

DOCKET NO. **SA - 510**

EXHIBIT NO. **13X - J**

**NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.**

Documentation of NASA Ames Research Center Simulations

NATIONAL TRANSPORTATION SAFETY BOARD

Office of Research and Engineering
Washington, D.C.

November 8, 1995

Documentation of NASA Ames Research Center Simulations

A. ACCIDENT DCA-94-MA-076

Location : Aliquippa, Pennsylvania
Date : September 8, 1994
Time : 1904 Eastern Daylight Time
Aircraft : Boeing 737-300, N513AU

B. GROUP IDENTIFICATION

The Aircraft Performance Group met at the National Aeronautics and Space Administration's (NASA) Ames Research Center in Moffet Field, California from July 11 to July 13, 1995. The following group members participated in the investigation:

Chairman : Thomas R. Jacky, NTSB
Member : Bob McCullough, USAir
Member : Keakini Kaulia, ALPA
Member : Steven E. O'Neal, FAA
Member : James Kerrigan, Boeing Commercial Airplane Group

Additionally, the following persons participated in the investigative effort:

William W. Y. Chung, NASA
Martin Ingham, Boeing Commercial Airplane Group

C. SUMMARY

On September 8, 1994 at 1904 Eastern Daylight Time, USAir Flight 427, a Boeing 737-3B7, N513AU, crashed while maneuvering to land at Pittsburgh International Airport, Pittsburgh, Pennsylvania. The airplane was being operated on an instrument flight rules (IFR) flight plan under the provisions of Title 14, code of Federal Regulation (CFR), Part 121, on a regularly scheduled flight from Chicago O'Hare International Airport, Chicago, Illinois, to Pittsburgh. The airplane was destroyed by impact forces and fire near Aliquippa, Pennsylvania. All 132 persons on board the airplane were fatally injured.

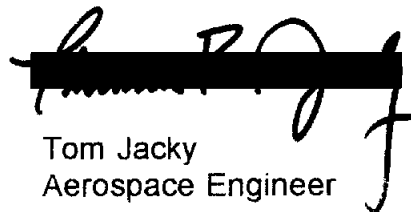
D. DETAILS OF INVESTIGATION

The Human Performance and Aircraft Performance Groups conducted simulator sessions at the National Aeronautics and Space Administration's (NASA) Ames Research Center from July 11 through July 13, 1995. Data sets from the Flight Data Recorder (FDR), Cockpit Voice Recorder (CVR), Kinematic Studies, and a computer-synthesized CVR recording, were utilized by the Ames Research Center's Vertical Motion Simulator. The attached data represent information gathered during the sessions, most notably the VMS system's estimation of the motion prescribed by the Kinematic Studies.

The following combinations of data sets were used for the simulation runs:

- 1) Kinematic Motion only
- 2) Kinematic Motion, FDR Controls, and CVR
- 3) Kinematic Motion, Kinematic Controls, CVR

The computer-synthesized CVR tape was used during runs 2 and 3 at the request of the simulator participants.


Tom Jacky
Aerospace Engineer

Attachments

1. NTSB 737 Simulation VMS Motion System Response vs. Flight Data
2. NTSB 737 Simulation Briefing Notes Presented July 11, 1995

ATTACHMENT 1

NTSB 737 Simulation VMS Motion System Response vs. Flight Data

NTSB 737 Simulation VMS Motion System Response vs Flight Data

**Flight data are in solid lines
VMS data are in dashed lines**

July 11, 1995

VMS Motion Variables

ALONFU: Longitudinal accelerometer reading, body axis, ft/sec^2 .
AXPCG: Longitudinal acceleration, pilot station, body axis, ft/sec^2 .
VLONFU: Longitudinal velocity, inertial axis, ft/sec .
PLONC: Longitudinal position command, inertial axis, ft .
PLONFU: Longitudinal position response, inertial axis, ft .
RLX: Motion limit flag, longitudinal axis, n.d..

ALATFU: Lateral accelerometer reading, body axis, ft/sec^2 .
AYPCG: Lateral acceleration, pilot station, body axis, ft/sec^2 .
VLATFU: Lateral velocity, inertial axis, ft/sec .
PLATC: Lateral position command, inertial axis, ft .
PLATFU: Lateral position response, inertial axis, ft .
RLY: Motion limit flag, lateral axis, n.d..

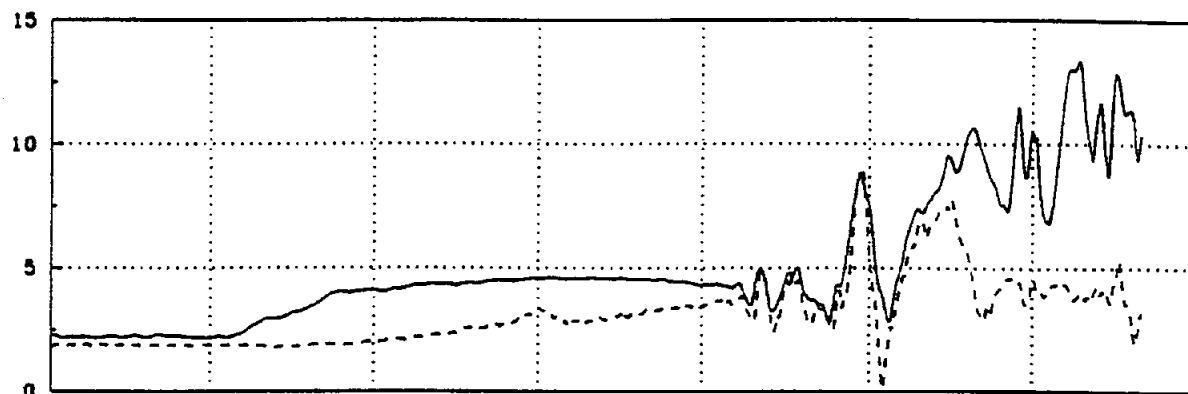
AZFU: Vertical accelerometer reading, body axis, ft/sec^2 .
AZPCG: Vertical acceleration, pilot station, body axis, ft/sec^2 .
VZFU: Vertical velocity, inertial axis, ft/sec .
PZC: Vertical position command, inertial axis, ft .
PZFU: Vertical position response, inertial axis, ft .
RLZ: Motion limit flag, vertical axis, n.d..

PSDFU: Roll angular accelerometer reading, body axis, rad/sec^2 .
PPHISC: Roll attitude command, inertial axis, rad .
PHISFU: Roll attitude reading, inertial axis, rad .
RLP: Motion limit flag, roll axis, n.d..

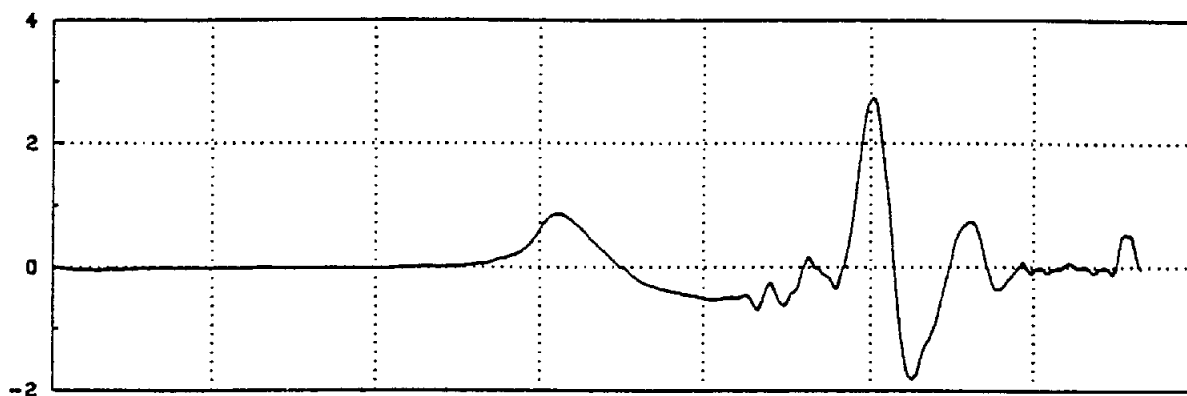
QSDFU: Pitch angular accelerometer reading, body axis, rad/sec^2 .
QSFU: Pitch angular rate transducer reading, body axis, rad/sec .
PHTSC: Pitch attitude command, inertial axis, rad .
THTSFU: Pitch attitude reading, inertial axis, rad .
RLQ: Motion limit flag, pitch axis, n.d..

RSDFU: Yaw angular accelerometer reading, body axis, rad/sec^2 .
PPSISC: Yaw attitude command, inertial axis, rad .
PSISFU: Yaw attitude reading, inertial axis, rad .
RLR: Motion limit flag, yaw axis, n.d..

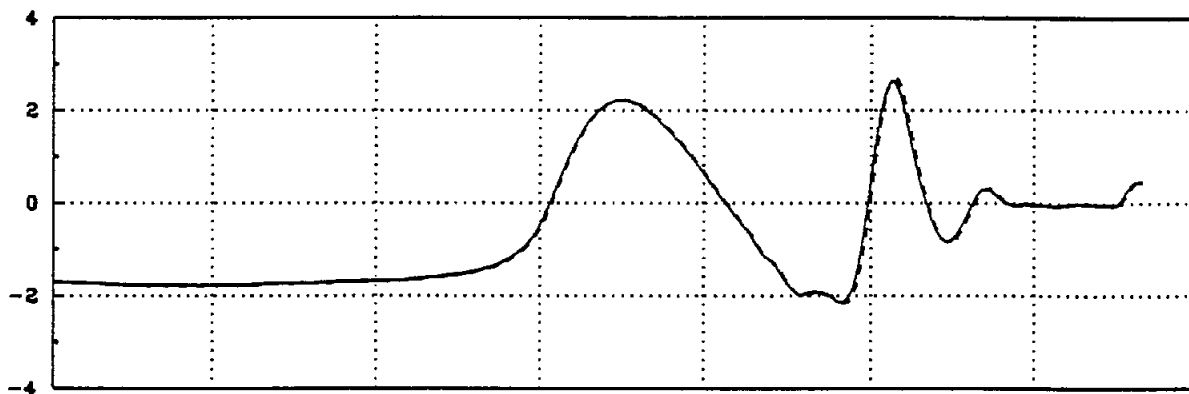
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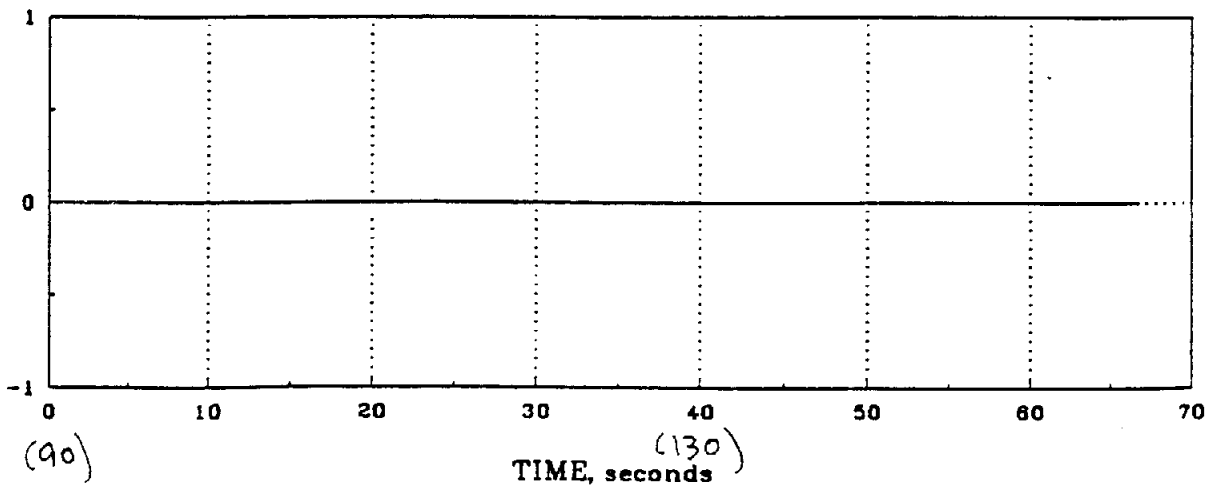
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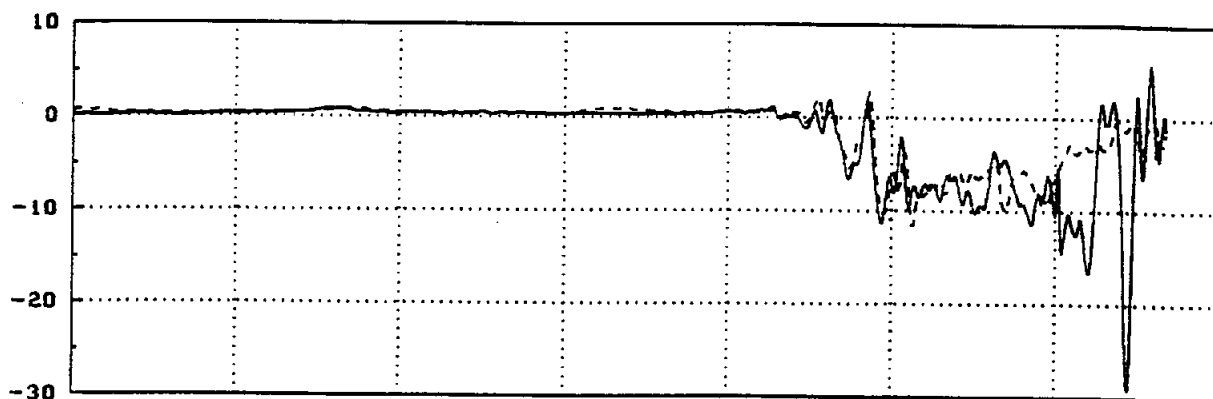
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PLONFU



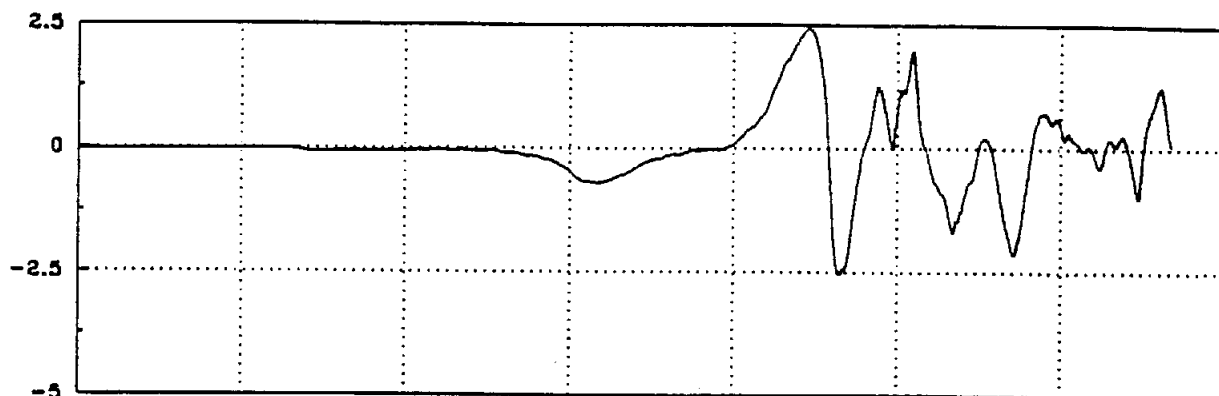
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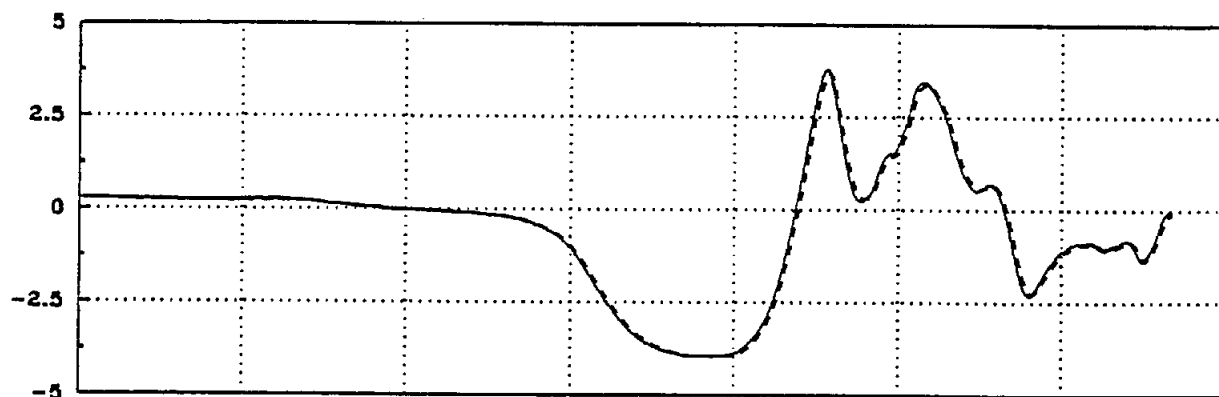
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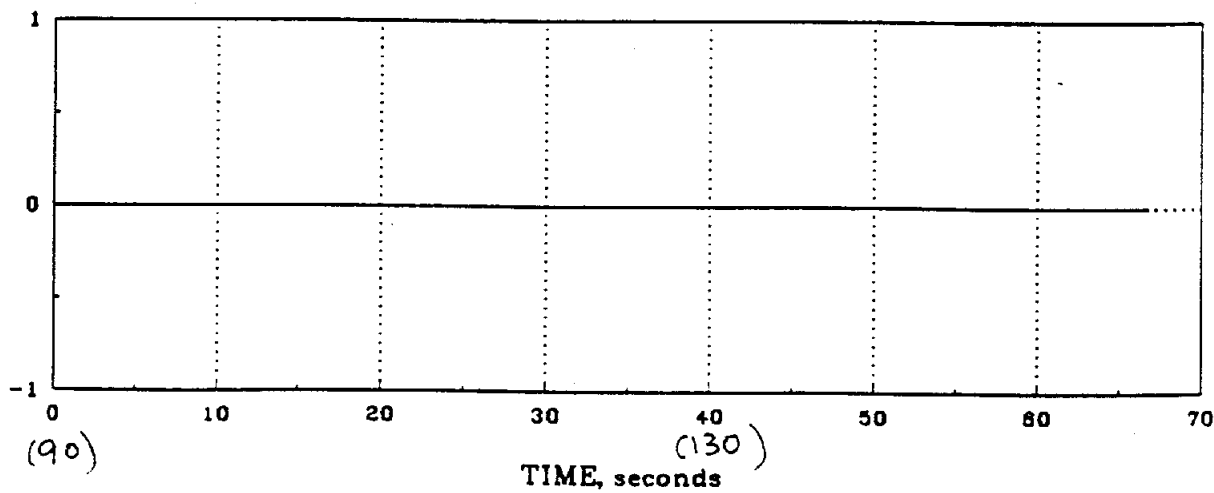
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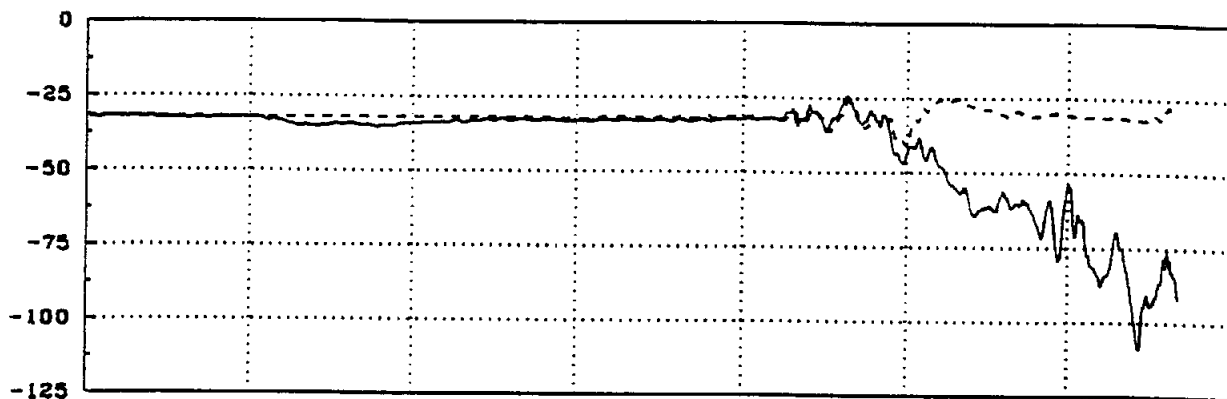
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PLATFU



