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# FLIGHT TEST RESULTS FOR A SEPARATE SURFACE STABILITY AUGMENTED BEECH MODEL 99

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CONTENTS

CONTENTS (cont.)

CONTENTS (cont.)

FIGURES

FIGURES (cont.)

FIGURES (cont.)

FIGURES (cont.)

## TABLES

## SYMBOLS

| | |
|---|---|
| $F_a$ | Wheel force (aileron), N (lb) |
| $F_e$ | Wheel force (elevator), N (lb) |
| $F_r$ | Rudder pedal force, N (lb) |
| K | Gain constant |
| p, $\dot{\phi}$ | Roll rate, deg per sec |
| q, $\dot{\theta}$ | Pitch rate, deg per sec |
| r, $\dot{\psi}$ | Yaw rate, deg per sec |
| S | Laplace operator |
| $\alpha$ | Angle of attack, deg |
| $\beta$ | Sideslip angle, deg |
| $\gamma$ | Flight path angle, deg |
| $\delta_{AP}$ | Right primary aileron deflection, deg |
| $\delta_{AS}$ | Right secondary aileron deflection, deg |
| $\delta_{COL}$ | Control column deflection, deg |
| $\delta_{EP}$ | Primary elevator deflection, deg |
| $\delta_{ES}$ | Secondary elevator deflection, deg |
| $\delta_f$ | Flap deflection, deg |
| $\delta_R$ | Rudder pedal deflection, deg |
| $\delta_{RP}$ | Primary rudder deflection, deg |
| $\delta_{RS}$ | Secondary rudder deflection, deg |
| $\delta_w$ | Control wheel deflection, deg |
| $\theta$ | Pitch angle, deg |
| $\phi$ | Bank angle, deg |
| $\psi$ | Heading angle, deg |

## ABBREVIATIONS

| | |
|---|---|
| FAR | Federal Aviation Regulations |
| ILS | Instrument landing system |
| KU-FRL | The University of Kansas-Flight Research Laboratory |
| MAC | Mean aerodynamic chord |
| NASA | National Aeronautics and Space Administration |
| NASA-DFRC | NASA Dryden Flight Research Center |
| PCM | Pulse code modulation |
| RMS | Root mean square |
| TIMS | Turbulence intensity measuring system |
| SSSA | Separate surface stability augmentation |

# CHAPTER 1

# INTRODUCTION

## 1.1 Purpose of Document

The purpose of this document is to serve as a final report on NASA Contract No. NAS4-2148 awarded to the University of Kansas Flight Research Laboratory (KU-FRL) for the time period from February 1, 1974 to August 1, 1976. The work accomplished under the contract can be summarized as follows:

1. Fabrication of necessary electronics to implement an attitude command control system on a Beech Model 99 airliner using separate surface controls.
2. Modification of a Beech Model 99 to include separate surface controls.
3. Performance of a fault analysis and an environmental test of the control system electronics.
4. Completion of a flight test program defining the performance of the SSSA attitude command control system.

Steps one through three above are documented in References 1 and 2 and will not be discussed in detail in this report. The bulk of this report deals with the performance and evaluation of the SSSA Model 99 flight test program.

## 1.2 Program Objectives

The primary objective of the SSSA Model 99 program was to determine whether an attitude command control system could be implemented on a Beech Model 99 airliner using separate surface controls. Two secondary objectives were to determine whether the pilot workload required to perform a specified maneuver modeling an Instrument Landing System (ILS) approach in turbulence was reduced, and whether the ride qualities of the aircraft were improved by the SSSA attitude command control system. The results of the flight test program and the accomplishment of the specified objectives will be discussed in this report.

## 1.3 Program Organization

Theoretical and wind tunnel studies for the SSSA program were done under NASA grants from September 1, 1971 to January 31, 1974. The hardware fabrication and installation and the flight test program were done under NASA contract NAS4-2148 from February 1, 1974 to August 1, 1976. A complete list of reports detailing this work is included in the Bibliography.

KU-FRL was the prime contractor responsible for all aspects of the program. The feedback control network was designed, fabricated and installed by KU-FRL. The control surfaces were designed and the flight test program was planned by KU-FRL.

Beech Aircraft Corporation, Wichita, Kansas, was subcontracted to make the necessary aircraft modifications and control surface installations. Beech Aircraft was also responsible for the flutter evaluation and for supporting the flight test program under the direction of KU-FRL engineers.

The Boeing Company, Wichita, Kansas, was subcontracted by Beech Aircraft to perform the flutter analysis, and by KU-FRL to reduce the flight test data.

Figure 1.1 shows the organization of the program and responsibilities of the various organizations involved. For a detailed summary of previous KU-FRL organization see Reference 1.

## 1.4 Acknowledgements

The authors would like to acknowledge Dr. D. G. Daugherty and Mr. Leland R. Johnson for their contributions in the electrical design area, and the cooperation and contributions of Beech Aircraft Corp. and Boeing Aircraft Co. of Wichita, Kansas.

