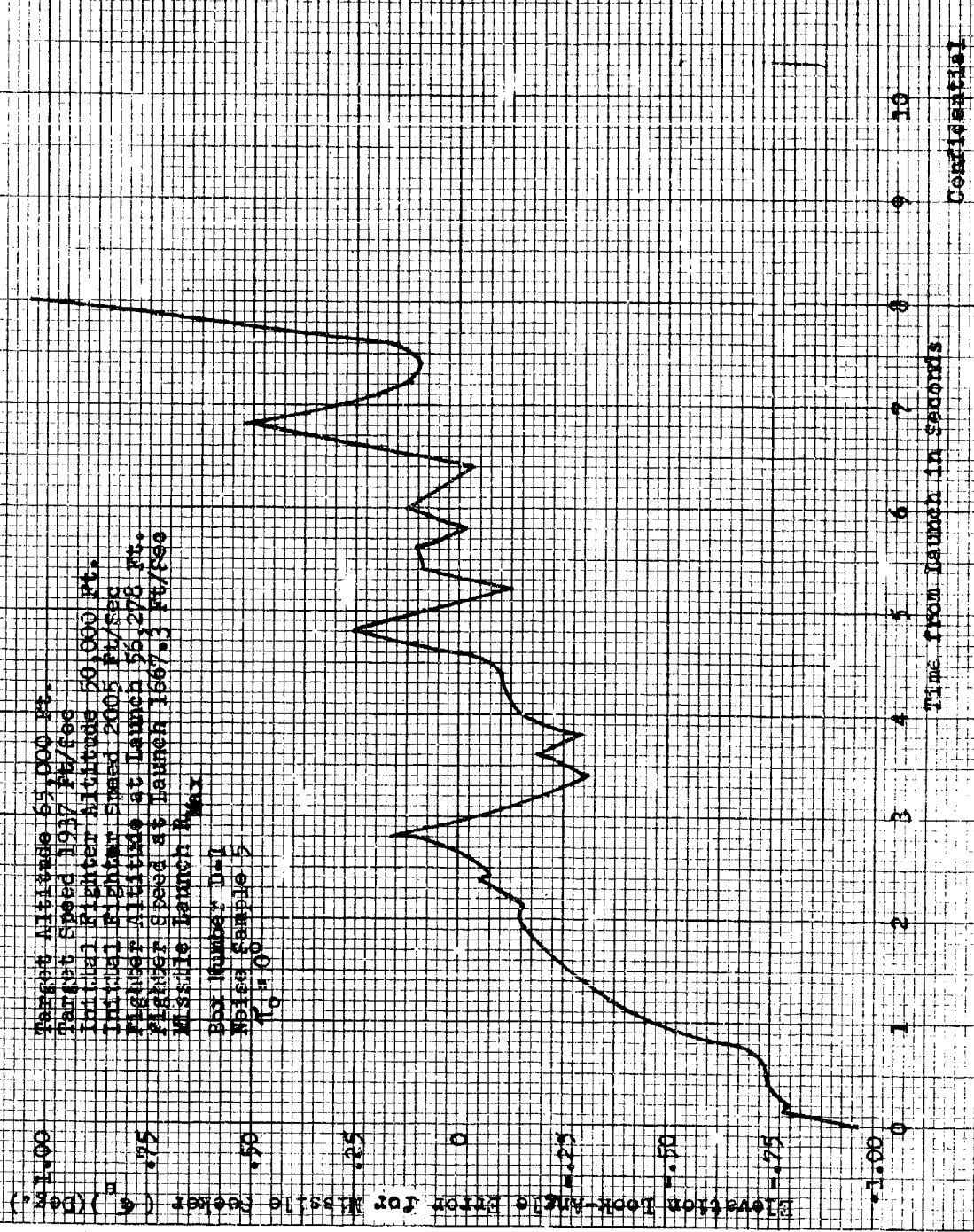


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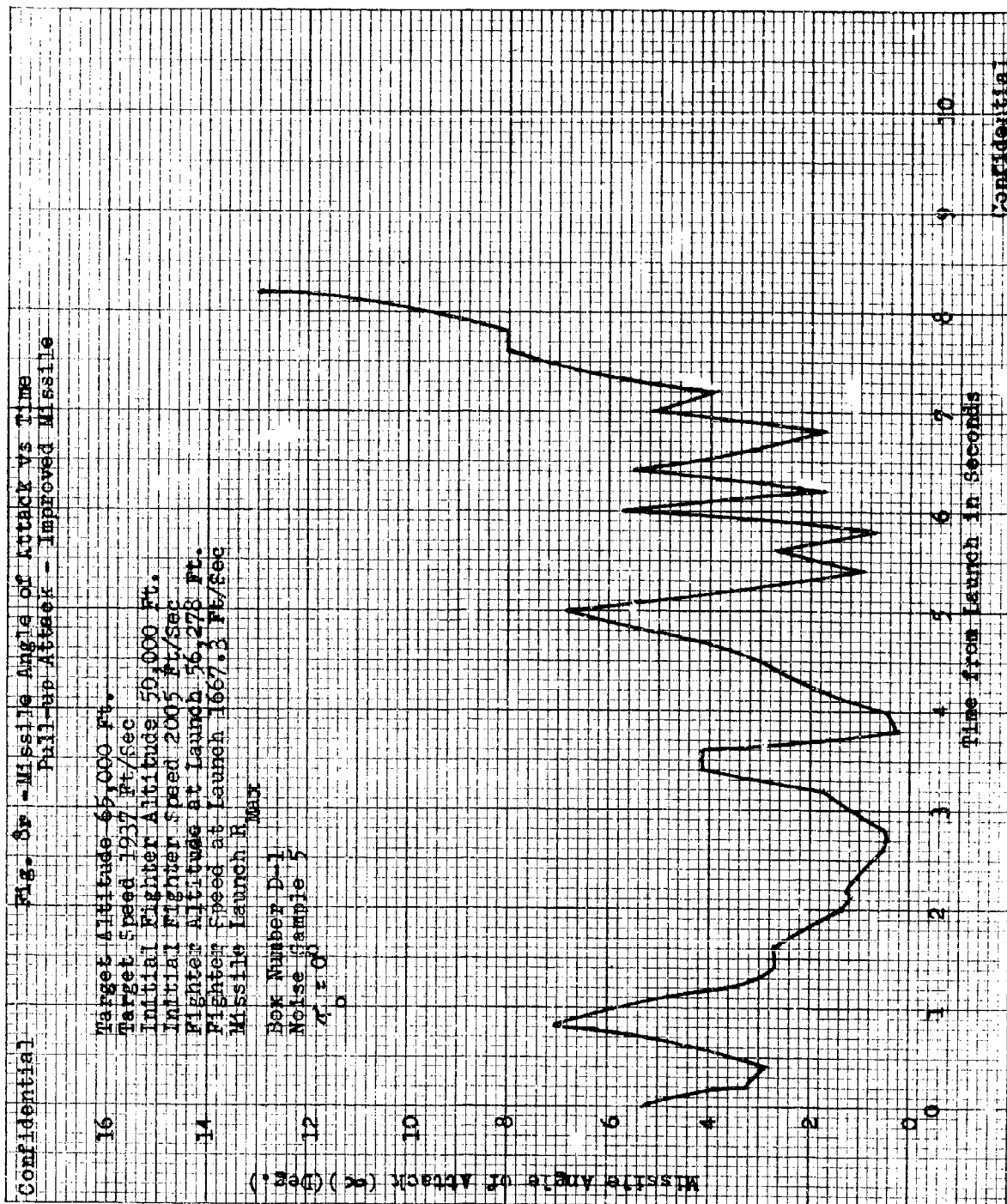
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Fig. 8a - Elevation Look-Angle Error for Missile Seeker vs Time

Pull-up Attack - Improved Missile

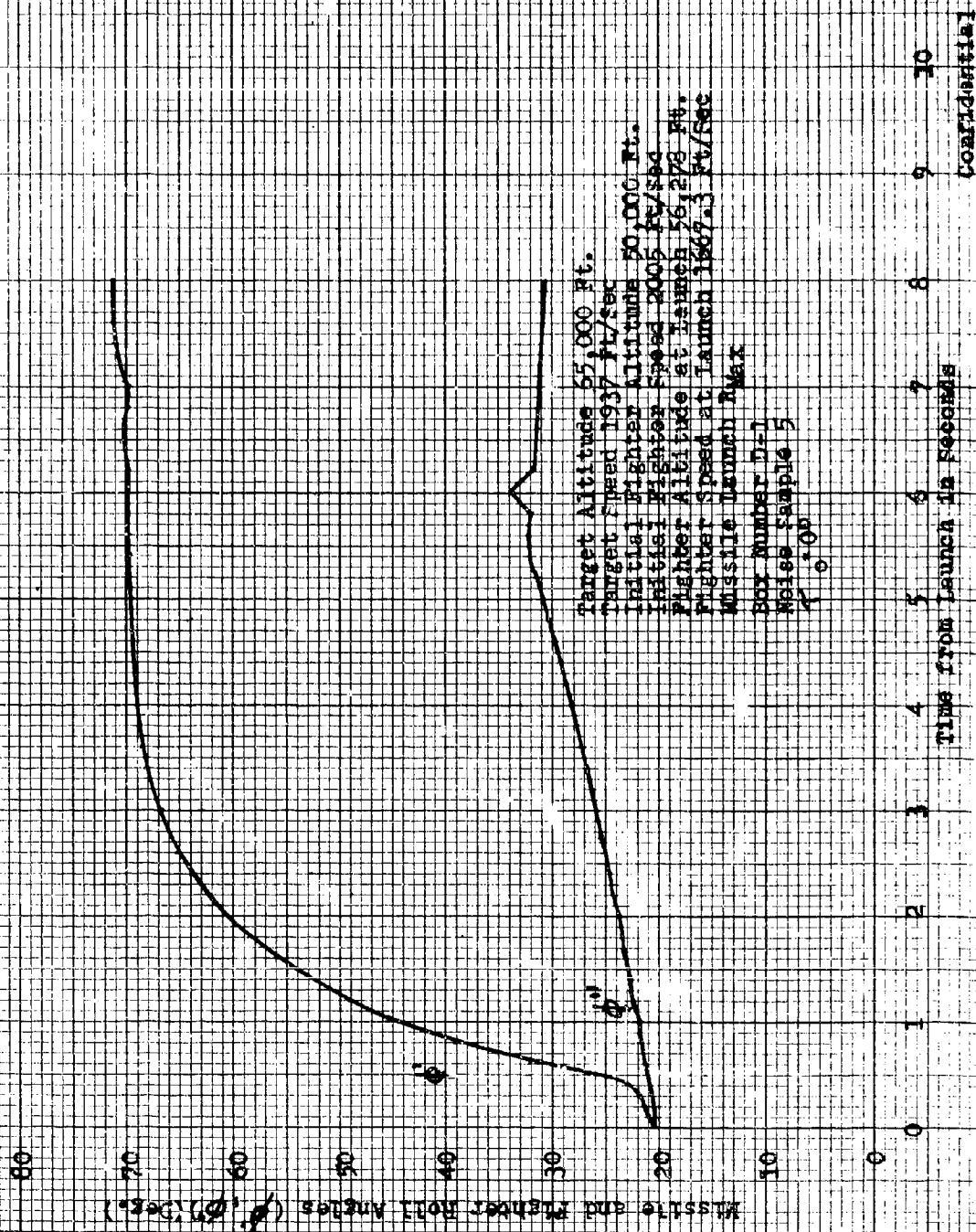


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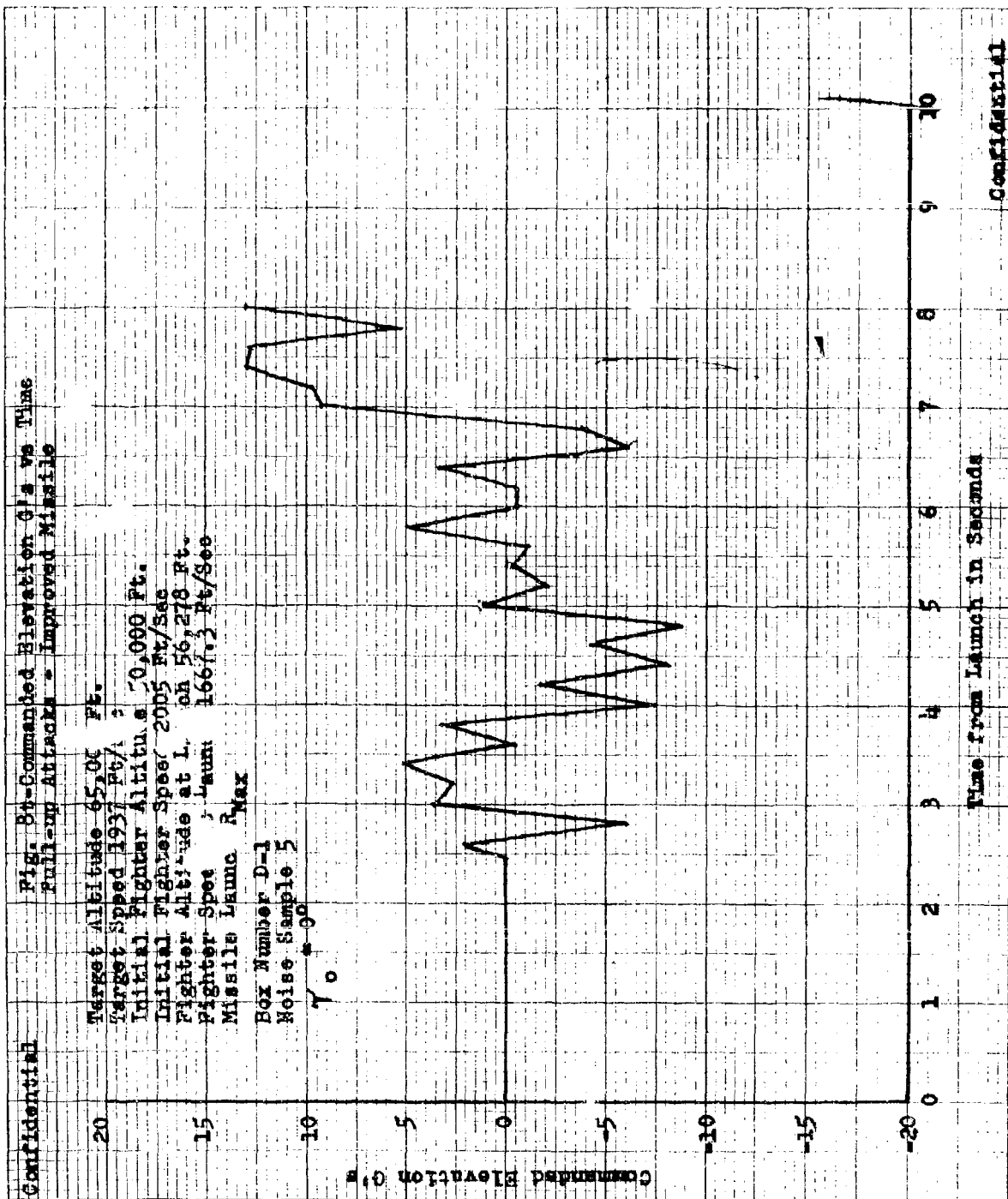