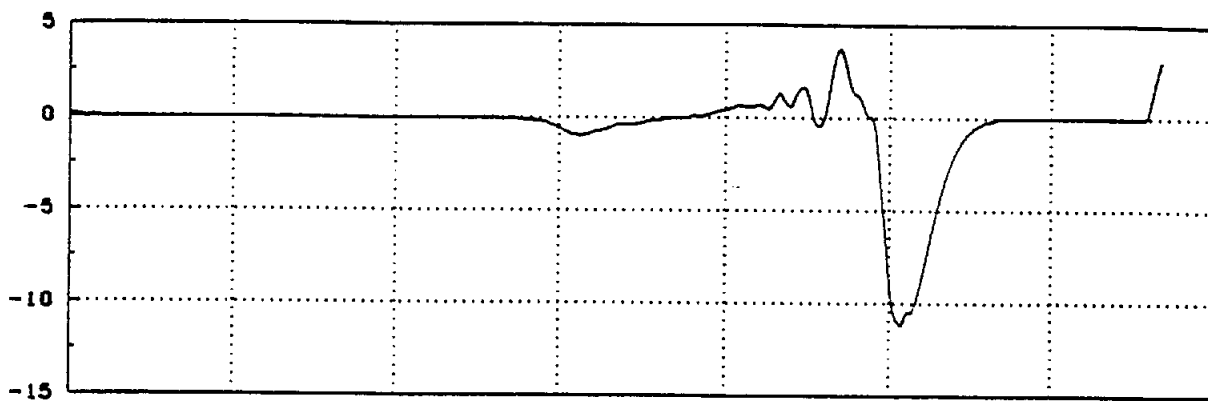
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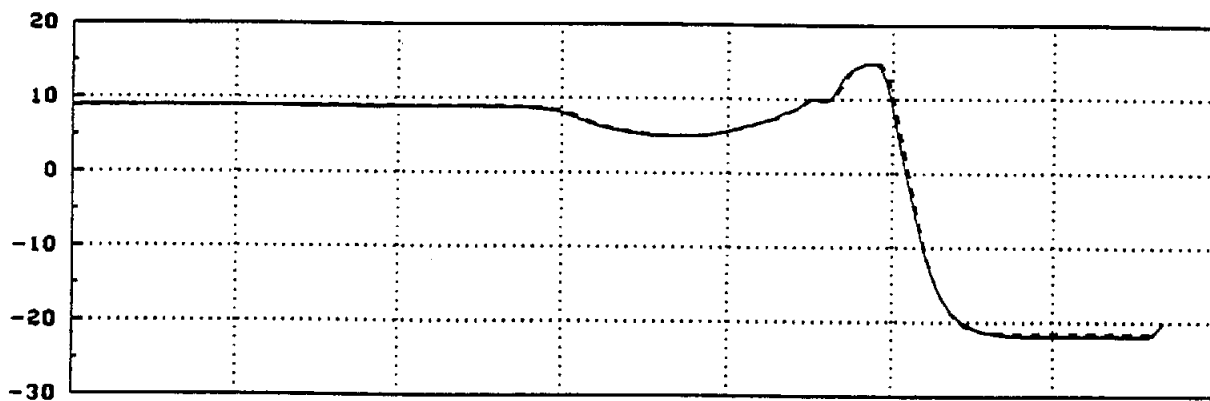
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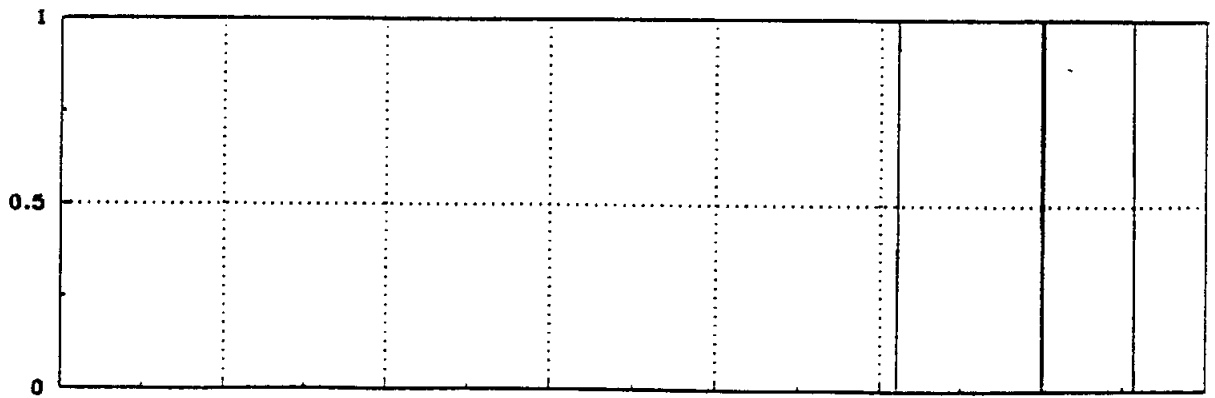
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PZC
PZFU



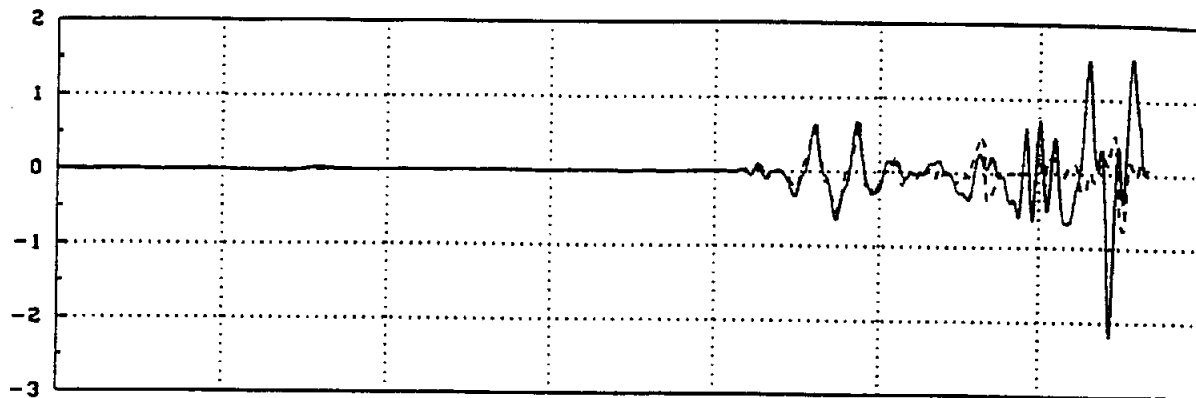
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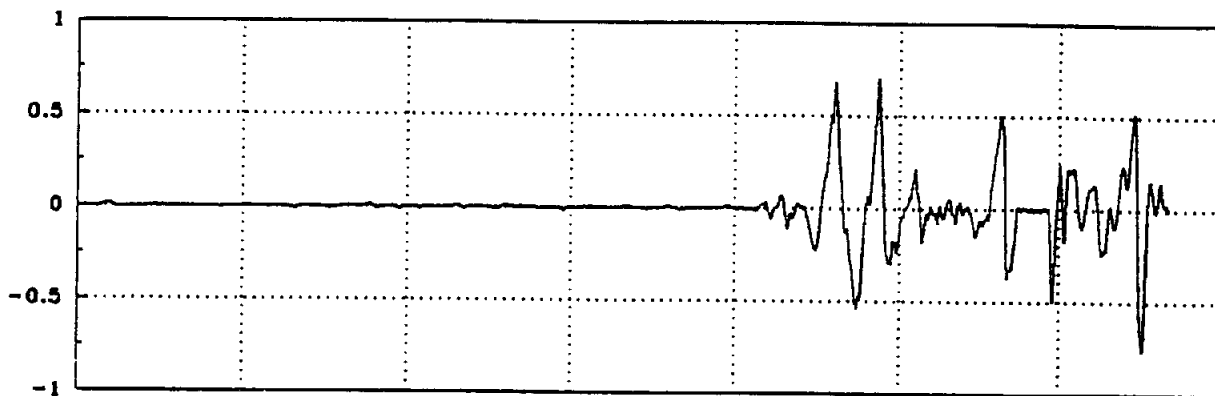
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(130)
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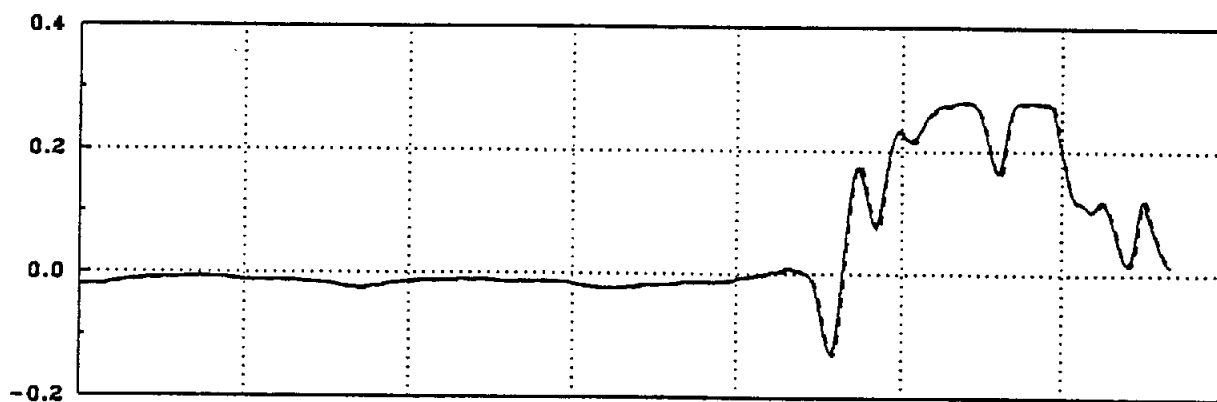
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PSDFU



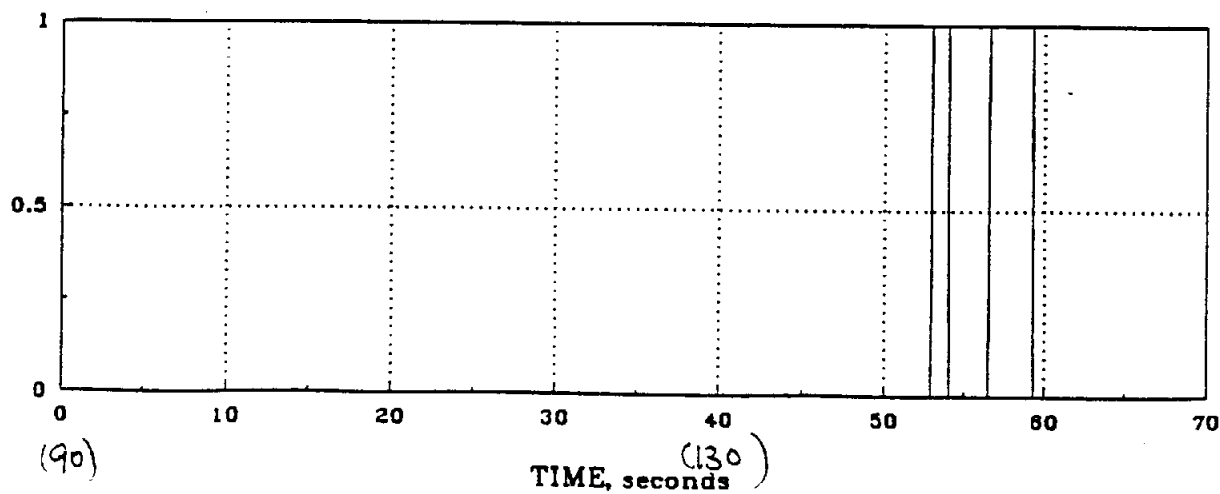
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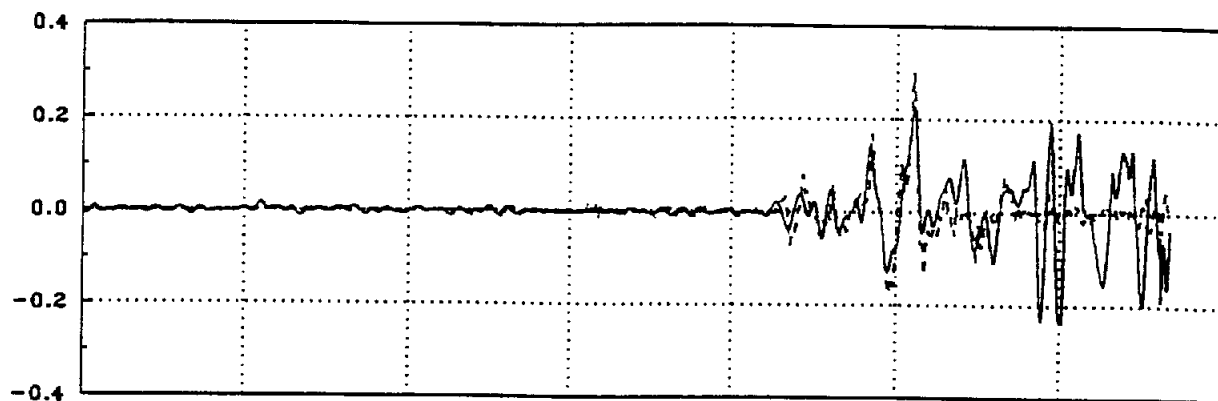
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PHISFU



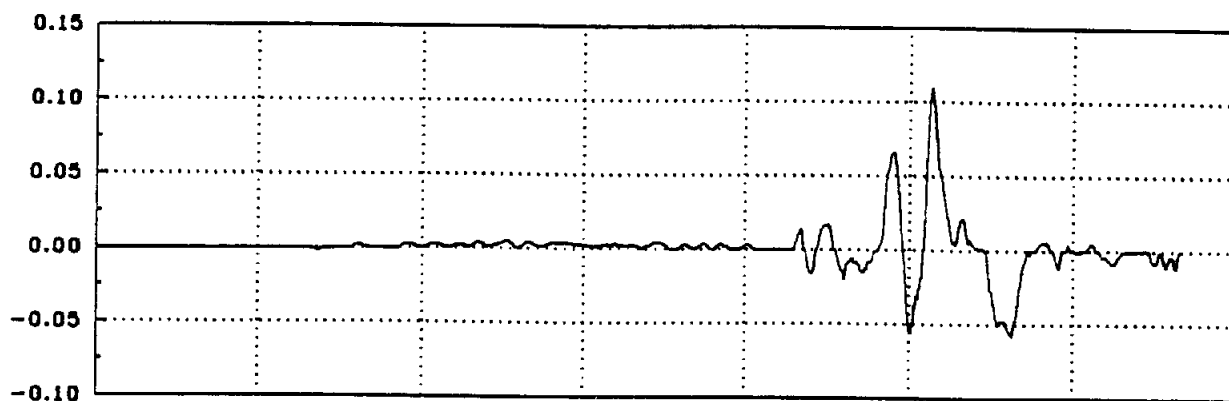
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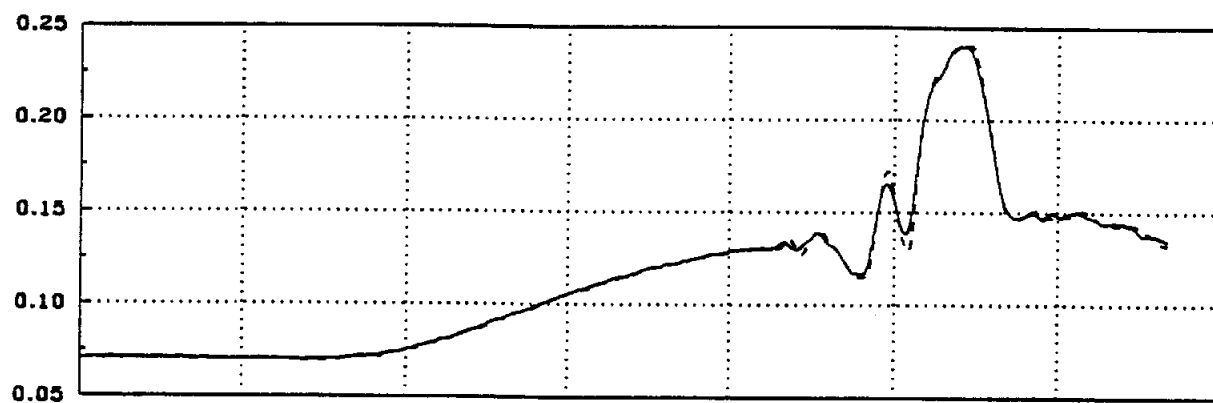
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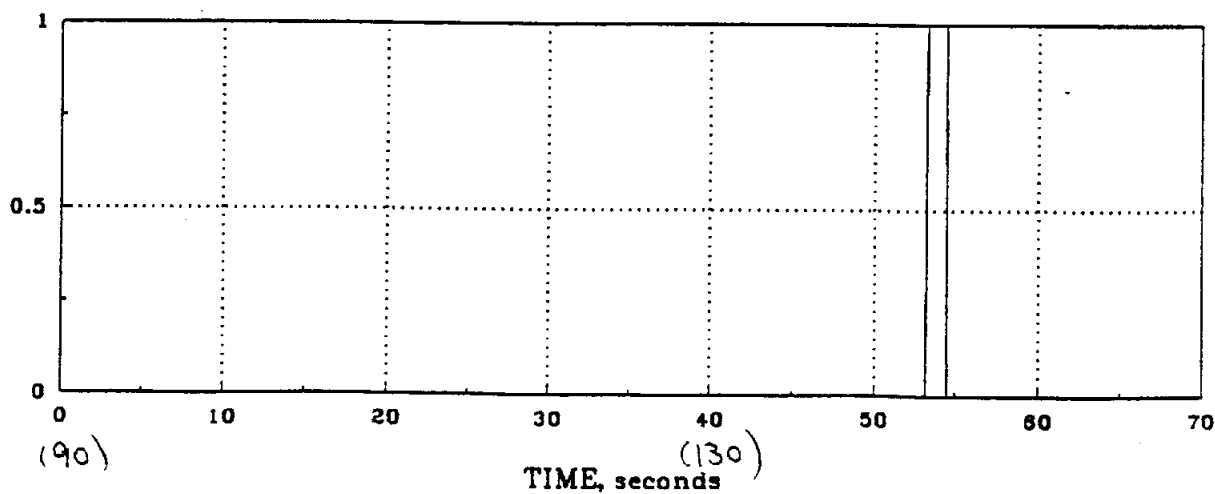
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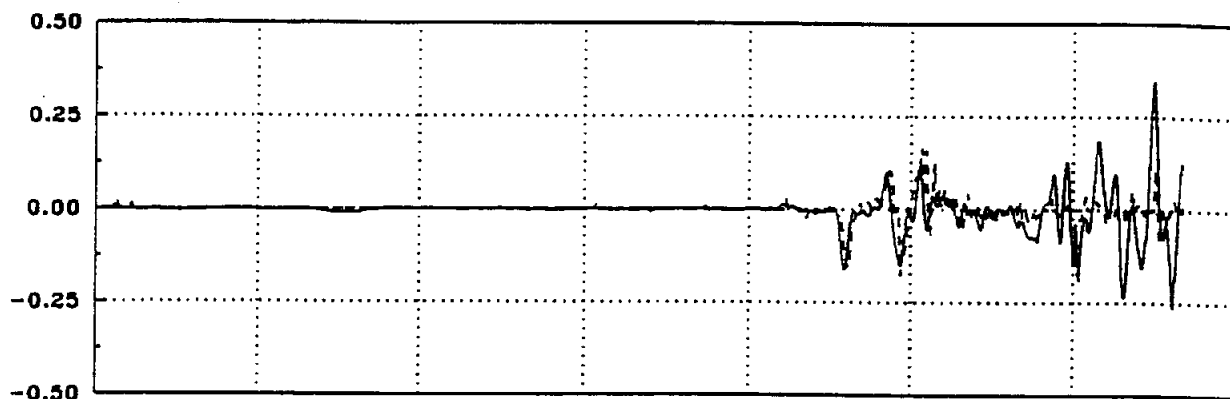
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THTSFU



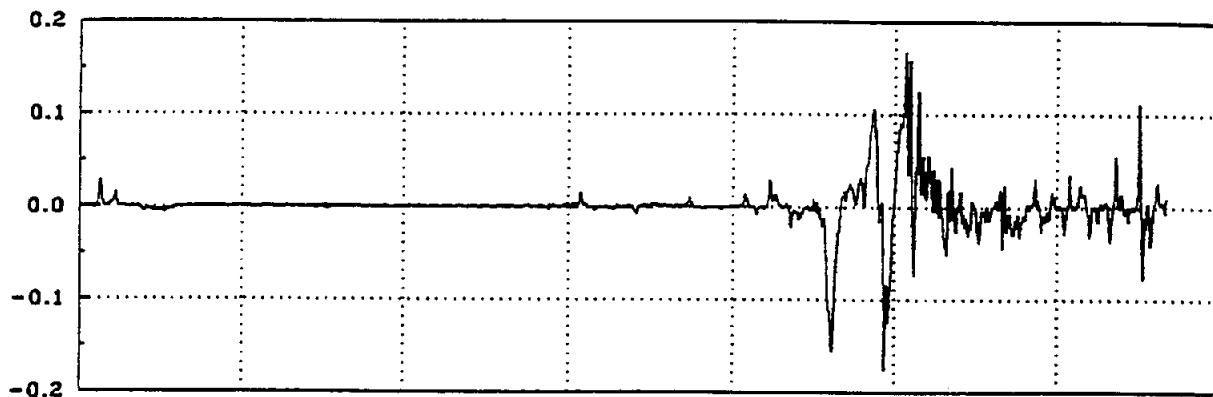
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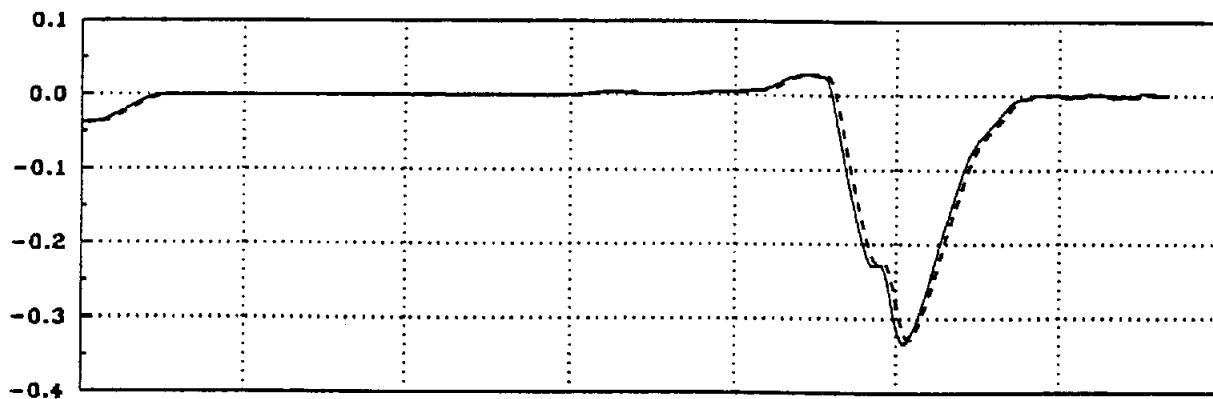
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RSDFU



