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This report describes an experiment to collect data for modeling pilot behavior during low visibility approach and landing. The data is presented in a form suitable for use in forming a pilot model of the optimal control type.

The experiment was conducted as a part of Phase II of a low visibility landing simulation program (LOVISIM) conducted at the Air Force Flight Dynamics Laboratory and sponsored by the Federal Aviation Administration.

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Item 20 Abstract continued

A C-135B aircraft was simulated on the AFFDL/FGD hybrid simulator, with visual and motion cues and a gust disturbance provided. One pilot was used in the experiment, and three different visibility conditions, going from clear air to Category II minimums. The pilot repeated each condition ten times in a random order.

Experiment results are presented on pilot eye scanning, glide slope and localizer tracking, touchdown conditions, and pilot opinions. The data are compared with a similar experiment conducted during Phase I of LOVISIM.

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FOREWORD

This report presents the results of an experiment conducted to collect a data base for modeling a piloted low visibility landing approach and touchdown. It was conducted as a part of Phase II of the FAA/USAF Low Visibility Landing Simulation Program, Project Number 2187, Task Number 02, Work Unit Number 02.

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LIST OF SYMBOLS AND ABBREVIATIONS

AFFDL	-	Air Force Flight Dynamics Laboratory
ANOVA	-	Analysis of variance
a_x	-	Longitudinal acceleration, ft/sec^2
CAVU	-	Ceiling and visibility unlimited
CDC	-	Control Data Corporation
c.g.	-	Center of gravity
C_{l_p}	-	An aircraft stability derivative
γ	-	Flight path angle, deg.
DOT	-	Department of Transportation
δ_{ac}	-	Aileron deflection, deg.
δ_{ec}	-	Elevator deflection, deg.
δ_{rc}	-	Rudder deflection, deg.
$\Delta x, \Delta y$	-	Aim point coordinates
EAI	-	Electronics Associates, Inc.
FAA	-	Federal Aviation Administration
FGD	-	Systems Dynamics Branch
$F_{i,j,\alpha}$	-	F statistic used in statistical tests
g	-	Acceleration due to gravity, 32.2 ft/sec^2
GPIP	-	Glide path intercept point
$G/S_{ERROR_{IND}}$	-	Indicated glide slope error
h_{cg}	-	Center of gravity height, ft.
h_{eye}	-	Pilot's eye height, ft.

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$\dot{h}_{IND}$ - Indicated sink rate, ft/min

$\dot{h}$ - Sink rate, ft/sec.

$\dot{h}_{it}, \dot{h}_{\mu}, \dot{h}_{\alpha i}, \dot{h}_{\varepsilon_{ij}}$ - Symbols used in regression analysis

ILS - Instrument landing system

$LOC_{ERROR_{IND}}$ - Indicated localizer error

LOVISIM - Low Visibility Landing Simulation Program

M - Statistic used in test for homogeneous variances

n_z - Normal acceleration (g's)

p,q,r - Aircraft angular velocities, deg./sec.

p_g, q_g, r_g - Gust angular velocities, deg./sec.

PSB - Pitch steering bar

RPM1,2,3,4 - Engine revolutions per minute, for 4 engines, percent

RSB - Roll steering bar

RVR - Runway visual range

SVR - Slant visual range

$\sigma_{(\cdot)}$ - Standard deviation of $(\cdot)$ variable

$\sigma_{iju}, \sigma, \alpha_i, \delta_{ij}, \varepsilon_{iju}$ - Symbols used in ANOVA mathematical model

$T_{\delta 1, \delta 2, \delta 3, \delta 4}$ - Throttle position, for 4 engines, deg.

T.O. - Technical order

u,v,w - Body axes referenced velocities, ft/sec.

u_g, v_g, w_g - Gust velocities, ft/sec.

USAF - United States Air Force

V_e - East velocity, knots

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V_{WIND}	-	Wind velocity, ft/sec.
$\dot{x},\dot{y},\dot{z}$	-	Earth referenced velocities, ft/sec.
χ^2	-	Statistic used in test for goodness of fit
Y	-	Cross track error, ft.
ψ,θ,ϕ	-	Yaw, pitch, and roll, deg.
$\dot{\psi}$	-	Yaw rate, deg./sec.

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I. INTRODUCTION

The Federal Aviation Administration (FAA) is supporting a long range study of the problems involved in aircraft low visibility landing at the Air Force Flight Dynamics Laboratory (AFFDL), under FAA/USAF Inter-Agency Agreement DOT FA70WAI-173. This effort is to extend over several years, and to rely extensively upon flight simulation using the AFFDL engineering flight simulators.

As a part of this effort, work is to be performed to develop accurate mathematical models of the pilot's control behavior when landing in reduced visibility. (These models are termed pilot models.) In the development of pilot models, a suitable data base must be constructed using appropriate experiments. The data base is used both for determining parameters in the pilot model, and for determining the appropriateness of the particular model. To collect this data base, during both Phase I and Phase II of the FAA Low Visibility Landing Simulation Program (LOVISIM), experiments were run to collect pilot modeling data.

This technical report gives the results of the Phase II simulation experiments conducted by the Systems Dynamics Branch (FGD) on 10 and 11 October 1974 and on 4 and 5 November 1974 as part of Phase II of the FAA Low Visibility Landing Simulation Program (LOVISIM). The basic purpose of these experiments was to extend the Phase I pilot modeling data base. This report does not itself include any pilot models, but summarizes and presents the results of the experiments in a form suitable for developing a pilot model of the optimal control type.

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It should be emphasized that this particular experiment used only one subject and was a limited part of the total Phase II program.

II. DESCRIPTION OF THE SYSTEM SIMULATED

The task simulated in this experiment was that of final approach, flare, and touchdown of a commercial transport in circumstances of degraded visibility. The aircraft was to perform a normal instrument landing system (ILS) approach in conditions of light turbulence. The simulation was performed using the FGD multicrew cab, visual and motion systems, and hybrid computer. The simulated aircraft dynamics were those of a Boeing 707, and the turbulence was supposed to correspond to the Dryden Model of MIL-F-8785B. [2] A more extensive description of the simulation can be found in Reference 3. The improvements and modifications to the simulation described in Reference 3 that were made for the simulation used in this experiment were:

1. improve the visual display by installing new plumbicon tubes
2. remove the factor of 2.75 multiplying C_{ℓ_p}
3. add a landing gear simulation, and improve the ground effects model.
4. modify the flight director simulation, so that its block diagram exactly coincided with the block diagram of a Collins FD-109 flight director.
5. add an operating inner marker.
6. add a yaw damper.

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III. DESCRIPTION OF THE EXPERIMENT

3.1 Objectives

The main purpose of these experiments was to extend the Phase I pilot modeling data base. To do this, four specific objectives were formulated, and the experiments designed to satisfy these objectives. These specific objectives were:

1. to determine if wearing the eye electrodes affected pilot performance

2. to evaluate the improvement in the sink rate at touchdown of the simulated system

3. to compare the Phase II pilot modeling experiment results with the Phase I pilot modeling experiment results

4. to measure pilot eye scanning using skin electrodes and test the hypothesis that the pilot scans more during moderate fog conditions than during dense fog or clear air conditions.

3.2 Experiment Design

To satisfy these objectives, 23 simulation runs were made on 10 and 11 October 1974, and 30 simulation runs were made on 4 and 5 November 1974. The October runs were to collect data to satisfy objectives 1 and 2, and the November runs were to collect data to satisfy objectives 2 through 4. The same pilot was used for all simulation runs. Three visibility conditions were used, namely,

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ceiling and visibility unlimited (CAVU), 400 feet breakout altitude/1600 feet runway visual range (400/1600), and 100 feet breakout altitude/1200 feet runway visual range (100/1200). Light turbulence was simulated as a disturbance on all runs.

During October, twenty-three simulation runs were made. On 10 October, when no electrodes were used, four CAVU runs were made, five 400/1600 runs were made, and five 100/1200 runs were made. On 11 October, when the electrodes were used, two CAVU runs were made, four 400/1600 runs were made, and three 100/1200 runs were made. On both of these days, the order of presentation of the visibility cases was random.

During November, thirty simulation runs were made. These runs were organized in a randomized plan, to study the effect of visibility. The same pilot and same turbulence generating system were used for all runs. Three visibility conditions were used. The order of presentation of visibility conditions to the pilot is shown in Table I.

3.3 Turbulence Disturbance

Each run was supposed to have a turbulence disturbance corresponding to the Dryden spectrum of MIL-F-8785B. The intensity of the turbulence was nominally to be 1/4 of the 500 feet moderate turbulence level. During the October simulation runs, measurements made of the actual turbulence inputs showed that they were much smaller than desired. Typical measured values of the turbulence during the October runs were:

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σ_{u_g} = .81 FT/SEC

σ_{v_g} = 1.28 "

σ_{w_g} = .93 "

σ_{p_g} = .21 DEG/SEC

σ_{q_g} = .28 "

σ_{r_g} = .24 "

For the November simulation runs, the turbulence model was improved and checked out further, and satisfactory gust intensities were obtained. Typical measured values of the turbulence during the November runs were:

σ_{u_g} = 2.33 FT/SEC

σ_{v_g} = 2.84 "

σ_{w_g} = 1.85 "

σ_{p_g} = .41 DEG/SEC

σ_{q_g} = .30 "

σ_{r_g} = .56 "

These values are within 15 percent of the desired values, which is good agreement considering they were calculated from a short sample of a noise signal.

3.4 Pilot

The pilot for all of these simulation runs was a 26 year old Air Force Captain who was current in the KC-135A, and attached to an operational squadron. His total flying hours were 970, and he had 250 hours in the KC-135 within the previous year. He had, during training, experience flying a C-130 down to field minimums (Little Rock AFB and Adams Fld, Little Rock, Ark) in poor visibility.

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TABLE I.

ORDER OF PRESENTATION OF FOG STRUCTURES TO PILOT

(SCANNING INSTRUMENTATION ON PILOT)

RUN	FOG STRUCTURE	RUN	FOG STRUCTURE
1	400/1600	16	100/1200
2	CAVU	17	100/1200
3	400/1600	18	400/1600
4	CAVU	19	400/1600
5	400/1600	20	400/1600
6	400/1600	21	100/1200
7	CAVU	22	CAVU
8	100/1200	23	100/1200
9	100/1200	24	CAVU
10	100/1200	25	CAVU
11	CAVU	26	100/1200
12	CAVU	27	CAVU
13	CAVU	28	100/1200
14	400/1600	29	100/1200
15	400/1600	30	400/1600

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His previous simulator experience was confined to training simulators.

3.5 Conduct of the Experiment

Each simulation run was initiated with the aircraft trimmed, on the glide slope and localizer, at a range of 15,000 feet from the glide path intercept point (GPIP). The pilot did not know in advance what the visibility conditions would be, and he was instructed to fly the simulator as if it were a real aircraft. He was also instructed not to execute a missed approach, but to land regardless of circumstances, and comment later if he thought he should have gone around. He was briefed that there would be light to moderate turbulence, but no cross winds. The simulation run was ended after touchdown, and the pilot then filled out a questionnaire. During the simulation runs, the co-pilot (engineer conducting the simulation, seated in the right seat), periodically called out airspeed, called out altitude at 200 and 100 ft, and called runway environment cues (strobes, etc).

Before the experiment started, the pilot was briefed on its overall objectives and methods, and on the part he would perform. To familiarize the pilot with the simulator, he flew several touch and go landings and box patterns in clear air, then he flew several simulated approaches in the fog conditions. Data collection did not begin until the pilot stated that he did not require further familiarization runs on the simulator.

3.6 Data Collection and Reduction

The variables listed in Table II were recorded on magnetic tape at ten times per second. The data tapes were then converted from EAI 8400 tape format to CDC Cyber 74 tape format using the CDC Cyber 74, and the Cyber 74 was used to sort the data and compute those statistics

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TABLE II: MAGNETIC TAPE DATA

1. Range, FT
2. Y, FT (cross track error)
3. h_{cg}, FT (c.g. height)
4. h_{eye}, FT (eye height)
5. $\dot{x}$, FT/SEC } earth referenced velocities
6. $\dot{y}$, FT/SEC } earth referenced velocities
7. $\dot{h}$, FT/SEC } earth referenced velocities
8. u, FT/SEC } body axes referenced
9. v, FT/SEC } body axes referenced
10. w, FT/SEC } body axes referenced
11. a_x, FT/SEC^2 (longitudinal acceleration)
12. η_z, g (normal acceleration)
13. ψ, DEG (yaw)
14. θ, DEG (pitch)
15. ϕ, DEG (roll)
16. γ, DEG (flight path angle)
17. p, RAD/SEC (rolling velocity)
18. q, RAD/SEC (pitching velocity)
19. r, RAD/SEC (yawing velocity)
20. $\dot{\psi}$, DEG/SEC (yaw rate)
21. $\dot{h}_{IND}$, FT/Min (indicated sink rate)
22. V_e, KT East Velocity
23. PSB (Pitch Steering Bar)
24. RSB (Roll Steering Bar)
25. $G/S_{ERROR_{IND}}$ (indicated glide slope error)

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TABLE II: MAGNETIC TAPE DATA (Cont'd)

26.	LOC $ERROR_{IND}$ (indicated localizer error)	
27.	RPM 1, %	(Engine RPM, for 4 engines)
28.	RPM 2, %	
29.	RPM 3, %	
30.	RPM 4, %	
31.	δ_{e_c}, DEG (elevator deflection)	
32.	δ_{a_c}, DEG (aileron deflection)	
33.	δ_{r_c}, DEG (rudder deflection)	
34.	T_{δ_1}, DEG	(Throttle positions, for 4 engines)
35.	T_{δ_2}, DEG	
36.	T_{δ_3}, DEG	
37.	T_{δ_4}, DEG	
38.	V_{WIND} (wind velocity)	
39.	EVENT (event marker) or Eye Data	
40.	$u_g \times 10^{-3}$, FT/SEC	(gust disturbances)
41.	$v_g \times 10^{-3}$, FT/SEC	
42.	$-w_g \times 10^{-3}$, FT/SEC	
43.	$.5p_g \times 10^{-2}$, RAD/SEC	
44.	$q_g \times 10^{-2}$, RAD/SEC	
45.	$-r_g \times 10^{-2}$, RAD/SEC	
46.	SVR, FT (slant visual range)	
47.	ΔX, FT	(aim point coordinates)
48.	ΔY, FT	
49.	RUN NUMBER	
50.	TIME, SEC	

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desired. Further details concerning data collection and reduction using the magnetic tape procedure are given in Reference 3.

In addition to the data recorded on magnetic tape, the pilot was asked to evaluate each run by filling out a questionnaire, and data were collected using miniature skin electrodes concerning whether the pilot was looking inside or outside the cockpit.

The questionnaire is included as Appendix 1. The pilot ratings requested on the questionnaire are from two rating scales proposed for low visibility landing studies by FGD, after the experiment reported on in Reference 3 indicated the unsuitability of the conventional Cooper-Harper Rating Scale [4] for this task. The scales request ratings between 1 and 10, with 1 being the best and 10 the worst. The first scale is supposed to rate landing performance, and the second scale is supposed to rate the pilot effort required to achieve that performance. The charts used by the pilot to arrive at a rating are given as Figures 1 and 2.

Appendix 2 explains the use of the stick-on electrodes, and how they were connected for this experiment. The output of the electrode array was a short pulse whenever the pilot looked up, and a short pulse of opposite polarity whenever he looked down. Since the pilot began all runs looking at the instruments, whether he was looking inside or outside the cockpit was determined by counting pulses (and noting their polarity). The theory behind the miniature skin electrode measurements is given in Reference 1. The actual data were recorded on a pen-chart type recorder, using a speed of 5 mm/sec. The recordings were annotated with the run number, the polarity of in and out glances, and the start and stop positions of the runs. In addition, for the November runs,

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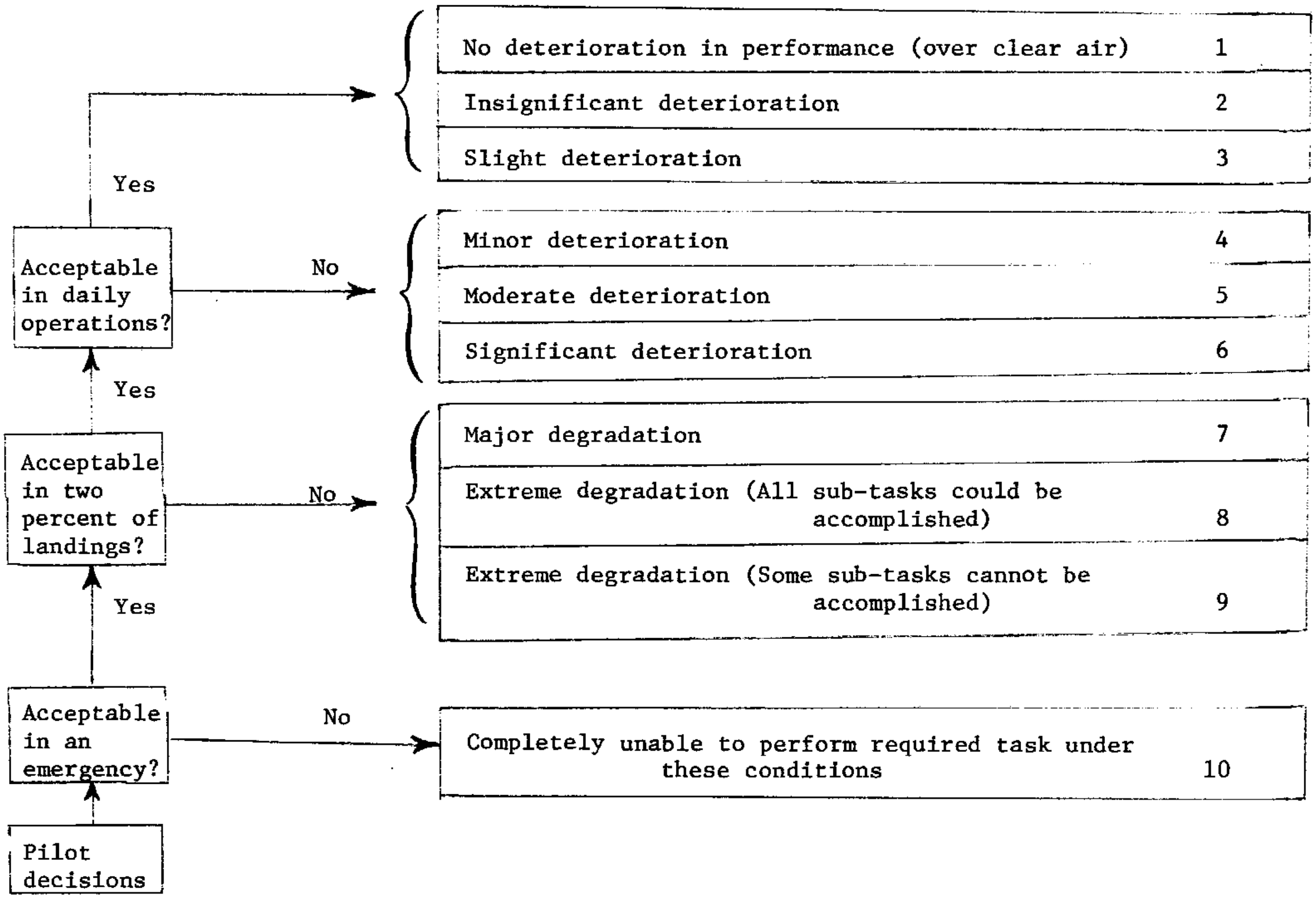

FIGURE 1: PERFORMANCE RATING SCALE

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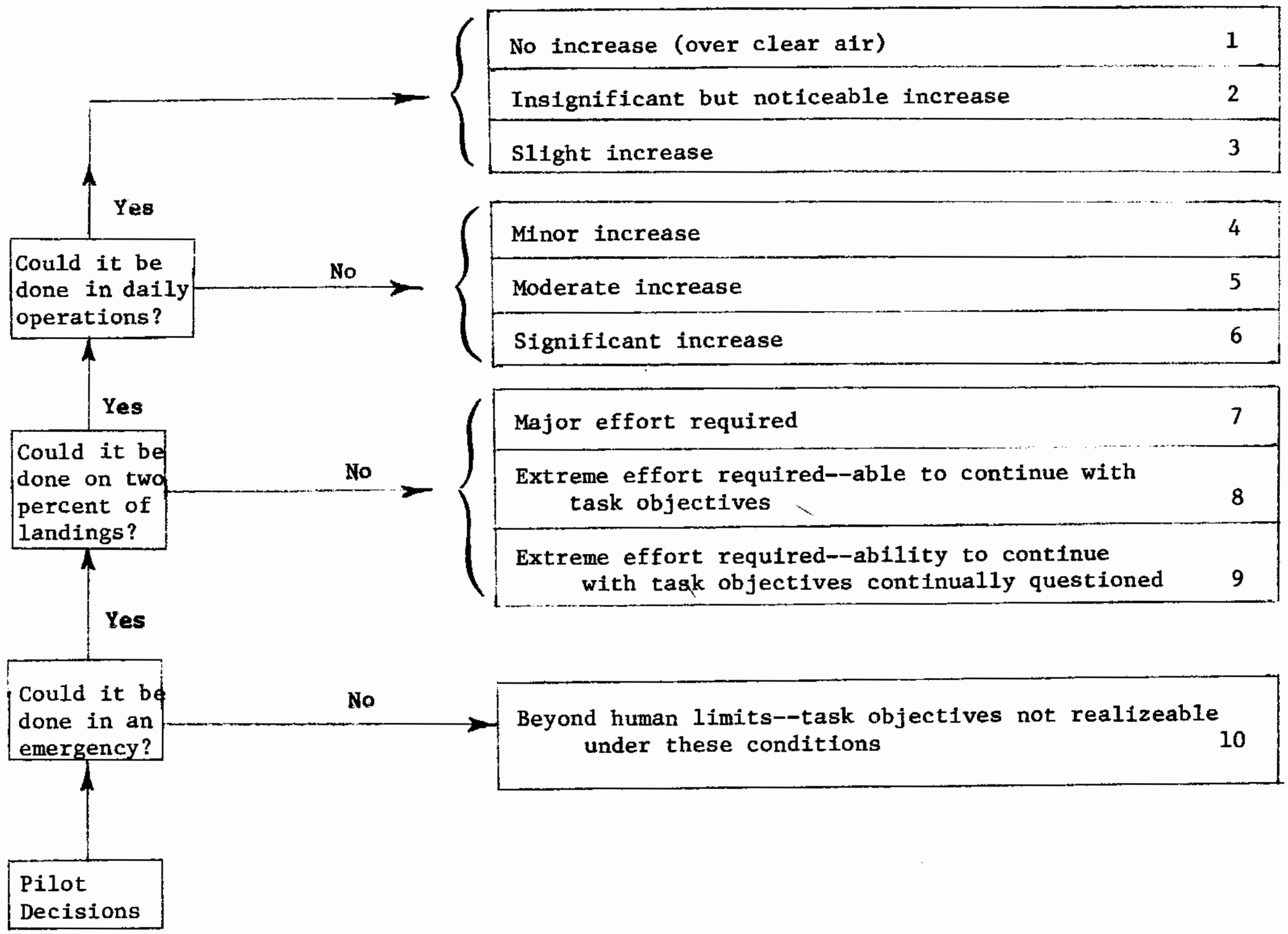

FIGURE 2: EFFORT RATING SCALE

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the eye motion data were recorded on the digital magnetic tape at 10 samples per second, in place of the event marker used in other portions of Phase II.

IV. RESULTS OF THE EXPERIMENT

4.1 OBJECTIVE 1: To determine if wearing the eye electrodes affected pilot performance.

This objective was accomplished by studying both pilot comments and data about the pilot's glide slope and localizer tracking performance. The data used to satisfy this objective were collected during the October simulation runs.

While wearing the electrodes, and after each day's simulation runs, the pilot was asked if the electrodes disturbed him or were objectionable or uncomfortable. He stated that they did not disturb him, and were barely noticeable when he was wearing them. They did not interfere with his vision in any way, and he tended to forget about their presence (especially when his attention was directed at accomplishing a specific task).

To quantitatively check the effect of the electrodes upon the pilot's performance, means and standard deviations of specific variables were computed for each run for all of the data collected between the ranges of 5000 feet and 1500 feet to the GPIP. The variables for which these means and standard deviations were computed were Y, h, $\dot{Y}$, $\dot{h}$, ψ, θ, ϕ, p, q, r, δ_e (Elevator deflection) and δ_a (Aileron deflection). Over the 5000 feet to 1500 feet segment, the data should represent steady state glide slope and localizer tracking, hence time average statistics should accurately represent the pilot's tracking performance.

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The standard deviations calculated by this procedure are given in Table III, organized as to whether the electrodes were on (E) or off (N), and also organized by visibility condition. Also given in Table III are the mean of the standard deviations for each combination of visibility and electrode condition.

Inspection of Table III does not indicate that there was any noticeable effect due to wearing the electrodes, or any effect on tracking performance due to visibility. As Y represents localizer error, h represents glide slope error, and $\dot{h}$ the sink rate, and these are the most important variables to control in an ILS approach, the possibliity of an electrode or visibility effect upon their standard deviations was investigated further.

To conduct this investigation, the standard deviations for Y, h, and h were organized into a nested classification, [5] the main group being whether the electrodes were on or off, and the subgroups being the visibility conditions. Each standard deviation is considered to be one observation. Use of this classification means that the standard deviations were assumed to follow the mathematical model

$$\sigma_{iju} = \sigma + \alpha_i + \delta_{ij} + \epsilon_{iju}$$

where

σ_{iju} = the calculated standard deviation for a particular simulation run.

σ = mean of all the standard deviations

α_i = electrode effect term

δ_{ij} = visibility effect term

ϵ_{iju} = random variation terms.

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TABLE III: TIME AVERAGE STANDARD DEVIATIONS, WITH AND WITHOUT EYE ELECTRONICS

RUN NR.	ELECTRODE CONDITION	VISIBILITY	Y FT	h FT	$\dot{Y}$ FT/SEC	$\dot{h}$ FT/SEC	ψ DEG	θ DEG	φ DEG	p DEG/SEC	q DEC/SEC	r DEG/SEC	δ_e DEG	δ_a DEG
			STANDARD DEVIATIONS											
102	N	CAVU	1.01	6.63	.27	1.97	.11	.51	.55	.36	.83	.09	1.23	.82
108	N	CAVU	9.15	8.45	.67	3.16	.71	.88	.68	.67	.79	.37	1.45	2.01
111	N	CAVU	4.06	4.12	.67	2.08	.28	.73	.85	.84	.88	.30	1.36	1.52
112	N	CAVU	5.58	8.42	1.43	2.33	.83	.89	1.84	1.58	.32	.50	.51	2.20
	MEAN		4.95	6.91	.76	2.39	.48	.75	.98	.86	.71	.32	1.14	1.64
116	E	CAVU	12.29	3.91	1.21	1.20	.64	.35	1.50	1.16	.28	.44	.56	1.96
119	E	CAVU	9.85	5.58	1.04	3.04	.30	.80	1.04	.82	.49	.29	.98	1.36
	MEAN		11.07	4.75	1.13	2.12	.47	.58	1.27	.99	.39	.37	.77	1.66
100	N	400/1600	5.07	.47	1.07	.50	.38	.15	.56	.47	.17	.13	.40	1.57
104	N	"	7.38	4.70	2.45	2.15	.72	.68	.97	.54	.49	.19	1.00	1.92
107	N	"	3.93	4.29	1.95	2.11	.62	.52	1.61	1.05	.48	.32	.64	2.62
109	N	"	14.65	1.81	1.97	1.48	.40	.73	2.14	1.46	.72	.40	1.43	2.81
114	N	"	6.58	6.66	1.32	3.31	.59	.89	1.24	1.03	.85	.41	1.58	2.55
	MEAN		7.52	3.59	1.75	1.91	.54	.59	1.30	.91	.54	.29	1.01	2.29
115	E	400/1600	3.44	6.83	1.92	2.93	.60	.73	1.80	1.59	.56	.41	1.08	3.86
118	E	"	4.99	7.20	.64	2.11	.30	.60	.95	.74	.38	.28	.79	1.83
120	E	"	3.86	2.84	1.78	.41	.62	.15	.72	.59	.19	.43	.15	2.46
123	E	"	5.80	4.70	1.62	.73	.58	.33	1.54	1.07	.36	.44	.63	1.99
	MEAN		4.52	5.39	1.49	1.55	.53	.45	1.25	1.00	.37	.39	.66	2.54
101	N	100/1200	7.28	13.03	1.66	5.07	.50	1.81	1.41	1.32	1.21	.32	2.57	4.33
103	N	"	12.41	14.34	1.07	3.35	.30	.82	1.17	1.07	.75	.20	1.60	3.49
105	N	"	9.00	4.85	1.45	2.37	.24	.83	1.28	1.12	.71	.36	1.24	3.17
106	N	"	14.47	6.44	2.15	2.89	.44	1.00	1.21	1.21	.79	.39	1.43	3.08
113	N	"	3.47	4.12	1.53	1.69	.27	.56	.51	.54	.60	.27	1.01	2.16
	MEAN		9.33	8.56	1.57	3.07	.35	1.00	1.12	1.05	.81	.31	1.57	3.25
117	E	100/1200	5.63	3.94	2.17	1.63	.68	.47	1.11	.87	.23	.25	.34	2.43
121	E	"	5.35	1.55	.91	.95	.42	.30	.55	.60	.21	.28	.30	2.35
122	E	"	2.29	5.36	.95	1.51	.43	.39	.69	.70	.35	.31	.60	2.27
	MEAN		4.42	3.62	1.34	1.36	.51	.39	.78	.72	.26	.28	.41	2.35

NOTE; N = No electrodes used; E = electrodes used.

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After the standard deviations had been classified as above, an analysis of variance [5] was performed for each of y, h, and $\dot{h}$ standard deviations. All three of these analyses of variance resulted in both group (electrode) and subgroup (visibility) effects not being significant at the .05 level for type I error. These Analysis of Variance (ANOVA) Tables are given as Tables IV, V, and VI. The use of the .05 level for type I error means that there is one chance in 20 of rejecting the null hypothesis as being not significant when it is true.

The nonsignificance of the electrode effect corresponds well with the pilot's comments that the electrodes did not bother him. The nonsignificance of the visibility effects is possibly due to the pilot flying an ILS approach, depending on the instruments for guidance, irrespective of the outside visibility. In this case, from 5000 feet to 1500 feet from the GPIP, the aircraft would be at altitudes of from 250 feet to 75 feet, and the data used would reflect mostly glide slope and localizer instrument tracking.

4.2 OBJECTIVE 2: To evaluate the improvement in the sink rate at touchdown of the simulated system.

The sink rate at touchdown ($\dot{h}$) was picked for special attention because it appears to be related to the realism of the simulation. Touchdown was defined to be the first instant at which the c.g. height of the aircraft was 15 feet, which corresponds approximately to initial wheel contact. The sink rate $\dot{h}$ was determined for these times from the data recorded on magnetic tape.

Two analyses were performed. The first used only the data from the 30 runs in November, and was concerned with the possibility of the

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TABLE IV. ANOVA TABLE, Y STANDARD DEVIATIONS

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F RATIO	SIGNIFICANT
Between main groups	1	12.11	12.11	1.07	No
Subgroups within main groups	4	110.19	27.55	2.43	No
Within subgroups	17	192.85	11.34		
TOTAL	22	315.15			

$F_{1,\ 17,\ .05} = 4.45$ $F_{4,\ 17,\ .05} = 2.96$

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TABLE V: ANOVA TABLE, h STANDARD DEVIATIONS

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F RATIO	SIGNIFICANT?
Between main groups	1	14.96	14.96	1.71	No
Subgroups within main groups	4	69.17	17.29	1.97	No
Within subgroups	17	144.06	8.77		
TOTAL	22	233.19			

$F_{1, 17, .05} = 4.45$ $F_{4, 17, .05} = 2.96$

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TABLE VI: ANOVA TABLE, $\dot{h}$ STANDARD DEVIATIONS

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F RATIO	SIGNIFICANT?
Between main groups	1	3.95	3.95	3.80	No
Subgroups within main groups	4	4.14	1.04	1.00	No
Within subgroups	17	17.75	1.04		
TOTAL	22	25.84			

$F_{1, 17, .05} = 4.45$ $F_{4, 17, .05} = 2.96$

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simulated fog affecting $\dot{h}$ at touchdown. The second analysis used the data from both the October and November runs, and was concerned with possible learning effects.

To investigate the effect of fog upon the sink rate at touchdown, the values of sink rate for the 30 runs were arranged in three groups according to visibility condition. An M test for homogeneous variances [6] was performed, which produced a value of M of 3.20. This value of M was not significant at the .05 level for type I error, so the hypothesis of equal variances was accepted.

To investigate the hypothesis that the mean sink rates were equal for the three visibility cases, an analysis of variance was used [6]. The model for this analysis of variance was

$$\dot{h}_{it} = \dot{h}_{\mu} + \dot{h}_{\alpha_i} + \dot{h}_{\varepsilon_{it}}$$

where

$\dot{h}_{\mu}$ = sink rate grand mean

$\dot{h}_{\alpha_i}$ = visibility effect, i=1, 2, 3

$\dot{h}_{\varepsilon_{it}}$ = random error, i=1, 2, 3, t=1,---,10.

The analysis of variance table is given as Table VII. The F ratio of 1.02 is not significant at the .05 level, so the hypothesis that the $\dot{h}_{\alpha_i}$ are all identically zero is accepted.

Since the visibility condition has no effect upon either the mean or standard deviation of $\dot{h}$, the grand mean and pooled estimate of the variance can be used. Thus the mean sink rate is -6.50 ft/sec and the standard deviation of the sink rate is 2.40 ft/sec. A mean sink rate of -6.5 ft/sec is considerably above the sink rate of -2 ft/sec given as nominal by T.O. 1C-135A-1-1, but is considerably below the -12 ft/sec sink rates of the data of Reference 3. Thus the simulator

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improvements listed in Section II, which were installed subsequent to the collection of the data given in Reference 3, seem to have improved, but not completely overcome, problems of the realism of the simulation.

To study possible learning effects, all of the sink rate at touchdown data from the October and November runs were arranged in the order in which the runs were made. This resulted in 53 data points. A regression analysis was then performed upon the data, to determine the degree of predictability of the sink rate, given the cumulative run number.

Analyses were performed with 2nd, 4th, and 10th order regression polynomials, with the 4th order polynomial finally chosen as best representing the data. The analysis of variance for the terms of the 4th order polynomial is given as Table VIII. From this table, it is seen that the important term in the regression is the quadratic term. However, since a 2nd order polynomial cannot adequately represent a flattened curve, the 4th order polynomial was used.

The regression polynomial determined was

$$\dot{h} = - 14.47 + 1.42\, x - .082\, x^2 + .00197\, x^3 - .00002\, x^4$$

where x denotes the cumulative run number. This curve is plotted in Figure 3, along with the actual data points. Figure 4 is a histogram of the residuals, and indicates that the curve yields a good fit to the data.

Examining Figure 3, the regression curve indicates that for

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TABLE VII: ANOVA TABLE FOR $\dot{h}$ AT TOUCHDOWN

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F RATIO
Between visibilities	2	11.76	5.88	1.02
Within visibilities	27	155.01	5.76	
TOTAL	29	166.77		

TABLE VIII. ANOVA TABLE FOR $\dot{h}$ REGRESSION COEFFICIENTS

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F RATIO
Linear term	1	15.66	15.66	1.90
Quadratic term	1	87.26	87.26	10.60
Cubic term	1	9.96	9.96	1.21
Quartic term	1	20.88	20.88	2.54
Deviation about regression	48	395.23	8.23	
TOTAL	52	528.98		

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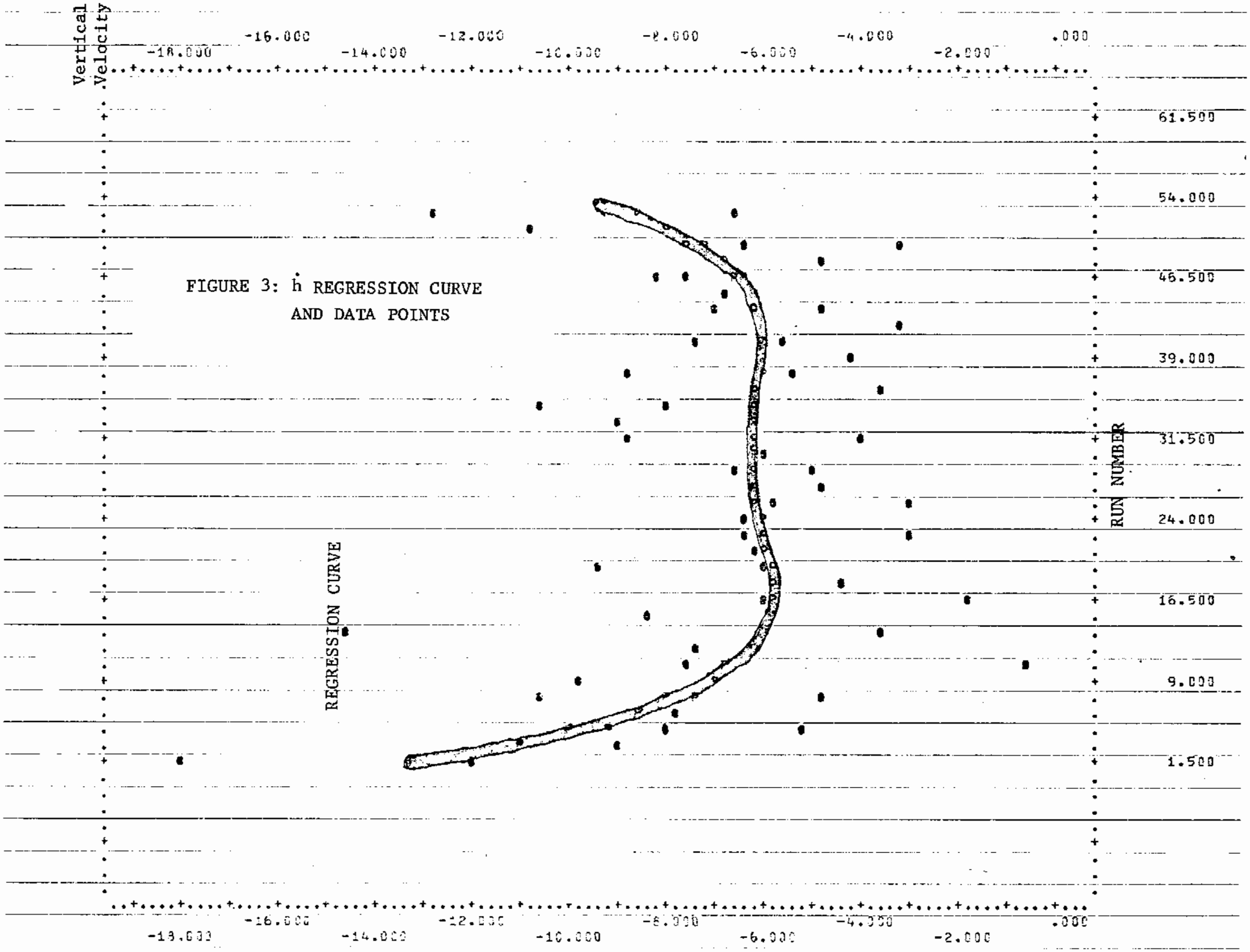

FIGURE 3: $\dot{h}$ REGRESSION CURVE AND DATA POINTS

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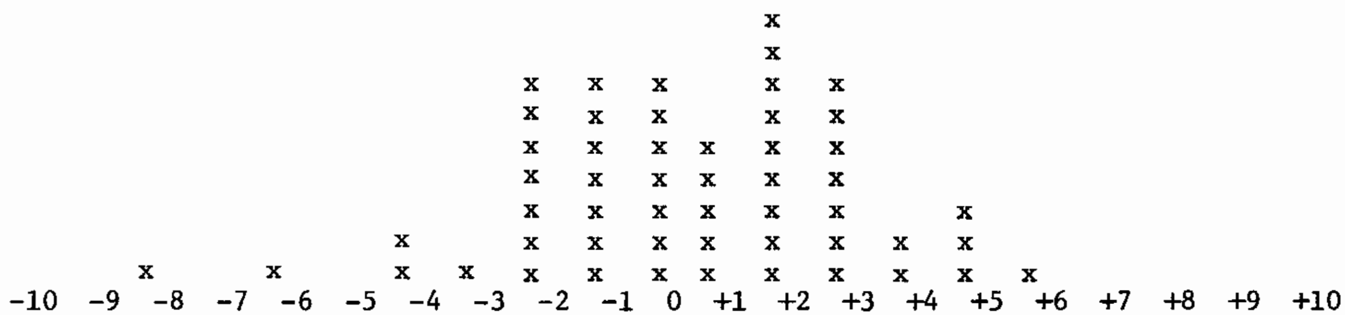
Figure 4. HISTOGRAM OF RESIDUALS OF

4TH ORDER POLYNOMIAL FIT TO $\dot{h}$ VS. RUN NUMBER



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the first 10 to 15 simulation runs, the pilot was learning to fly the simulator. During these runs, his sink rate at touchdown decreased from initial values of about -12 ft/sec to values around -6 ft/sec, and the regression polynomial here represents his learning curve. The relationship between sink rate at touchdown and cumulative run number then reached a plateau and remained there until 4 to 5 runs before the end of the program, at which point the sink rate at touchdown began to increase. This increase in the sink rate at touchdown is probably associated with two runs having high sink rates. These high sink rates could be due to the combination of poor visibility (these runs had 100 ft breakout altitudes, and the immediately preceding and succeeding runs did not) and the pilot relaxing as he knew he was almost finished but was being delayed by simulation computer malfunctions.

The analysis of the sink rate at touchdown thus yields that the sink rate is not affected by visibility, and its values show that the simulator improvements removed some of the simulator problems. Also, the pilot requires 10 to 15 runs to "learn" the simulator, and he should probably be kept "in the blind" as to when the program will end to avoid a relaxation in the last few runs.

4.3 OBJECTIVE 3: To compare the Phase II pilot modeling experiment results with the Phase I pilot modeling experiment results.

To compare the two experiments, the data from this simulation was analyzed and reported on in the same categories as the data from the previous experiment, namely: pilot ratings and questionnaire; stationary statistics; ensemble statistics; touchdown statistics;

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and plots from a "typical" run. Because of the change in the pilot rating scale, the pilot rating results will not be similar. Also, due to the simulator improvements made during the time between the two experiments, the touchdown data for the second experiment is data taken actually at touchdown, instead of at a fixed height above the runway, and therefore such items as the touchdown footprints of the two simulations are not comparable. After the data from this simulation have been analyzed, they will then be compared with the data from Phase I.

This section is organized in a manner parallel to Reference 3, so as to permit easy comparison with Phase I. The pilot ratings and questionnaires are treated in Section 4.3.a, which corresponds to Section 4.1 of Reference 3. Stationary tracking statistics are considered in Section 4.3.b, corresponding to Section 4.2 of Reference 3. Ensemble statistics are discussed in Section 4.3.c, paralleling Section 4.3 of Reference 3. Touchdown statistics are presented in Section 4.3.d, which parallels Section 4.4 of Reference 3. Section 4.3.e discusses plots from typical runs and is the analog of Section 4.5 of Reference 3. Finally, Section 4.3.f compares the results of the Phase I and Phase II pilot modeling experiments.

Summarizing the results of this section, the objective was satisfied as the results of the two experiments are comparable and can be used collectively for pilot modeling. However, there are many minor differences between the two experiments. These differences seem to be related to variability between pilots, the addition of the yaw damper, and the C_{ℓ_p} change.

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4.3.a Pilot Ratings and Questionnaire

As mentioned previously, after each simulation run the pilot completed a questionnaire and provided pilot ratings. The questionnaire is given in Appendix 1. The pilot ratings were of two types, a performance rating and an effort rating. The rationale used to determine the ratings is given in Figures 1 and 2. Table IX gives the mean and standard deviations of these ratings for each visibility condition. Examining the entries in the table, it is seen that the performance ratings for CAVU and 400/1600 visibility conditions are similar, while the performance rating for the 100/1200 visibility condition has a larger mean and a larger standard deviation. For the effort ratings, the mean rating increases as the visibility decreases, while the standard deviations show no particular pattern. The standard deviations for the effort scale are approximately constant, which indicated that the effort scale might have constant sensitivity, a characteristic of the psychological continuum [7].

Comparing the mean pilot ratings with the decision process used to determine the ratings (given in Figs. 1 and 2), it is seen that the pilot performance rated the CAVU and 400/1600 cases on the border between acceptable for daily operations and acceptable in only two percent of landings. The 100/1200 case was performance rated as being acceptable in only two percent of landings. The standard deviations of the ratings were so large that a plus and minus one sigma band about the ratings would cover over 3 ratings, hence, the reliability of the ratings is probably low.

The effort ratings were noticeably worse than the performance

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TABLE IX: PILOT RATING STATISTICS

VISIBILITY	PERFORMANCE RATING		EFFORT RATING	
	MEAN	STD. DEV.	MEAN	STD. DEV.
CAVU	3.50	1.72	5.60	1.51
400/1600	3.70	1.77	6.10	.99
100/1200	4.80	2.78	7.30	1.16

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ratings, with the CAVU and 400/1600 cases being effort rated acceptable in only two percent of landings, and the 100/1200 case being effort rated acceptable only in an emergency. Again, the standard deviations of the ratings are high, so the reliability of the ratings is probably low.

In addition to the ratings, the pilot responses to the questionnaire answers were tabulated. Table X gives the categories used for the tabulation, and the percentage of yes responses. In addition, Table XI gives the frequency that the pilot mentioned a specific instrument when he referred to instruments after going visual. This frequency is expressed as a percent of the number of times the pilot referred to instruments after going visual.

The pilot's estimate of visibility in the fog cases is generally poor. The 100/1200 case questionnaire replies were accurate only because the pilot knew that the worst fog case was the Cat II minimum, and he could readily detect the differences between the two fog conditions. In general, when in fog the pilot tended to estimate the breakout altitude as being lower than it actually was, and the runway visual range as being higher than it actually was.

The pilot's go around decisions occurred when he considered that his lateral error at the runway threshold was too large, and were mainly related to the quality of the flight path and localizer tracking. The special circumstances surrounding transition all occurred in the 100/1200 case, and were optical illusions or misapprehensions by the pilot. In the first instance, the pilot interpreted the initial visual cues as indicating that the aircraft was in a severe nose down attitude, and he had to cross check his

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TABLE X. TABULATED PILOT QUESTIONNAIRE RESPONSES

QUESTION	VISIBILITY		
	CAVU	400/1600	100/1200
1. Was the pilot's visibility estimate correct?	100%	10%	100%
2. Would the pilot have gone around?	10%	10%	20%
3. Was anything special about the transition from instruments to visual?	0%	0%	3%
4. What was the quality of touchdown?			
Good	40%	50%	40%
Average	50%	50%	50%
Poor	10%	0%	10%
5. What was the quality of the flight path?			
Good	20%	70%	50%
Average	80%	10%	40%
Poor	0%	20%	10%
6. Were instruments referred to after going visual?	90%	80%	50%
7. Did turbulence bother the pilot?	70%	100%	90%

(NOTE: The table lists percent of yes responses.)

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TABLE XI. FREQUENCY OF REFERRING TO A SPECIFIC INSTRUMENT, WHEN THE PILOT REFERS TO INSTRUMENTS AFTER GOING VISUAL

INSTRUMENT	VISIBILITY		
	CAVU	400/1600	100/1200
ADI (Attitude direction indicator)	100%	50%	100%
A/S (Airspeed indicator)	100%	12.5%	0%
VVI (Vertical velocity indicator)	100%	75%	40%
ALT (Altimeter)	66%	50%	80%
HSI (Horizontal situation indicator)	78%	0%	0%

(NOTE: The Table lists the percent of times that a specific instrument was referred to in the cases where instruments were referred to after going visual.)

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instruments to ensure maintaining a safe attitude. In the second instance, the aircraft appeared lower to the pilot than it actually was, and in the third instance, the pilot could not detect a drift to the left soon enough for a safe approach.

4.3.b Stationary Statistics

Glide slope and localizer tracking performance, and the effect of visibility upon them, were investigated using the same ergodic assumption used to analyze the Phase I data (Ref. 3). The same statistics were computed as for Phase I, by breaking the data up into a block of data collected between 10,000 and 5000 feet from the GPIP, and a block of data collected between 5000 and 1500 feet from the GPIP. The 10000 to 5000 feet block was taken to represent the approach phase and the 5000 to 1500 feet block was taken to represent the terminal approach phase.

For each of these blocks, a standard deviation was computed for localizer error (y), glide slope error (h), yaw (ψ), pitch (θ), roll (ϕ), yaw rate (p), pitch rate (q), roll rate (r), elevator deflection (δ_e), aileron deflection (δ_a), and rudder deflection (δ_r). The standard deviations obtained for each combination of variable, data block, visibility, and run were then averaged with respect to run to obtain an average standard deviation for each combination of variable, visibility, and data block distance from the GPIP. The results of these calculations are given in Table XII. Appendix 3 gives the standard deviations for each run for the 10,000 to 5000 feet data blocks, and Appendix 4 gives them for the 5000 to 1500 feet data blocks.

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TABLE XII. AVERAGE STATIONARY STATISTICS FOR SELECTED VARIABLES

VARIABLE	VISIBILITY						
	CAVU		400/1600		100/1200		
	10000-5000	5000-1500	10000-5000	5000-1500	10000-5000	5000-1500	Units
Y	14.79	11.79	13.78	11.93	17.02	11.33	Feet
ψ	.79	.95	.93	.73	1.08	.81	Degs
θ	.77	.72	.94	.95	.83	.80	"
ϕ	1.67	2.08	1.45	2.59	1.37	1.28	"
p	1.30	1.77	1.13	1.63	.98	1.18	Deg/Sec
q	.84	.58	.70	.90	.66	.75	"
r	.69	.67	.71	.73	.73	.70	"
δ_e	1.23	1.07	1.26	1.72	1.26	1.47	Degs
δ_a	3.26	4.07	3.44	4.27	3.52	4.11	"
δ_r	.63	.84	.54	.78	.56	.55	"
h	9.58	5.26	8.94	11.63	9.36	8.95	Ft

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Examining the data given in Table XII, no large trend stands out distinctly. There is a tendency for localizer tracking error to improve when going from the 10,000 to 5000 feet range to the 5000 to 1500 feet range. Accompanying this is a tendency for yaw rate and aileron deflection to increase. However, yaw, roll, and roll rate do not show such a tendency. In fact, roll rate tends to be constant irrespective of visibility or distance from the GPIP. The rudder standard deviation seems consistent with the presence of a yaw damper.

The localizer error standard deviation for the three visibilities is essentially identical for the 5000 to 1500 feet block. This is not true for the glide slope error, nor does the glide slope error always decrease as the runway is approached. The glide slope error decreases for the CAVU and 100/1200 cases, but it increases for the 400/1600 case. The only large change is the decrease in the CAVU case.

Pitch seems to be range independent, and to vary slightly from visibility to visibility. Pitch rate increases in the fog cases as range decreases, but decreases in the CAVU case. This is accompanied by a similar increase in elevator deflection in the fog cases as range decreases, and decrease in the CAVU case.

4.3.c Ensemble Statistics

Ensemble statistics for a random process are statistics computed for a specific time using several realizations of the process. For all of the data collected, means and standard deviations as a function of range from the GPIP (equivalent to time in this case) were computed for each visibility case. This was done by selecting the 10 runs

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for each visibility case, sorting the data by range, and computing the statistics. A more complete description of the method of data sorting and of computation may be found in Reference 3.

Appendix 5 presents plots of the ensemble statistics, in the form of a plot of the mean value versus range, with plus and minus one standard deviation about the mean indicated. These plots run from the highest range on the right, to the lowest range on the left. Plots of glide slope error, localizer error, displayed glide slope error, displayed localizer error, x, u, y, v, h, ω, ϕ, p, θ, q, ψ, r, δ_e, δ_a, δ_r, throttles 1 through 4, u gust, w gust, p gust, and r gust are presented in that order.

The ensemble plots show that the pilot and aircraft started low and to the right of the glide path, and smoothly approached the glide path as range decreased. The glide slope error for CAVU and 400/1600 is similar, the mean being oscillatory and the standard deviations of similar magnitude. However, in the 100/1200 case, the mean is now not oscillatory, although the standard deviations are not very different in magnitude from the other cases. In the CAVU case, the localizer error tended to funnel down as the runway threshold was approached while for the fog cases the error standard deviations tended to remain almost constant as a function of range.

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Similar comments hold about the displayed glide slope and localizer error. Again, the displayed localizer error reduced as the runway was approached in the CAVU case, but not in the 400/1600 or 100/1200 cases. In fact, in the 400/1600 case, the displayed error reached a maximum between about 2000 to 4000 feet from the GPIP. This corresponds to altitudes of from 100 to 200 feet, which is the region in which the pilot was making his transition from instrument flight to visual flight. Also, the displayed and actual glide slope error tended to be low near the runway threshold for both the CAVU and 400/1600 cases, while it tended to be high at the runway threshold for the 100/1200 case.

The velocities are all of similar character for all three cases, except for $\dot{h}$, where the 100/1200 case exhibits a pronounced flare, the CAVU case exhibits a lesser amount of flare, and the data for the 400/1600 case ends before flare appears, indicating a very late flare for these cases. The Euler angles and Euler angle rates also are similar, except that θ for CAVU and 100/1200 reflect flare, while θ for 400/1600 does not.

The control surface deflections are similar for the three visibility cases. The plots indicate that the rudder is used independently of the yaw damper only in about the last 1000 feet of the approach, for a final correction just before touchdown. The throttles are maintained at a constant setting up to the last 1000 feet of the approach, at which point they are cut back sharply.

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4.3.d Touchdown Statistics

On every simulation run, the along-track position with respect to the GPIP (x), the cross-track position with respect to the runway centerline (y), and the sink rate ($\dot{h}$) were determined at touchdown. In the coordinate system used, short of the GPIP was positive, right of the runway was positive (when facing the runway while located on the glide path), and up was positive. Touchdown was defined to occur when the c.g. height of the aircraft was 15 feet.

The x, y, and $\dot{h}$ values from each run were then sorted as to visibility, and a mean value and standard deviation calculated for each variable for each visibility condition. The hypothesis that the standard deviations did not change as visibility changed was then tested using the M test for homogeneous variances (Ref. 6). At the .05 significance level, this hypothesis of invariant standard deviations was accepted for y and $\dot{h}$, but not for x. Applying an F test with .05 significance level to the x standard deviations for CAVU and 400/1600, the hypothesis was accepted that these standard deviations were the same. Thus the only visibility effect found in the standard deviations was that the x standard deviation increased for the 100/1200 visibility condition.

After the standard deviations had been analyzed, the means were analyzed. For y and $\dot{h}$, a one factor analysis of variance (Ref. 6) was performed. At the .05 significance level, this analysis accepted the hypothesis that there was no difference in the means of y or of $\dot{h}$ due to visibility. Therefore grand means and pooled estimates of standard deviations (Ref. 6) were computed

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for y and $\dot{h}$, and are presented in Table XIII. For the x means, a t test (Ref. 6) at the .05 significance level accepted the hypothesis that the CAVU and 400/1600 x means were equal. Therefore, the only visibility effect found in the means was that the x mean for the 100/1200 case had a considerably larger magnitude than for the CAVU and 400/1600 cases. The x means and standard deviations are also given in Table XIII.

In addition, the touchdown points (x and y) were plotted to form a footprint of the landings. The plot of the actual data is given in Figure 5, where the cross locates the GPIP, and the outline indicates the region within which the center of gravity must lie for the aircraft wheels to be on the runway pavement. The data points are coded to indicate the visibility condition, and it can readily be seen that three of the 100/1200 case runs are considerably further down the runway than the cluster of the remaining data points.

Besides plotting the data points, .5 probability ellipses were calculated for the 100/1200 case and for the combined CAVU and 400/1600 cases using the assumption of normality (Ref. 8). These ellipses are given as Figures 6 and 7. The ellipse for the CAVU and 400/1600 cases is relatively small and almost centered on the GPIP, while the ellipse for the 100/1200 case extends far beyond the GPIP. The parameters of the ellipses are given in Table XIV.