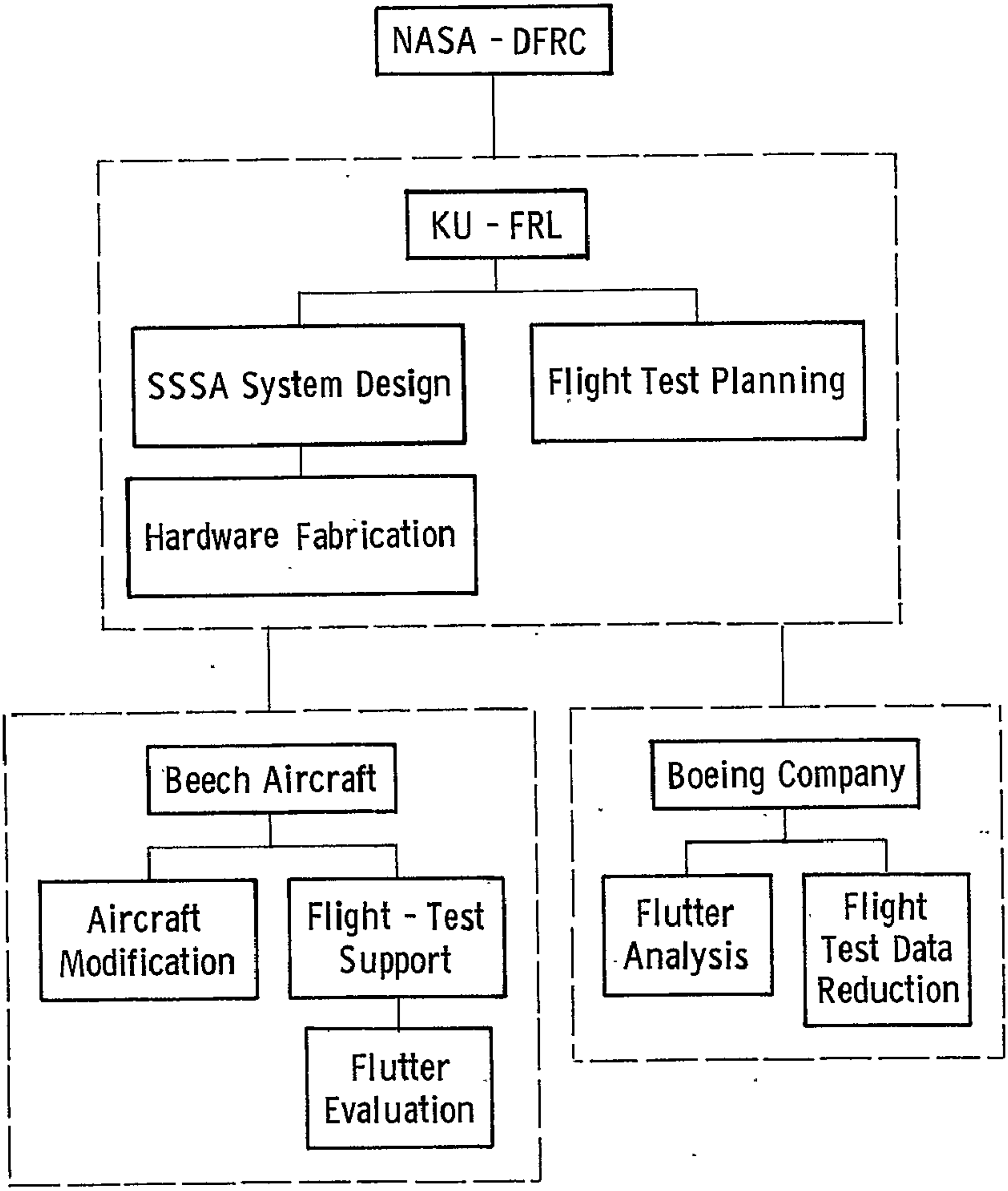



FIGURE 1.1 SSSA Model 99 Program Organization

# CHAPTER 2

# AIRCRAFT CONTROL CONCEPTS

## 2.1 Rate Command Control

Conventional aircraft are controlled in the roll axis by a rate command system. This means that the pilot commands a rate of aircraft response with a control deflection. A typical roll response to a step aileron input for a rate command system is shown in Figure 2.1.

When the pilot of a rate command system wants to fly a constant bank angle he must make the following physical and mental manipulations:

1. Determine the desired bank angle (mental);
2. Determine how fast the aircraft is to respond (mental);
3. Displace the lateral controls to attain the desired response (physical);
4. Determine the precise time to reduce the control displacement (mental);
5. Displace the controls to command zero roll rate and the desired roll attitude (physical); and
6. Monitor the aircraft attitude and make necessary control inputs to maintain the desired attitude (mental and physical).

Under certain circumstances, the pilot's ability to make these manipulations may be exceeded resulting in a degradation in control or complete loss of control of the aircraft. Examples of circumstances that may degrade the pilot's performance are weather conditions, cockpit distractions, system failures, vertigo, nausea, atmospheric turbulence and inherent aircraft instabilities.