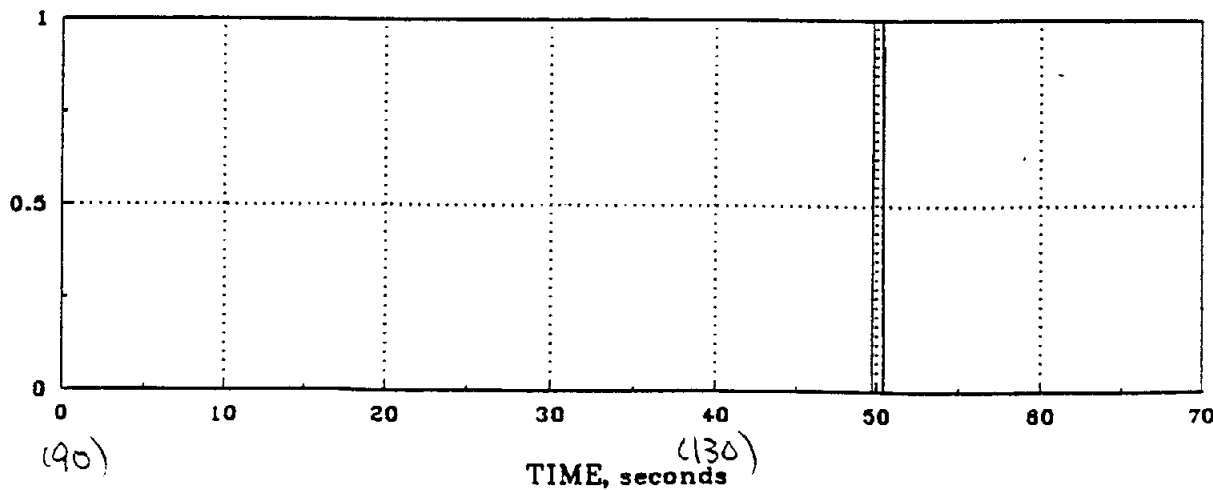
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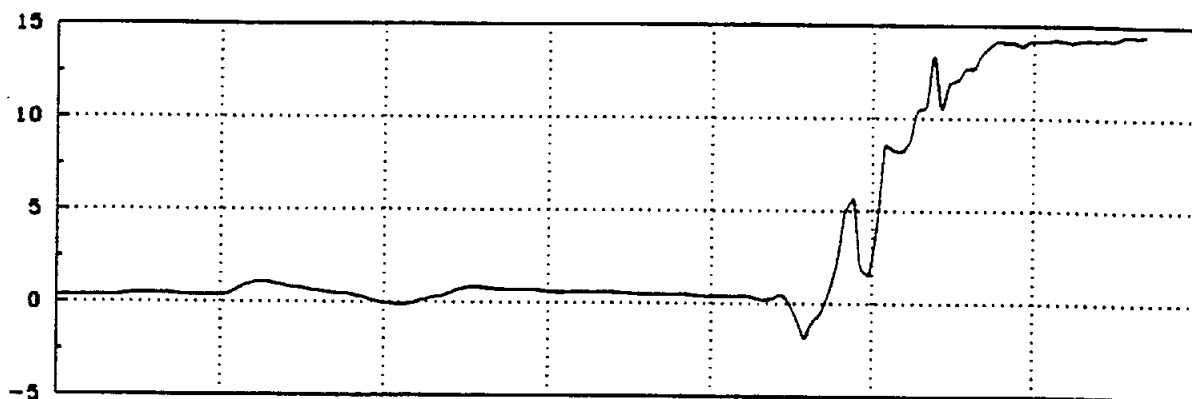
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PSISFU



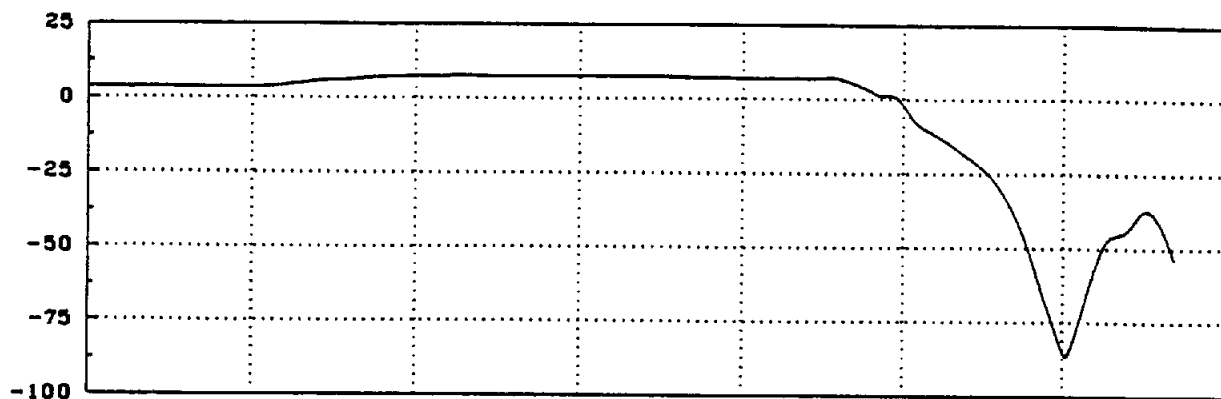
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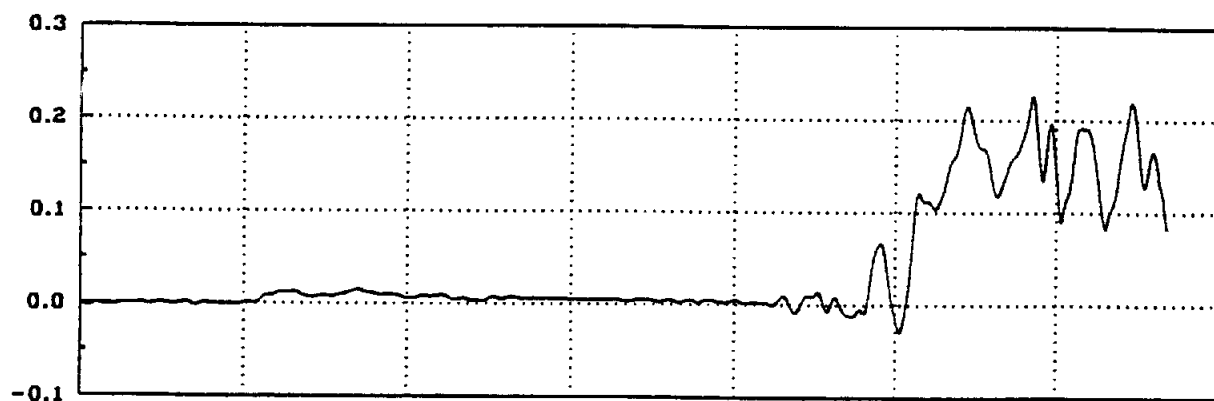
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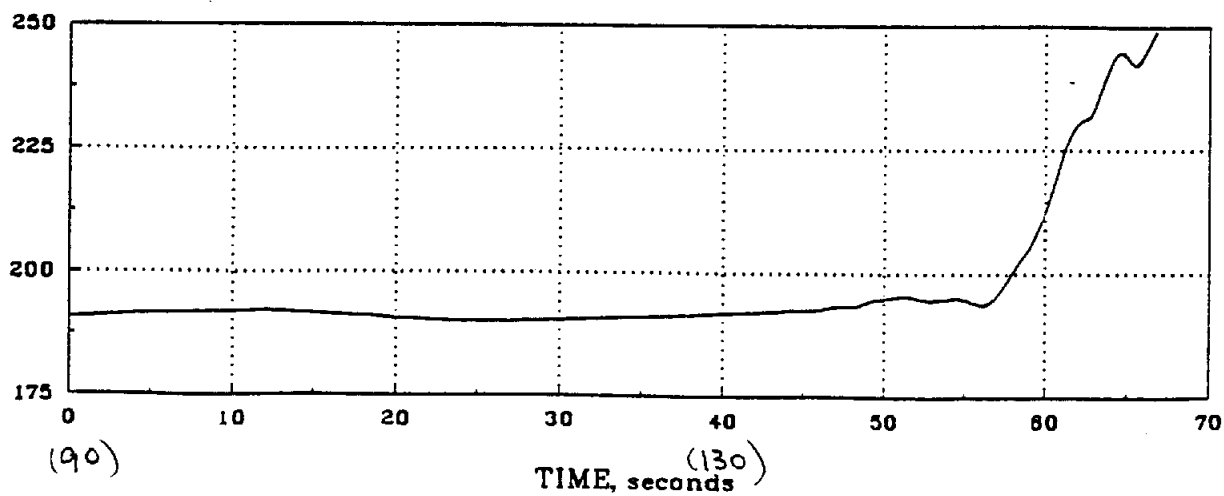
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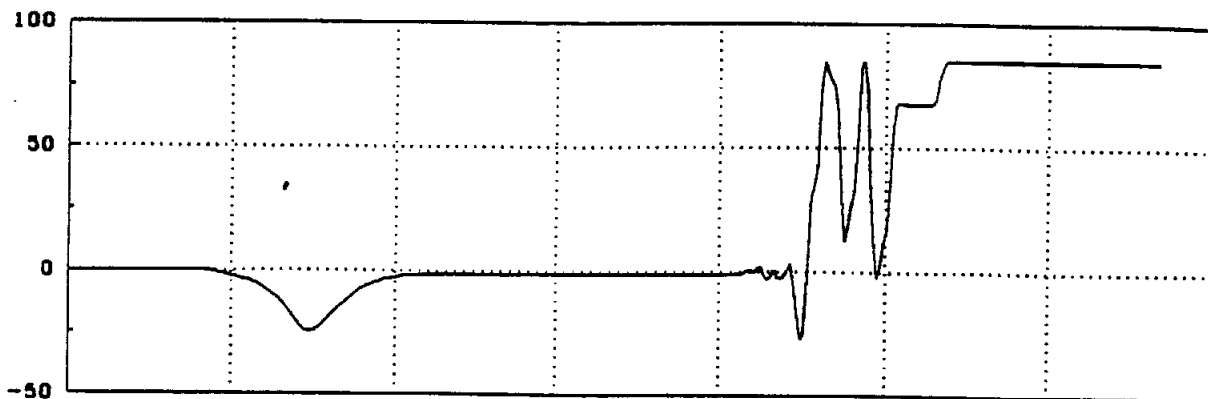
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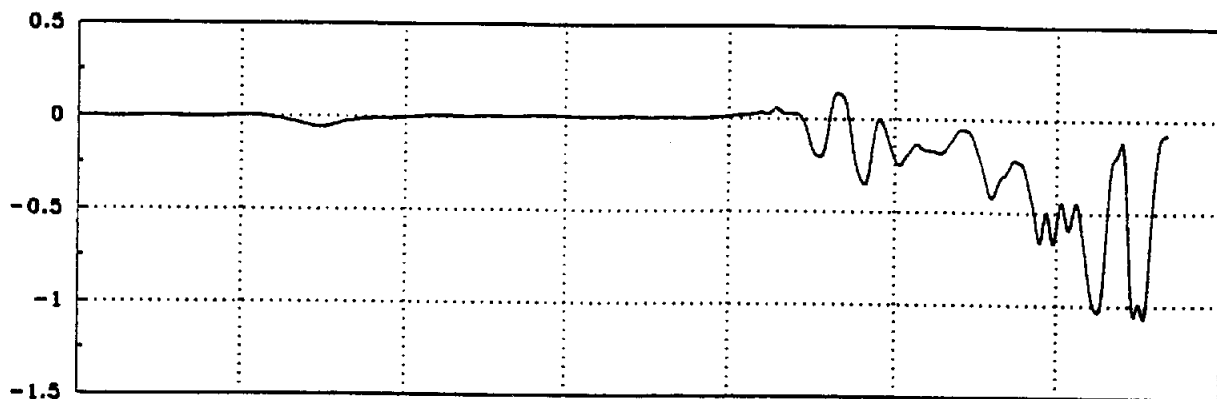
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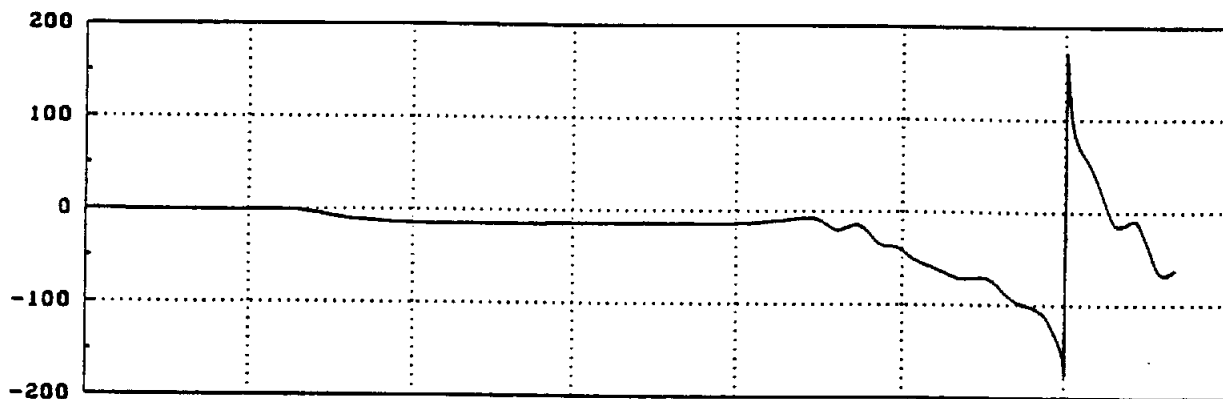
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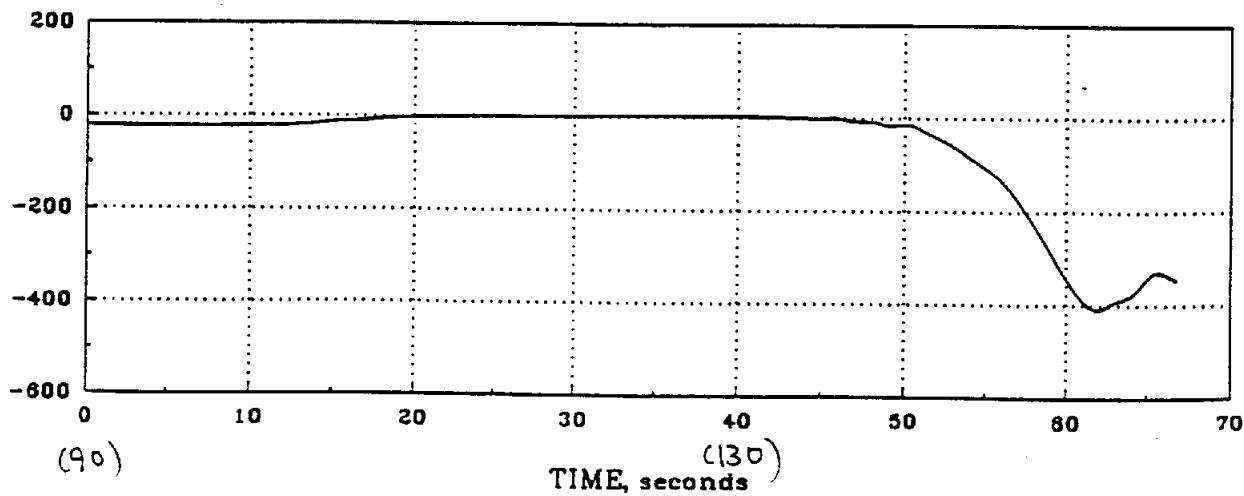
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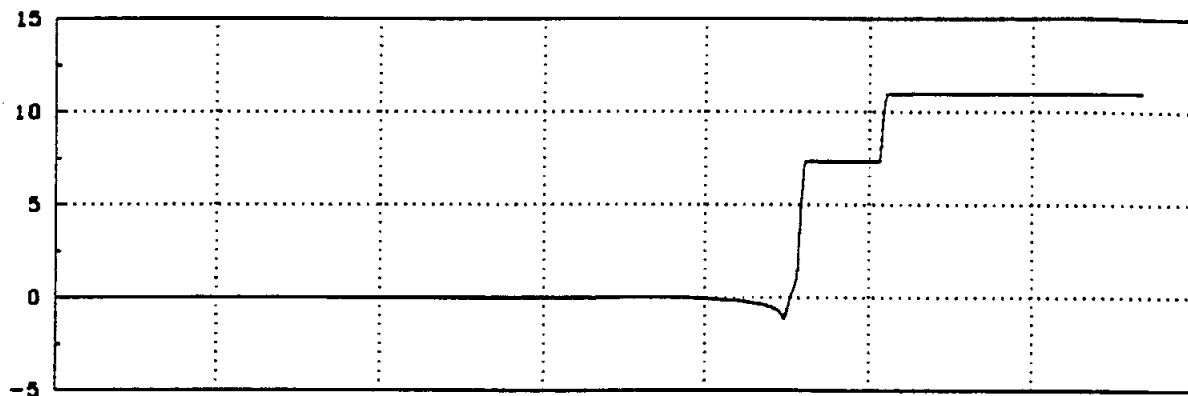
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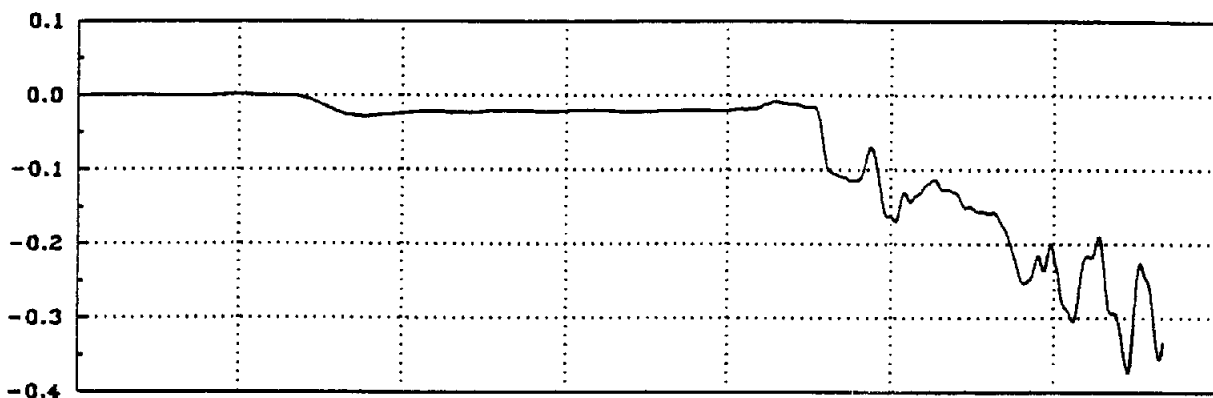
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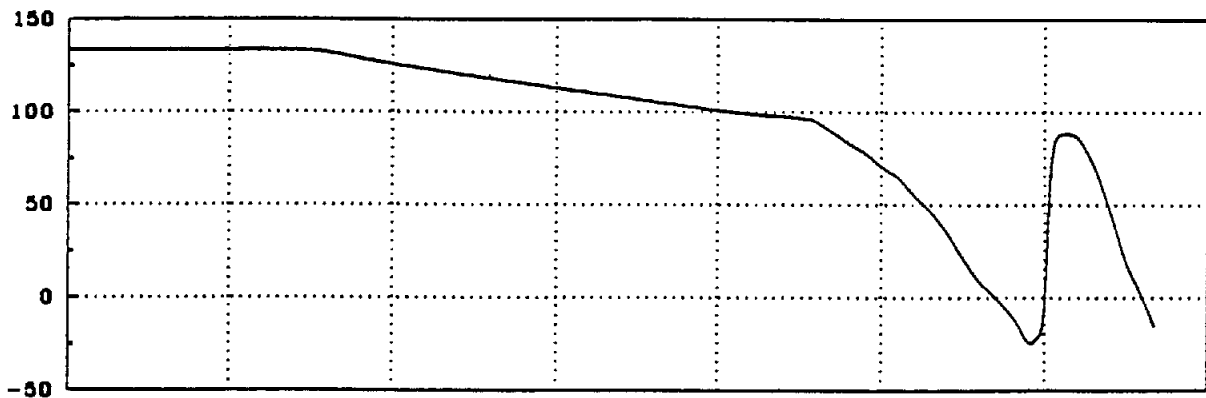
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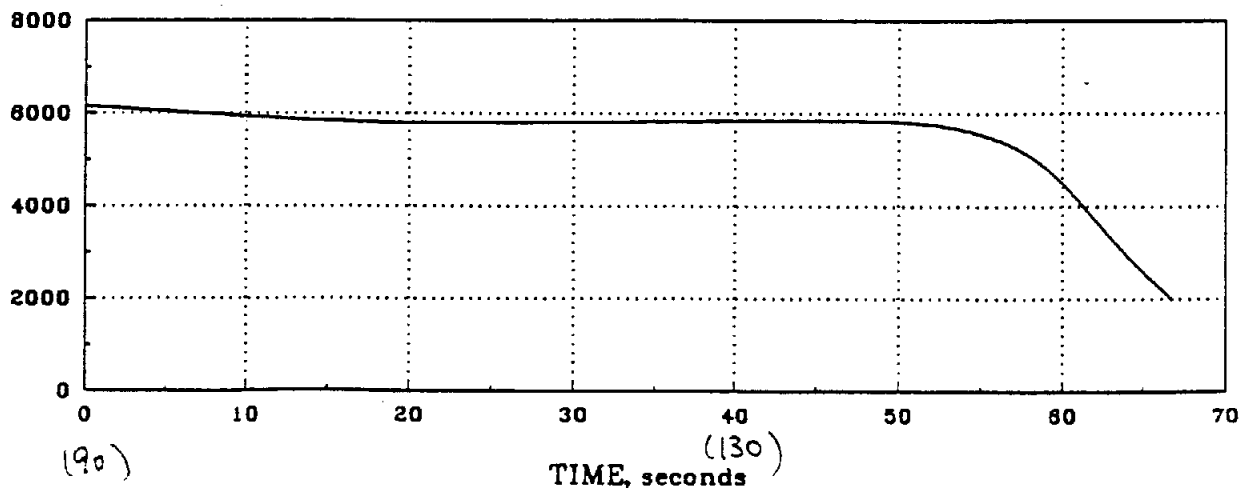
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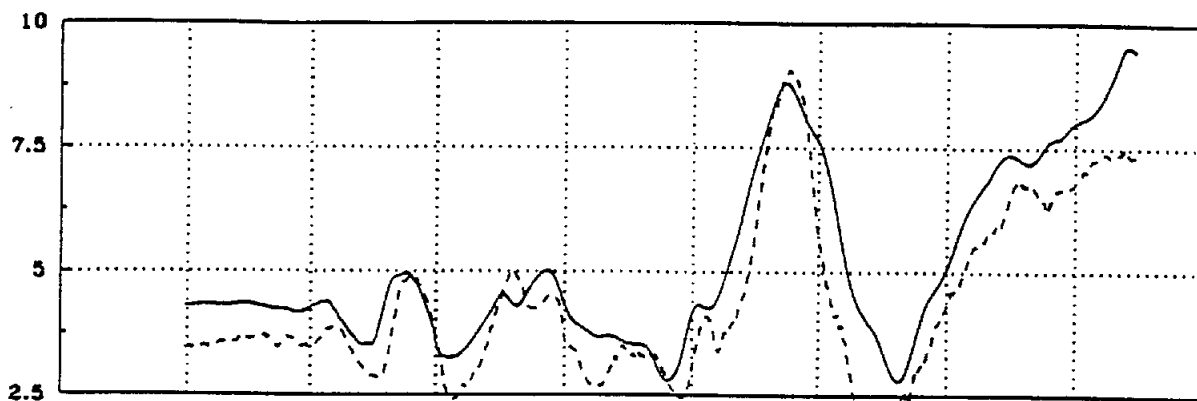
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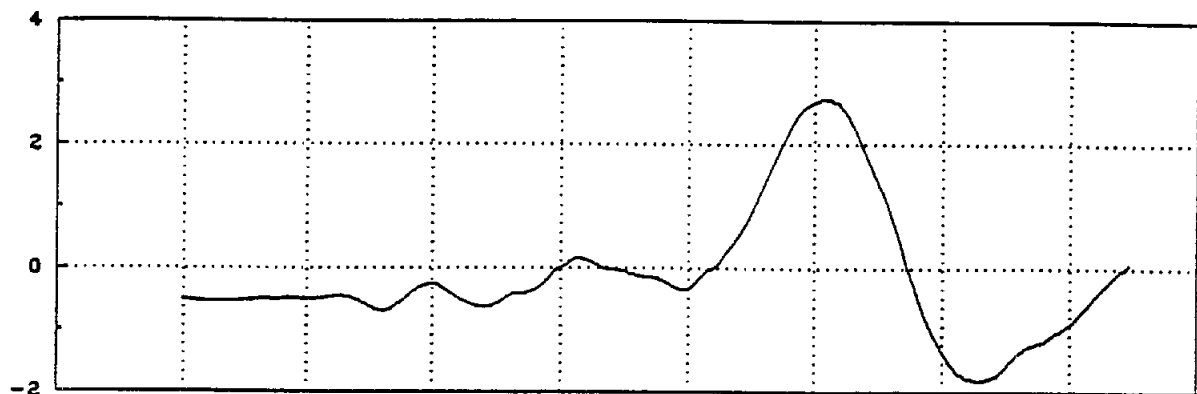
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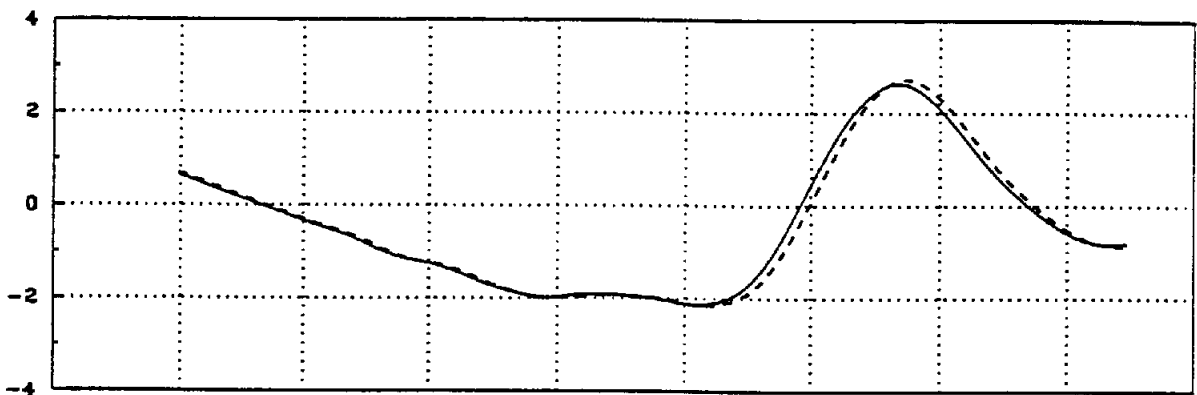
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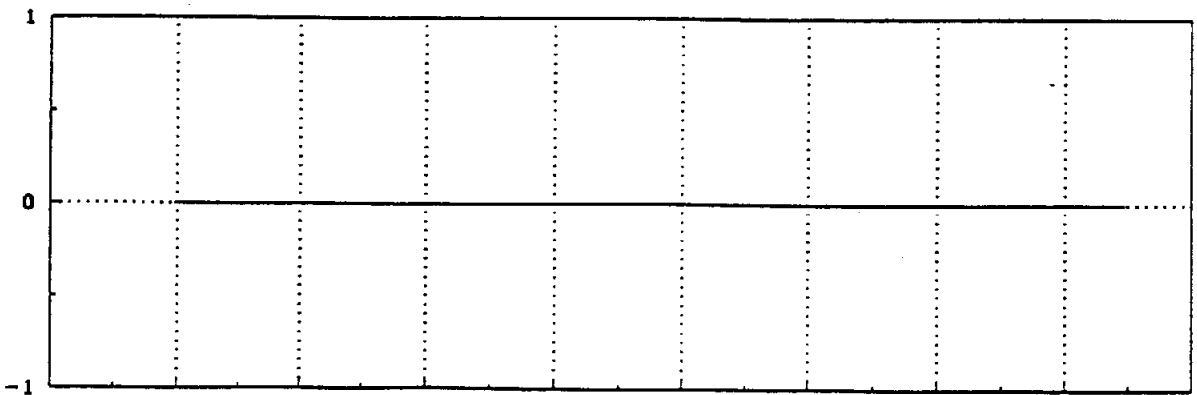
VLONFU