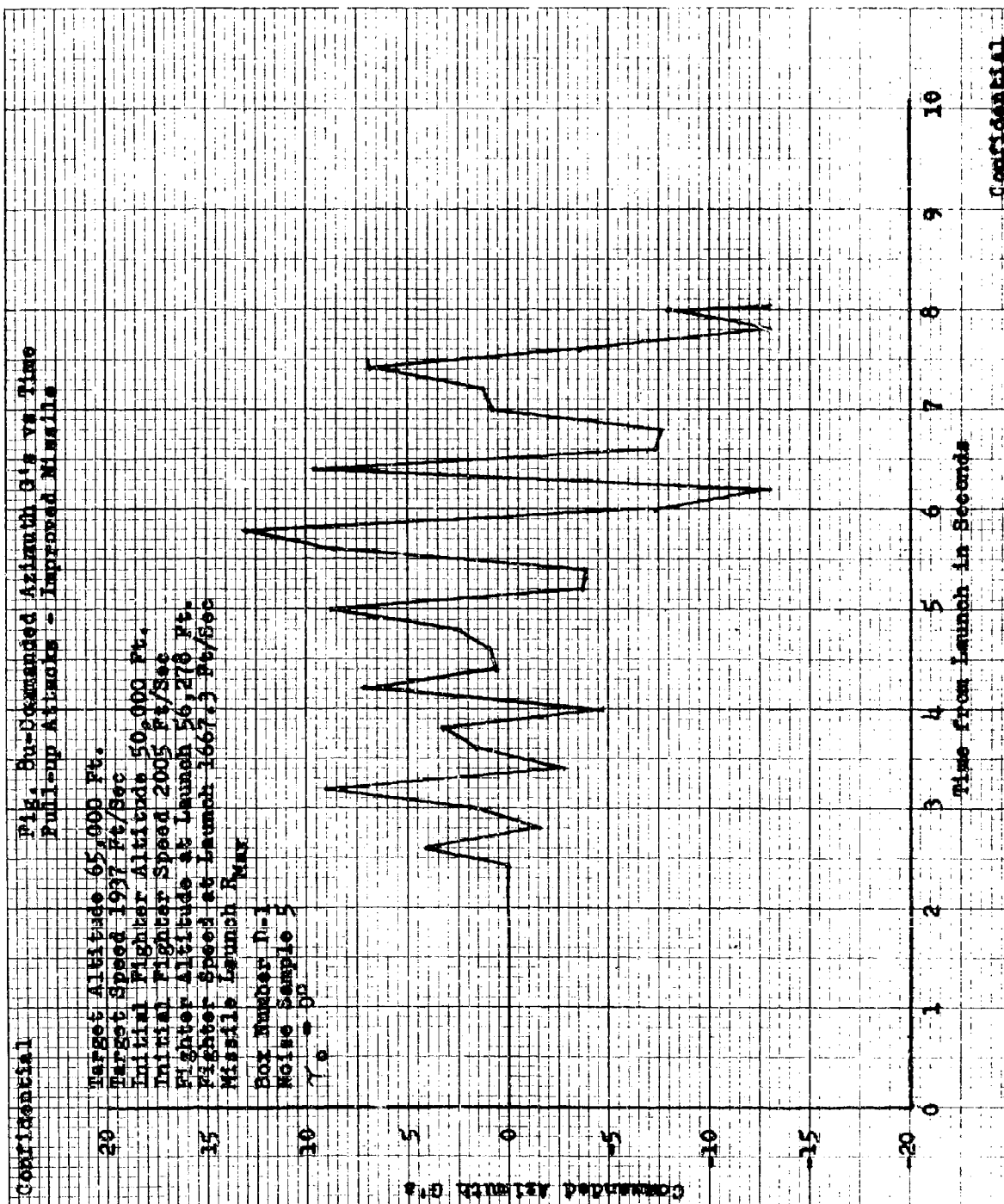
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Fig. 3a - Missile and Fighter Roll Angles vs Time
Full-up Attacks - Improved Missile



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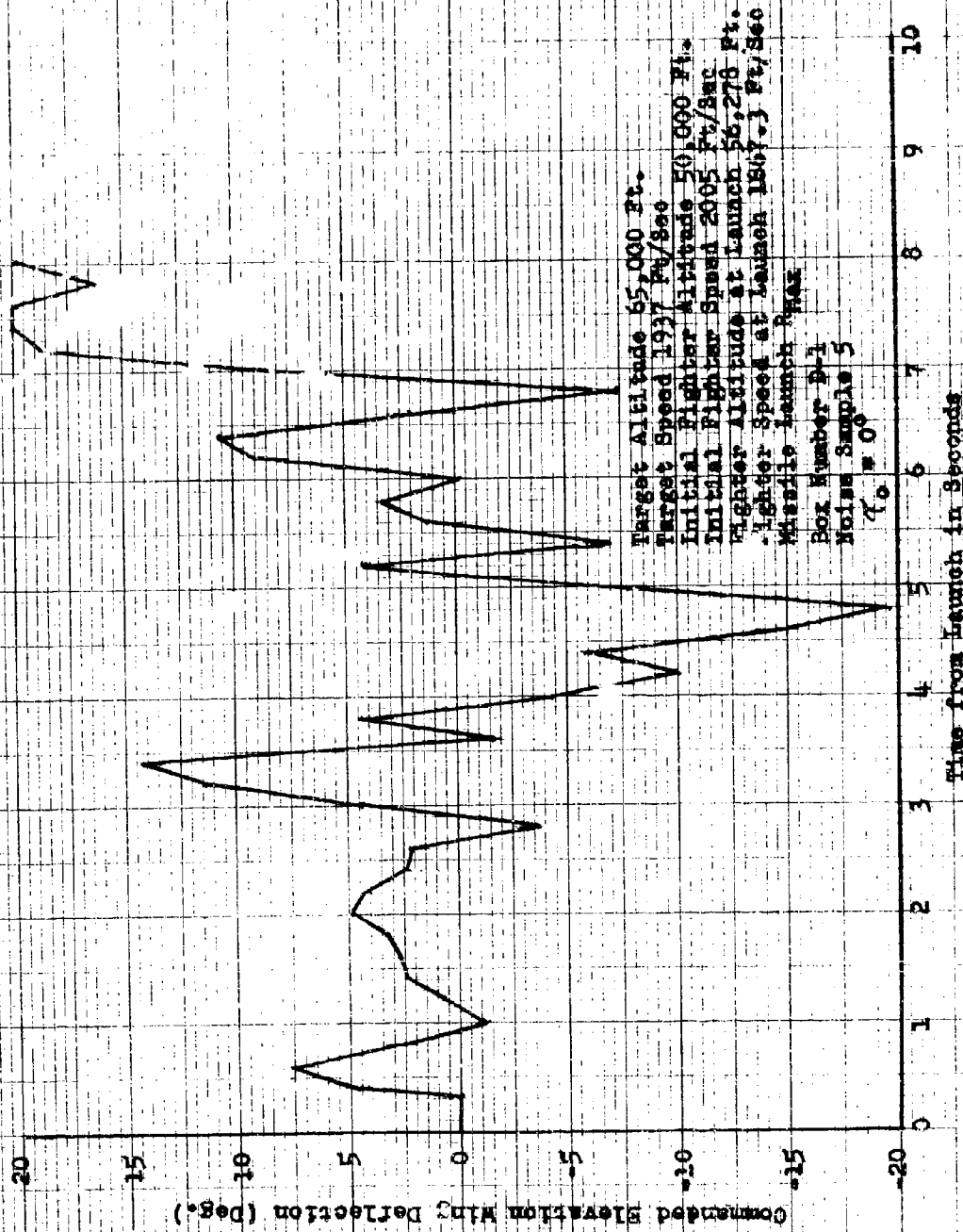




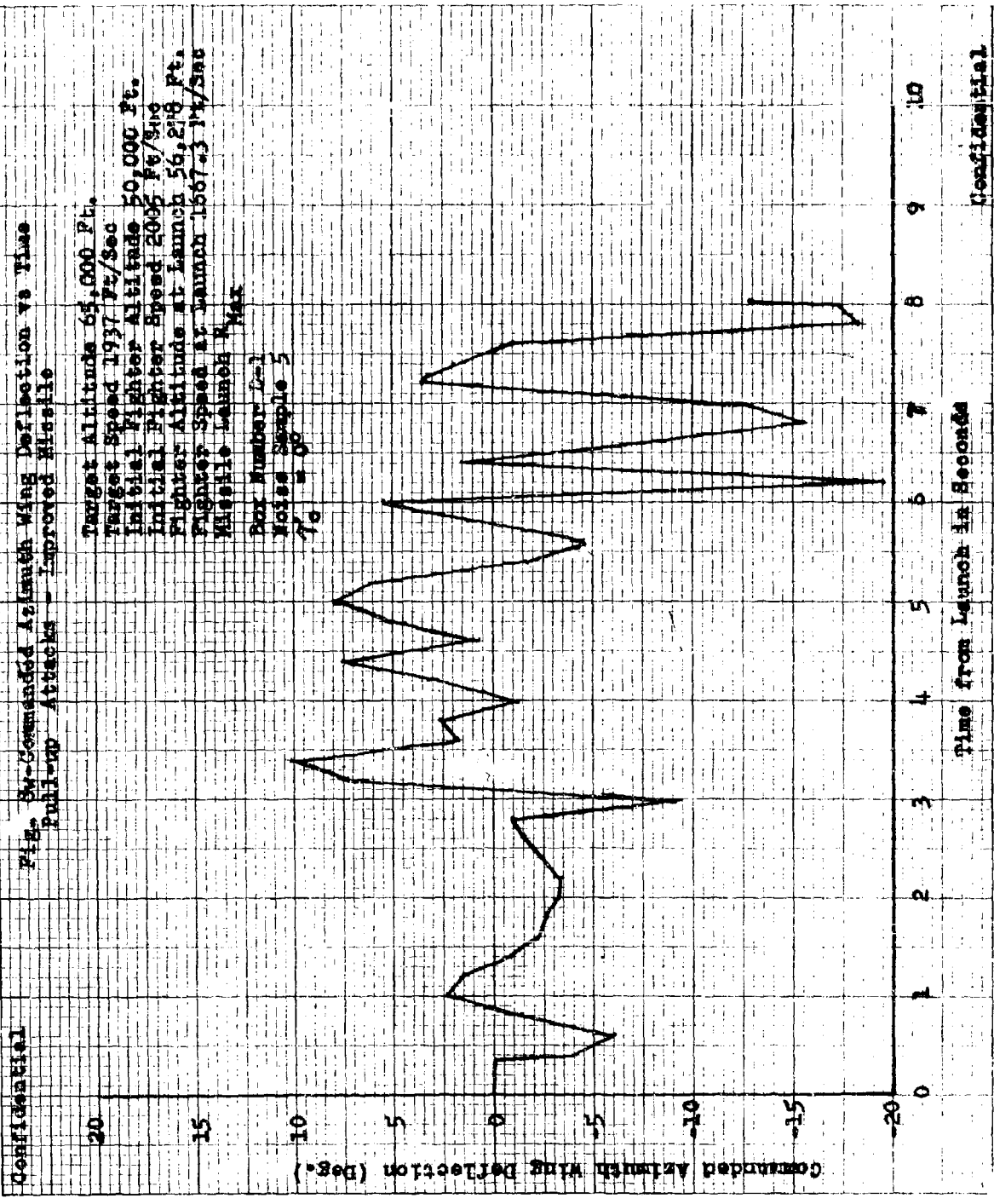


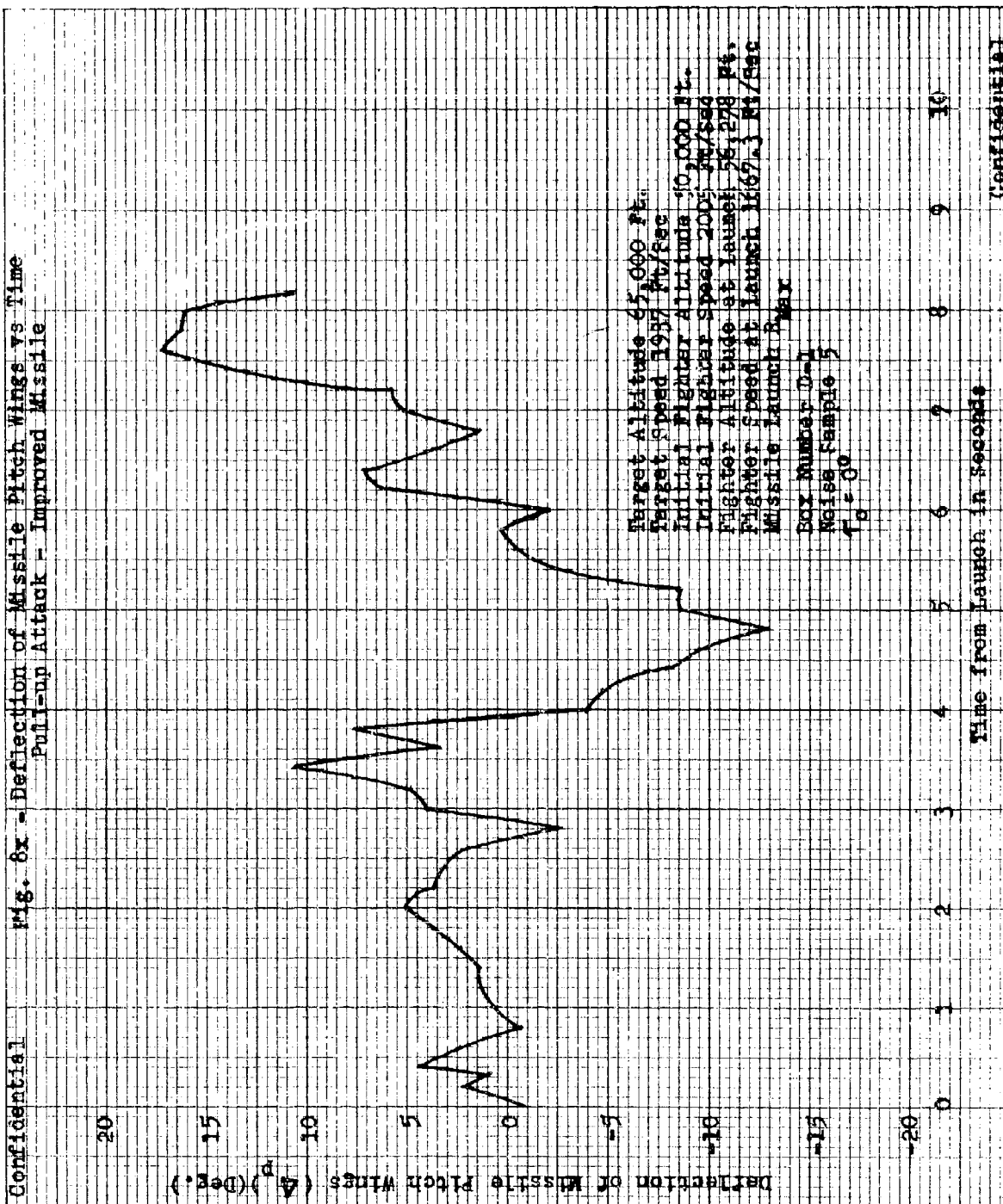
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Fig. 8v-Commanded Elevation Wing Detachment vs Time
Pull-up, Attacks - In, Moved Missile