## 2.2 Attitude Command Control

A basic premise of attitude command is that if the manipulations required by the pilot to control the aircraft are reduced, the chances for loss of control under the circumstances described in section 2.1 will be reduced. Attitude command control means that a control input establishes a steady state attitude, not a rate. An attitude command

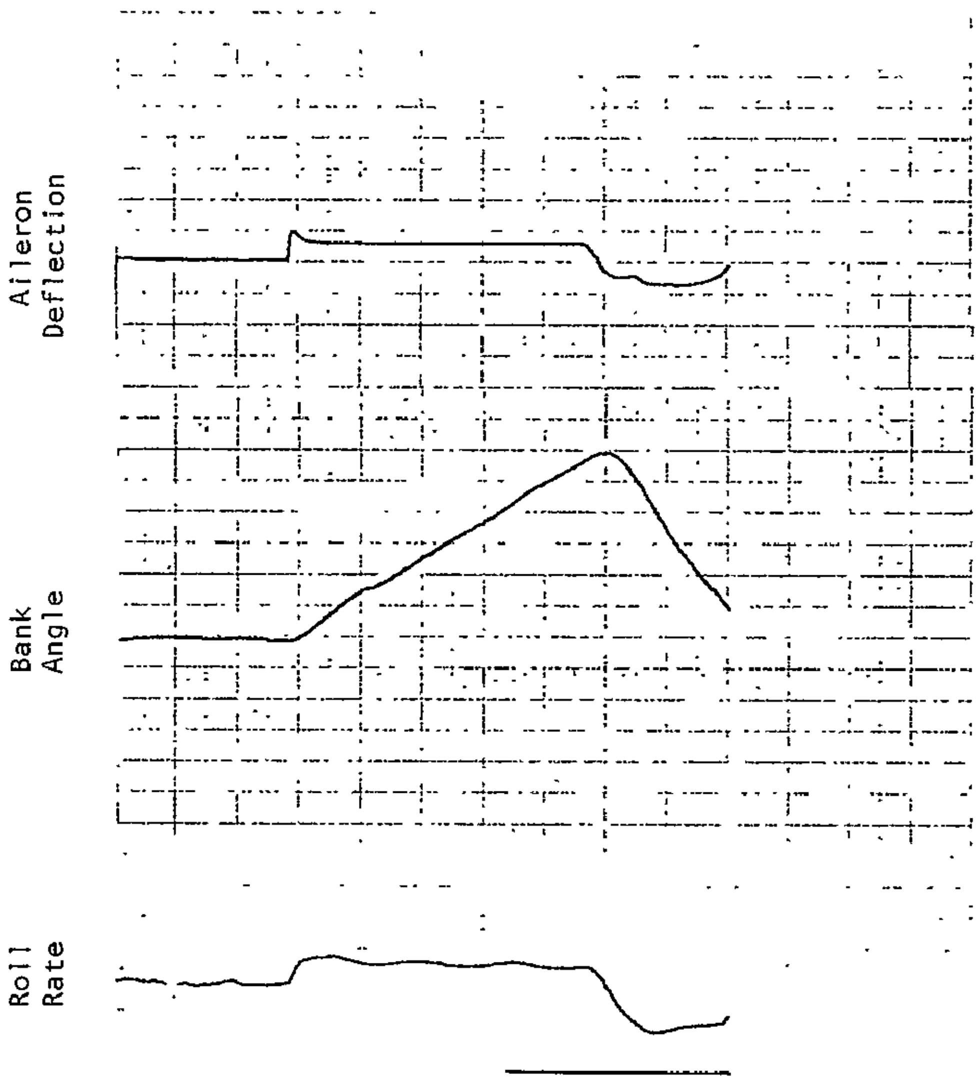



FIGURE 2.1 Rate Command Roll Response Due to a Step Aileron Input

roll response as a result of a step aileron input is shown in Figure 2.2. The attitude established is directly proportional to the control input which reduces the pilot manipulations required to fly a constant bank angle to the following:

1. Determine the roll attitude desired (mental) and
2. Displace the control wheel to attain the desired roll attitude (physical).

No mention has been made of the aircraft's response in the pitch and yaw axes. The conventional aircraft appears to respond as attitude command about these axes as shown in Figure 2.3. Close examination of the aircraft equations of motion (Reference 3) reveals that the attitude is not being controlled directly, but indirectly by the angle of attack, $\alpha$, or the angle of sideslip, $\beta$. Attitude command is the control of the Euler angles: bank angle, $\phi$; pitch angle, $\theta$; and yaw angle, $\psi$. These angles are described in Figure 2.4. However, the Euler angles, $\theta$ and $\psi$, can be related to the angle of attack, $\alpha$, and the angle of sideslip, $\beta$, by the following relationships:

$$\theta = \text{Flight Path Angle, } \gamma + \alpha \qquad (2.1)$$

$$\psi = \text{Aircraft Track} - \beta \qquad (2.2)$$

These relationships are graphically presented in Figure 2.5. The equations of motion indicate that the controls of a conventional aircraft directly control $\alpha$ and $\beta$ and affect $\theta$ and $\psi$ by the relationships described by equations (2.1) and (2.2). This gives the pilot the impression that he has attitude command but, in the strictest sense, it is not attitude command because there are no forces or moments that are generated to maintain the Euler angle or attitude. The only forces and moments generated are those associated with angle of attack, $\alpha$, and sideslip, $\beta$.