The touchdown data appear to display a definite visibility effect. The fog does not affect the pilot's cross track error performance or sink rate performance, but has a substantial effect upon his along track performance. In his along track performance,

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TABLE XIII. TOUCHDOWN STATISTICS

	MEAN	STANDARD DEVIATION
Along Track (x)		
CAVU and 400/1600	-125 feet	487 feet
100/1200	-743 feet	1031 feet
Cross Track (y)	4.5 feet	24 feet
Sink Rate ($\dot{h}$)	-6.5 ft/sec	2.4 ft/sec

TABLE XIV. PROBABILITY ELLIPSE PARAMETERS

PARAMETER	CAVU & 400/1600	100/1200 UNITS
Number of points	20	10
Mean of x	-125	-743 feet
Standard deviation of x	474	1031 feet
Mean of y	6.3	.9 feet
Standard deviation of y	19	31 feet
Correlation coefficient	-.14	-.015
Semimajor axis	559	1214 feet
Semiminor axis	22	37 feet
Eccentricity	.999	1.000
Angle of rotation	-.319	-.02 degrees

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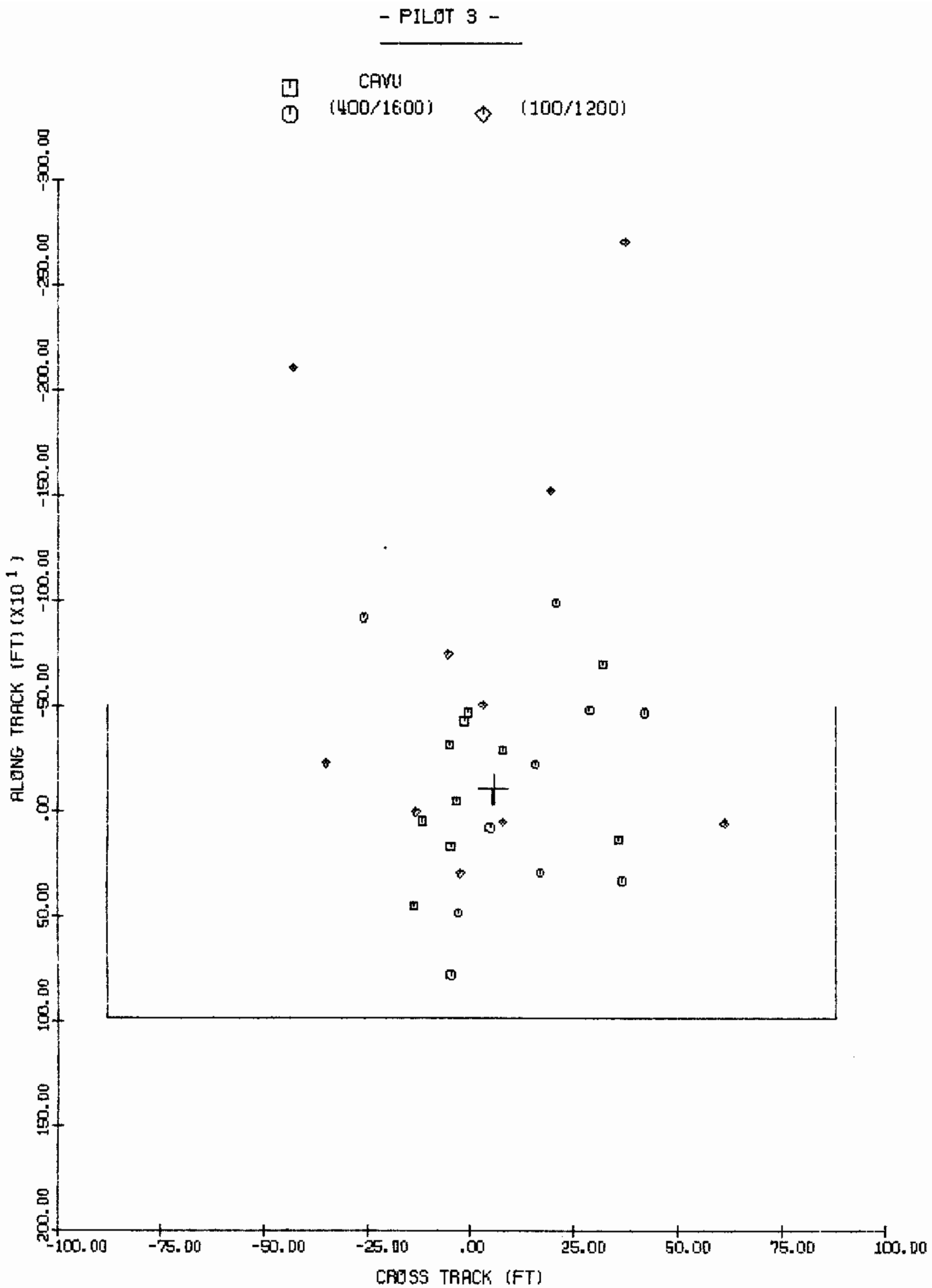

Figure 5: TOUCHDOWN DATA PLOT

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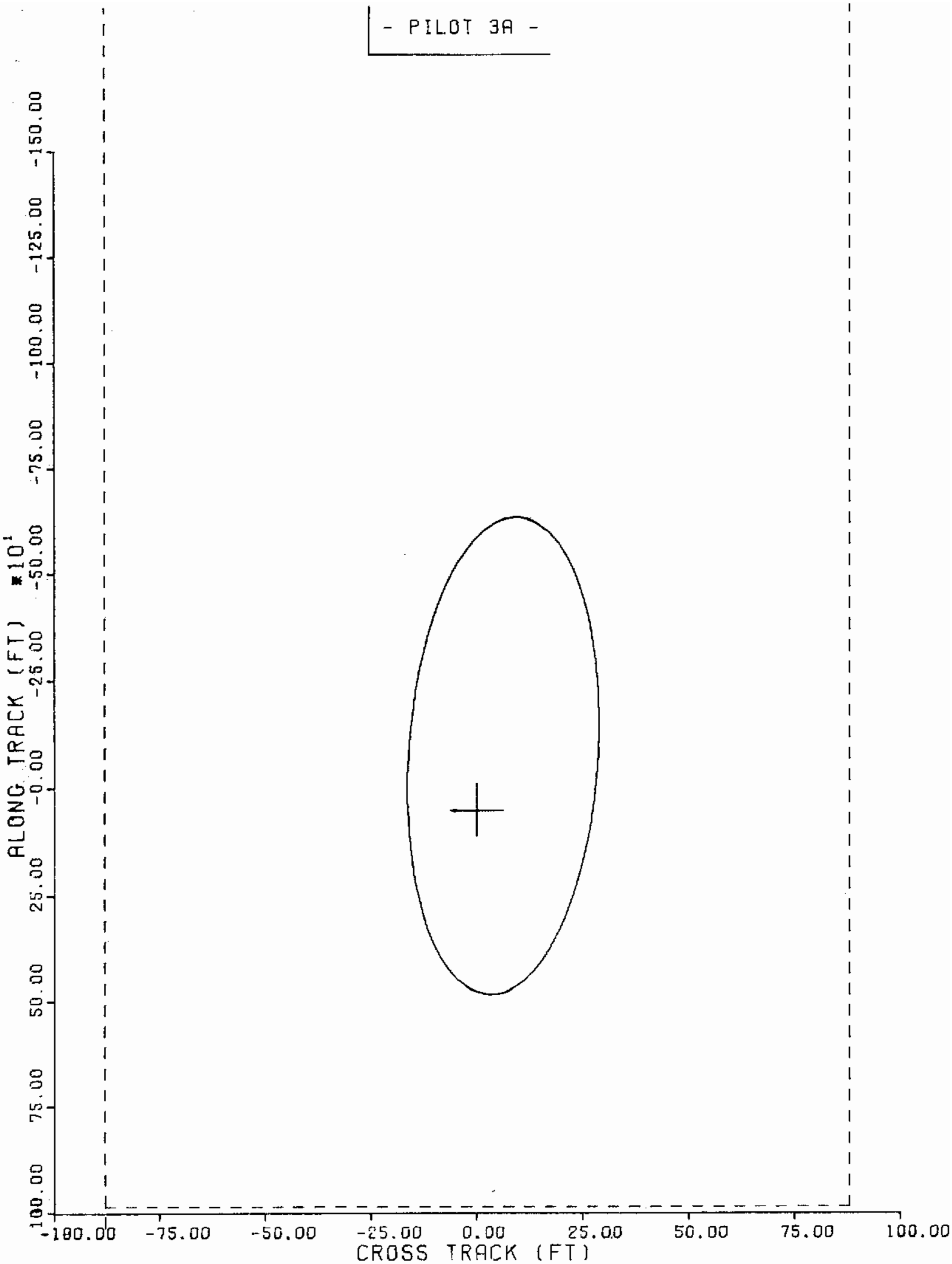

Fig. 6: PROBABILITY ELLIPSE FOR CAVU AND 400/1600

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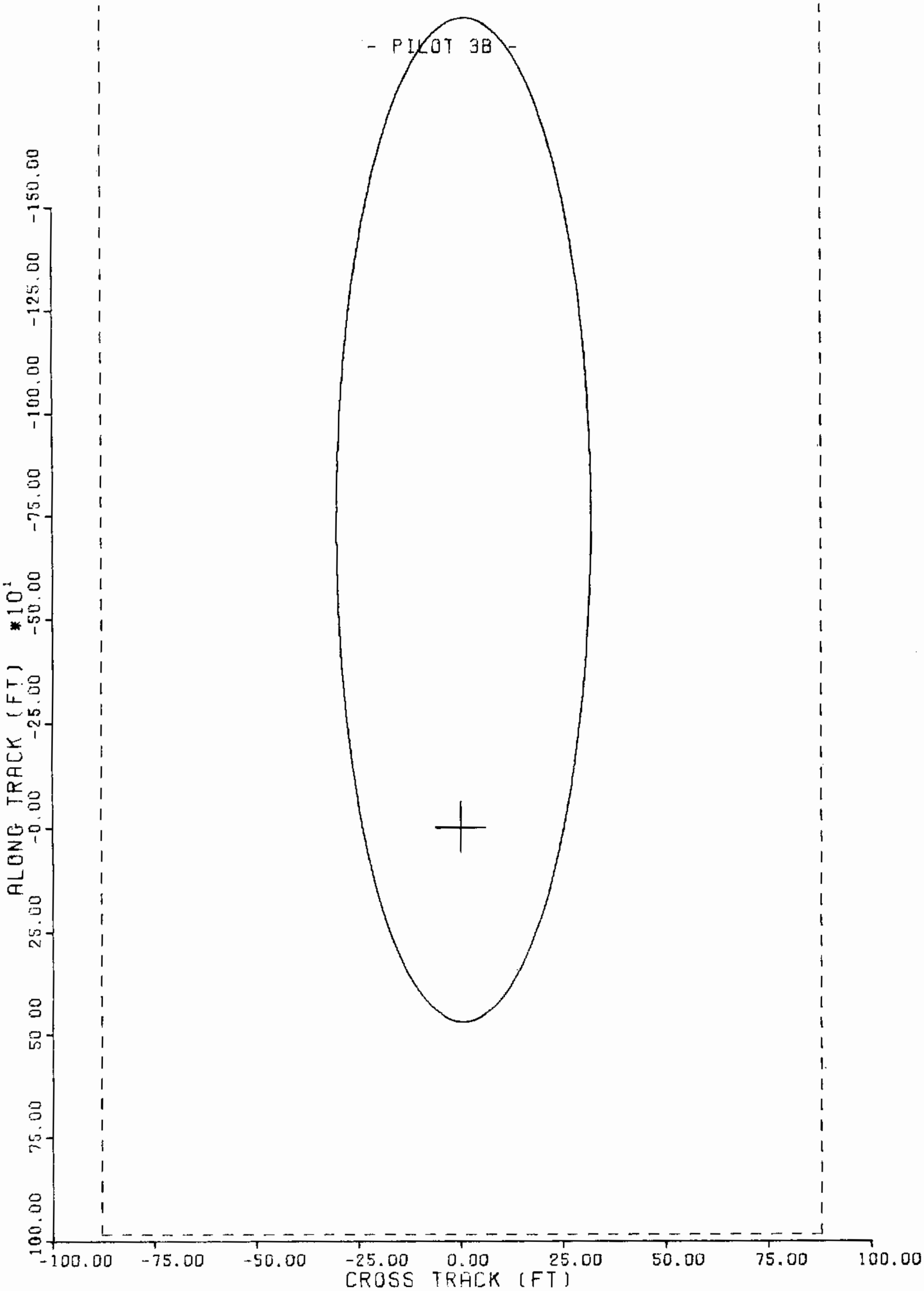

Fig. 7: PROBABILITY ELLIPSE FOR 100/1200

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the lighter of the fogs has no effect when compared to clear air but the heavier fog results in greater dispersions in touchdown points, and a shift of the touchdown points farther down the runway. In some of these runs, the pilot seemed to "float" down the runway until he was certain it was safe to touch down. This indicates that the pilot delayed touchdown until he recognized certain visual cues.

4.3.e Plots from Typical Runs

Appendix 6 contains plots of variables versus time for run 121, a CAVU run, Run 120, a 400/1600 run, and Run 127, a 100/1200 run. The variables plotted are λ, altitude error, α, β, ψ, θ, ϕ, p, q, r, δ_a, δ_r, u gust, v gust, ω gust, p gust, q gust, and r gust in that order.

The character of the plots is similar. They show that the rudder is used by the pilot essentially only for last minute corrections just before touchdown; the other rudder inputs are due to the yaw damper. The turbulence inputs appear to have a random character, and to succeed in exciting the various aircraft modes. Most control inputs from the pilot show a definitely pulse-like form.

4.3.f Comparison with Previous Experiment

In comparing the results obtained in this experiment with those obtained in the experiment of Reference 3, the main differences are:

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1. In this experiment, the pilot did flare the aircraft immediately prior to touchdown. Flare was absent in the first experiment.

2. The "s" curve phenomena observed in the first experiment was not present in this experiment.

3. The touchdown data from the two experiments are not comparable due to the presence of flare in one experiment, and its absence in the other.

4. The pilot ratings are not comparable as different scales were used.

Despite these differences, the two experiments can be used collectively for pilot modeling. This is due to the great similarity in the conditions of the two experiments. The pilot opinion responses indicated that both the Phase I pilots and the Phase II pilot had similar opinions regarding the simulation and their performance, and similar patterns in referring to the instruments after visual contact. Comparing pilot tracking performance as given for Phase II in the ensemble statistics plots of Appendix 5 of this report with pilot tracking performance as given for Phase I in the ensemble statistics plots of Appendix 7 of Reference 3, the general character is similar as to magnitude and range variation of the standard deviations. If the "s" curve phenomenon is neglected the pilot tracking performance indicated by the ensemble statistics plots is basically similar.

Even with the basic similarity of the results of the two experiments, detailed comparison of the data shows many minor differences. These minor differences may be due to the different experience of the three pilots used, or may be due to the changes in the simulation,

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or may be due to both these conditions. Unfortunately, the data were collected in such a way that pilot experience and simulation change effects cannot be separated.

Table XV presents stationary statistics standard deviations for y, h, ψ, θ, ϕ, p, q, r, δ_e, δ_a, and δ_r for each visibility condition for all three pilots used in the two experiments. These standard deviations are from the average stationary statistics computed for the 5000 feet to 1500 feet segment of the approach (as in Section 4. 3.b). They represent steady state glide slope and localizer tracking performance of the two experiments. Examining the standard deviations, for y it is seen that the pilot in the second experiment (Pilot 3) did not exhibit the increase in y standard deviation as visibility degraded that was present in the first experiment (Pilots 1 and 2). Although the h standard deviation was worst in the intermediate fog case in Experiment 2 as in Experiment 1, the h standard deviation in the worst fog case was not comparable in magnitude to the CAVU case h standard deviation for Experiment 2 as it was for Experiment 1. This implies that the trade-off between lateral and longitudinal error that seemed to exist in Experiment 1 did not exist in Experiment 2.

The θ, q, and δ_e standard deviations were all slightly larger in Experiment 2 than in Experiment 1. This was especially true in the two fog cases, and when coupled with the larger h standard deviations in fog in Experiment 2, indicates that Pilot 3 used more control effort in the longitudinal axis. His use of more control effort in the longitudinal axis seems to have resulted in poorer performance.

Comparing lateral axis variables, ψ and p seem to be slightly

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smaller in Experiment 2, while r seems to be approximately the same in the two experiments. ϕ has a tendency to be slightly higher in the CAVU and 400/1600 cases in the second experiment. δ_a shows less variation with visibility in Experiment 2 than in Experiment 1, but the magnitudes are approximately the same in the two experiments. δ_r is always larger in Experiment 2, because of the yaw damper which was used in Experiment 2 and not used in Experiment 1. The better y standard deviations in the fog cases in Experiment 2 seem to be due to Pilot 3 having a more consistent control input through the aileron, and to the yaw damper supplying rudder inputs. The yaw damper, by affecting the dutch roll mode in a different way than the C_{ℓ_p} change, might have resulted in the aircraft simulated in Experiment 2 having better handling qualities than the aircraft simulated in Experiment 1.

As can be seen in the preceding discussion, most differences in the data from the two simulations can be related back to the control inputs δ_e, δ_a, and δ_r. The probable cause of the differences can therefore be taken to be the difference between pilots. The only simulation factors which seem to have had effect on glide slope and localizer tracking are the addition of the yaw damper, and the modification of the flight director. The primary effect of these changes seems to have been to modify the pilot's behavior.

When the ensemble plots of h and y from Experiments 1 and 2 are compared, it is seen that h was smooth in Experiment 1, with y being oscillatory. However, in Experiment 2, this had reversed in two of the three visibilities, with h now being oscillatory and y being smooth. It almost appears as if the "s" curve in lateral tracking in

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Experiment 1 had shifted to an oscillation in longitudinal tracking in Experiment 2. However, this longitudinal oscillation does not appear in the Experiment 2 100/1200 case, and possibly is associated with the particular pilot.

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TABLE XV. PHASE I AND PHASE II STATIONARY STATISTICS

NOTE: Pilots 1 and 2 were Phase I, Pilot 3 was Phase II.

(a) GLIDE SLOPE ERROR STANDARD DEVIATION - h - FEET

		VISIBILITY	
PILOT	CAVU	400/1600	100/1200
1	6.78	5.40	5.77
2	6.17	7.64	3.65
3	5.26	11.63	8.95

(b) LOCALIZER ERROR STANDARD DEVIATION - y - FEET

		VISIBILITY	
PILOT	CAVU	400/1600	100/1200
1	13.66	16.44	27.18
2	12.10	21.40	18.90
3	11.79	11.93	11.33

(c) YAW STANDARD DEVIATION - ψ - DEGREES

		VISIBILITY	
PILOT	CAVU	400/1600	100/1200
1	1.24	1.19	.91
2	.73	1.00	1.05
3	.95	.73	.81

(d) PITCH STANDARD DEVIATION - θ - DEGREES

		VISIBILITY	
PILOT	CAVU	400/1600	100/1200
1	.56	.51	.70
2	.66	.64	.54
3	.72	.95	.80

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TABLE XV. PHASE I AND PHASE II STATIONARY STATISTICS (Cont.)

(e) ROLL STANDARD DEVIATION – ϕ – DEGREES

	VISIBILITY		
PILOT	CAVU	400/1600	100/1200
1	1.56	1.45	1.57
2	1.73	2.17	1.20
3	2.08	2.59	1.28

(f) YAW RATE STANDARD DEVIATION – p – DEG/SEC

	VISIBILITY		
PILOT	CAVU	400/1600	100/1200
1	.79	.87	.80
2	.96	1.24	.97
3	.58	.90	.75

(g) PITCH RATE STANDARD DEVIATION – q – DEG/SEC

	VISIBILITY		
PILOT	CAVU	400/1600	100/1200
1	.51	.49	.57
2	.59	.55	.55
3	.67	.73	.70

(h) ROLL RATE STANDARD DEVIATION – r – DEG/SEC

	VISIBILITY		
PILOT	CAVU	400/1600	100/1200
1	.64	.52	.67
2	.53	.77	.57
3	.84	.78	.55

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TABLE XV. PHASE I AND PHASE II STATIONARY STATISTICS (Cont.)

(i) ELEVATOR DEFLECTION STANDARD DEVIATION - δ_e - DEG

PILOT	VISIBILITY CAVU	400/1600	100/1200
1	.84	.78	.87
2	1.04	.95	.95
3	1.07	1.72	1.47

(j) AILERON DEFLECTION STANDARD DEVIATION - δ_a - DEG

PILOT	VISIBILITY CAVU	400/1600	100/1200
1	3.54	3.67	2.57
2	4.20	5.60	3.82
3	4.07	4.27	4.11

(k) RUDDER DEFLECTION STANDARD DEVIATION - δ_r - DEG

PILOT	VISIBILITY CAVU	400/1600	100/1200
1	.14	.04	.00
2	.12	.84	.00
3	.84	.78	.55

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4.4 OBJECTIVE 4: To measure pilot eye scanning using skin electrodes and test the hypothesis that a pilot scans more during moderate fog conditions than during dense fog or clear air conditions.

To satisfy this objective, data on up/down eye movements were collected on the 30 simulation runs made in November. The data were then manually reduced to determine whether the pilot was looking inside the cockpit at the instruments, or outside the cockpit at the visual scene, for every second of every run. The knowledge of where the pilot was looking throughout the run was then used to determine the number of in/out/in scans for each run, the duration of each scan, the time intervals between scans, the duration of the interval immediately before touchdown during which the pilot was completely visual, and the wheel height at which the pilot went completely visual.

The manner in which the pilot divided his attention for each run is presented in Appendix 7. For each run, this appendix lists the visibility condition, and the duration and order of all inside and outside scans, starting at the touchdown point and working backwards.

Table XVI presents statistics on pilot scanning derived using the data of the appendix. The specific variables considered are the duration of the final fully visual period, the wheel height at the start of the final fully visual period, the number of scans outside the cockpit before the final fully visual period, the duration of scans outside the cockpit, and the duration of the intervals between outside the cockpit scans. The statistics presented are medians

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and ranges, instead of means and standard deviations, as the distributions involved are definitely non-Gaussian, and the median is less distorted by a few extreme points than the mean. The definition of median used here is that the median is the point such that one half the data is smaller, and one half is larger. The range is defined to be the largest data point minus the smallest data point. Figures 8 through 12 present histograms of the final fully visual period durations, the wheel heights, the number of scans, their duration, and the duration of the intervals between scans.

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TABLE XVI PILOT SCANNING STATISTICS

VARIABLE	STATISTICS	VISIBILITY CONDITION		
		CAVU	400/1600	100/1200
Time duration of final fully visual period	Median	18.5 sec	16.25 sec	14.3 sec
	Range	23.2 sec	14.4 sec	22.8 sec
Wheel height at start of final fully visual period	Median	147.5 ft	105 ft	60 ft
	Range	285 ft	115 ft	40 ft
Number of scans outside cockpit before final fully visual period	Median	7	1.5	0
	Range	5	3	1
Duration of scans outside cockpit	Median	1.8 sec	.9 sec	1.2 sec
	Range	29.6 sec	.9 sec	8.6 sec
Duration of intervals between scans outside cockpit	Median	4.0 sec	4.5 sec	.6 sec
	Range	22.2 sec	20.9 sec	.4 sec

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Figure 8. HISTOGRAMS OF TIME DURATION OF

FINAL FULLY VISUAL PERIOD

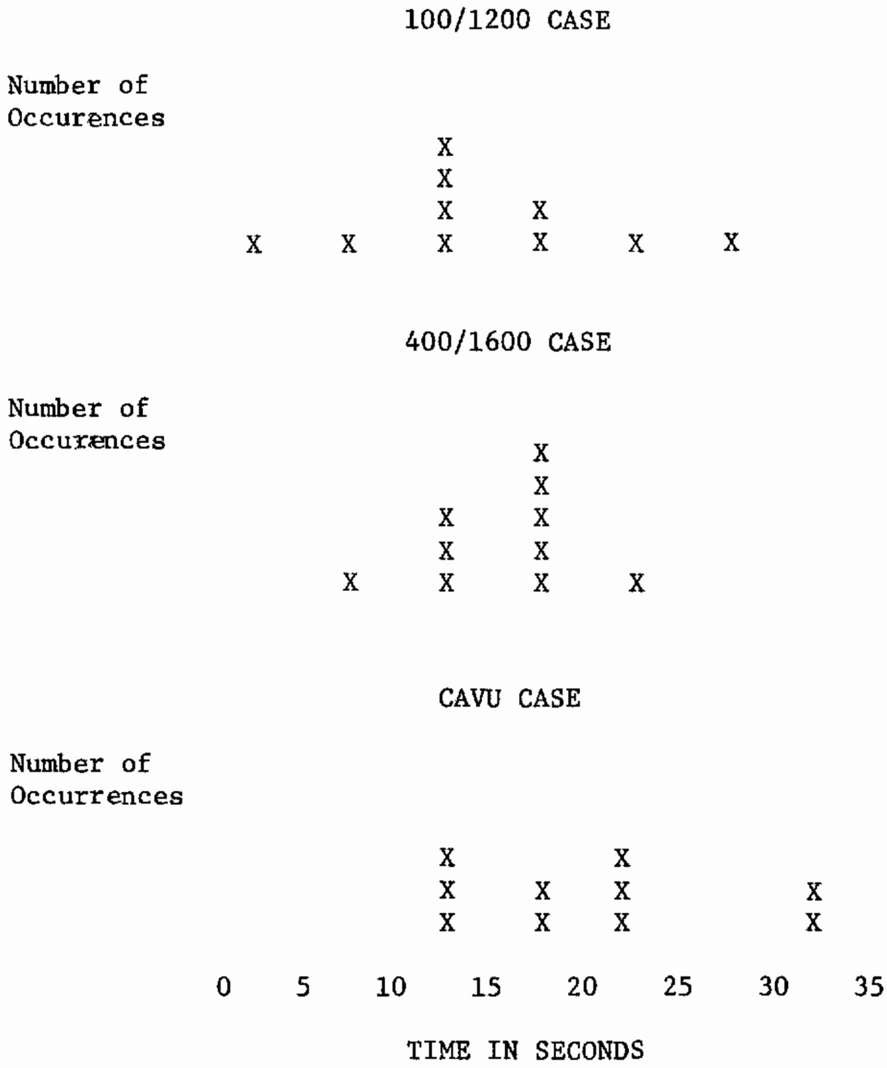

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Figure 9. HISTOGRAMS OF WHEEL HEIGHT AT START OF FINAL FULLY VISUAL PERIOD

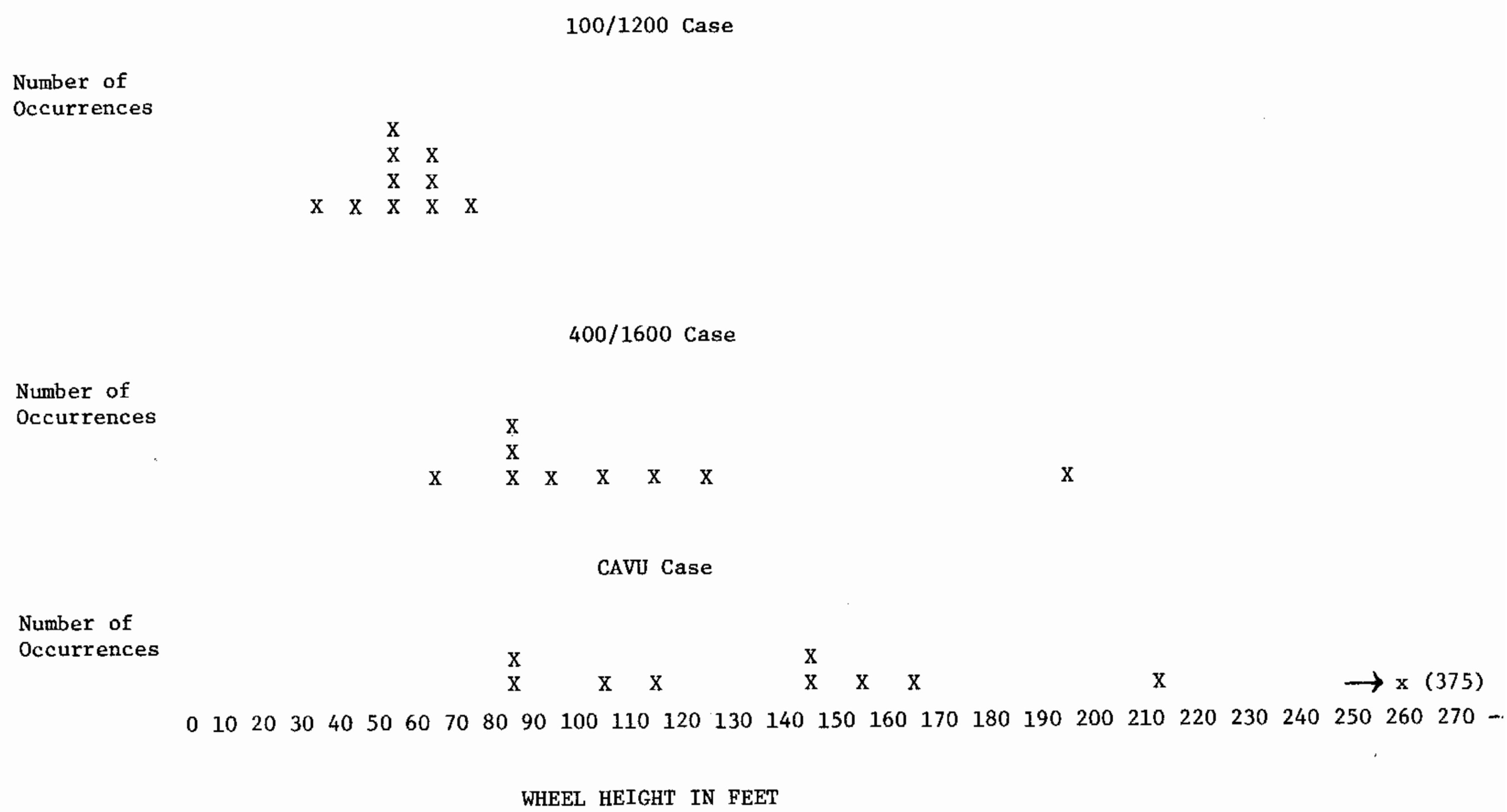

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Figure 10. HISTOGRAMS OF THE NUMBER OF SCANS OUTSIDE THE COCKPIT BEFORE THE FINAL FULLY VISUAL PERIOD

```
                            100/1200 CASE
              X
Number of     X
Occurrences   X
              X
              X   X
              X   X
              X   X

                            400/1600 CASE

Number of     X       X
Occurrences   X   X   X   X
              X   X   X   X


                              CAVU CASE
Number of
Occurrences                       X   X
                                  X   X   X
                          X       X   X   X   X

              0   1   2   3   4   5   6   7   8   9   10

                             NUMBER OF SCANS
```


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Figure 11. HISTOGRAMS OF DURATION OF SCANS OUTSIDE COCKPIT

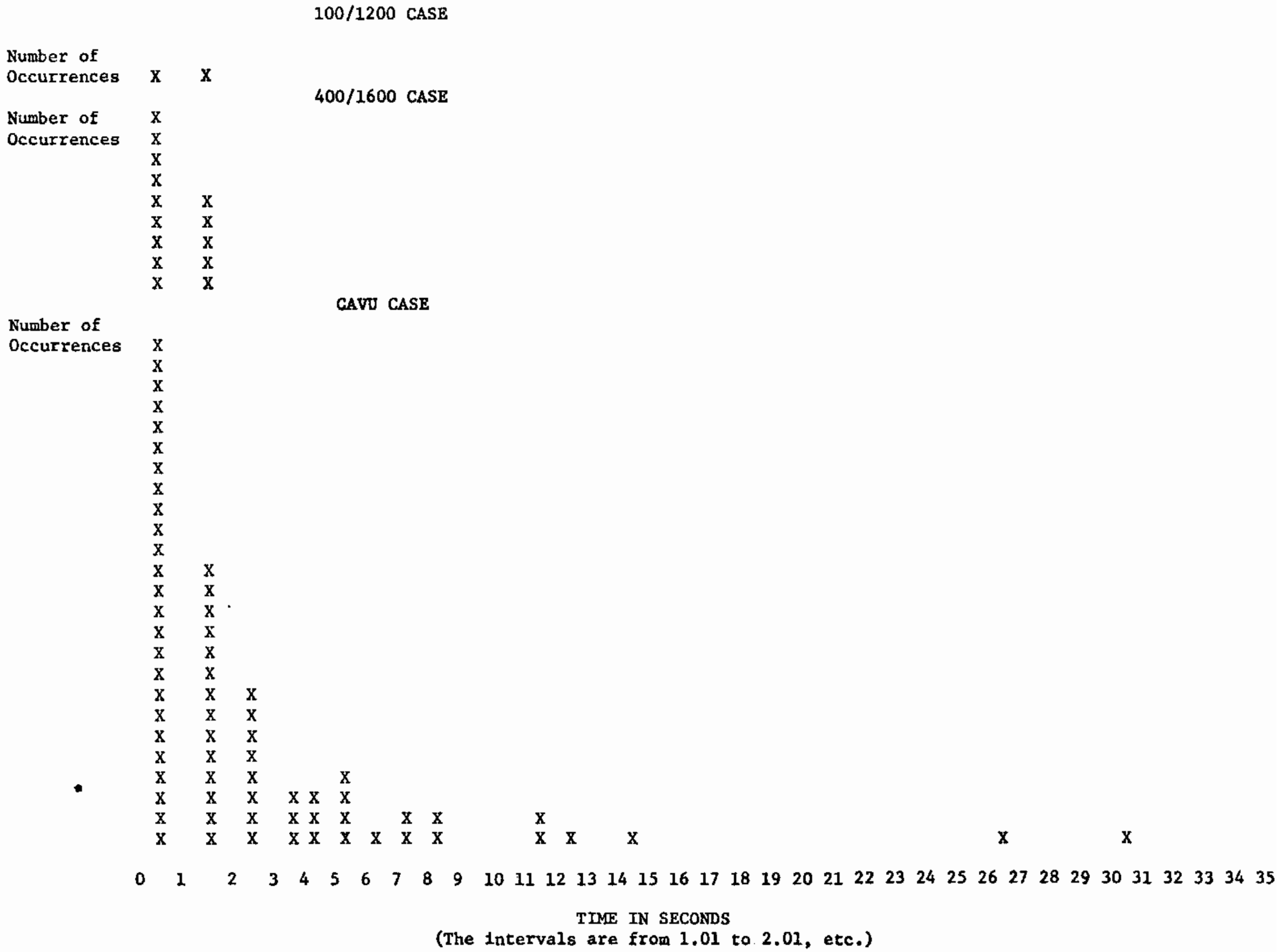

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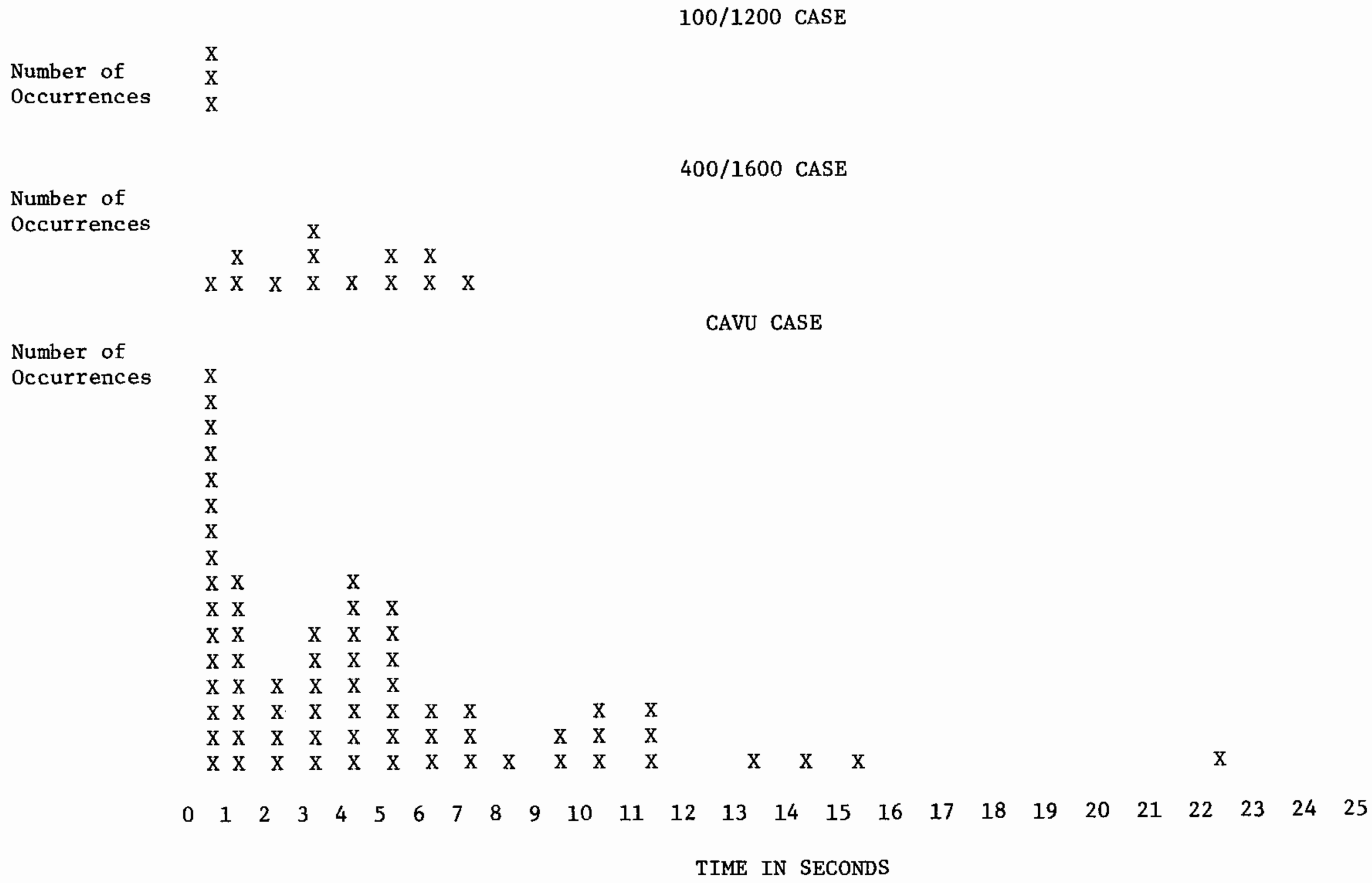
Figure 12. HISTOGRAMS OF DURATION OF INTERVALS BETWEEN OUTSIDE COCKPIT SCANS



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The pilot was always flying completely visual at touchdown. In no case did he refer to the instruments below a wheel height altitude of 40 feet, which corresponds to a c.g. height of 54.5 feet. During the runs, the copilot called out airspeed deviation of $\pm$ 3 knots, passing through 100 and 200 feet altitude, and when the copilot first had contact with the runway environment. Because of this, the pilot never scanned out of the cockpit when the aircraft was above the breakout altitude of the simulated fog.

For the 100 feet breakout altitude case, on 70 percent of the runs the pilot did no scanning at all, but transitioned from instruments to visual and remained visual thereafter. On the other three cases, he referred briefly to the instruments once. On these three runs occurred the lowest altitude transitions from instruments to visual flight. Pilot comments indicated that there usually was no time to scan back and forth at the 100 feet breakout case. Those cases where the pilot referred to instruments after going visual were said by the pilot to be for the purpose of checking aircraft attitude. He stated that he found it difficult to precisely determine aircraft attitude from the visual display alone even in the clear air case.

In the clear air case, the pilot scanned back and forth between the instruments and the visual scene throughout the run and finally transitioned to completely visual flight at about 150 feet altitude. The transition to completely visual flight occurred at the highest altitude of the three cases in the clear air case. While he was scanning between instruments and the visual scene, the pilot apportioned his time so that on the average 61% of the time was spent

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on the instruments, and 39% of the time on the visual scene. However, great variability existed in the allotment of time between the instruments and the visual scene.

When the breakout altitude was 400 feet, the pilot's scanning behavior was intermediate between the 100 feet case and the clear air case. Scanning from instruments to the visual scene and then back to the instruments was usually present, being noted on 70 percent of the 400/1600 simulation runs as opposed to being noted on only 30 percent of the 100/1200 simulation runs. However, this scanning differed from the clear air case in the time allotment between the instruments and the visual scene. Within the 400 feet breakout, the pilot now apportioned only an average of 17% of his time to the visual scene, and spent an average of 83% of his time on the instruments when exhibiting scanning behavior. He thus spent about 50 percent less time looking at the visual scene in this fog case than he did when the air was clear. The altitude at which the pilot went completely visual was about 100 ft, lying between the 150 feet of the clear air case and the 60 feet of the 100 feet breakout case.

These data do not support the hypothesis that a pilot tends to scan more during moderate fog conditions than during dense fog or clear air conditions. Instead, the data indicate that scanning behavior continually decreases as the fog density increases and the breakout altitude lowers. A typical scenario for scanning on a low visibility approach would have the pilot solely on instruments until breakout, then begin scanning from the instruments to the visual scene and back until a certain altitude is reached, at which point the pilot will transition completely to the visual scene. The altitude of

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transition from scanning to only visual is a function of the breakout altitude, as is the time allocation between instruments and the visual scene while scanning.

It was noted that a scan length of .6 to .8 seconds appears to be the minimum scan length for the pilot to fix the visual scene and obtain useful information from the scene.

The data indicate that three different scan patterns are present, depending on the visibility. For the 100 feet breakout altitude, no scanning is present, and what the pilot does is transition from instruments to the visual scene about the time he initiates flare. For the 400 feet breakout altitude, the histograms of the outside-the-cockpit-scan durations and of the time-inside-the-cockpit-between-scans indicate that the time outside the cockpit has a definite time, corresponding closely to the minimum scan length mentioned above, and the time between scans seems almost uniformly distributed over the interval of 1 to 8 seconds. Insufficient data exists to verify this hypothesis, but it appears that the scanning behavior could be modeled by an alternating renewal process [Ref 9] where the distributions of the times between the two classes of events were uniform distributions.

Examining the histograms of inside and outside cockpit times for the CAVU conditions, they are seen to resemble exponential distributions. Using a .05 level for type I error, χ^2 goodness of fit and Kolmogorov-Smirnov tests [Ref 6] accepted the distribution of the intervals between outside cockpit scans as having an exponential

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distribution with parameter 4.87, the mean of the intervals. The χ^2 goodness of fit and Kolmogorov-Smirnov tests accepted the duration of scans outside the cockpit as coming from an exponential distribution with parameter 3.88, the mean of the intervals, at the .025 level but rejected it at the .05 level. The rejection at the .05 level occurred due to a larger number of short scans (1-2 seconds) than allowed by the distribution. The scanning process in the CAVU condition can thus be represented by an alternating renewal process, and this alternating renewal process can be approximated by an alternating Poisson process [Ref 9]. The implication of the duration between scans outside the cockpit being exponentially distributed is that the probability that the pilot will scan outside the cockpit is not affected by the time since his last scan [Ref 10].

V. CONCLUSIONS AND RECOMMENDATIONS

Based upon the data presented in Part IV, it is concluded that the eye electrodes did not affect pilot performance and that the sink rate at touchdown was typically about -6 feet per second. This value of sink rate is high, but the pilot did exhibit flare behavior in this simulation. The data agree sufficiently with those collected in the previous FGD experiment for the results of the two experiments to be used collectively for pilot modeling. Pilot eye scanning was measured with skin electrodes, and the scan pattern was found to vary markedly with visibility, from a definite back and forth scan behavior

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in clear air to an all inside to all outside pattern in the heaviest fog.

It is felt that individual characteristics of the pilot may account for some of the results obtained. Therefore, it is recommended that additional data be collected using other pilots. In addition, efforts to improve the simulation fidelity should continue, and be verified by experiment.

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APPENDIX 1: PILOT QUESTIONNAIRE

(To be completed after each simulation run)

RUN IDENTIFICATION (Supplied):

FOG RATING SCALE:

a. Performance rating:

b. Effort rating:

1. What was your estimate of visibility?

2. Would you have gone around if allowed to? If so, why?

3. Did you rate your flight path as good, average, or poor? Why?

4. Did turbulence bother you? If so, how?

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5. Was anything special about the transition from instruments to visual? (Altitude, optical illusions, etc)

6. Did you continue to refer to your instruments after going visual? If so, which instruments?

7. What was the quality of touchdown? If poor, what was the possible cause?

General Remarks:

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APPENDIX 2: USING MINIATURE SKIN ELECTRODES TO MEASURE EYE MOTION

The purpose of this appendix is to describe how to measure eye motion using miniature skin electrodes. The particular electrodes used are skin electrodes manufactured by Beckman Instruments, Inc., Clinical Instruments Operations, 2400 Harbor Blvd., Fullerton, Calif, 92634. These electrodes came in a kit (part number 670626) consisting of three color coded electrodes, adhesive collars for attaching the electrodes, conductive paste to ensure good skin contact, and a cable to connect the electrodes to the recording system.

The electrodes are attached to the skin using the following procedure. First, a drop of conductive paste is rubbed into the skin where the electrode is to be applied, and then rubbed off. The electrode surface is wiped clean, and an adhesive collar is attached to the electrode, being sure that the electrode contact is exposed. A drop of conductive paste is then placed upon the exposed electrode contact, and the adhesive collar is used to attach the electrode to the skin so that the electrode contact touches the skin at the desired point.

In the experiment reported on here, vertical movements of the eye were of interest, so as to be able to determine whether the pilot was looking inside or outside the cockpit. The electrode locations to measure vertical eye motion are shown in Figure 2.1. The positive electrode is located directly above the active eye, approximately 1/4" toward the center of the face. The negative

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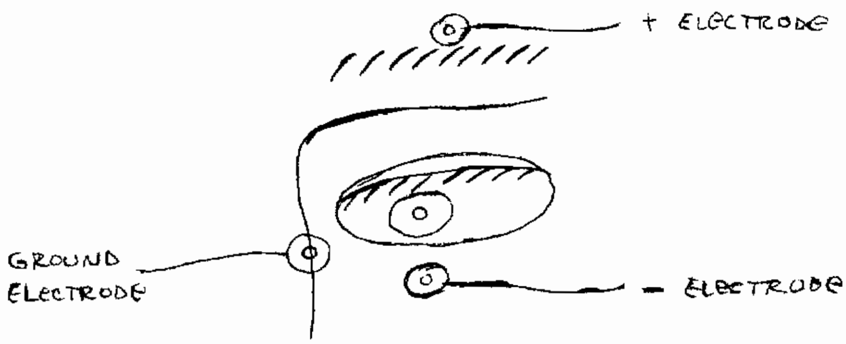

FIGURE 2.1 ELECTRODE POSITION TO MEASURE VERTICAL EYE MOTION

electrode is located directly below the active eye, and the ground electrode is positioned as far as possible toward the bridge of the nose. These electrode positions resulted in a strong indication of vertical eye motion, and virtual undetectability of horizontal eye motion.

To record the eye motion signals, the leads from the electrodes are connected to the input of a differential amplifier, and the amplifier output drives a pen chart recorder and/or magnetic tape unit. The differential amplifier used was a model 1A7A plug-in unit in a Tectronix type 545 oscilloscope. The amplifier gain was set to .2 volts/centimeter, the bandpass filter was set for DC to 100 Hertz, and the trace position was adjusted to zero to remove output biases. When data was recorded, the oscilloscope was in the AC mode, and when data was not recorded, the oscilloscope input was grounded. To avoid shocking the subject, it is necessary that the electrodes be either disconnected or grounded together whenever equipment is turned on or off or switch settings are changed. Also, to avoid noise and overloading the differential amplifier front

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end, the subject should be floating electrically, and the oscilloscope and recorder firmly grounded (3 prong). An aid to keeping the subject floating electrically is to have him wear surgical rubber gloves.

The output of the differential amplifier was recorded using a Brush strip chart recorder, with the gain set at .1 volt per chart division, and a recording speed of 5 millimeters per second. The pen position control was used to remove DC biases and drifts and to center the pen. The output signals for up-down eye movements were typically $\pm$ 1. volt, with a noise level (threshold) of about .1 to .2 volts. Motion of the eye from up to down, or vice versa, would produce a pulse in the output. Whether the motion was up or down determined the polarity of the pulse. Figure 2.2 shows an output trace for up-down scanning of the eye. In addition to being recorded on the brush recorder, the operational amplifier output was trunked into the digital recording system, and recorded on magnetic tape at a rate of 10 samples per second.

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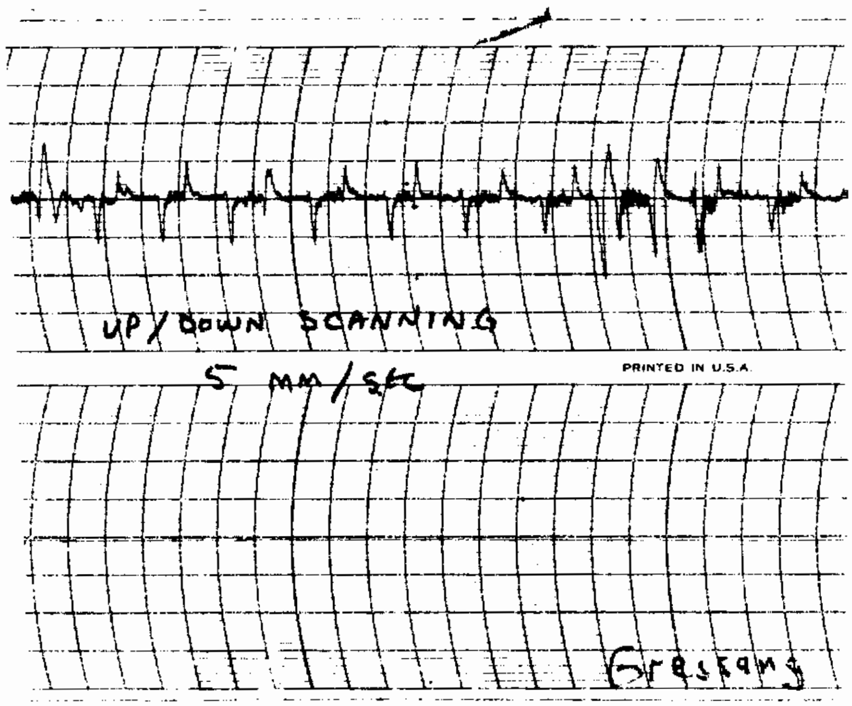

Figure 2.2 OUTPUT TRACE FOR UP-DOWN EYE SCANNING

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APPENDIX 3

STATIONARY STATISTICS FOR

10000 TO 5000 FEET DATA BLOCKS, PER RUN

CAVU RUNS

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FOR RUN # 121

COMPUTATION RANGE IS 10000 FT TO 5000 FT

VARIABLE	MEAN	STD DEV
RANGE	7450.14	1457.88
Y	44.22	11.00
XDOT	237.63	1.86
YDOT	1.50	1.37
HDOT	-12.11	3.45
PSI	-.97	.72
THETA	-1.12	.83
PHI	.00	1.85
P	-.12	1.36
Q	.00	.61
R	.03	.74
U	237.71	1.85
V	6.28	3.64
W	-7.12	3.01
D	-.06	.10
LOCERR	-.14	.04
DE	.09	1.07
DA	-.68	2.76
DR	.11	.69
DT1	27.84	.06
DT2	28.98	.08
DT3	28.88	.06
DT4	28.18	.07
CG HEIGHT	-6.62	12.21
U GUST	-4.06	3.10
V GUST	-4.82	2.19
W GUST	-1.04	1.89
P GUST	.20	.34
Q GUST	.00	.34
R GUST	-.02	.51

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FOR RUN # 123

COMPUTATION RANGE IS 10000 FT TO 5000 FT

VARIABLE	MEAN	STD DEV
RANGE	7400.71	1486.85
Y	52.08	19.21
XDOT	235.19	1.34
YDOT	-2.55	1.46
HDOT	-12.08	2.82
PSI	-2.38	.86
THETA	-1.07	.79
PHI	.46	1.49
P	.31	1.27
Q	.02	.68
R	-.02	.77
U	235.24	1.22
V	7.75	3.46
W	-7.26	3.18
D	-.10	.06
LOCERR	-.15	.05
DE	.31	1.21
DA	-1.85	2.99
DR	.04	.67
DT1	27.77	.07
DT2	28.87	.09
DT3	29.10	.06
DT4	28.29	.07
CG HEIGHT	-10.49	9.13
U GUST	-1.71	1.91
V GUST	-6.38	2.76
W GUST	-.71	2.59
P GUST	.16	.52
Q GUST	.08	.38
R GUST	-.02	.56

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FOR RUN # 126

COMPUTATION RANGE IS 10000 FT TO 5000 FT

VARIABLE	MEAN	STD DEV
RANGE	7400.40	1486.66
Y	41.66	15.40
XDOT	233.81	2.24
YDOT	1.77	1.71
HDOT	-12.14	4.35
PSI	-1.99	.65
THETA	-.62	.95
PHI	-.16	1.90
P	.07	1.45
Q	-.06	.79
R	.01	.62
U	233.80	2.15
V	10.52	2.98
W	-9.28	3.20
D	-.13	.11
LOCERR	-.13	.06
DE	.28	1.66
DA	-1.35	3.56
DR	.05	.69
DT1	27.99	.07
DT2	28.54	.08
DT3	29.15	.07
DT4	28.35	.07
[illegible]G HEIGHT	-14.41	13.72
U GUST	-1.80	2.93
V GUST	-9.41	1.74
W GUST	-2.50	1.65
P GUST	.22	.34
Q GUST	.02	.27
R GUST	-.03	.51

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FOR RUN # 130

COMPUTATION RANGE IS 10000 FT TO 5000 FT

VARIABLE	MEAN	STD DEV
RANGE	7449.11	1517.07
Y	13.00	25.48
XDOT	233.38	1.03
YDOT	2.57	3.04
HDOT	-12.83	1.85
PSI	-.81	.78
THETA	-1.08	.38
PHI	.11	2.54
P	-.09	1.76
Q	.09	.59
R	-.08	.65
U	233.61	1.09
V	6.58	2.63
W	-7.96	2.21
D	-.21	.08
LOCERR	-.05	.08
DE	-.15	.98
DA	.10	3.35
DR	-.20	.71
DT1	27.98	.07
DT2	28.84	.06
DT3	29.18	.07
DT4	28.58	.07
CG HEIGHT	-23.59	6.34
U GUST	.28	2.12
V GUST	-6.29	2.05
W GUST	-1.79	1.67
P GUST	-.03	.38
Q GUST	.03	.31
R GUST	-.10	.48

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FOR RUN # 131

COMPUTATION RANGE IS 10000 FT TO 5000 FT

VARIABLE	MEAN	STD DEV
RANGE	7500.64	1486.16
Y	35.56	10.59
XDOT	239.16	1.53
YDOT	1.04	2.83
HDOT	-11.72	1.96
PSI	-.89	1.03
THETA	-1.27	.61
PHI	-.57	1.55
P	.06	1.35
Q	-.01	.57
R	.05	.73
U	239.20	1.44
V	5.35	3.62
W	-6.08	2.62
D	-.13	.04
LOCERR	-.11	.04
DE	.49	.76
DA	-.93	2.58
DR	-.07	.71
DT1	28.09	.06
DT2	28.84	.09
DT3	29.15	.07
DT4	28.31	.07
CG HEIGHT	-14.82	7.70
U GUST	-1.24	2.13
V GUST	-4.59	2.06
W GUST	-1.49	2.14
P GUST	.24	.43
Q GUST	-.02	.32
R GUST	.01	.52

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FOR RUN # 132

COMPUTATION RANGE IS 10000 FT TO 5000 FT

VARIABLE	MEAN	STD DEV
RANGE	7399.98	1488.26
Y	1.54	14.16
XDOT	234.46	2.73
YDOT	-1.48	2.68
HDOT	-11.13	2.67
PSI	-1.26	1.18
THETA	-1.25	.91
PHI	.85	1.76
P	.22	1.34
Q	.07	.92
R	.19	.68
U	234.66	2.51
V	4.33	3.84
W	-5.63	2.57
D	-.12	.06
LOCERR	-.00	.04
DE	-.08	1.75
DA	-1.50	3.78
DR	.03	.55
DT1	26.84	.06
DT2	26.81	.07
DT3	27.90	.06
DT4	27.00	.06
CG HEIGHT	-14.83	10.88
U GUST	.92	1.55
V GUST	-2.63	2.63
W GUST	.17	1.76
P GUST	.13	.46
Q GUST	.07	.29
R GUST	.02	.50

Contrails

FOR RUN # 146

COMPUTATION RANGE IS 10000 FT TO 5000 FT

VARIABLE	MEAN	STD DEV
RANGE	7401.16	1486.66
Y	76.44	8.39
XDOT	228.78	1.06
YDOT	-1.39	1.14
HDOT	-10.80	2.84
PSI	-3.19	.51
THETA	.10	,.83
PHI	.33	1.15
P	.08	1.15
Q	-.04	.63
R	.10	.69
U	228.66	1.06
V	11.94	2.41
W	-15.91	2.79
D	-.05	.06
LOCERR	-.23	.01
DE	.21	.98
DA	-1.19	3.37
DR	.08	.53
DT1	28.09	.06
DT2	28.95	.07
DT3	28.62	.07
DT4	28.45	.07
CG HEIGHT	-2.10	6.58
U GUST	-1.01	1.78
V GUST	-10.30	2.32
W GUST	-1.64	1.49
P GUST	.23	.52
Q GUST	.02	.25
R GUST	.01	.63

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Contrails

FOR RUN # 149

COMPUTATION RANGE IS 10000 FT TO 5000 FT

VARIABLE	MEAN	STD DEV
RANGE	7399.12	1486.74
Y	64.28	13.51
XDOT	232.76	2.08
YDOT	-1.11	3.92
HDOT	-9.85	2.73
PSI	-2.69	.79
THETA	-.57	.61
PHI	-.69	1.44
P	.08	1.19
Q	.31	2.14
R	.07	.72
U	232.71	1.88
V	10.40	3.16
W	-7.39	3.22
D	-.00	.11
LOOEPR	-.19	.04
DE	.41	1.41
DA	-1.11	3.46
DR	-.17	.64
DT1	28.12	.08
DT2	28.51	.09
DT3	28.94	.08
DT4	28.67	.09
DG HEIGHT	1.17	14.50
U GUST	1.10	2.29
V GUST	-9.72	2.60
W GUST	-.57	2.25
P GUST	.14	.48
Q GUST	.05	.34
R GUST	.04	.55

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Contrails

FOR RUN 150

COMPUTATION RANGE IS 10000 FT TO 5000 FT

VARIABLE	MEAN	STD DEV
RANGE	7451.10	1514.22
Y	15.92	14.58
XDOT	231.67	1.37
YDOT	-1.91	1.75
HDOT	-11.38	3.28
PSI	-2.03	.83
THETA	-.59	1.00
PHI	.23	1.53
P	-.04	.93
Q	.06	.77
R	.15	.70
U	231.77	1.24
V	6.99	3.63
W	-8.55	3.16
D	-.09	.06
LOCERR	-.05	.04
DE	-.17	1.34
DA	-.60	3.12
DR	-.08	.49
DT1	28.08	.07
DT2	28.21	.07
DT3	28.75	.07
DT4	28.09	.07
CG HEIGHT	-6.94	7.36
U GUST	.76	1.56
V GUST	-5.85	2.36
W GUST	-1.42	2.16
P GUST	.03	.37
Q GUST	.01	.35
R GUST	.04	.49

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Contrails

FOR RUN # 153

COMPUTATION RANGE IS 10000 FT TO 5000 FT

VARIABLE	MEAN	STD DEV
RANGE	7400.99	1486.42
Y	-15.32	15.55
XDOT	235.89	1.55
YDOT	-1.77	2.32
HDOT	-12.72	3.40
PSI	-1.52	.56
THETA	-1.00	.82
PHI	.42	1.53
P	.40	1.24
Q	.15	.71
R	.12	.55
U	236.02	1.54
V	5.12	2.17
W	-8.26	2.36
D	-.14	.04
LOCERR	.05	.05
DE	-.09	1.16
DA	-1.91	3.58
DR	-.20	.64
DT1	27.99	.09
DT2	28.61	.08
DT3	29.08	.09
DT4	28.78	.08
CG HEIGHT	-13.70	7.38
U GUST	-1.67	1.71
V GUST	-3.89	1.88
W GUST	-1.18	2.30
P GUST	.31	.44
Q GUST	.06	.33
R GUST	.02	.49

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Contrails

400/1600 RUNS

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Contrails

FOR RUN # 120

COMPUTATION RANGE IS 10000 FT TO 5000 FT

VARIABLE	MEAN	STD DEV
RANGE	7500.98	1486.69
Y	.97	13.04
XDOT	231.93	2.29
YDOT	-1.42	2.92
HDOT	-11.68	5.23
PSI	-1.68	1.00
THETA	-.60	1.35
PHI	1.16	1.25
P	-.00	1.20
Q	.06	1.05
R	.17	.70
U	232.10	2.07
V	6.04	3.71
W	-8.84	3.15
D	-.01	.13
LOCERR	-.00	.04
DE	-.09	1.82
DA	-1.10	3.71
DR	.12	.64
DT1	27.69	.06
DT2	28.70	.09
DT3	28.95	.06
DT4	28.47	.06
CG HEIGHT	2.06	15.30
U GUST	.05	2.37
V GUST	-3.88	2.79
W GUST	-1.59	1.38
P GUST	.12	.54
Q GUST	-.02	.28
R GUST	-.01	.61

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Contrails

FOR RUN # 122

COMPUTATION RANGE IS 10000 FT TO 5000 FT

VARIABLE	MEAN	STD DEV
RANGE	7450.22	1515.24
Y	-11.07	14.47
XDOT	232.34	1.25
YDOT	.12	4.45
HDOT	-12.19	4.02
PSI	-1.31	.97
THETA	-.71	.99
PHI	.94	1.46
P	.41	1.26
Q	-.00	.72
R	.00	.79
U	232.54	1.19
V	6.24	3.88
W	-8.81	3.21
D	-.06	.07
LOCERR	.03	.04
DE	.16	1.52
DA	-2.09	3.78
DR	.07	.72
DT1	27.86	.07
DT2	28.69	.08
DT3	29.10	.07
DT4	28.42	.06
CG HEIGHT	-5.75	8.55
U GUST	-2.04	1.56
V GUST	-4.68	3.06
W GUST	-1.62	2.04
P GUST	.36	.42
Q GUST	.06	.33
R GUST	-.09	.59

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Contrails

FOR RUN # 124

COMPUTATION RANGE IS 10000 FT TO 5000 FT

VARIABLE	MEAN	STD DEV
RANGE	7450.61	1515.79
Y	34.86	21.84
XDOT	236.60	1.16
YDOT	-2.36	2.66
HDOT	-11.53	2.50
PSI	-1.89	1.13
THETA	-.87	.78
PHI	.07	1.86
P	.30	1.34
Q	-.01	.85
R	.05	.78
U	236.65	1.13
V	6.01	3.30
W	-7.51	2.88
D	-.04	.06
LOCERR	-.10	.06
DE	.44	1.57
DA	-1.85	4.05
DR	.02	.69
DT1	27.92	.06
DT2	28.91	.08
DT3	28.90	.06
DT4	28.57	.06
CG HEIGHT	-3.86	8.95
U GUST	-3.89	1.15
V GUST	-4.78	2.63
W GUST	-.65	1.42
P GUST	.30	.35
Q GUST	.00	.26
R GUST	-.02	.57

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Contrails

FOR RUN # 125

COMPUTATION RANGE IS 10000 FT TO 5000 FT

VARIABLE	MEAN	STD DEV
RANGE	7501.13	1486.65
Y	46.84	7.56
XDOT	235.48	1.57
YDOT	-.49	2.14
HDOT	-12.29	2.73
PSI	-1.31	.97
THETA	-1.62	.83
PHI	-.41	1.07
P	.04	1.02
Q	.02	.55
R	-.21	.48
U	235.64	1.51
V	5.52	2.39
W	-5.33	2.99
D	.02	.07
LOCERR	-.14	.02
DE	.25	.94
DA	-1.13	3.35
DR	-.07	.30
DT1	27.86	.07
DT2	28.62	.08
DT3	28.89	.07
DT4	28.79	.06
CG HEIGHT	5.80	8.63
U GUST	-.32	3.19
V GUST	-4.74	2.15
W GUST	-.09	1.62
P GUST	-.14	.56
Q GUST	.01	.29
R GUST	-.12	.44

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Contrails

FOR RUN # 134

COMPUTATION RANGE IS 10000 FT TO 5000 FT

VARIABLE	MEAN	STD DEV
RANGE	7401.63	1485.94
Y	-12.39	14.74
XDO.	233.60	1.54
YDOT	-1.70	1.95
HDOT	-11.60	2.13
PSI	-1.51	.84
THETA	-.98	.68
PHI	.11	1.66
P	.45	1.18
Q	-.00	.64
R	.15	.76
U	233.71	1.53
V	5.13	3.79
W	-7.14	2.70
D	-.00	.07
LOCERR	.04	.05
DE	.22	1.02
DA	-1.98	3.35
DR	.02	.62
DT1	28.11	.05
DT2	28.72	.10
DT3	28.91	.06
DT4	28.49	.06
CG HEIGHT	.19	7.97
U GUST	-.16	2.26
V GUST	-3.66	2.84
W GUST	-.47	1.90
P GUST	.47	.46
Q GUST	.04	.30
R GUST	.11	.58

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Contrails

FOR RUN # 135

COMPUTATION RANGE IS 10000 FT TO 5000 FT

VARIABLE	MEAN	STD DEV
RANGE	7500.88	1487.68
Y	.40	4.97
XDOT	229.99	1.41
YDOT	.01	1.48
HDOT	-12.20	3.03
PSI	-1.32	.64
THETA	-.59	.79
PHI	.20	1.12
P	.20	.77
Q	.02	.53
R	-.14	.59
U	230.19	1.32
V	6.00	2.68
W	-9.44	2.26
D	-.02	.06
LOCERR	-.00	.01
DE	-.04	1.07
DA	-1.34	2.16
DR	-.13	.41
DT1	28.28	.07
DT2	28.61	.09
DT3	28.97	.07
DT4	28.46	.07
CG HEIGHT	-1.94	7.75
U GUST	-2.03	2.03
V GUST	-5.34	2.39
W GUST	-1.90	1.81
P GUST	.20	.42
Q GUST	-.02	.32
R GUST	-.10	.47

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Contrails

FOR RUN # 141

COMPUTATION RANGE IS 10000 FT TO 5000 FT

VARIABLE	MEAN	STD DEV
RANGE	7451.97	1515.62
Y	15.33	8.85
XDOT	231.17	1.05
YDOT	.40	2.02
HDOT	-11.73	1.82
PSI	-1.67	.42
THETA	-.36	.65
PHI	.14	1.30
P	.10	.95
Q	.08	.48
R	-.14	.68
U	231.23	1.05
V	7.81	2.50
W	-9.97	2.17
D	-.08	.04
LOCERR	-.05	.03
DE	-.34	.97
DA	-.73	3.48
DR	-.16	.39
DT1	27.83	.07
DT2	28.58	.08
DT3	28.94	.07
DT4	28.77	.07
CG HEIGHT	-8.45	3.97
U GUST	-1.19	1.46
V GUST	-7.21	2.51
W GUST	-1.84	2.00
P GUST	.07	.41
Q GUST	-.00	.29
R GUST	-.10	.68

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Contrails

FOR RUN # 142

COMPUTATION RANGE IS 10000 FT TO 5000 FT

VARIABLE	MEAN	STD DEV
RANGE	7451.01	1515.06
Y	28.30	9.91
XDOT	234.27	1.26
YDOT	-.96	1.47
HDOT	-11.98	2.57
PSI	-1.85	.41
THETA	-1.07	.78
PHI	-.01	.88
P	.23	1.03
Q	-.01	.49
R	.09	.45
U	234.39	1.14
V	7.24	2.88
W	-7.28	2.23
D	.06	.06
LOCERR	-.08	.02
DE	.21	.68
DA	-2.01	3.43
DR	.04	.31
DT1	27.75	.07
DT2	28.68	.09
DT3	29.06	.07
DT4	28.82	.06
CG HEIGHT	9.76	7.65
U GUST	-.53	2.28
V GUST	-5.26	2.81
W GUST	-.98	1.96
P GUST	.24	.35
Q GUST	-.03	.29
R GUST	.04	.47