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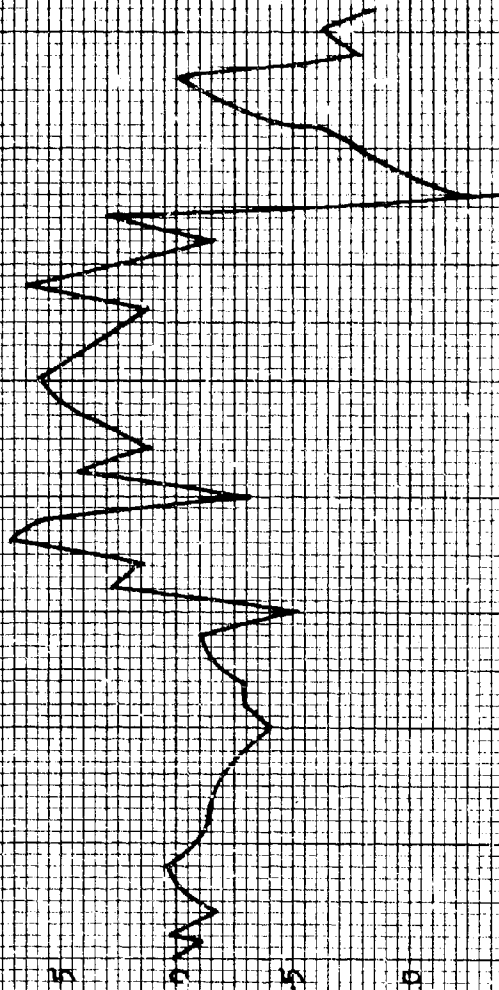


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Fig. 87-Deflection of Missile Yaw Wings vs Time
Pull-up Attack - Improved Missile

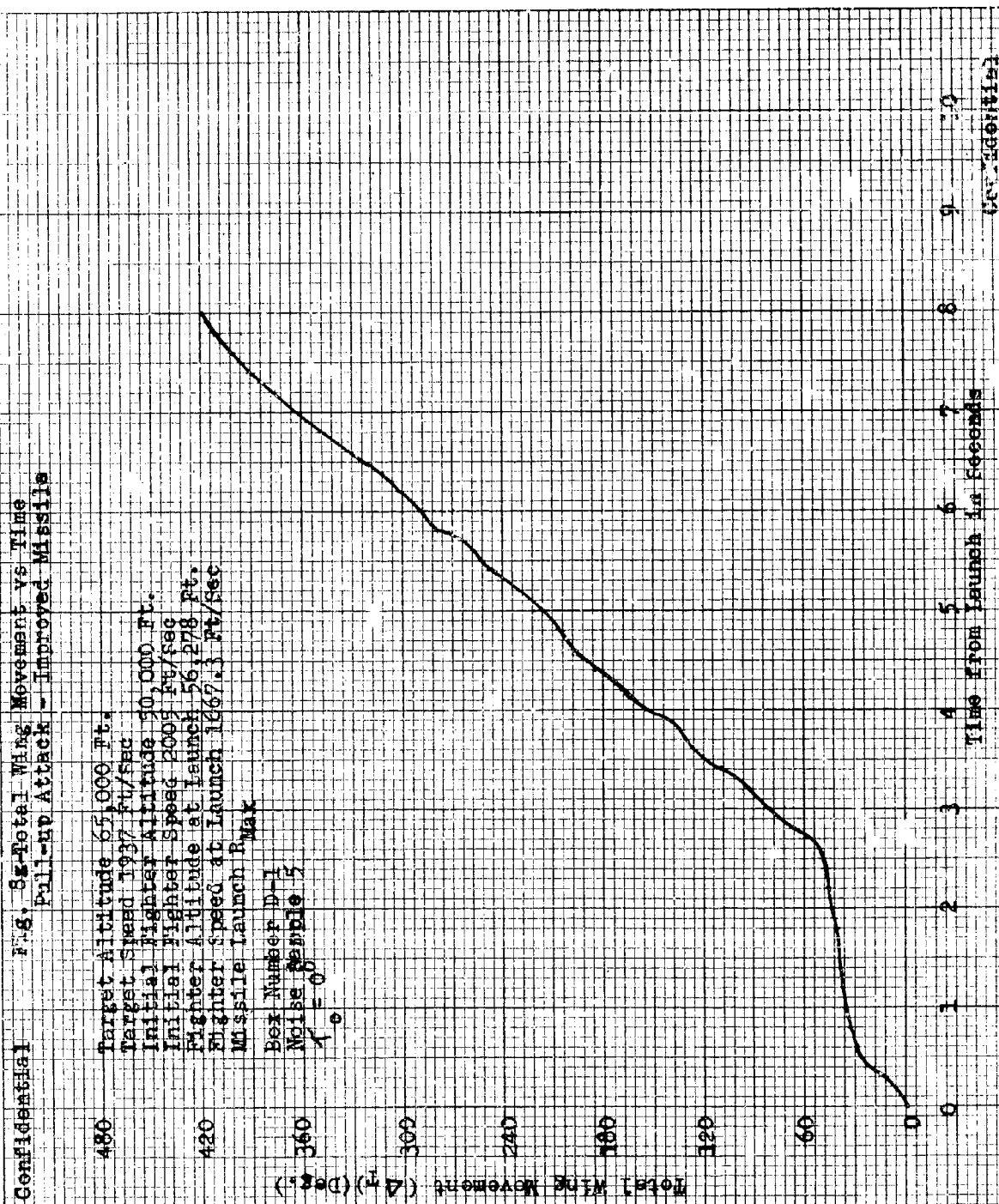
Target Altitude 65,000 Ft.
Target Speed 1937 Ft/Sec
Initial Fighter Altitude 50,000 Ft.
Initial Fighter Speed 2005 Ft/Sec
Fighter Altitude at Launch 56,278 Ft.
Fighter Speed at Launch 1667.3 Ft/Sec
Missile Launch Max
Box Number D-1
Noise Sample 5
2,100

Deflection of Missile Yaw Wings (A.Y.) (Deg.)



Time from Launch in Seconds

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Fig. 8 - Missile Altitude vs Time
Pull-up Attacks - Improved Missile

Target Altitude 65,000 Ft.
Target Speed 1937 Ft/Sec
Initial Fighter Altitude 50,000 Ft.
Initial Fighter Speed 2005 Ft/Sec
Fighter Altitude at Launch 56,278 Ft.
Fighter Speed at Launch 1667.3 Ft/Sec
Missile Launch Box

Box Number D-3

Noise Sample 5

$\gamma = 0$

0

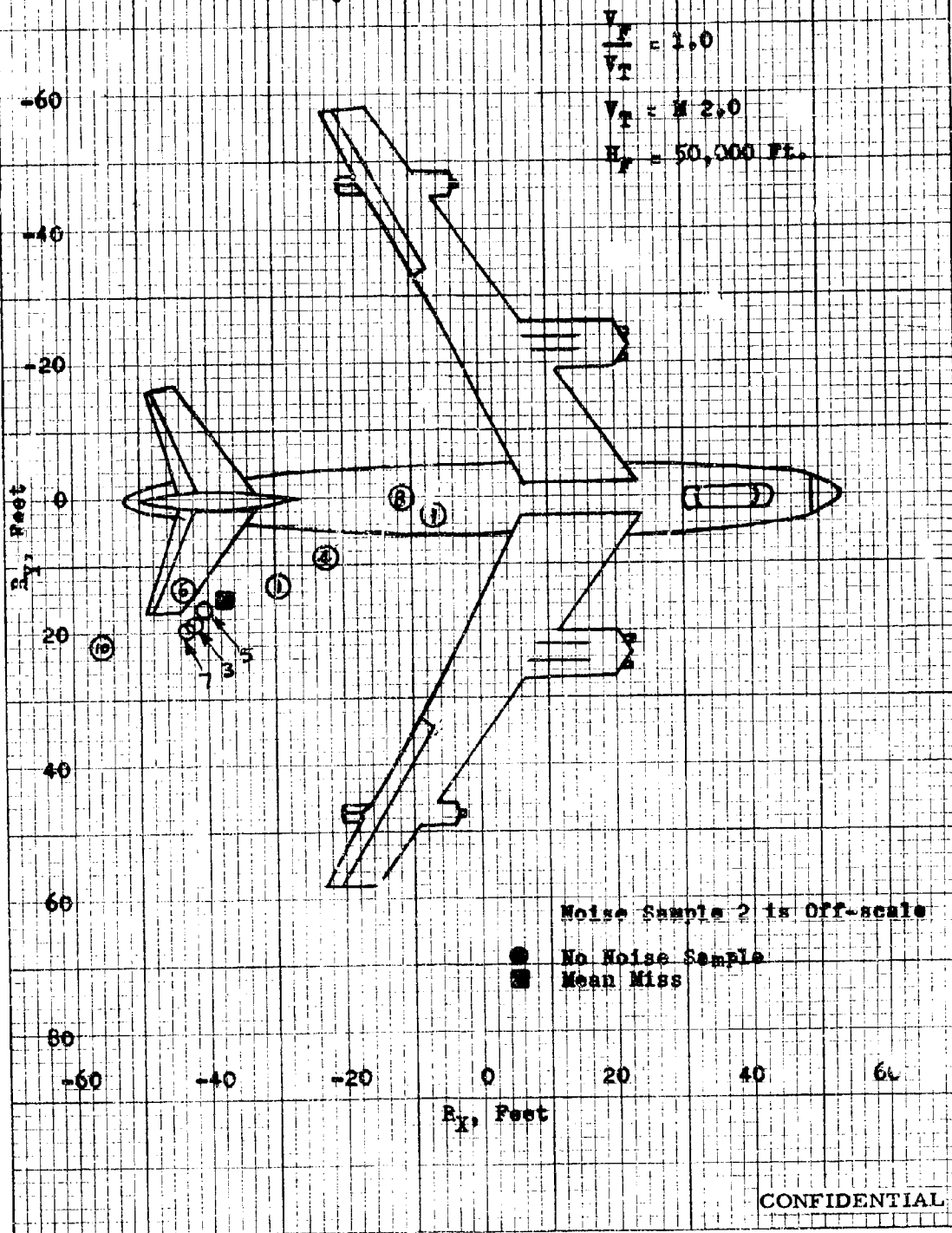
Missile Altitude (M) (Ft x 10³)

Time from Launch in Seconds

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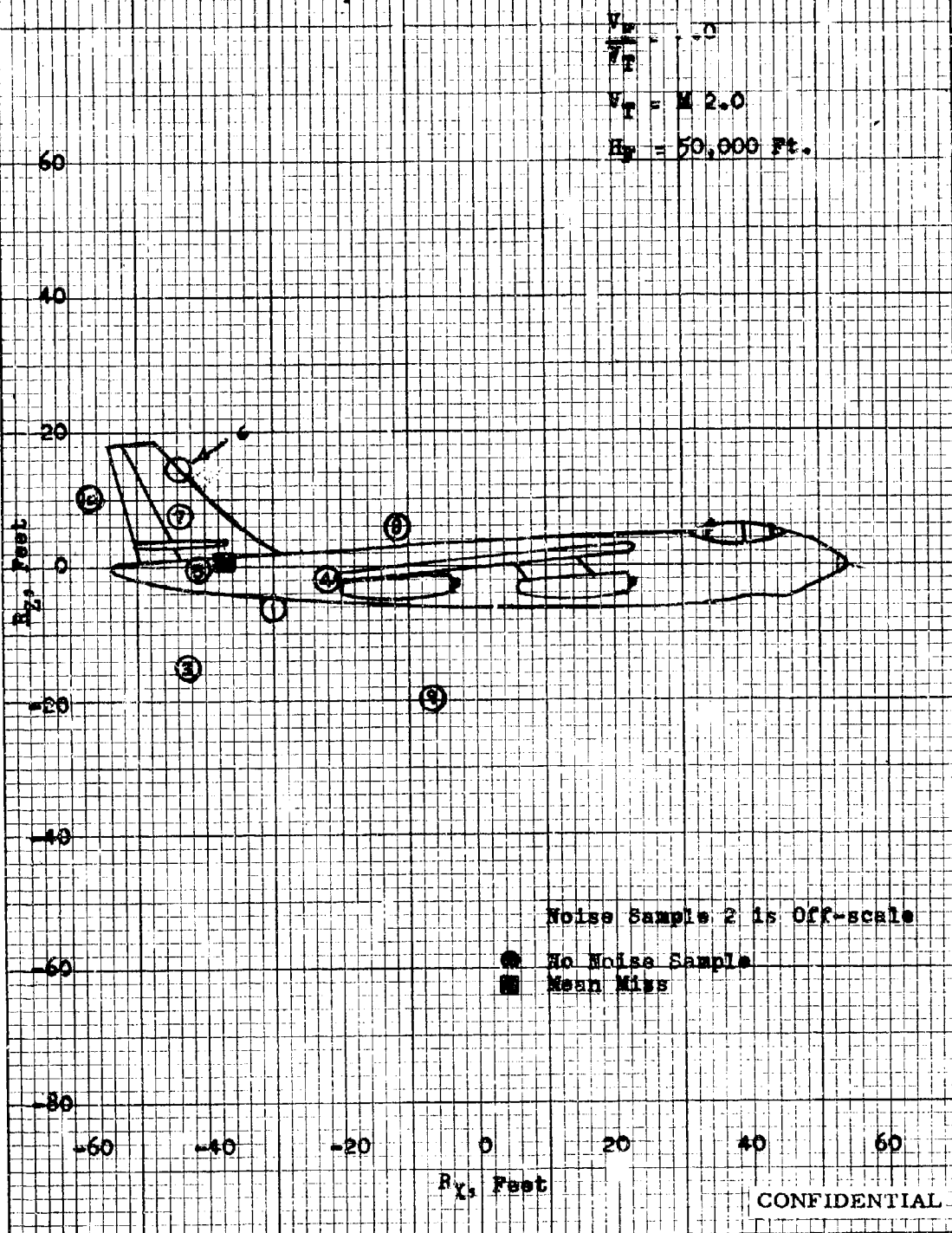
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Fig. 9a- Sparrow III Miss Distance - Co-altitude Attacks
 X-Y Miss Distance at the Target
 $T_D = 15^\circ$, Rwin Launch, Fighter Course - B-3
 Improved Missile