PLONC
PLONFU

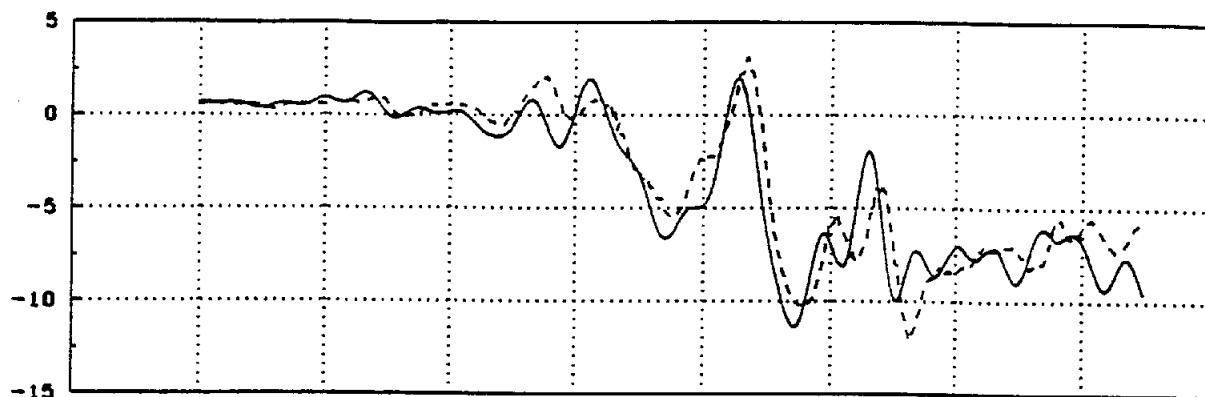


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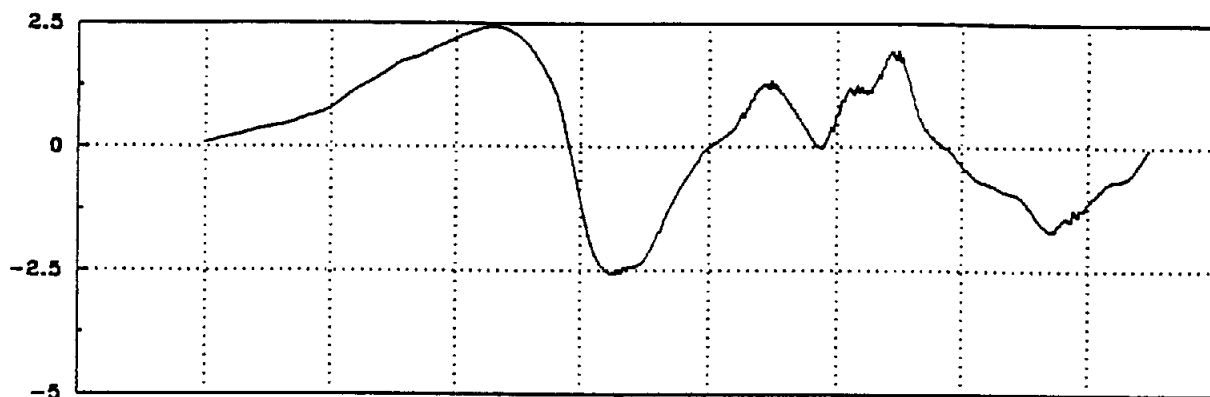


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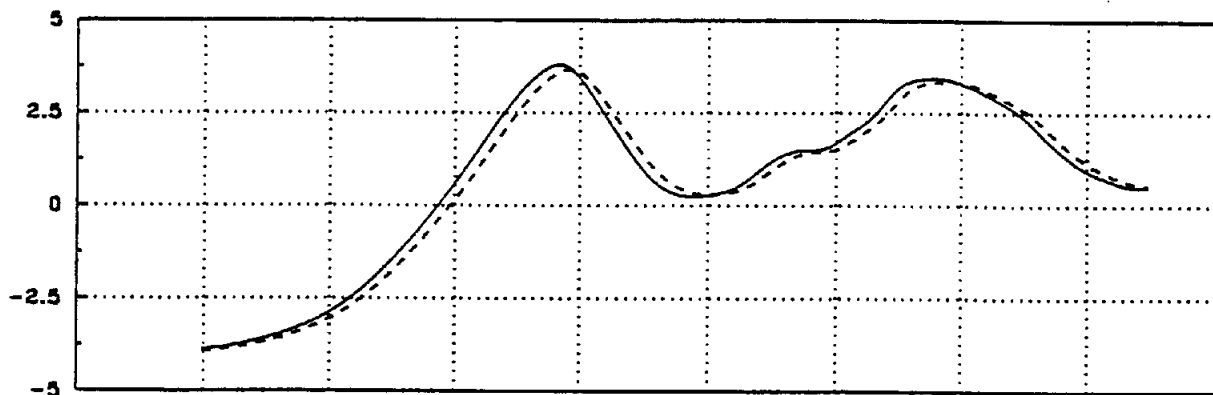
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AYPVMS



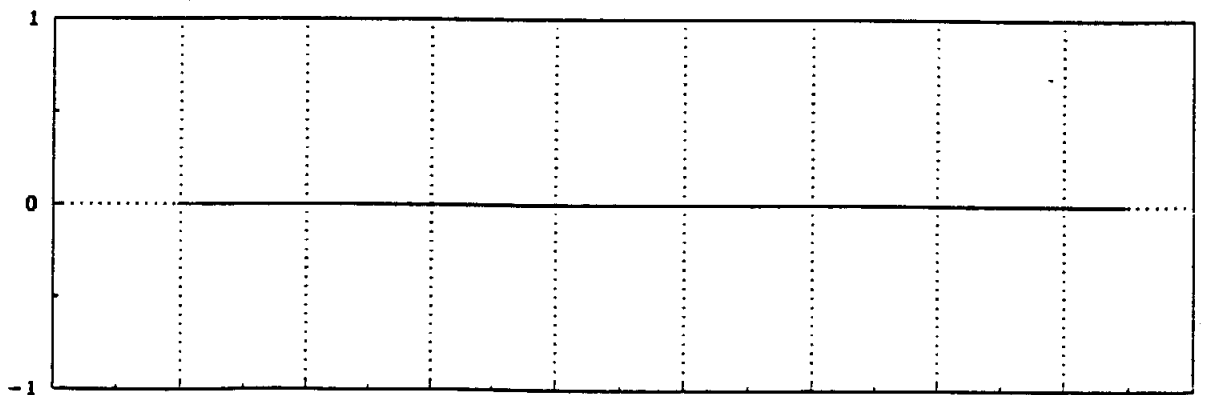
VLATFU



PLATC
PLATFU



RLY

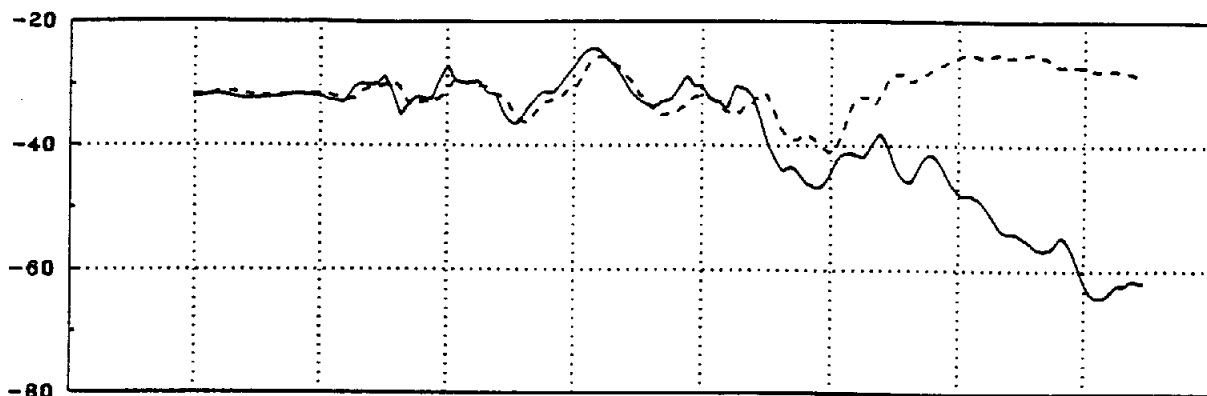


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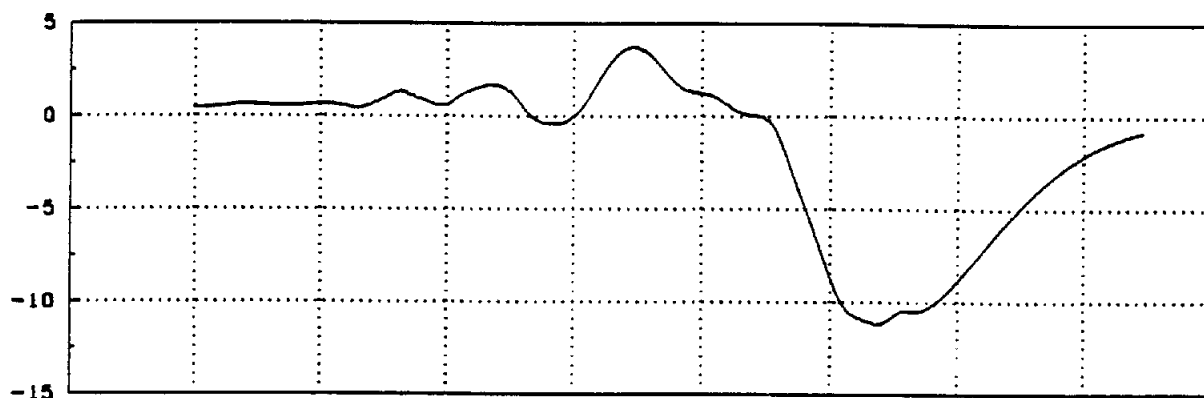
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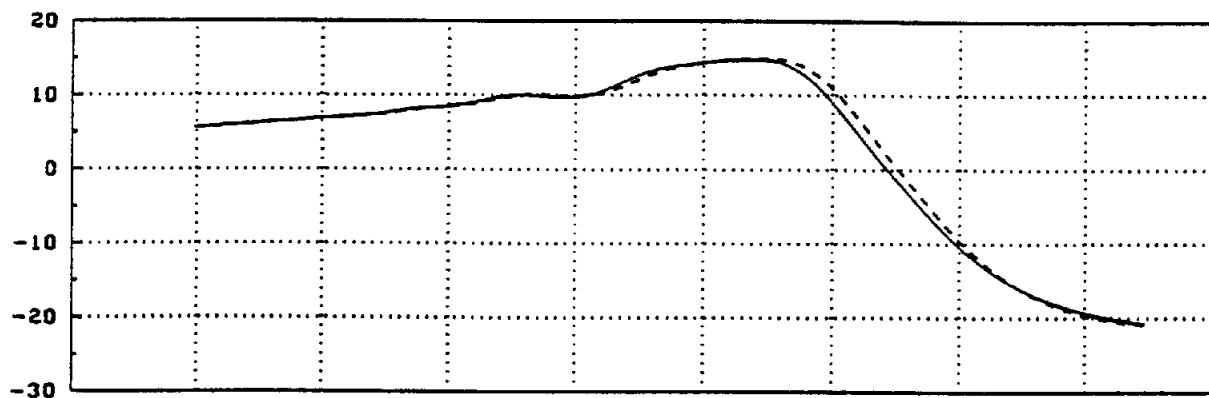
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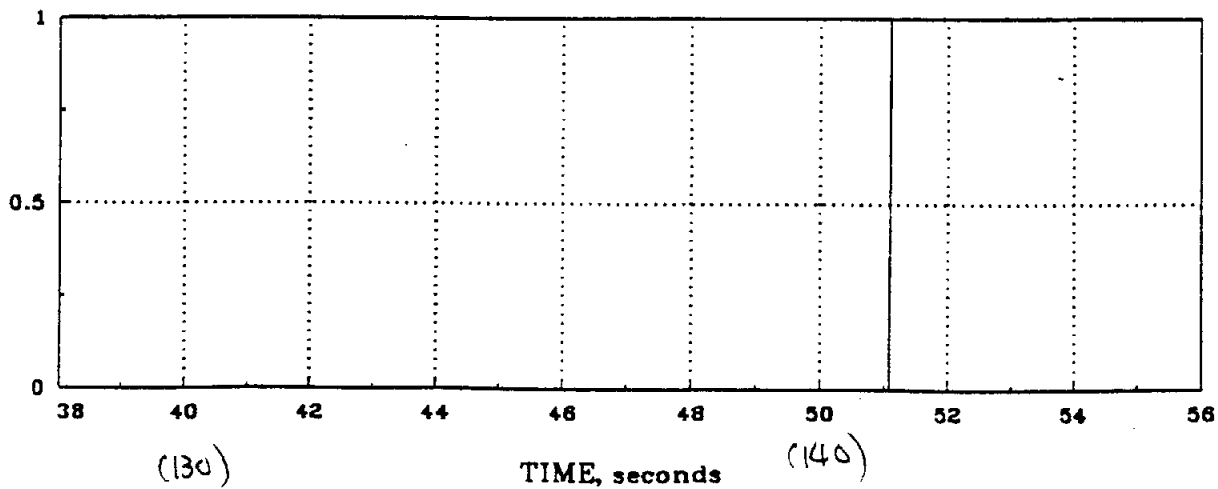
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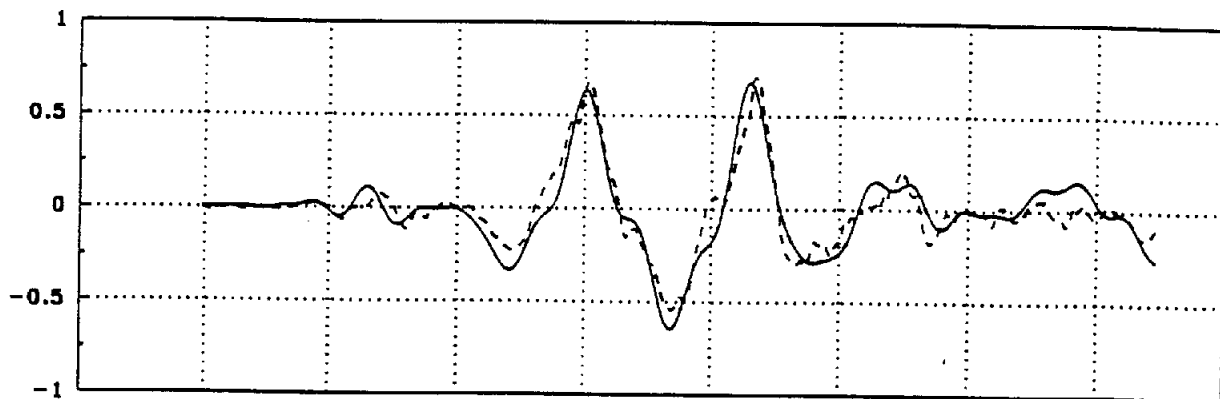
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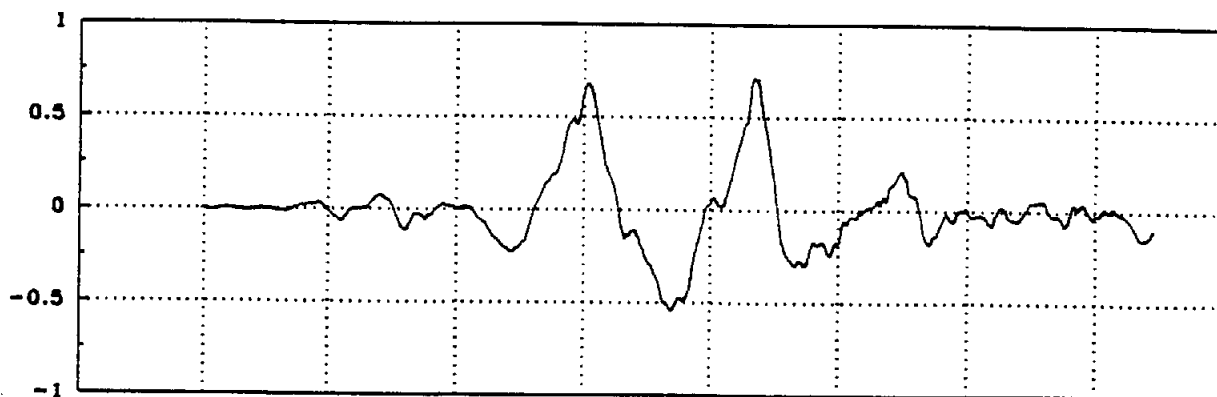
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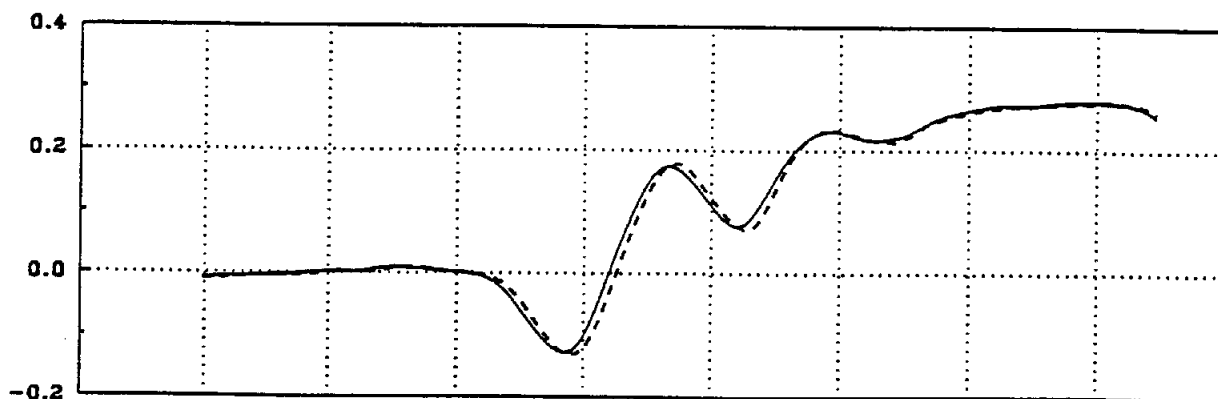
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PSDFU