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Contrails

FOR RUN # 143

COMPUTATION RANGE IS 10000 FT TO 5000 FT

VARIABLE	MEAN	STD DEV
RANGE	7450.47	1457.36
Y	13.54	22.98
XDOT	233.44	1.78
YDOT	-1.72	4.40
HDOT	-11.67	5.88
PSI	-1.62	1.86
THETA	-.70	1.69
PHI	-.50	2.57
P	.11	1.37
Q	.18	.99
R	.08	1.03
U	233.57	1.84
V	5.56	6.20
W	-8.40	4.08
D	-.08	.13
LOCERR	-.04	.07
DE	-.23	1.80
DA	-1.56	3.64
DR	-.00	.74
DT1	27.79	.08
DT2	28.53	.07
DT3	28.95	.08
DT4	28.69	.07
CG HEIGHT	-6.18	15.16
U GUST	1.47	1.23
V GUST	-3.95	3.88
W GUST	-1.89	1.59
P GUST	.35	.41
Q GUST	.01	.29
R GUST	.06	.67

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Contrails

FOR RUN # 158

COMPUTATION RANGE IS 10000 FT TO 5000 FT

VARIABLE	MEAN	STD DEV
RANGE	7450.71	1457.54
Y	18.06	16.25
XDOT	235.54	1.34
YDOT	-.33	4.72
HDOT	-11.75	2.76
PSI	-1.72	1.09
THETA	-.85	.87
PHI	.60	2.04
P	.24	1.20
Q	.08	.74
R	-.05	.88
U	235.58	1.42
V	7.38	5.97
W	-7.78	2.66
D	.02	.04
LOCERR	-.05	.05
DE	.44	1.22
DA	-1.42	3.42
DR	-.07	.55
DT1	27.90	.08
DT2	28.95	.08
DT3	28.92	.08
DT4	28.49	.08
CG HEIGHT	6.05	5.42
U GUST	-.57	1.70
V GUST	-6.47	4.49
W GUST	-1.37	1.53
P GUST	.27	.39
Q GUST	.03	.27
R GUST	-.12	.63

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Contrails

100/1200 RUNS

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Contrails

FOR RUN # 127

COMPUTATION RANGE IS 10000 FT TO 5000 FT

VARIABLE	MEAN	STD DEV
RANGE	7500.16	1486.12
Y	45.81	8.26
XDOT	234.04	1.30
YDOT	-.60	3.19
HDOT	-11.48	2.94
PSI	-1.60	.95
THETA	-.79	.73
PHI	-.45	1.91
P	.08	1.29
Q	-.01	.58
R	.04	.79
U	234.16	1.16
V	6.52	4.19
W	-7.83	2.53
D	-.01	.10
LOCERR	-.14	.03
DE	.26	1.11
DA	-1.04	4.00
DR	-.04	.75
DT1	27.96	.06
DT2	28.34	.09
DT3	28.79	.06
DT4	28.38	.06
CG HEIGHT	-.42	10.57
U GUST	-2.90	1.55
V GUST	-5.51	3.14
W GUST	-.70	1.93
P GUST	.18	.42
Q GUST	.04	.29
R GUST	.00	.56

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Contrails

FOR RUN # 128

COMPUTATION RANGE IS 10000 FT TO 5000 FT

VARIABLE	MEAN	STD DEV
RANGE	7451.09	1515.36
Y	25.61	18.60
XDOT	232.23	1.44
YDOT	-2.48	.96
HDOT	-12.71	2.11
PSI	-3.08	.76
THETA	-.62	.62
PHI	.24	.85
P	.33	1.11
Q	.10	.48
R	-.07	.69
U	232.22	1.34
V	10.67	3.58
W	-9.74	2.58
D	.02	.07
LOCERR	-.07	.05
DE	.02	.73
DA	-2.58	3.36
DR	-.03	.47
DT1	27.96	.06
DT2	28.67	.08
DT3	29.16	.58
DT4	28.95	.30
CG HEIGHT	5.39	8.24
U GUST	-1.79	2.99
V GUST	-8.78	3.15
W GUST	-1.96	1.52
P GUST	.35	.42
Q GUST	.00	.29
R GUST	-.02	.57

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Contrails

FOR RUN # 129

COMPUTATION RANGE IS 10000 FT TO 5000 FT

VARIABLE	MEAN	STD DEV
RANGE	7450.30	1457.62
Y	3.44	23.60
XDOT	232.11	1.32
YDOT	2.00	3.79
HDOT	-11.50	1.81
PSI	-.44	1.98
THETA	-.52	.51
PHI	.49	2.23
P	.18	.98
Q	.00	.47
R	.22	.76
U	232.26	1.21
V	4.45	6.08
W	-8.77	2.58
D	.03	.07
LOCERR	-.02	.07
DE	.19	.71
DA	-1.26	3.81
DR	.00	.64
DT1	27.76	.05
DT2	28.90	.09
DT3	28.78	.06
DT4	28.67	.06
CG HEIGHT	4.67	8.33
U GUST	-.44	1.67
V GUST	-2.89	4.22
W GUST	-1.74	2.24
P GUST	.34	.47
Q GUST	-.01	.34
R GUST	.05	.55

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Contrails

FOR RUN # 136

COMPUTATION RANGE IS 10000 FT TO 5000 FT

VARIABLE	MEAN	STD DEV
RANGE	7400.78	1487.76
Y	10.27	4.96
XDOT	232.03	1.31
YDOT	-.02	1.45
HDOT	-12.26	3.60
PSI	-1.55	.78
THETA	-.61	1.01
PHI	.01	1.23
P	.32	1.08
Q	.15	.60
R	.09	.63
U	232.15	1.32
V	6.92	2.89
W	-9.51	3.24
D	-.04	.09
LOCERR	-.03	.01
DE	-.44	1.08
DA	-1.96	4.01
DR	.06	.41
DT1	28.13	.05
DT2	28.70	.10
DT3	28.72	.06
DT4	28.38	.06
CG HEIGHT	-3.00	10.92
U GUST	-3.26	2.44
V GUST	-5.42	2.38
W GUST	-.56	2.10
P GUST	.21	.46
Q GUST	.02	.30
R GUST	.05	.46

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Contrails

FOR RUN # 137

COMPUTATION RANGE IS 10000 FT TO 5000 FT

VARIABLE	MEAN	STD DEV
RANGE	7399.93	1486.61
Y	-5.19	34.68
XDOT	233.61	1.15
YDOT	4.82	3.88
HDOT	-11.98	2.83
PSI	-.20	1.48
THETA	-.91	1.01
PHI	-.74	1.20
P	-.00	.77
Q	.13	.78
R	-.10	.70
U	233.84	1.04
V	6.26	2.91
W	-8.06	4.53
D	-.11	.07
LOCERR	.01	.10
DE	.18	1.41
DA	-.48	2.92
DR	-.23	.39
DT1	27.74	.07
DT2	28.86	.09
DT3	28.78	.07
DT4	28.48	.07
CG HEIGHT	-12.16	9.18
U GUST	-1.24	2.52
V GUST	-6.12	2.11
W GUST	-1.14	2.17
P GUST	.06	.49
Q GUST	-.00	.28
R GUST	-.02	.48

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Contrails

FOR RUN # 147

COMPUTATION RANGE IS 10000 FT TO 5000 FT

VARIABLE	MEAN	STD DEV
RANGE	7400.49	1485.78
Y	21.27	5.27
XDOT	224.70	1.15
YDOT	-.46	1.57
HDOT	-11.53	3.41
PSI	-2.84	.79
THETA	-.03	1.03
PHI	.27	.99
P	.14	.86
Q	-.06	.88
R	.06	.90
U	224.74	1.11
V	11.33	4.34
W	-11.11	4.04
D	-.03	.07
LOCERR	-.06	.01
DE	-.18	1.59
DA	-1.76	3.54
DR	-.04	.81
DT1	27.61	.07
DT2	28.68	.08
DT3	28.90	.07
DT4	28.59	.08
CG HEIGHT	1.05	8.90
U GUST	1.11	1.95
V GUST	-9.70	3.55
W GUST	-2.30	2.14
P GUST	.19	.38
Q GUST	-.00	.38
R GUST	-.02	.61

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Contrails

FOR RUN # 148

COMPUTATION RANGE IS 10000 FT TO 5000 FT

VARIABLE	MEAN	STD DEV
RANGE	7400.03	1487.36
Y	23.15	6.57
XDOT	227.98	1.00
YDOT	-.54	2.66
HDOT	-11.67	3.10
PSI	-1.83	1.31
THETA	.24	.92
PHI	.52	1.59
P	.29	.90
Q	-.01	.66
R	-.17	.84
U	228.04	1.14
V	7.40	3.28
W	-12.26	2.44
D	-.14	.08
LOCERR	-.07	.02
DE	.13	1.66
DA	-.94	3.88
DR	-.17	.56
DT1	29.49	2.20
DT2	29.87	1.96
DT3	30.76	2.96
DT4	29.76	2.28
CG HEIGHT	-13.36	9.80
U GUST	-1.58	2.04
V GUST	-6.94	2.82
W GUST	-3.01	1.67
P GUST	.28	.42
Q GUST	.03	.31
R GUST	-.15	.55

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Contrails

FOR RUN # 151

COMPUTATION RANGE IS 10000 FT TO 5000 FT

VARIABLE	MEAN	STD DEV
RANGE	7400.67	1486.08
Y	11.65	18.94
XDOT	224.95	1.94
YDOT	-2.17	1.96
HDOT	-10.27	3.93
PSI	-2.99	.66
THETA	.10	1.03
PHI	.42	1.39
P	.50	.81
Q	-.05	.87
R	.14	.58
U	225.03	1.75
V	10.21	4.00
W	-10.32	3.04
D	-.06	.07
LOCERR	-.03	.06
DE	-.23	1.88
DA	-2.69	3.01
DR	-.02	.44
DT1	27.75	.08
DT2	28.39	.08
DT3	28.69	.08
DT4	28.59	.08
CG HEIGHT	-3.47	10.87
U GUST	2.73	1.51
V GUST	-8.21	2.83
W GUST	-1.68	1.82
P GUST	.46	.35
Q GUST	.03	.31
R GUST	.06	.46

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Contrails

FOR RUN # 154

COMPUTATION RANGE IS 10000 FT TO 5000 FT

VARIABLE	MEAN	STD DEV
RANGE	7500.43	1486.84
Y	-20.10	39.56
XDOT	230.08	1.48
YDOT	-5.45	1.84
HDOT	-11.21	2.46
PSI	-3.70	1.05
THETA	-.35	.62
PHI	.34	1.05
P	.20	.86
Q	-.03	.62
R	.03	.71
U	230.12	1.59
V	9.95	4.06
W	-9.41	3.06
D	-.03	.07
LOCERR	.07	.12
DE	.25	1.28
DA	-1.94	2.88
DR	.08	.52
DT1	27.90	.08
DT2	28.73	.08
DT3	28.92	.08
DT4	28.36	.08
OG HEIGHT	-1.13	8.04
U GUST	-.12	.00
V GUST	-10.86	.00
W GUST	-3.54	.00
P GUST	-.42	.00
Q GUST	-.15	.00
R GUST	-.57	.00

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Contrails

FOR RUN # 157

COMPUTATION RANGE IS 10000 FT TO 5000 FT

VARIABLE	MEAN	STD DEV
RANGE	7451.75	1514.70
Y	28.30	9.72
XDOT	232.86	1.54
YDOT	-1.61	1.61
HDOT	-12.54	3.06
PSI	-2.17	1.05
THETA	-.43	.85
PHI	-.02	1.22
P	.23	1.12
Q	.03	.61
R	-.04	.69
U	232.93	1.43
V	7.82	3.22
W	-10.48	3.51
D	-.06	.06
LOCERR	-.08	.02
DE	.07	1.14
DA	-1.95	3.74
DR	-.14	.59
DT1	27.59	.07
DT2	28.51	.08
DT3	28.85	.06
DT4	28.66	.07
CG HEIGHT	-4.95	8.76
U GUST	-3.72	1.48
V GUST	-6.54	2.29
W GUST	-2.14	2.63
P GUST	.13	.61
Q GUST	-.02	.37
R GUST	-.00	.49

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Contrails

APPENDIX 4

STATIONARY STATISTICS

FOR 5000 TO 1500 FEET DATA BLOCKS, PER RUN

CAVU RUNS

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Contrails

FOR RUN # 121

COMPUTATION RANGE IS 5000 FT TO 1500 FT

VARIABLE	MEAN	STD DEV
RANGE	3100.86	1024.39
Y	37.64	11.75
XDOT	236.81	.70
YDOT	-2.84	1.34
HDOT	-13.64	1.91
PSI	-2.26	.78
THETA	-1.46	.59
PHI	-.02	1.86
P	.44	1.37
Q	.12	.38
R	-.27	.48
U	236.92	.53
V	7.09	3.98
W	-7.25	2.04
D	-.22	.15
LOCERR	-.15	.04
DE	-.11	.45
DA	-1.21	3.72
DR	-.08	.37
DT1	27.86	.07
DT2	29.00	.10
DT3	28.90	.07
DT4	28.21	.07
CG HEIGHT	-7.17	5.86
U GUST	-1.38	1.98
V GUST	-6.80	3.48
W GUST	-1.34	2.11
P GUST	.14	.42
Q GUST	-.01	.32
R GUST	-.14	.44

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Contrails

FOR RUN # 123

COMPUTATION RANGE IS 5000 FT TO 1500 FT

VARIABLE	MEAN	STD DEV
RANGE	3050.88	995.85
Y	22.96	7.90
XDOT	232.31	1.72
YDOT	-1.33	2.03
HDOT	-11.29	1.81
PSI	-1.65	.84
THETA	-.44	.84
PHI	-.12	2.96
P	.61	2.50
Q	-.04	.41
R	.12	.96
U	232.41	1.67
V	6.05	4.97
W	-9.16	2.96
D	-.19	.08
LOCERR	-.09	.03
DE	.35	.61
DA	-2.44	3.89
DR	-.15	1.29
DT1	26.91	2.34
DT2	27.77	2.77
DT3	28.28	2.32
DT4	27.34	2.61
CG HEIGHT	-8.89	6.21
U GUST	-1.63	1.86
V GUST	-5.05	1.84
W GUST	-1.75	2.04
P GUST	.55	.42
Q GUST	.06	.34
R GUST	-.01	.48

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Contrails

FOR RUN # 126

COMPUTATION RANGE IS 5000 FT TO 1500 FT

VARIABLE	MEAN	STD DEV
RANGE	3048.47	996.15
Y	34.56	15.51
XDOT	231.90	.93
YDOT	-3.76	.75
HDOT	-13.22	3.10
PSI	-2.88	.20
THETA	-1.37	1.02
PHI	-.01	.63
P	.37	.94
Q	.02	.78
R	.05	.42
U	232.04	.94
V	8.41	.76
W	-7.34	3.29
D	-.17	.17
LOCERR	-.13	.05
DE	.01	1.66
DA	-2.09	2.90
DR	-.17	.54
DT1	26.94	1.43
DT2	27.35	1.60
DT3	28.43	.98
DT4	27.32	1.41
CG HEIGHT	-5.51	5.00
U GUST	-1.58	1.54
V GUST	-6.79	1.30
W GUST	-.33	1.62
P GUST	.16	.46
Q GUST	.00	.26
R GUST	.02	.40

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Contrails

FOR RUN # 130

COMPUTATION RANGE IS 5000 FT TO 1500 FT

VARIABLE	MEAN	STD DEV
RANGE	3099.74	965.92
Y	12.51	19.99
XDOT	230.40	.47
YDOT	-4.26	1.64
HDOT	-11.40	2.03
PSI	-1.66	1.42
THETA	-.67	.34
PHI	.78	2.47
P	.52	2.04
Q	.01	.37
R	.34	.58
U	230.58	.38
V	2.99	5.64
W	-8.36	2.34
D	-.42	.12
LOCERR	-.04	.08
DE	-.25	.70
DA	-1.99	6.03
DR	-.09	1.07
DT1	27.98	.07
DT2	28.86	.08
DT3	29.17	.07
DT4	28.58	.07
CG HEIGHT	-19.01	3.04
U GUST	.83	1.33
V GUST	-.78	3.41
W GUST	-1.11	1.72
P GUST	.36	.35
Q GUST	.03	.30
R GUST	.10	.41

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Contrails

FOR RUN # 131

COMPUTATION RANGE IS 5000 FT TO 1500 FT

VARIABLE	MEAN	STD DEV
RANGE	3098.85	1026.32
Y	2.46	13.81
XDOT	233.49	1.63
YDOT	-2.55	2.55
HDOT	-11.77	1.96
PSI	-2.36	.95
THETA	-1.19	.58
PHI	.72	2.62
P	.56	2.37
Q	-.08	.54
R	.13	.85
U	233.59	1.62
V	7.77	4.58
W	-6.34	3.04
D	-.10	.07
LOCERR	-.01	.05
DE	.39	.74
DA	-2.04	4.35
DR	.07	1.04
DT1	28.05	.05
DT2	28.82	.08
DT3	29.10	.06
DT4	28.26	.06
CG HEIGHT	-4.14	4.89
U GUST	3.72	2.11
V GUST	-6.03	2.77
W GUST	-2.03	2.05
P GUST	.22	.45
Q GUST	-.03	.37
R GUST	.05	.57

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Contrails

FOR RUN # 132

COMPUTATION RANGE IS 5000 FT TO 1500 FT

VARIABLE	MEAN	STD DEV
RANGE	3050.17	997.76
Y	17.77	9.25
XDOT	231.40	.63
YDOT	-.01	4.27
HDOT	-11.73	1.20
PSI	-1.19	1.28
THETA	-.97	.51
PHI	-.84	2.57
P	-.08	2.10
Q	-.02	.40
R	-.10	.62
U	231.57	.61
V	5.29	2.25
W	-7.45	1.75
D	-.14	.05
LOCERR	-.07	.04
DE	.06	.73
DA	-.11	5.40
DR	-.17	.68
DT1	26.86	.06
DT2	26.81	.09
DT3	27.90	.06
DT4	27.00	.06
CG HEIGHT	-4.87	2.28
U GUST	-.33	1.14
V GUST	-4.52	2.00
W GUST	-.13	1.83
P GUST	.06	.36
Q GUST	-.02	.30
R GUST	.01	.54

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Contrails

FOR RUN # 146

COMPUTATION RANGE IS 5000 FT TO 1500 FT

VARIABLE	MEAN	STD DEV
RANGE	3050.51	995.33
Y	53.72	9.11
XDOT	226.96	.92
YDOT	-1.99	1.94
HDOT	-12.42	2.30
PSI	-2.65	1.24
THETA	-.85	.64
PHI	-.51	2.43
P	.18	1.96
Q	.02	.73
R	-.10	1.21
U	227.11	.89
V	9.04	6.04
W	-8.68	2.98
D	.12	.07
LOCERR	-.21	.03
DE	.39	1.31
DA	-.24	3.30
DR	-.36	1.28
DT1	28.12	.07
DT2	28.95	.09
DT3	28.66	.08
DT4	28.49	.08
CG HEIGHT	10.57	5.57
U GUST	3.17	3.08
V GUST	-9.41	3.34
W GUST	-1.59	2.07
P GUST	.16	.41
Q GUST	.04	.33
R GUST	-.03	.60

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Contrails

FOR RUN # 149

COMPUTATION RANGE IS 5000 FT TO 1500 FT

VARIABLE	MEAN	STD DEV
RANGE	3049.78	995.36
Y	4.39	9.20
XDOT	230.10	1.21
YDOT	-.68	4.33
HDOT	-12.63	4.01
PSI	-2.25	1.54
THETA	-.82	1.37
PHI	1.47	2.55
P	-.20	2.60
Q	-.03	1.04
R	.45	.54
U	230.22	1.02
V	9.12	3.37
W	-8.68	4.14
D	.32	.18
LOCERR	-.02	.03
DE	.45	2.17
DA	-.25	6.11
DR	.08	.96
DT1	28.12	.08
DT2	28.51	.08
DT3	28.94	.08
DT4	28.66	.09
CG HEIGHT	19.60	7.59
U GUST	-.59	1.34
V GUST	-6.89	1.71
W GUST	-.97	1.99
P GUST	.21	.39
Q GUST	.03	.32
R GUST	.08	.40

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Contrails

FOR RUN # 150

COMPUTATION RANGE IS 5000 FT TO 1500 FT

VARIABLE	MEAN	STD DEV
RANGE	3050.29	995.27
Y	9.53	10.49
XDOT	229.07	.80
YDOT	1.37	2.56
HDOT	-12.57	2.38
PSI	-1.74	.82
THETA	-.84	.57
PHI	-.32	1.86
P	.26	1.01
Q	-.04	.62
R	-.28	.53
U	229.23	.75
V	8.95	2.04
W	-8.88	2.73
D	-.12	.11
LOCERR	-.04	.04
DE	-.35	1.33
DA	-.57	2.37
DR	-.45	.48
DT1	28.12	.08
DT2	28.26	.07
DT3	28.78	.08
DT4	28.14	.08
CG HEIGHT	-.69	5.11
U GUST	.10	2.54
V GUST	-9.52	1.46
W GUST	-1.98	1.56
P GUST	.44	.45
Q GUST	.03	.28
R GUST	-.19	.43

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Contrails

FOR RUN # 153

COMPUTATION RANGE IS 5000 FT TO 1500 FT

VARIABLE	MEAN	STD DEV
RANGE	3100.23	967.22
Y	-.32	10.91
XDOT	235.00	1.25
YDOT	2.35	1.18
HDOT	-12.68	3.04
PSI	-1.21	.45
THETA	-1.61	.72
PHI	-.41	.81
P	.40	.83
Q	-.10	.55
R	-.18	.51
U	235.07	1.32
V	8.04	1.59
W	-5.85	1.63
D	-.06	.18
LOCERR	.00	.04
DE	.52	1.04
DA	-1.86	2.60
DR	-.28	.51
DT1	27.99	.08
DT2	28.61	.09
DT3	29.08	.08
DT4	28.79	.08
CG HEIGHT	2.85	7.02
U GUST	-1.07	1.29
V GUST	-7.78	1.99
W GUST	-.63	1.29
P GUST	.37	.58
Q GUST	-.01	.24
R GUST	-.13	.53

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Contrails

400/1600 RUNS

Contrails

FOR RUN # 120

COMPUTATION RANGE IS 5000 FT TO 1500 FT

VARIABLE	MEAN	STD DEV
RANGE	3150.30	996.17
Y	30.05	10.76
XDOT	228.45	1.11
YDOT	2.06	3.39
HDOT	-12.05	4.41
PSI	-1.34	1.04
THETA	-.74	1.26
PHI	-1.59	2.69
P	-.27	1.84
Q	.01	1.33
R	-.02	.80
U	228.67	1.04
V	7.98	2.59
W	-9.03	4.74
D	.06	.18
LOCERR	-.12	.05
DE	.08	2.32
DA	-1.02	5.56
DR	.35	1.08
DT1	27.67	.05
DT2	28.70	.09
DT3	28.94	.05
DT4	28.46	.05
CG HEIGHT	7.33	9.98
U GUST	2.73	1.14
V GUST	-5.91	2.97
W GUST	-1.82	2.46
P GUST	-.02	.32
Q GUST	.08	.33
R GUST	.09	.69

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Contrails

FOR RUN # 122

COMPUTATION RANGE IS 5000 FT TO 1500 FT

VARIABLE	MEAN	STD DEV
RANGE	3051.19	996.59
Y	30.36	12.93
XDOT	230.00	3.81
YDOT	1.96	3.69
HDOT	-8.29	7.05
PSI	-.93	.78
THETA	.51	1.57
PHI	-1.07	3.99
P	.15	2.49
Q	-.05	1.28
R	-.21	.87
U	230.12	3.69
V	6.37	5.24
W	-10.00	4.52
D	.01	.51
LOCERR	-.12	.06
DE	-.04	2.50
DA	-1.57	6.29
DR	-.03	1.34
DT1	27.89	.07
DT2	28.70	.08
DT3	29.11	.08
DT4	28.44	.06
CG HEIGHT	-1.06	29.22
U GUST	-.71	2.23
V GUST	-5.99	2.71
W GUST	-.70	1.86
P GUST	.20	.44
Q GUST	.06	.27
R GUST	-.09	.52

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Contrails

FOR RUN # 124

COMPUTATION RANGE IS 5000 FT TO 1500 FT

VARIABLE	MEAN	STD DEV
RANGE	3100.36	967.16
Y	27.82	12.17
XDOT	236.37	.43
YDOT	2.05	2.40
HDOT	-12.84	1.28
PSI	-1.46	.83
THETA	-.82	.59
PHI	-.06	2.50
P	.13	1.53
Q	-.04	.77
R	-.17	.76
U	236.34	.39
V	8.76	4.29
W	-9.03	2.58
D	-.21	.14
LOCERR	-.11	.06
DE	.26	1.66
DA	-.65	3.72
DR	-.15	.91
DT1	27.92	.06
DT2	28.93	.08
DT3	28.89	.06
DT4	28.57	.05
CG HEIGHT	-7.32	2.79
U GUST	-5.06	1.26
V GUST	-8.50	1.82
W GUST	-2.02	2.33
P GUST	-.03	.47
Q GUST	.05	.35
R GUST	-.04	.52

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Contrails

FOR RUN # 125

COMPUTATION RANGE IS 5000 FT TO 1500 FT

VARIABLE	MEAN	STD DEV
RANGE	3151.27	996.32
Y	15.70	13.05
XDOT	236.92	.68
YDOT	-2.17	2.43
HDOT	-11.83	1.91
PSI	-2.27	.26
THETA	-1.17	.61
PHI	.85	2.42
P	.46	.98
Q	-.03	.47
R	.10	.56
U	236.92	.57
V	7.78	3.39
W	-6.51	2.67
D	.05	.08
LOCERR	-.06	.05
DE	.32	.61
DA	-2.22	3.35
DR	.11	.38
DT1	27.85	.10
DT2	28.59	.20
DT3	28.89	.07
DT4	28.76	.14
CG HEIGHT	3.64	4.48
U GUST	-1.85	2.28
V GUST	-5.46	3.00
W GUST	-.86	1.97
P GUST	.33	.54
Q GUST	.02	.35
R GUST	.01	.50

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Contrails

FOR RUN # 134

COMPUTATION RANGE IS 5000 FT TO 1500 FT

VARIABLE	MEAN	STD DEV
RANGE	3050.91	996.52
Y	-27.48	13._3
XDOT	234.51	1.67
YDOT	2.31	3.01
HDOT	-12.75	2.83
PSI	-.03	.50
THETA	-1.54	.74
PHI	.28	2.11
P	.06	1.32
Q	-.00	.72
R	-.04	.57
U	234.73	1.55
V	3.07	3.65
W	-6.00	3.13
D	.02	.13
LOCERR	.11	.05
DE	.25	1.18
DA	-.45	3.37
DR	-.10	.55
DT1	28.13	.06
DT2	28.75	.09
DT3	28.92	.06
DT4	28.49	.07
CG HEIGHT	4.75	7.12
U GUST	-1.20	1.98
V GUST	-3.27	2.51
W GUST	.06	1.31
P GUST	.20	.27
Q GUST	.01	.31
R GUST	-.15	.36

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Contrails

FOR RUN # 135

COMPUTATION RANGE IS 5000 FT TO 1500 FT

VARIABLE	MEAN	STD DEV.
RANGE	3150.30	994.86
Y	11.79	11.26
XDOT	229.24	1.75
YDOT	1.77	2.45
HDOT	-8.75	3.27
PSI	-1.54	.92
THETA	.32	.87
PHI	-.46	2.78
P	.09	1.95
Q	.09	.82
R	.30	.63
U	229.27	1.53
V	8.54	5.30
W	-9.70	3.06
D	.15	.33
LOCERR	-.05	.05
DE	-.30	1.64
DA	-1.01	4.83
DR	-.04	.85
DT1	28.31	.06
DT2	28.64	.08
DT3	29.00	.05
DT4	28.49	.06
CG HEIGHT	6.29	16.56
U GUST	-.74	1.64
V GUST	-7.43	3.09
W GUST	-.33	1.35
P GUST	.24	.38
Q GUST	.03	.29
R GUST	.10	.49

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Contrails

FOR RUN # 141

COMPUTATION RANGE IS 5000 FT TO 1500 FT

VARIABLE	MEAN	STD DEV
RANGE	3100.73	968.18
Y	-6.15	13.20
XDOT	228.08	1.40
YDOT	-2.03	2.78
HDOT	-13.92	2.82
PSI	-2.09	.63
THETA	-.80	.90
PHI	.86	1.83
P	.14	1.51
Q	-.10	1.04
R	.22	.83
U	228.31	1.27
V	6.95	3.96
W	-10.29	3.82
D	-.13	.29
LOCERR	.03	.05
DE	-.25	2.08
DA	-2.18	3.48
DR	.22	.71
DT1	27.77	.06
DT2	28.53	.07
DT3	28.89	.06
DT4	28.72	.06
CG HEIGHT	-1.30	11.56
U GUST	-1.75	1.99
V GUST	-4.15	2.44
W GUST	-2.12	2.02
P GUST	.24	.45
Q GUST	.06	.33
R GUST	.02	.58

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Contrails

FOR RUN # 142

COMPUTATION RANGE IS 5000 FT TO 1500 FT

VARIABLE	MEAN	STD DEV
RANGE	3100.28	967.30
Y	9.91	3.33
XDOT	235.67	.73
YDOT	-.82	1.64
HDOT	-13.58	2.02
PSI	-1.14	.36
THETA	-1.78	.57
PHI	.16	1.32
P	.35	.83
Q	-.11	.82
R	.13	.53
U	235.92	.76
V	4.61	.98
W	-5.88	2.29
D	-.06	.16
LOCERR	-.04	.01
DE	.44	1.55
DA	-2.21	2.88
DR	-.04	.29
DT1	27.70	.07
DT2	28.63	.07
DT3	29.00	.08
DT4	28.76	.07
CG HEIGHT	.72	4.93
U GUST	-1.25	1.98
V GUST	-2.45	2.23
W GUST	-1.15	2.00
P GUST	.32	.42
Q GUST	-.02	.35
R GUST	.07	.60

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Contrails

FOR RUN # 143

COMPUTATION RANGE IS 5000 FT TO 1500 FT

VARIABLE	MEAN	STD DEV
RANGE	3100.49	1024.49
Y	-31.90	17.45
XDOT	229.18	3.83
YDOT	1.81	7.38
HDOT	-13.50	7.34
PSI	-.84	1.42
THETA	-1.26	1.63
PHI	.98	4.36
P	.16	2.14
Q	-.10	1.05
R	.01	.98
U	229.66	3.67
V	5.99	5.33
W	-7.86	4.58
D	.24	.37
LOCERR	.12	.07
DE	-.04	2.18
DA	-.76	5.61
DR	-.25	1.01
DT1	27.77	.07
DT2	28.49	.07
DT3	28.94	.06
DT4	28.67	.07
CG HEIGHT	20.74	22.49
U GUST	-1.51	1.05
V GUST	-5.84	3.59
W GUST	-.20	2.14
P GUST	.23	.33
Q GUST	-.02	.36
R GUST	-.15	.64

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FOR RUN # 158

COMPUTATION RANGE IS 5000 FT TO 1500 FT

VARIABLE	MEAN	STD DEV
RANGE	3099.13	1024.17
Y	55.37	12.02
XDOT	233.31	.75
YDOT	-1.23	6.02
HDOT	-13.30	2.45
PSI	-1.40	.57
THETA	-1.30	.75
PHI	-2.08	1.91
P	.17	1.69
Q	-.04	.71
R	.00	.79
U	233.55	.86
V	5.02	6.23
W	-7.77	3.03
D	.17	.09
LOCERR	-.22	.05
DE	.71	1.51
DA	-1.07	3.59
DR	-.27	.68
DT1	27.87	.08
DT2	28.93	.09
DT3	28.88	.09
DT4	28.46	.08
CG HEIGHT	14.79	7.16
U GUST	-2.29	1.13
V GUST	-4.90	5.19
W GUST	-1.4	

FA1SBGB //// END OF LIST //

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100/1200 RUNS

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Contrails

FOR RUN # 127

COMPUTATION RANGE IS 5000 FT TO 1500 FT

VARIABLE	MEAN	STD DEV
RANGE	3099.77	1024.63
Y	-19.73	24.08
XDOT	233.78	.44
YDOT	-5.01	2.66
HDOT	-13.86	2.51
PSI	-2.33	1.16
THETA	-1.11	.59
PHI	1.57	1.42
P	.79	1.76
Q	.11	.58
R	.07	.72
U	234.11	.48
V	5.32	3.11
W	-8.85	3.09
D	-.17	.18
LOCERR	.08	.10
DE	-.03	.94
DA	-3.66	5.31
DR	.10	.55
DT1	27.95	.07
DT2	28.33	.08
DT3	28.78	.07
DT4	28.38	.07
CG HEIGHT	-4.21	8.64
U GUST	-1.08	1.46
V GUST	-3.09	2.63
W GUST	-1.54	2.14
P GUST	.19	.37
Q GUST	.00	.35
R GUST	-.04	.48

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FOR RUN # 128

COMPUTATION RANGE IS 5000 FT TO 1500 FT

VARIABLE	MEAN	STD DEV
RANGE	3100.81	966.26
Y	-3.85	2.63
XDOT	231.97	1.45
YDOT	.25	.82
HDOT	-10.49	2.85
PSI	-2.22	.62
THETA	-.27	.80
PHI	.47	.67
P	.04	.56
Q	-.08	.81
R	.14	.70
U	231.92	1.38
V	9.93	2.47
W	-9.05	3.14
D	.04	.25
LOCERR	.01	.01
DE	.41	1.49
DA	-1.92	2.95
DR	.08	.54
DT1	27.93	.07
DT2	28.65	.08
DT3	30.08	.07
DT4	29.41	.07
CG HEIGHT	.20	11.33
U GUST	-2.23	1.73
V GUST	-7.33	2.48
W GUST	-2.15	2.20
P GUST	.08	.35
Q GUST	.02	.36
R GUST	-.04	.51

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FOR RUN # 129

COMPUTATION RANGE IS 5000 FT TO 1500 FT

VARIABLE	MEAN	STD DEV
RANGE	3149.91	995.82
Y	3.13	18.46
XDOT	230.01	.74
YDOT	-4.10	.70
HDOT	-12.21	3.31
PSI	-2.19	.86
THETA	-.49	.91
PHI	-.16	.87
P	.18	1.05
Q	.10	.57
R	-.30	.67
U	230.17	.72
V	5.22	3.17
W	-10.01	3.37
D	-.16	.14
LOCERR	-.01	.07
DE	-.14	1.00
DA	-1.61	3.49
DR	.02	.48
DT1	27.75	.07
DT2	28.92	.07
DT3	28.77	.07
DT4	28.64	.07
CG HEIGHT	-6.07	7.43
U GUST	.08	2.14
V GUST	-4.31	3.23
W GUST	-2.21	2.19
P GUST	.05	.50
Q GUST	.06	.38
R GUST	-.21	.58

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FOR RUN # 136

COMPUTATION RANGE IS 5000 FT TO 1500 FT

VARIABLE	MEAN	STD DEV
RANGE	3100.26	966.31
Y	24.48	6.56
XDOT	230.63	.91
YDOT	.79	1.87
HDOT	-11.50	2.52
PSI	-1.04	1.04
THETA	-.45	.75
PHI	-.75	1.70
P	-.10	1.36
Q	-.05	.77
R	-.07	.97
U	230.82	.87
V	5.44	5.59
W	-9.33	2.85
D	.01	.07
LOCERR	-.10	.03
DE	.43	1.47
DA	.38	4.21
DR	-.14	.84
DT1	28.14	.06
DT2	28.72	.09
DT3	28.76	.07
DT4	28.40	.07
CG HEIGHT	2.63	4.45
U GUST	-1.89	1.33
V GUST	-5.47	3.89
W GUST	-2.03	1.62
P GUST	.24	.57
Q GUST	.05	.29
R GUST	-.04	.60

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FOR RUN # 137

COMPUTATION RANGE IS 5000 FT TO 1500 FT

VARIABLE	MEAN	STD DEV
RANGE	3779.22	1120.16
Y	22.81	6.37
XDOT	216.33	59.85
YDOT	-.27	1.02
HDOT	-6.24	2.45
PSI	-2.46	.82
THETA	-.04	.89
PHI	-.30	1.37
P	.13	.99
Q	-.27	.44
R	.18	.70
U	216.21	59.82
V	10.37	4.18
W	-5.83	4.11
D	.03	.15
LOCERR	-.08	.02
DE	.91	.85
DA	-1.25	4.01
DR	.20	.50
DT1	25.87	7.16
DT2	26.93	7.45
DT3	26.83	7.42
DT4	26.55	7.34
CG HEIGHT	2.80	10.60
U GUST	-.54	1.22
V GUST	-8.45	3.08
W GUST	.45	1.99
P GUST	.42	.54
Q GUST	.02	.36
R GUST	.02	.56

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FOR RUN # 147

COMPUTATION RANGE IS 5000 FT TO 1500 FT

VARIABLE	MEAN	STD DEV
RANGE	3100.82	967.56
Y	16.09	6.41
XDOT	223.44	.87
YDOT	-1.05	1.04
HDOT	-10.28	3.99
PSI	-2.73	.44
THETA	.17	.86
PHI	.30	1.06
P	.27	.99
Q	.14	.73
R	.02	.48
U	223.49	.75
V	10.16	2.34
W	-10.58	3.64
D	-.09	.21
LOCERR	-.06	.02
DE	-.74	1.31
DA	-1.61	3.28
DR	-.11	.37
DT1	27.59	.08
DT2	28.66	.09
DT3	28.88	.07
DT4	28.58	.08
CG HEIGHT	-2.16	7.68
U GUST	2.19	1.80
V GUST	-8.75	1.42
W GUST	-.14	2.65
P GUST	.19	.38
Q GUST	.08	.31
R GUST	.01	.37

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FOR RUN # 148

COMPUTATION RANGE IS 5000 FT TO 1500 FT

VARIABLE	MEAN	STD DEV
RANGE	3050.36	996.13
Y	17.80	5.17
XDOT	233.63	3.65
YDOT	-.90	1.08
HDOT	-12.44	4.40
PSI	-2.94	.87
THETA	-.66	1.08
PHI	.31	1.28
P	.12	1.18
Q	.08	1.23
R	.04	.88
U	233.39	3.68
V	11.77	4.53
W	-9.38	3.87
D	.01	.22
LOCERR	-.07	.02
DE	.76	2.63
DA	-1.73	4.55
DR	.01	.67
DT1	32.88	.07
DT2	32.69	.08
DT3	35.31	.07
DT4	33.28	.07
CG HEIGHT	7.01	9.55
U GUST	-1.21	1.60
V GUST	-9.70	2.93
W GUST	-1.52	2.80
P GUST	.32	.46
Q GUST	.03	.34
R GUST	.01	.57

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FOR RUN # 151

COMPUTATION RANGE IS 5000 FT TO 1500 FT

VARIABLE.	MEAN	STD DEV
RANGE	3100.38	967.45
Y	1.19	10.38
XDOT	226.57	1.81
YDOT	2.47	.43
HDOT	-12.48	1.64
PSI	-1.40	.59
THETA	-.81	.60
PHI	-.05	1.09
P	-.06	.97
Q	-.12	.73
R	.10	.66
U	226.73	1.79
V	8.79	2.63
W	-8.97	3.09
D	-.07	.13
LOCERR	-.01	.04
DE	-.43	1.31
DA	-.74	3.55
DR	-.12	.52
DT1	27.74	.08
DT2	28.38	.08
DT3	28.69	.09
DT4	28.58	.08
CG HEIGHT	2.14	4.45
U GUST	-1.14	2.09
V GUST	-7.69	1.95
W GUST	.12	2.06
P GUST	.24	.43
Q GUST	-.00	.24
R GUST	-.00	.45

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FOR RUN # 154

COMPUTATION RANGE IS 5000 FT TO 1500 FT

VARIABLE	MEAN	STD DEV
RANGE	3100.22	1024.80
Y	-38.81	27.22
XDOT	230.21	.55
YDOT	6.04	2.59
HDOT	-14.40	1.51
PSI	-.91	.75
THETA	-.70	.88
PHI	1.19	1.72
P	.20	1.96
Q	.33	.85
R	.01	.60
U	230.34	.45
V	10.63	2.43
W	-11.13	3.24
D	-.22	.25
LOCERR	.15	.10
DE	-.67	2.07
DA	-.81	6.11
DR	-.16	.53
DT1	27.88	.09
DT2	28.69	.08
DT3	28.91	.09
DT4	28.35	.09
CG HEIGHT	-4.12	8.98
U GUST	-.12	.00
V GUST	-10.86	.00
W GUST	-3.54	.00
P GUST	-.42	.00
Q GUST	-.15	.00
R GUST	-.57	.00

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Contrails

FOR RUN # 157

COMPUTATION RANGE IS 5000 FT TO 1500 FT

VARIABLE	MEAN	STD DEV
RANGE	3049.34	993.19
Y	14.36	6.03
XDOT	230.36	.83
YDOT	.57	1.72
HDOT	-8.93	2.53
PSI	-1.83	.98
THETA	-.08	.61
PHI	.10	1.62
P	.03	1.02
Q	.16	.80
R	.10	.65
U	230.33	.72
V	8.57	4.06
W	-8.21	3.92
D	.10	.35
LOCERR	-.06	.03
DE	-.03	1.67
DA	-1.30	3.60
DR	-.06	.48
DT1	27.64	.09
DT2	28.55	.08
DT3	28.88	.08
DT4	28.71	.08
CG HEIGHT	4.52	16.36
U GUST	-1.05	1.21
V GUST	-7.25	2.39
W GUST	.66	2.21
P GUST	.20	.53
Q GUST	.07	.26
R GUST	-.05	.43

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Contrails

APPENDIX 5

PLOTS OF ENSEMBLE STATISTICS

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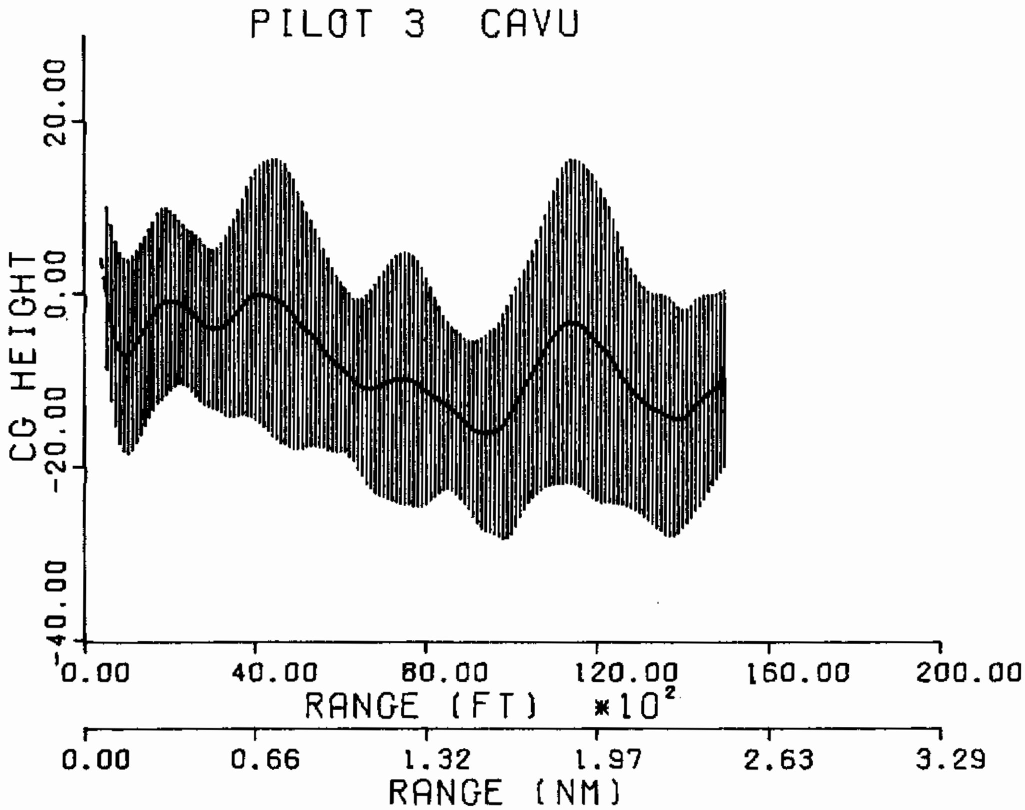

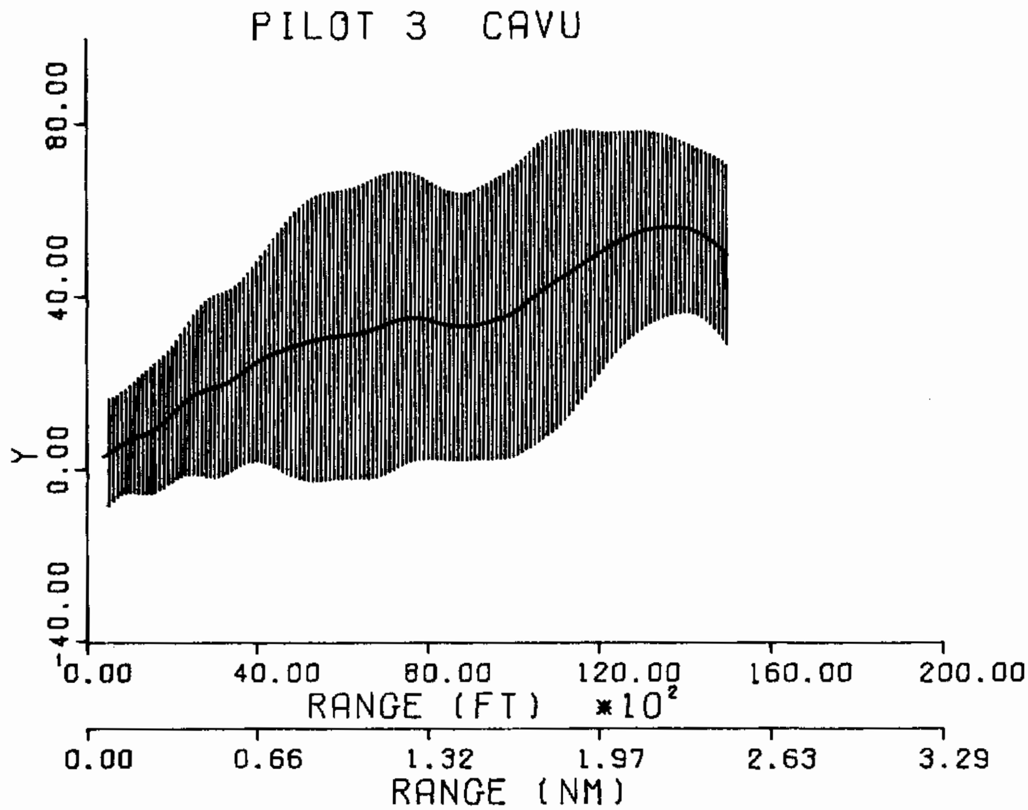

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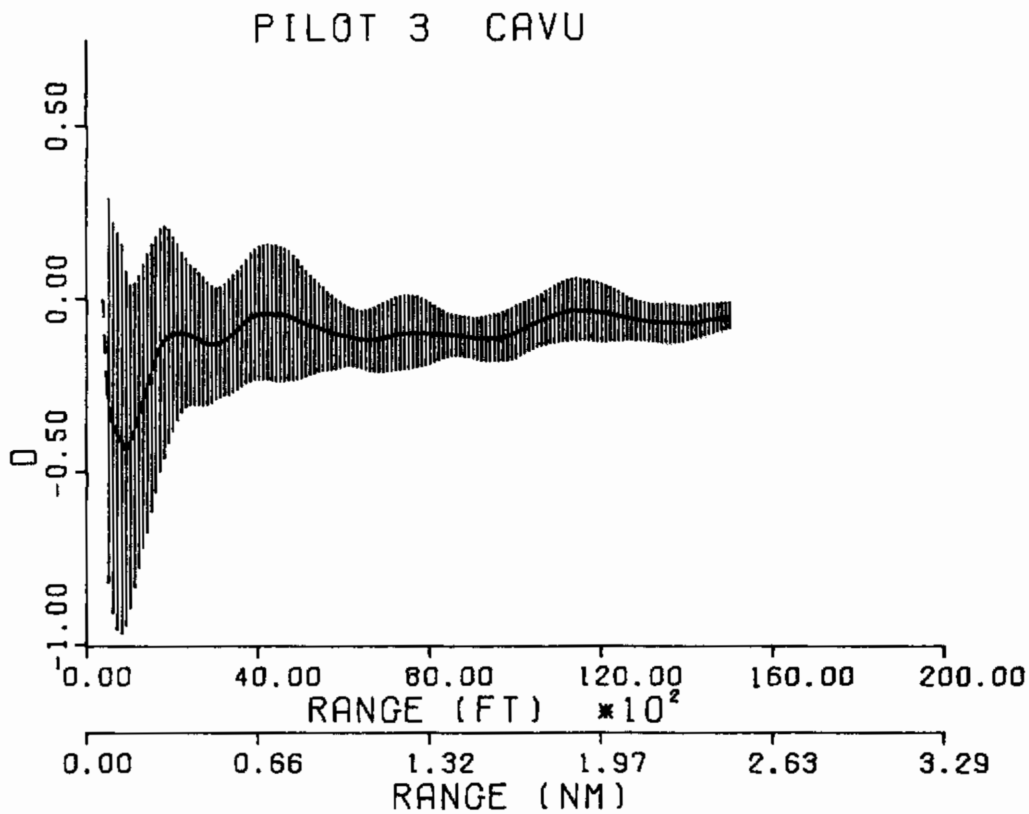

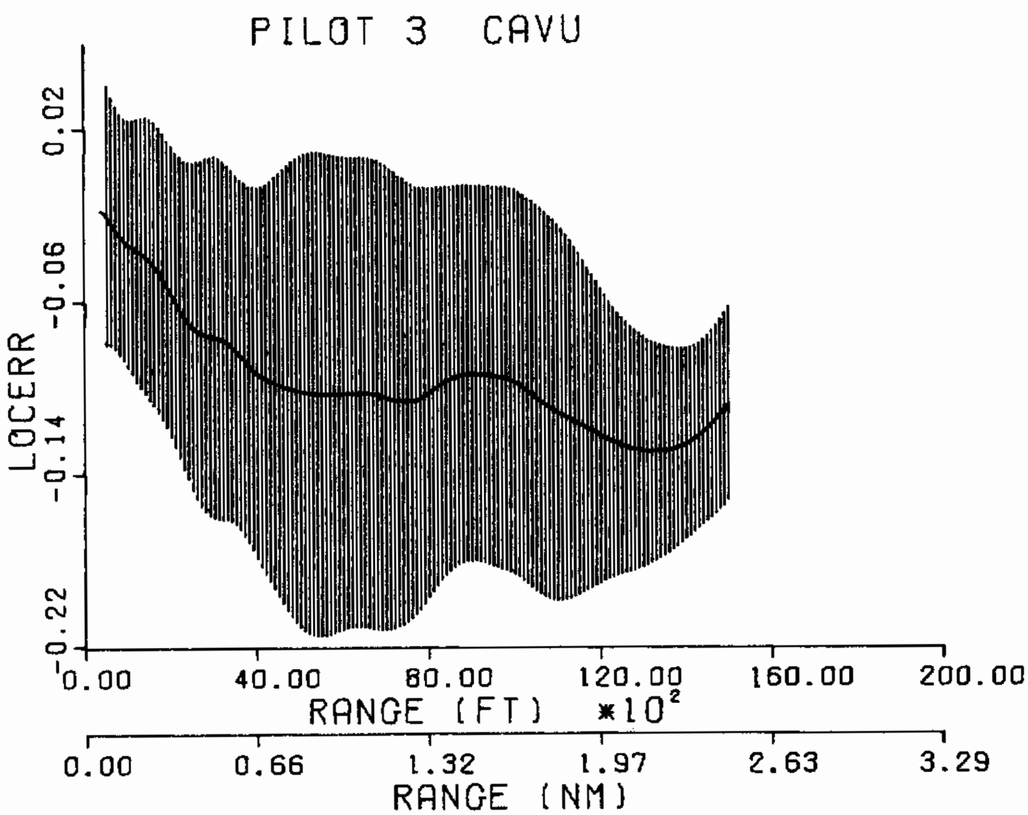

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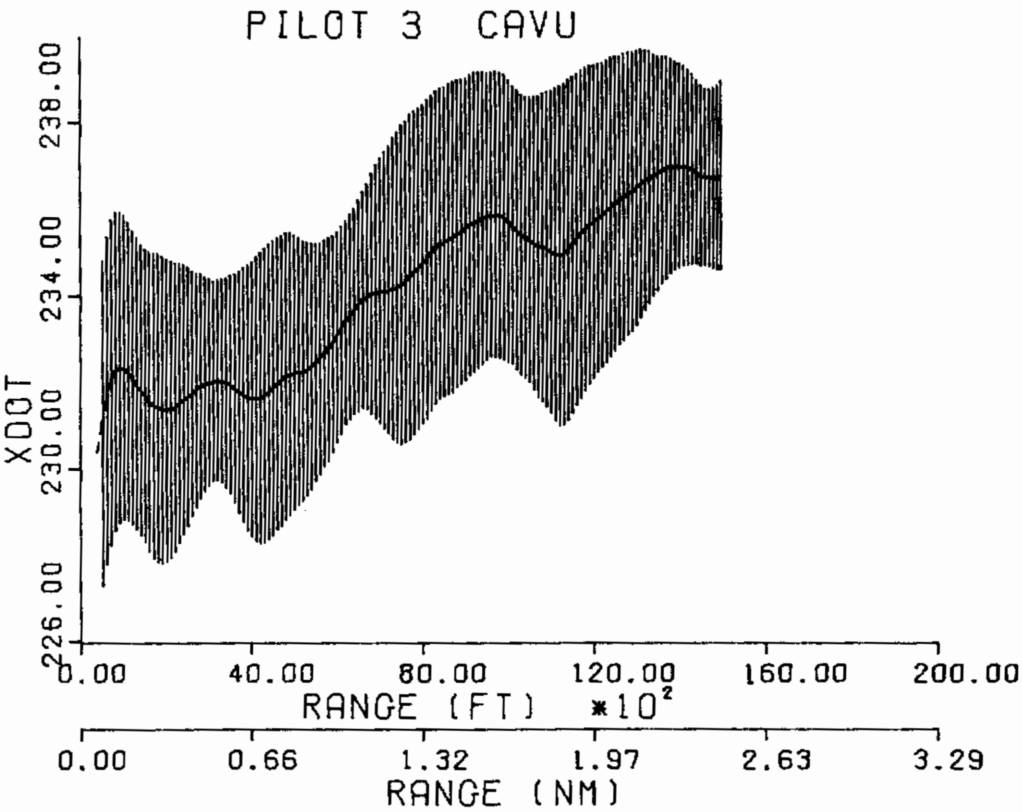

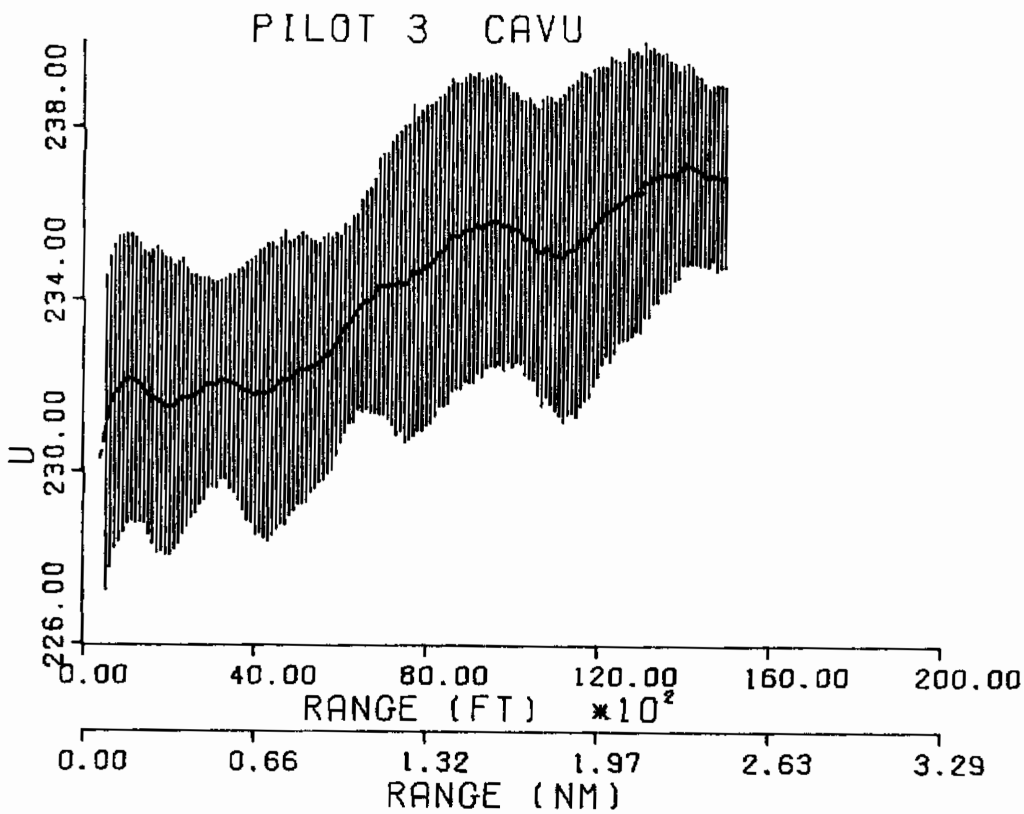

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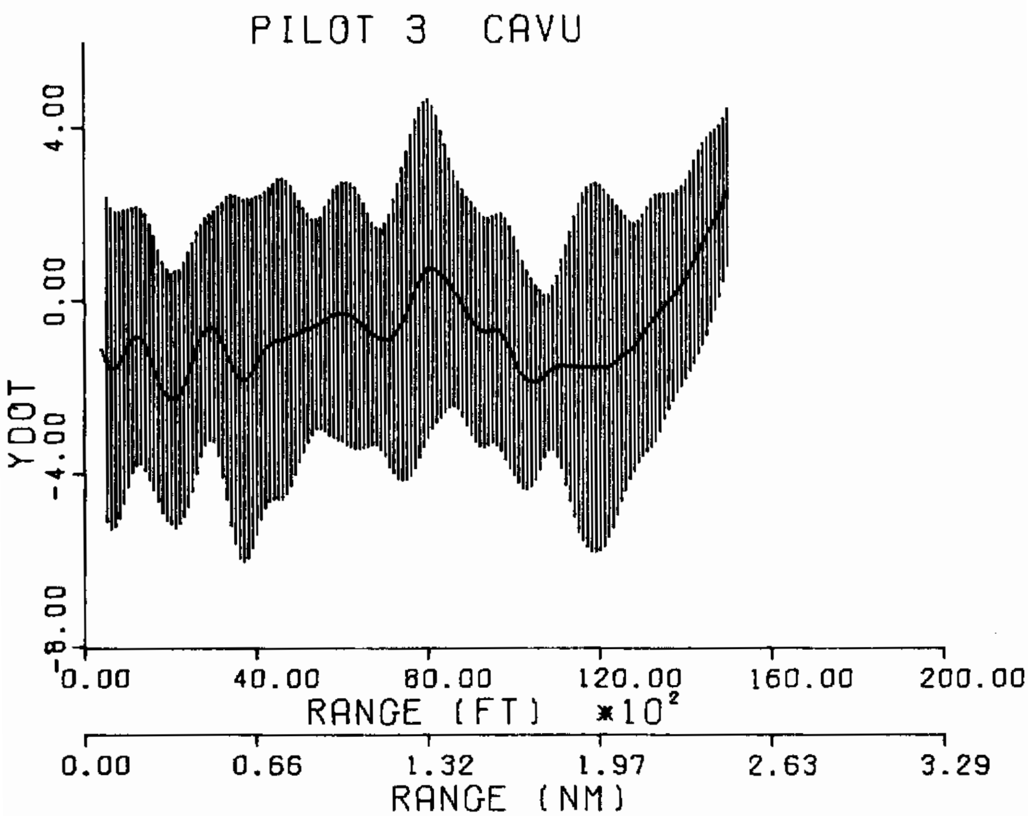