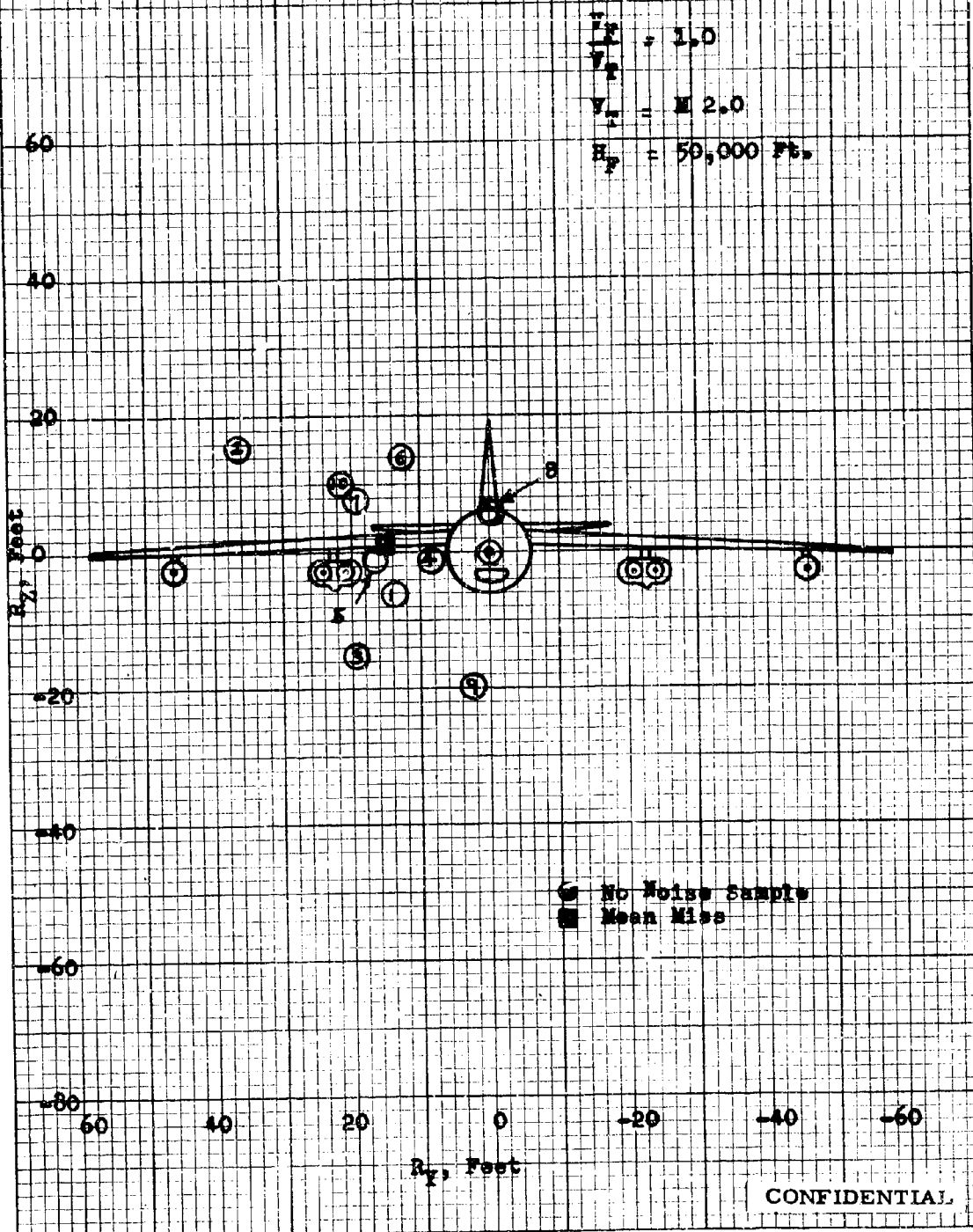
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Fig. 66- Sparrow III Miss Distance - Co-altitude Attack
X-Z Miss Distance at the Target
T-15, B-15 Launch, Fighter Course - P-3
Improved Missile



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Fig. 9a- Sparrow III Miss Distance - Co-altitude Attacks
 Y-Z Miss Distance at the Target
 $\gamma = 15^\circ$, 2 min Launch, Fighter Course - B-3
 Improved Missile

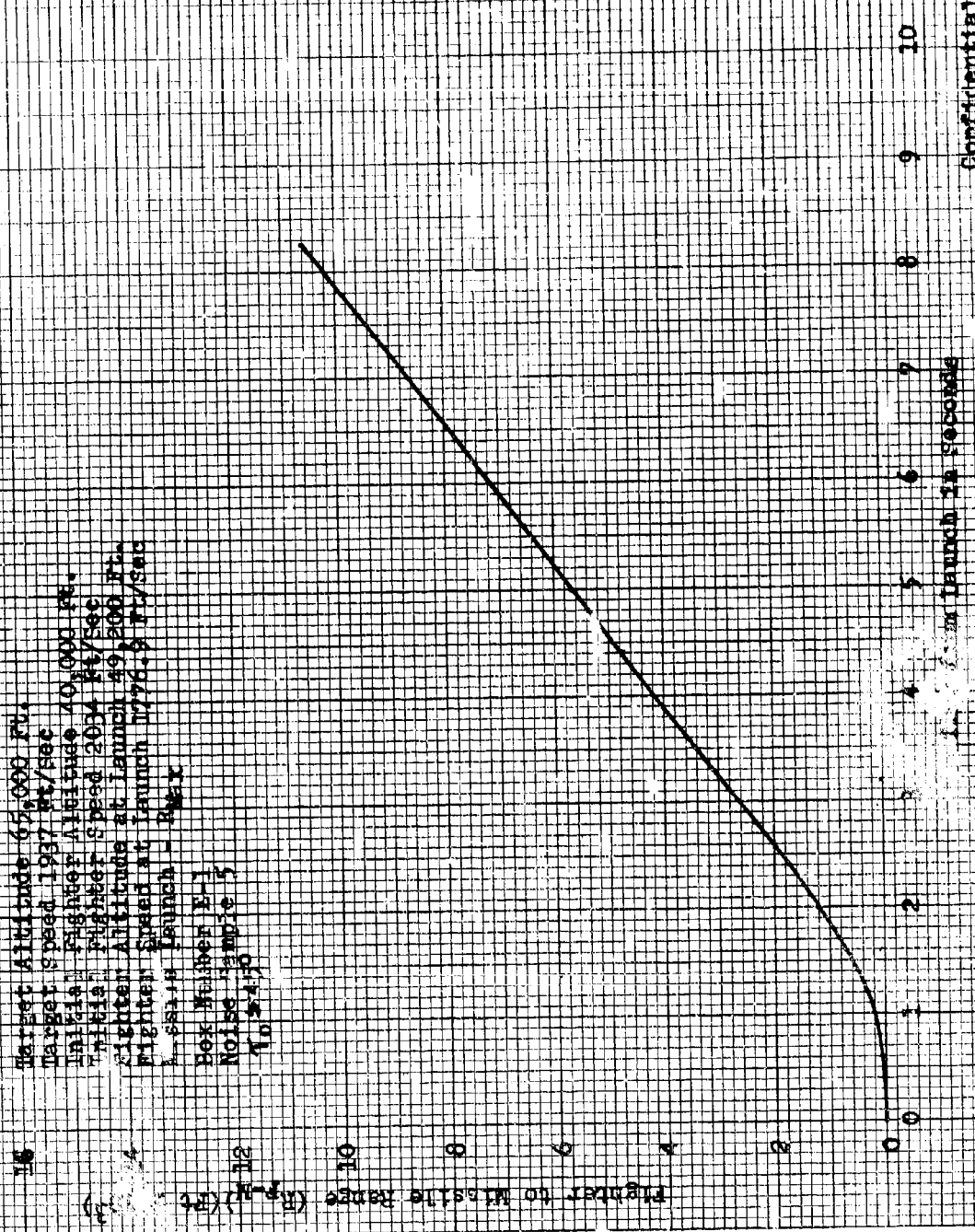


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 NEUFEL & BESSER CO. BALDWIN, N.Y.

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Fig. 50 - Flight or 20 Missile Range vs Time
Pull-up Attacks - Improved Missile

Target Altitude 65,000 Ft.
Target Speed 1937 Ft/Sec
Initial Fighter Altitude 40,000 Ft.
Initial Fighter Speed 2034 Ft/Sec
Fighter Altitude at launch 49,200 Ft.
Fighter Speed at launch 1776.8 Ft/Sec
Launch launch - Box
Box Number E-1
Noise sample 5
(0.543)



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Fig. 9a - Missile to Target Range vs Time
 Pull-up Attacks - Improved Missile

Target Altitude 65,000 Ft.
 Target Speed 1937 Ft/sec
 Initial Fighter Altitude 40,000 Ft.
 Initial Fighter Speed 2034 Ft/sec
 Fighter Altitude at Launch 49,200 Ft.
 Fighter Speed at Launch 1776.9 Ft/sec
 Missile Launch - R Max

Box Number B-1
 Noise Sample 5
 $\sigma = 450$

Missile to Target Range (Feet) x 10³

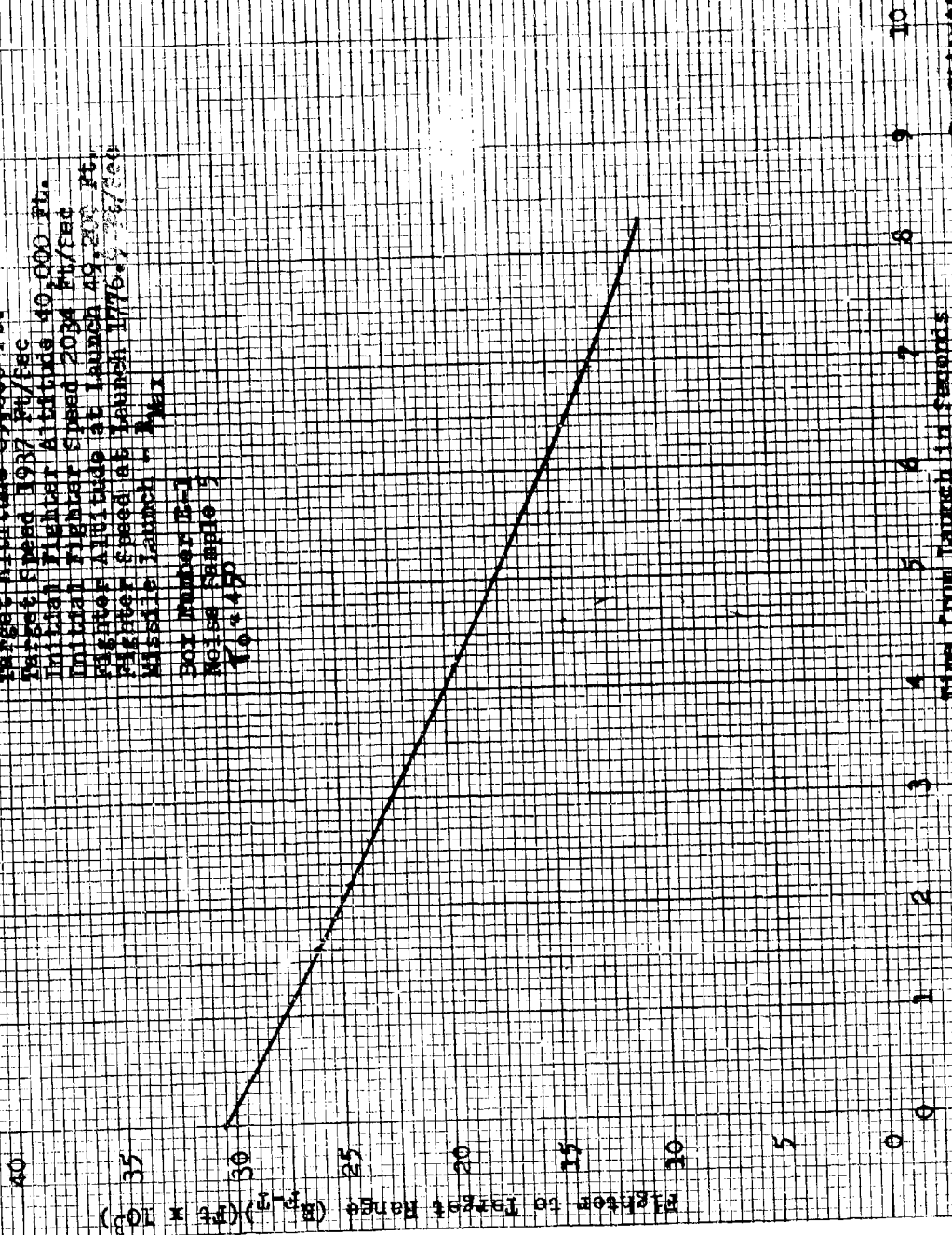
Time from launch in seconds

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Fig. 94 - Fighter to Target Range vs Time
Pull-up Attacks - Improved Missile

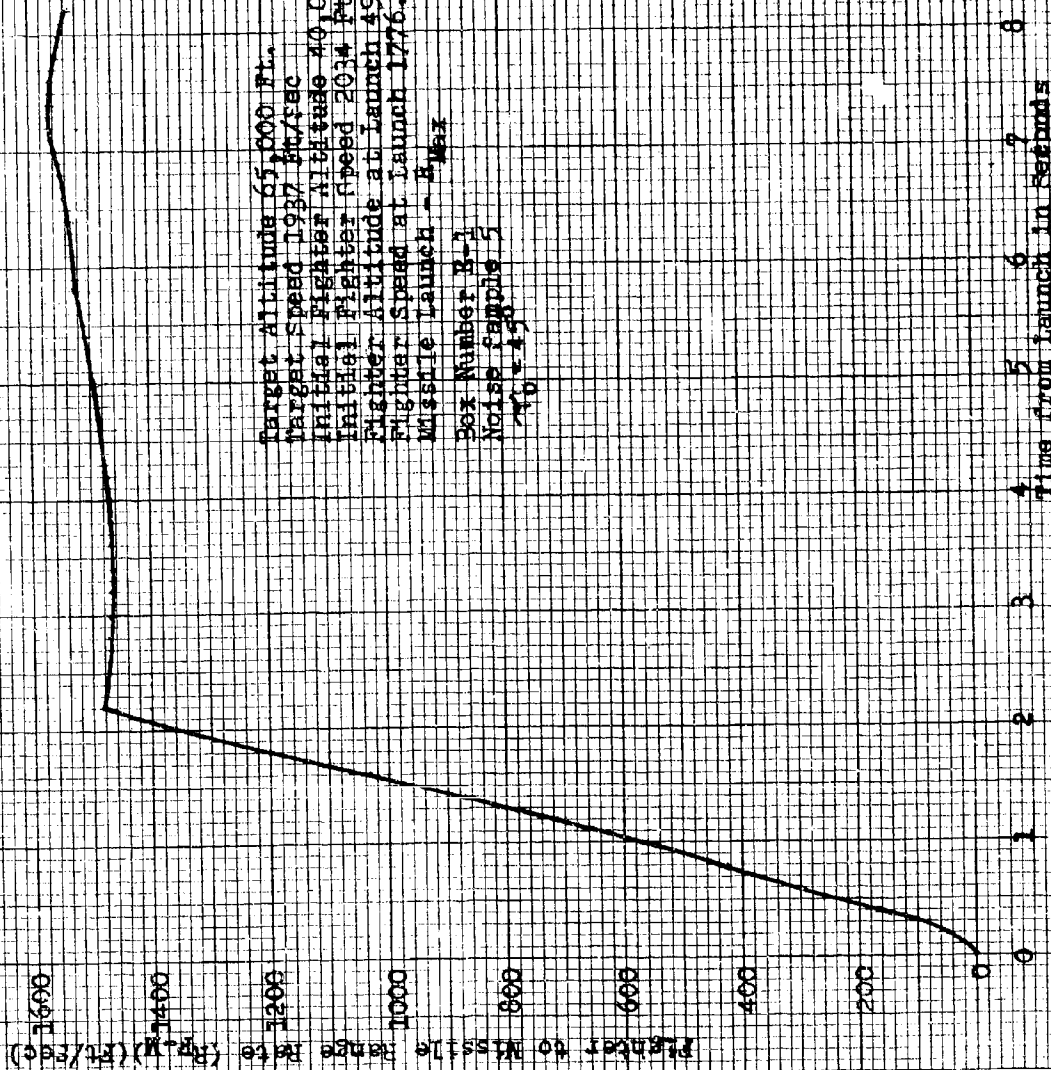
Target Altitude 65,000 Ft.
Target Speed 1937 ft/sec
Initial Fighter Altitude 40,000 Ft.
Initial Fighter Speed 2034 ft/sec
Fighter Altitude at Launch 49,200 ft.
Fighter Speed at Launch 1776 ft/sec
Missile Launch - Max
Fox Hunter E-1
Noise Sample 3
10-4-50



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Fig. 98- Fighter to Missile Range Rate vs Time
Pull-up Attacks - Improved Missile