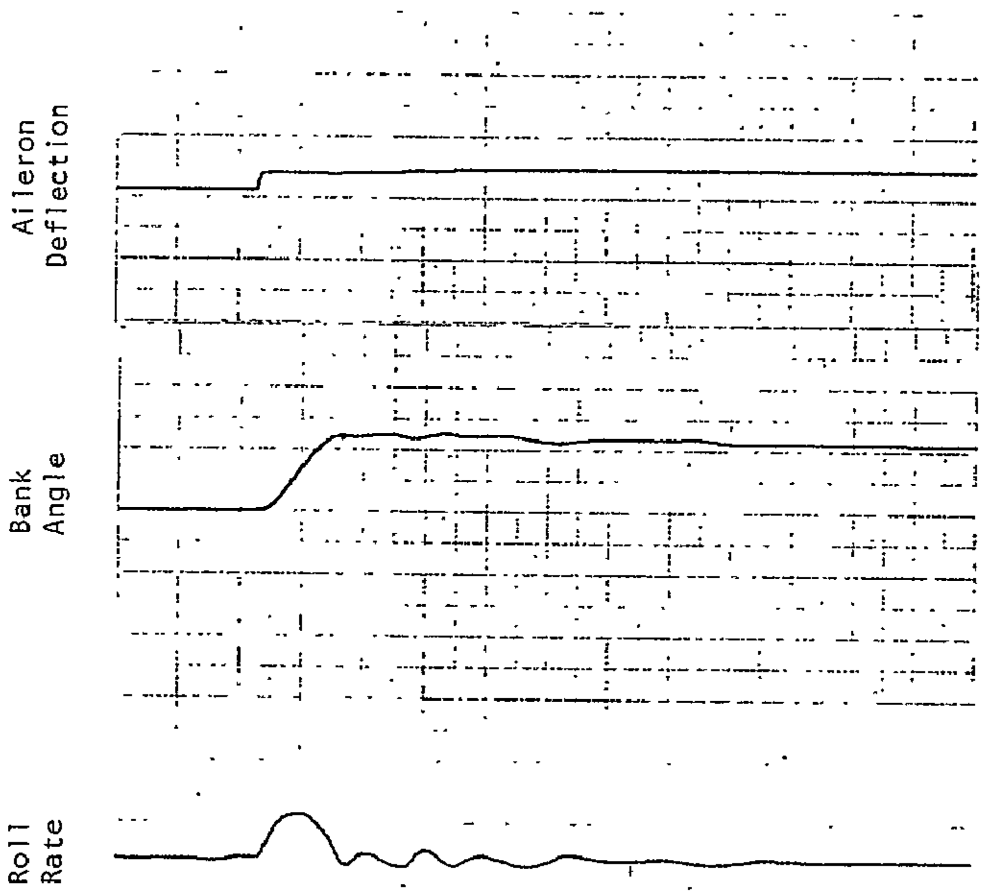



FIGURE 2.2 Attitude Command Roll Response Due to Step Aileron Input

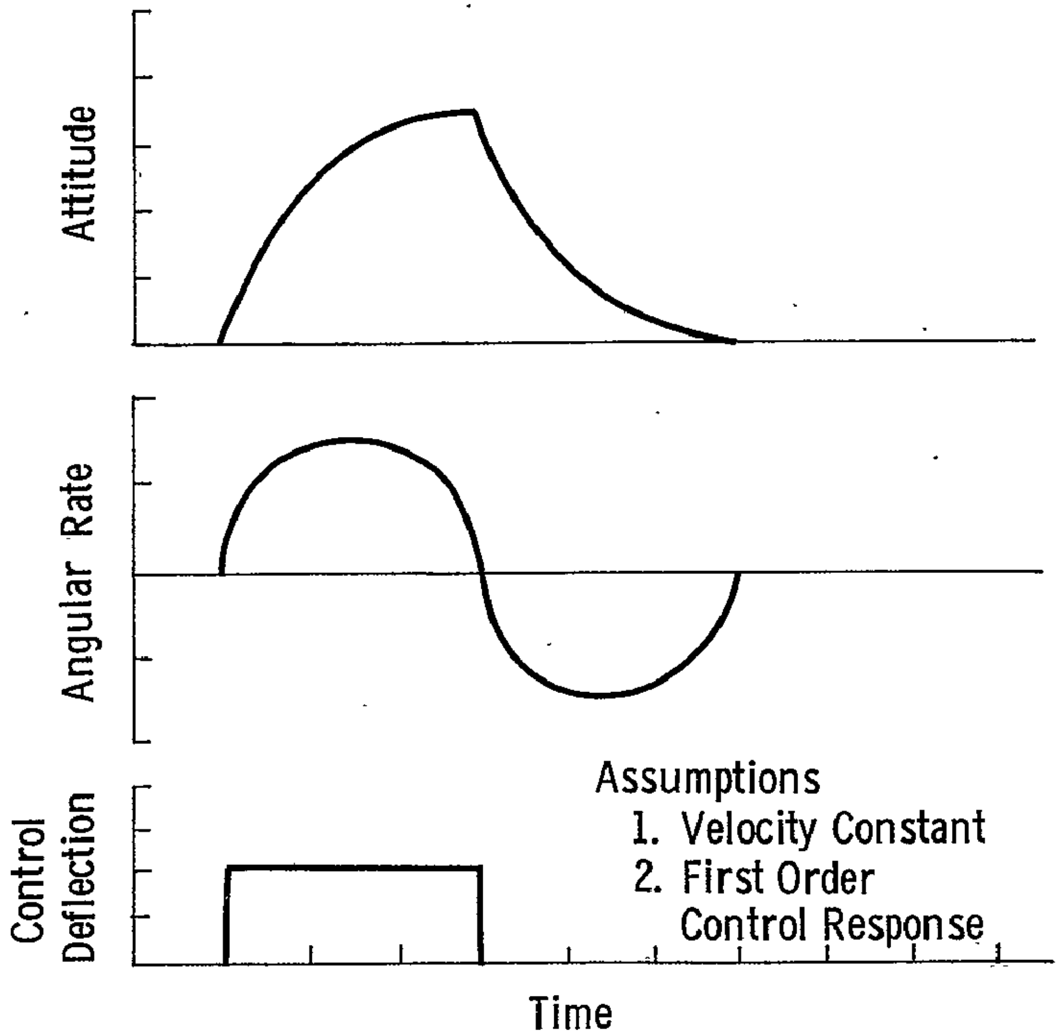



FIGURE 2.3 Conventional Aircraft Control Response About Pitch and Yaw Axes

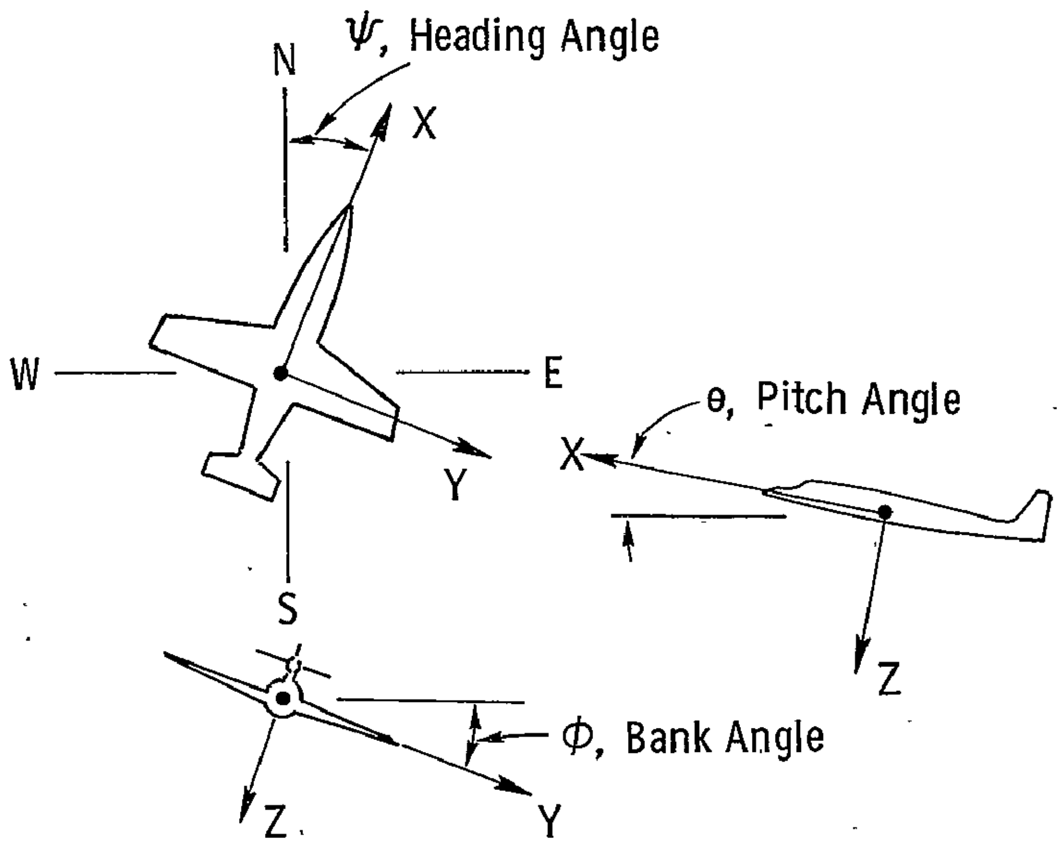



FIGURE 2.4 Euler Angle Description

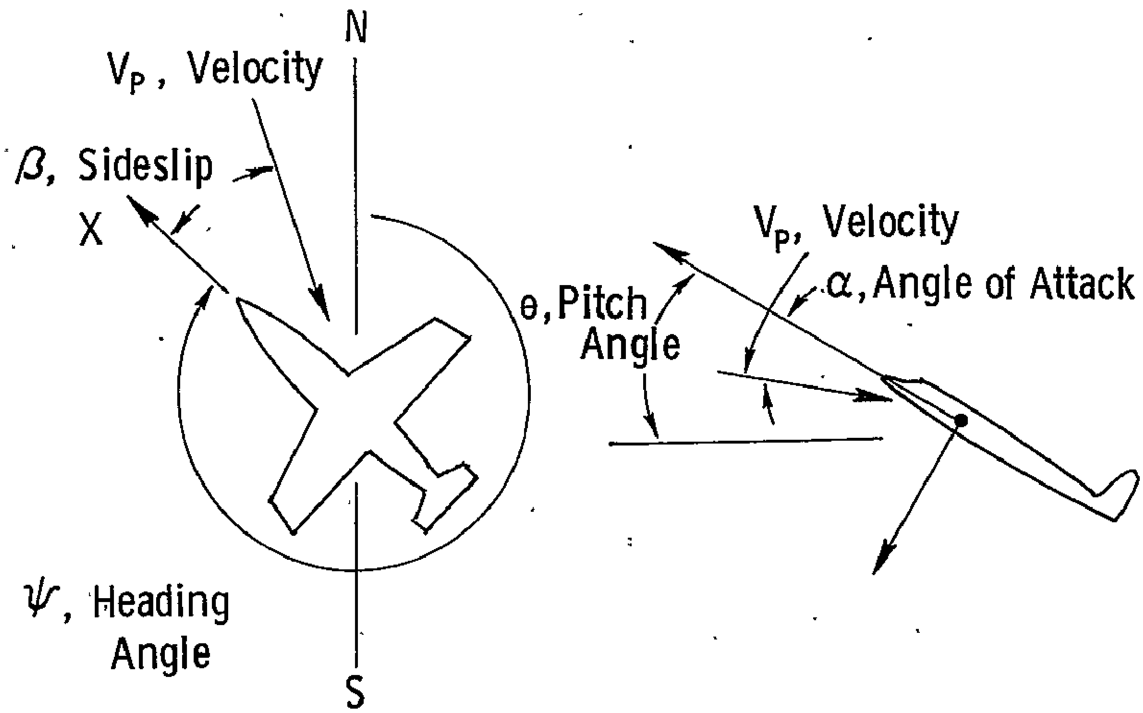



FIGURE 2.5 Angle of Sideslip and Attack Description

## CHAPTER 3

## IMPLEMENTATION OF ATTITUDE COMMAND

### 3.1 Attitude Command Control System

The concept of attitude command, as described in the previous section, was extensively investigated by the NASA Dryden Flight Research Center (NASA-DFRC), Edwards, California. This investigation was summarized in Reference 4. The conclusion of that investigation was that attitude command resulted in a significant improvement in the handling qualities of the airplane while flying an ILS approach in turbulent air.

The method utilized to implement attitude command for the NASA investigation was as follows:

1. All aircraft control surfaces were servo controlled.
2. An irreversible, hydraulic system was installed to activate the control surfaces.
3. An on-board computer was installed to control the hydraulically activated, servoed control surfaces.

This configuration worked quite well for the investigation; however, it would present some practical limitations if the system were implemented on a production aircraft.