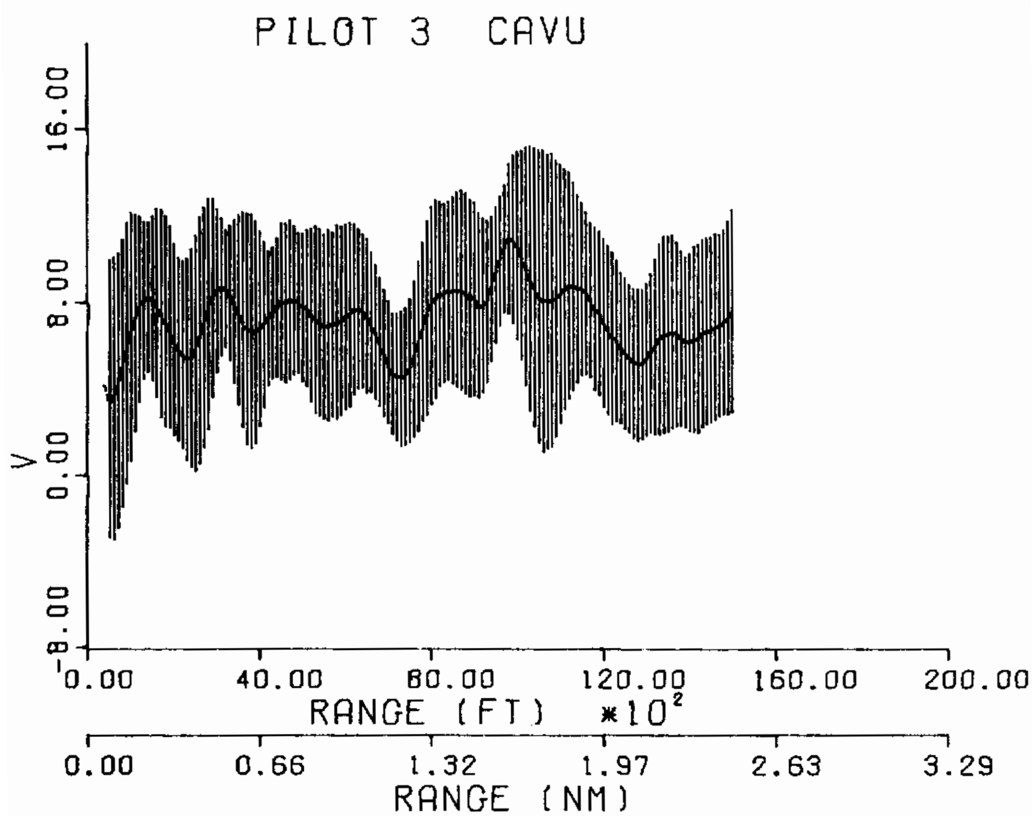

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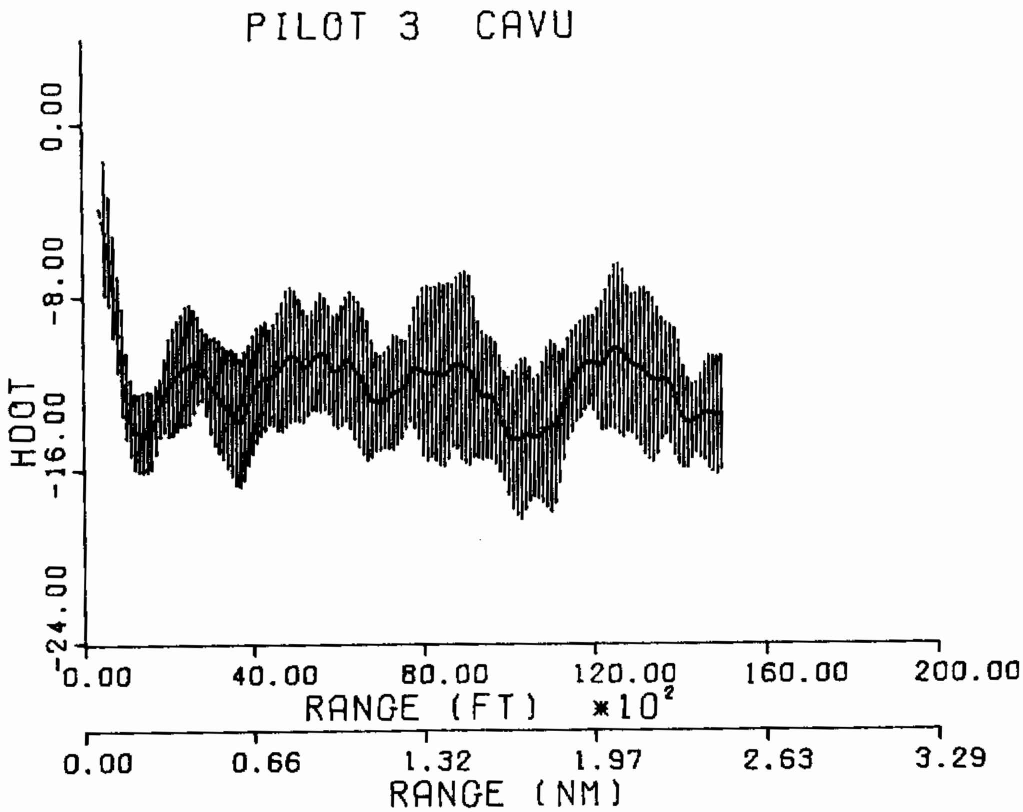

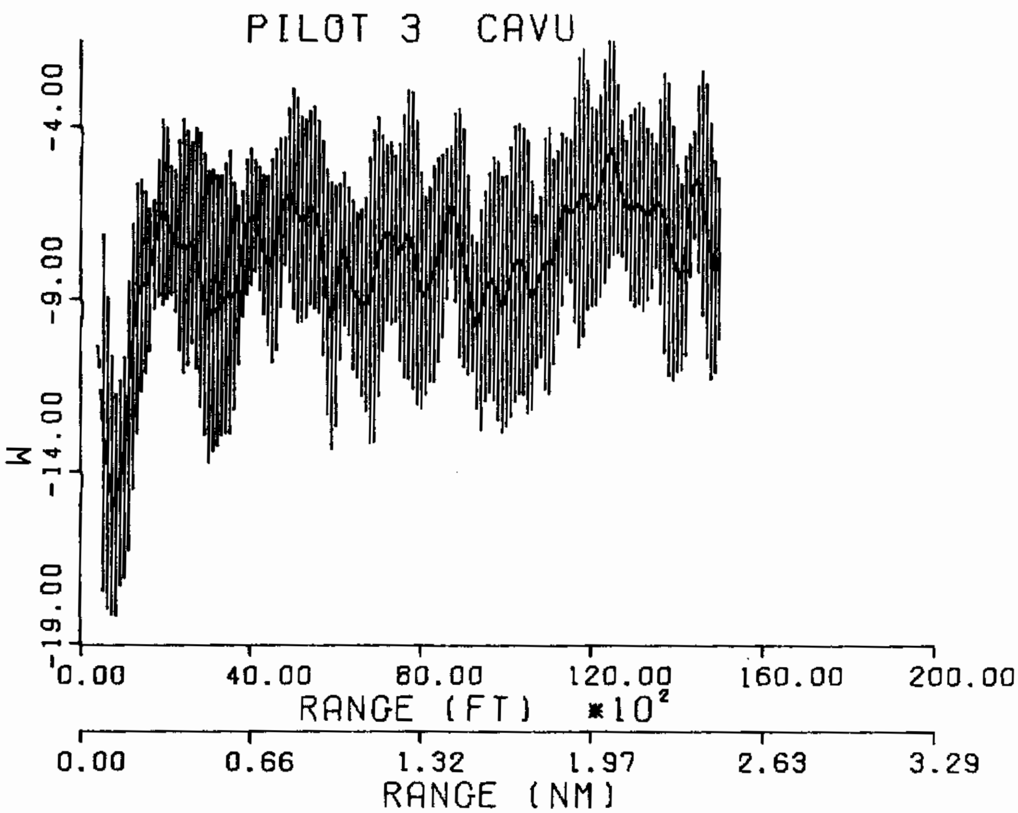

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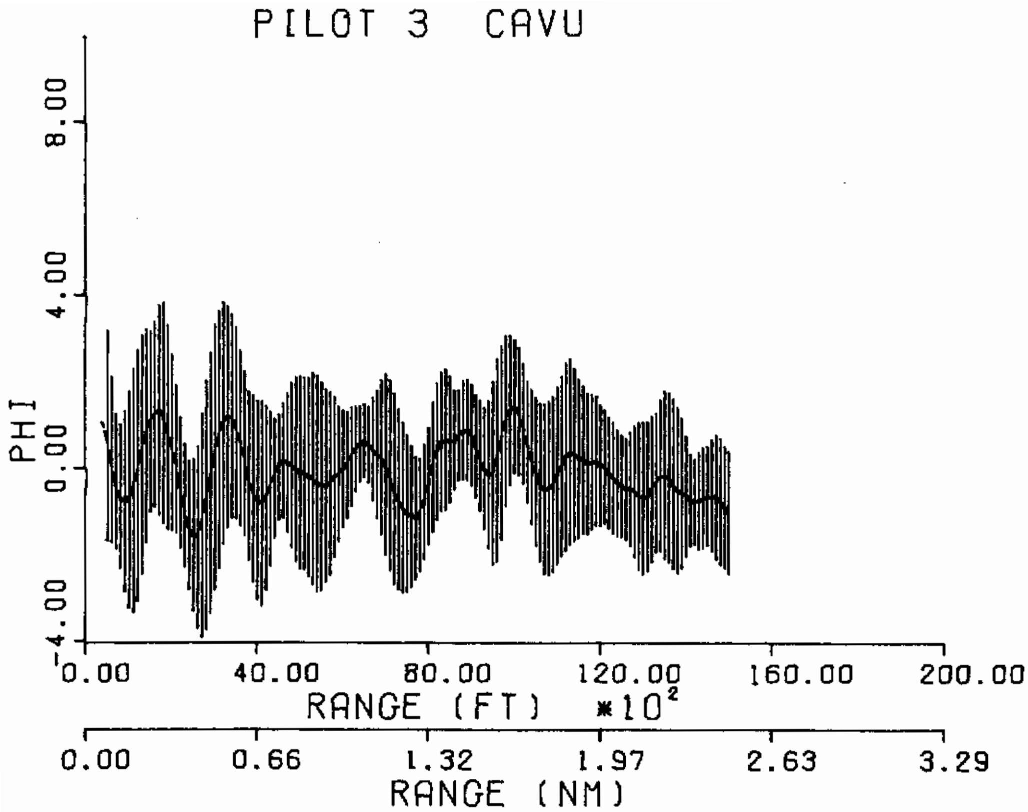

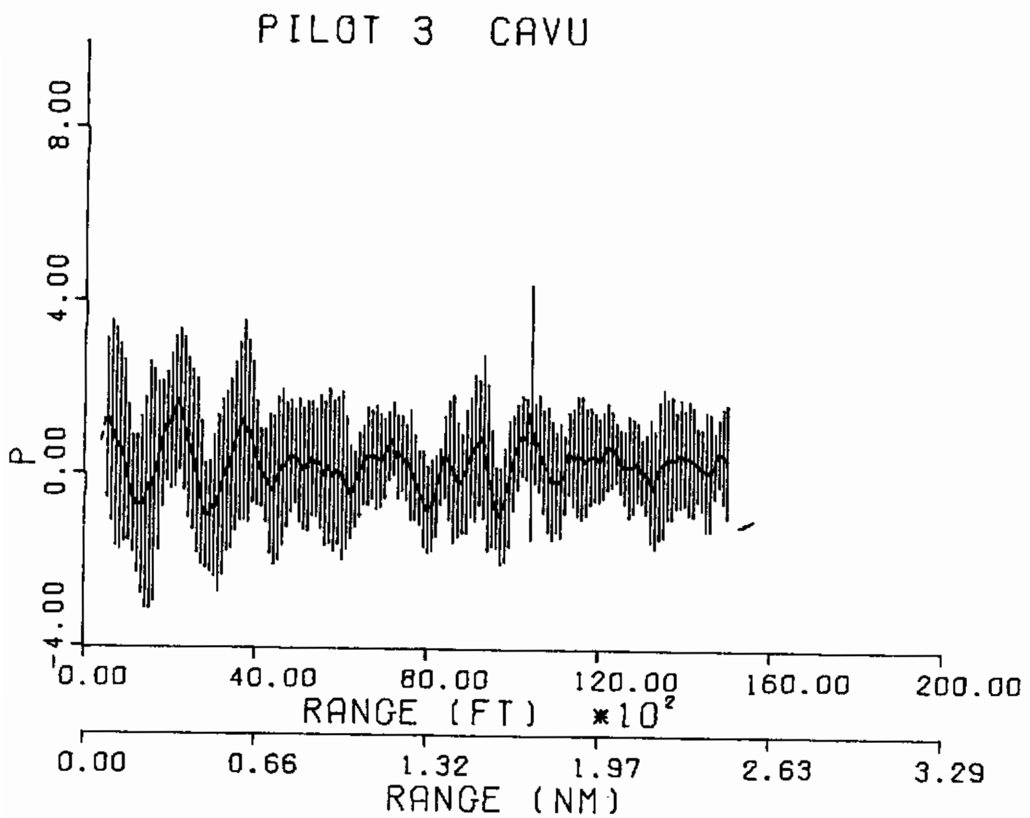

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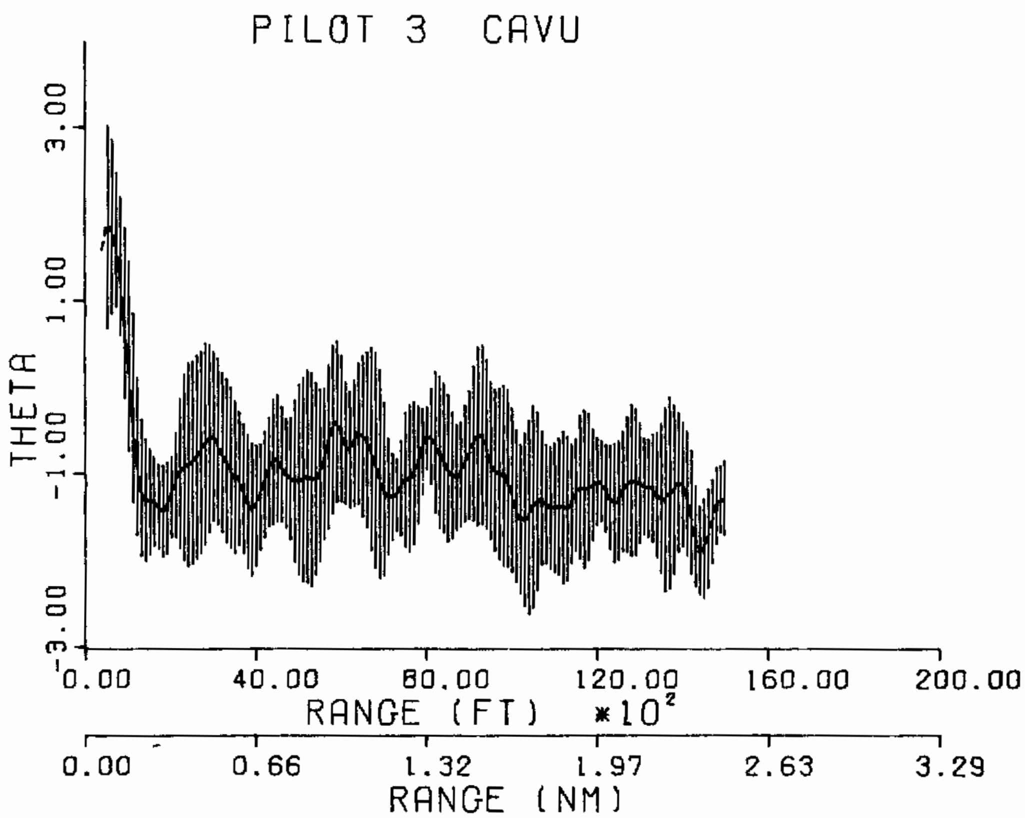

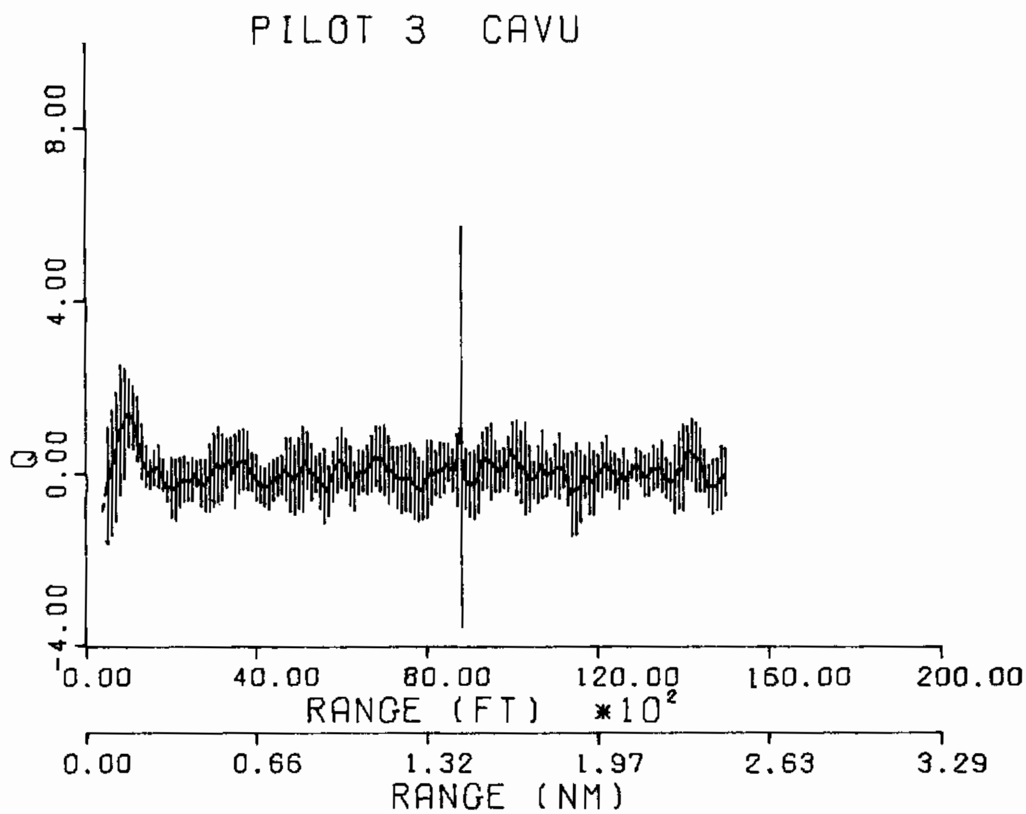

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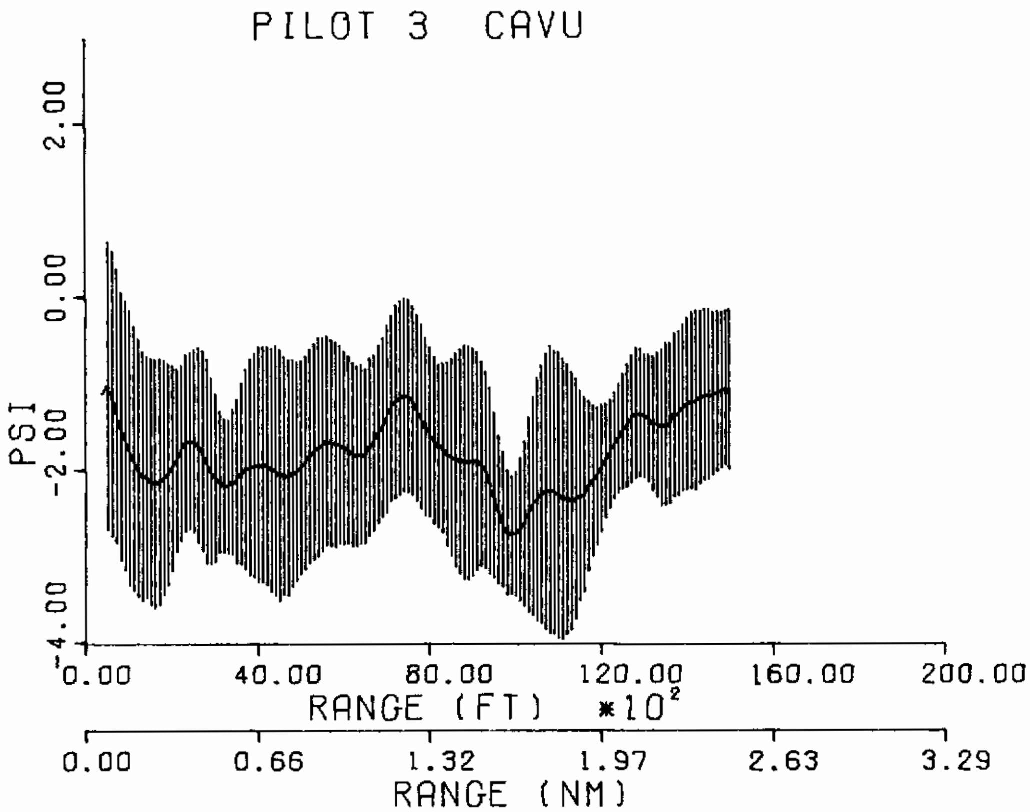

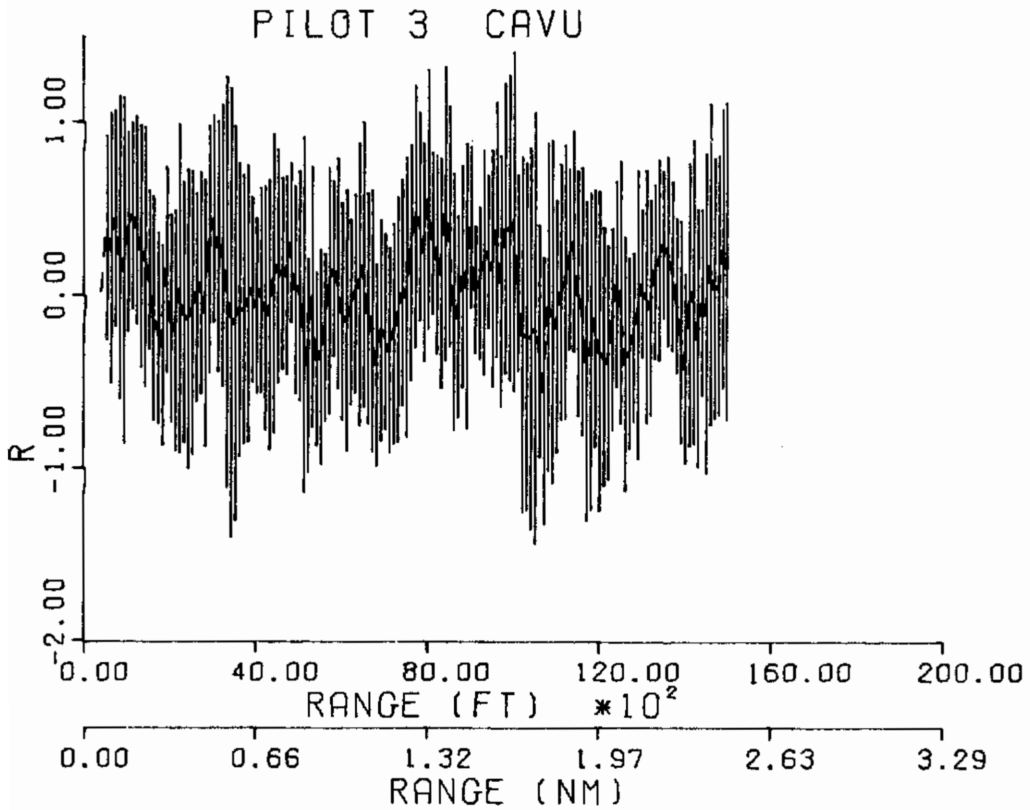

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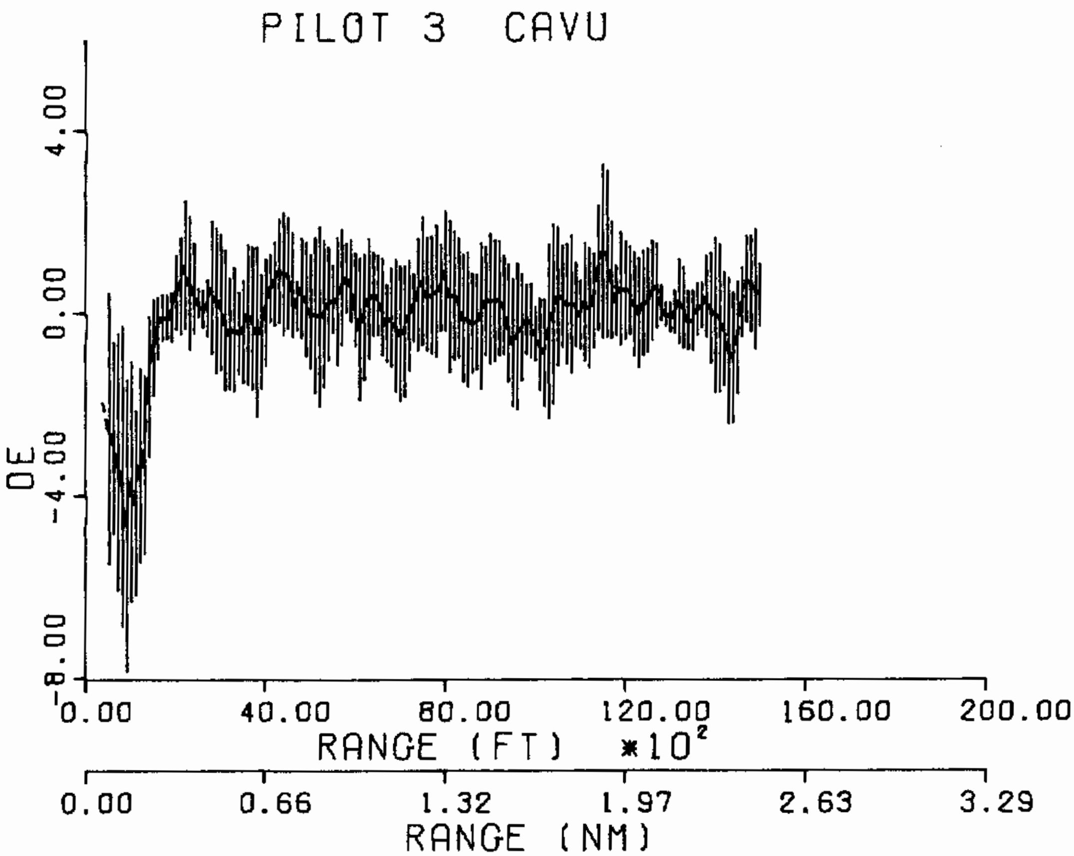

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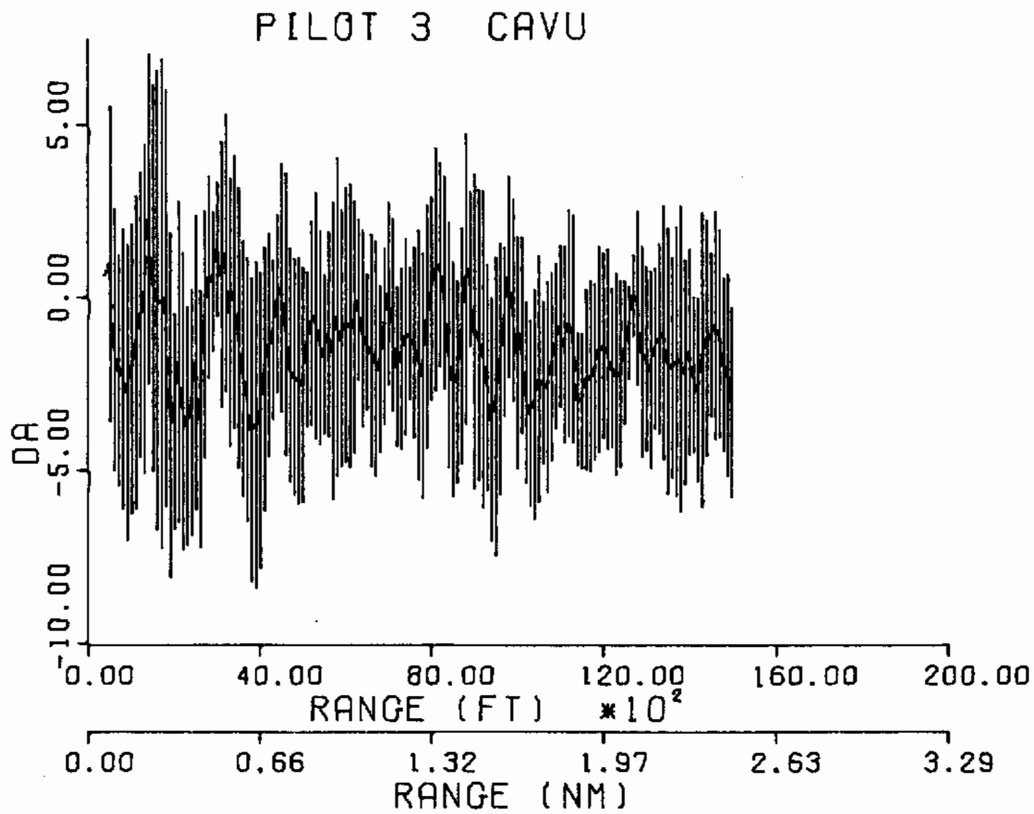

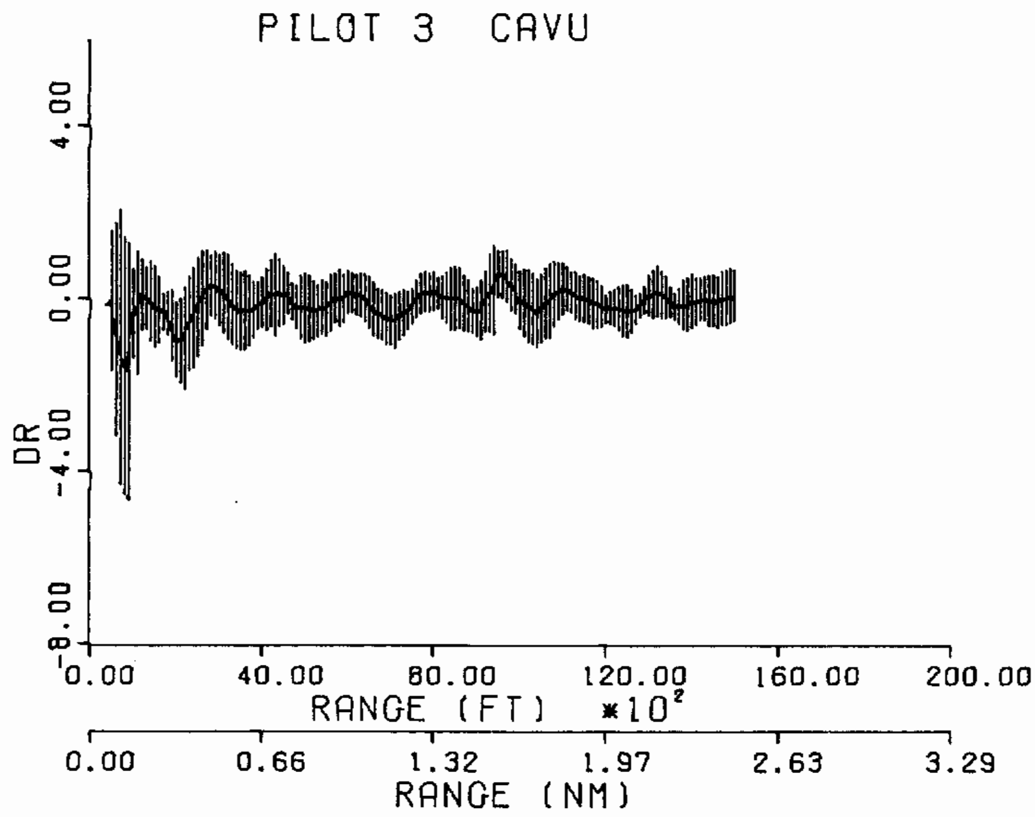

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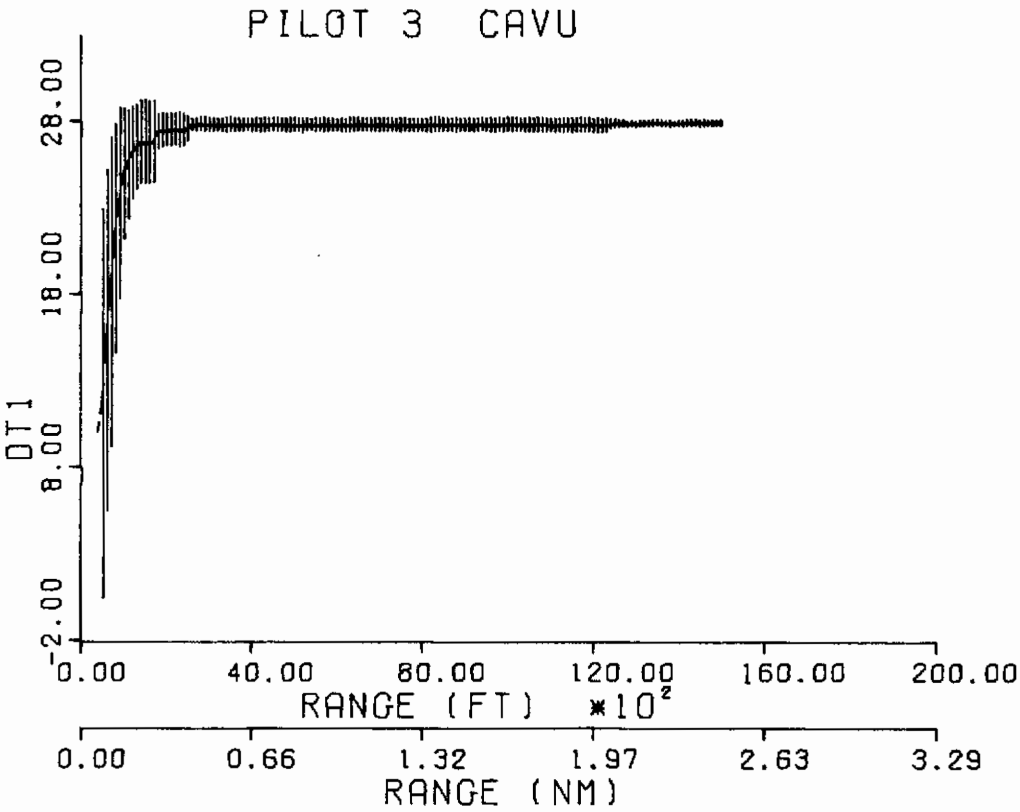

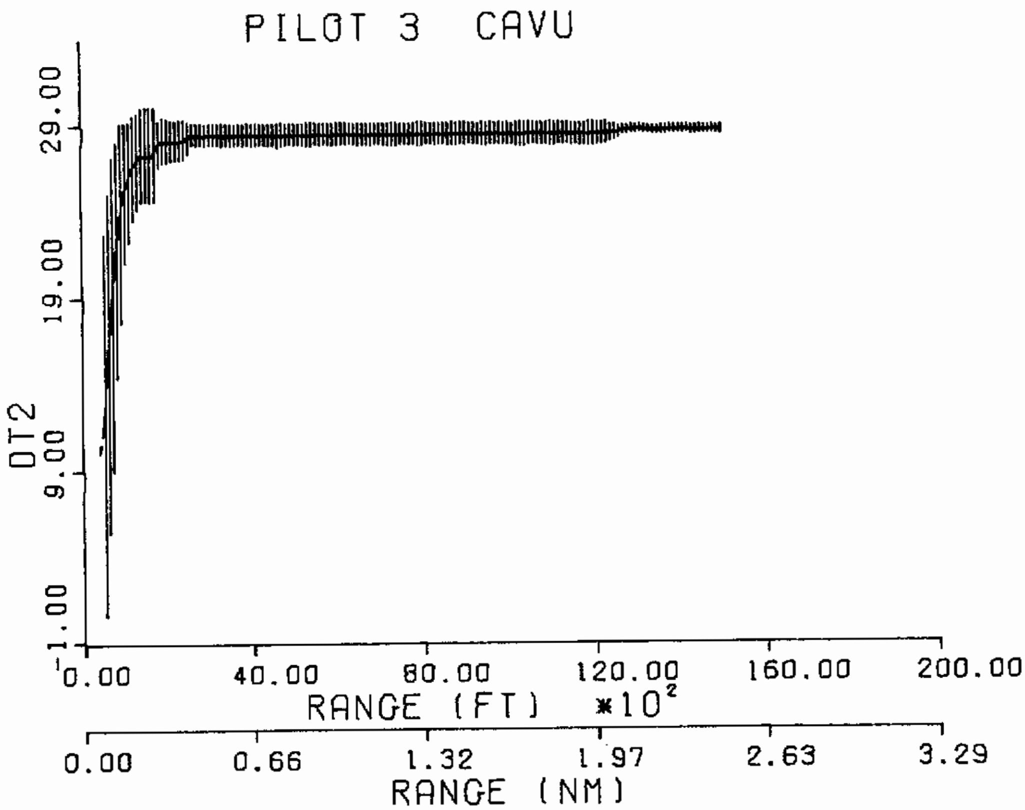

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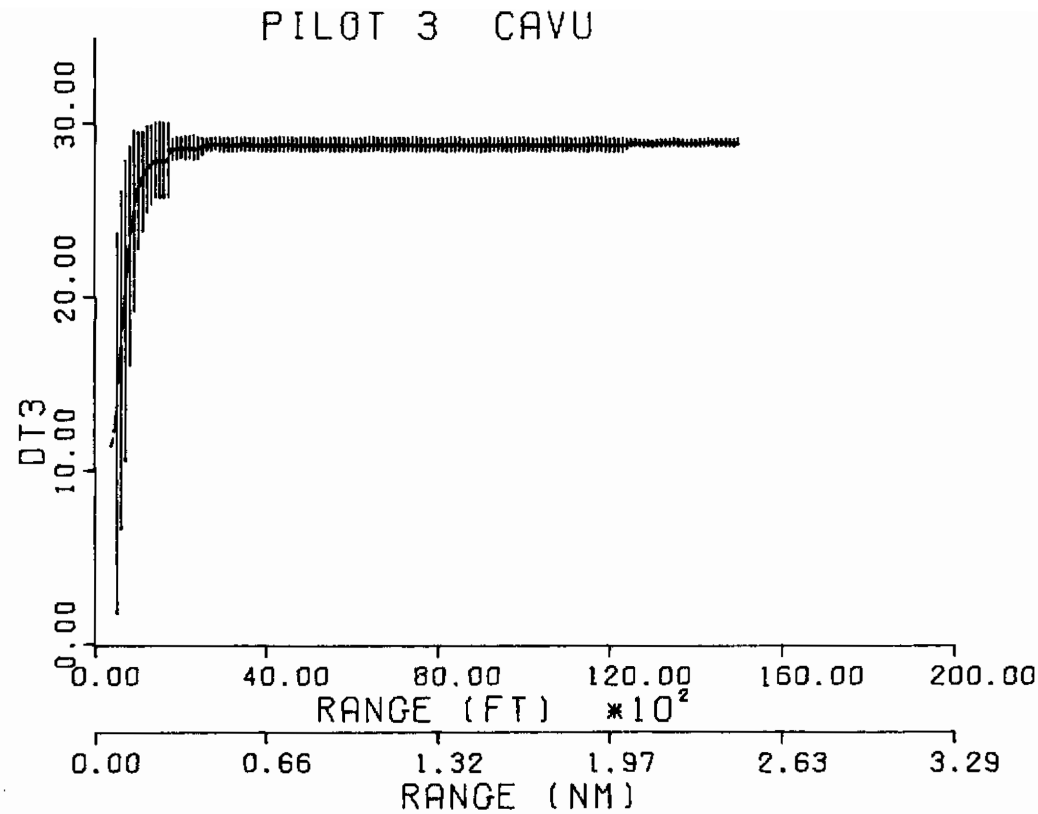

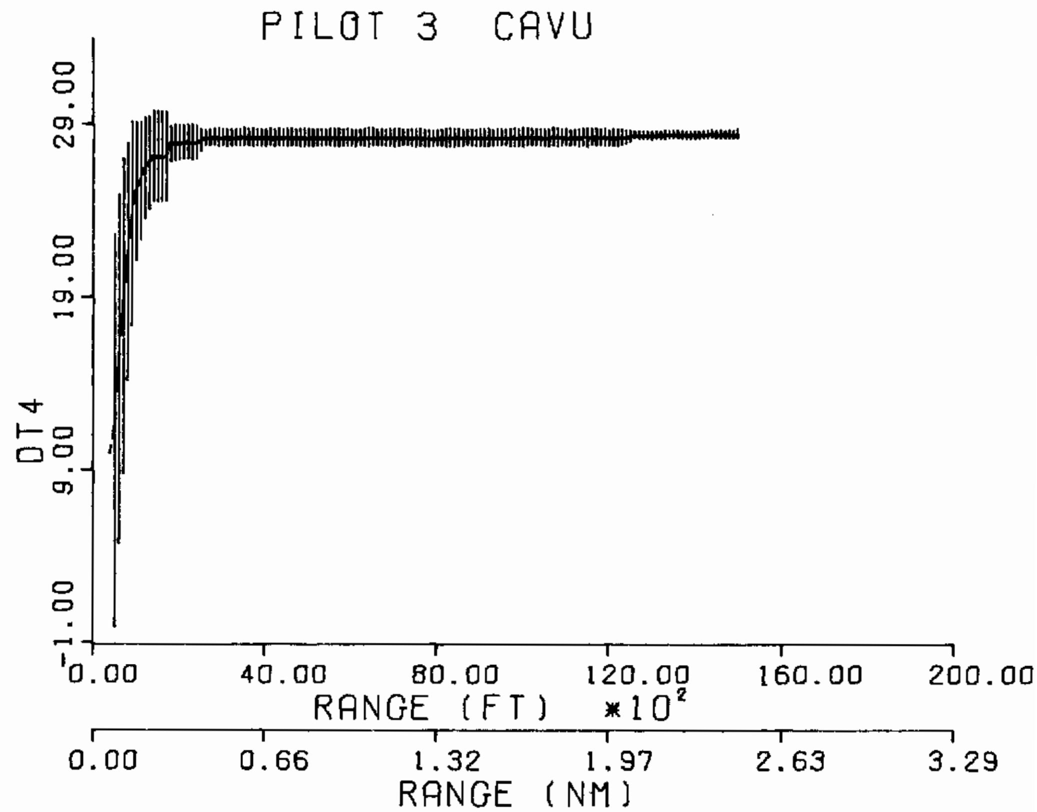

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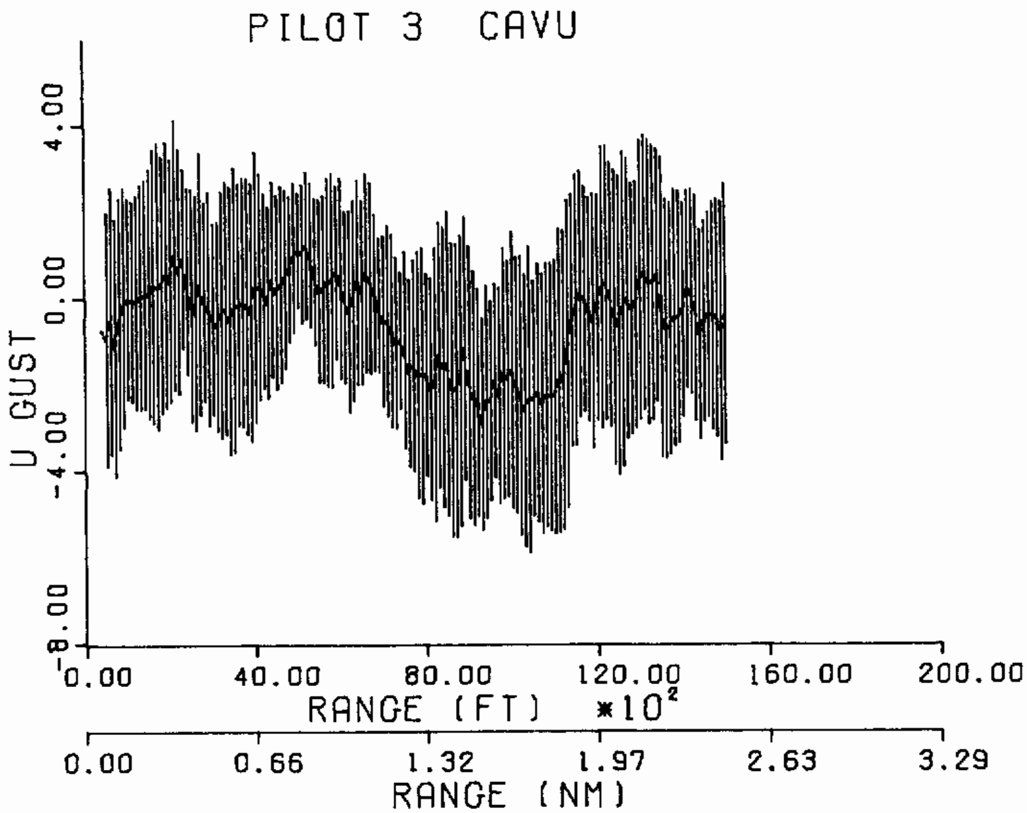

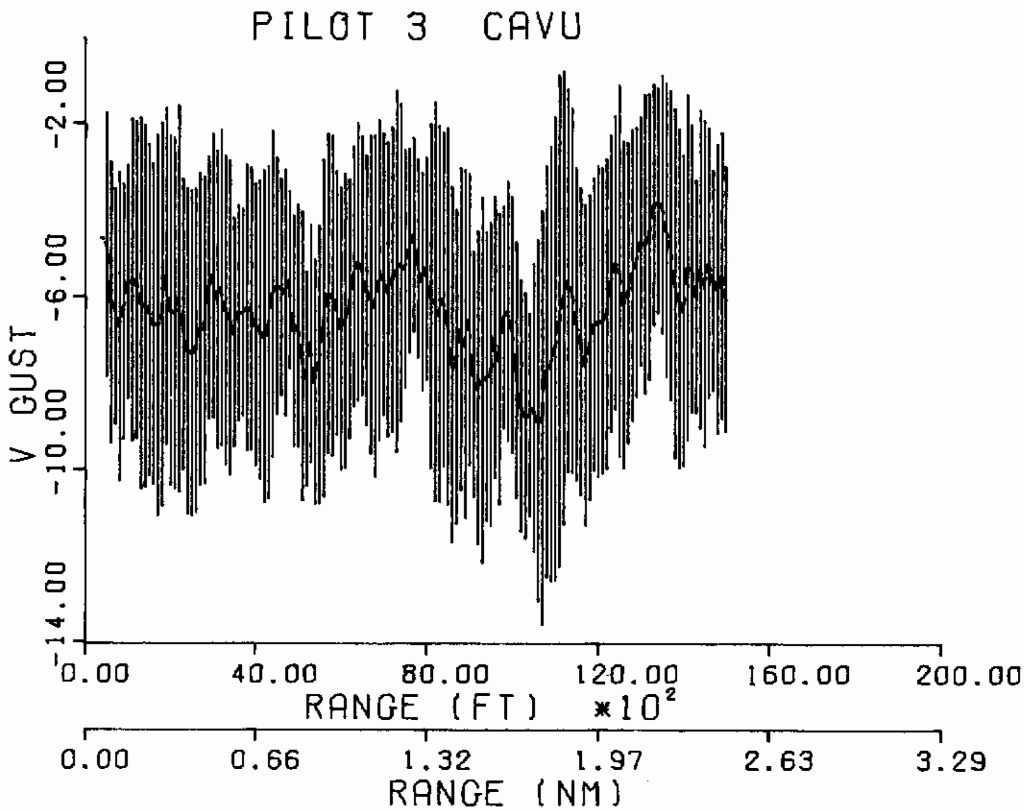

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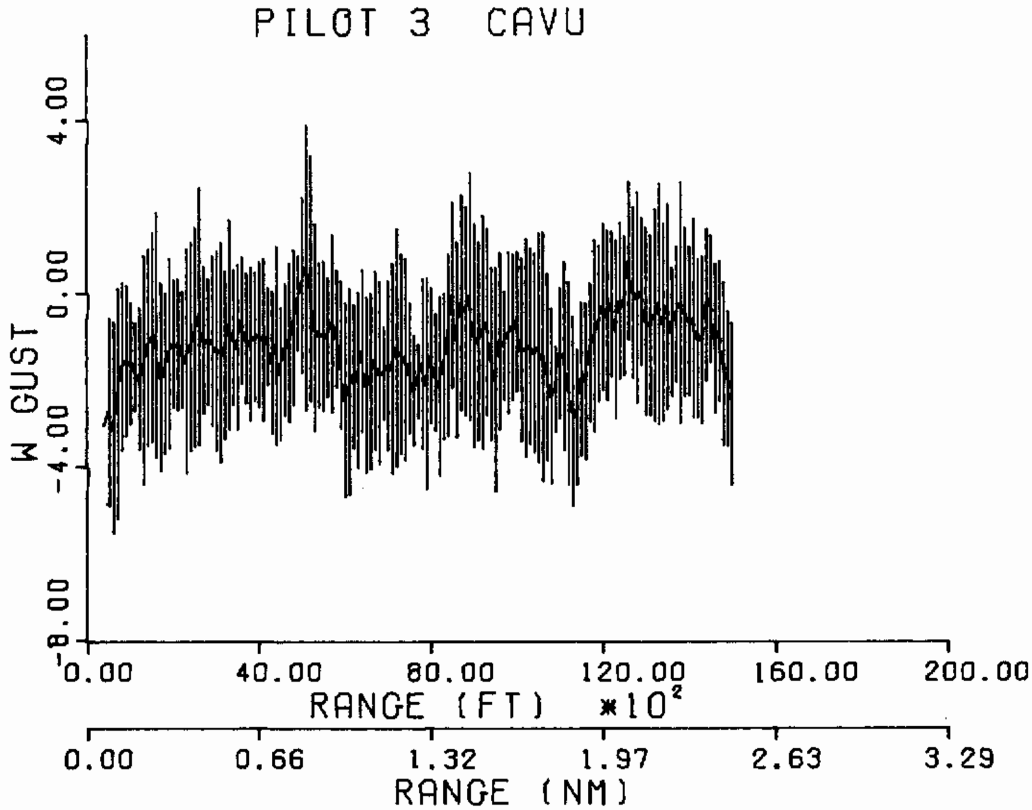

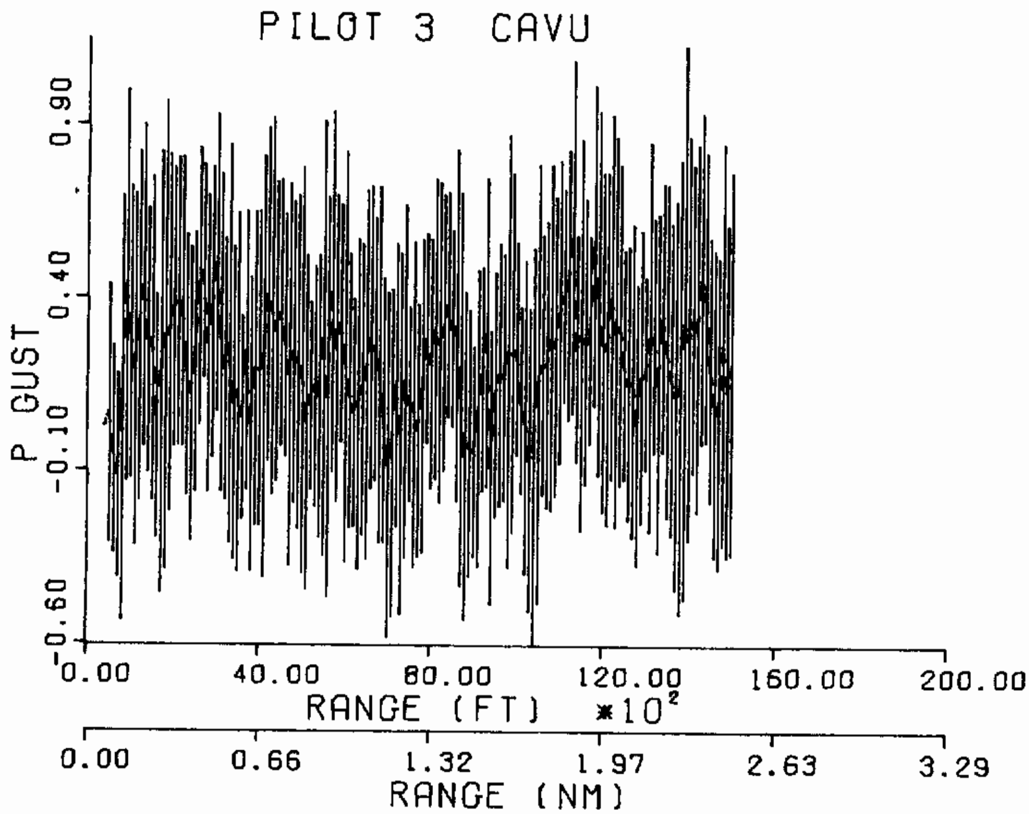

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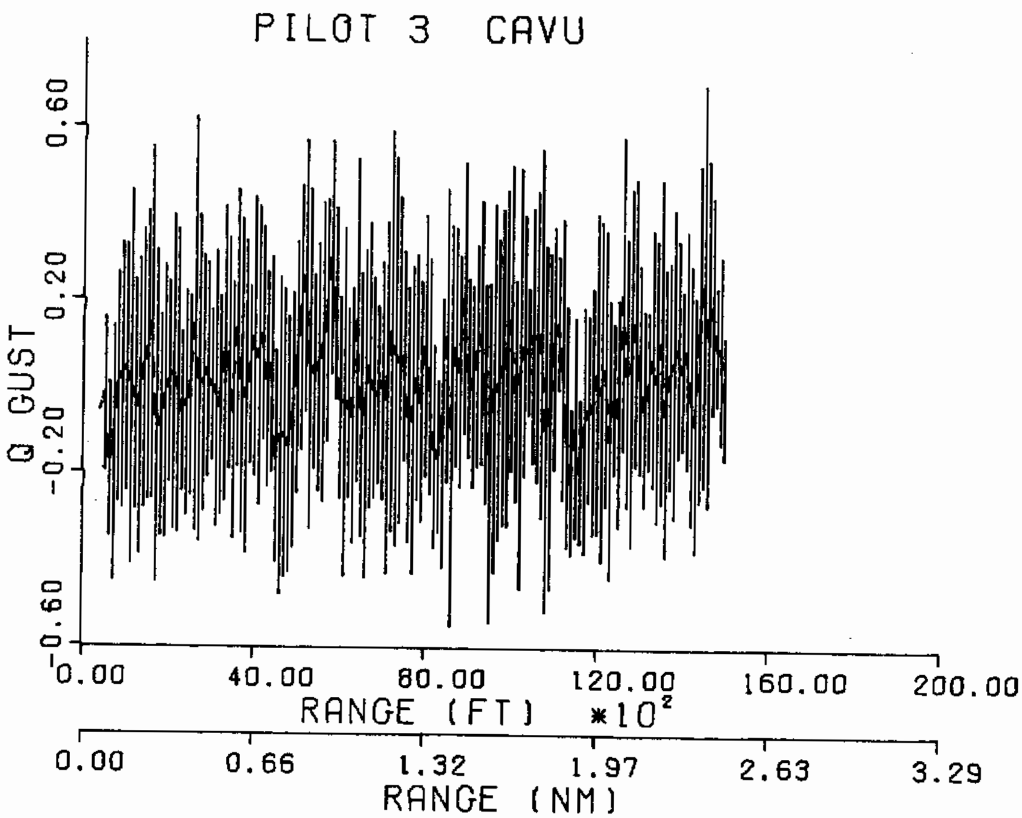

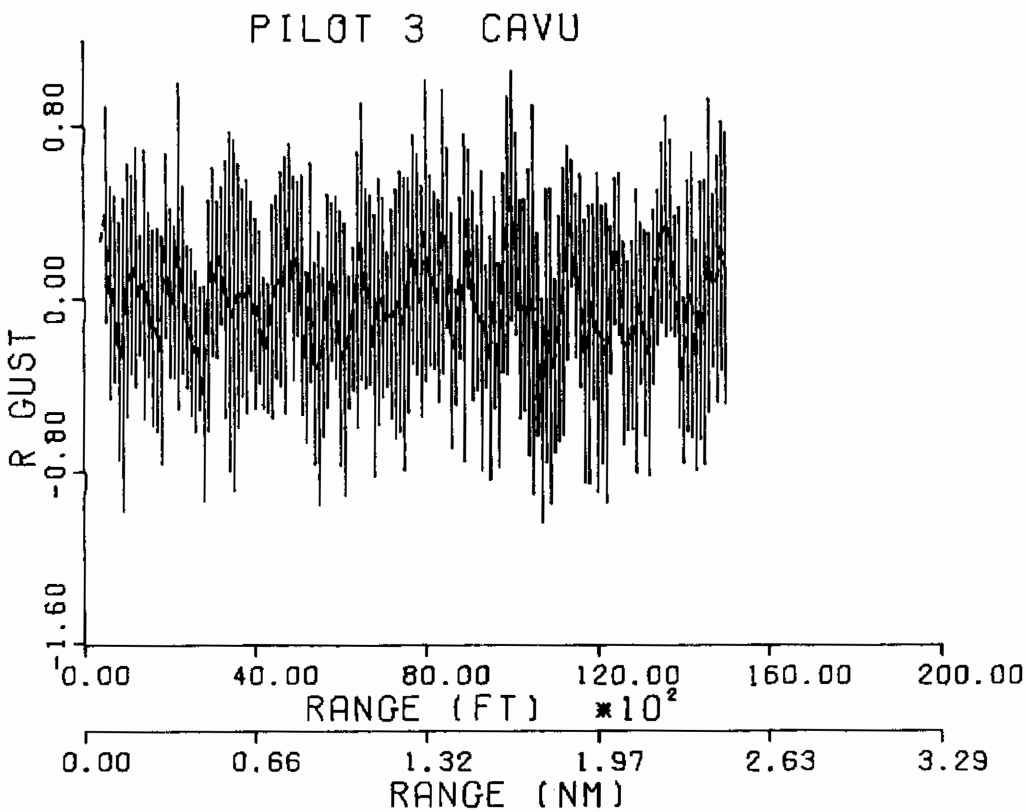

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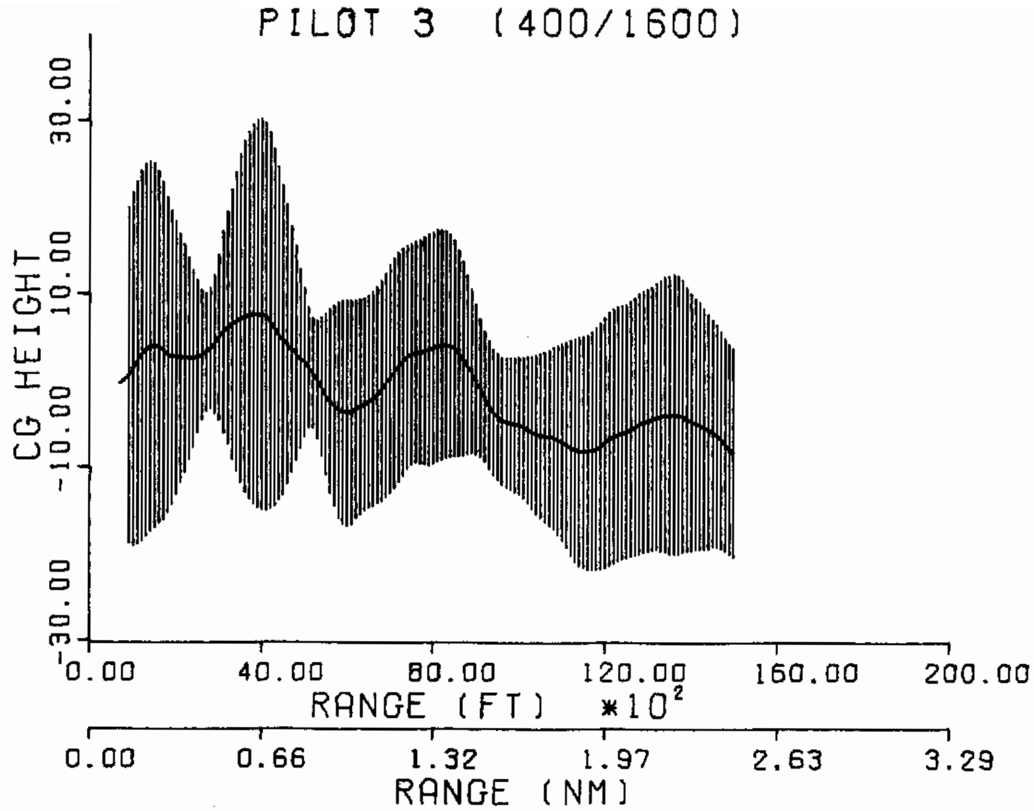

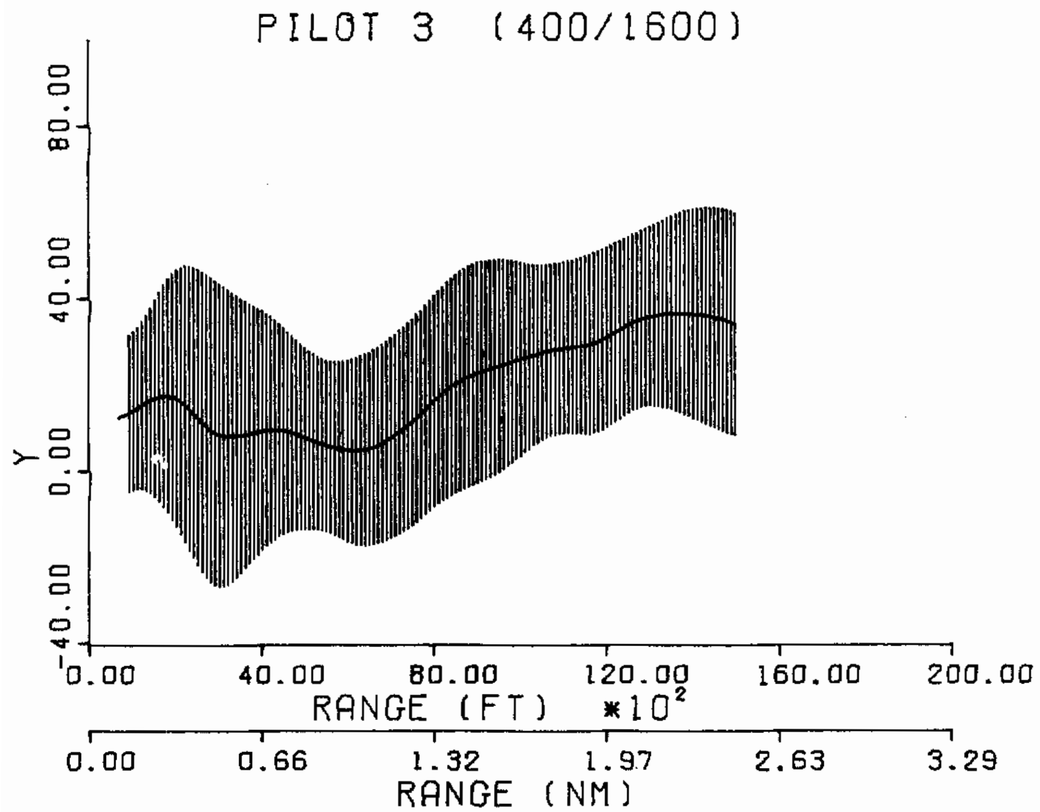

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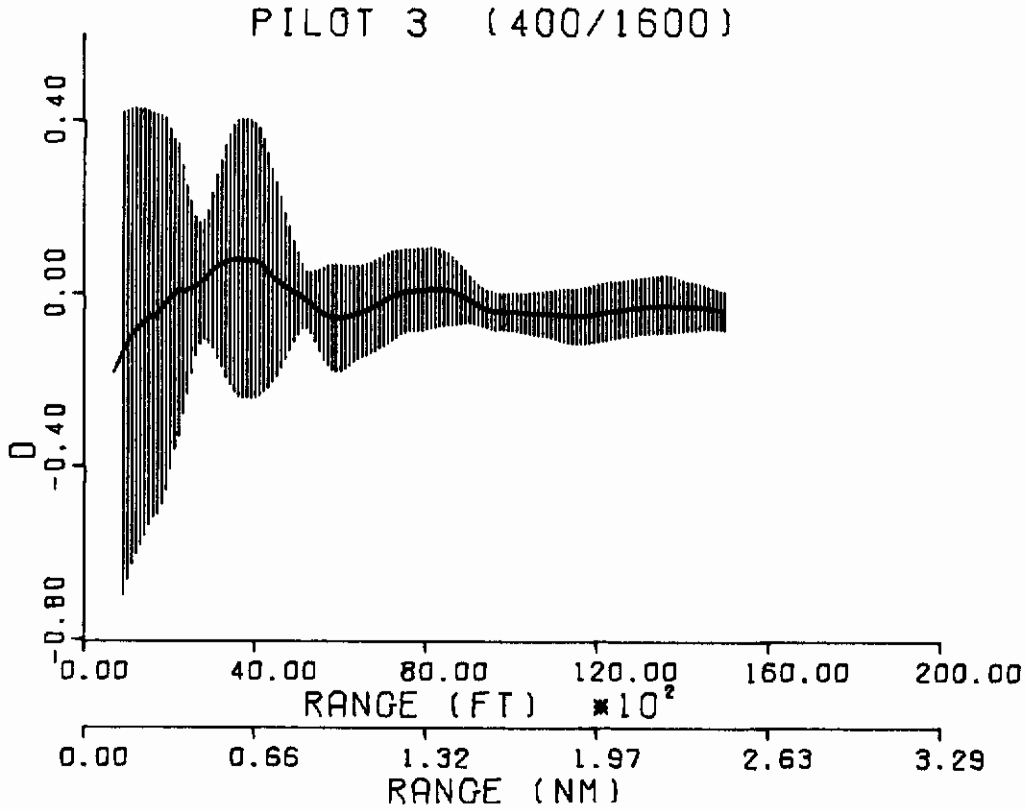