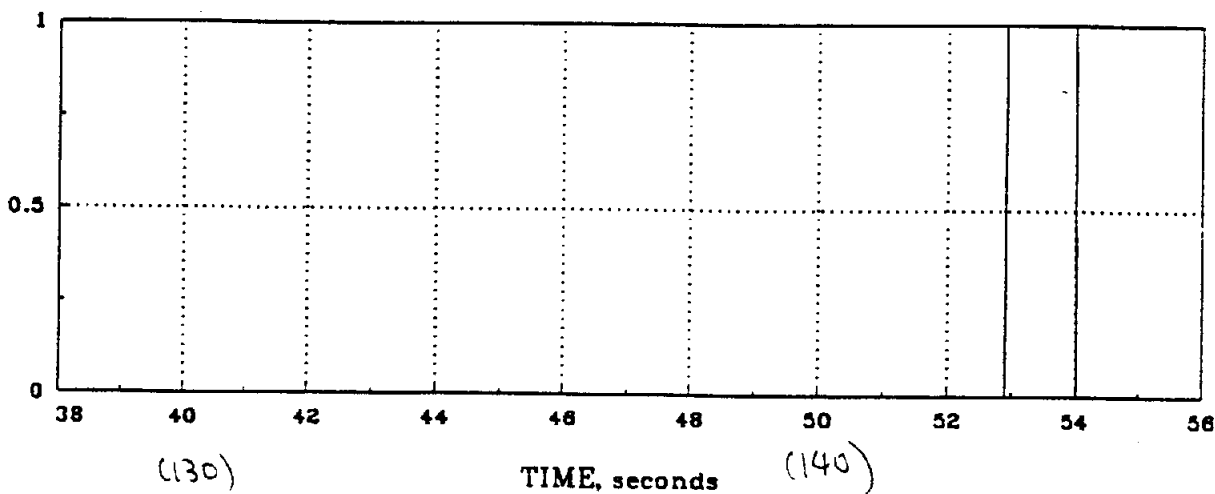
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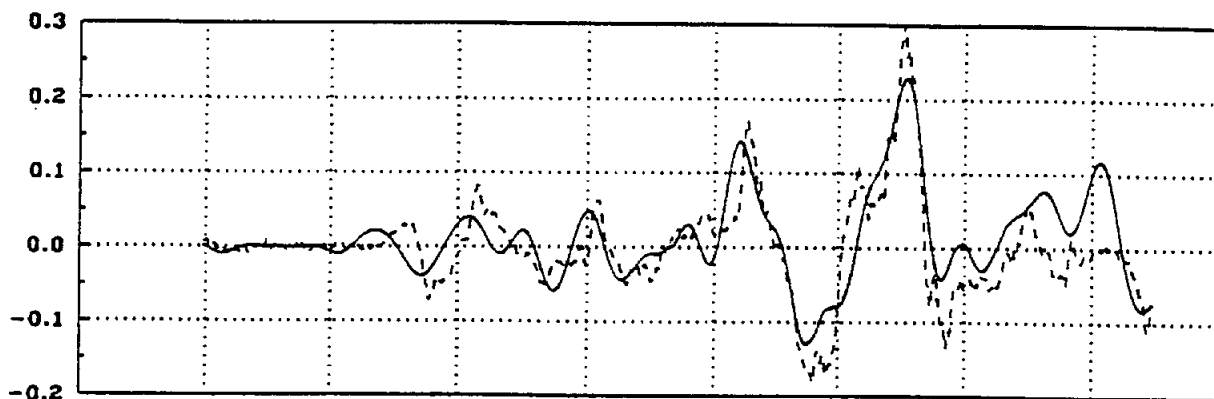
PPHISC
PHISFU



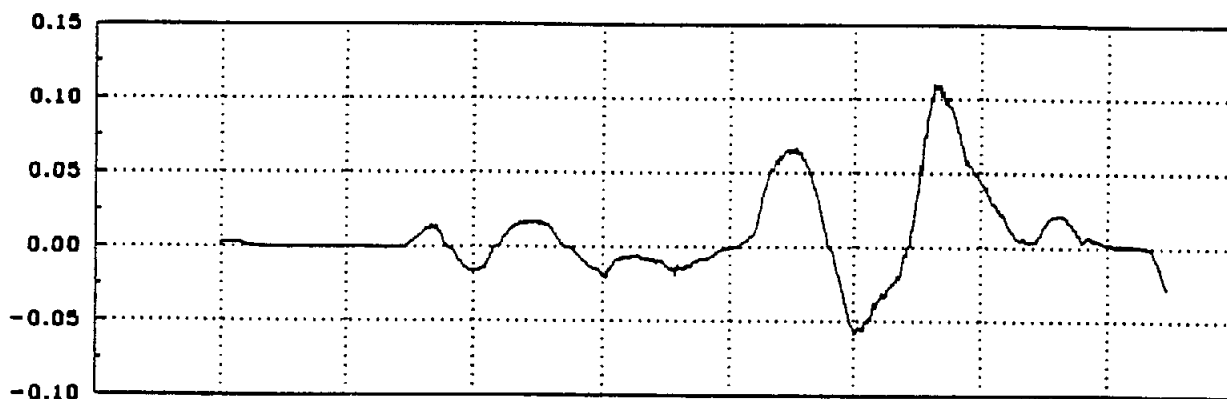
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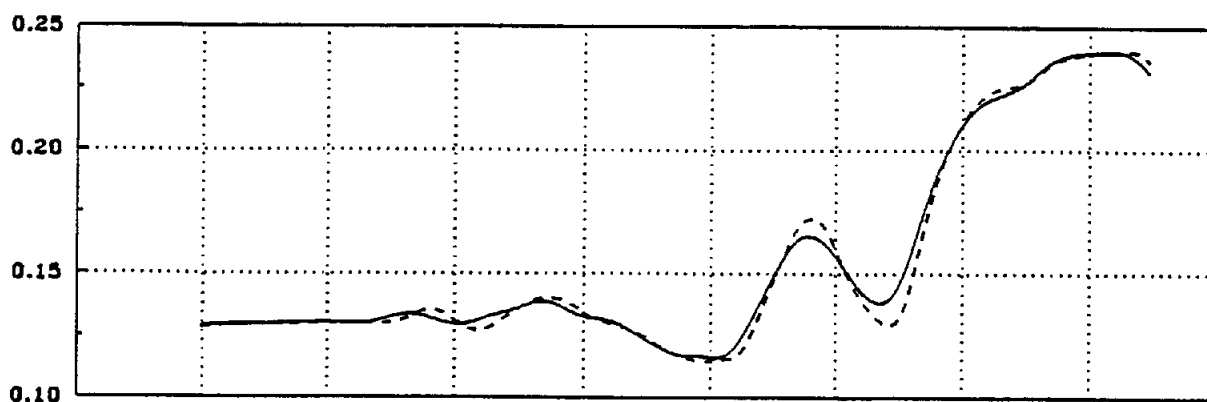
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QSDFU



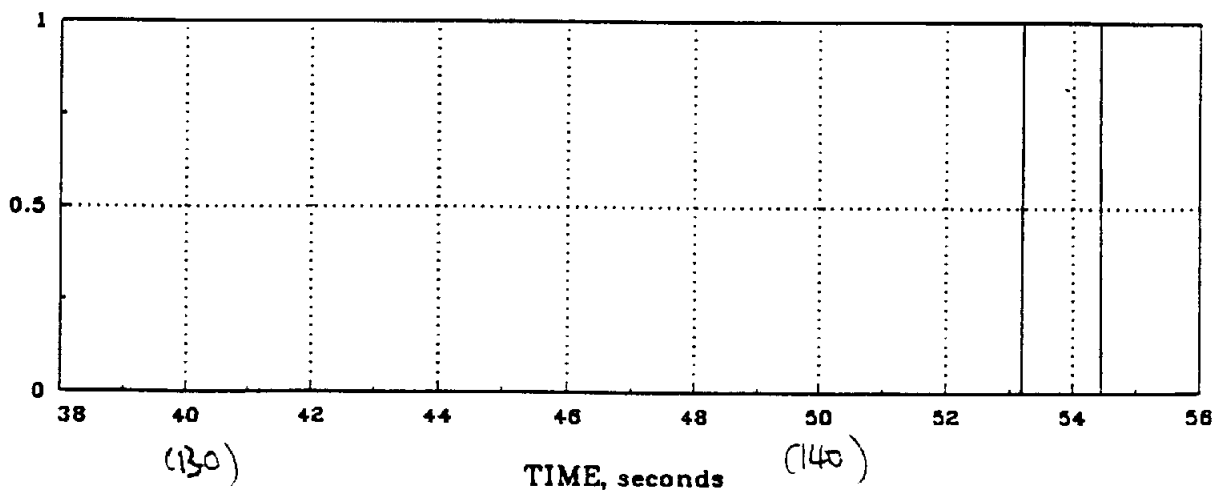
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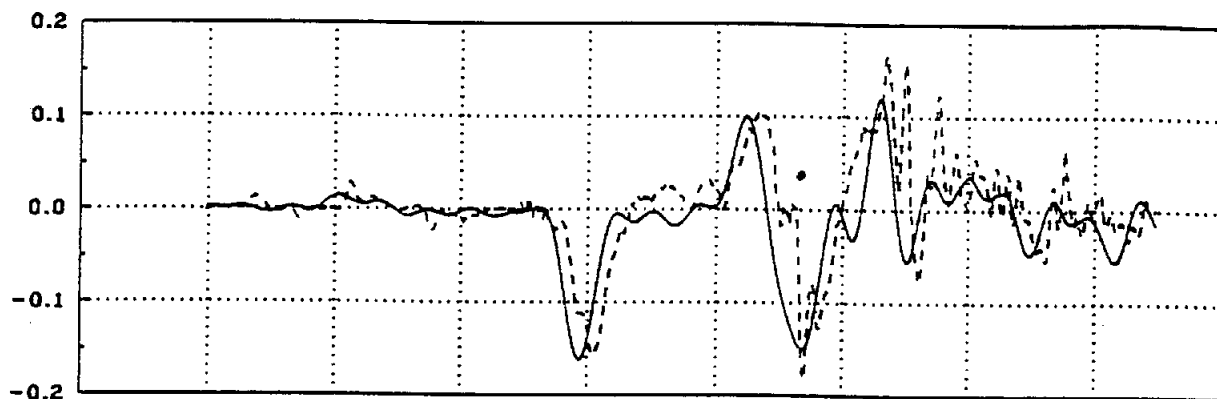
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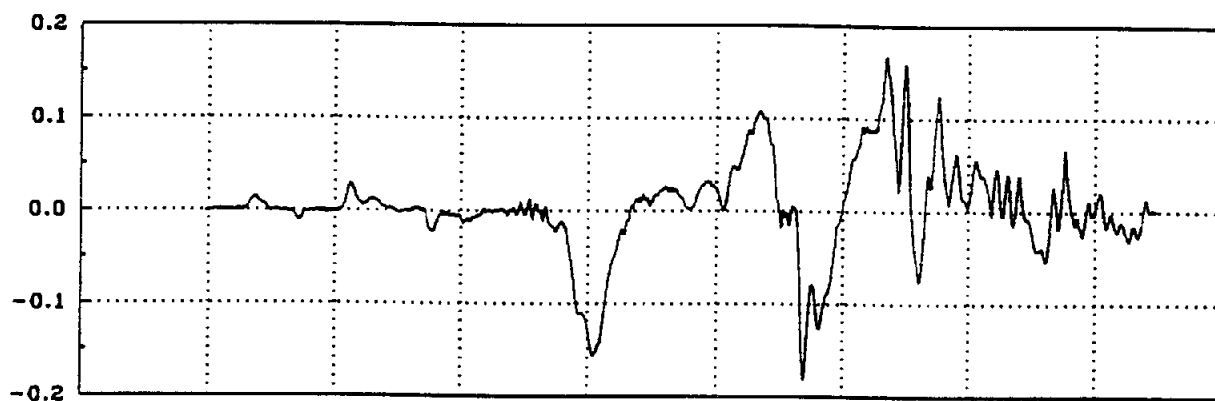
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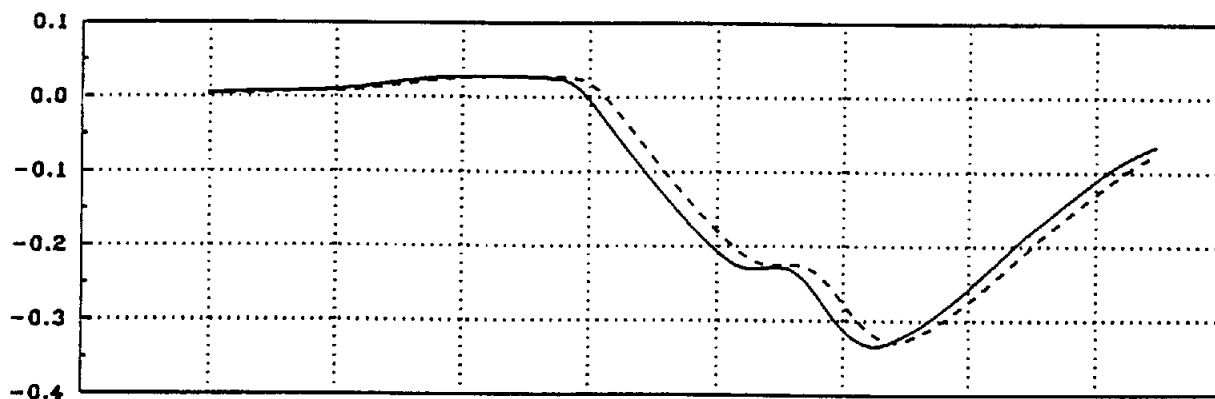
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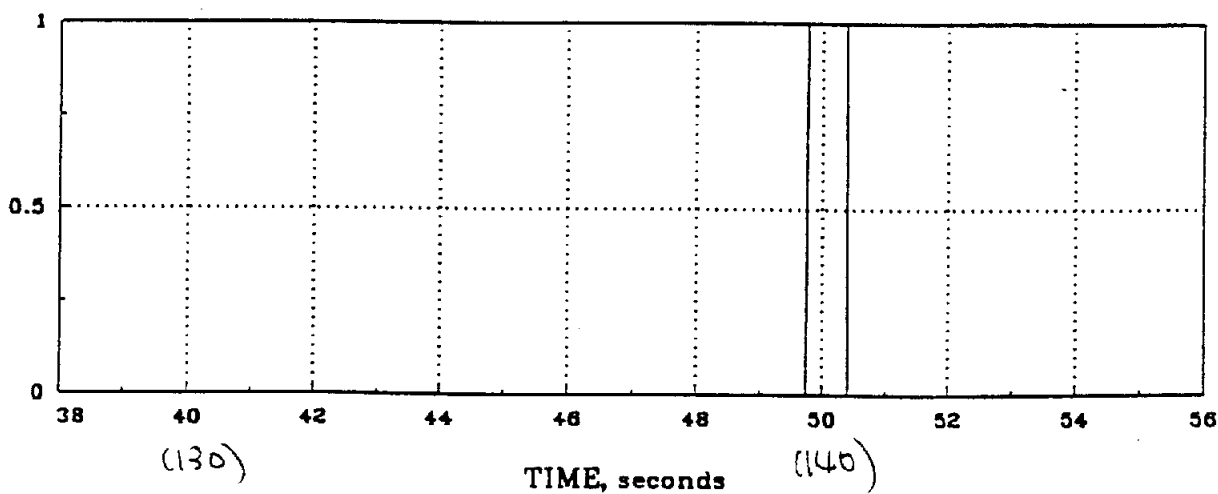
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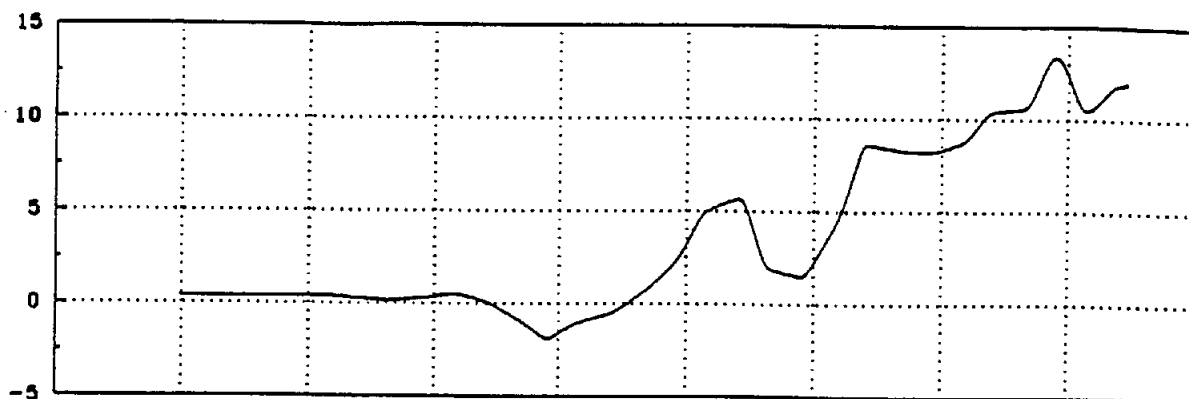
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PSISFU



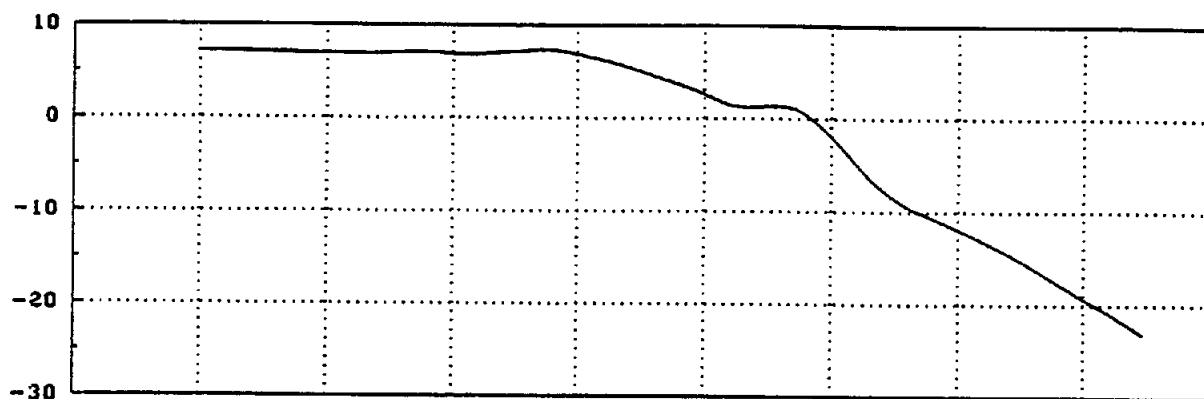
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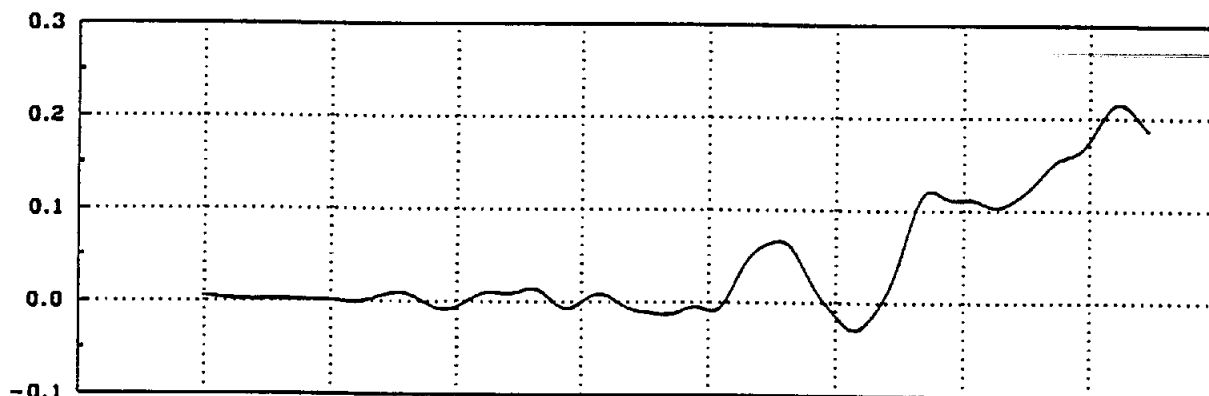
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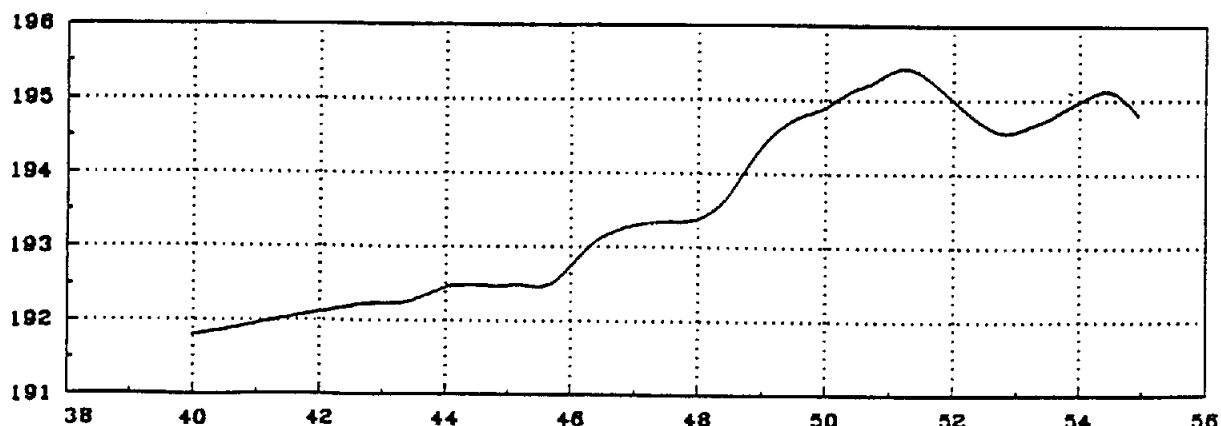
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QB