The first limitation is the prohibitive cost of this type of control system. Most light, general aviation aircraft do not have a hydraulic system. Therefore, this cost alone would substantially increase the unit price.

Another limitation to consider is the weight of this type of configuration. In many instances this installation could reduce the payload of the aircraft by as much as 50%.

The complexity of this configuration also presents some limitations. Due to the requirement for a hydraulic system rework, the possibility of modifying existing production aircraft is impractical.

The final limitation, and possibly the most important, is meeting the Federal Air Regulations (FAR) certification criteria for control system malfunctions. The FAR specify aircraft response limitations in the event a servo controlled surface fails in a hard-over condition. The aircraft must meet these criteria or provide an adequate level of redundancy to preclude the possibility of a control hard-over. It would be quite difficult to meet these criteria with the entire control surface servo controlled, which implies that redundancy would be required. This would result in a further increase in weight and cost.

## 3.2 Separate Surface Stability Augmented, Attitude Command Control System

3.2.1 Separate Surface Stability Augmentation (SSSA) Concept. One method of minimizing the limitations mentioned above is Separate Surface Stability Augmentation. This concept is depicted in Figure 3.1. The existing, conventional control system is retained. However, a small separate surface is isolated from the primary control system and operates independently for implementation of attitude command.

This configuration alleviates some of the most critical limitations that existed on the NASA attitude command control system. The system is relatively lightweight; it does not require a hydraulic system; and the conventional control system is retained intact except for the loss of the separate surface area. The most important consideration is that the surface can be sized to meet the FAR hard-over criteria, therefore eliminating the necessity for redundancy. The actual sizing of the separate surface, or secondary control, considered the trade-off between sizing the control for saturation during atmospheric turbulence versus aircraft performance in the event of a control surface hard-over. The control surface sizing for the Beechcraft Model 99 is described in detail in Reference 2. A summary of SSSA control surface areas is presented in Table 3.1.

3.2.2 Model 99 SSSA System Operational Description. The KU-FRL SSSA system provided attitude command in all three axes: roll, pitch and yaw. There were two operational modes for the system: slave and command. The slave mode did not provide attitude command; the secondary or separate surfaces were slaved to the primary control surfaces