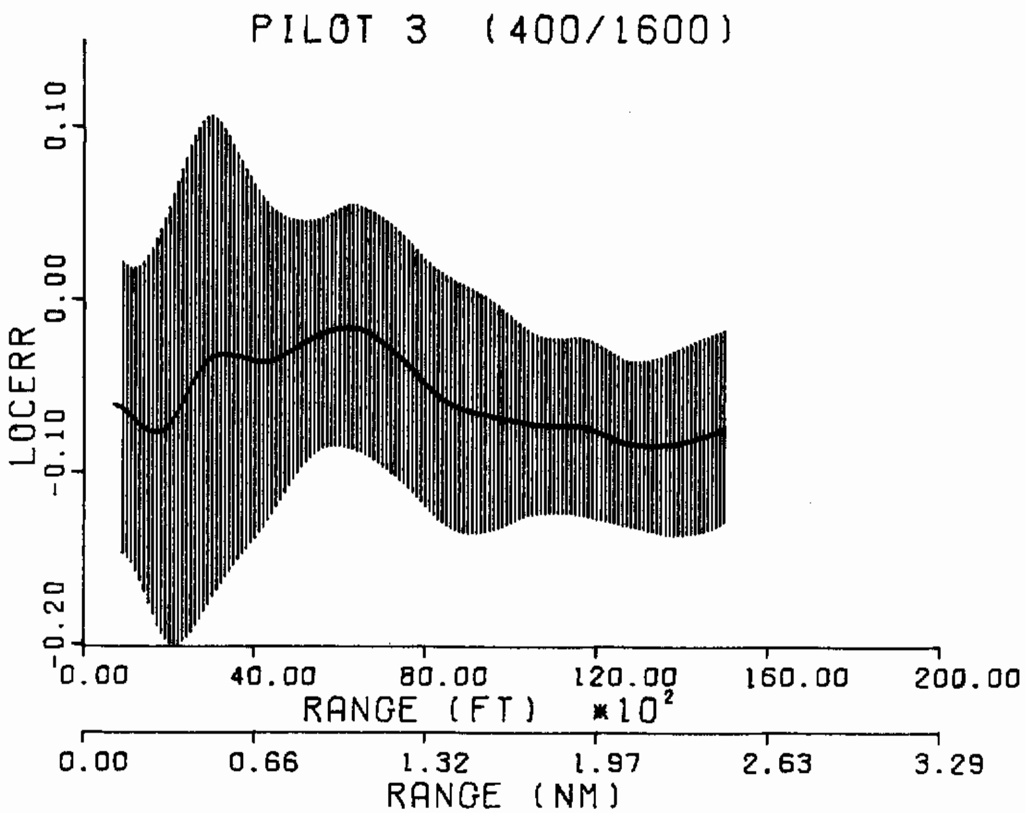

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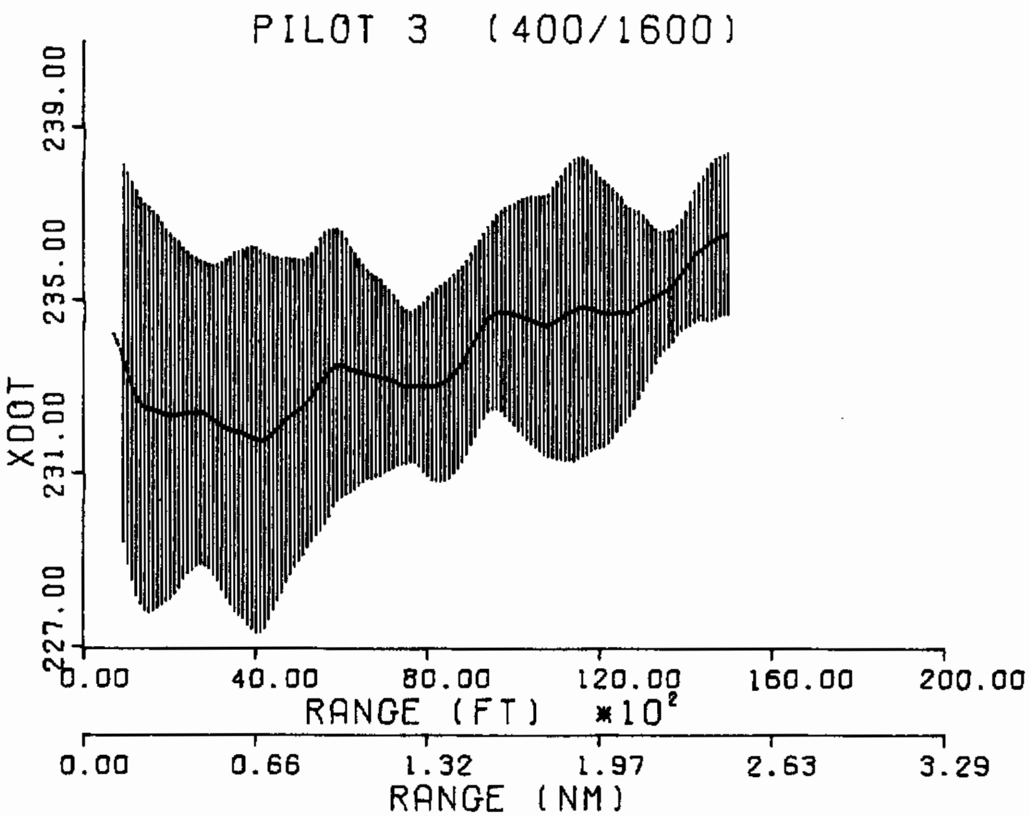

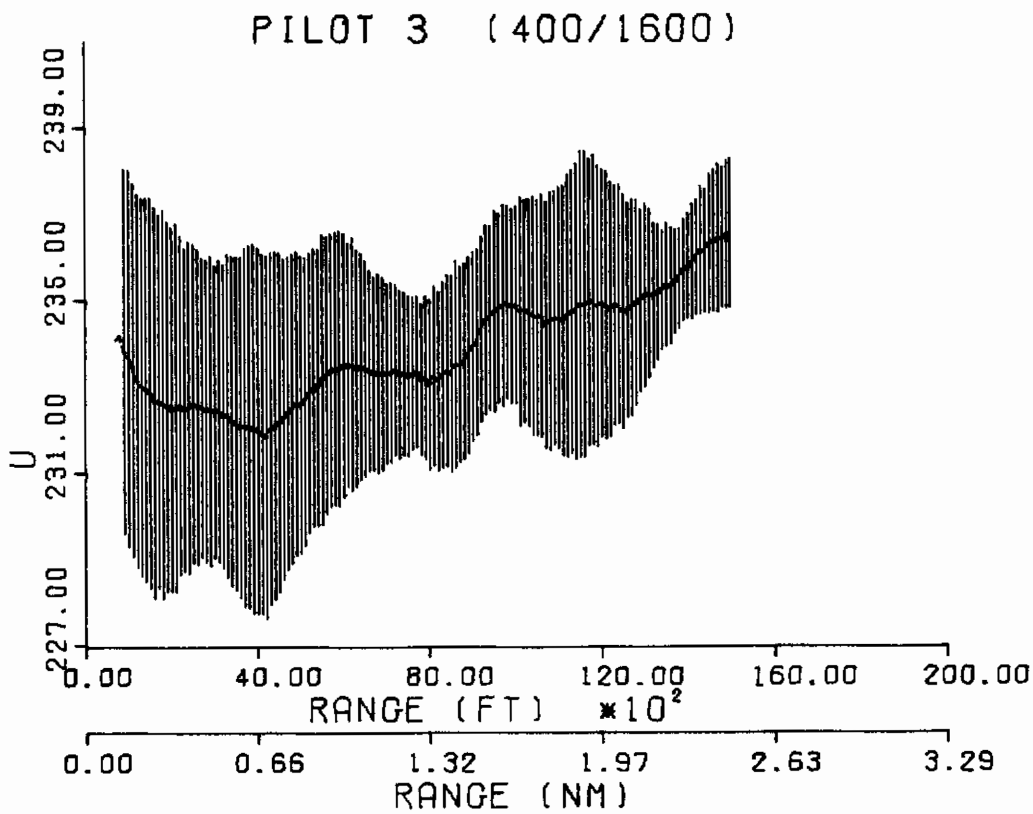

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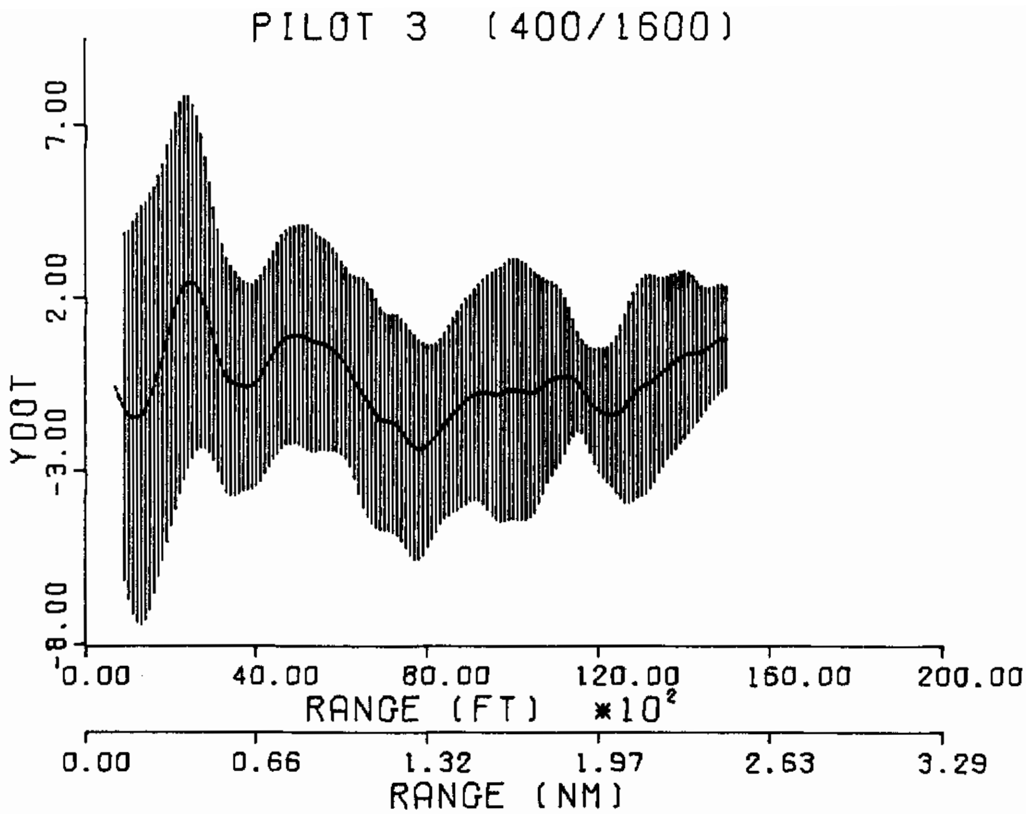

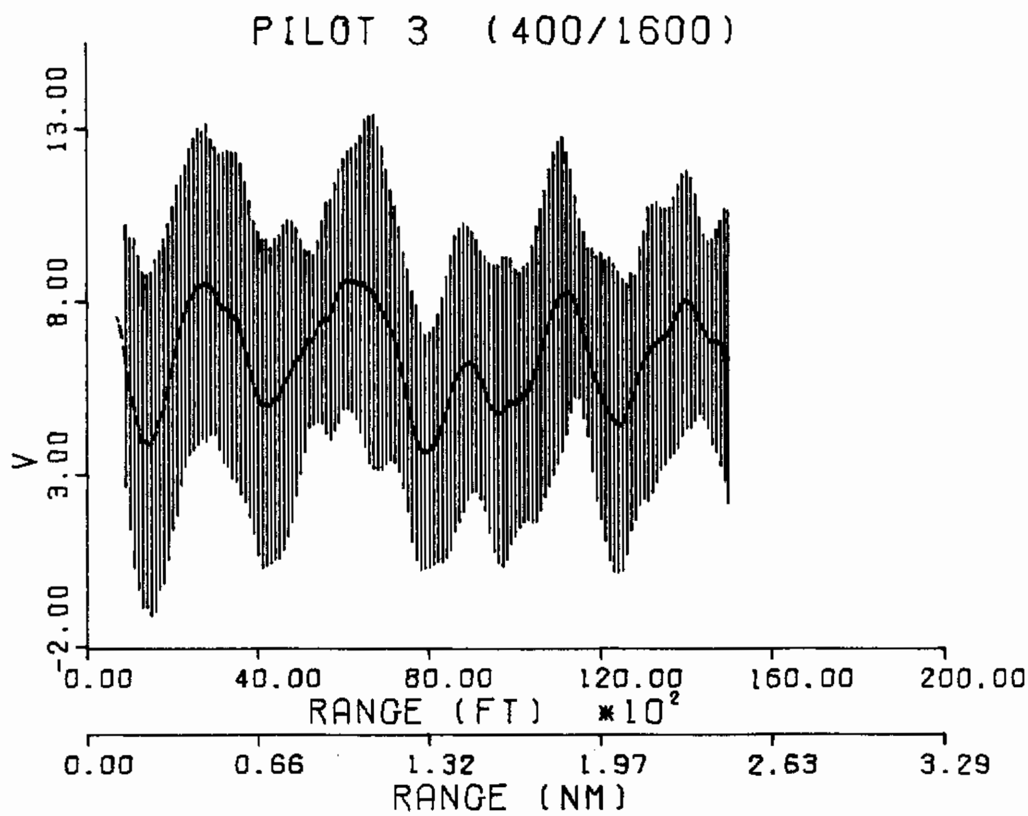

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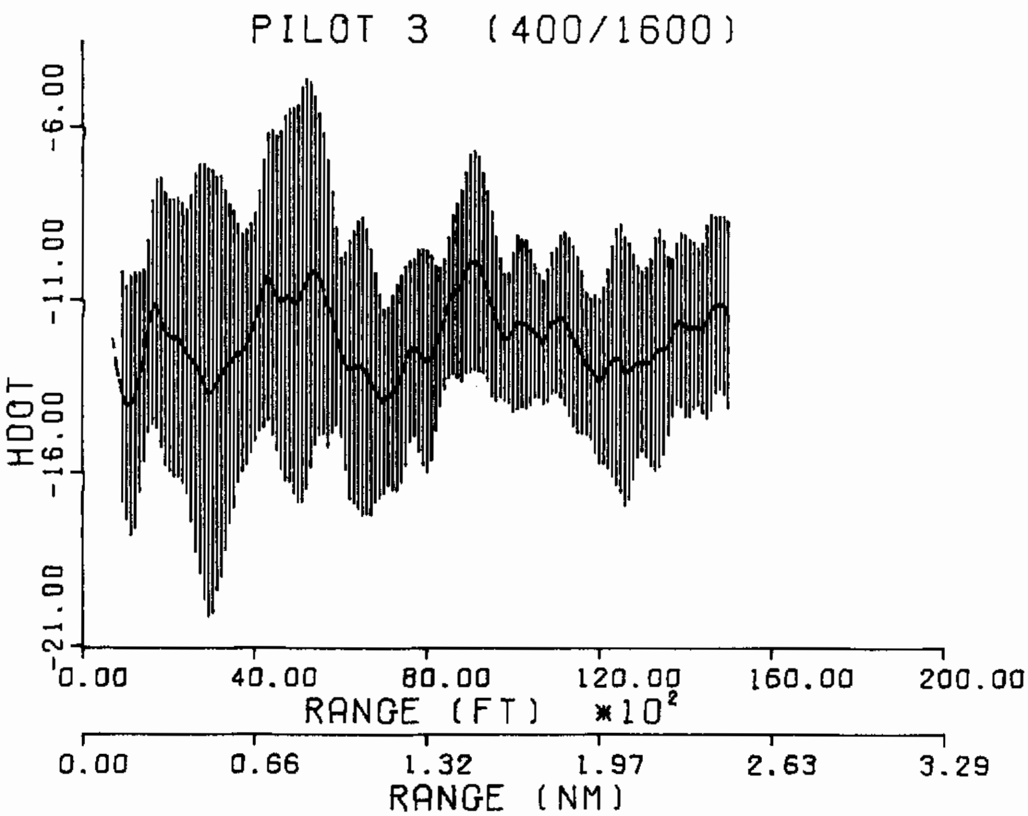

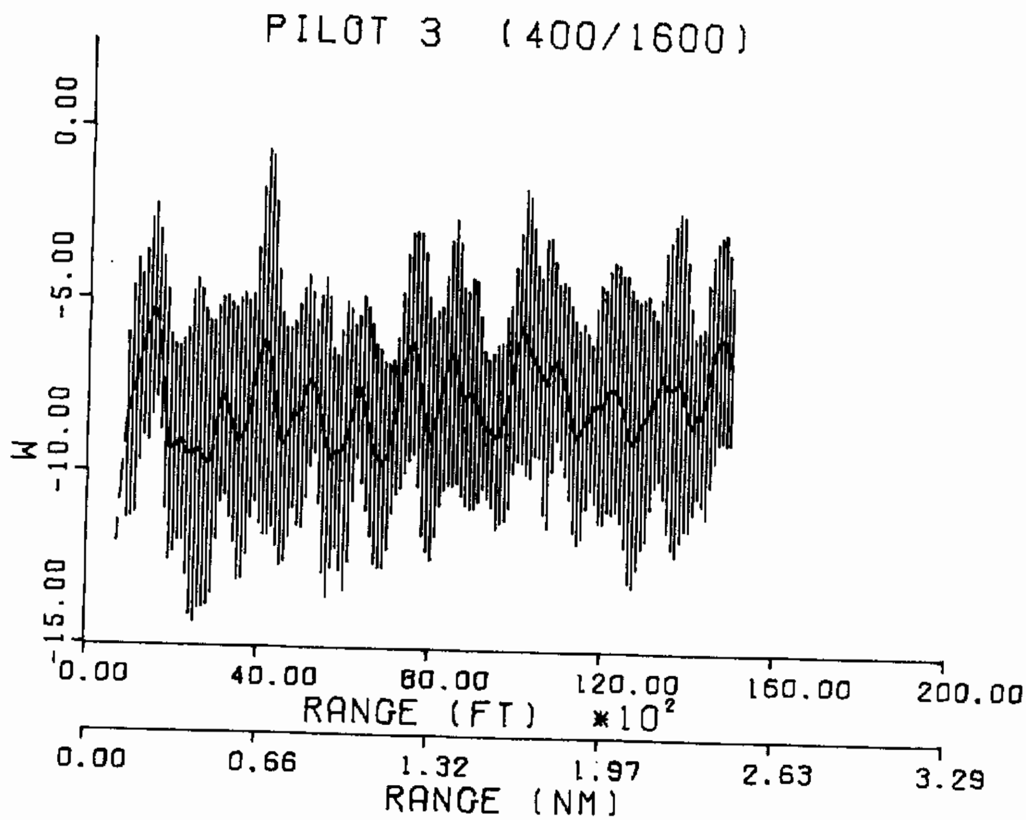

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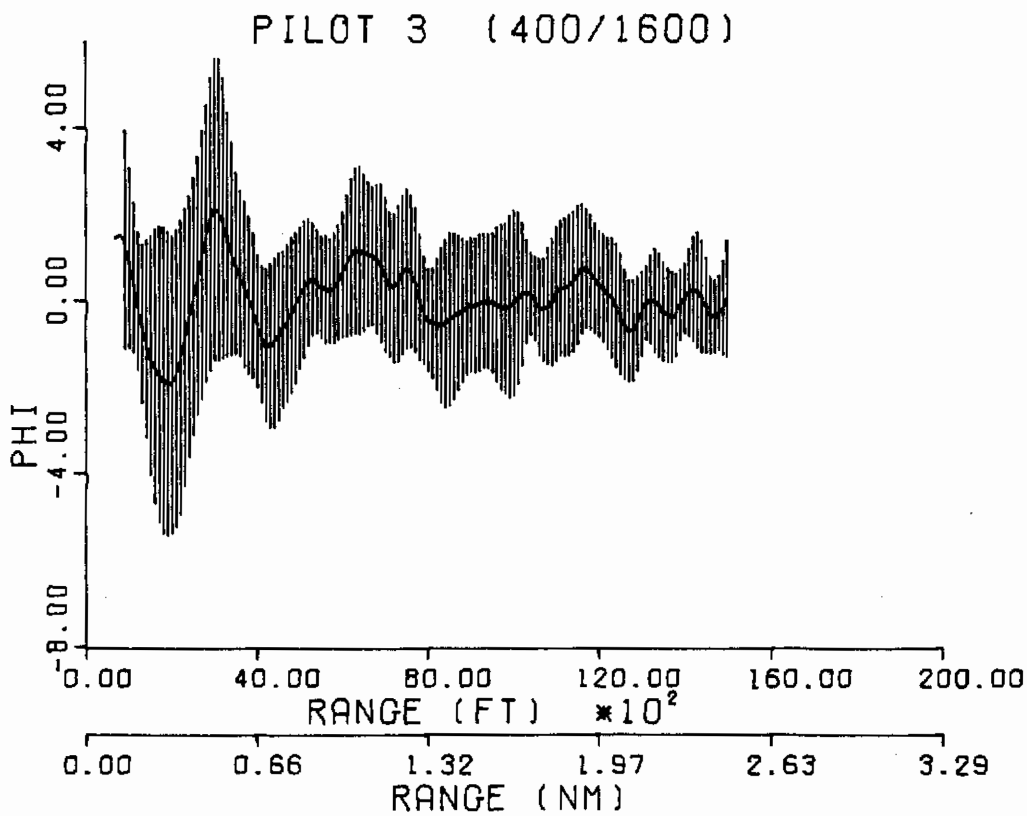

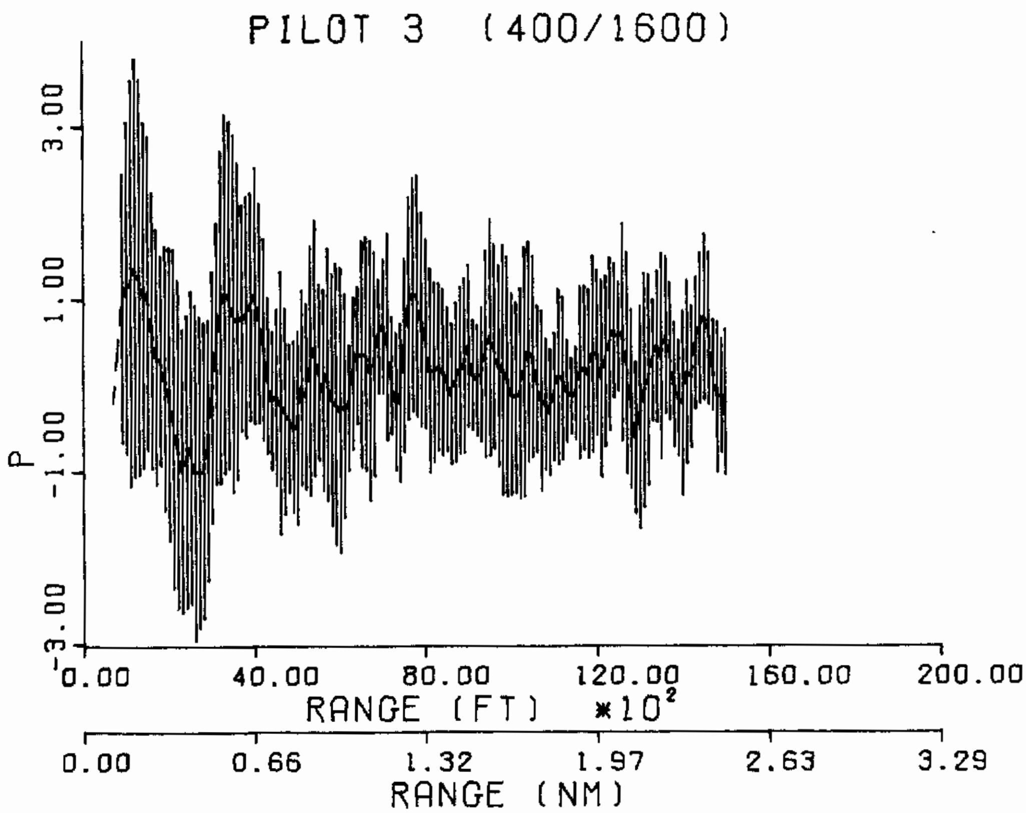

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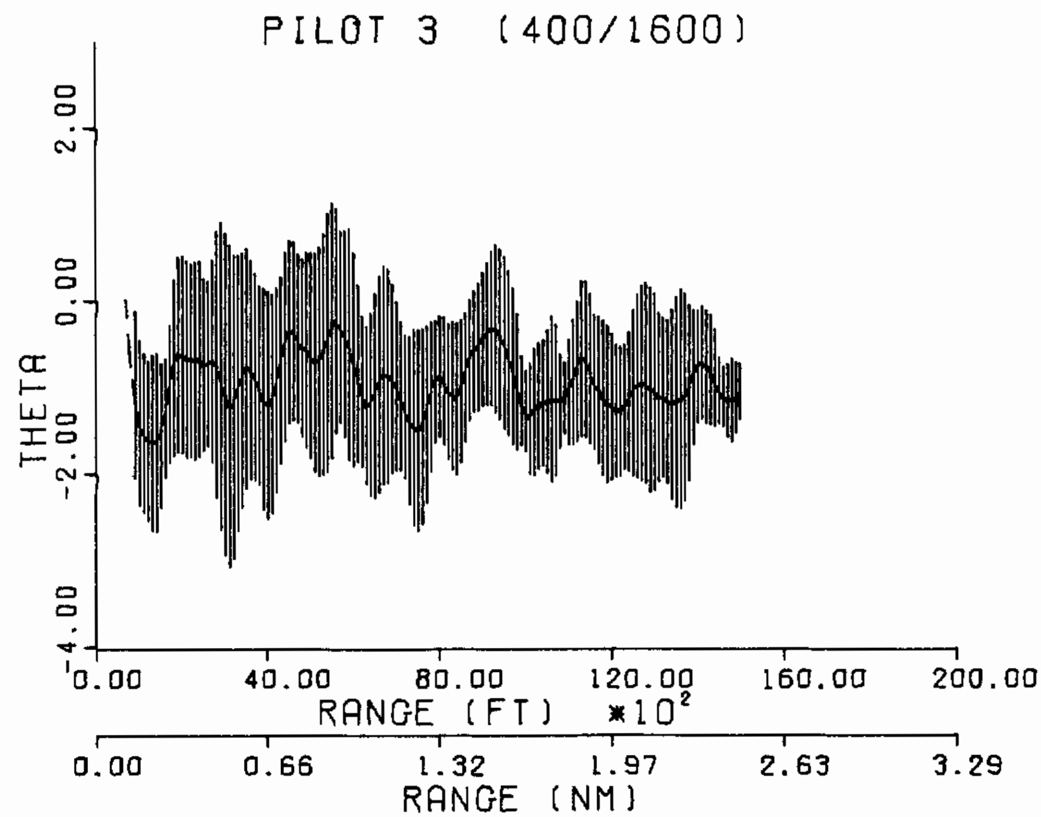

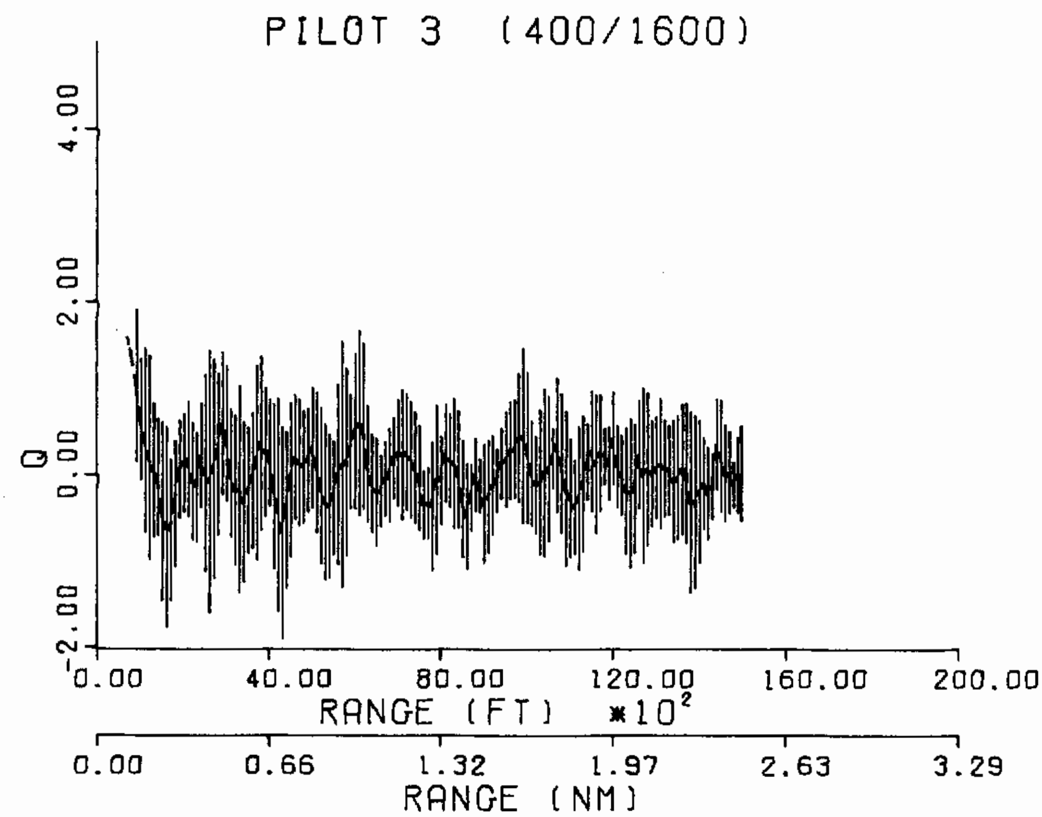

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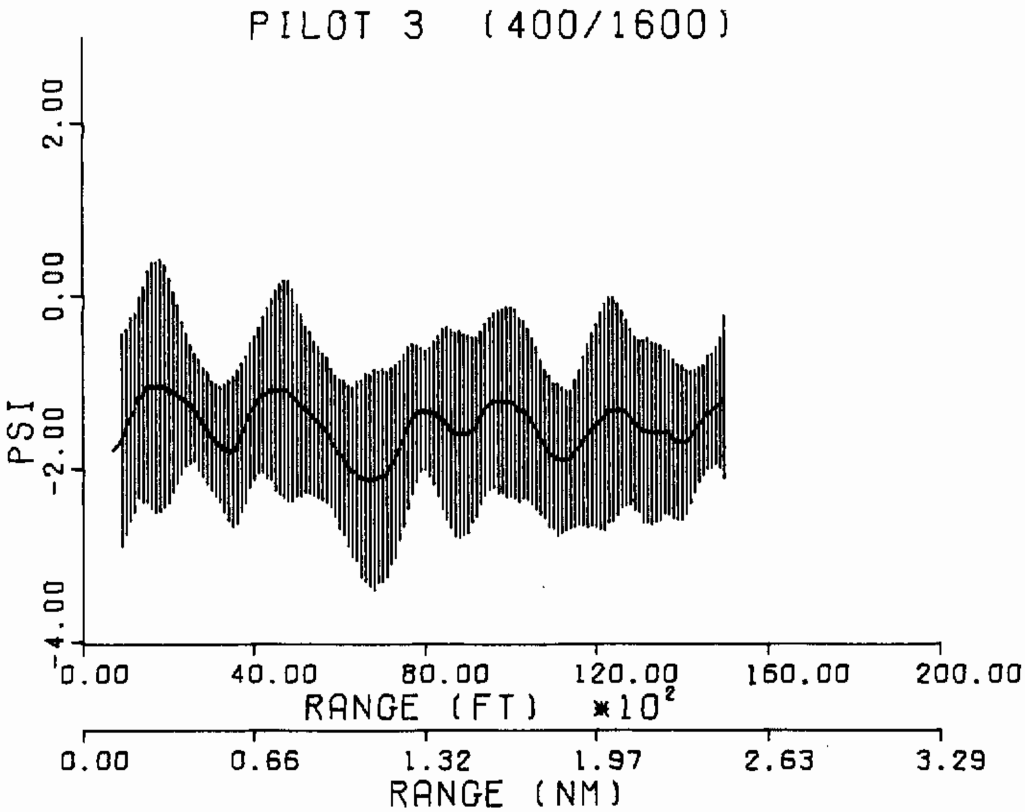

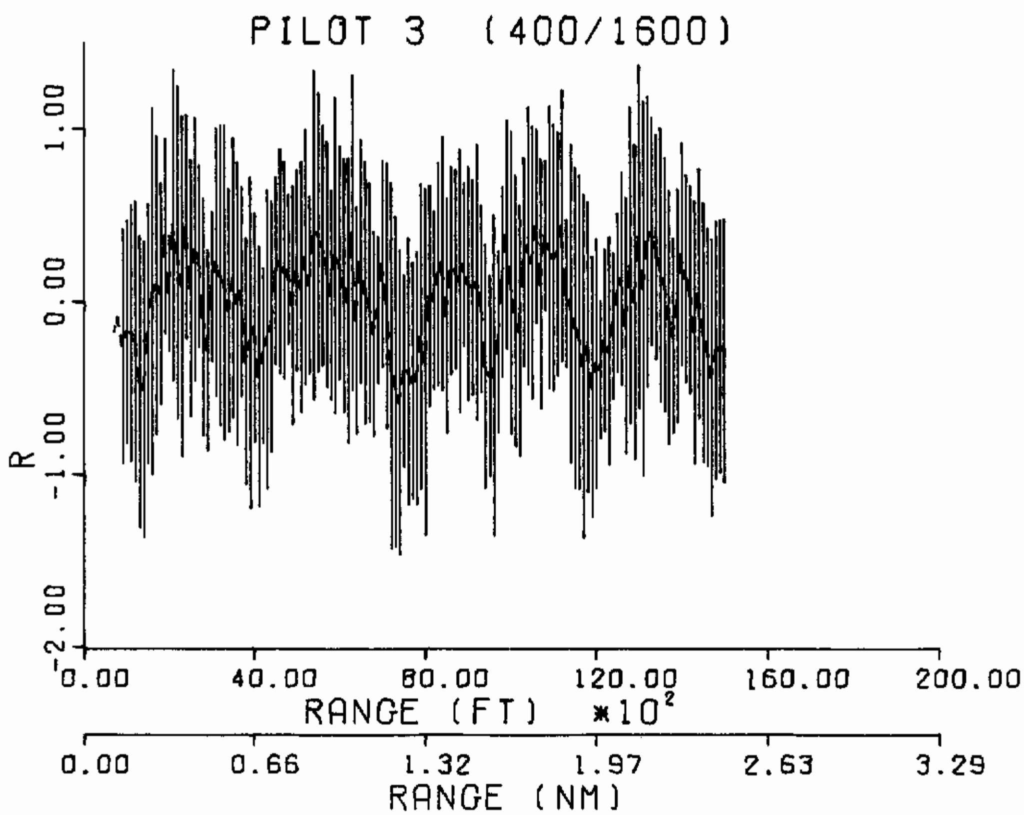

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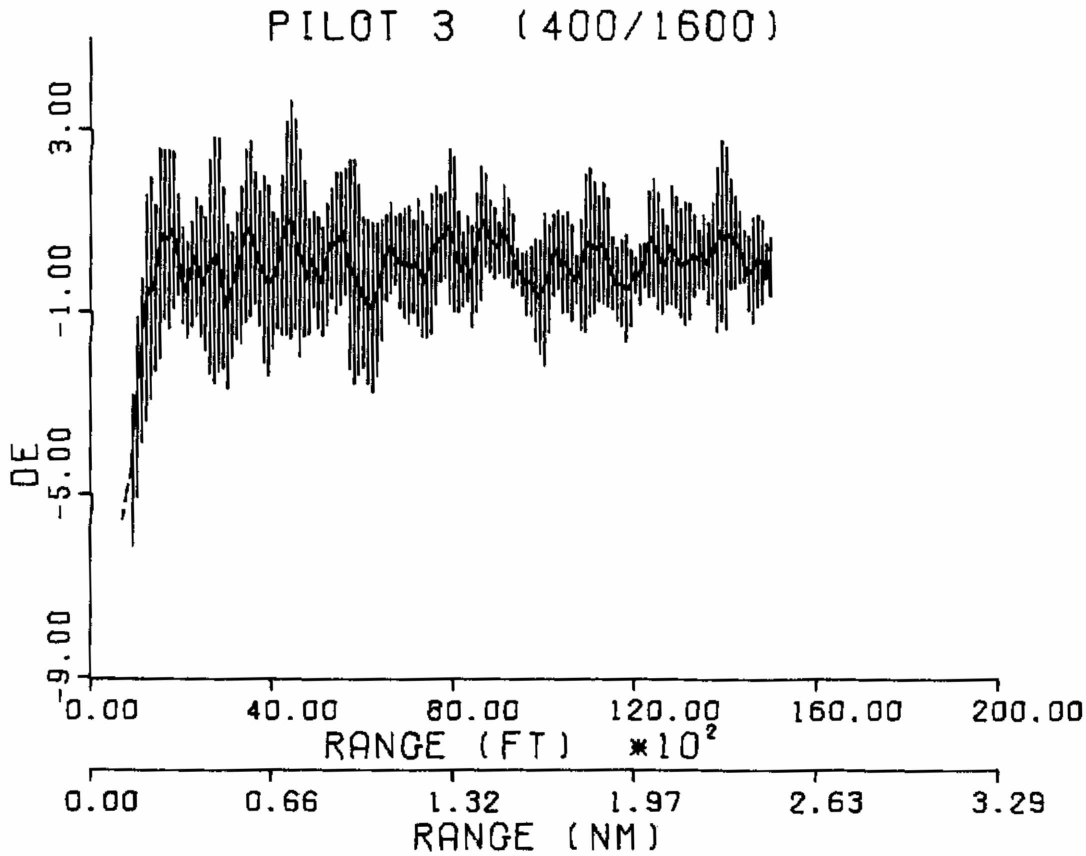
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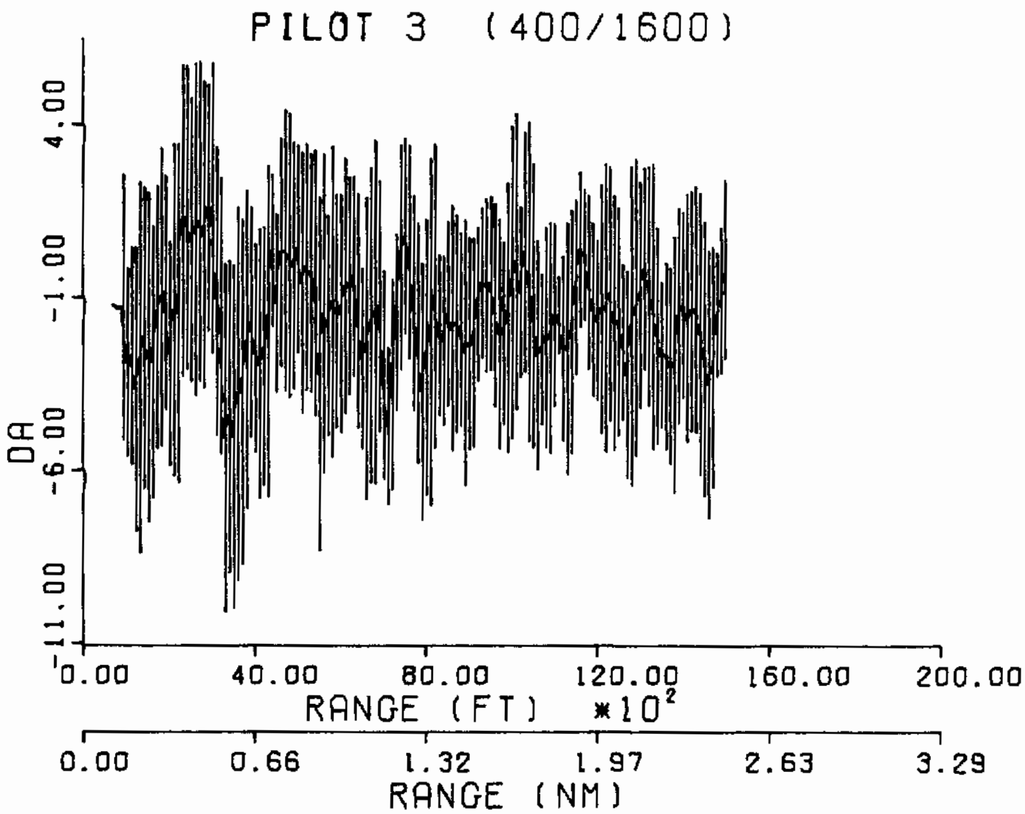
2.63
3.29
RANGE (NM)

Contrails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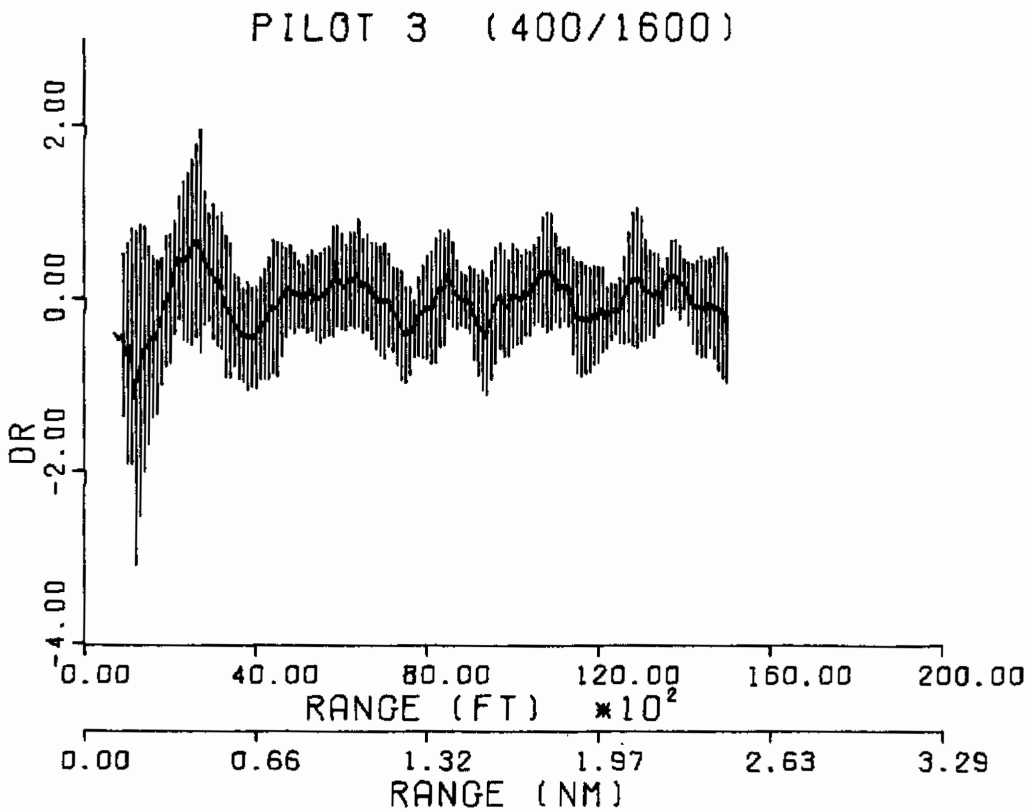
RANGE (NM)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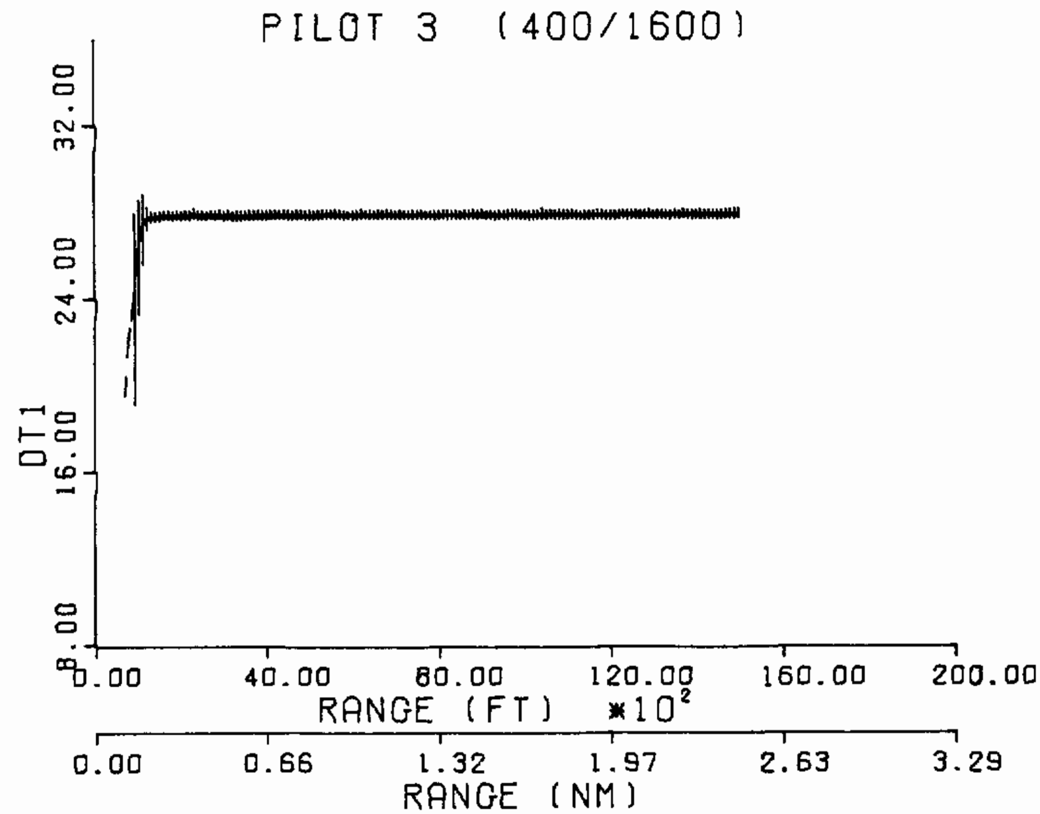

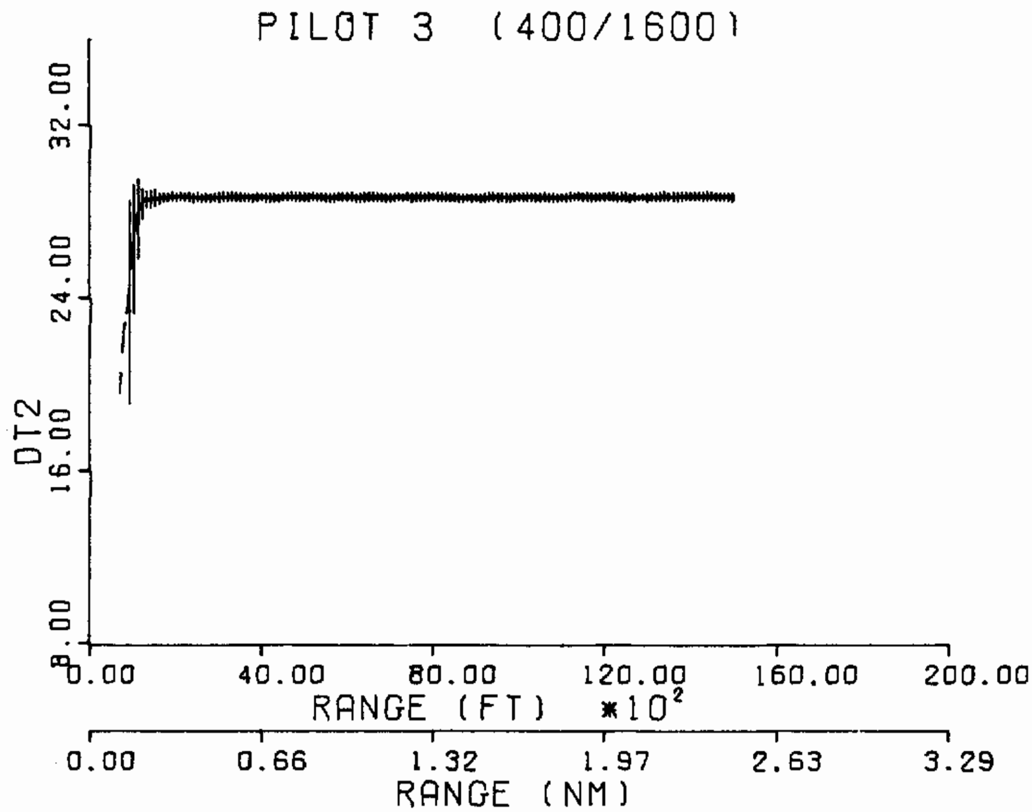

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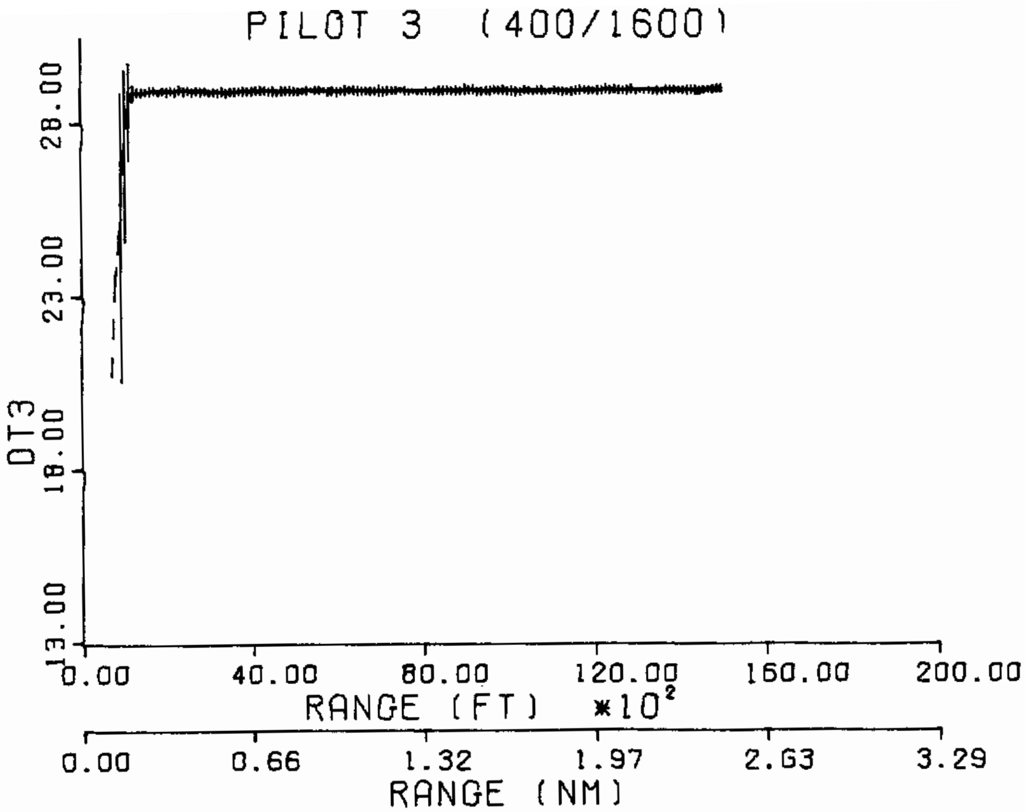

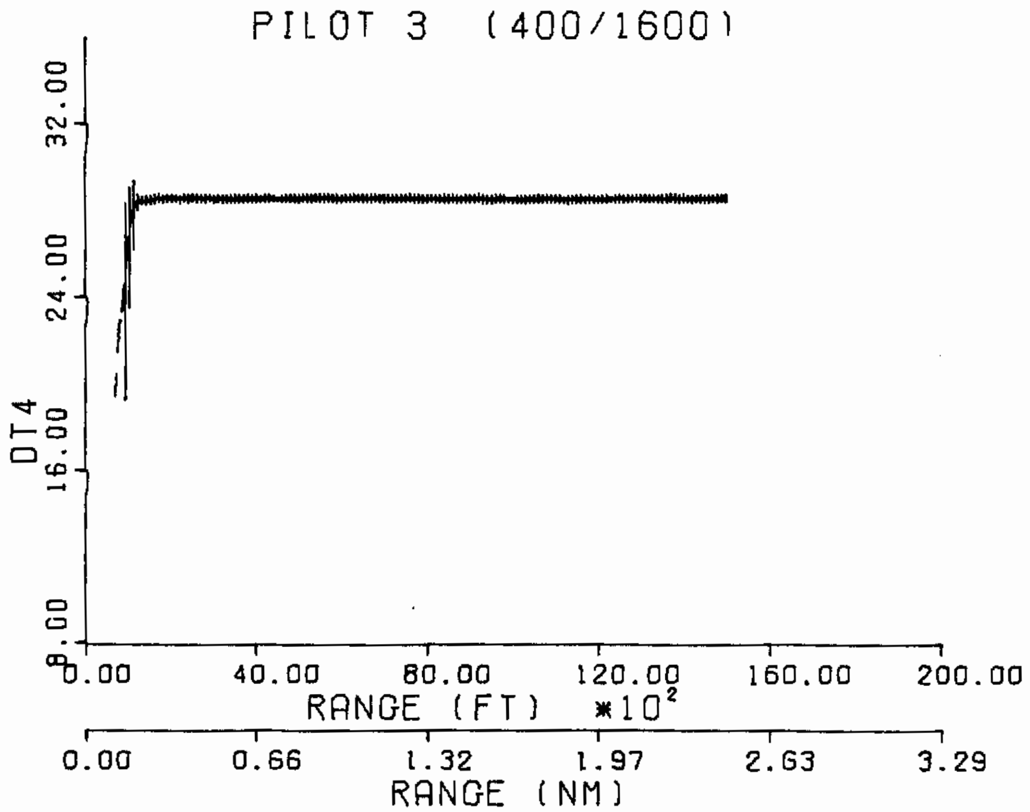

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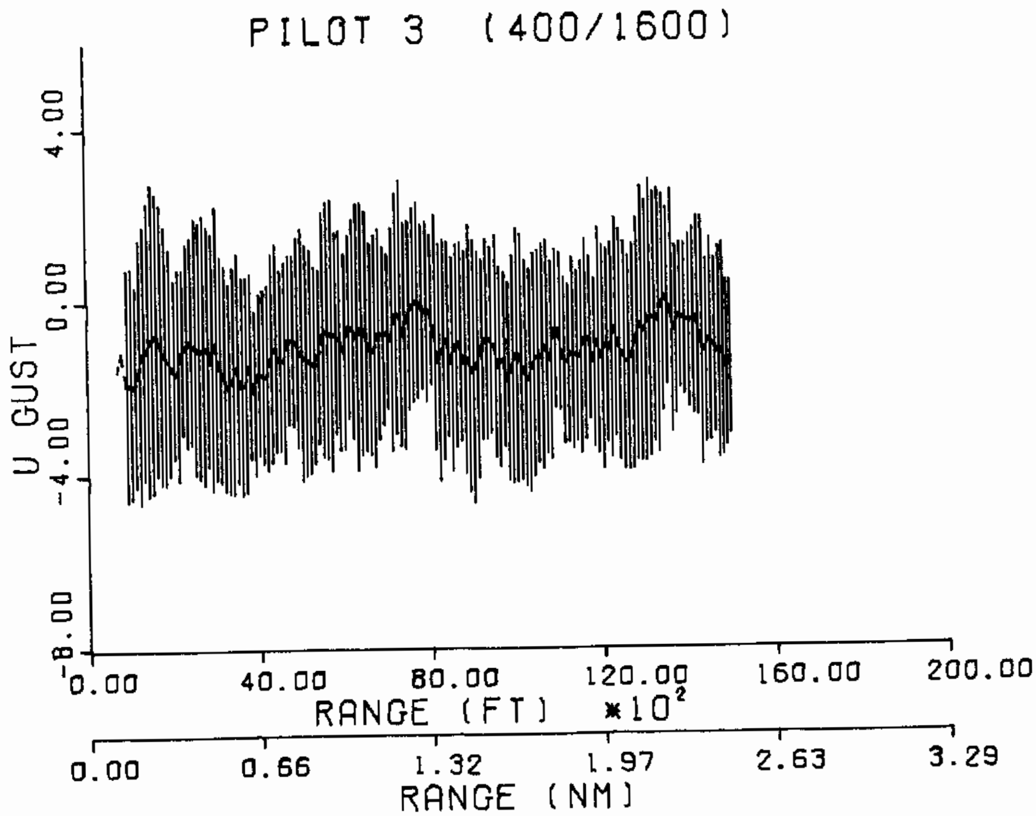
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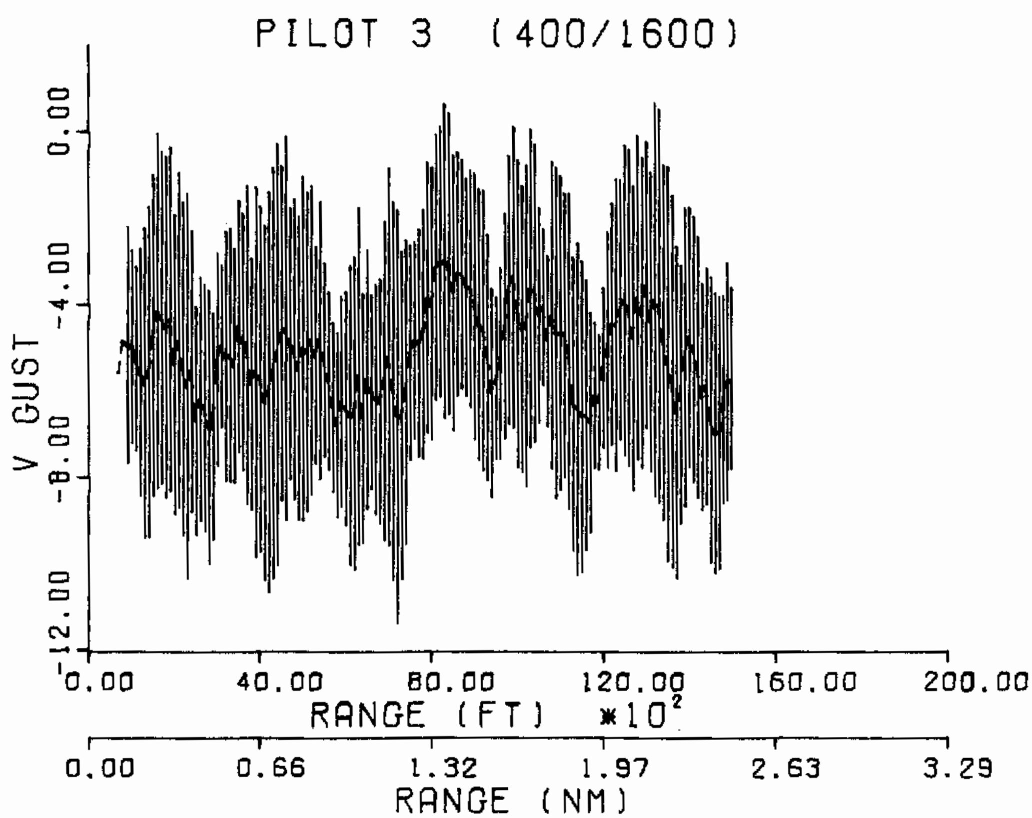
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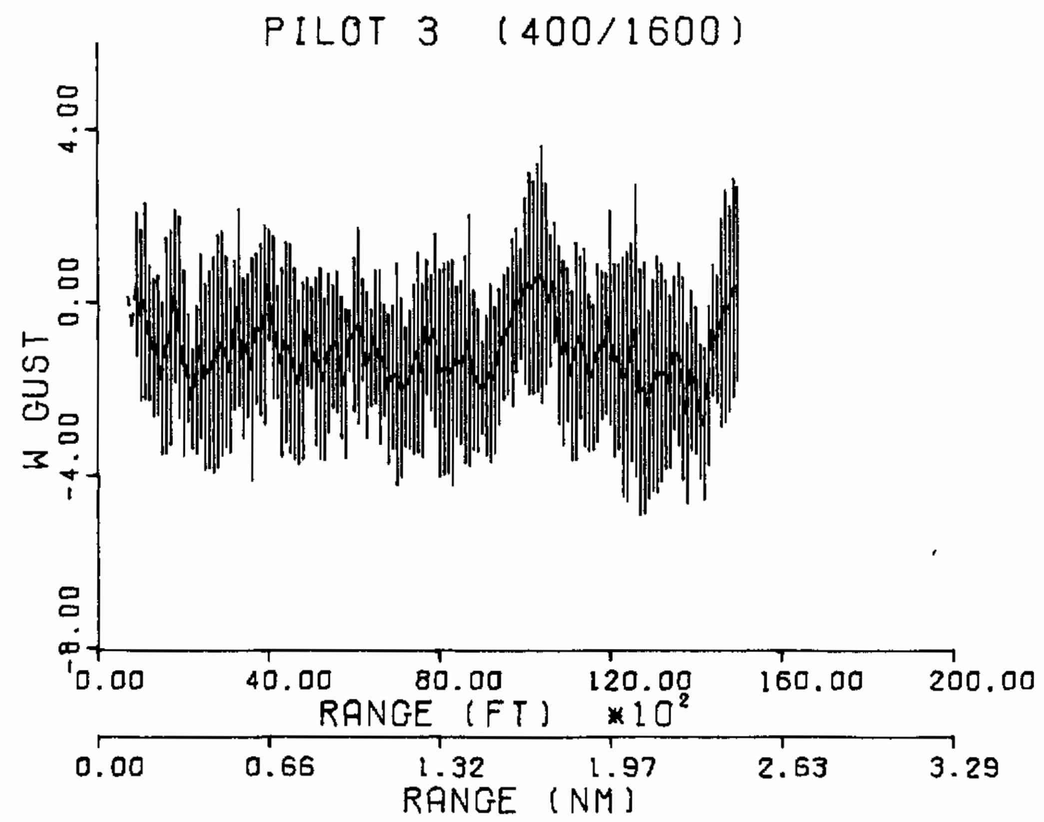