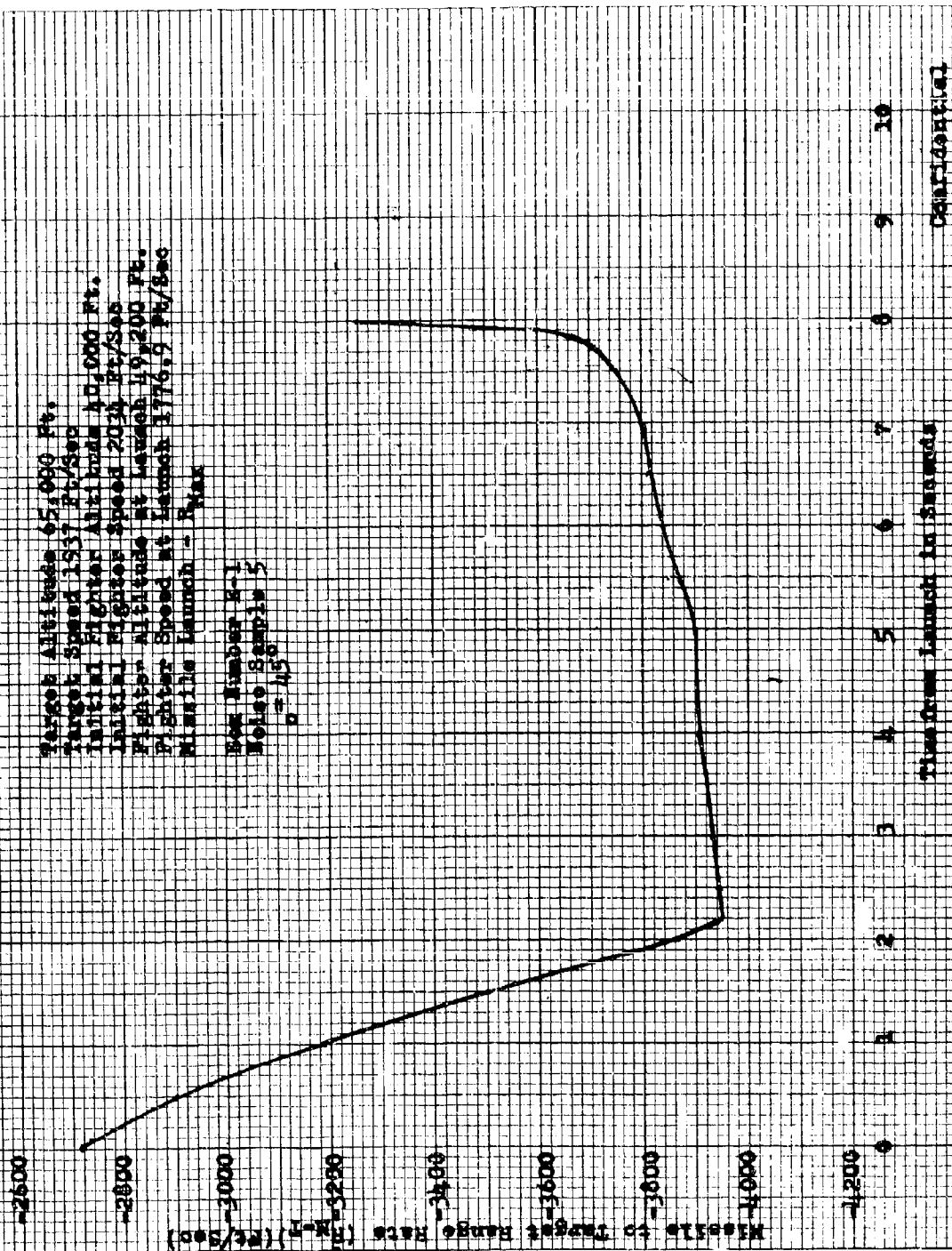
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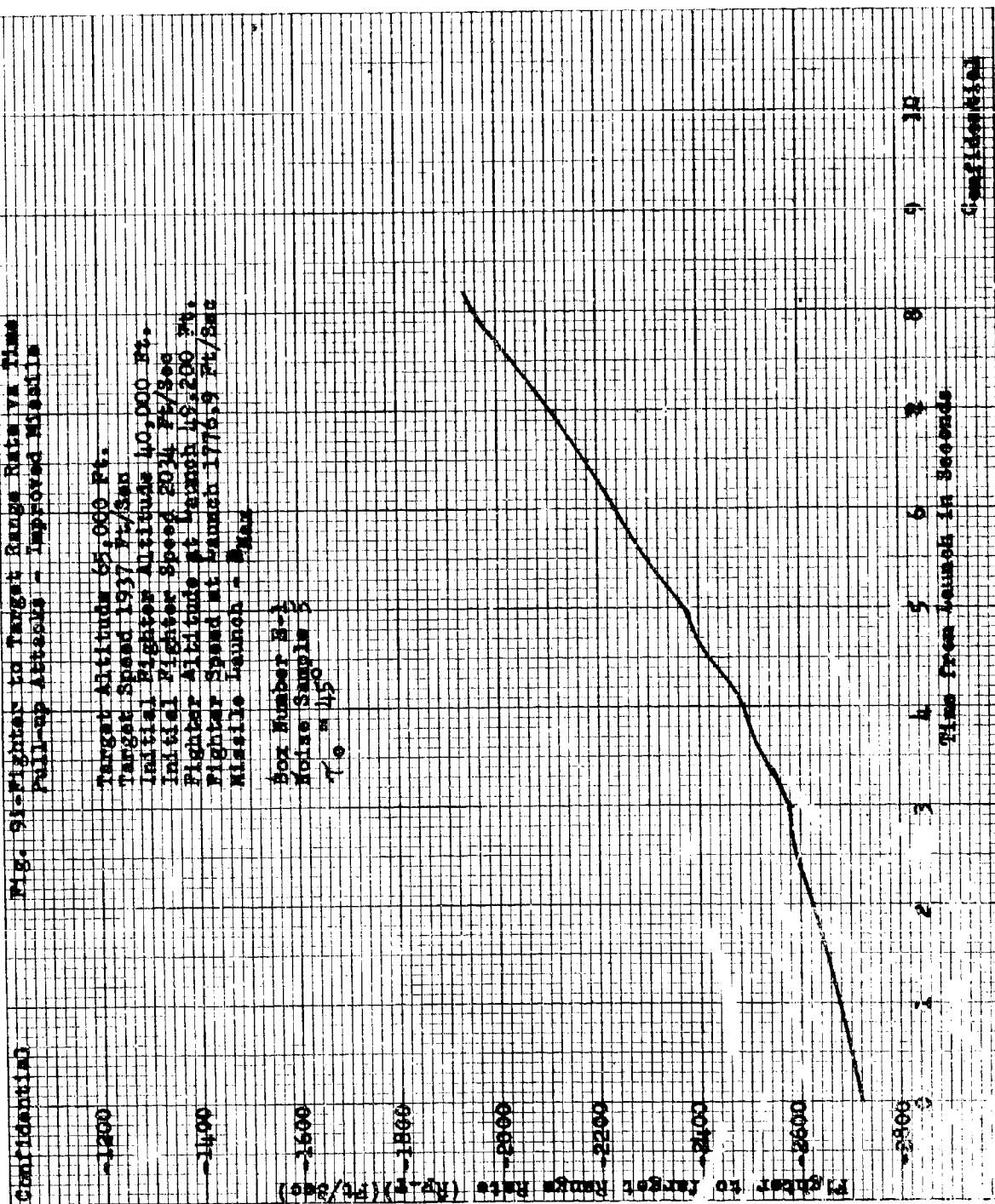
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Fig. 9b. Missile to Target Range Rate vs Time
Full-on Attacks - Improved Missile

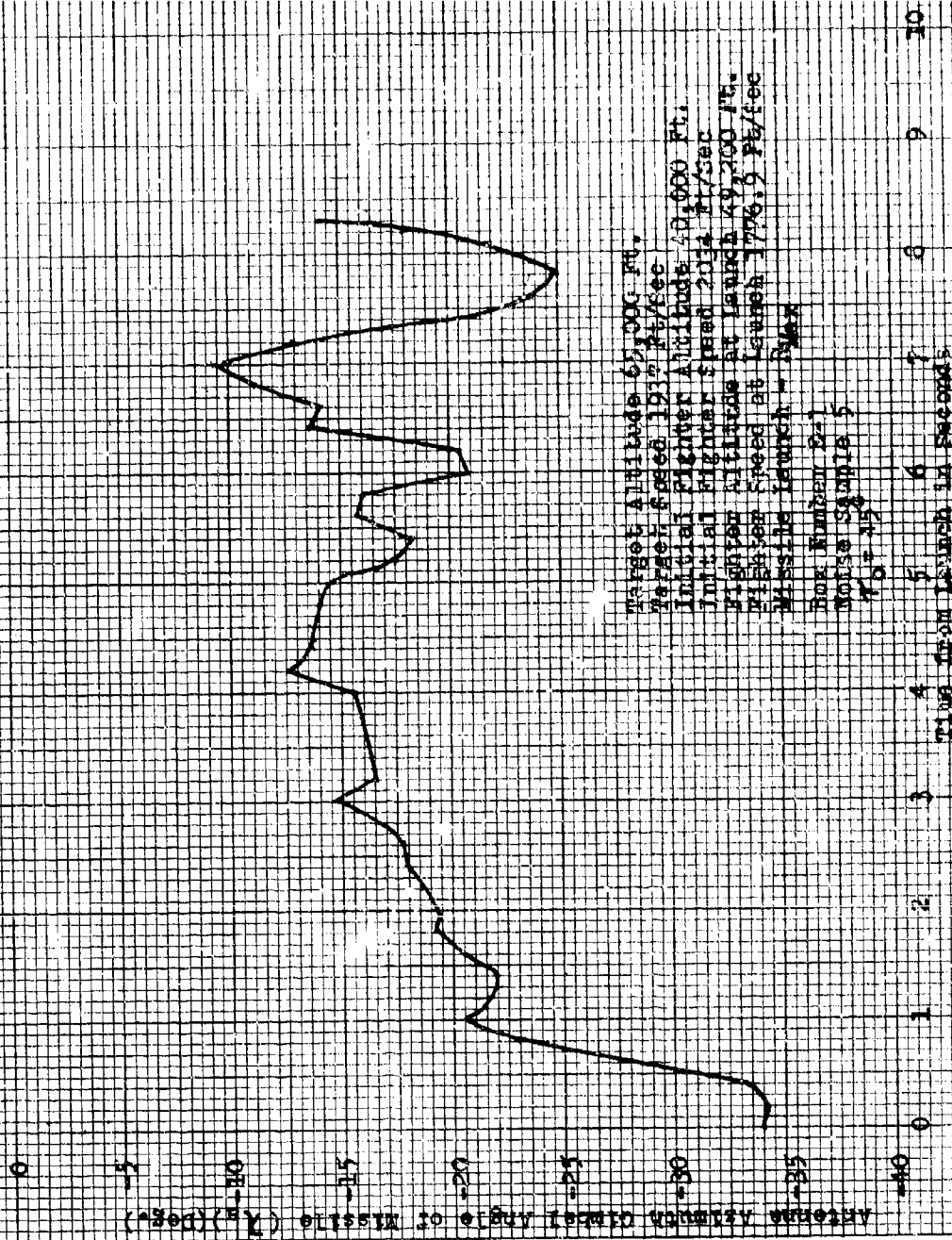


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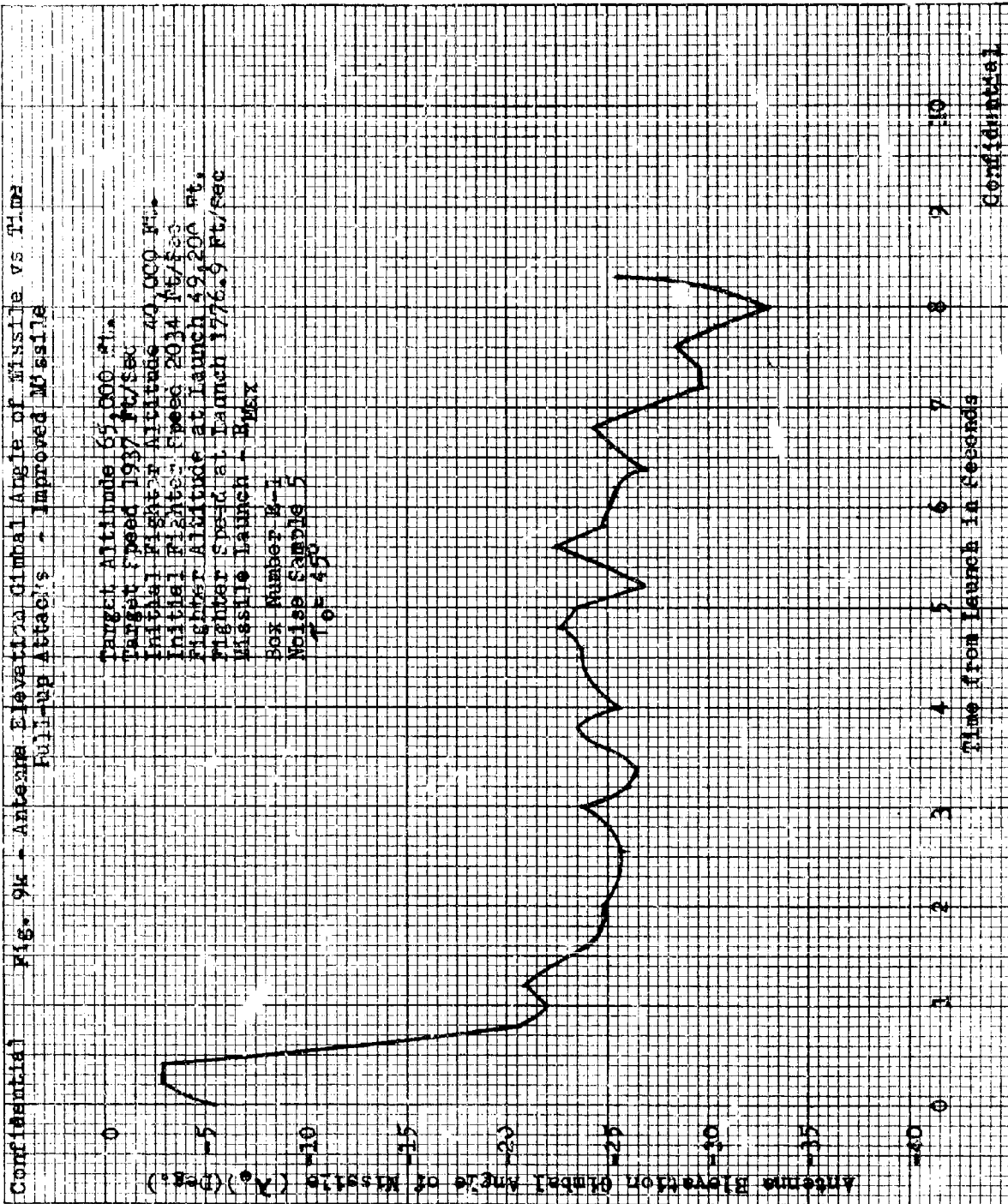


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Fig. 9j - Antenna Azimuth Gimbal Angle of Missile, Vs Time
Roll-up Attacks - Improved Missiles