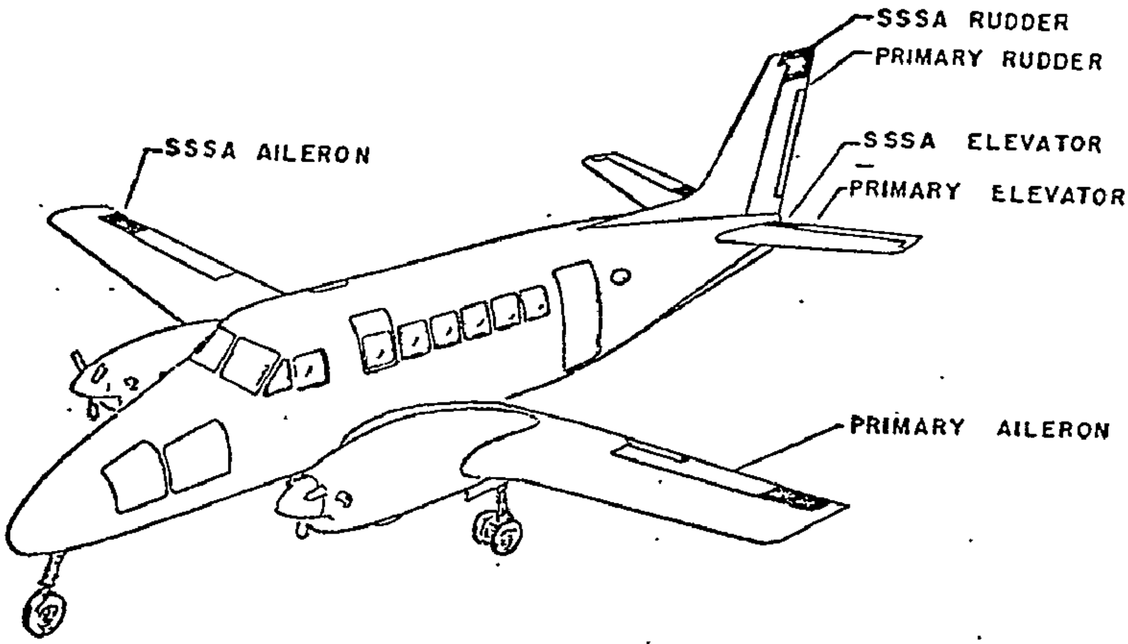



FIGURE 3.1. General Arrangement of the SSSA Surface

Table 3.1. SSSA Model 99 Control Area

| SSSA Control | Total Area Aft of Hinge Line, $m^2$ ($ft^2$) | SSSA Area, $m^2$ ($ft^2$) | SSSA Area % of Total |
|---|---|---|---|
| Elevator | 8.04 (26.39) | 1.67 (5.46) | 20.7% |
| Aileron | 2.12 ( 6.95) | 0.80 (2.61) | 37.6% |
| Rudder | 3.68 (12.08) | 1.07 (3.52 | 29.1% |

providing primary control tracking by the separate surfaces. This mode also represented the basic Model 99 with the exception of a slight reduction in control forces.

The command mode, which implemented attitude command, is represented in block diagram form for the roll, pitch and yaw axes in Figures 3.2, 3.3 and 3.4 respectively.

In all three axes the attitude command control loop can be represented as shown in Figure 3.5. This diagram is not intended to be an accurate representation of the control system but it does exemplify the basic attitude command control system: a single input or controlling function, primary control deflection, and two feedback loops, angular rate and angular displacement.

3.2.3 SSSA Sub-System Operational Description. The previous section simplified the system block diagrams by considering only the attitude command control loop. However, to physically implement the control system several sub-systems were required which complicated the basic system. These systems are listed below.

1. auto-trim;
2. gyro erection cut-out;
3. pitch reference; and
4. yaw attitude command (heading hold)

The following paragraphs provide a detailed description of the purpose and function of the sub-systems listed above.

3.2.3.1 Auto-Trim - The auto-trim system was incorporated to perform two functions. The first and primary function was to keep the separate surface elevator position as close to zero as possible.

The basic pitch axis attitude command system is rather limited in authority, approximately $\pm 10°$ pitch attitude control. Therefore, it would not be unusual for the basic system to become saturated. If a malfunction occurred or the pitch axis system was disengaged under these saturated conditions, the aircraft would experience a rather drastic trim change. To preclude this possibility, the auto-trim system monitored the separate surface elevator position and automatically