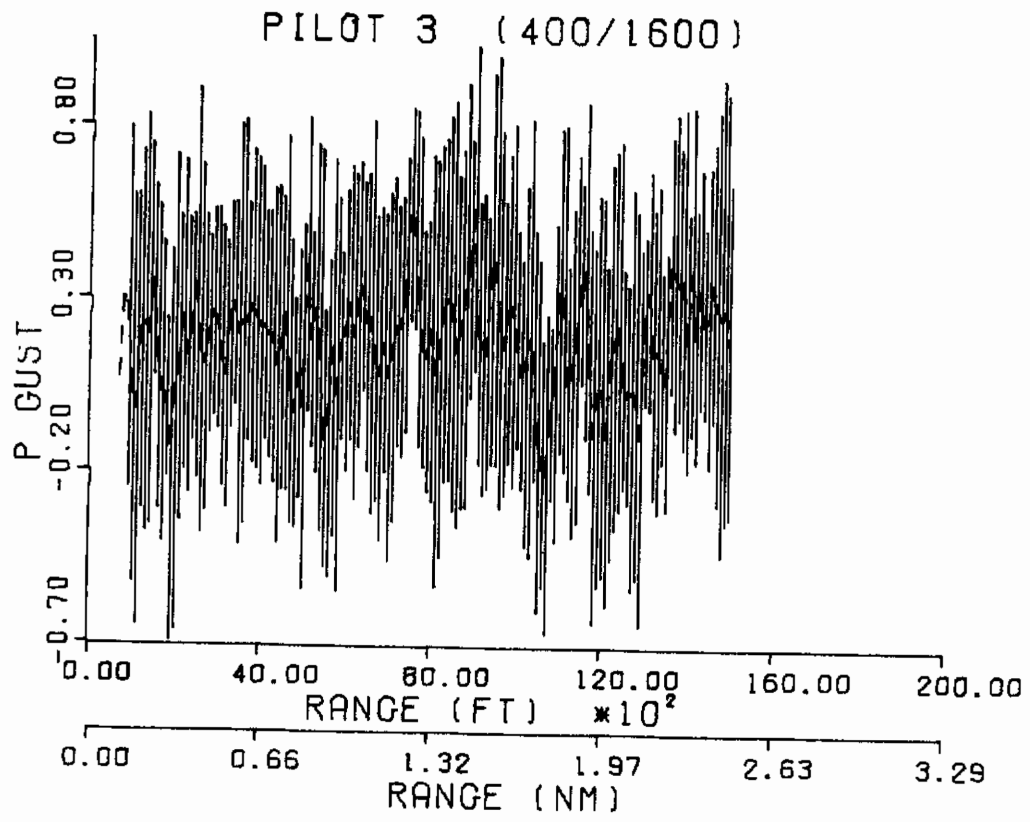

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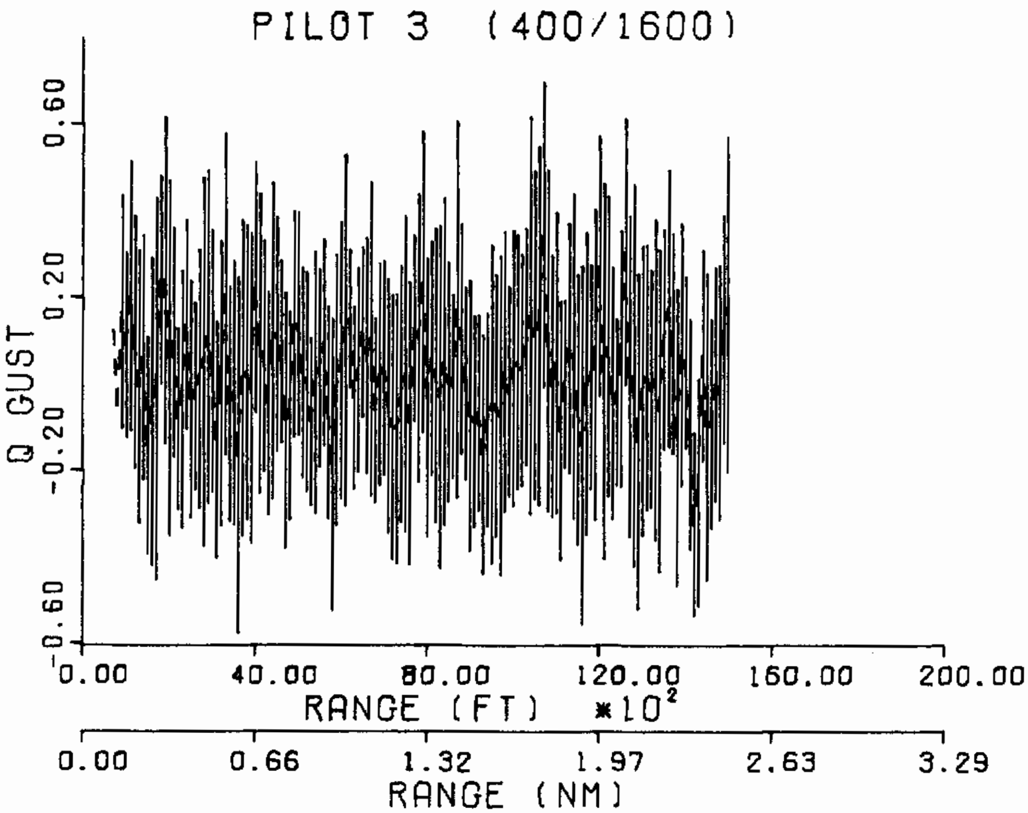

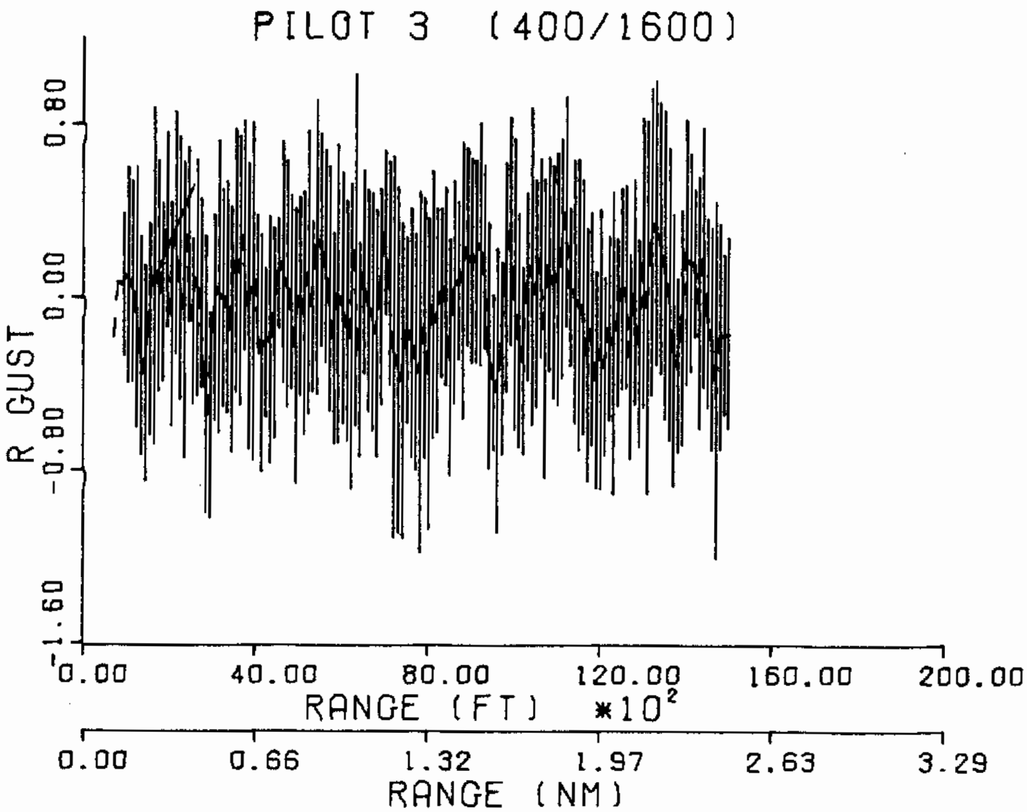

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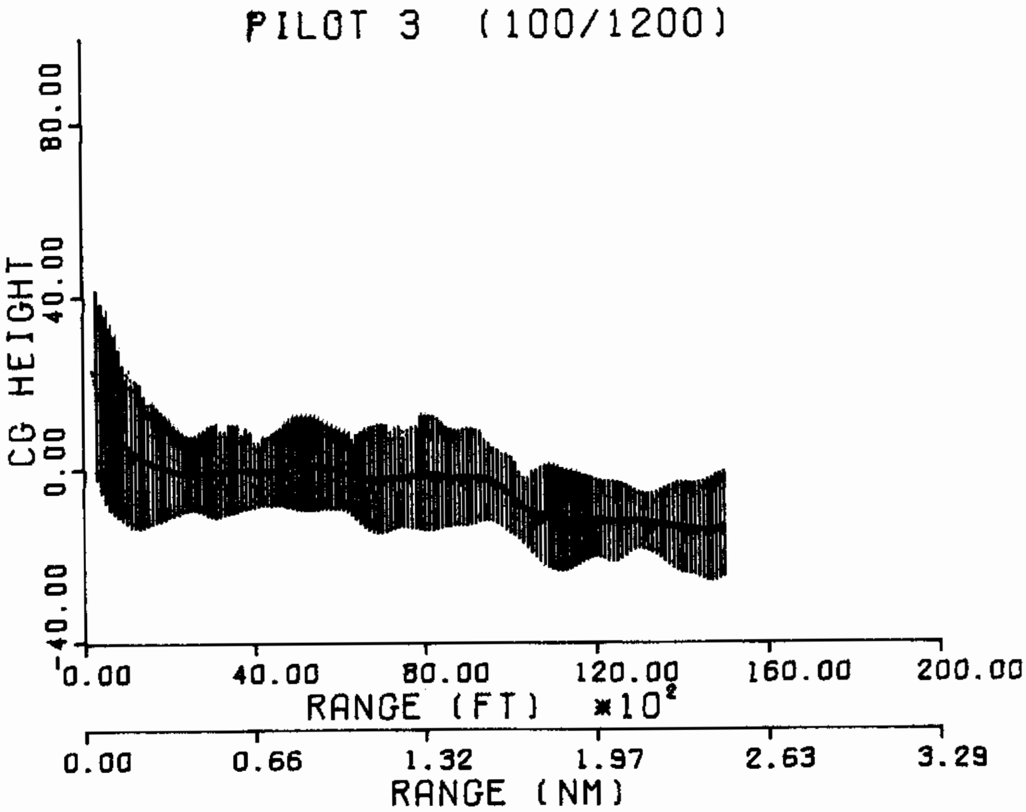

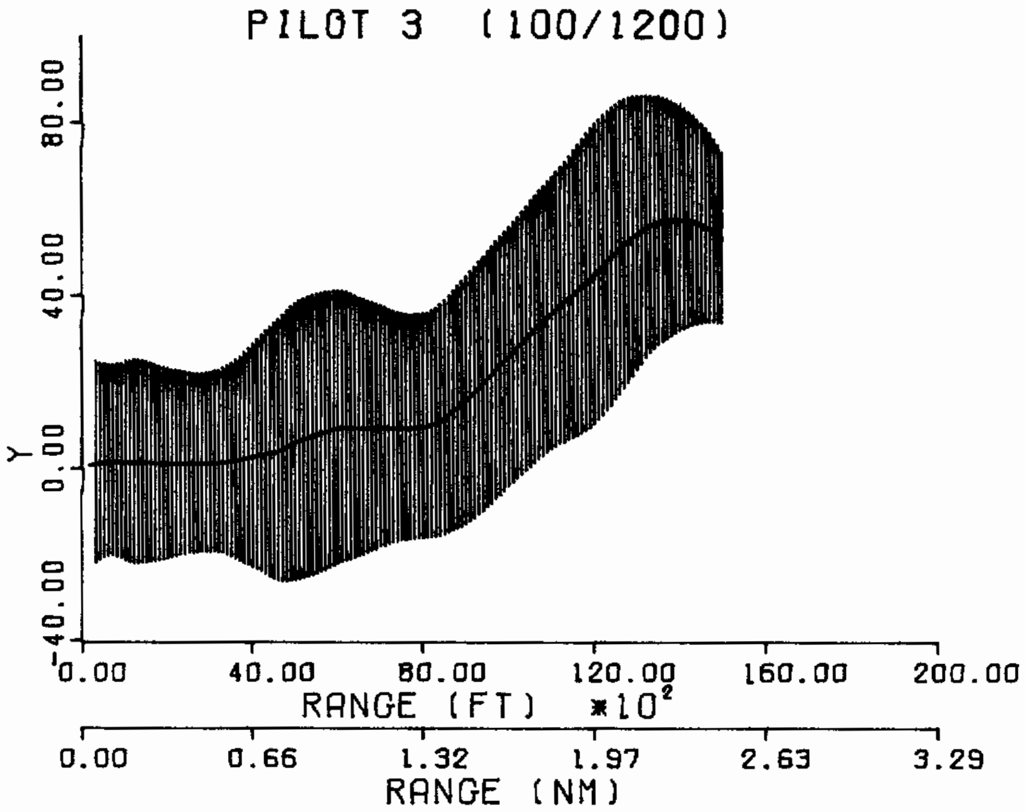

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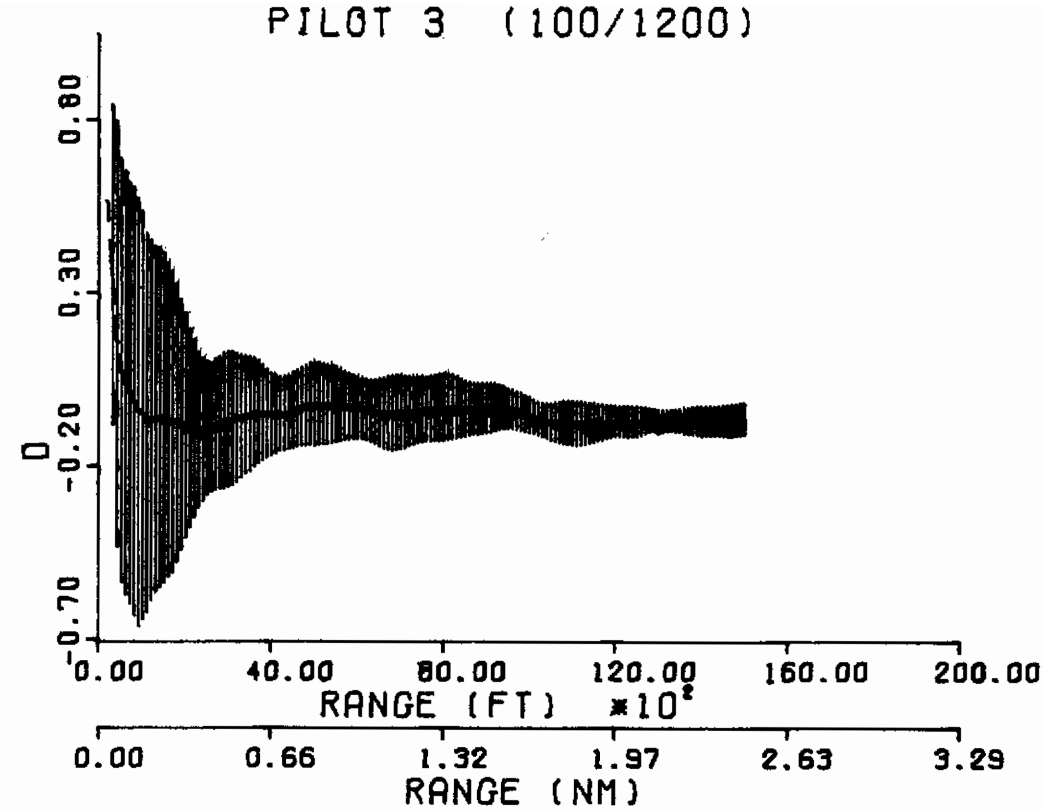

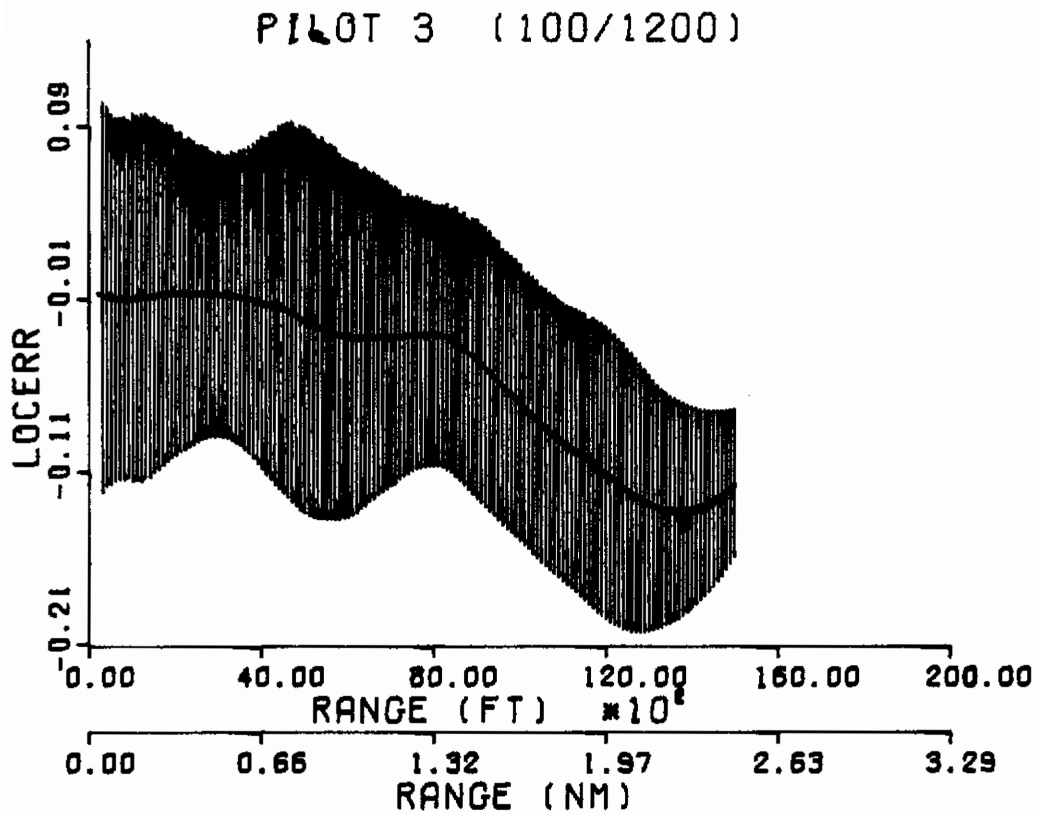

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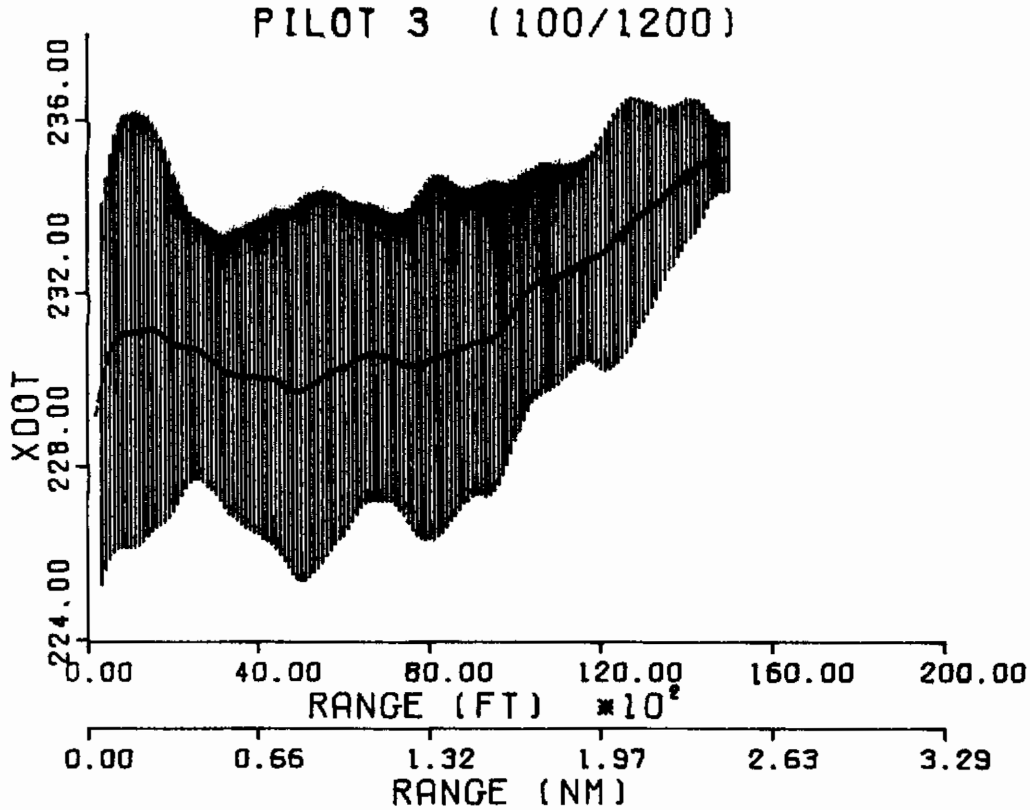

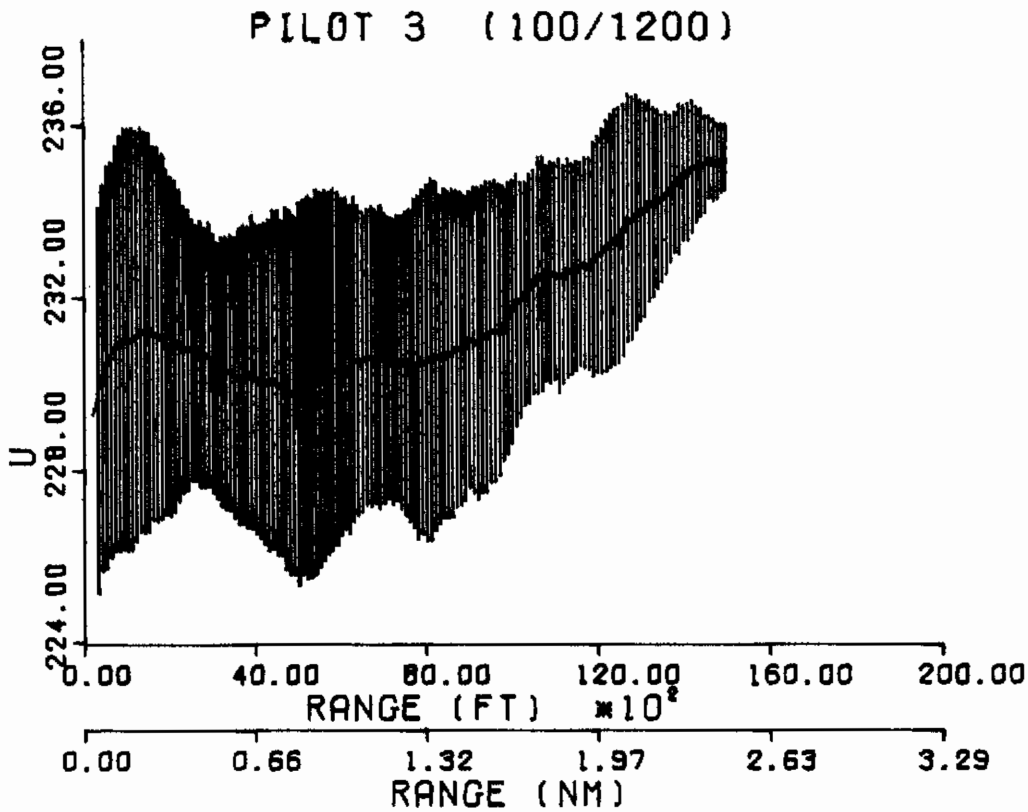

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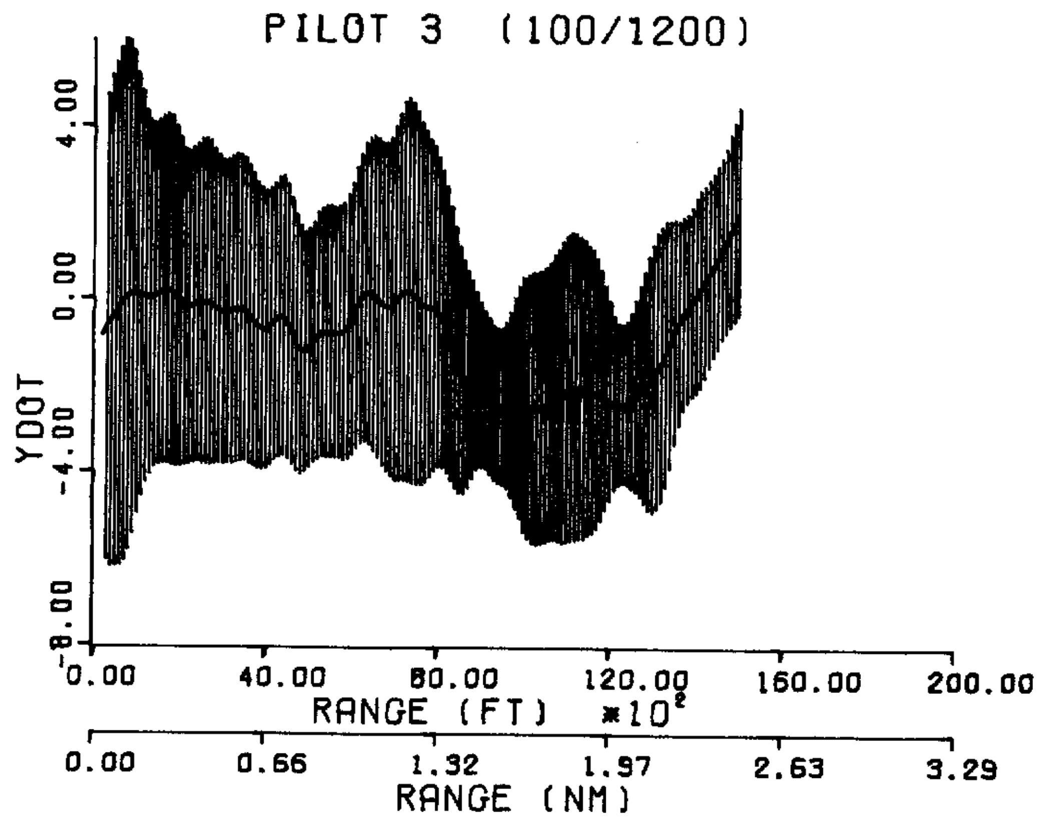

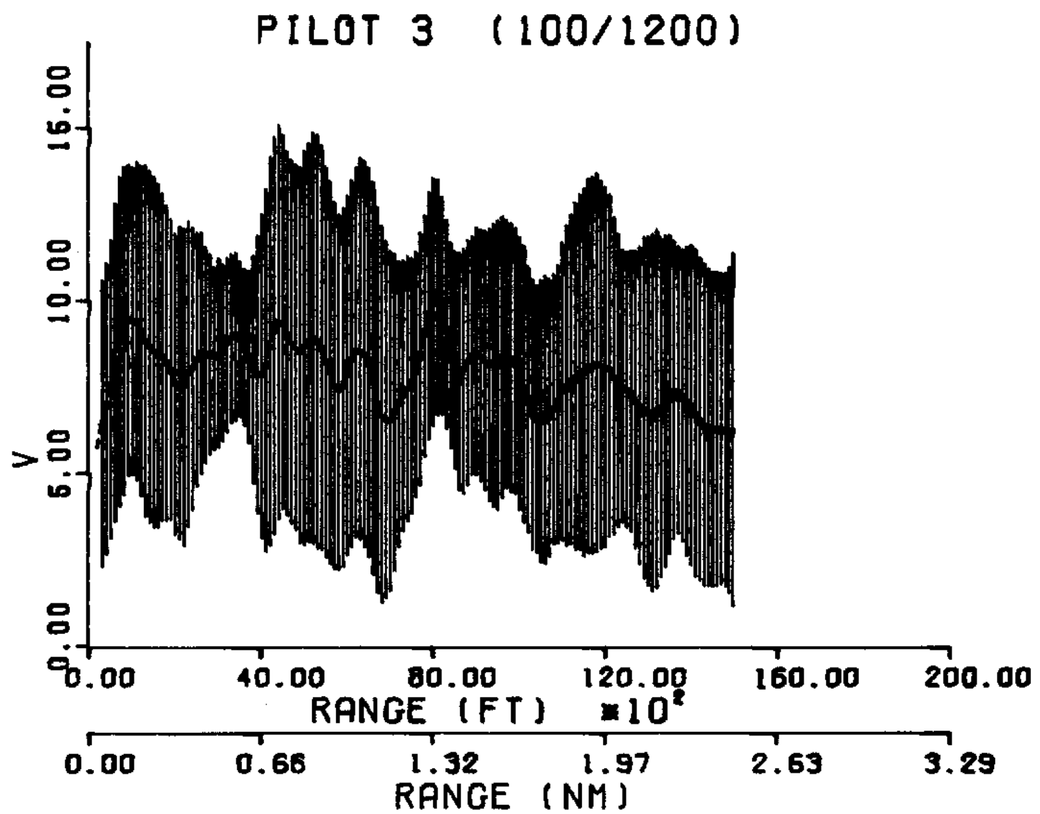

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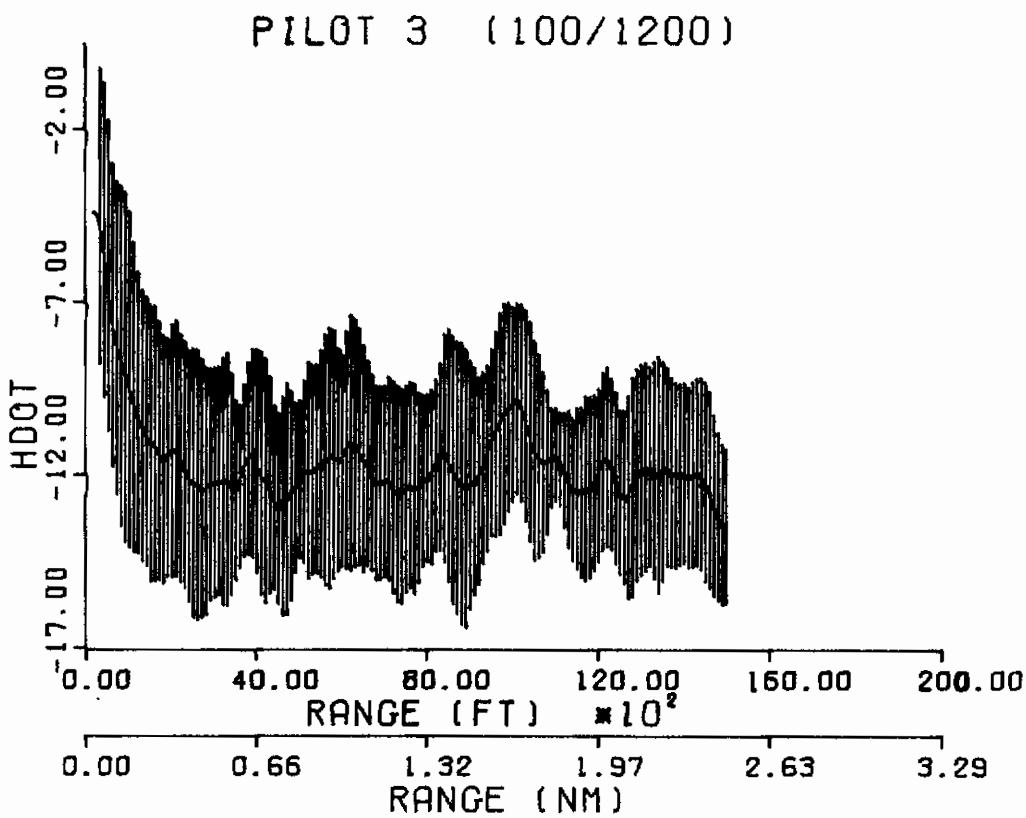

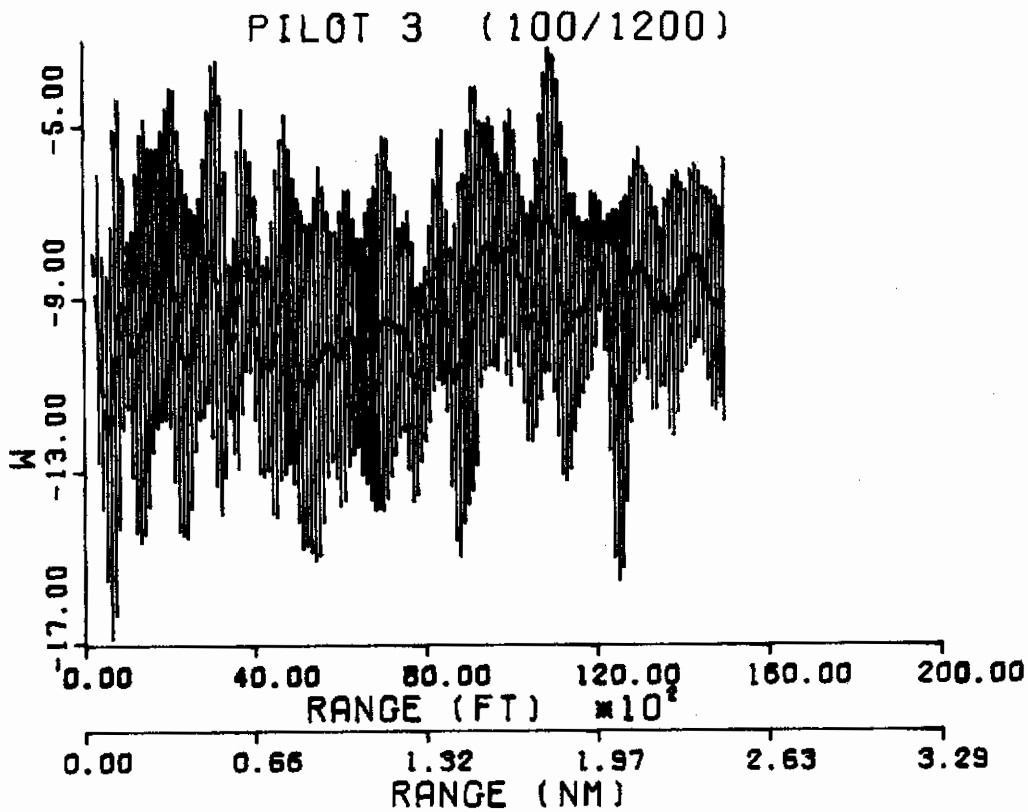

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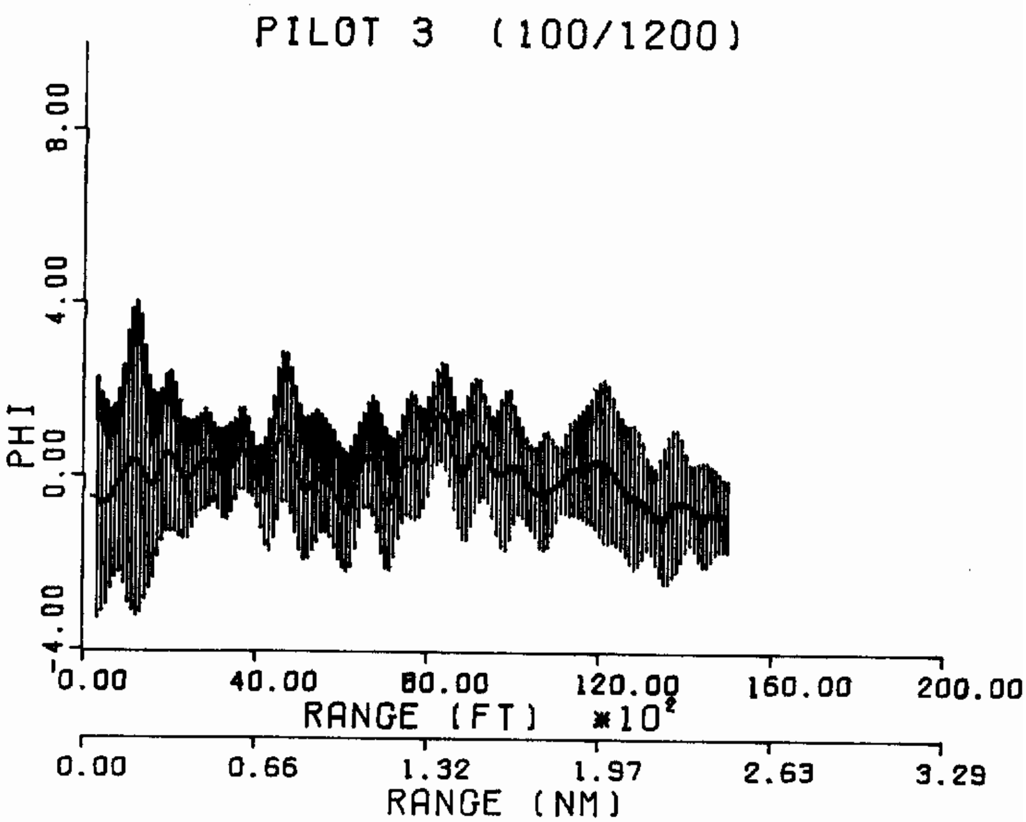

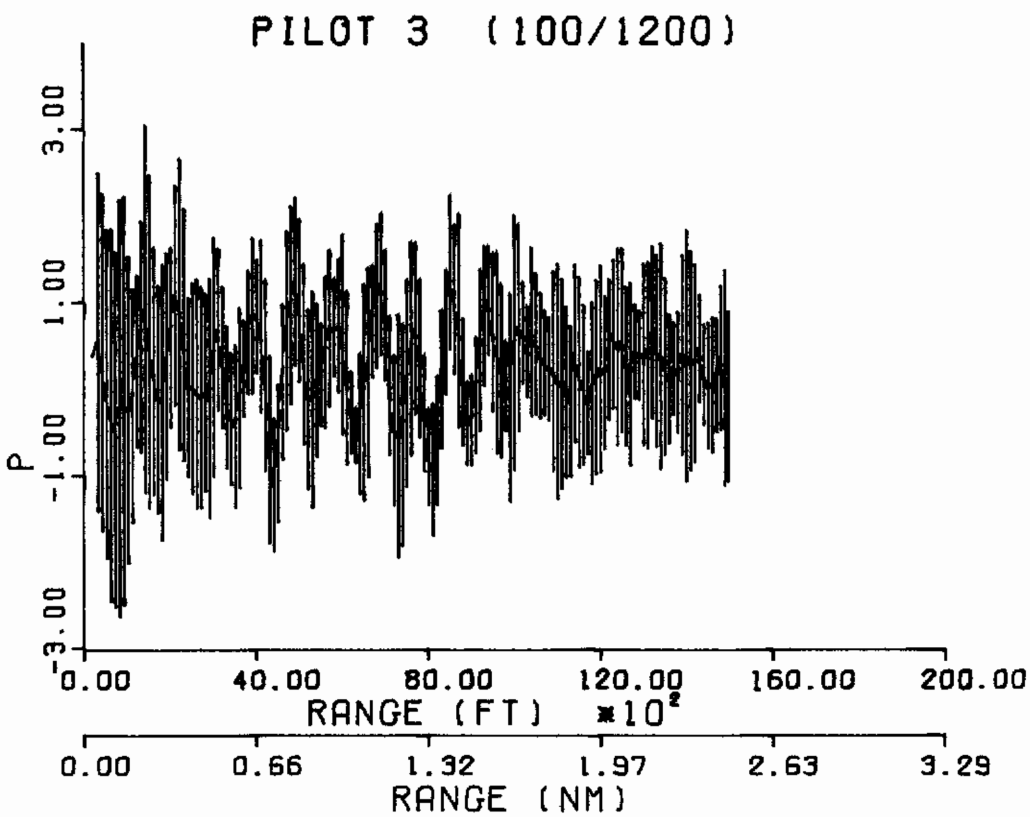

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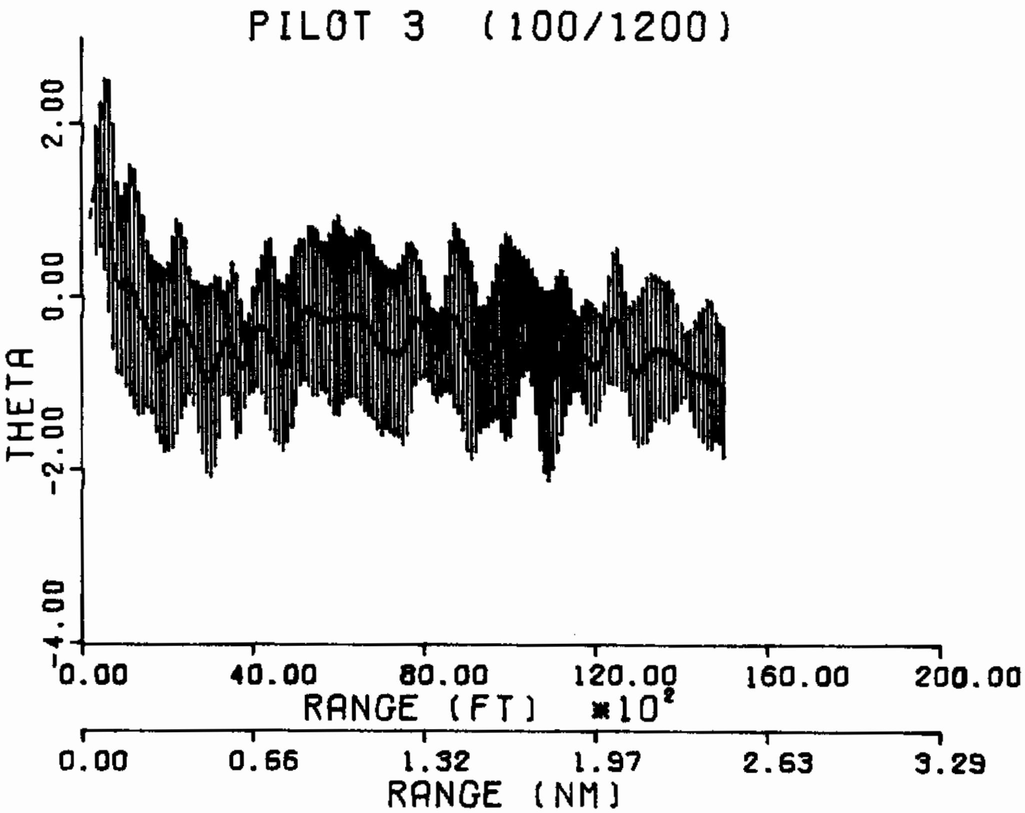

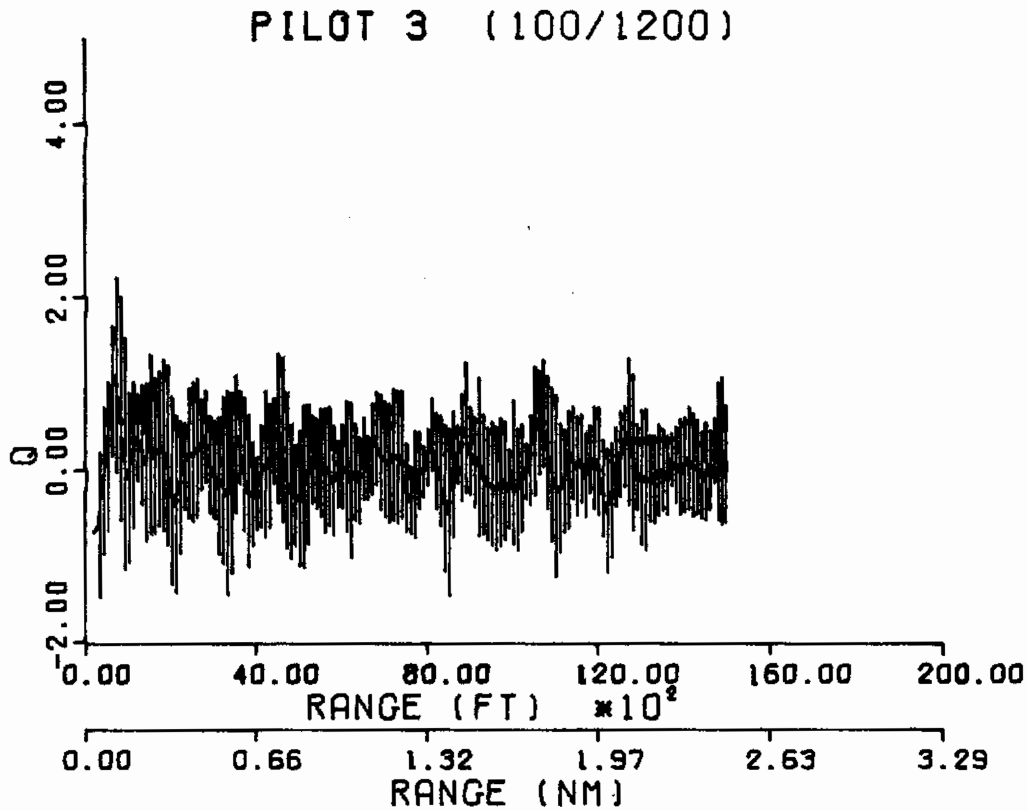

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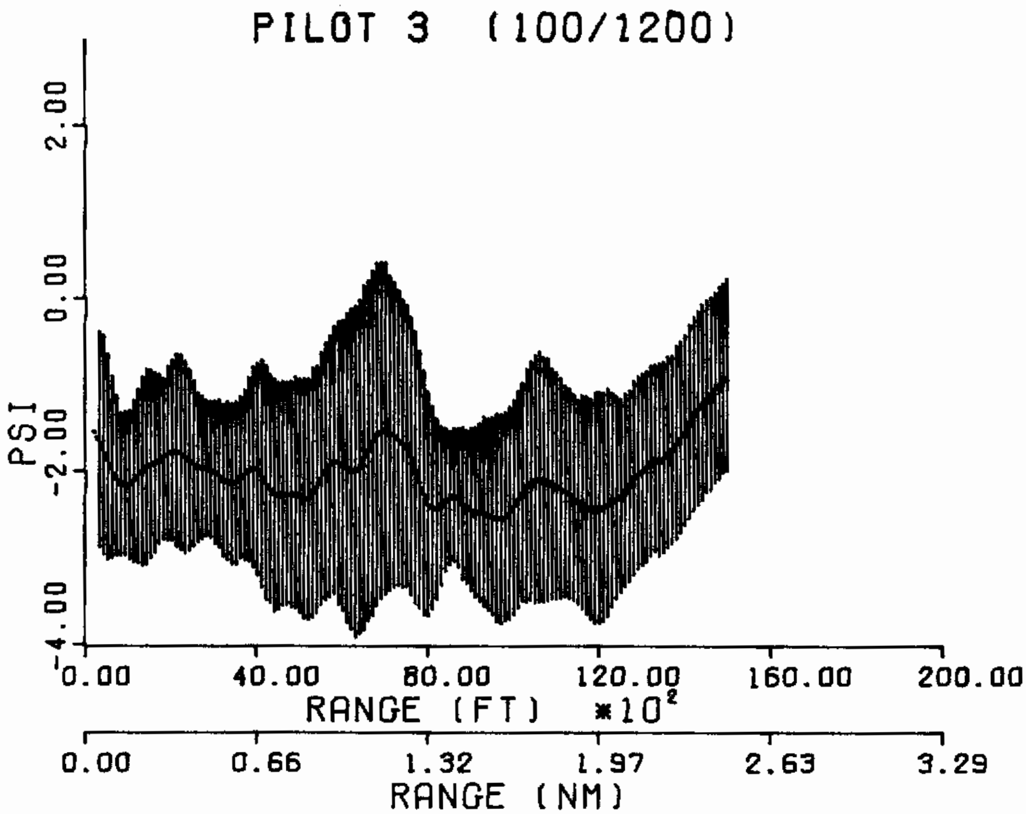

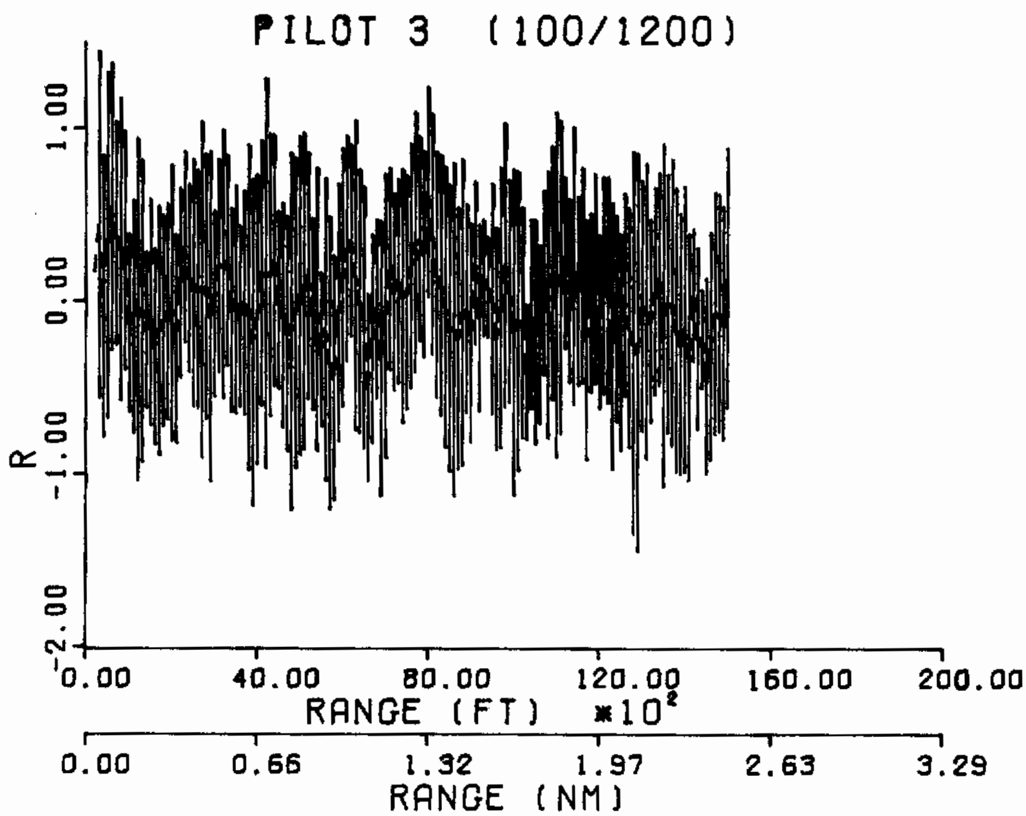

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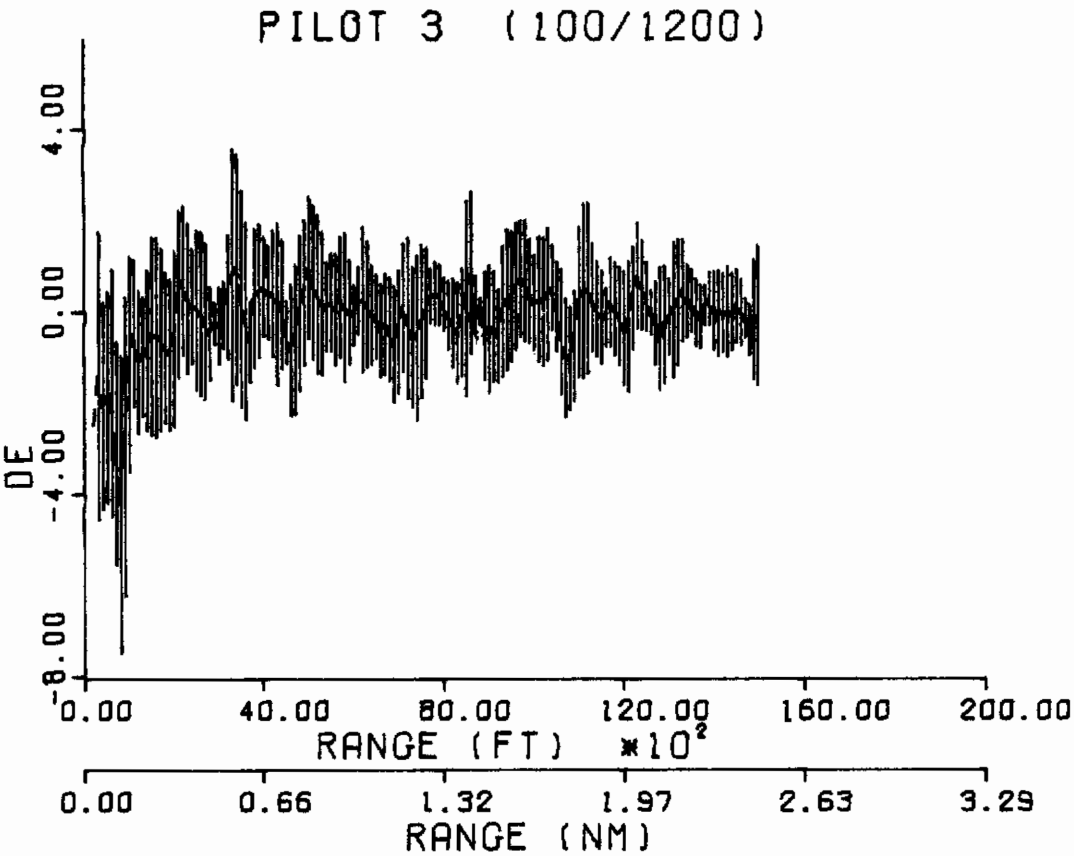

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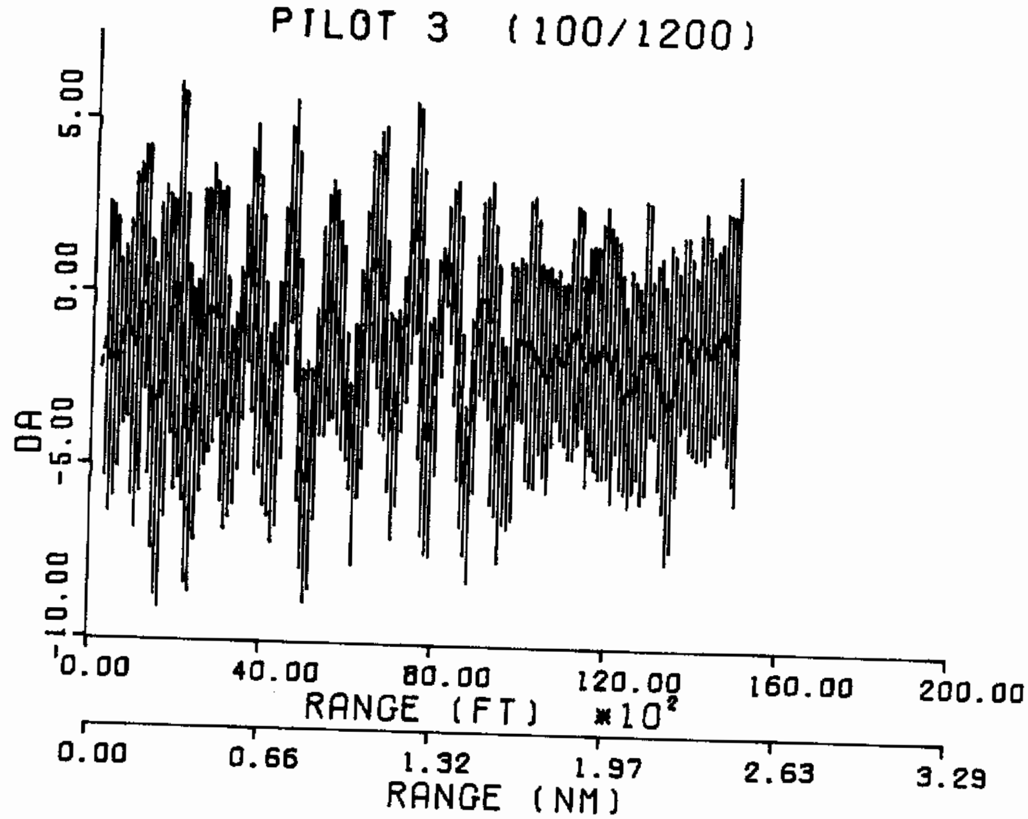

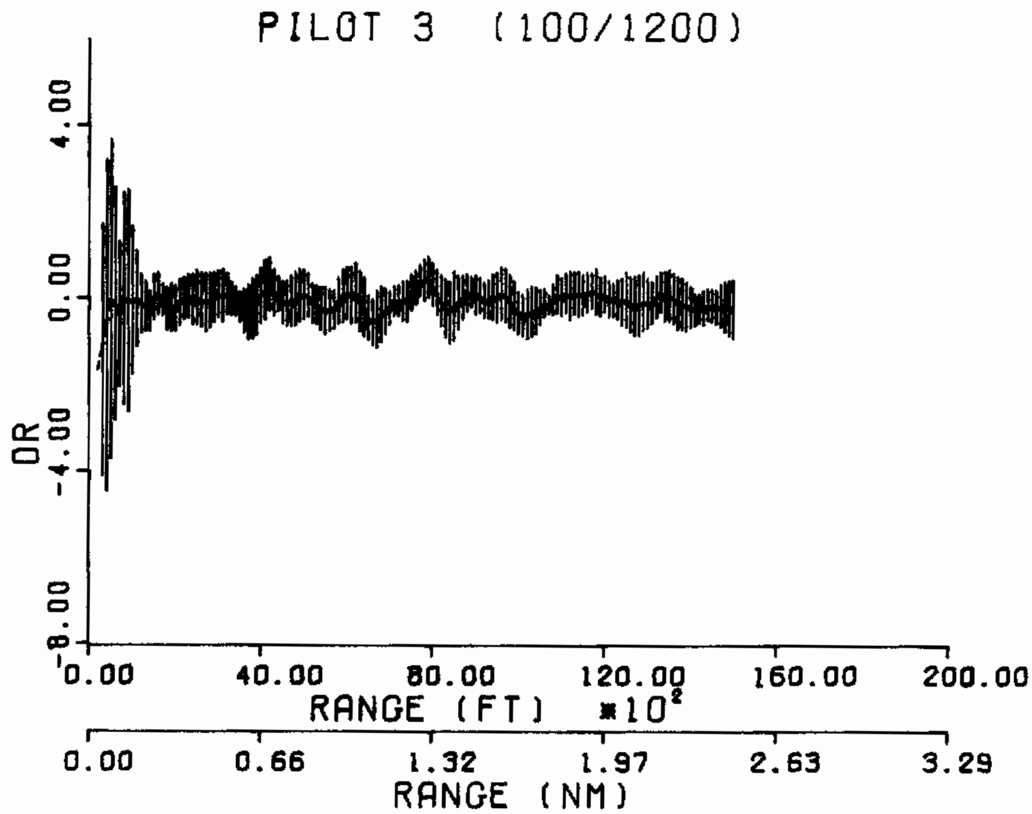

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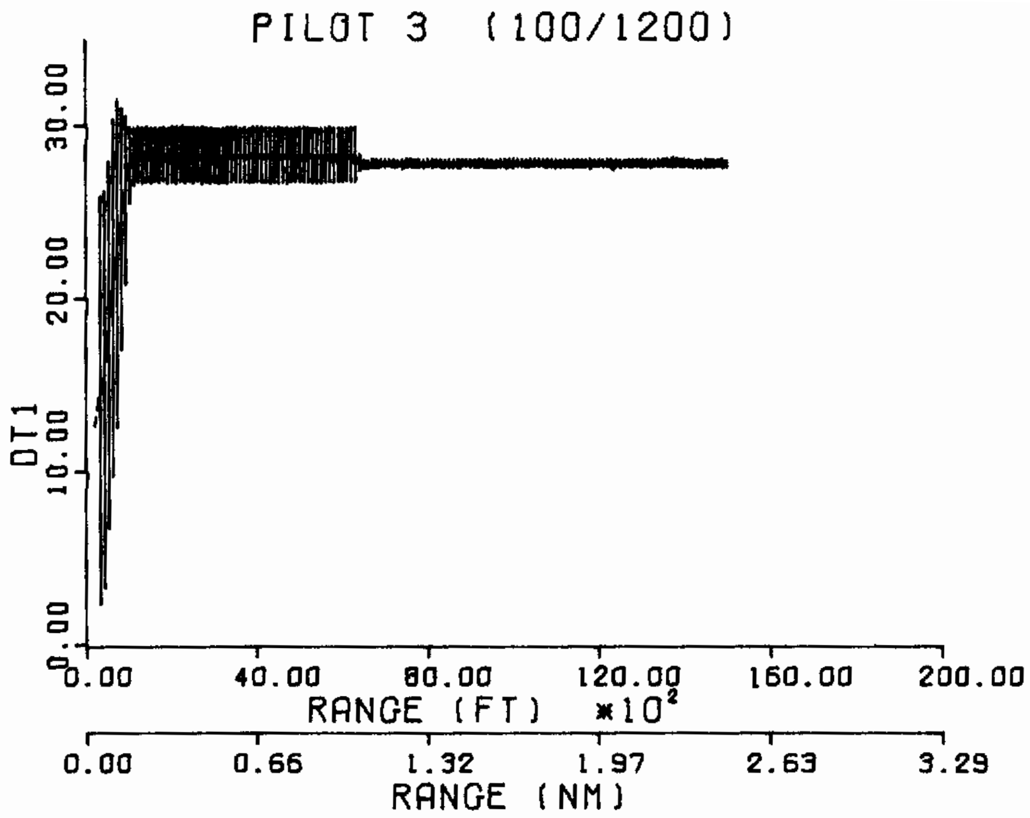