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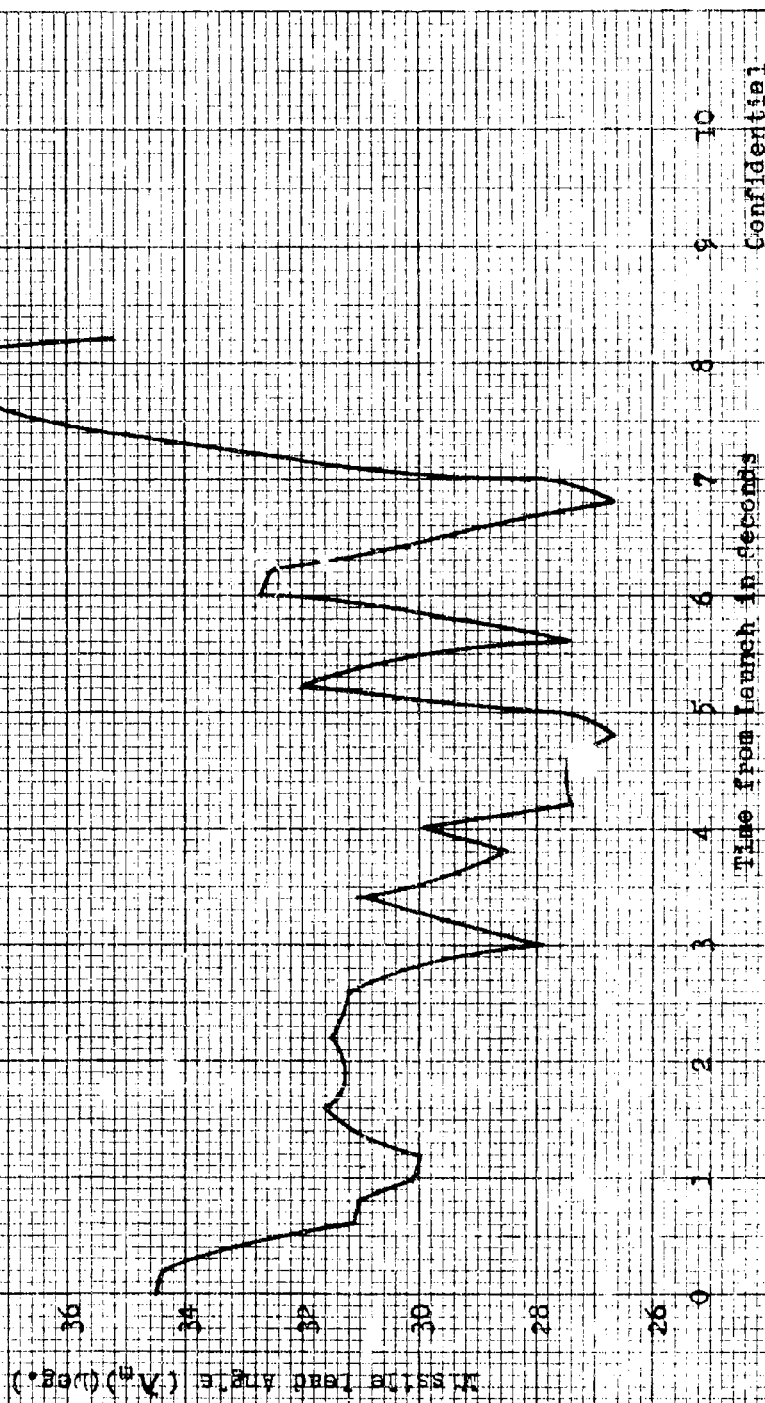


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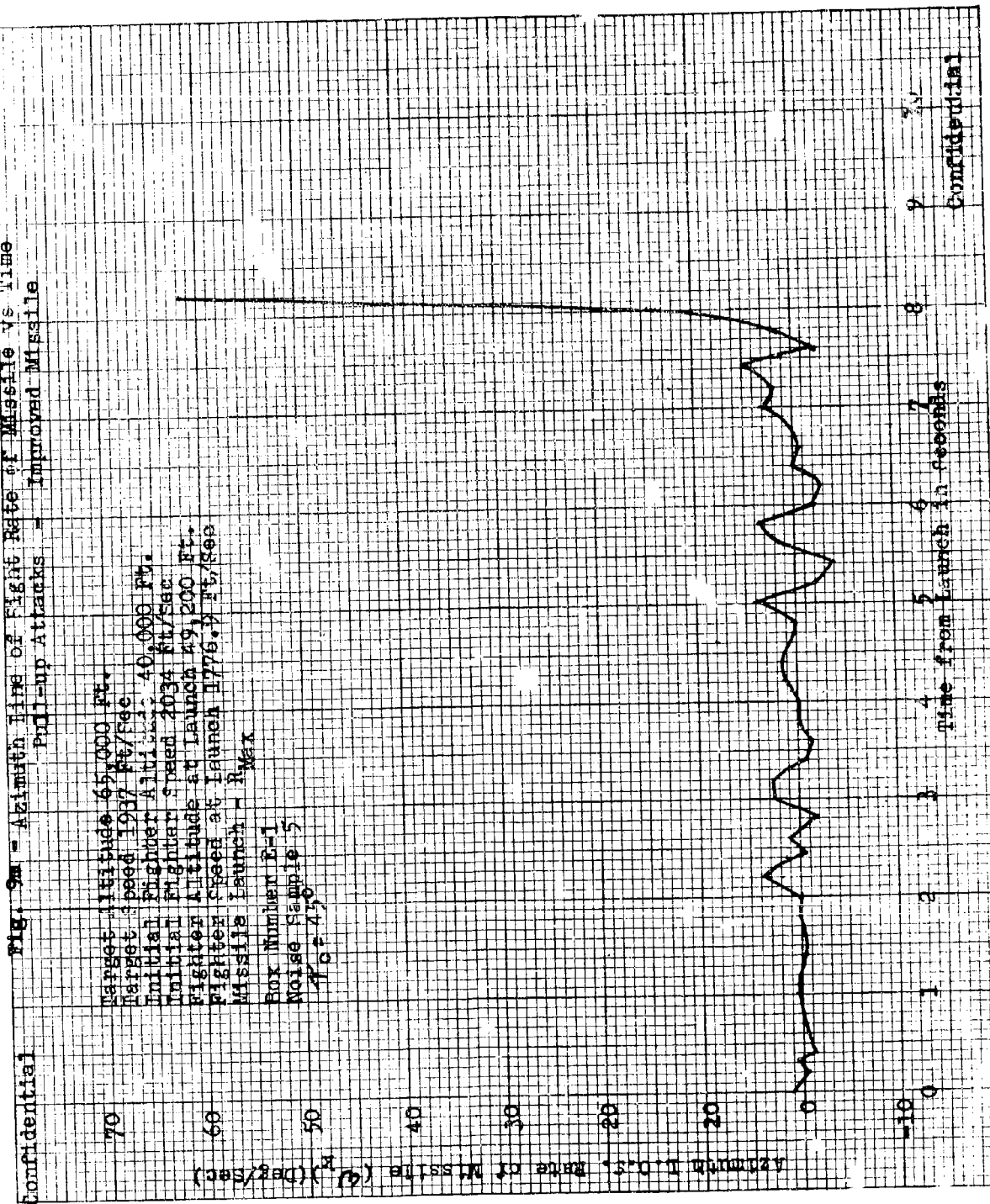
Fig. 9-1 - Missile Lead Angle vs Time
Full-up Attacks - Improved Missile

Target Altitude 65,000 Ft.
Target Speed 1937 ft/sec
Initial Fighter Altitude 40,000 Ft.
Initial Fighter Speed 2034 ft/sec
Fighter Altitude at launch 49,200 Ft.
Fighter Speed at launch 1776.9 ft/sec
Missile Launch - R Max

Box Number B-2
Noise Sample 5
 $\alpha_0 = 1.5^\circ$



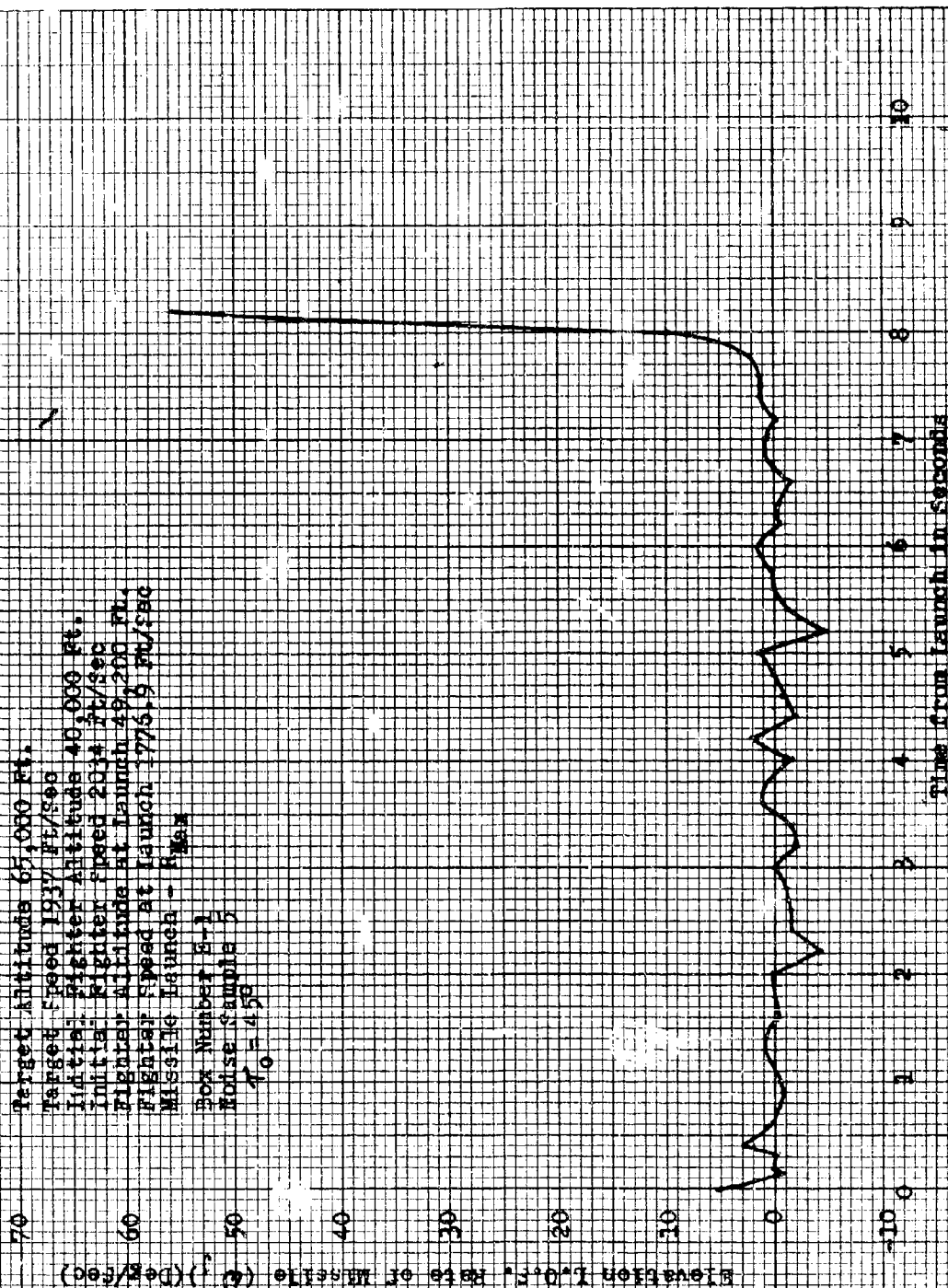
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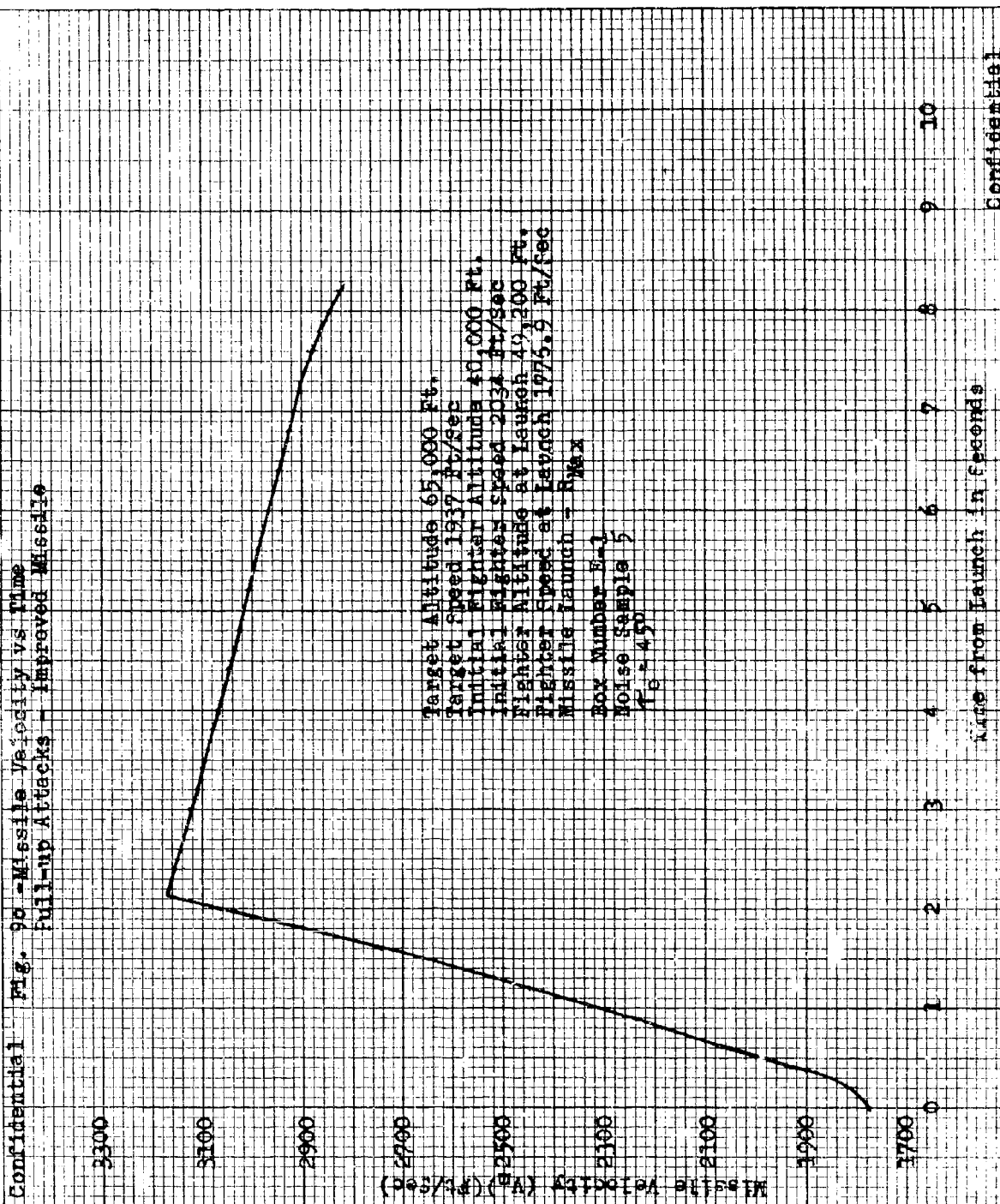
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Fig. 9a - Elevation Line of Sight Rate of Missile vs Time
Pull-up Attacks - Improved Missile

Target Altitude 65,000 Ft.
Target Speed 1937 Ft/Sec
Initial Fighter Altitude 40,000 Ft.
Initial Fighter Speed 2014 Ft/Sec
Fighter Altitude at launch 49,200 Ft.
Fighter Speed at launch 1775.9 Ft/Sec
Missile launch - 8.5 sec
Box Number 5-1
False Sample 5
 $\sigma_0 = 4.56$