VCAL

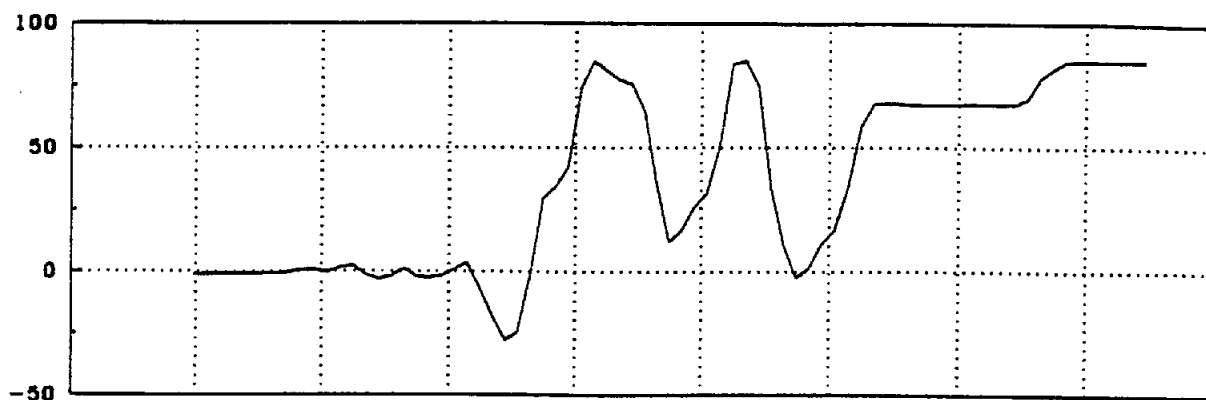


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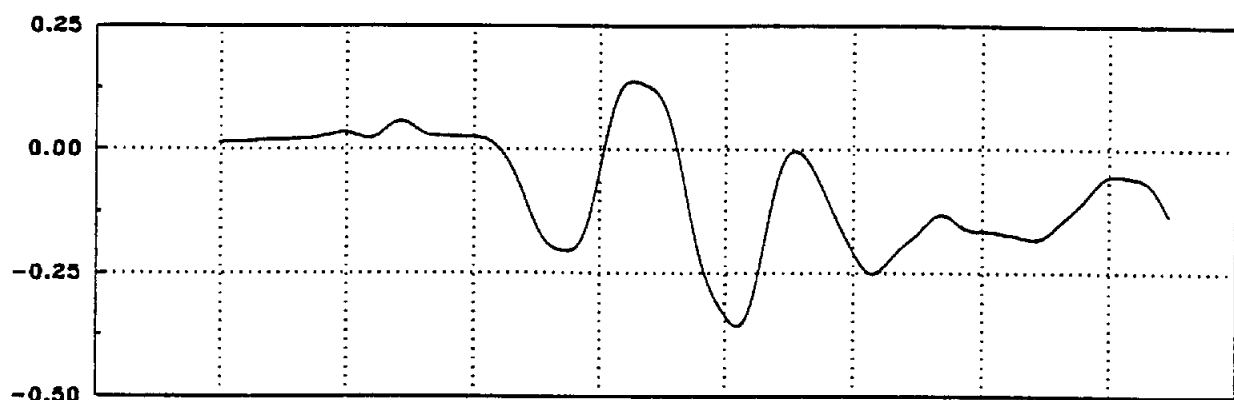
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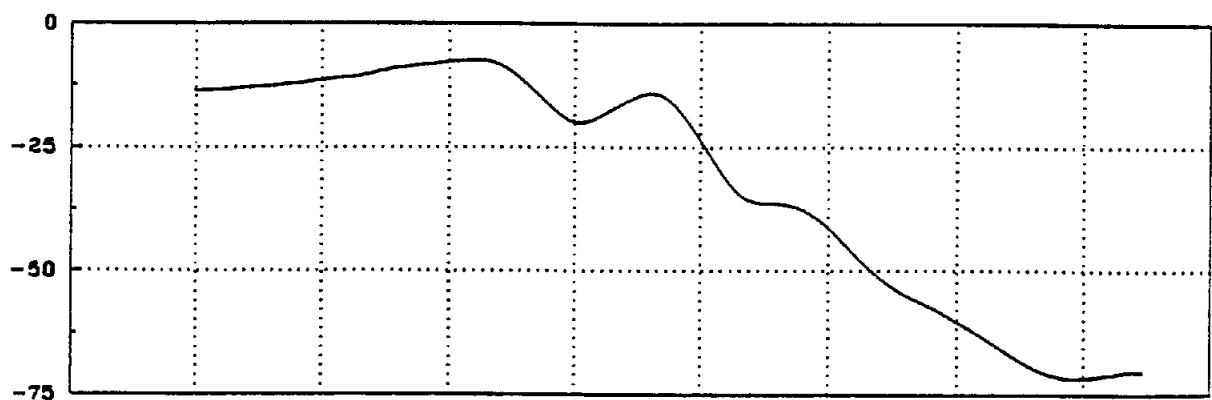
WHEEL



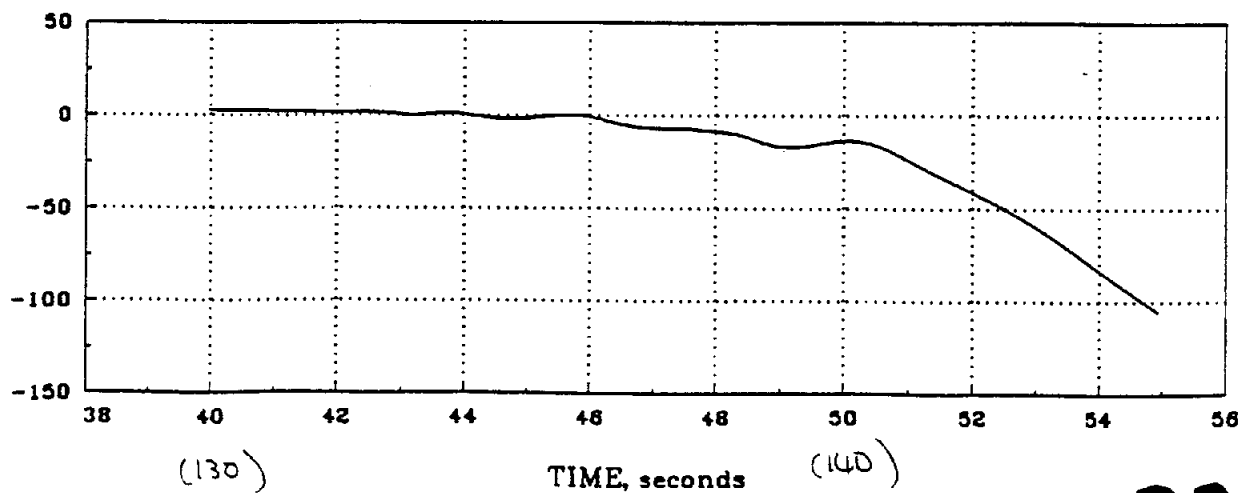
PB



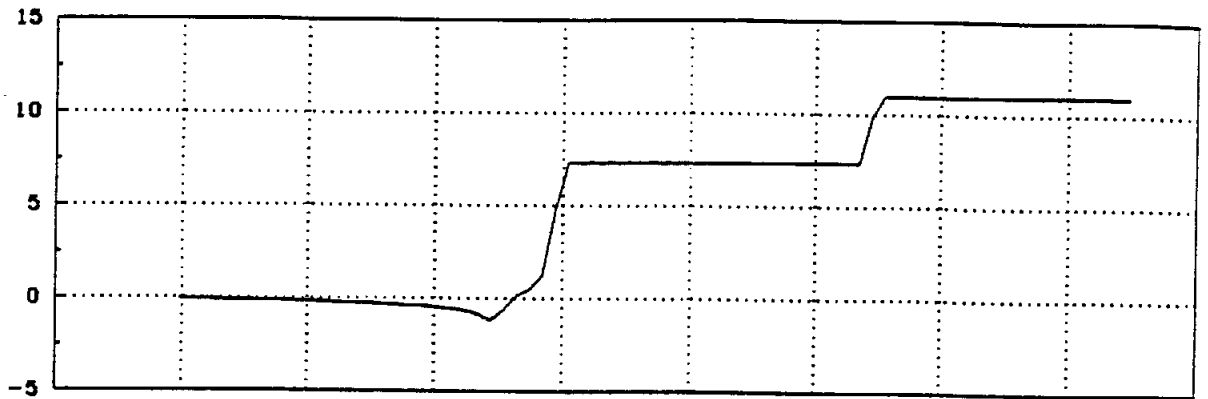
PHI



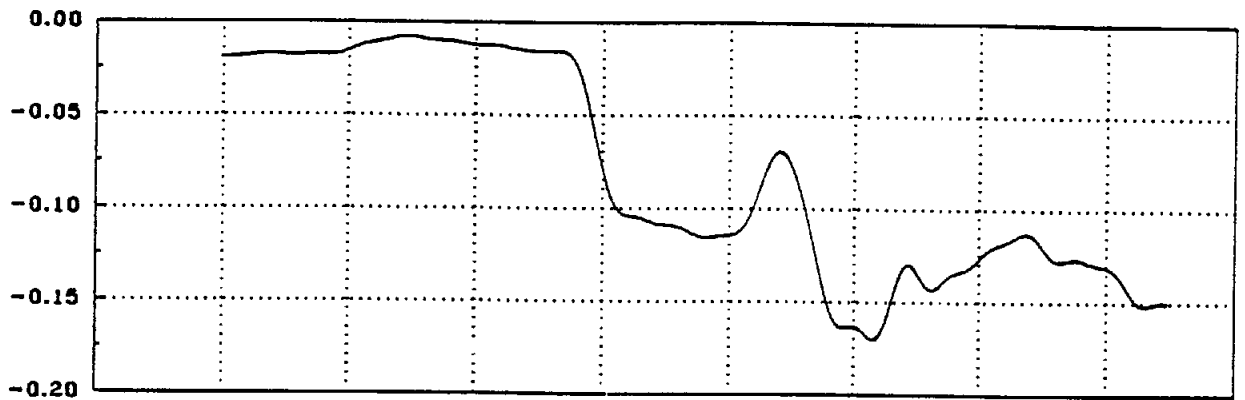
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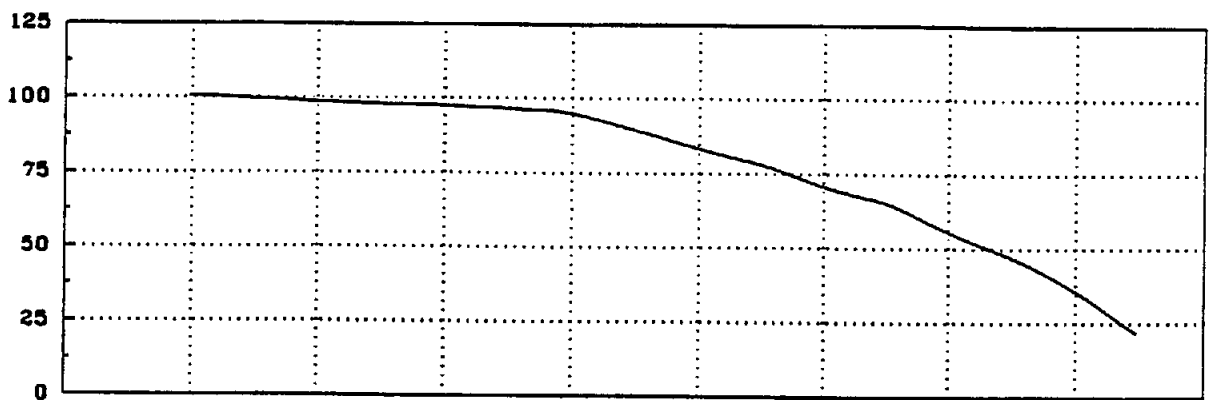
PEDAL



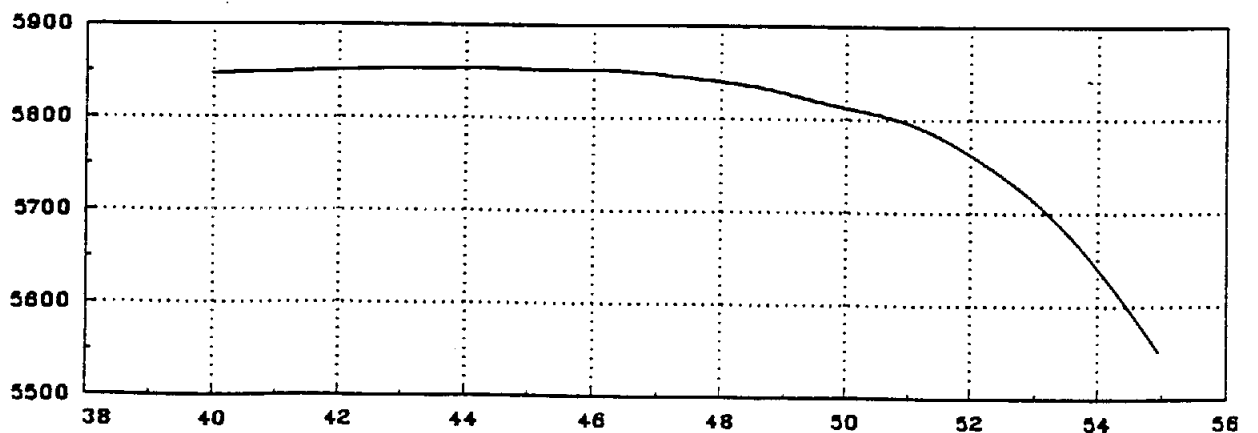
RB



PSI



ALT



(130)

TIME, seconds

(140)

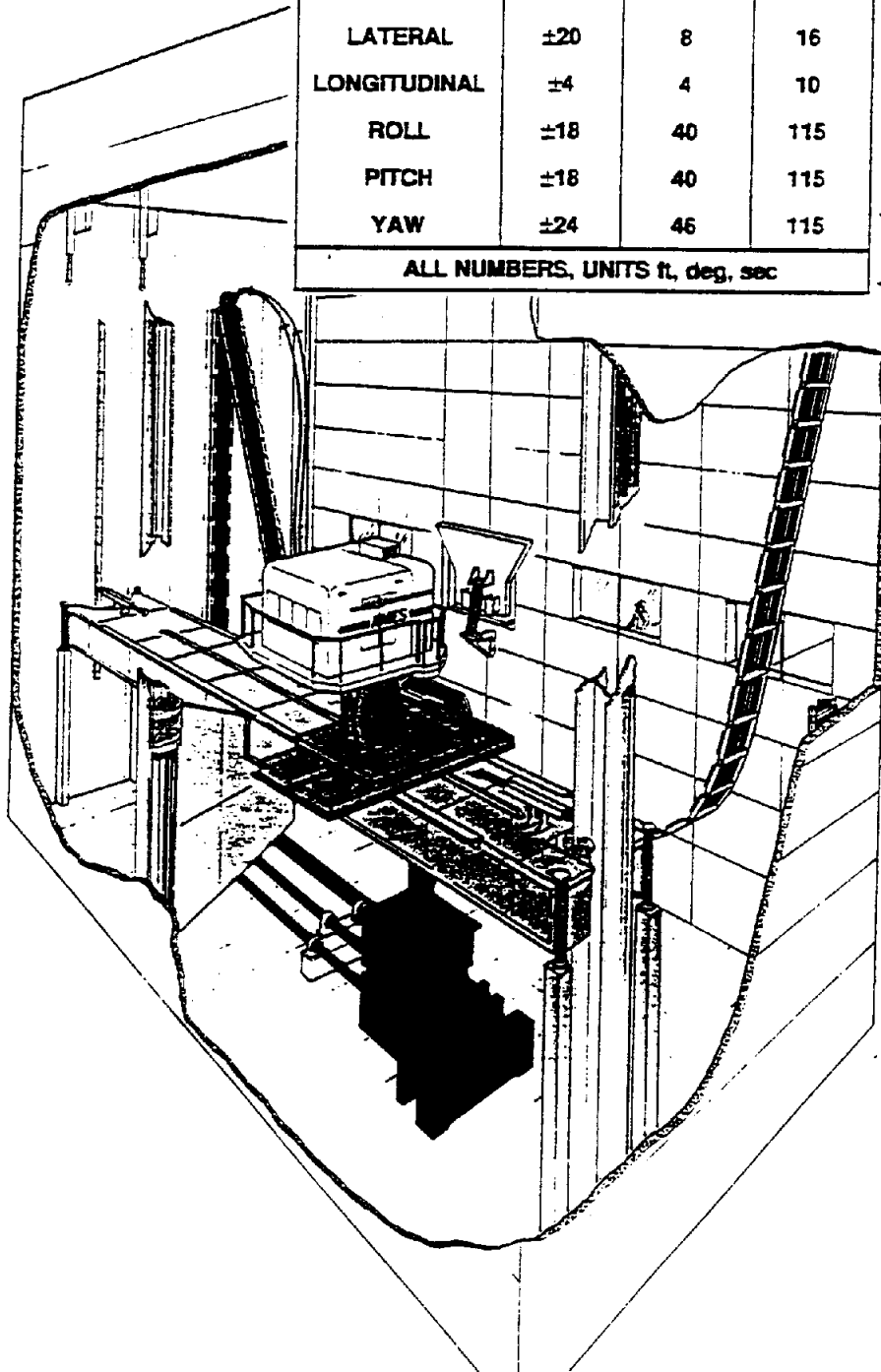
23

ATTACHMENT 2

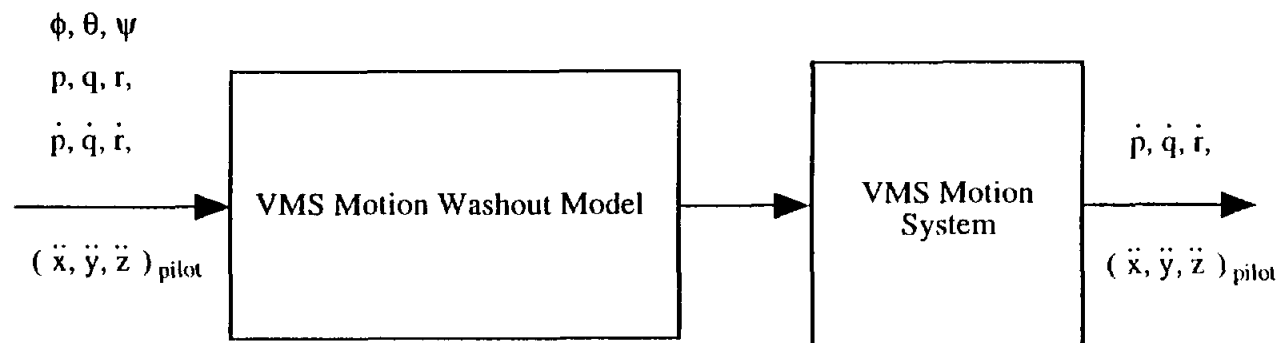
NTSB Simulation Briefing Notes Presented July 11, 1995

VERTICAL MOTION SIMULATOR

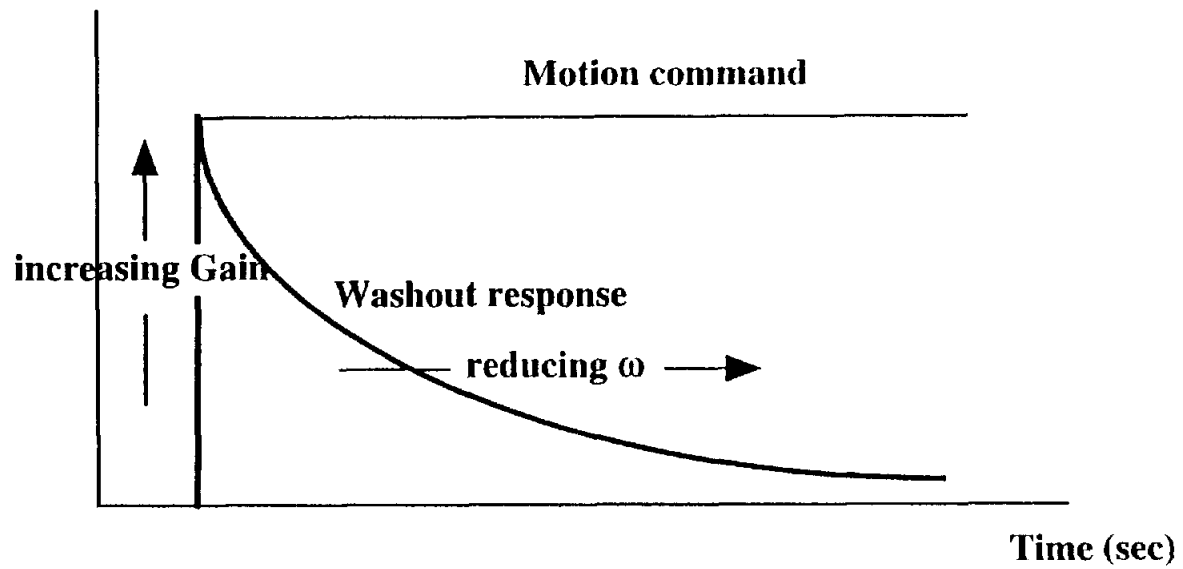
VMS NOMINAL OPERATIONAL MOTION LIMITS			
AXIS	DISPL	VELOCITY	ACCEL
VERTICAL	± 30	16	24
LATERAL	± 20	8	16
LONGITUDINAL	± 4	4	10
ROLL	± 18	40	115
PITCH	± 18	40	115
YAW	± 24	46	115
ALL NUMBERS, UNITS ft, deg, sec			