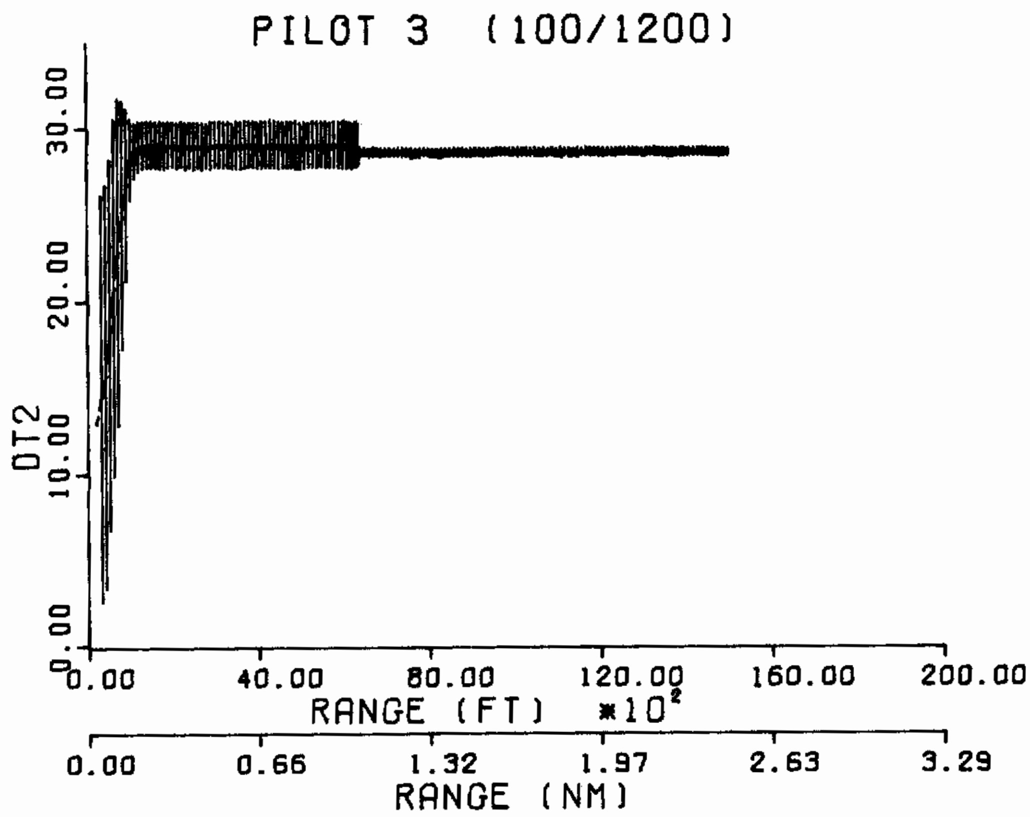

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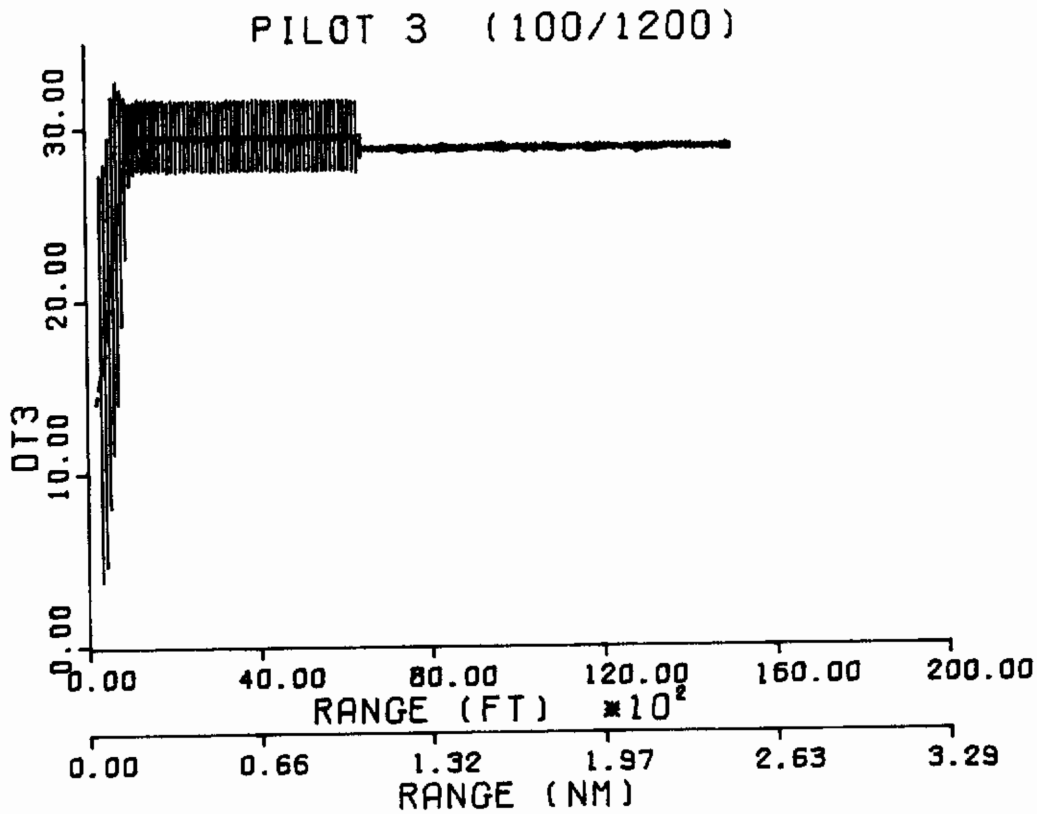

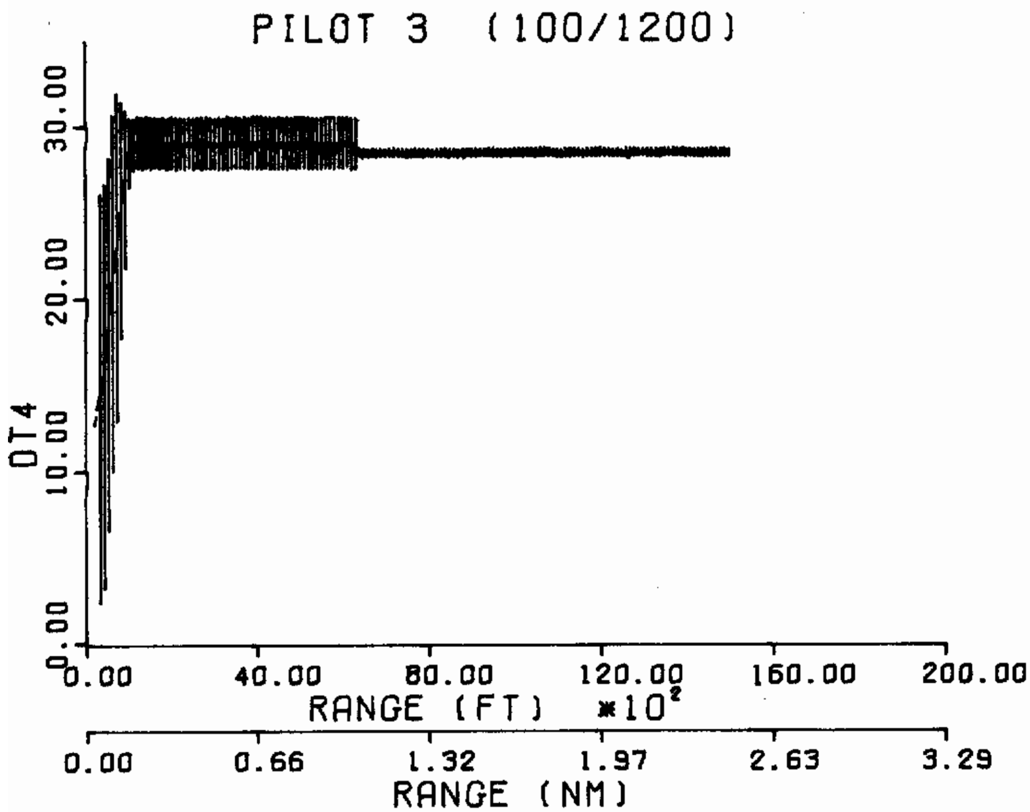

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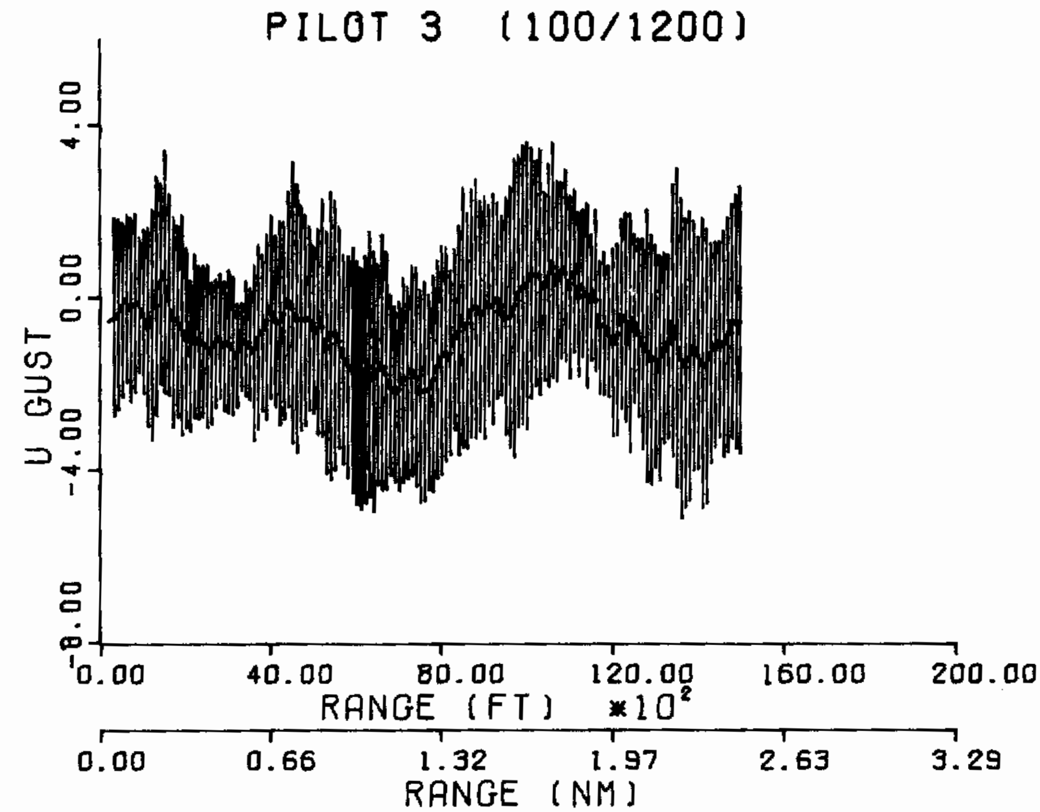

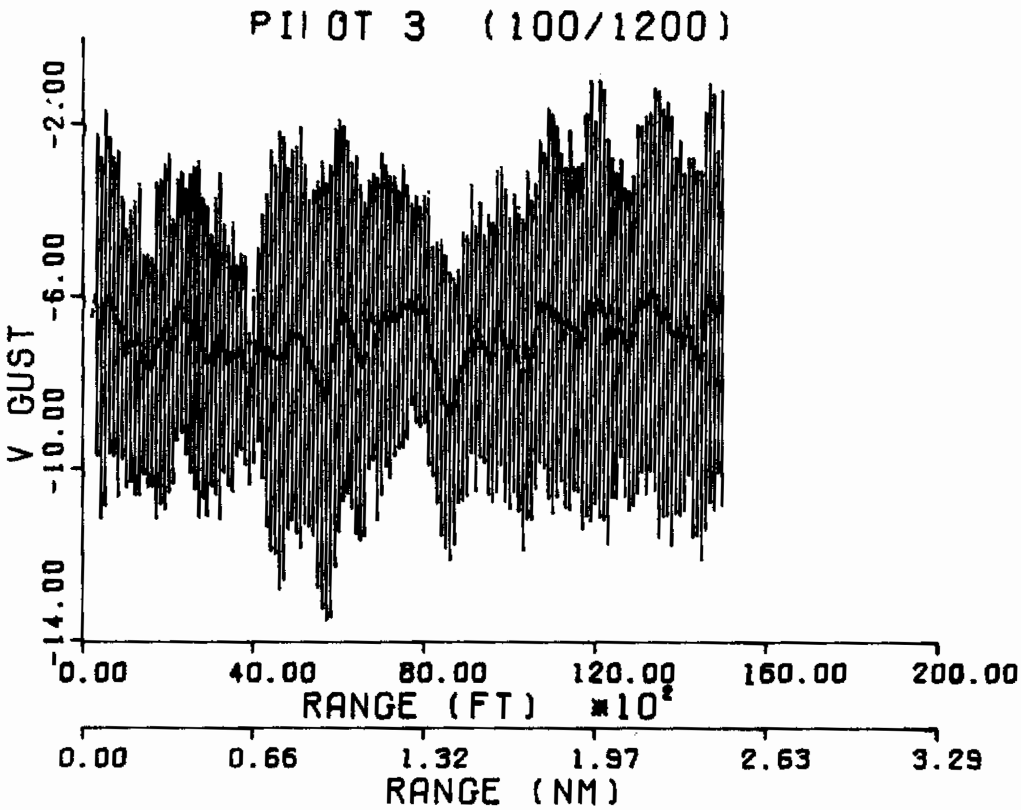

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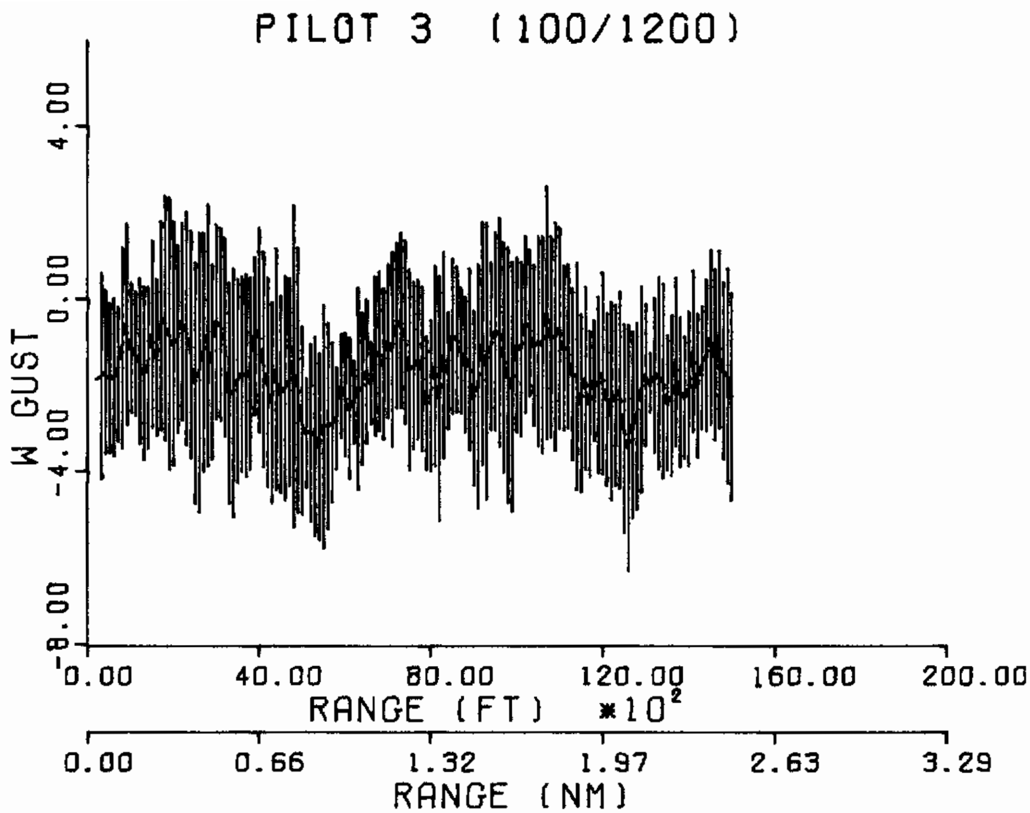

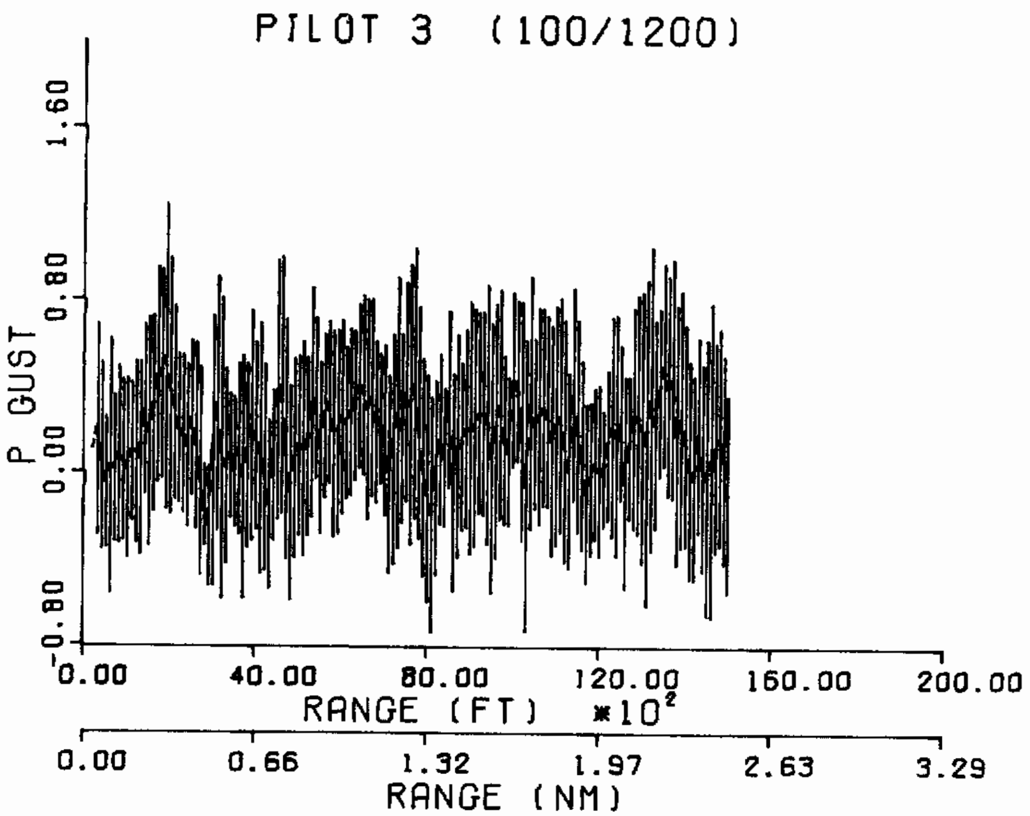

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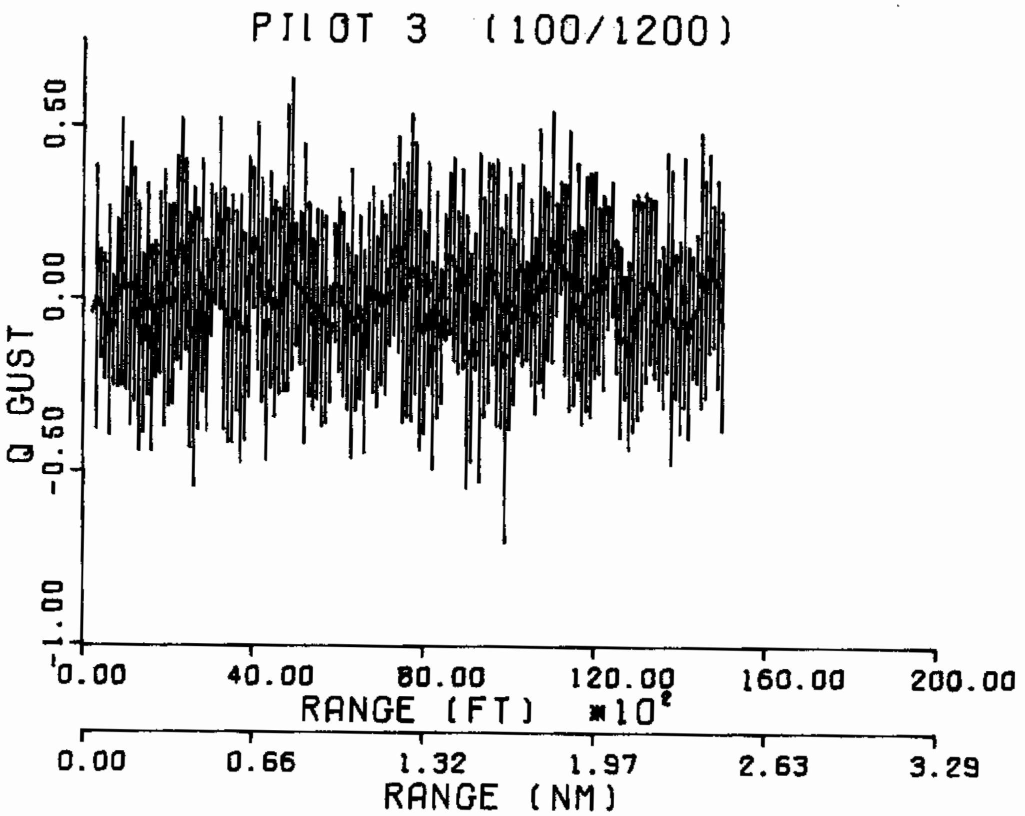

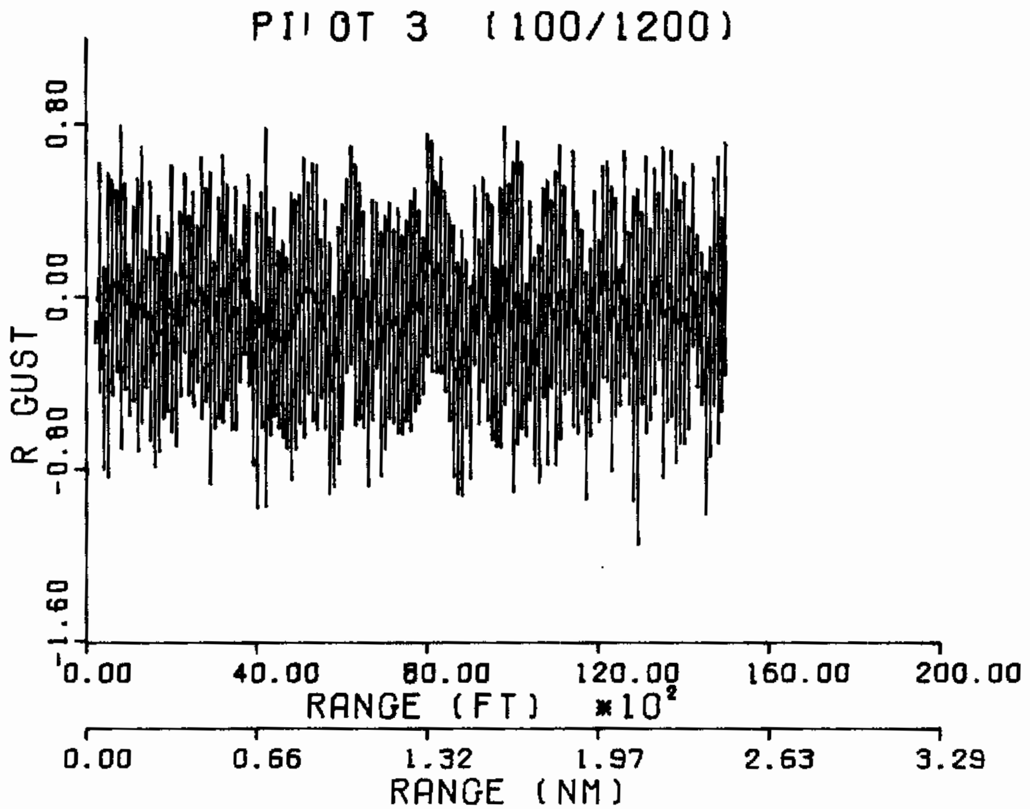

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APPENDIX 6

PLOTS FROM TYPICAL RUNS

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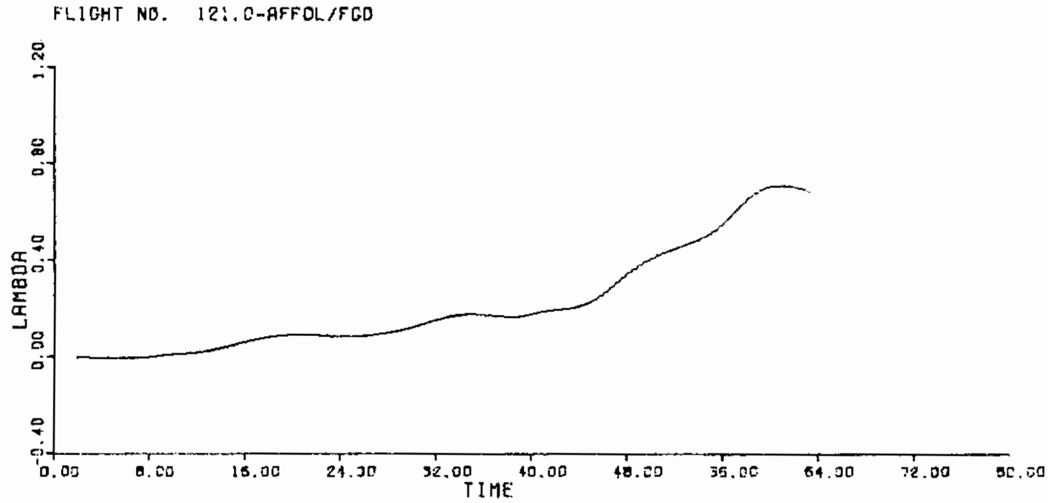

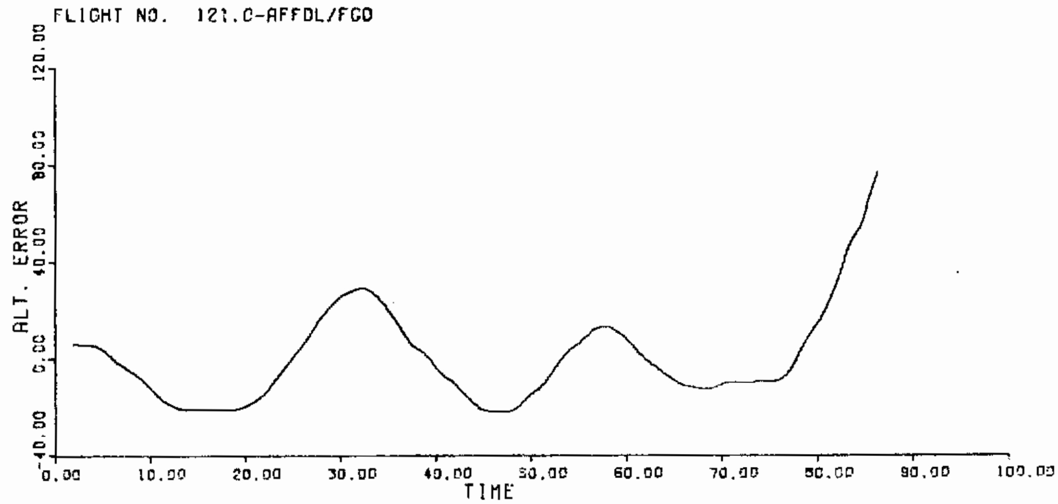

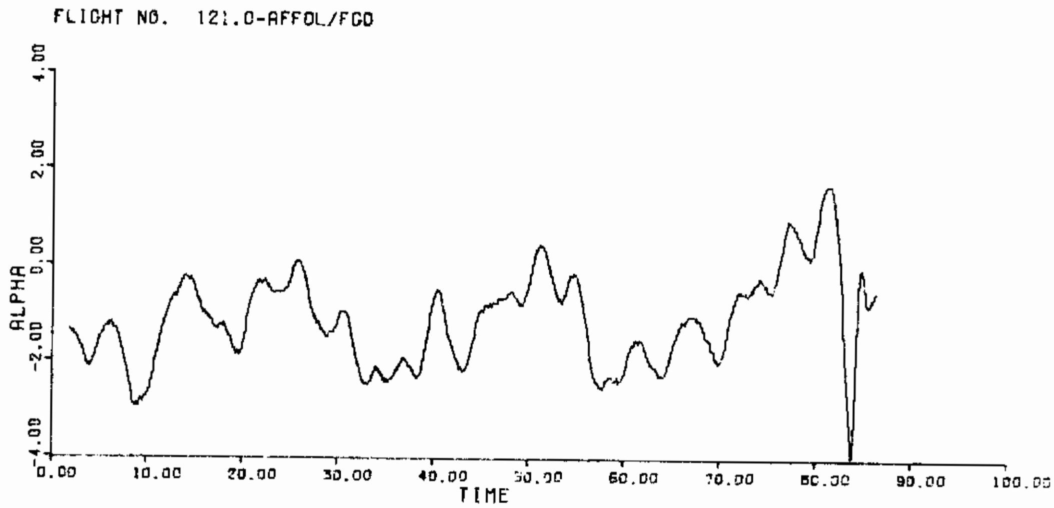

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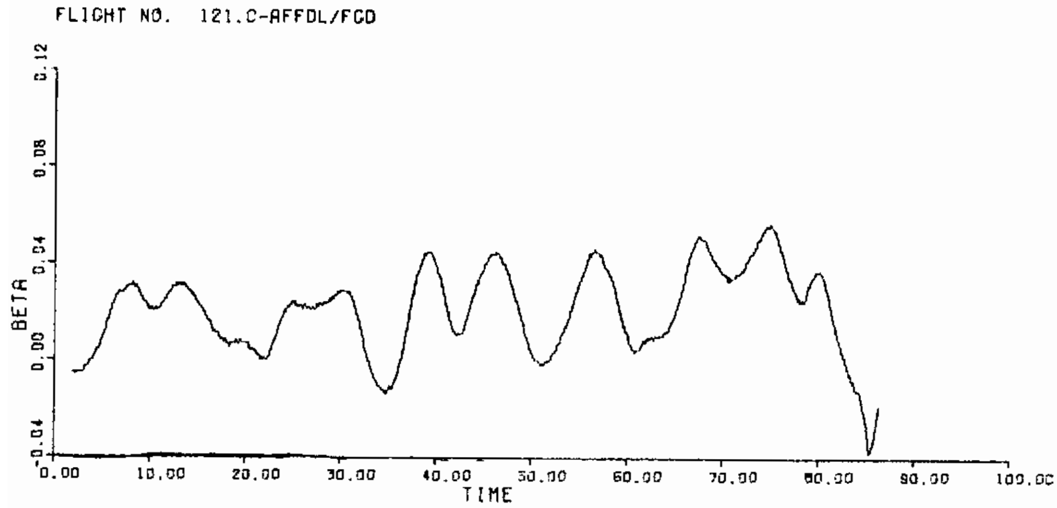

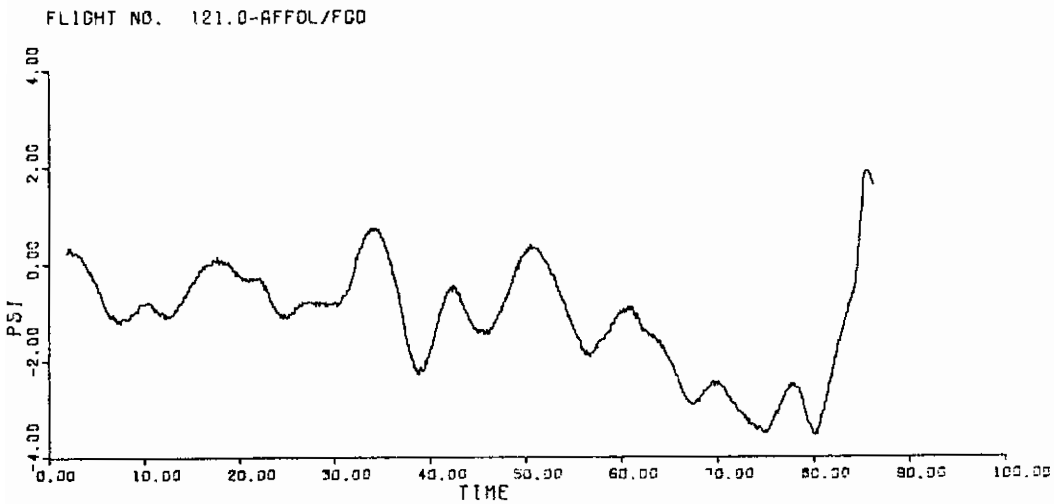

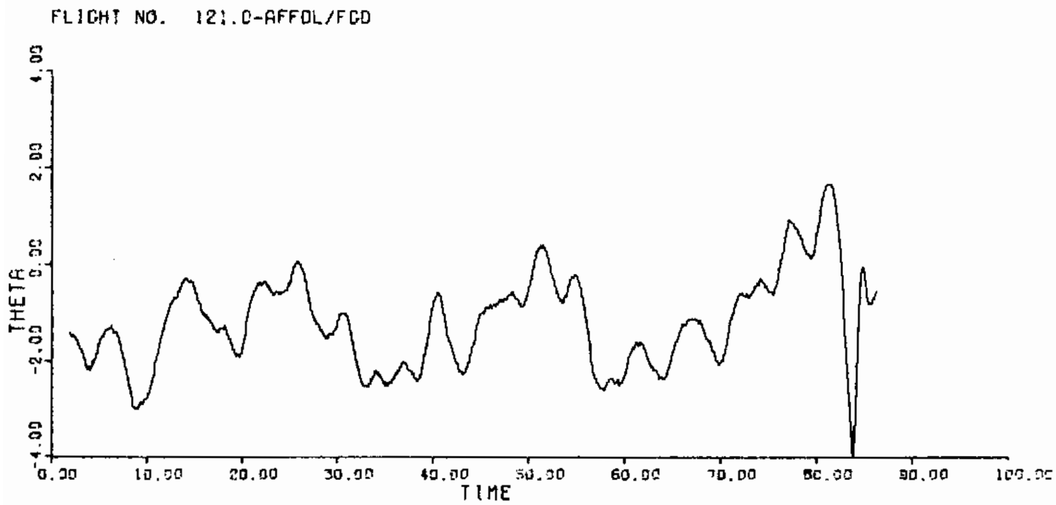

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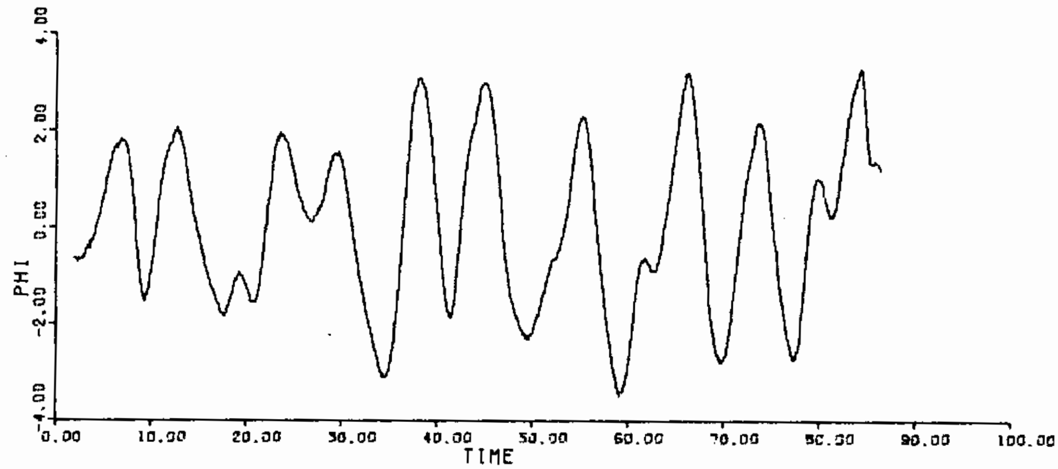

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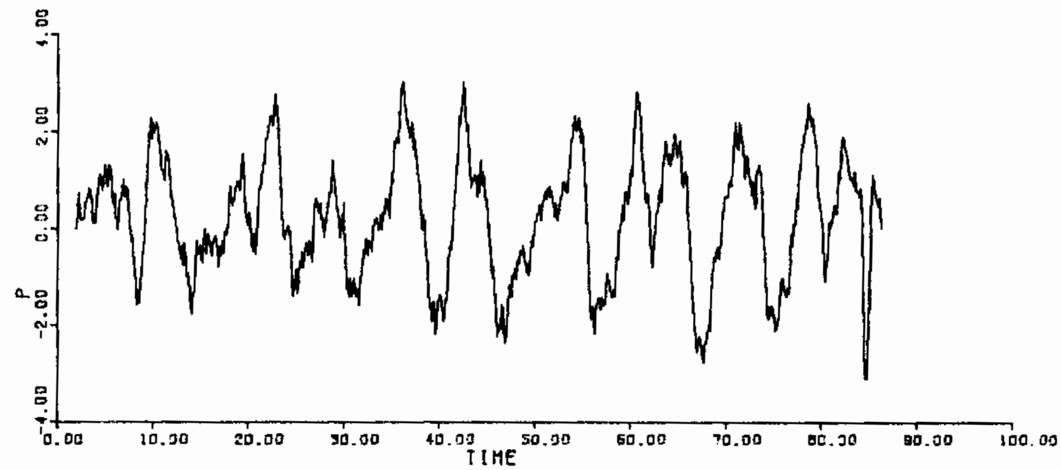

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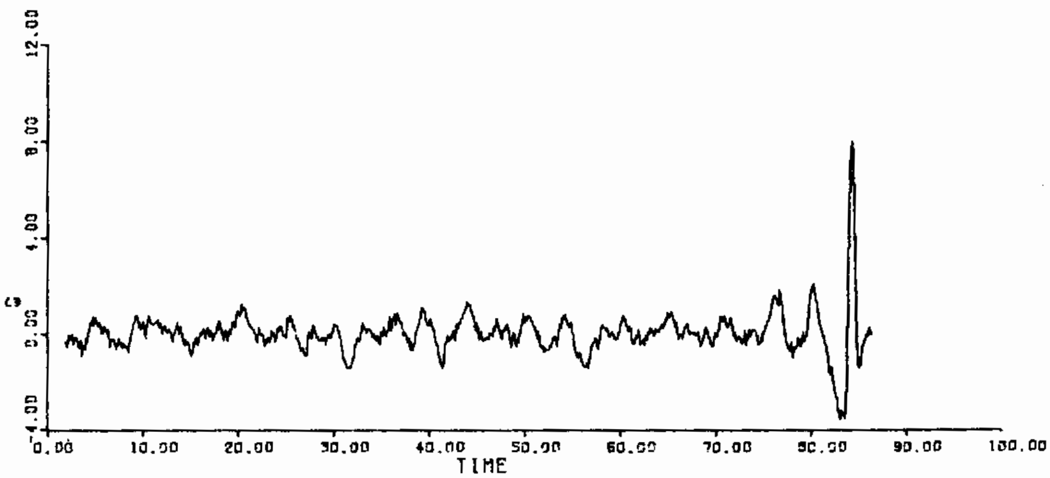

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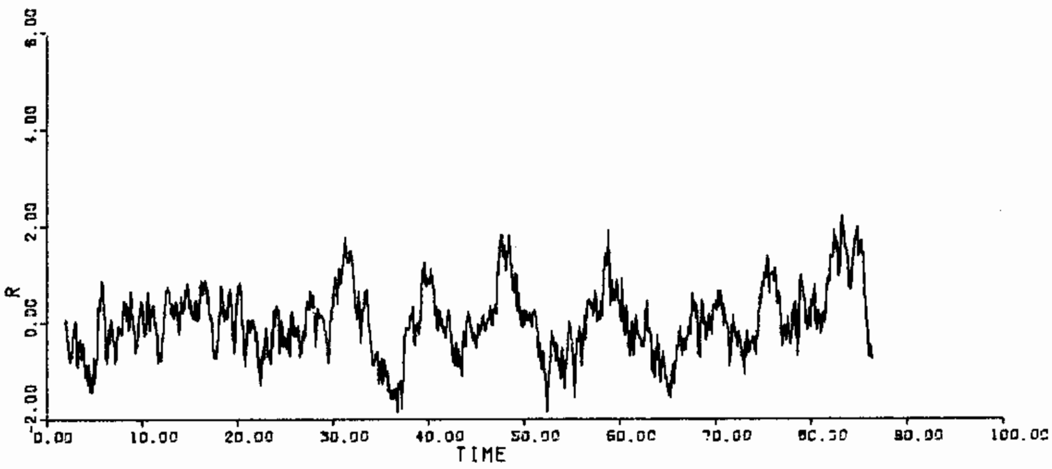

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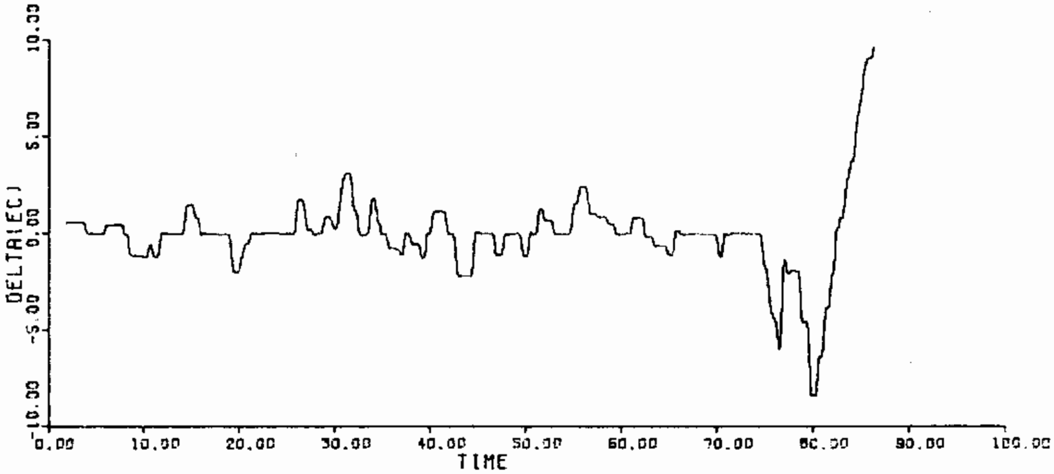

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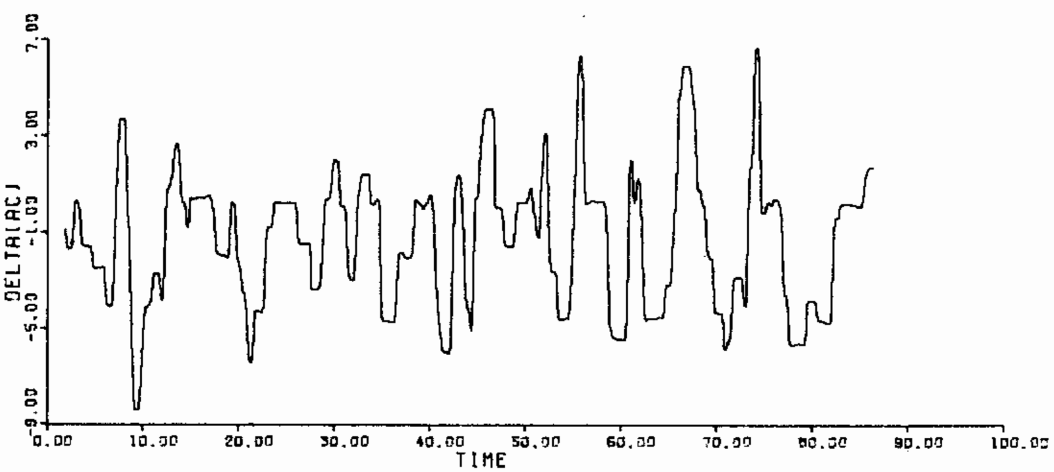

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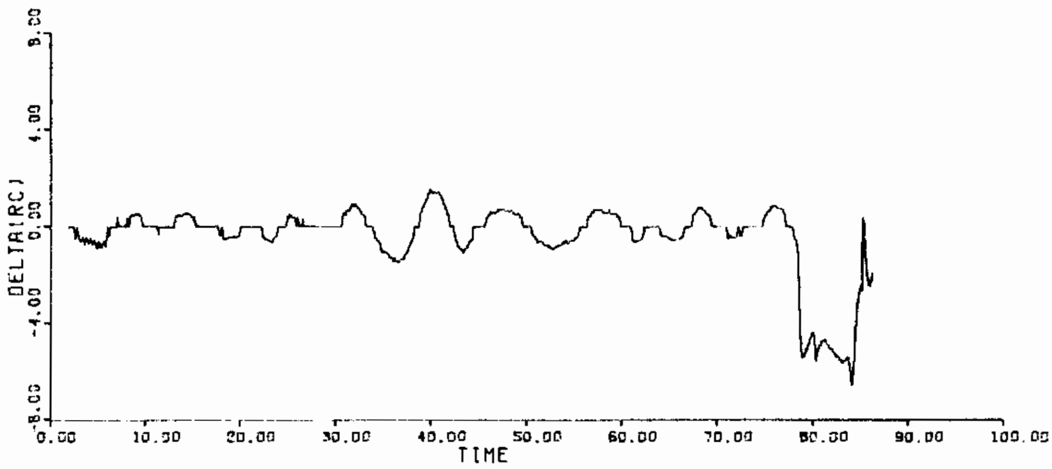

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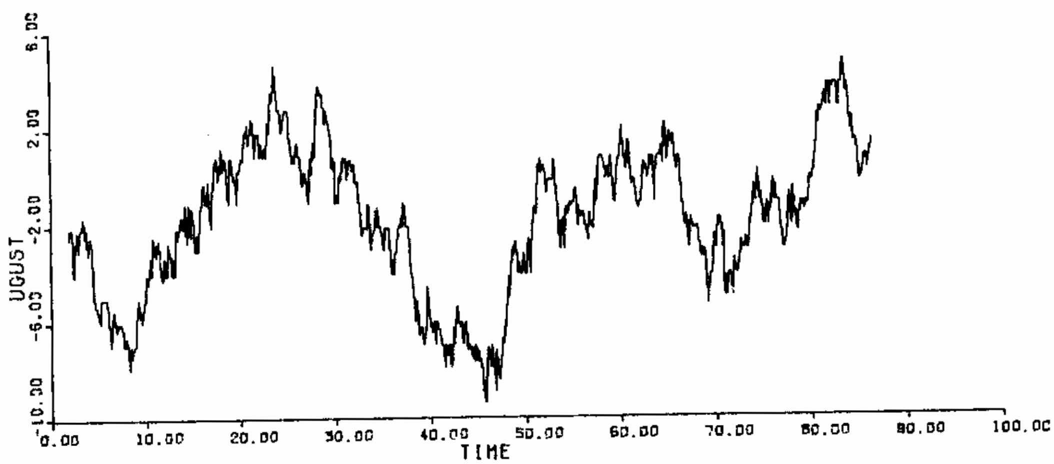

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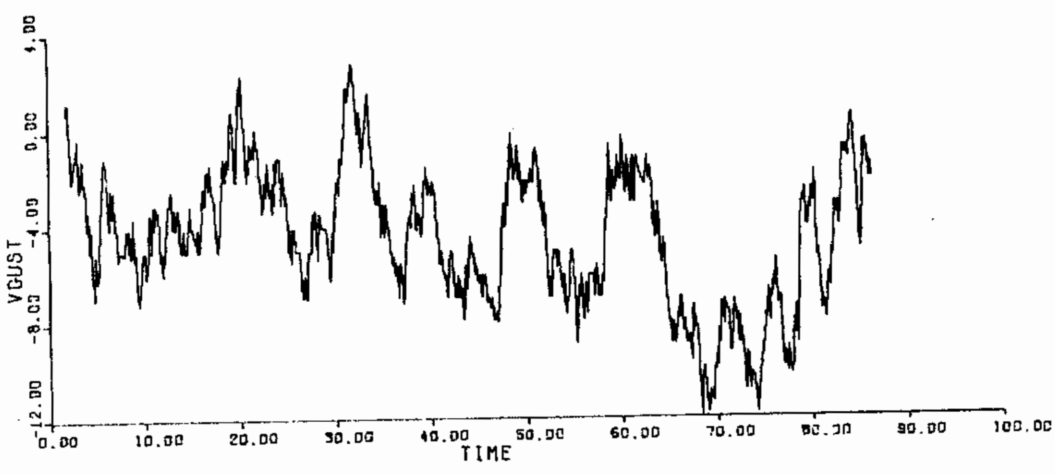

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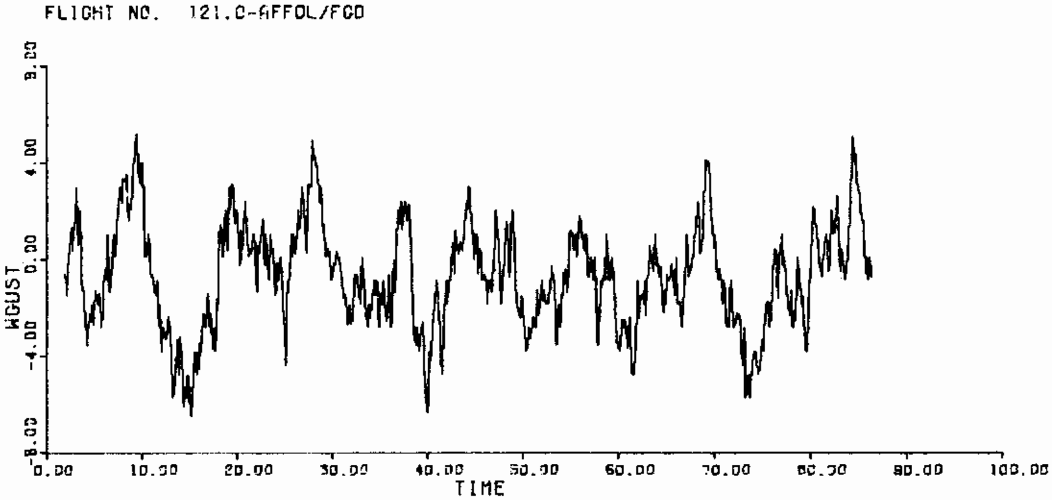

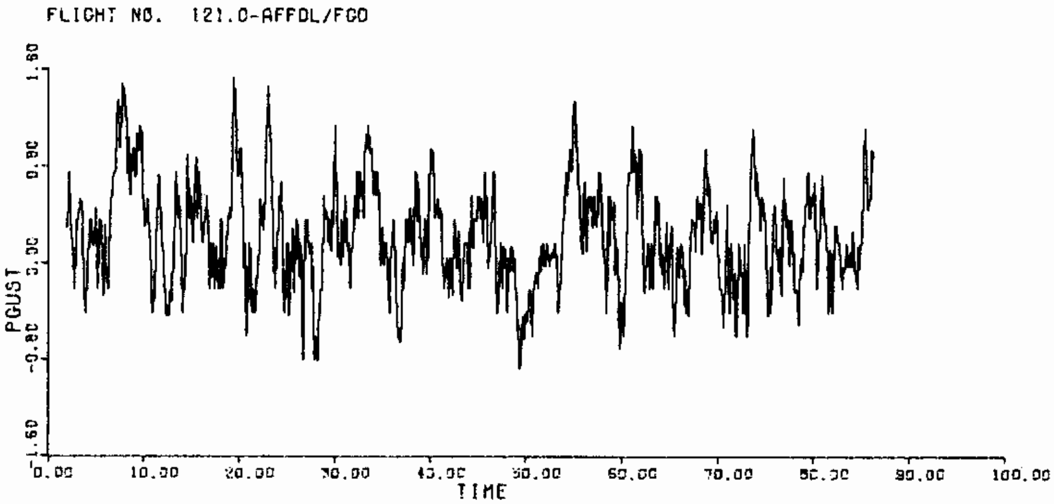

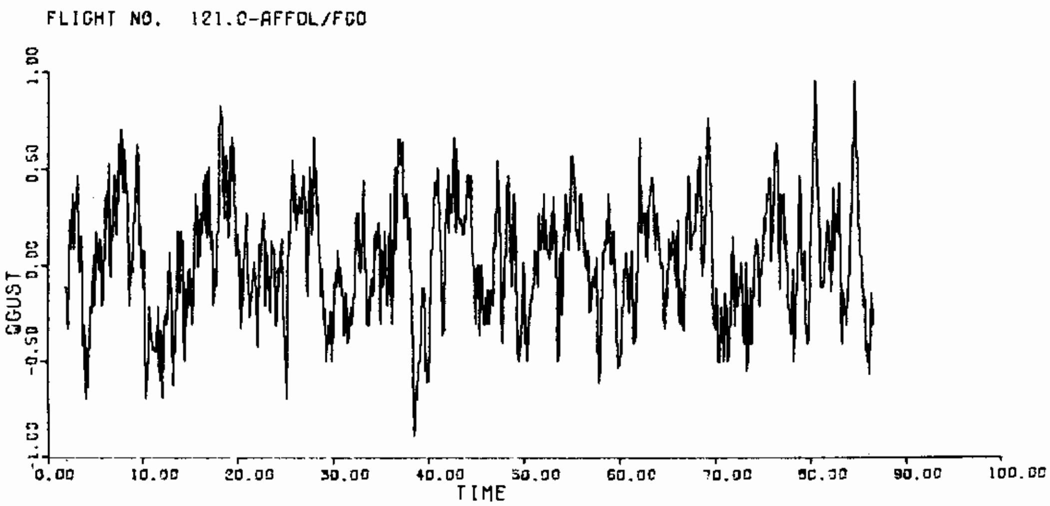

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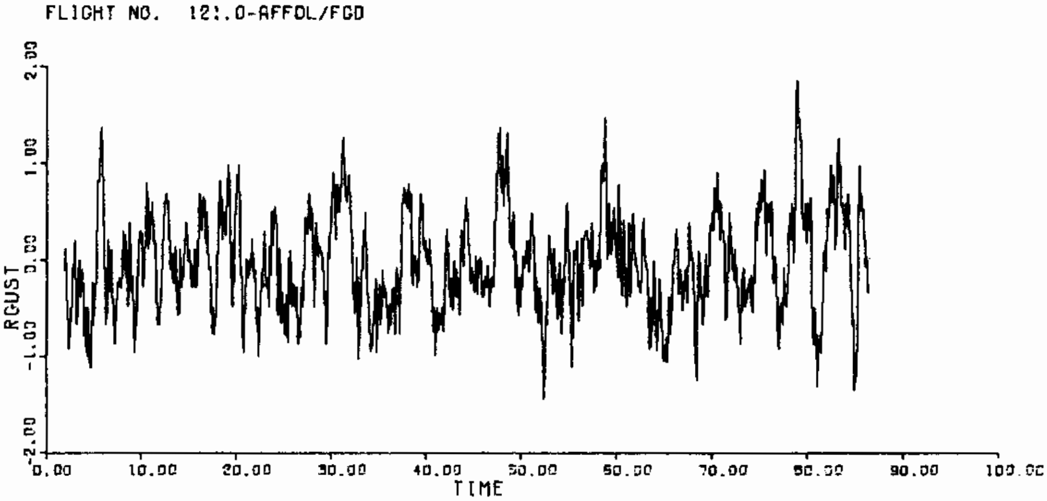

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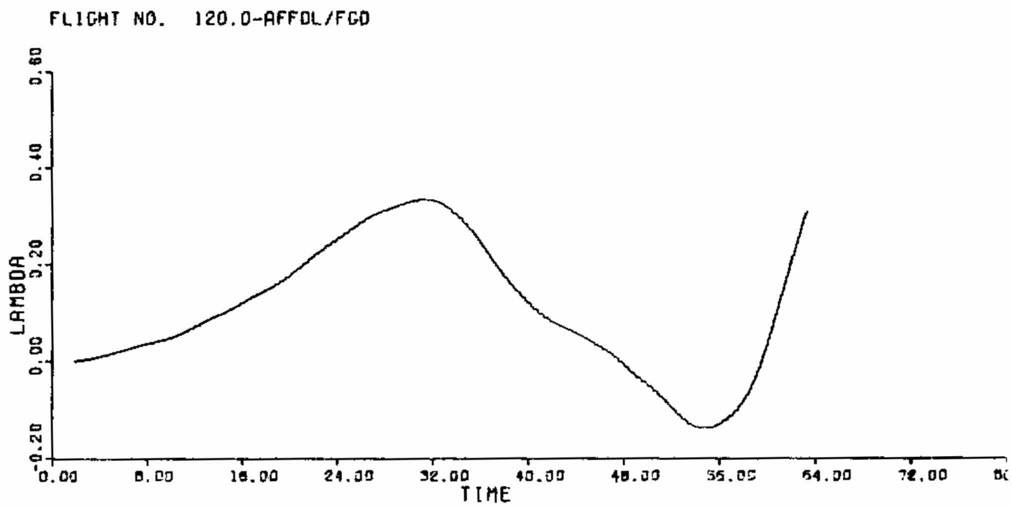

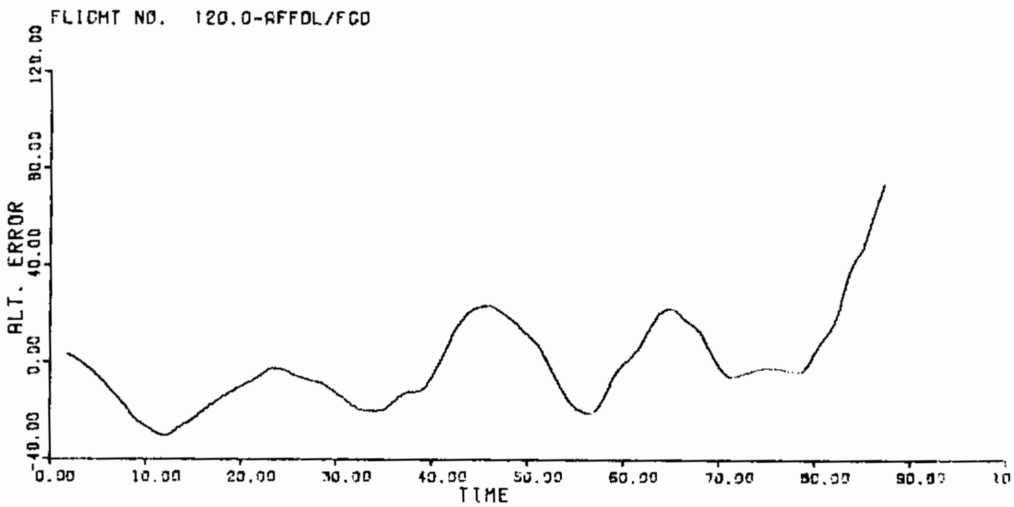

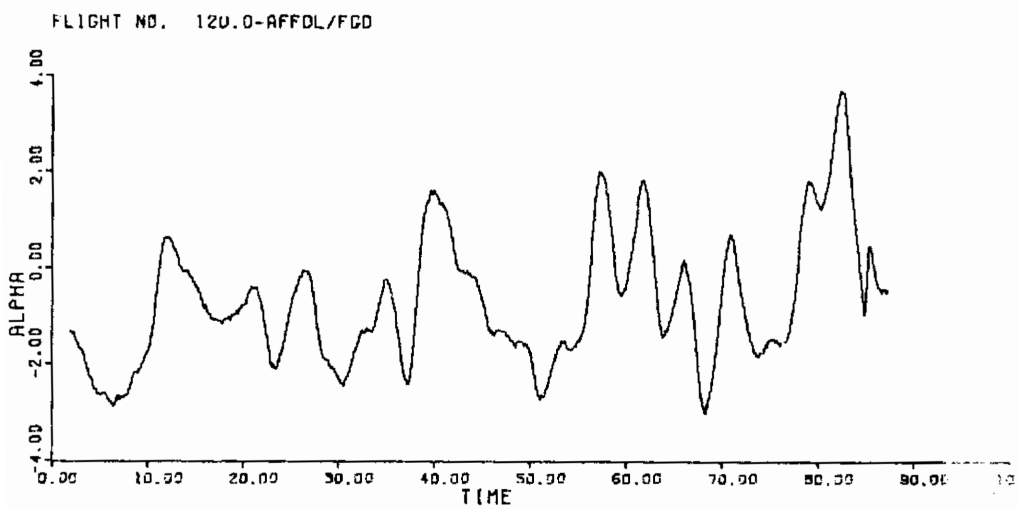

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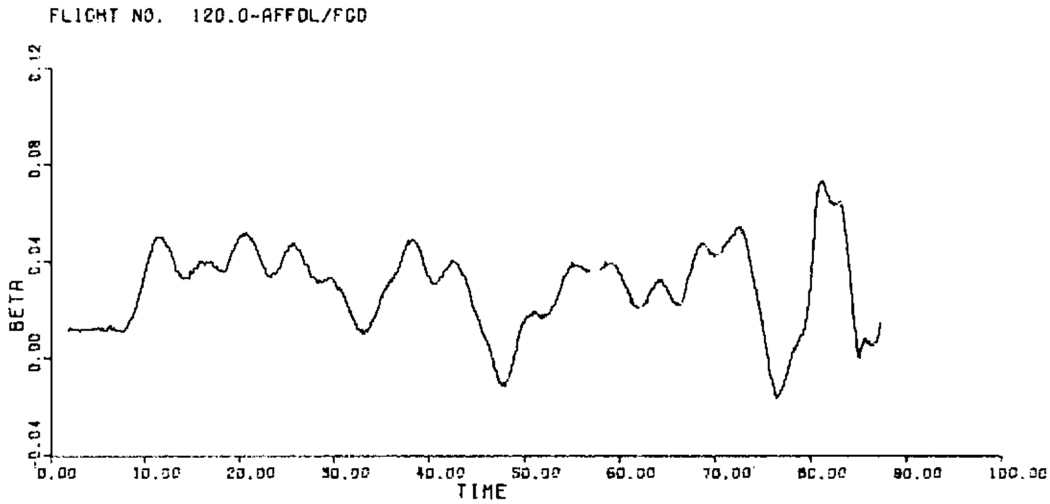