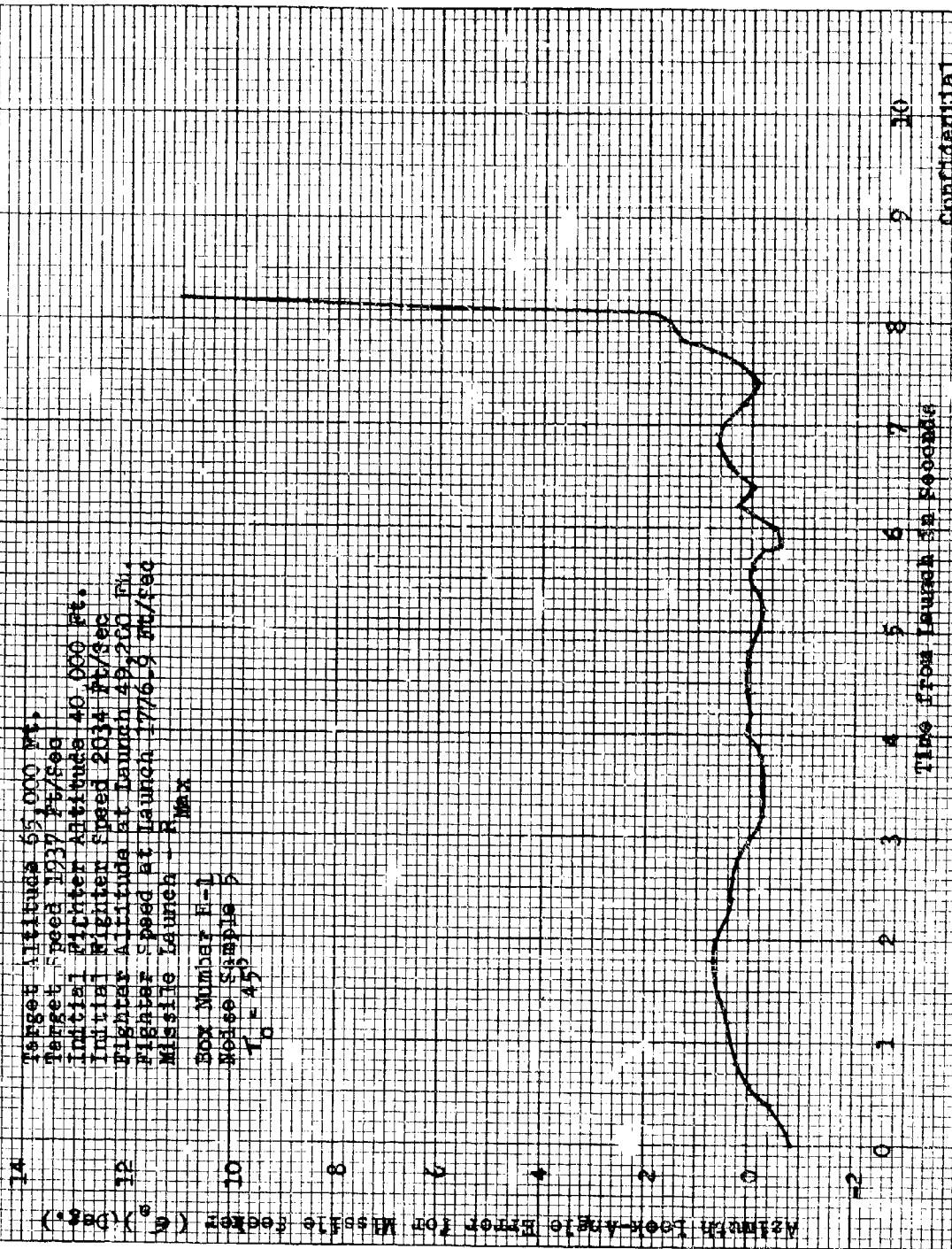


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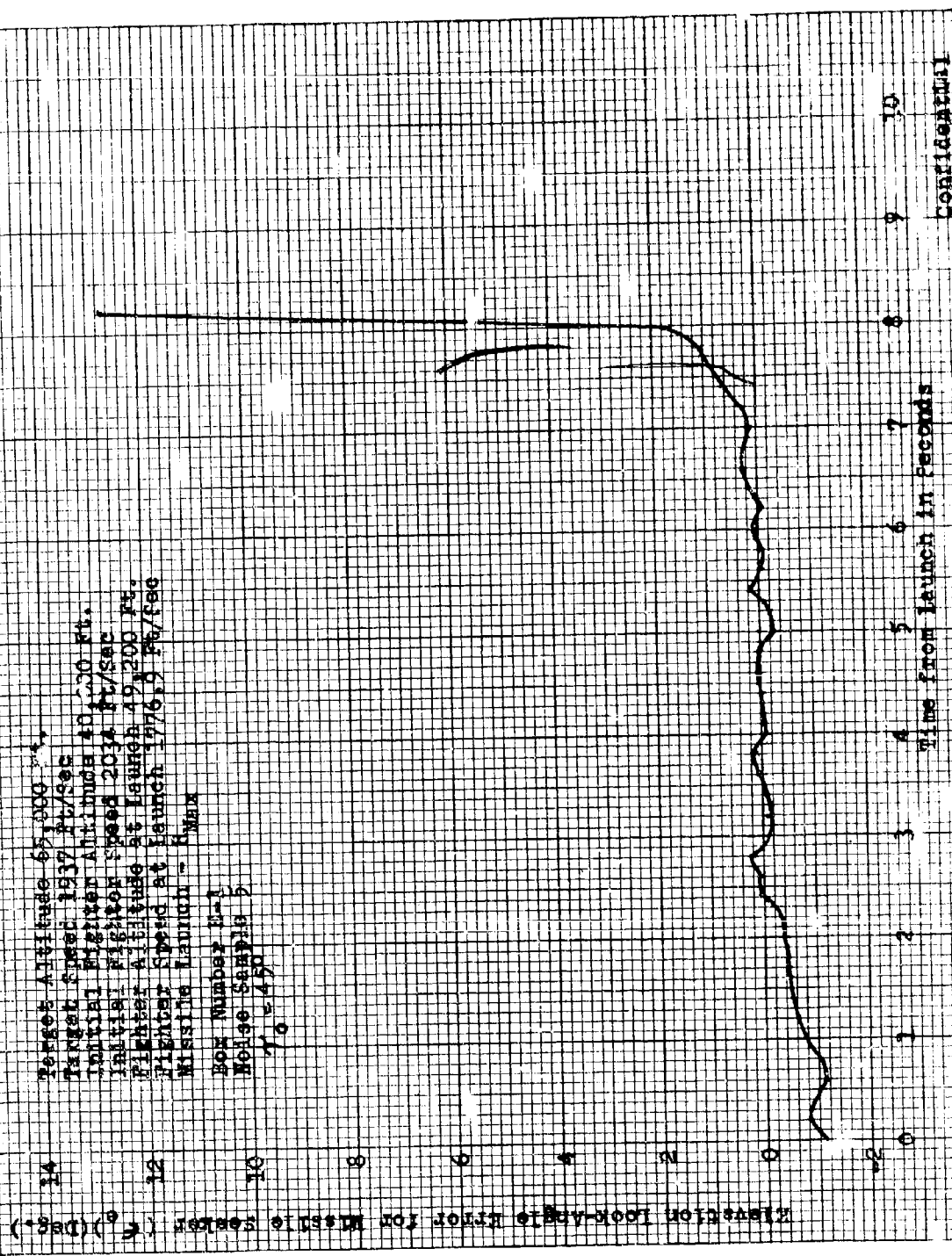
Fig. 9a- Azimuth Look-Angle Error for Missile Seeker vs Time
Pull-up Attacks - Improved Missile



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Fig. 9a - Elevation Look-Angle Error for Missile Feeder vs Time
Pull-up Attacks - Improved Missile

Target Altitude 65,000 ft.
Target Speed 1937 ft/sec
Initial Fighter Altitude 40,000 ft.
Initial Fighter Speed 2034 ft/sec
Fighter Altitude at Launch 49,200 ft.
Fighter Speed at Launch 1776 ft/sec
Missile Launch - 8 MEX
Box Number E-1
Hodge Sample 5
41-450



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Fig. 9 - Missile Angle of Attack vs Time
Pull-up Attacks - Improved Missile

Target Altitude 65,000 Ft.
Target Speed 1917 Ft/Sec
Initial Fighter Altitude 43,000 Ft.
Initial Fighter Speed 2314 Ft/Sec
Fighter Altitude at Launch 59,200 Ft.
Fighter Speed at Launch 1776.9 Ft/Sec
Missile Launch - 8 sec

Box Number 5-1
Noise Sample 5
40 30 25 20 15 10 5 0

Missile Angle of Attack (X) (Deg.)

Time from Launch in Seconds

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Fig. 5a - Missile and Fighter Roll Angles vs Time
Pull-up Attitude - Improved Missile

Target Altitude 65,000 Ft.
Target Speed 1937 Ft/Sec
Initial Fighter Speed 2034 Ft/Sec
Initial Fighter Altitude 40,000 Ft.
Fighter Altitude at Launch 49,200 Ft.
Fighter Speed at Launch 1776.9 Ft/Sec
Missile Launch - Rmax

P < Number 2-1
Noise Sample 5
 $\alpha = 45^\circ$

Missile and Fighter Roll Angles (ϕ, ϕ'') (Deg.)

120

100

80

60

40

20

0

-20

-40

0

1

2

3

4

5

6

7

8

9

10

Time from Launch in Seconds

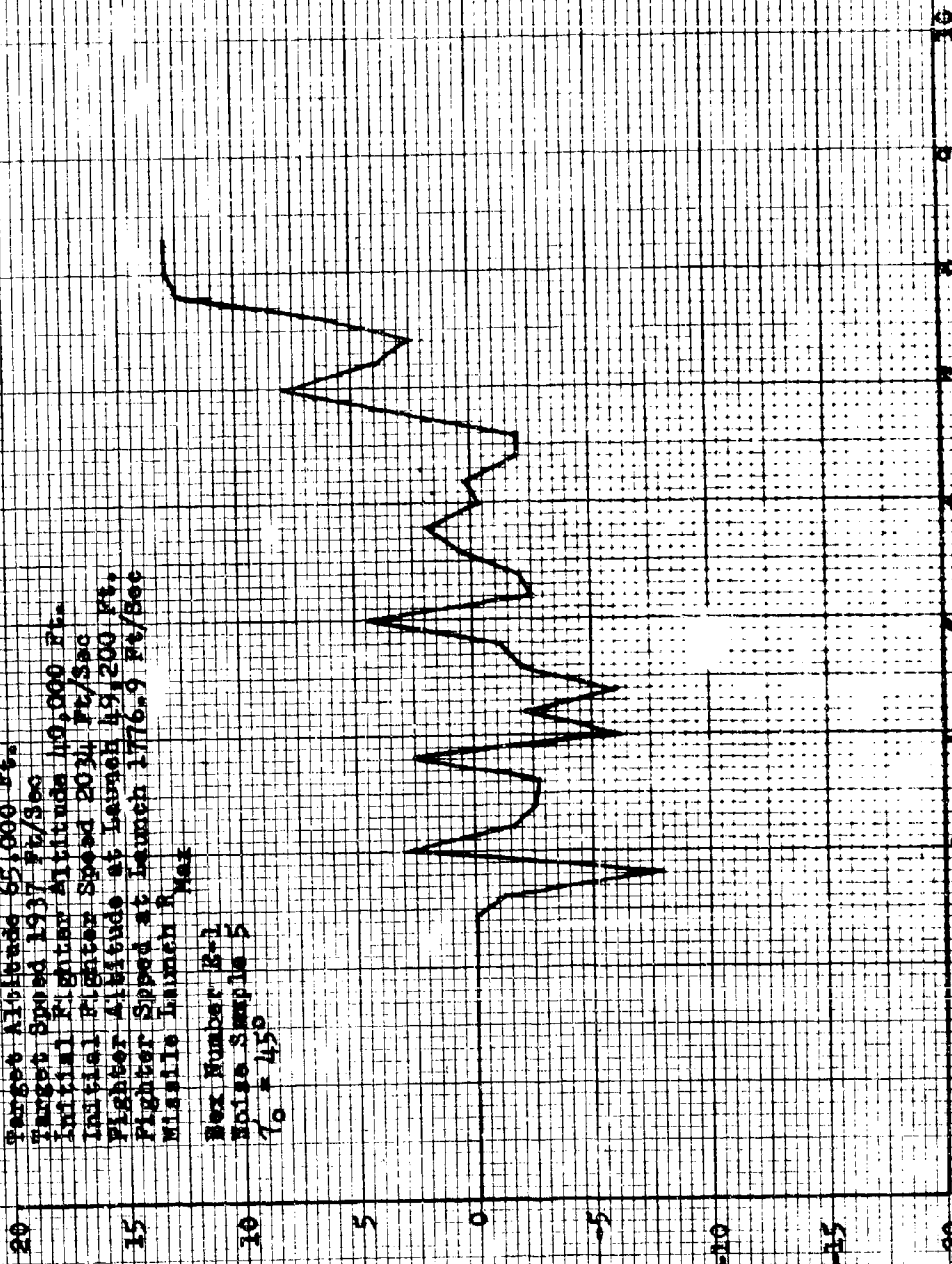
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Fig. 96-Commanded Elevation Q's vs Time
 Pull-up Attacks - Improved Missile

Target Altitude 65,000 Ft.
 Target Speed 1937 Ft/Sec
 Initial Fighter Altitude 10,000 Ft.
 Initial Fighter Speed 2034 Ft/Sec
 Fighter Altitude at Launch 19,200 Ft.
 Fighter Speed at Launch 1776.9 Ft/Sec
 Missile Launch Az

Box Number B-1
 Spike Sample 5
 $T_0 = 450$

Commanded Elevation Q's



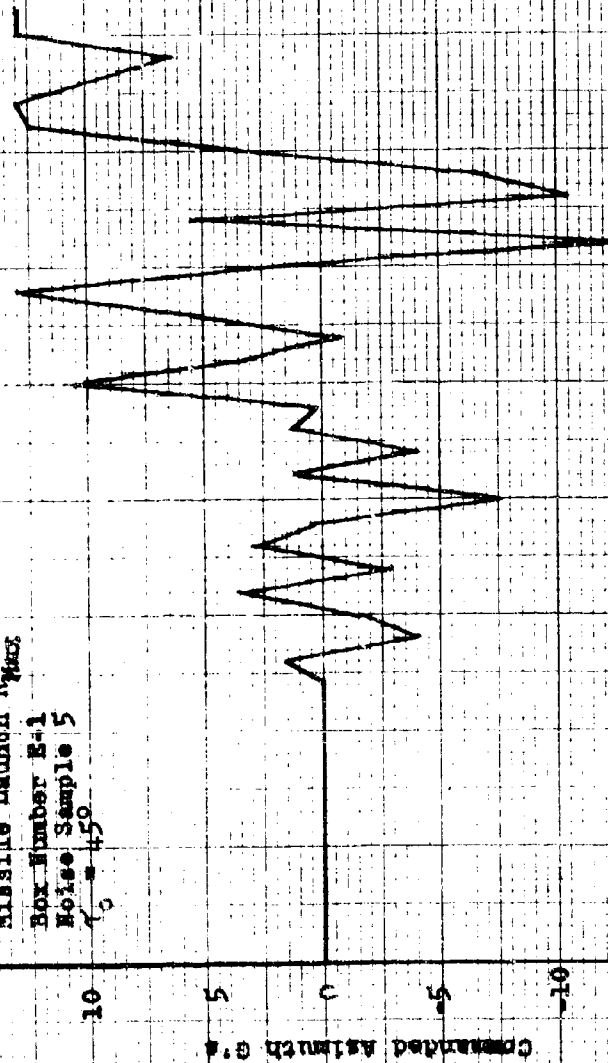
Time from Launch in Seconds

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Fig. 9a-Commanded Assault 3's vs Time
Pull-up Attacks - Improved M-60's

Box Number E-1
Noise Sample 5

657-2



Time From Launch in Seconds

Confidential

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Fig. 97-Commanded Elevation Wing Deflection vs Time
Pull-up Attacks Improved Missile

Target Altitude 65,000 Ft.
Target Speed 1937 Ft/Sec
Initial Fighter Altitude 40,000 Ft.
Initial Fighter Speed 2034 Ft/Sec
Fighter Altitude at Launch 49,200 Ft.
Fighter Speed at Launch 1776.9 Ft/Sec
Missile Launch Max

Box Number B-1

Noise Sample 5

$\sigma_c = 45^\circ$

Commanded Elevation Wing Deflection (Deg.)