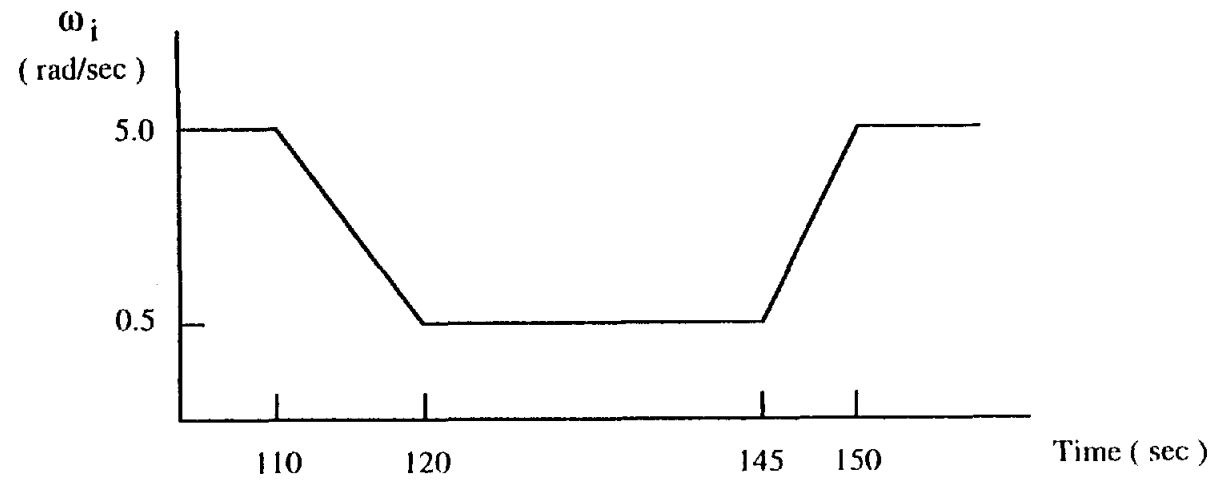
NTSB 737 Simulation VMS Motion System



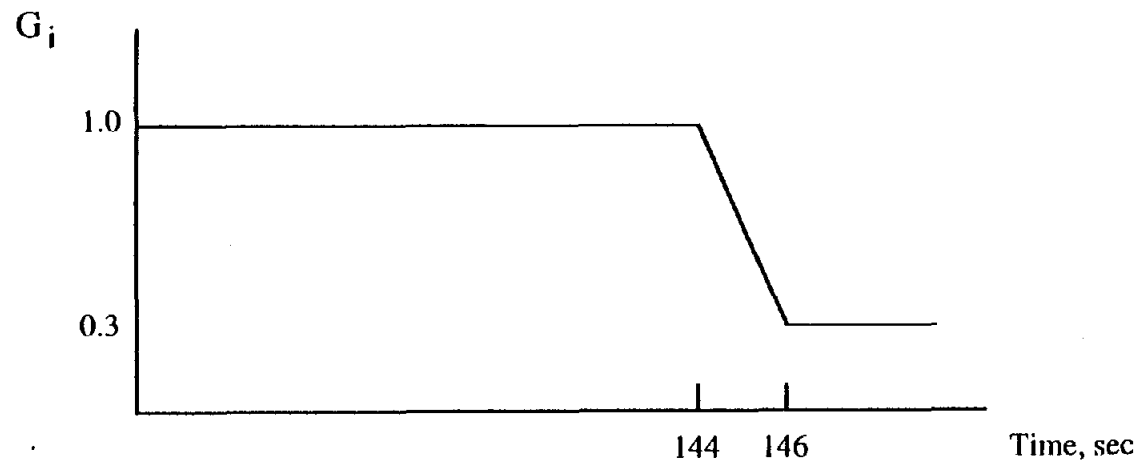
Example of Motion Washout Filter Response



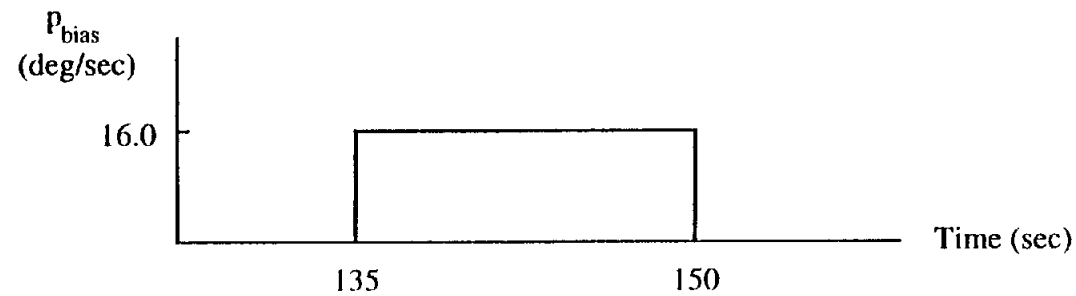
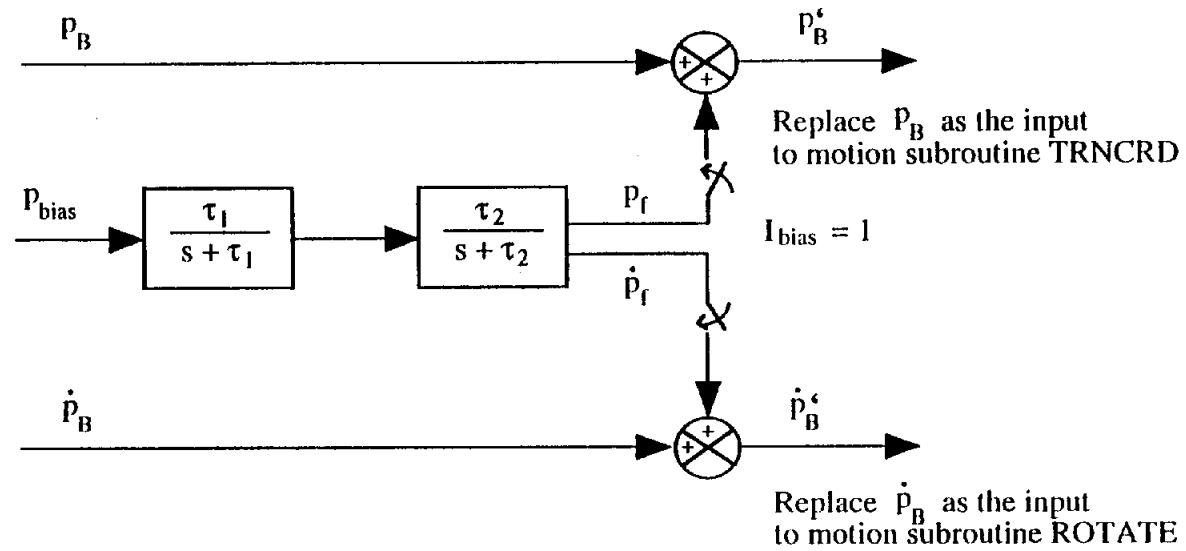
NTSB 737 Simulation VMS Motion Washout Frequency Setup



NTSB 737 Simulation VMS Motion Washout Gain Setup

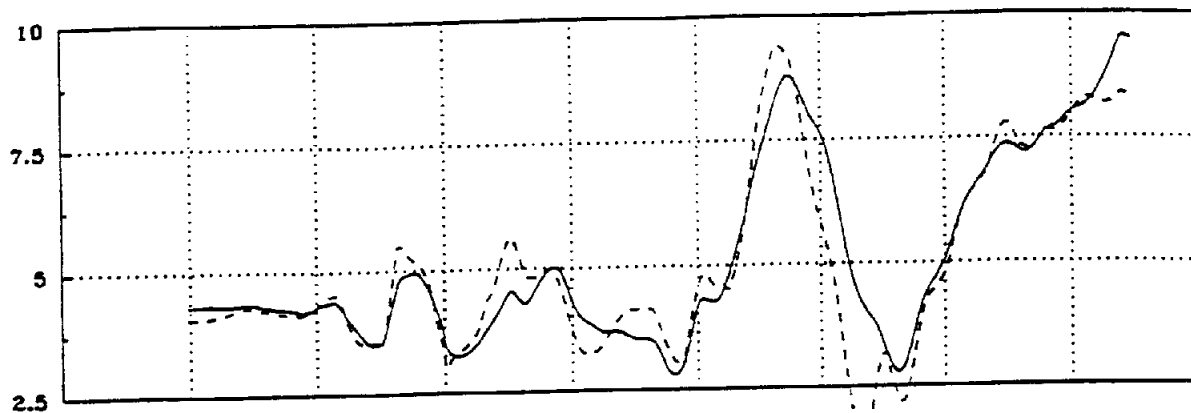


NTSB 737 Simulation VMS Motion Roll Rate Bias

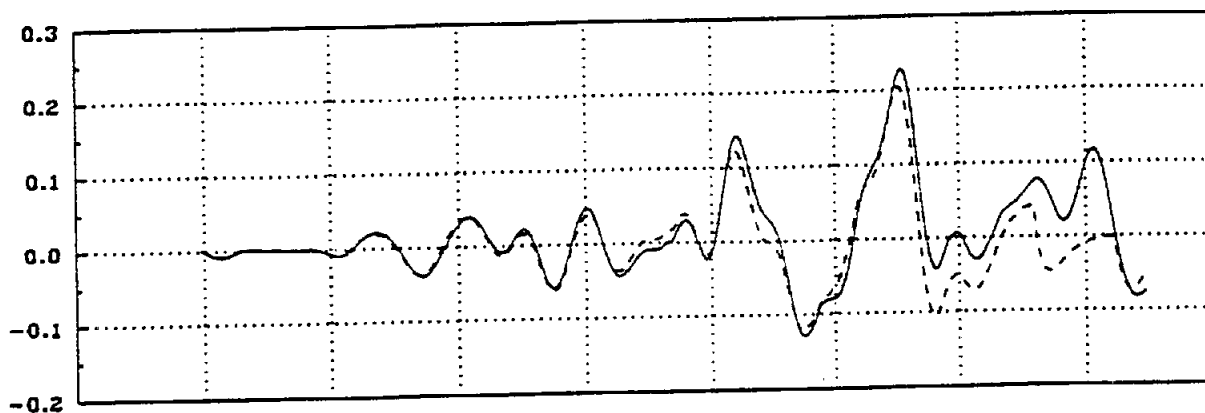


Estimated VMS_Motion System Response vs Flight Data

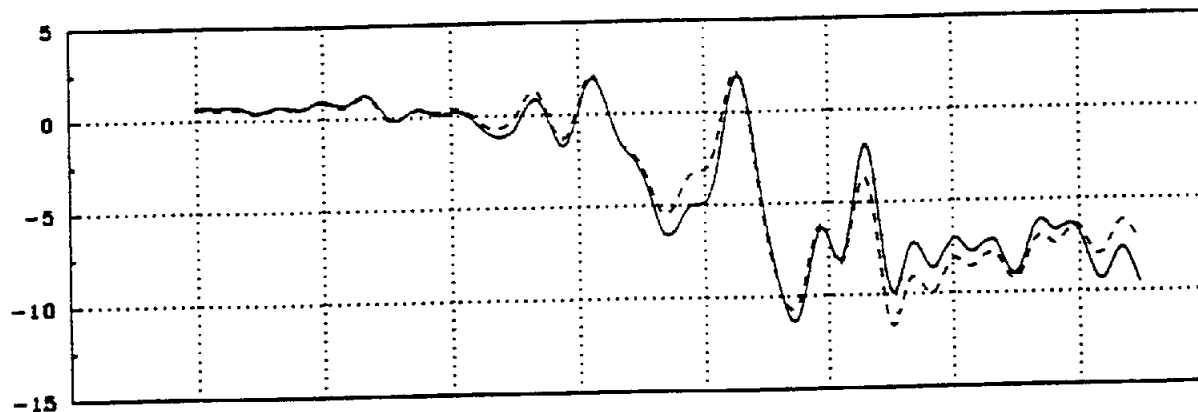
AXP
AXPVMS
ft/sec²



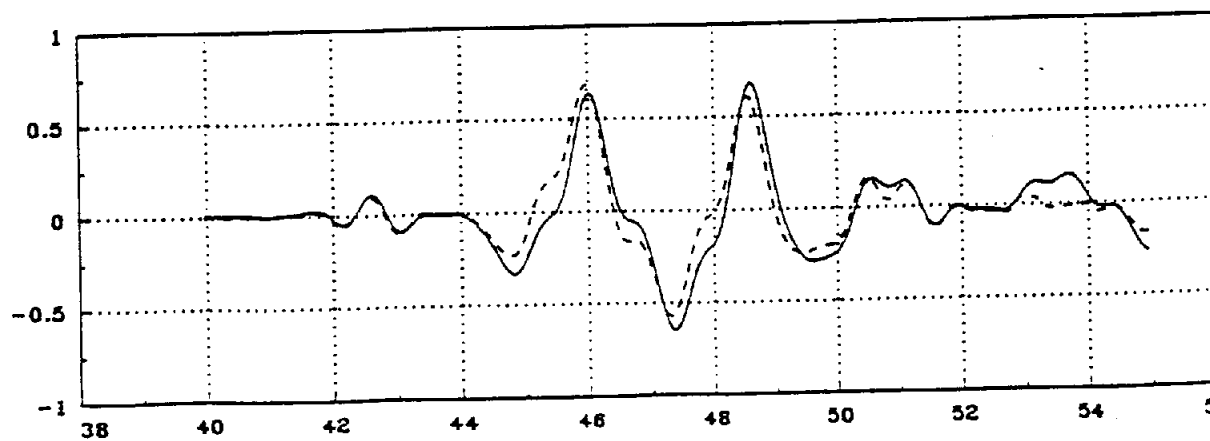
QBD
QSDVMS
rad/sec²



AYP
AYPVMS
ft/sec²



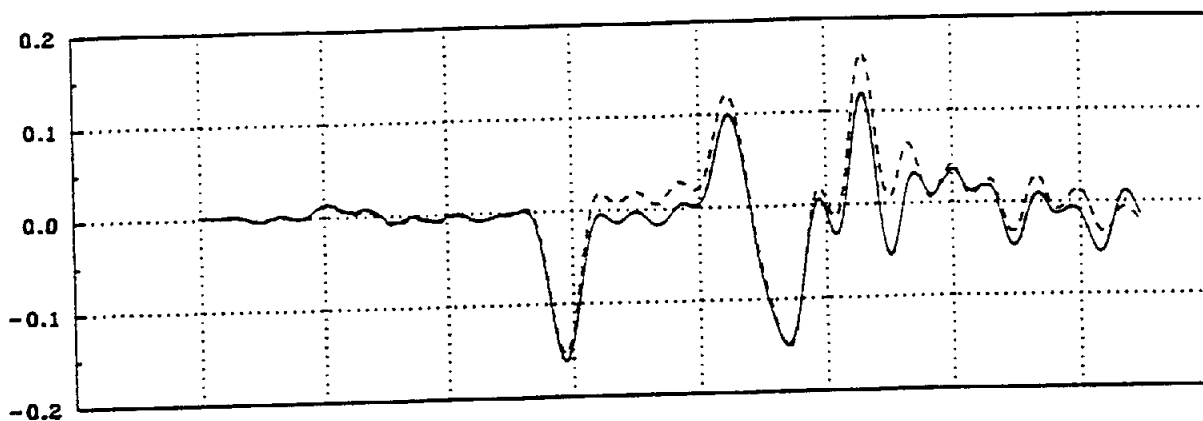
PBD
PSDVMS
rad/sec²



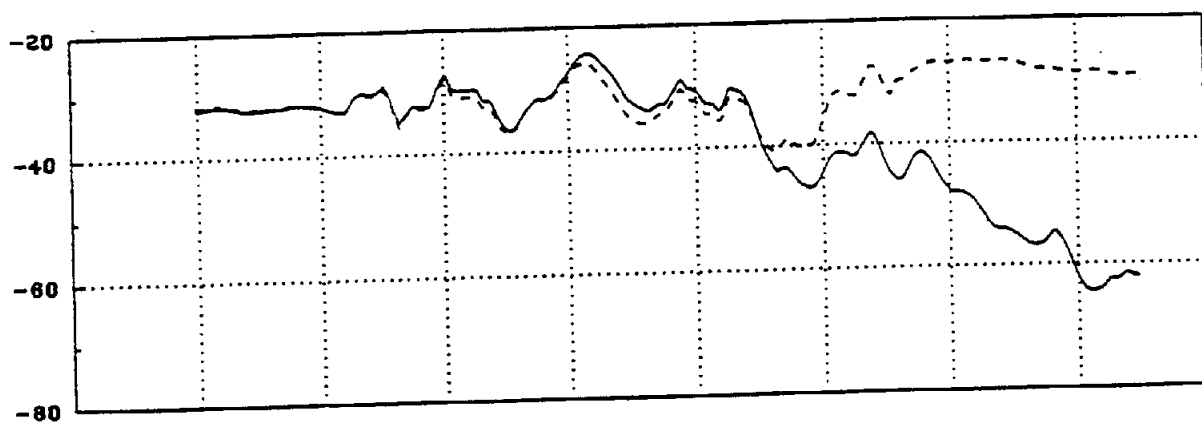
(130)