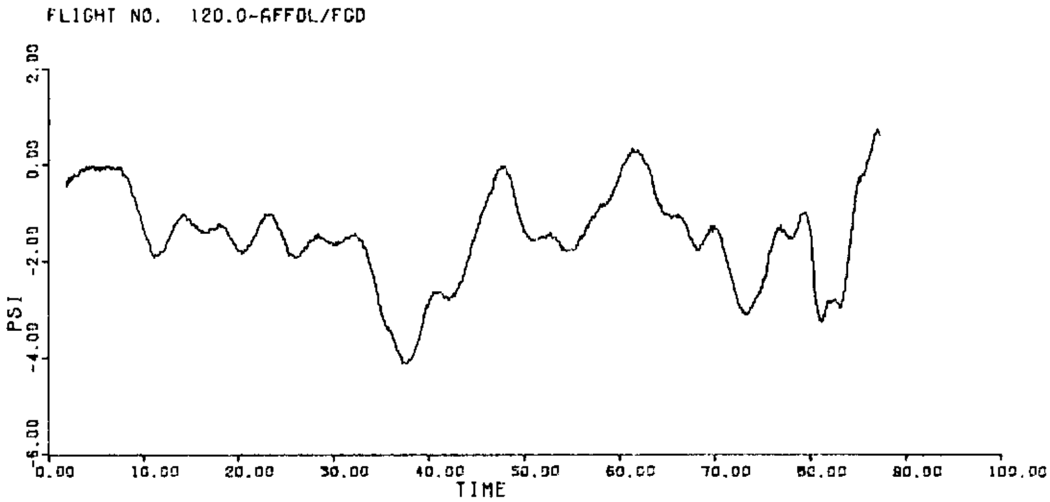

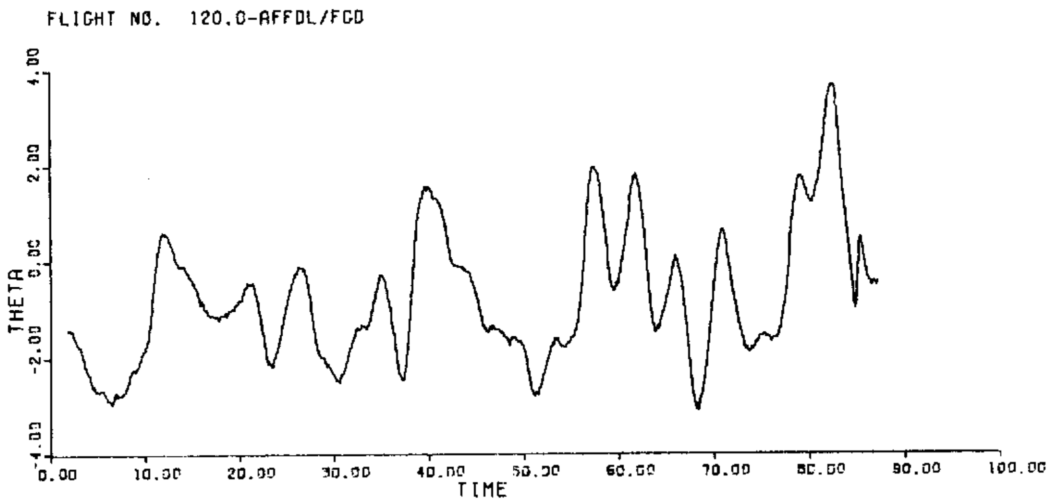

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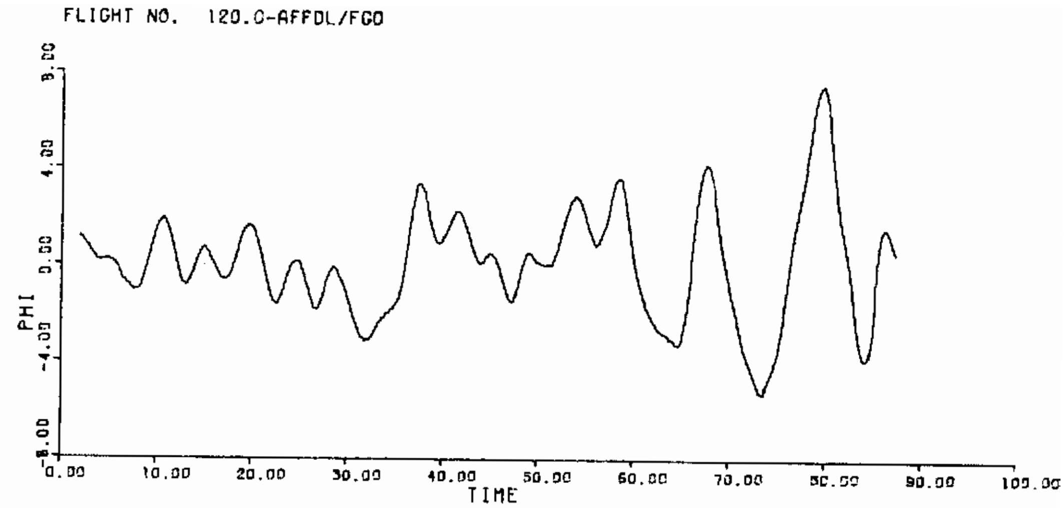

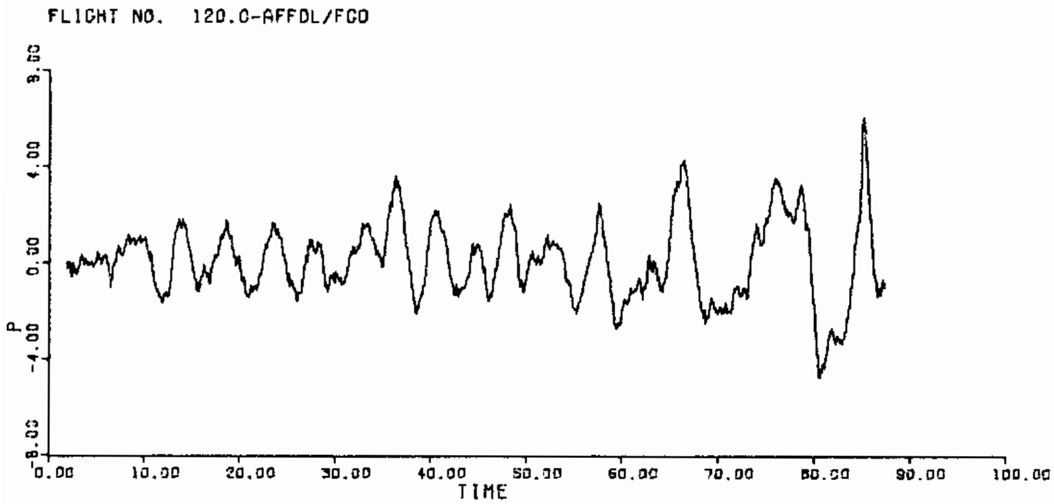

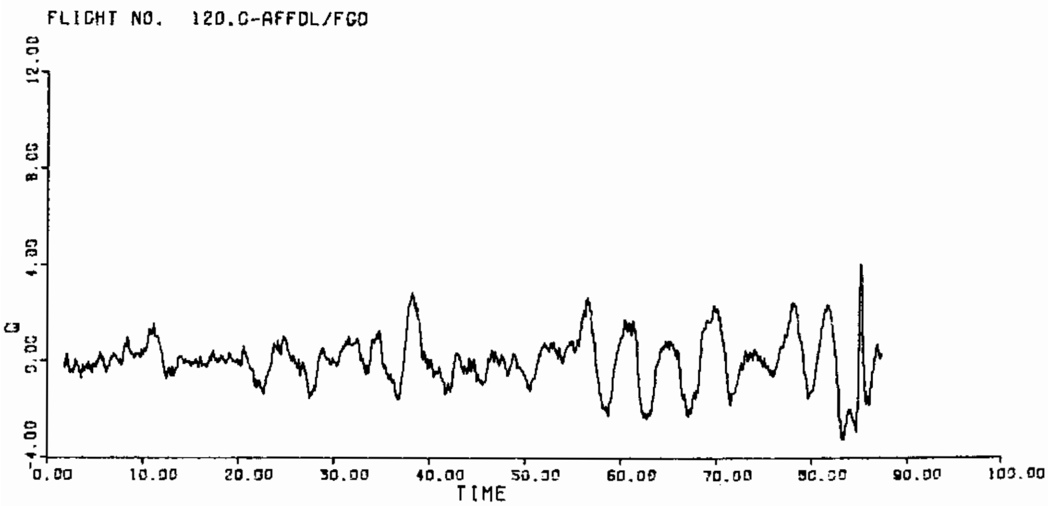

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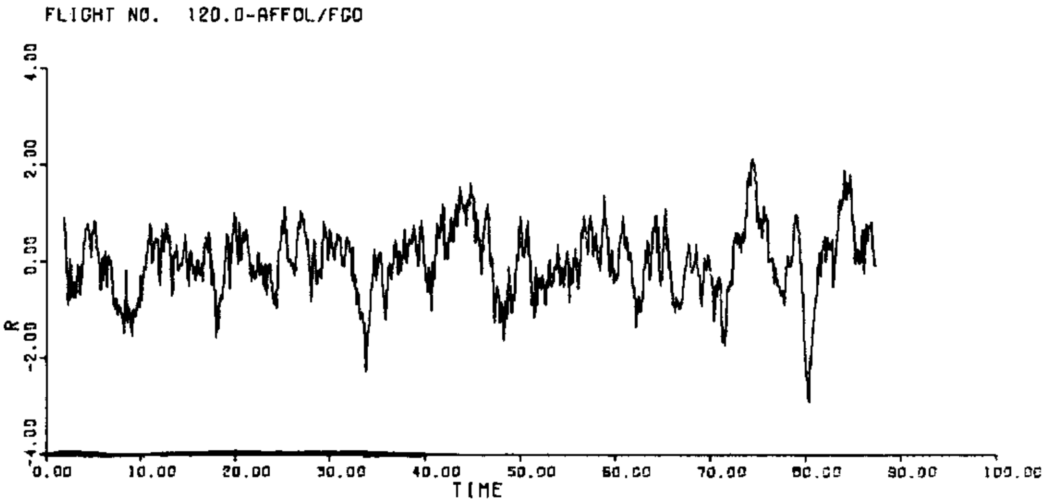

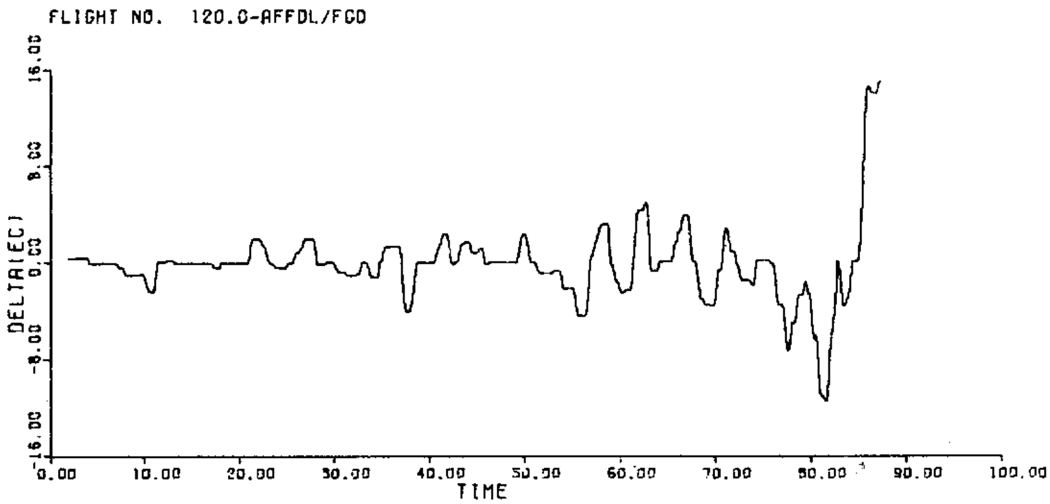

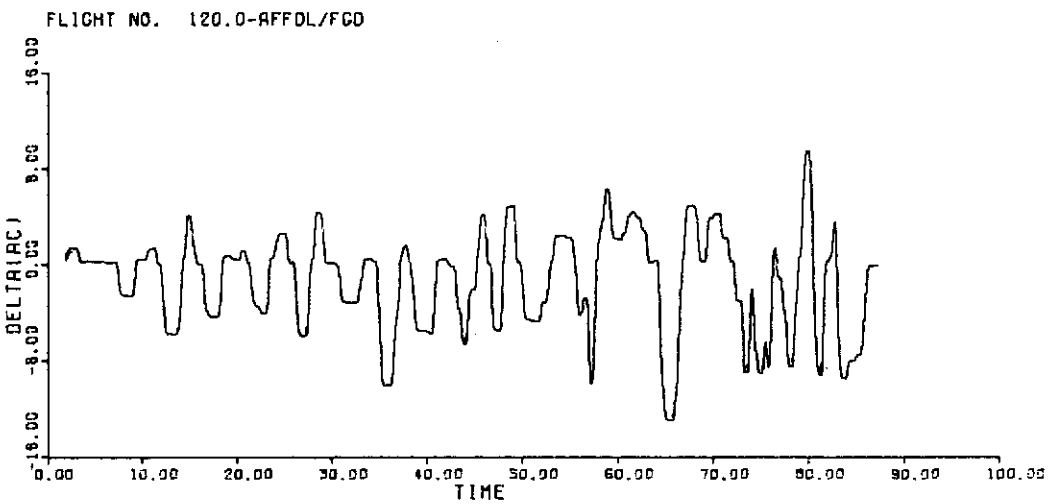

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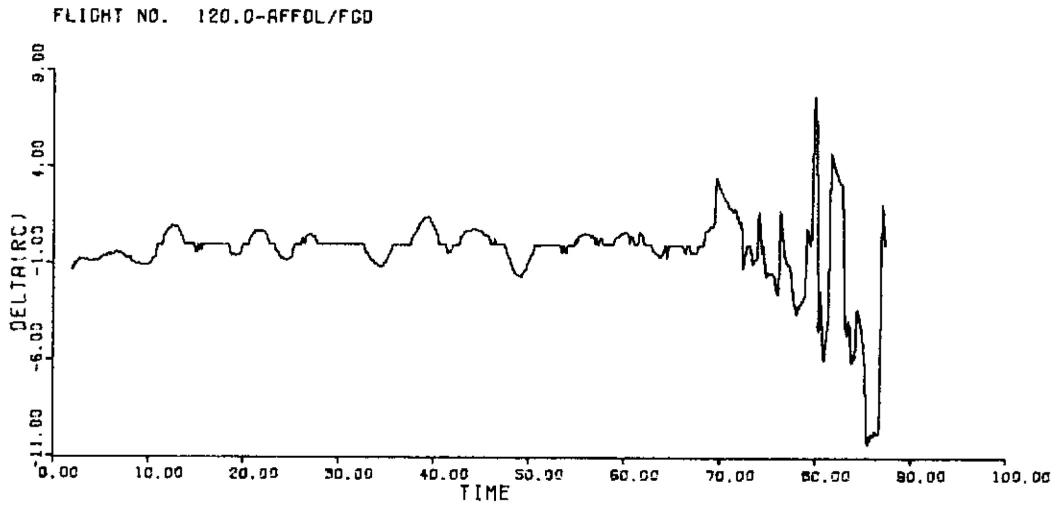

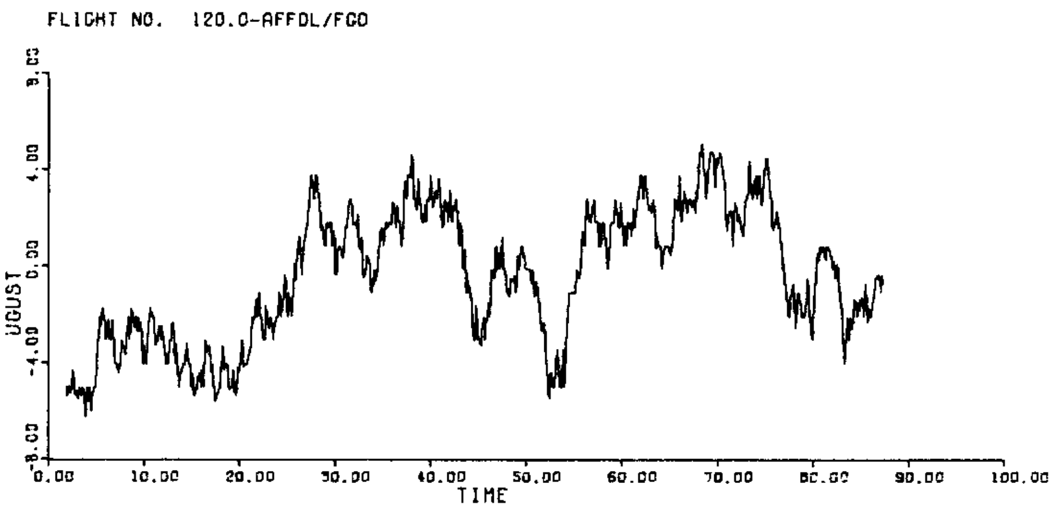

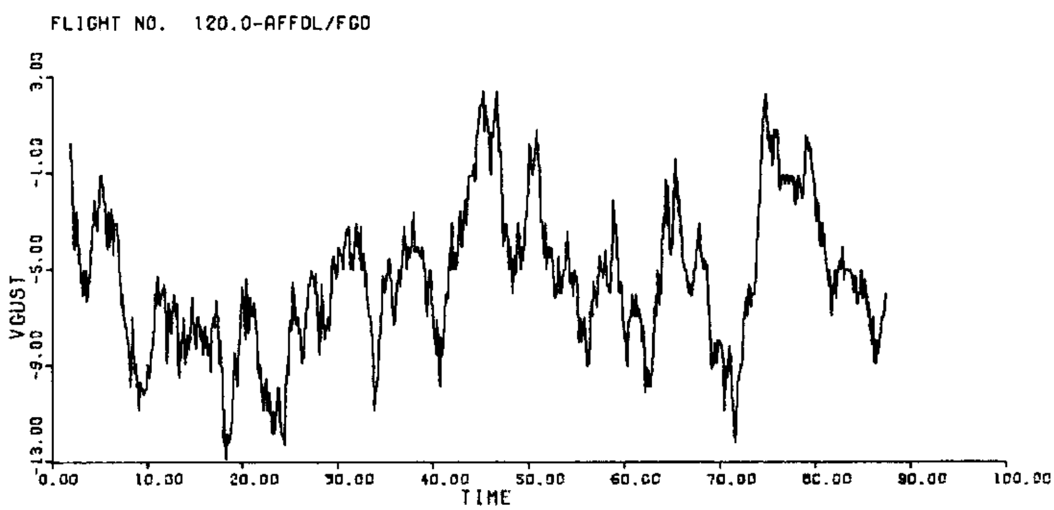

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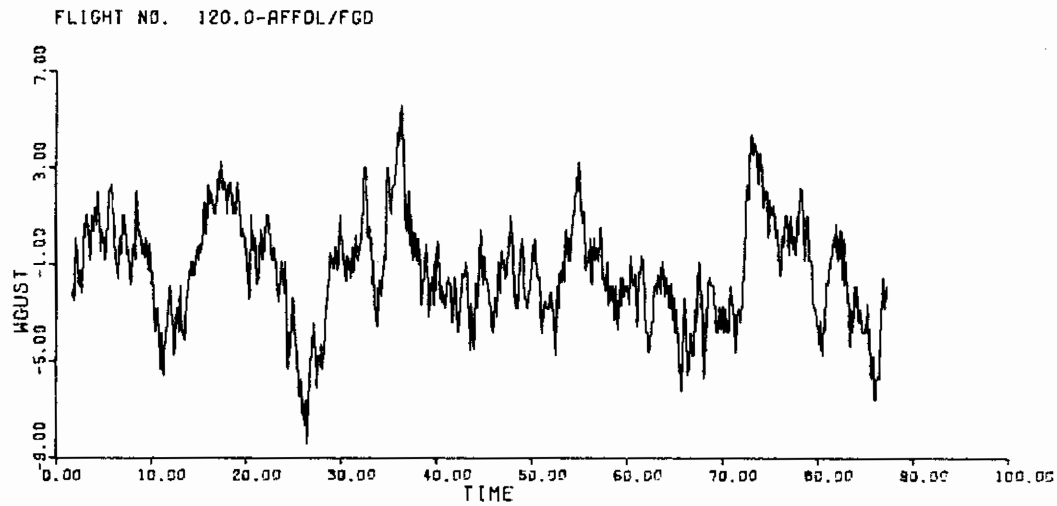

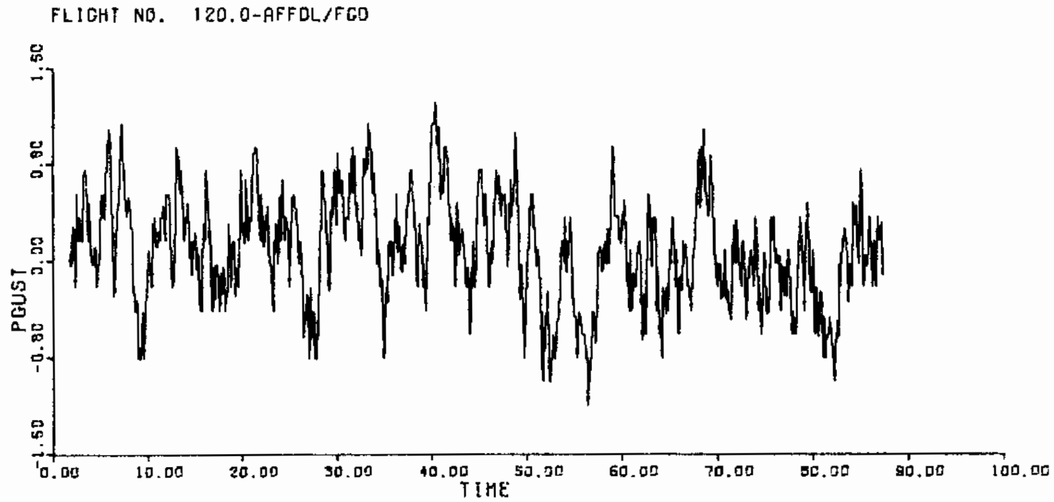

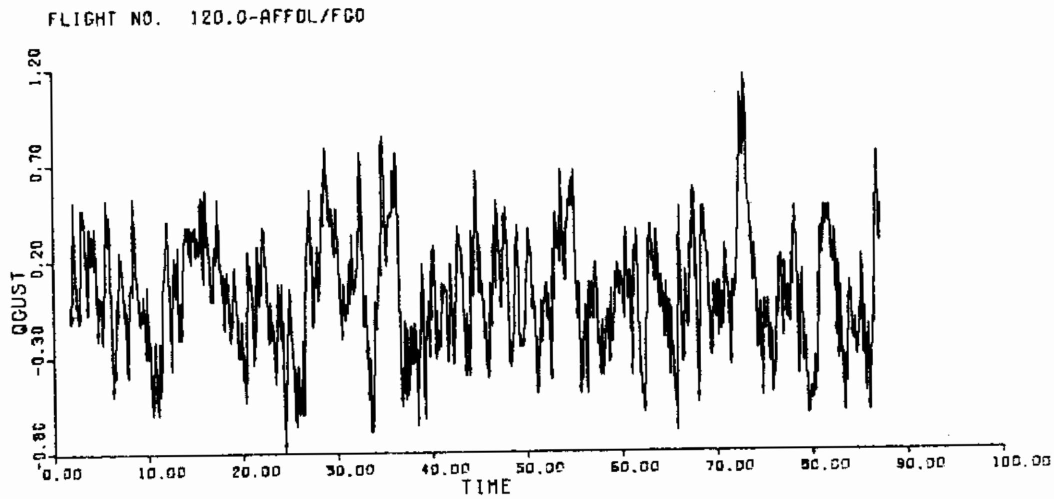

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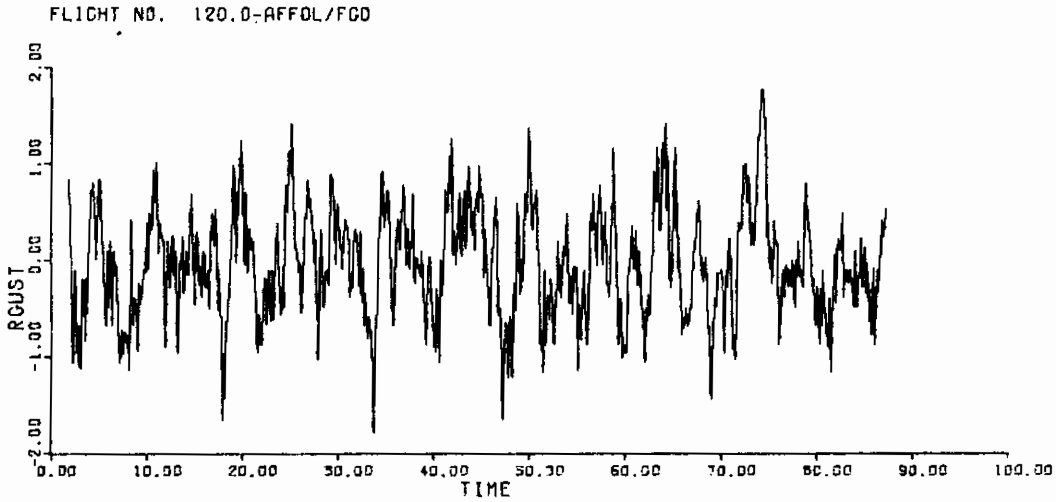

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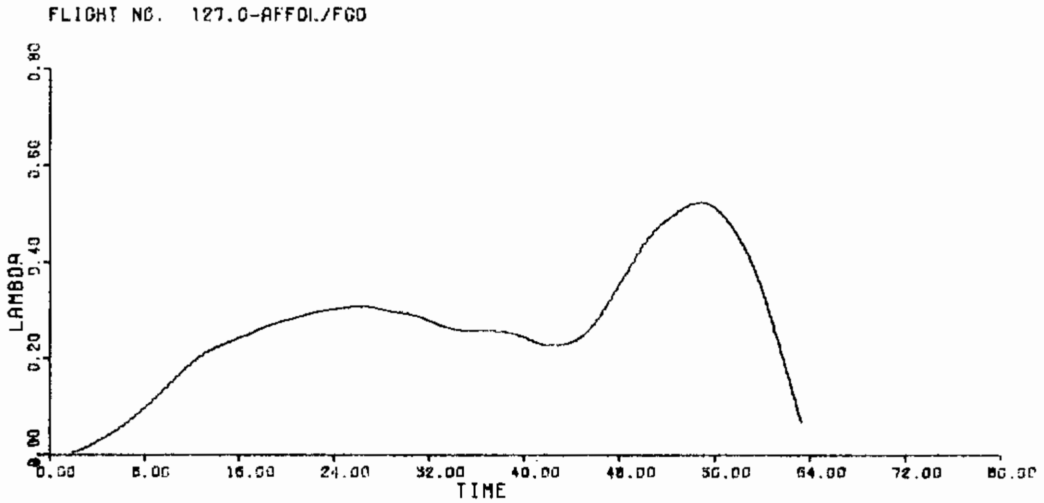

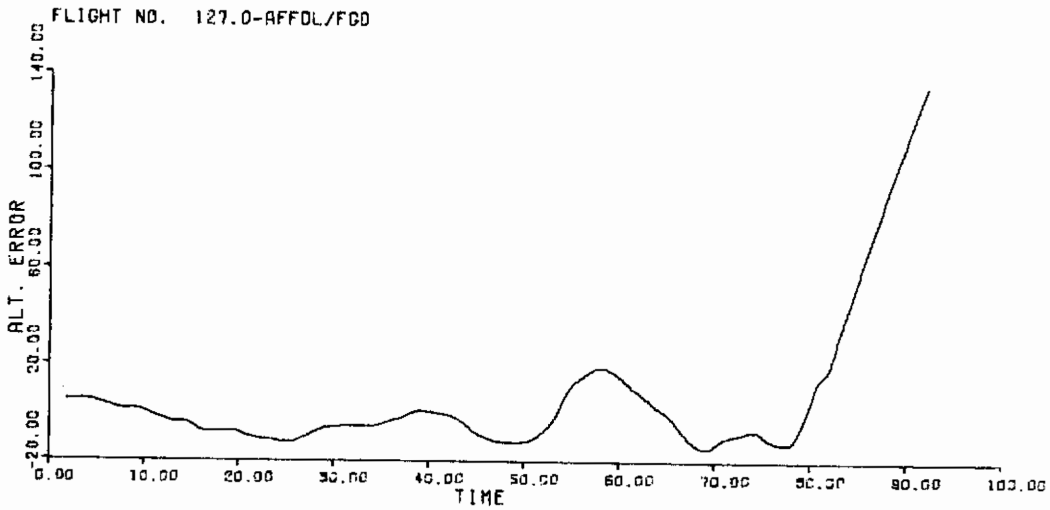

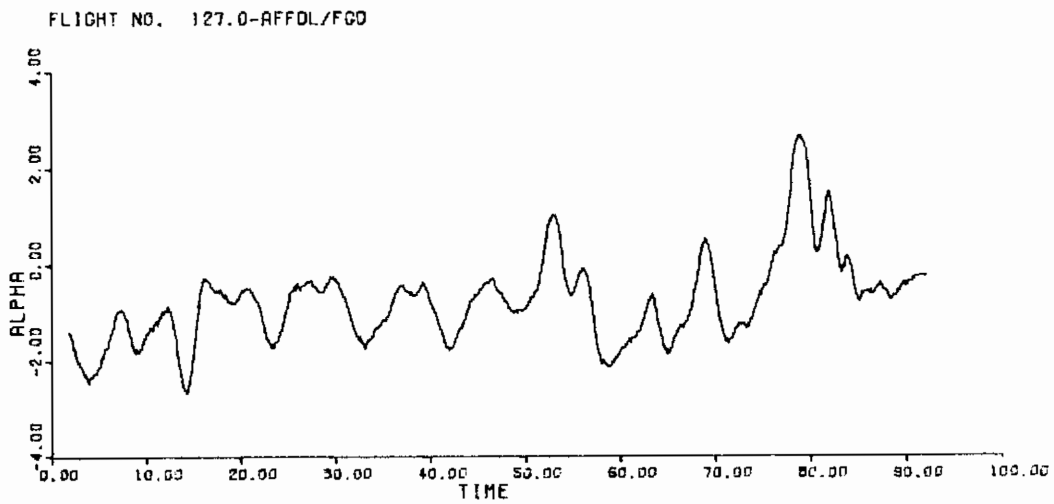

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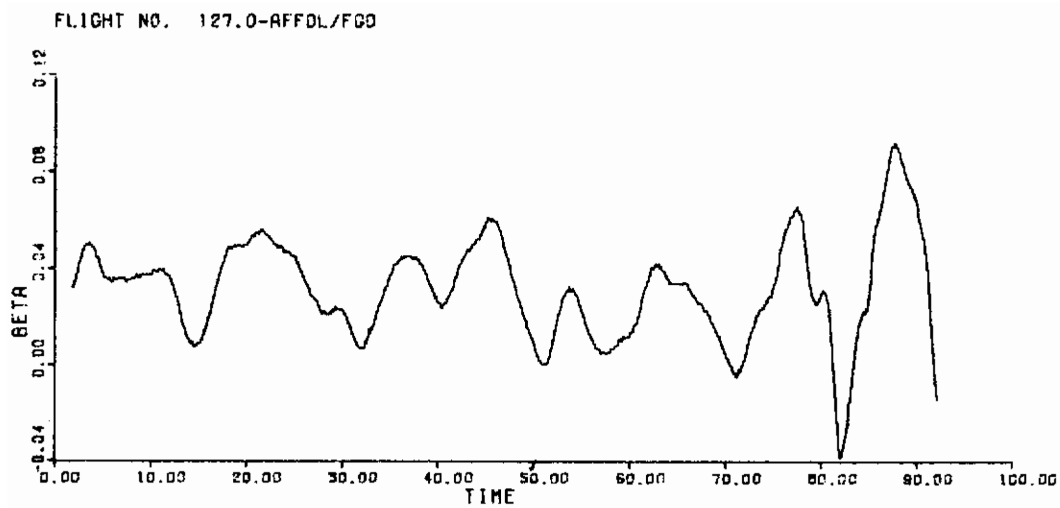

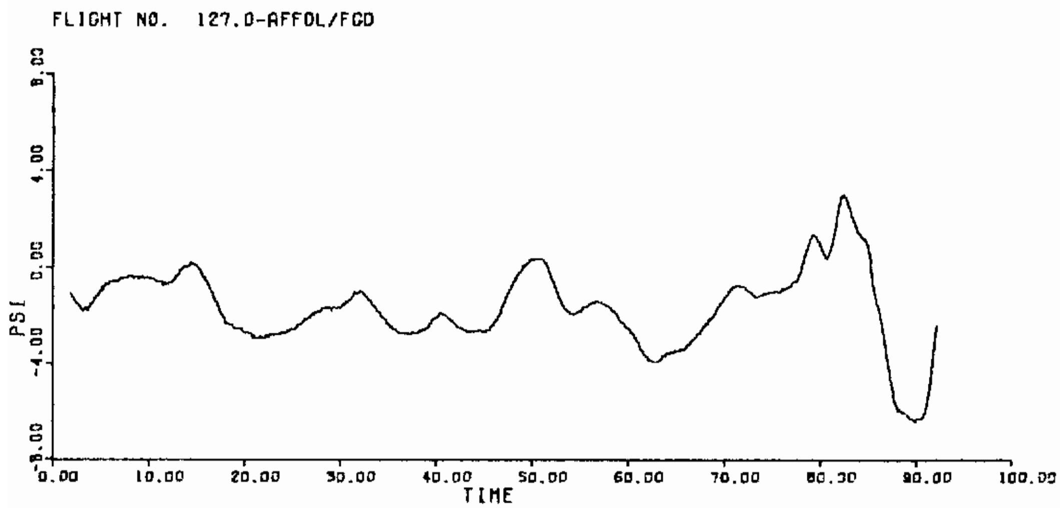

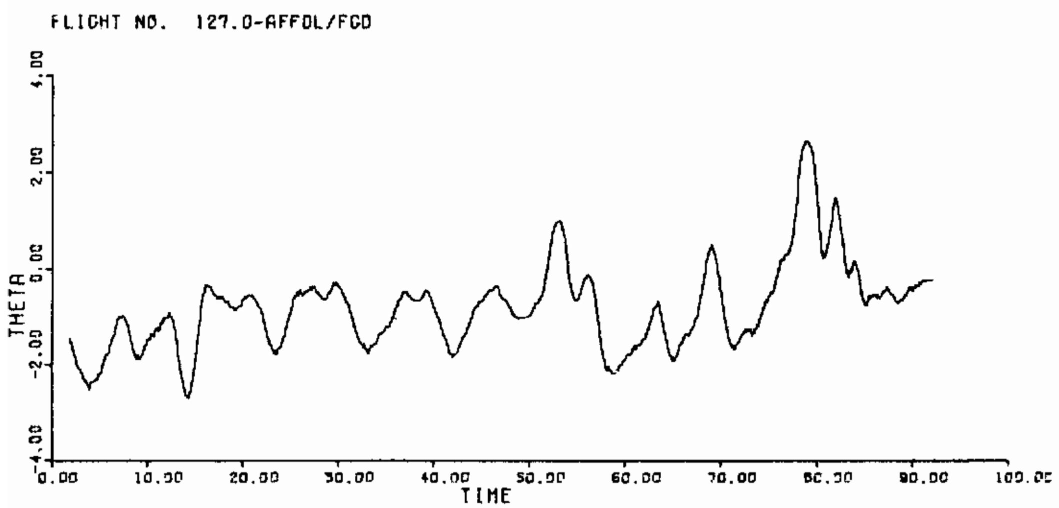

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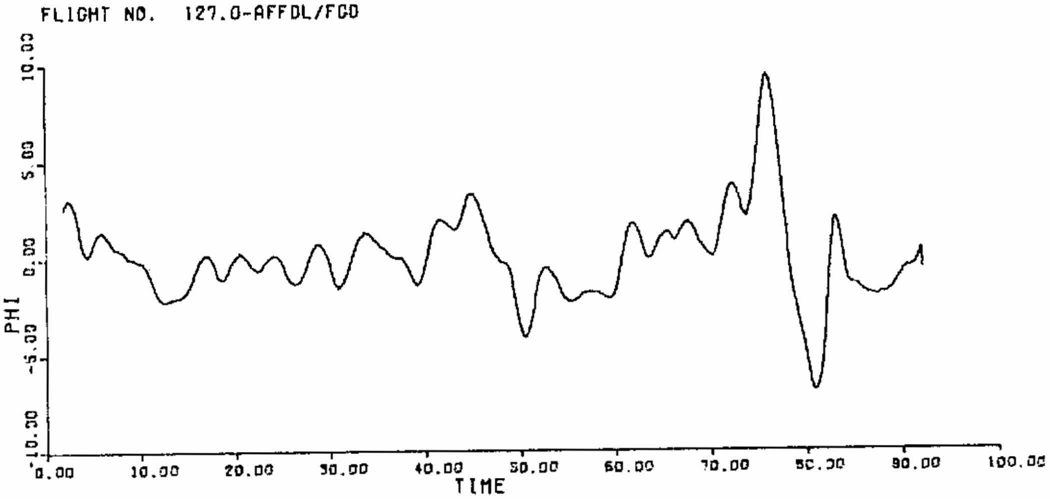

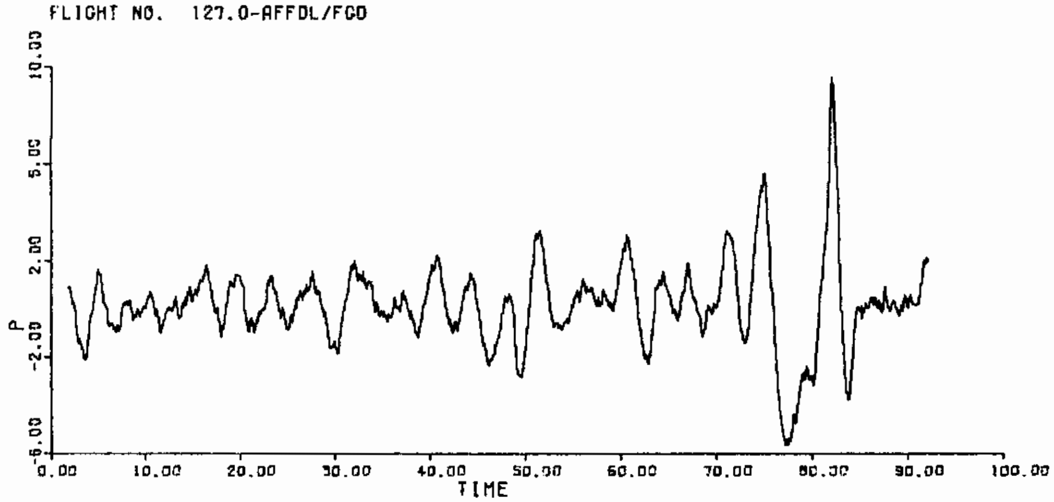

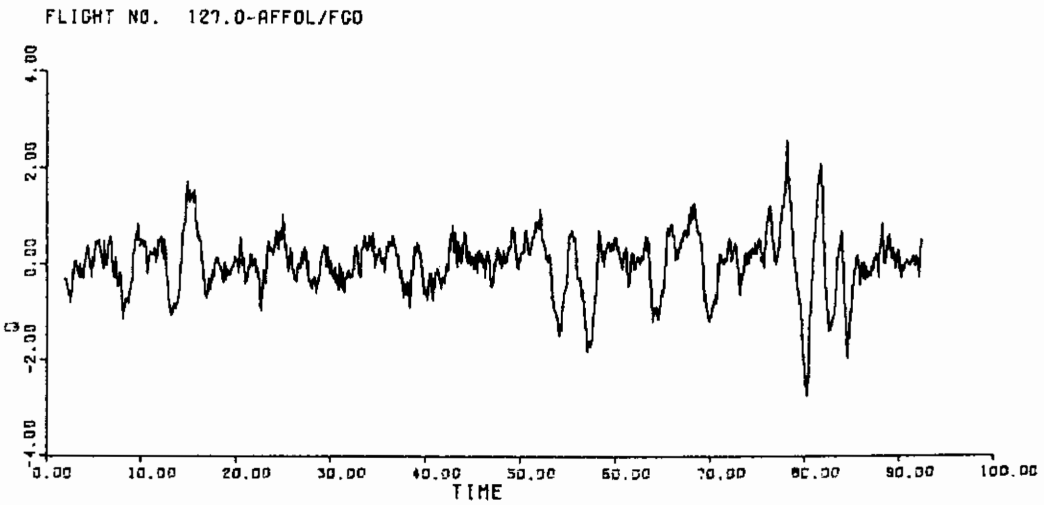

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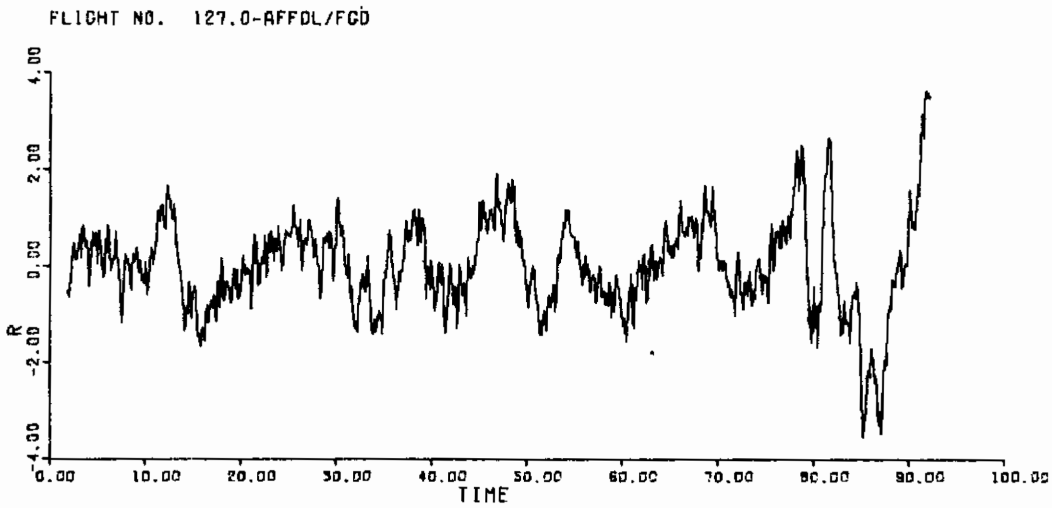

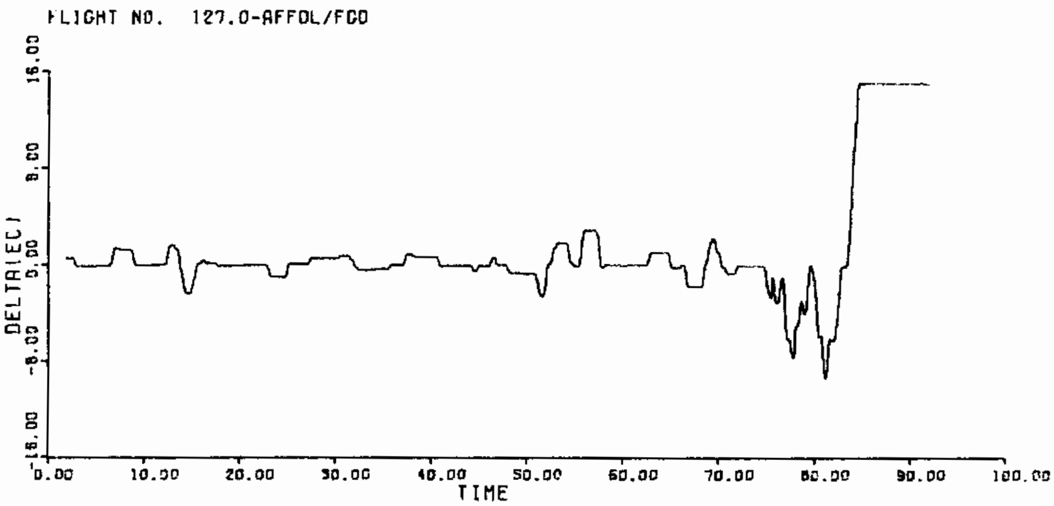

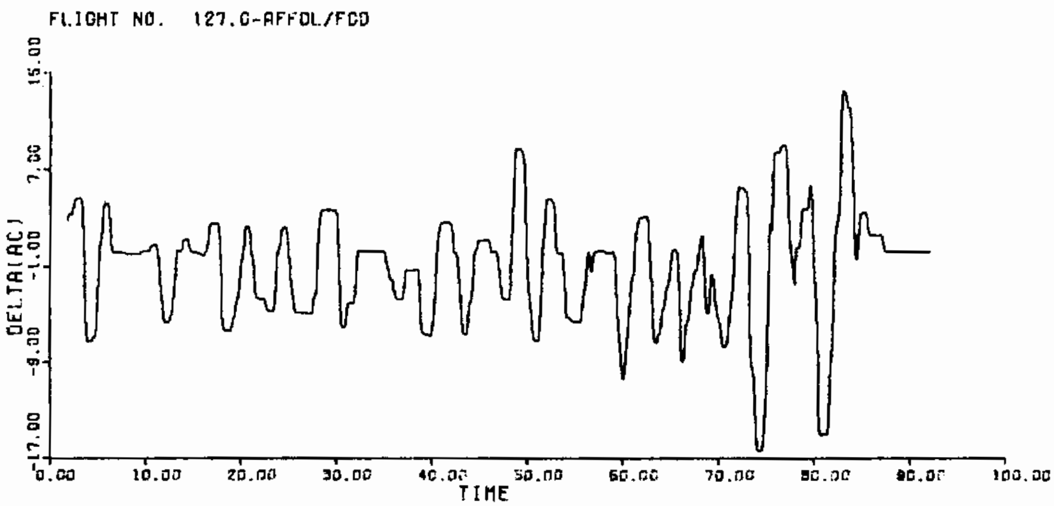

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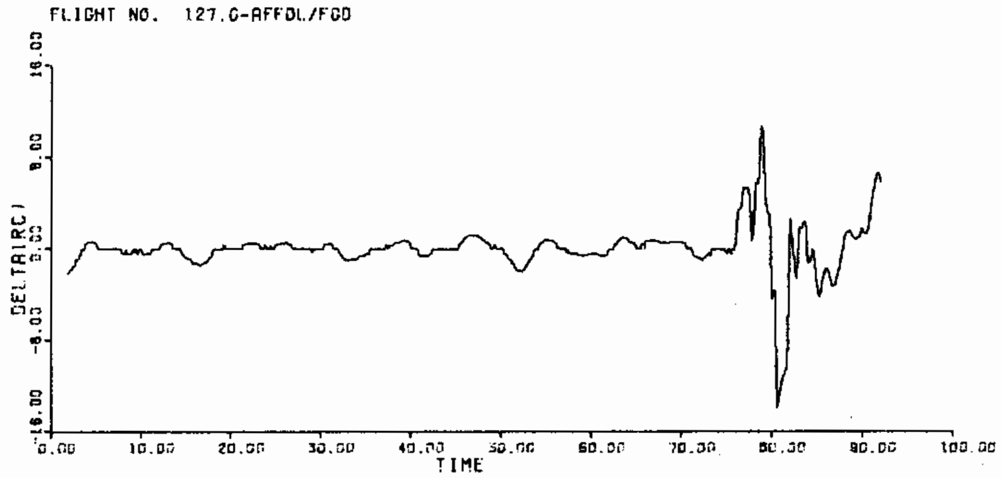

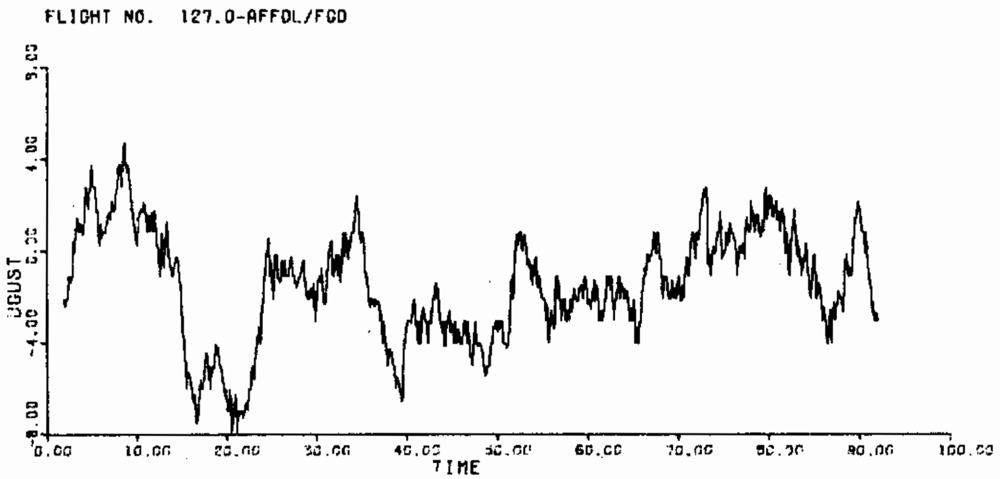

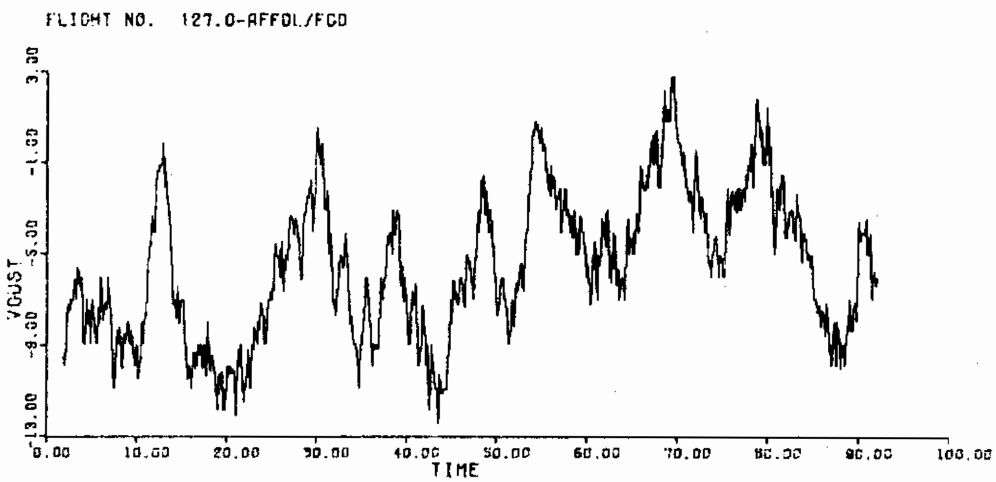

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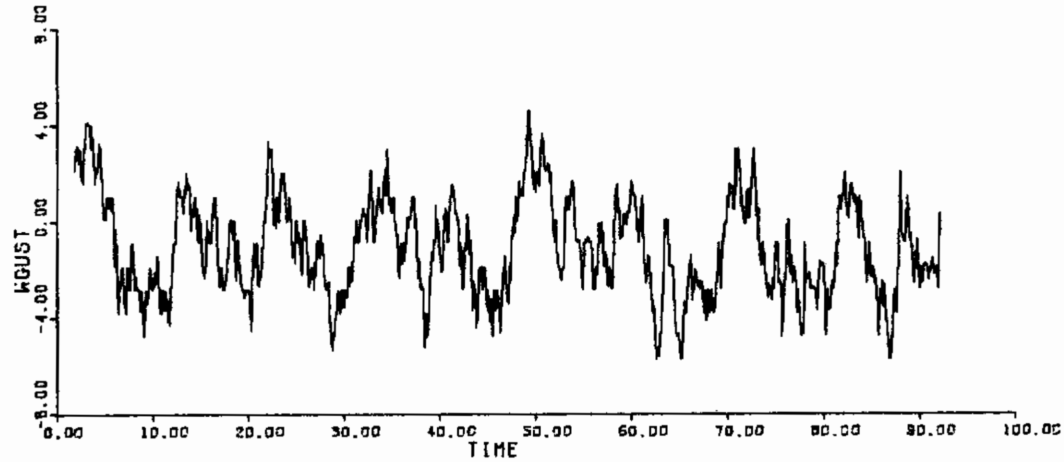

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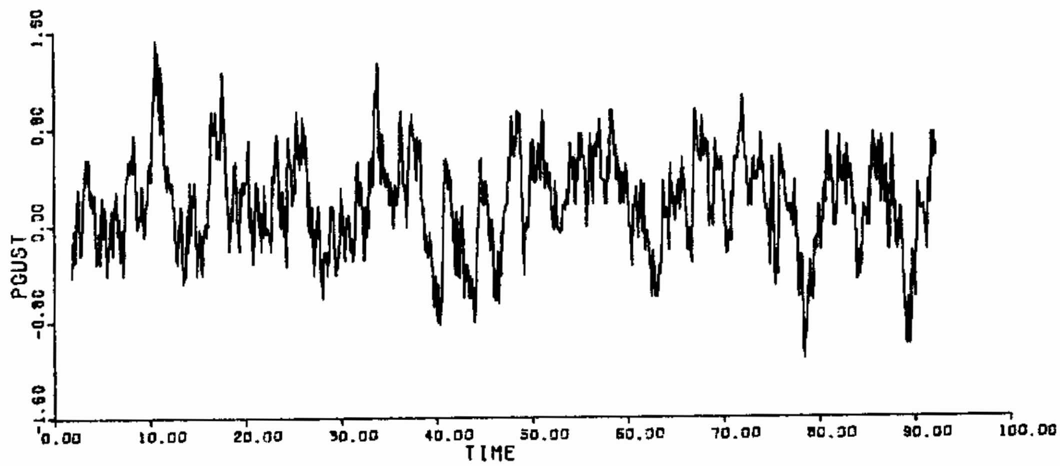

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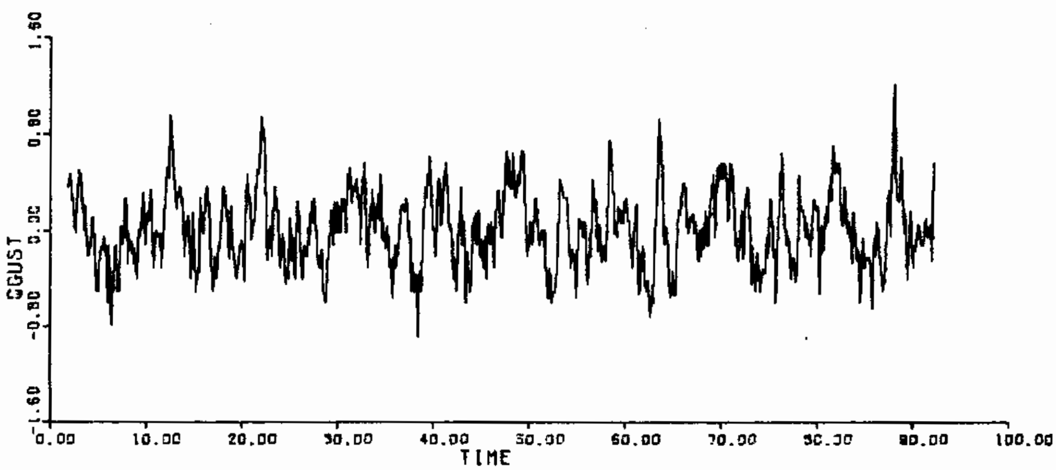

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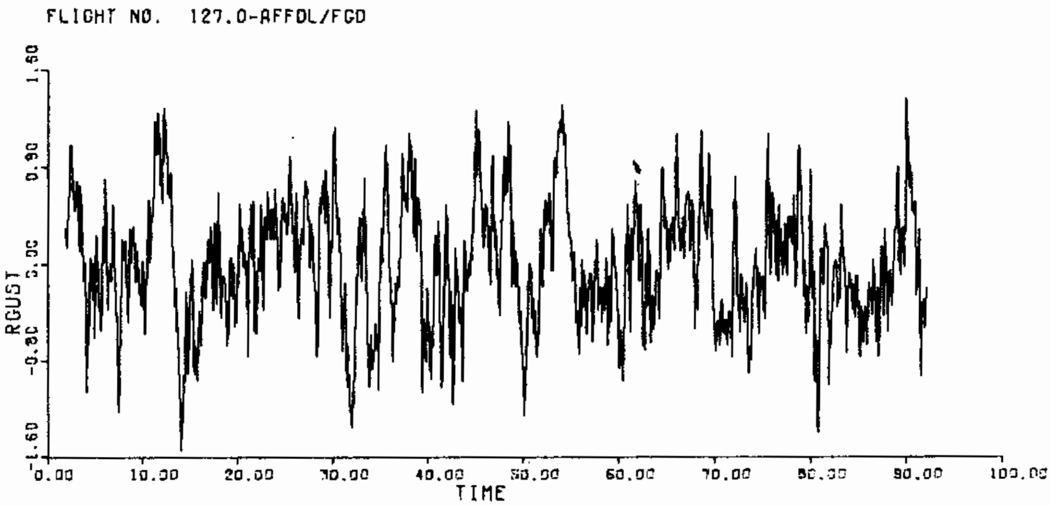

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APPENDIX 7

DURATION AND ORDER OF INSIDE AND OUTSIDE COCKPIT SCANS

NOTE: TD denotes touchdown. 24.6 out means the pilot was looking outside the cockpit for 24.6 seconds. 4. in means the pilot was looking inside the cockpit for 4 seconds. The farther down a column under a particular run, the later the scan. Percent out gives the percent of time the pilot was looking out of the cockpit, while he was scanning. In computing percent out, the final visual section and any initial time within the fog were excluded.

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CAVU CASES

	RUN 121	RUN 123	RUN 126	RUN 130	RUN 131	RUN 132	RUN 146	RUN 149	RUN 150	RUN 153
% out	48%	32%	22%	67%	55%	22%	48%	83%	8%	8%
	3.6 in									
	1.8 out									
	4.5 in			6.8 in		2.8 in				
	2.8 out			1.2 out		.4 out				
	1.4 in	4.8 in	16.5 in	8. in		15.4 in				
	.8 out	.6 out	3. out	5.6 out		.9 out	26.4 out			
	1.0 in	11.2 in	2.2 in	1. in	6.8 in	10. in	6.5 in		17. in	17. in
	3.4 out	.6 out	1.8 out	14.8 out	1. out	.6 out	.8 out		.6 out	1. out
	1.2 in	5. in	1. in	1. in	3.2 in	10.8 in	10.8 in		11.6 in	14.8 in
	8. out	.8 out	1. out	2.4 out	8.4 out	1.8 out	1.8 out		1. out	.6 out
	4.6 in	22.8 in	11.6 in	.8 in	1.6 in	5.2 in	3.8 in	3.8 in	7.4 in	5. in
	5.8 out	2.6 out	2. out	1.8 out	5.7 out	1.2 out	1. out	30 out	1.2 out	.6 out
	5. in	3.8 in	7.4 in	1. in	1.2 in	4.2 in	6. in	1. in	2. in	8.8 in
	1.4 out	7.8 out	2. out	1.6 out	2.2 out	2.6 our	3.2 out	11.6 out	1. out	.8 out
	4.1 in	.7 in	5. in	1. in	5.3 in	1.7 in	5.6 in	5.2 in	13.8 in	6.4 in
	2.6 out	1. out	.8 out	5.6 out	4.2 out	1.8 out	3.6 out	12. out	1. out	1.6 out
	2.2 in	.8 in	11. in	1. in	.6 in	4.1 in	7. in	1.4 in	4. in	6. in
	2.8 out	8.4 out	5. out	13. out	4.4 out	6.5 out	1. out	7.2 out	.6 out	1. out
	4. in	1. in	.8 in	1.8 in	2.8 in	1. in	1.4 in	1. in	2.8 in	4. in
	24.6 out	13. out	10.8 out	16. out	34. out	12.8 out	16.2 out	33.8 out	22.8 out	20.8 out
	TD	TD	TD	TD	TD	TD	TD	TD	TD	TD

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Contrails

100/1200 CASES

	RUN 147	RUN 148	RUN 151	RUN 155	RUN 157	RUN 127	RUN 128	RUN 129	RUN 136	RUN 138
% Out	N/A	50%	N/A	N/A	94%	N/A	N/A	N/A	N/A	66%
		74.4 in			78. in					71. in
		1. out			9.6 out					1.2 out
	78. in	1. in	77. in	76.4 in	.6 in	73.4 in	75.8 in	75.6 in	75.7 in	.6 in
	15.4 out	27.2 out	14.8 our	22.6 out	4.4 out	13.8 out	6.2 out	12.2 out	15.2 out	13. out
	TD	TD	TD	TD	TD	TD	TD	TD	TD	TD

400/1600 CASES

	RUN 158	RUN 141	RUN 142	RUN 143	RUN 120	RUN 122	RUN 124	RUN 125	RUN 134	RUN 135
% Out	14%	N/A	7%	22%	12%	23%	22%	N/A	N/A	17%
				50.2 in	55. in					
				1. out	.5 out					
			45. in	5. in	5.4 in	67. in				60.2 in
			.8 out	.6 out	.8 out	.6 out				.6 out
	71. in		22. in	4. in	6.5 in	5.4 in	64.4 in			7.2 in
	1.1 out		1.2 out	1.3 out	.8 out	1.4 out	1. out			1.2 out
	6.6 in	74.3 in	3.8 in	1. in	3. in	1.2 in	3.5 in	69.9 in	66.4 in	1.8 in
	18.5 out	6.4 out	12.6 out	16.9 out	12.8 out	10.8 out	20.8 out	15.6 out	19.5 out	17.2 out
	TD	TD	TD	TD	TD	TD	TD	TD	TD	TD

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