Time from Launch in Seconds

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FIG. 94-Commanded Azimuth Wing Deflection vs Time
Pull-up Attack - Improved Missile

Target Altitude 35,000 Ft.
Target Speed 1927 Ft/Sec
Initial Fighter Altitude 49,000 Ft.
Initial Fighter Speed 2034 Ft/Sec
Fighter Altitude at Launch 49,2000 Ft.
Fighter Speed at Launch 1775.9 Ft/Sec
Missile Launch Angle

Box Number K-1
Noise Sample 5
 $\sigma = 450$

Commanded Azimuth Wing Deflection (Deg.)

Time from Launch in Seconds

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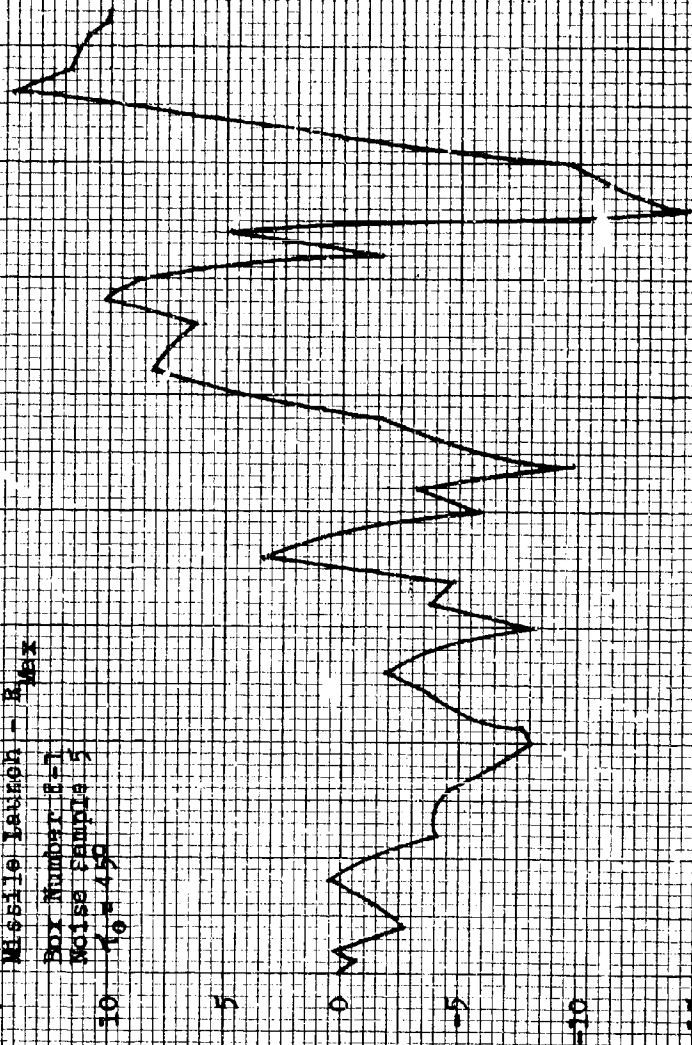
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Fig. 8x- Deflection of Missile Yaw Wings vs Time
Pull-up Attacks - Improved Missile

Target Altitude 65,000 Ft.
Target Speed 1337 ft/sec
Initial Fighter Altitude 40,000 Ft.
Initial Fighter Speed 2034 ft/sec
Fighter Altitude at launch 49,200 Ft.
Fighter speed at launch 1776.9 ft/sec
Missile launch - 2.4 sec

Box Number 8-7
Noise Sample 5
 $V_0 = 450$

Deflection of Missile Yaw Wings (°)



Time from Launch in Seconds

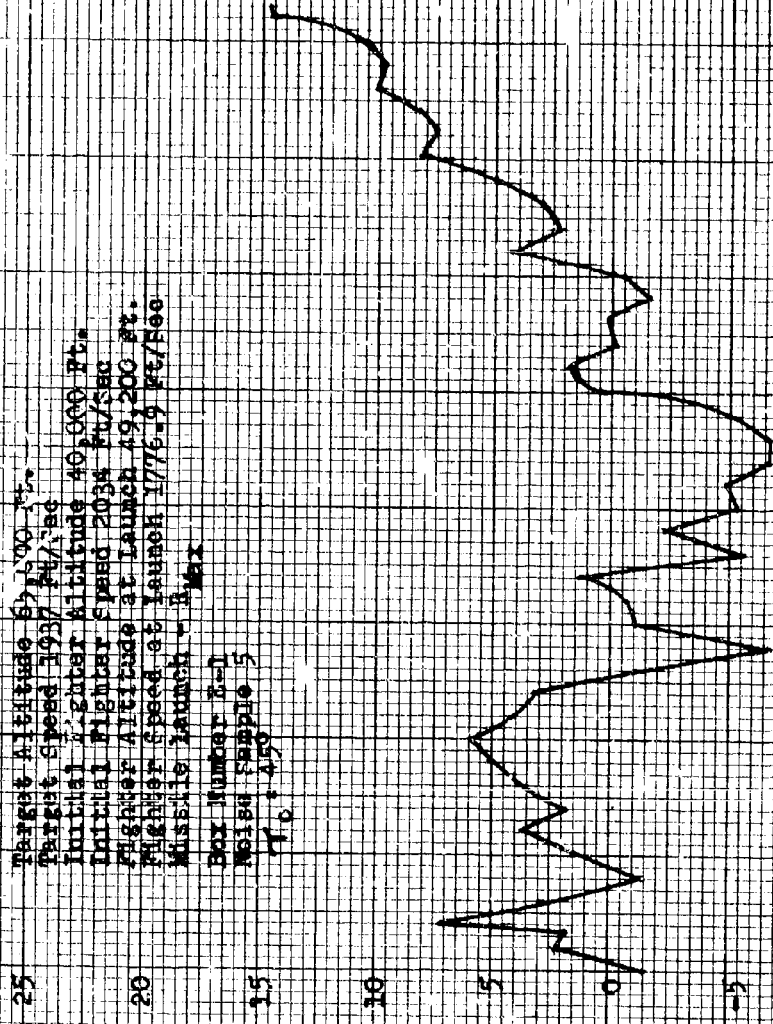
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Fig. 97 - Deviation of Missile Pitch Wings vs Time
Pull-up Attacks - Improved Missile

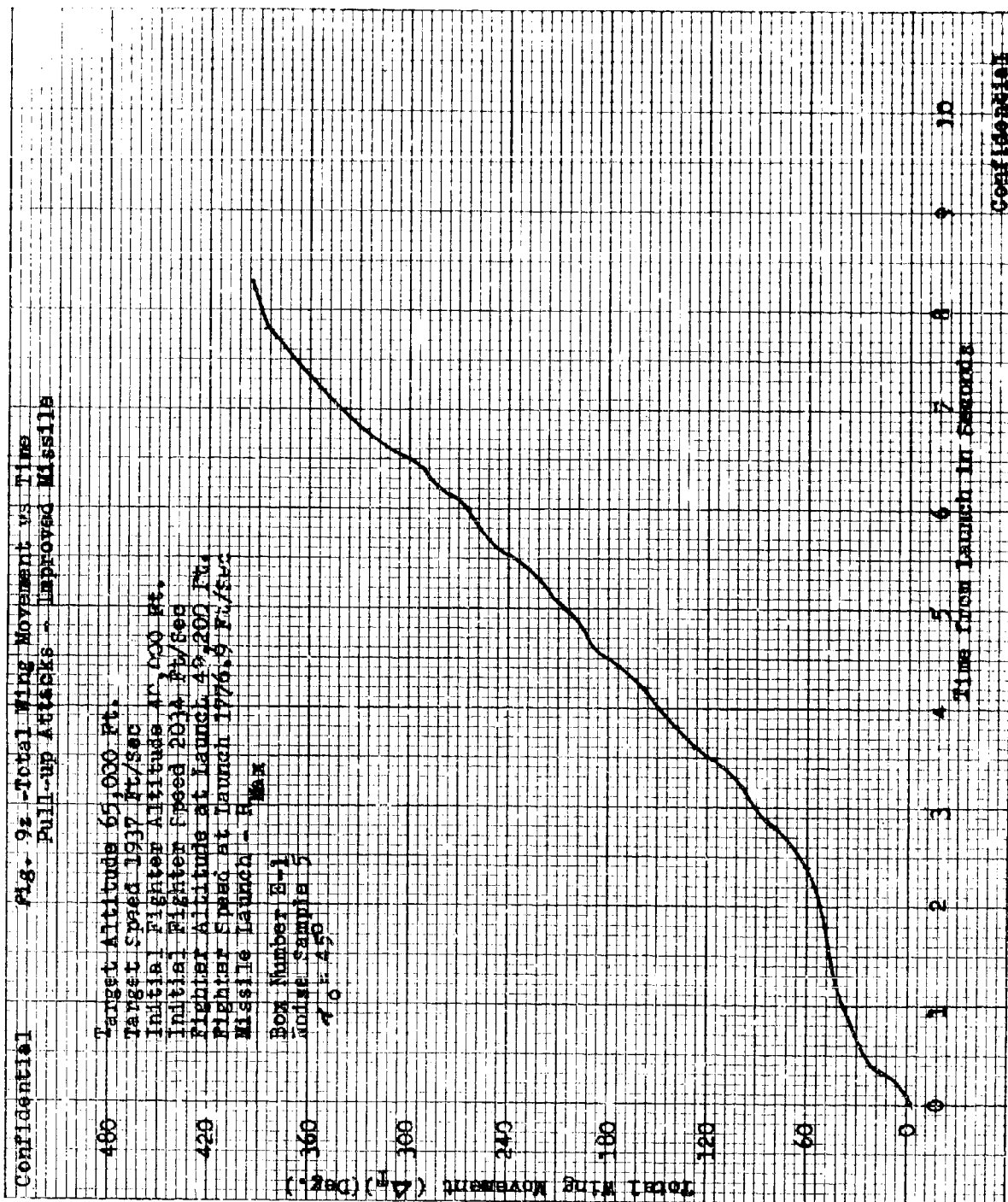
Target Altitude 67,000 ft.
Target Speed 1937 ft/sec
Initial Fighter Altitude 40,000 ft.
Initial Fighter Speed 2034 ft/sec
Fighter Altitude at Launch 49,200 ft.
Fighter Speed at Launch 1776.9 ft/sec
Missile Launch - 11.6 sec
Box Number 3-1
Noise Sample 5
10 + 150

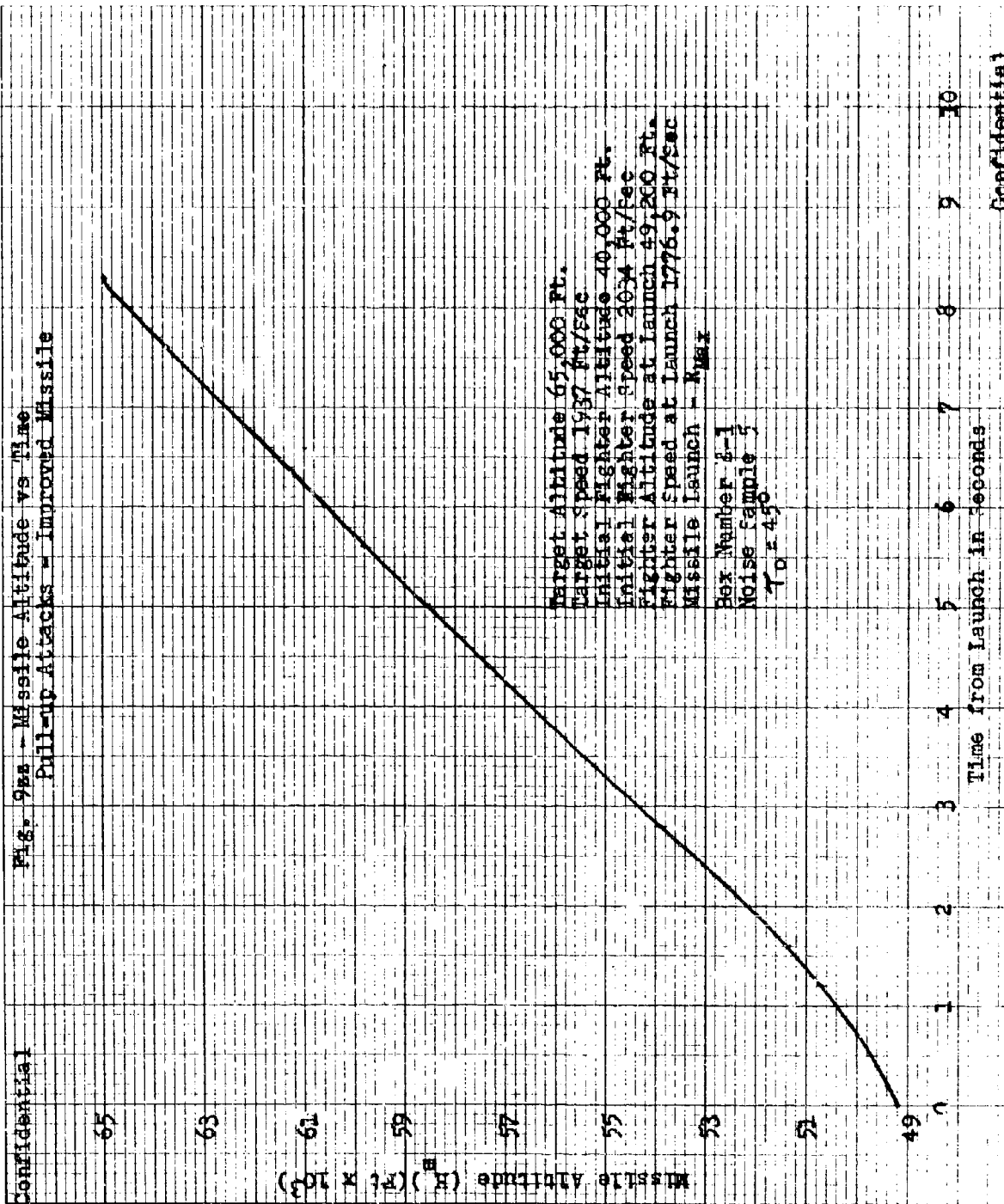
Deviation of Missile Pitch Wings (Degrees)



Time from Launch in seconds

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Research Reports Section**

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CC: Tina Smallwood, Code 1221.1 *ts 3/8/01*
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☐ Possible Change in Classification

Thank you,

Mary Templeman

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DN (9) Memo. rept.
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Schmookler,M.
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