TIME, seconds

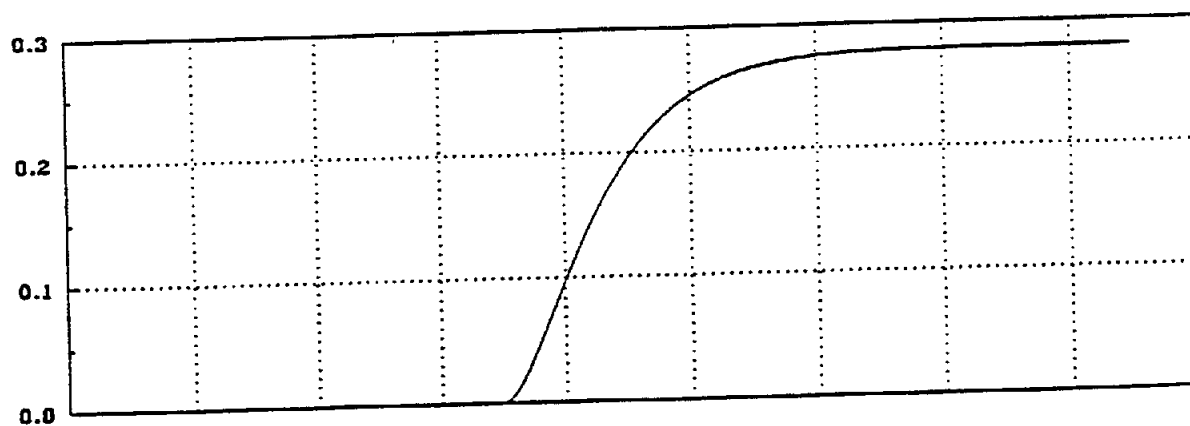
RBD
RSDVMS
rad/sec²



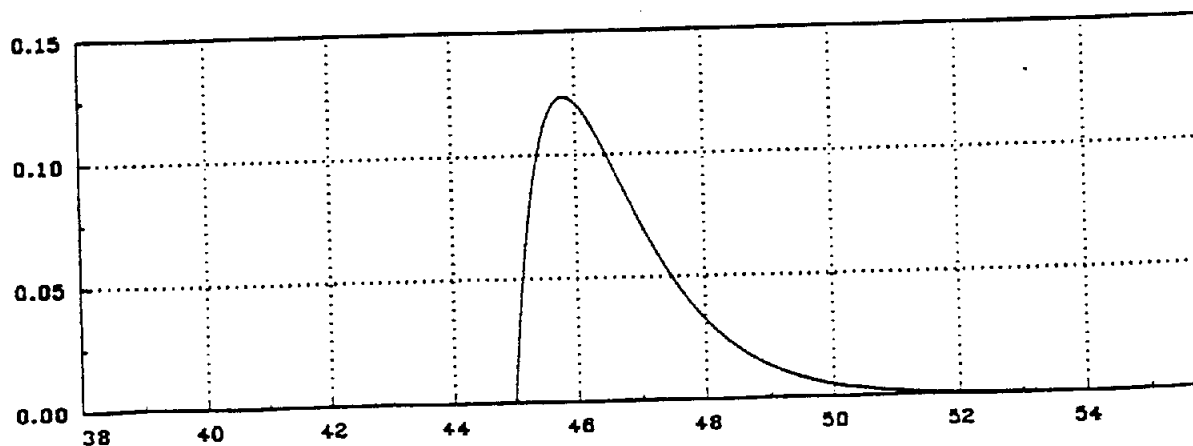
AZP
AZPVMS
ft/sec²



PF
rad/sec

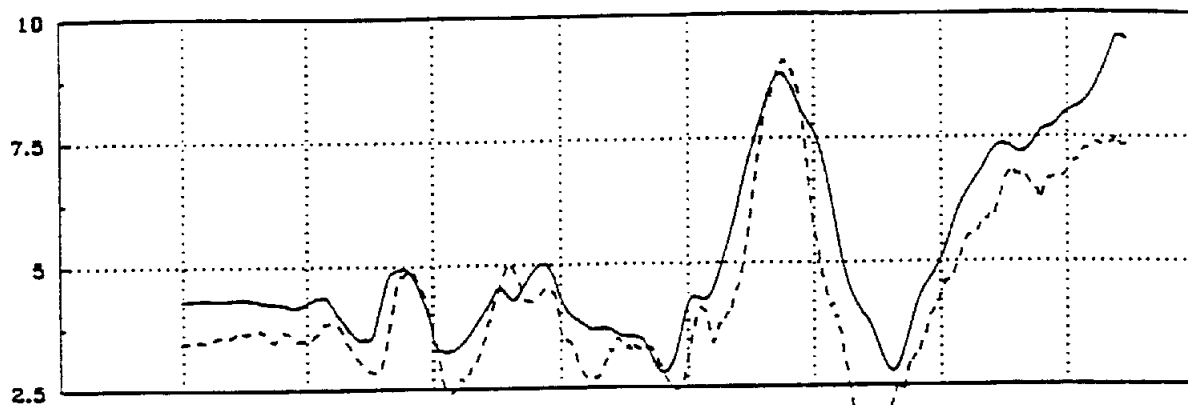


PFD
rad/sec²

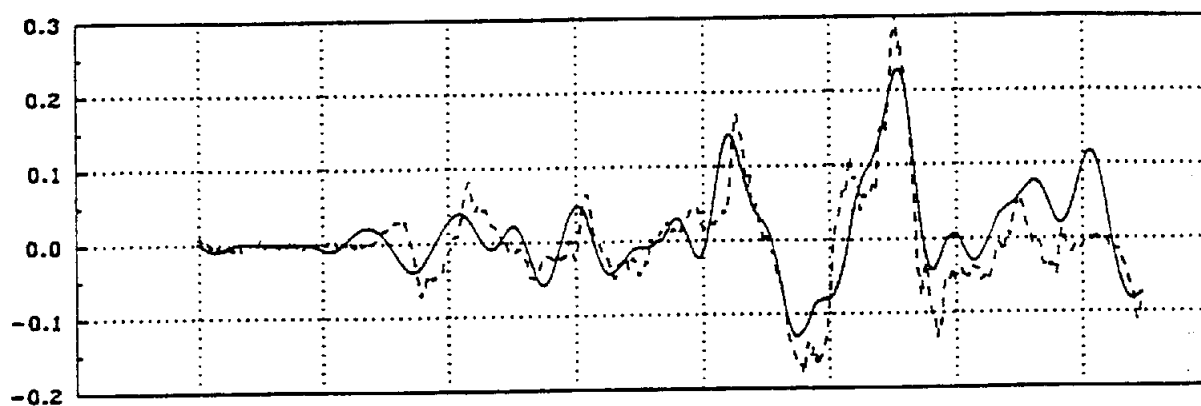


Actual VMS Motion System Response vs Flight Data

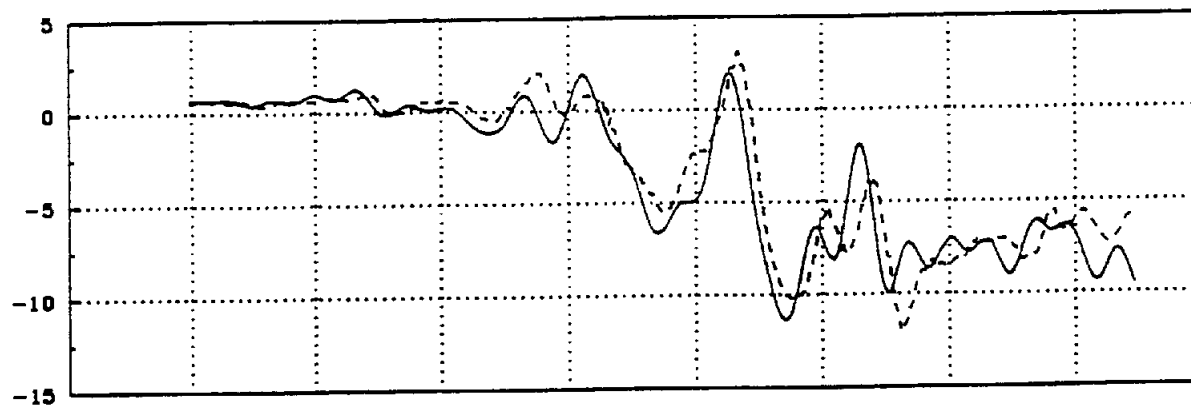
AXP
AXPVMS
ft/sec²



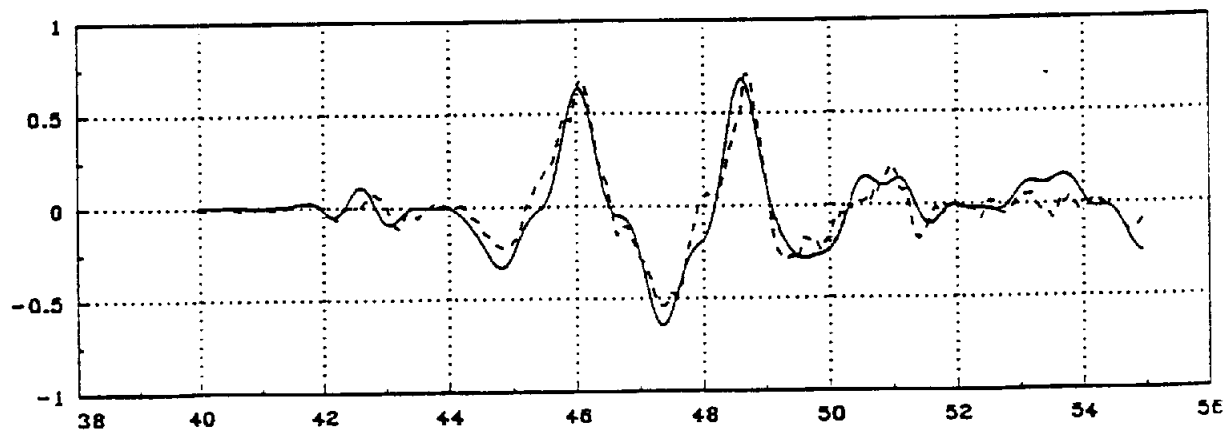
QBD
QSDVMS
rad/sec²



AYP
AYPVMS
ft/sec²



PBD
PSDVMS
rad/sec²

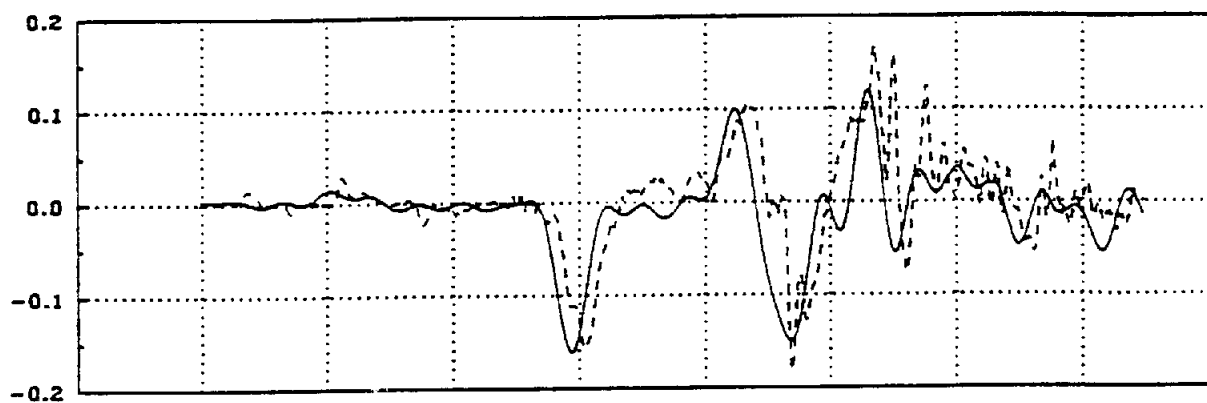


(130)

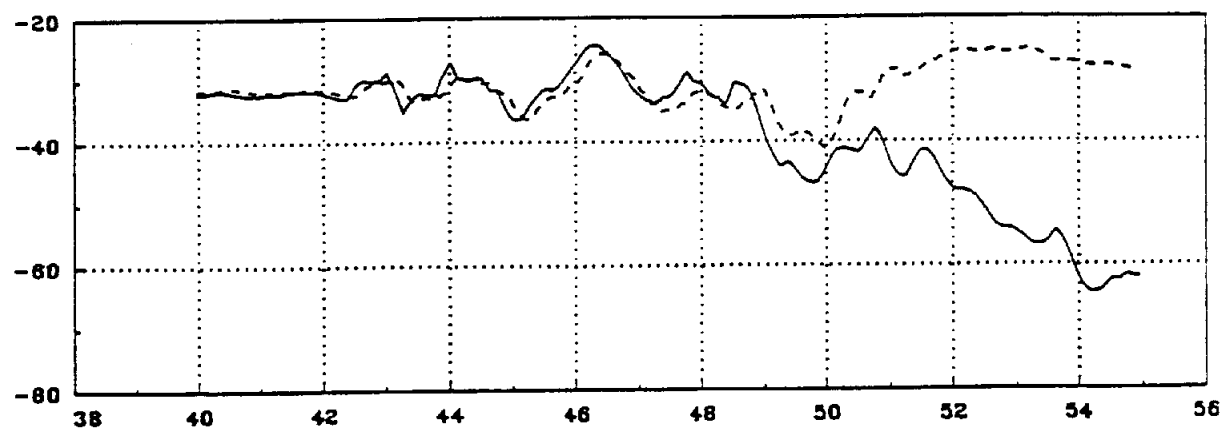
TIME, seconds

34

RBD
RSDVMS
rad/sec²



AZP
AZPVMS
ft/sec²

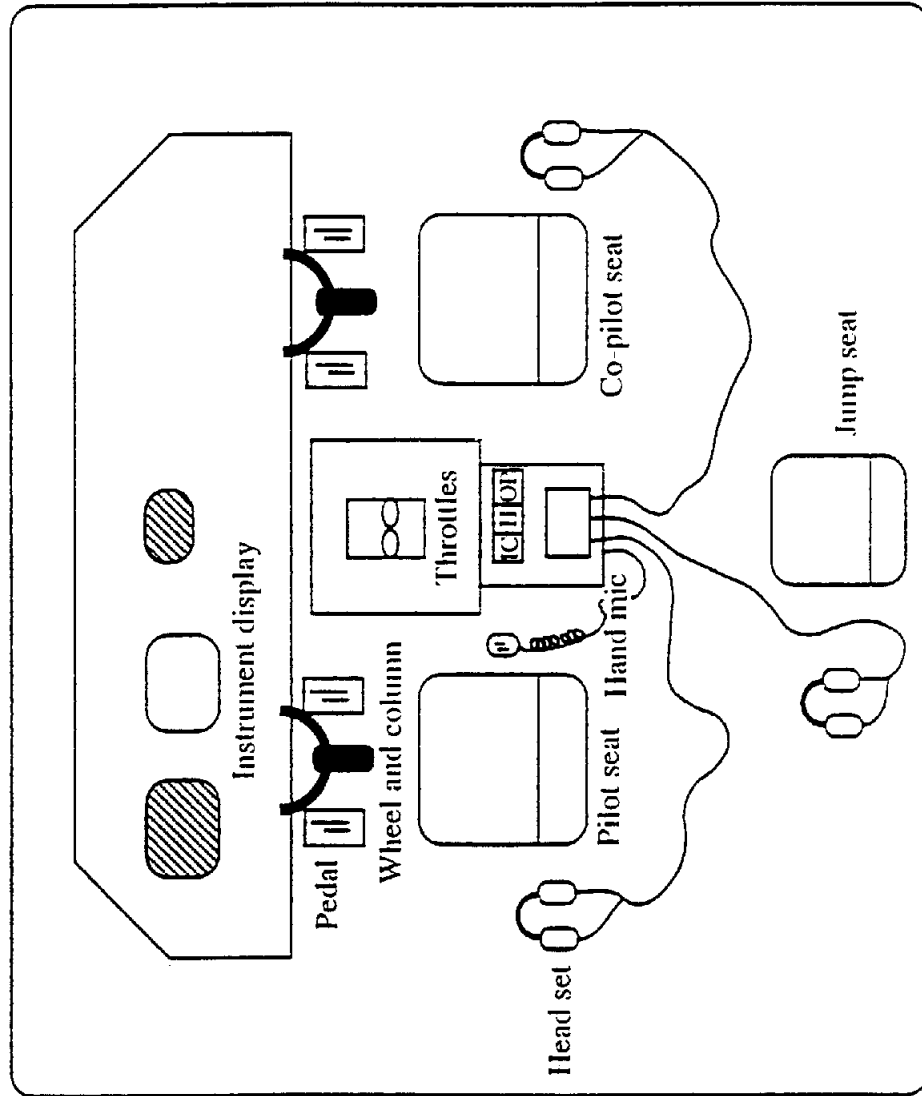


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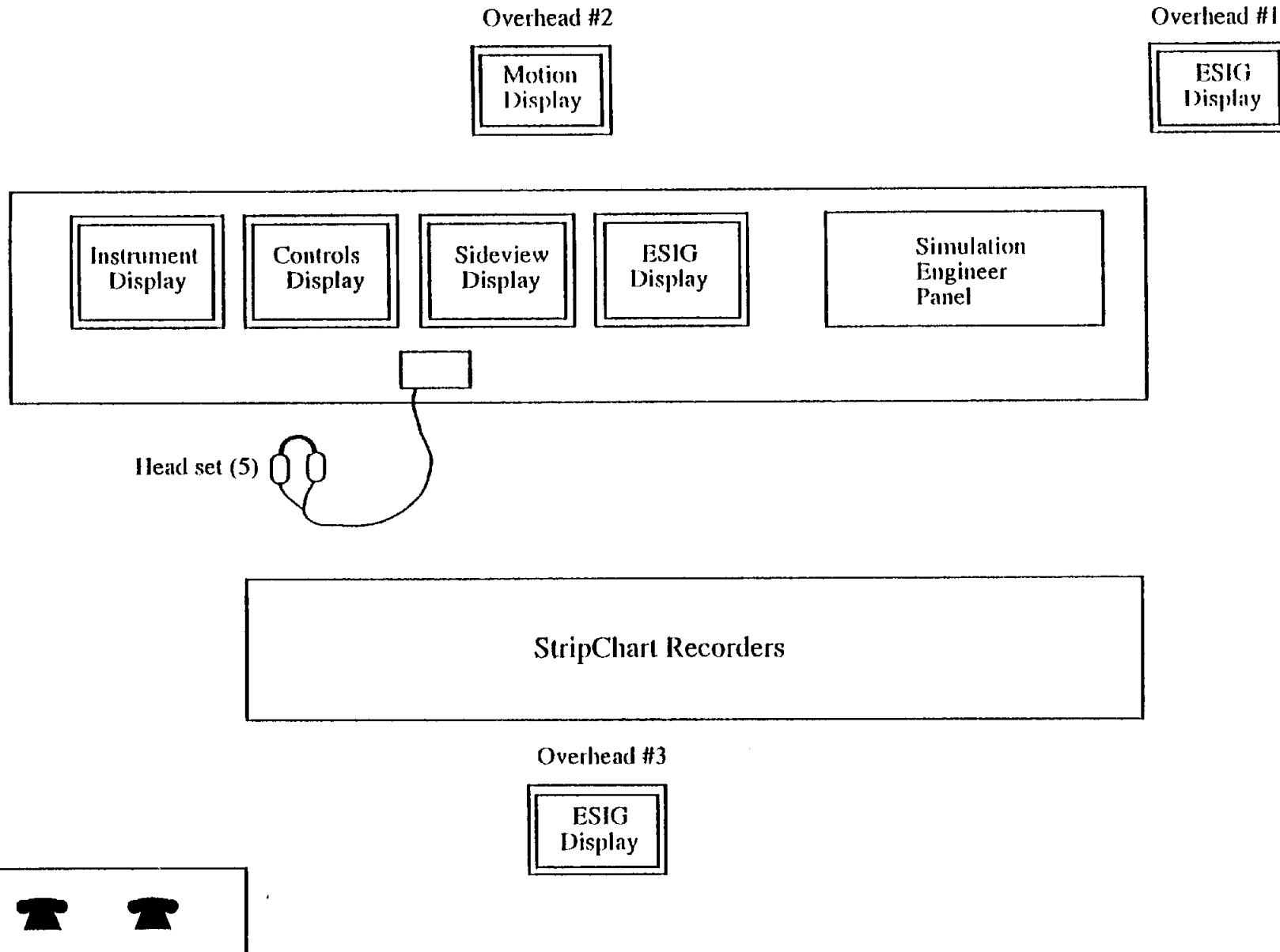
TIME, seconds

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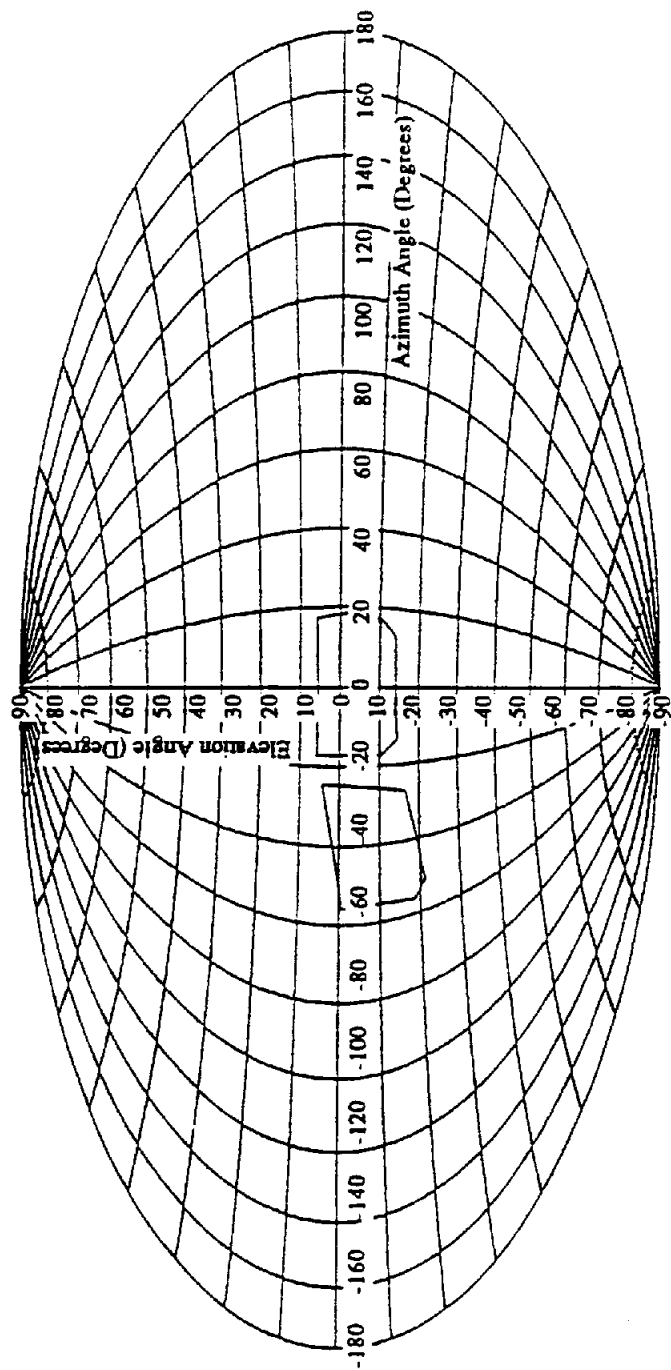
NTSB 737 Simulation Cab Layout



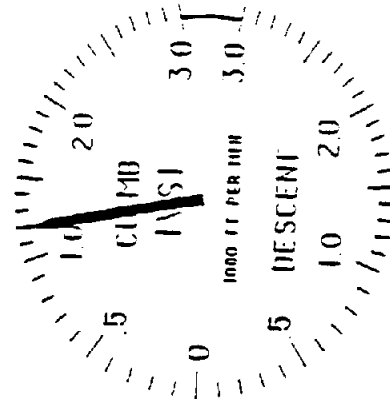
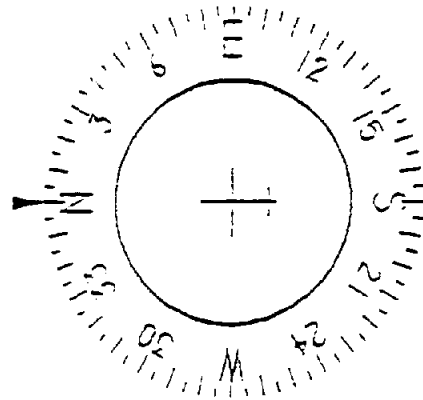
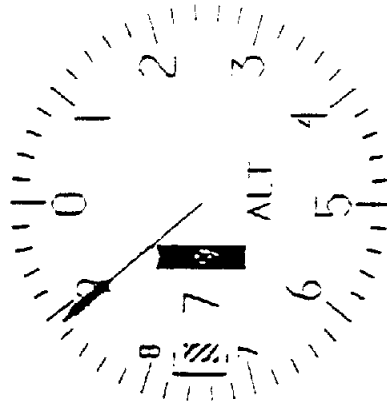
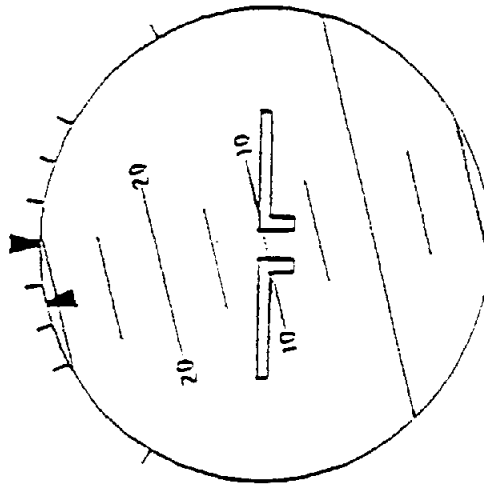
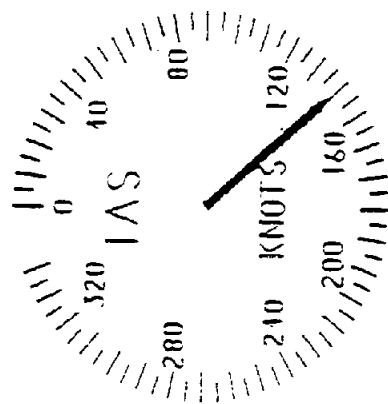
NTSB 737 Simulation Lab Layout



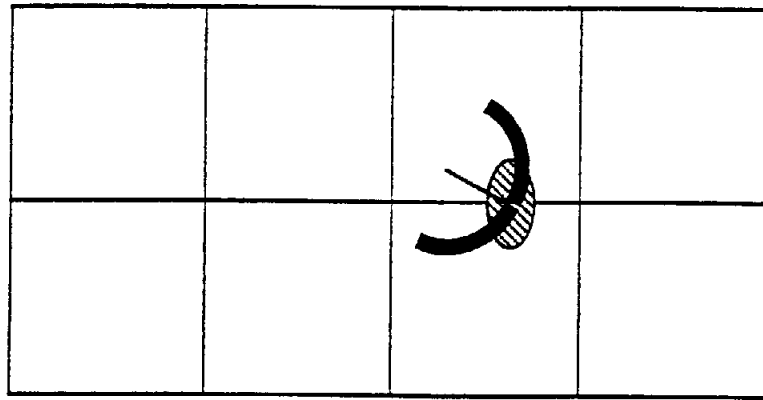
NTSB 737 Simulation Pilot's Field of View Plot



NTSB 737 Simulation Instrument Display



NTSB 737 Simulation Control Position Display



Wheel and
column



Pedal



Pedal



Throttle

VMS System Performance and Operational Procedures

VMS Operational Procedure

Pre-Motion Safety Checks

Pilot-Task Briefing

Safety Walk Through

Normal Motion Procedure

Center Position

Initial Position

Operate

Dock

Switching Seat Procedure

Center Position

Loop Open

Loop Close