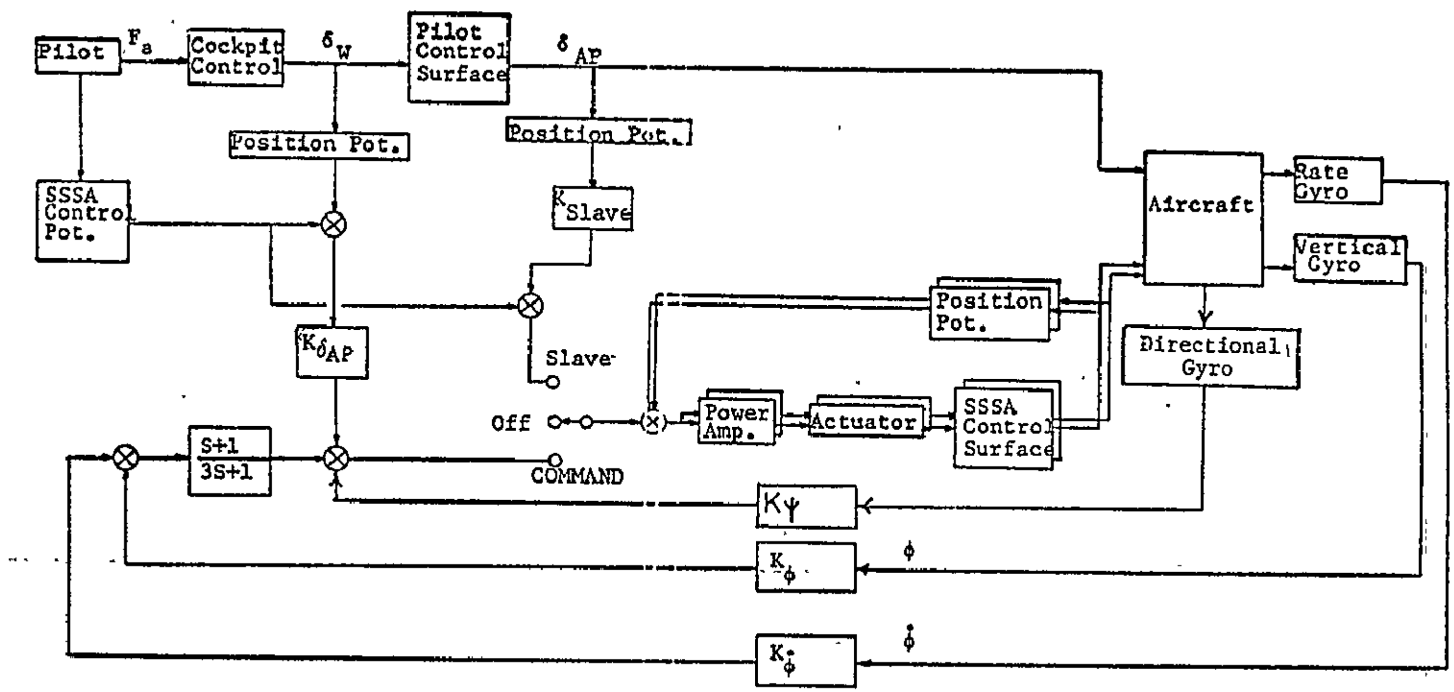
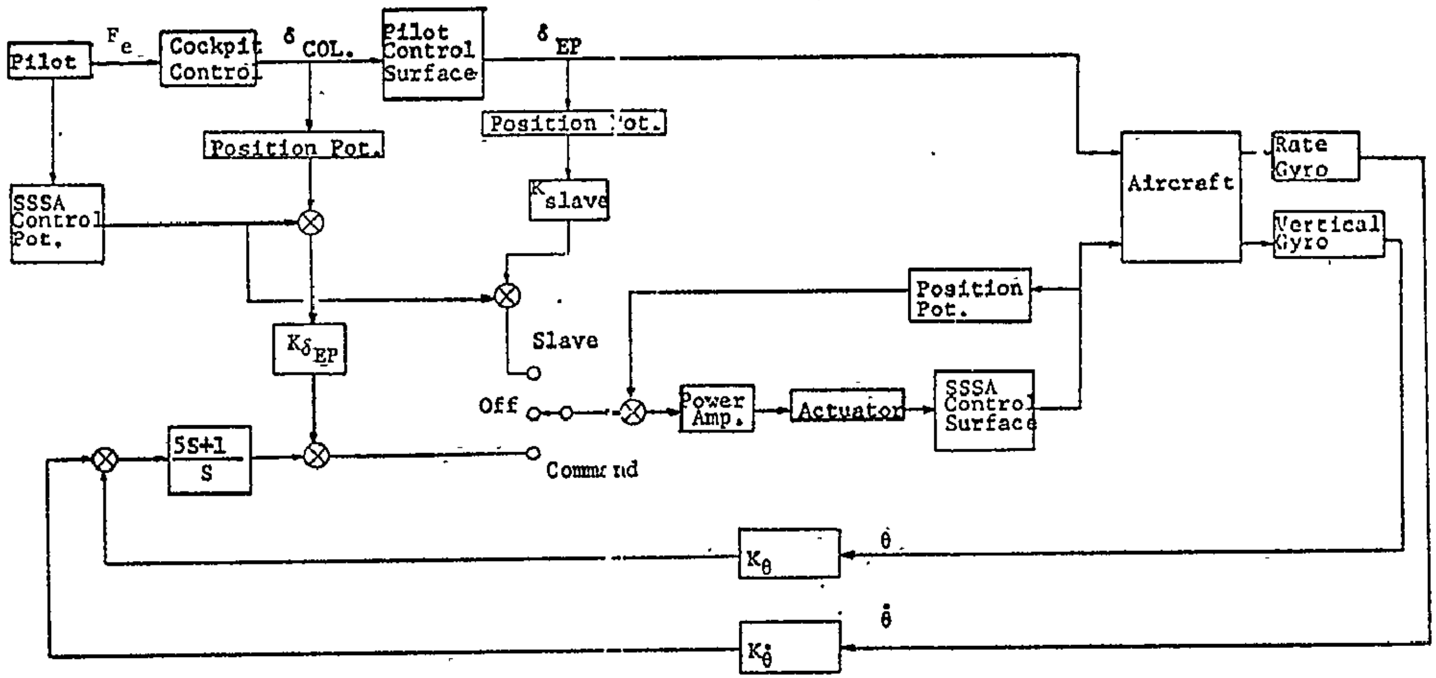



FIGURE 3.2 Block Diagram - Roll Axis




NOTE:

1. $\frac{5S+1}{S}$ shaping network represents a static gain of 5.

2. The value of $K_\theta$ and $K_{\dot\theta}$ in Table 7.3 must be divided by 5 to use in this diagram.

FIGURE 3.3 Block Diagram - Pitch Axis

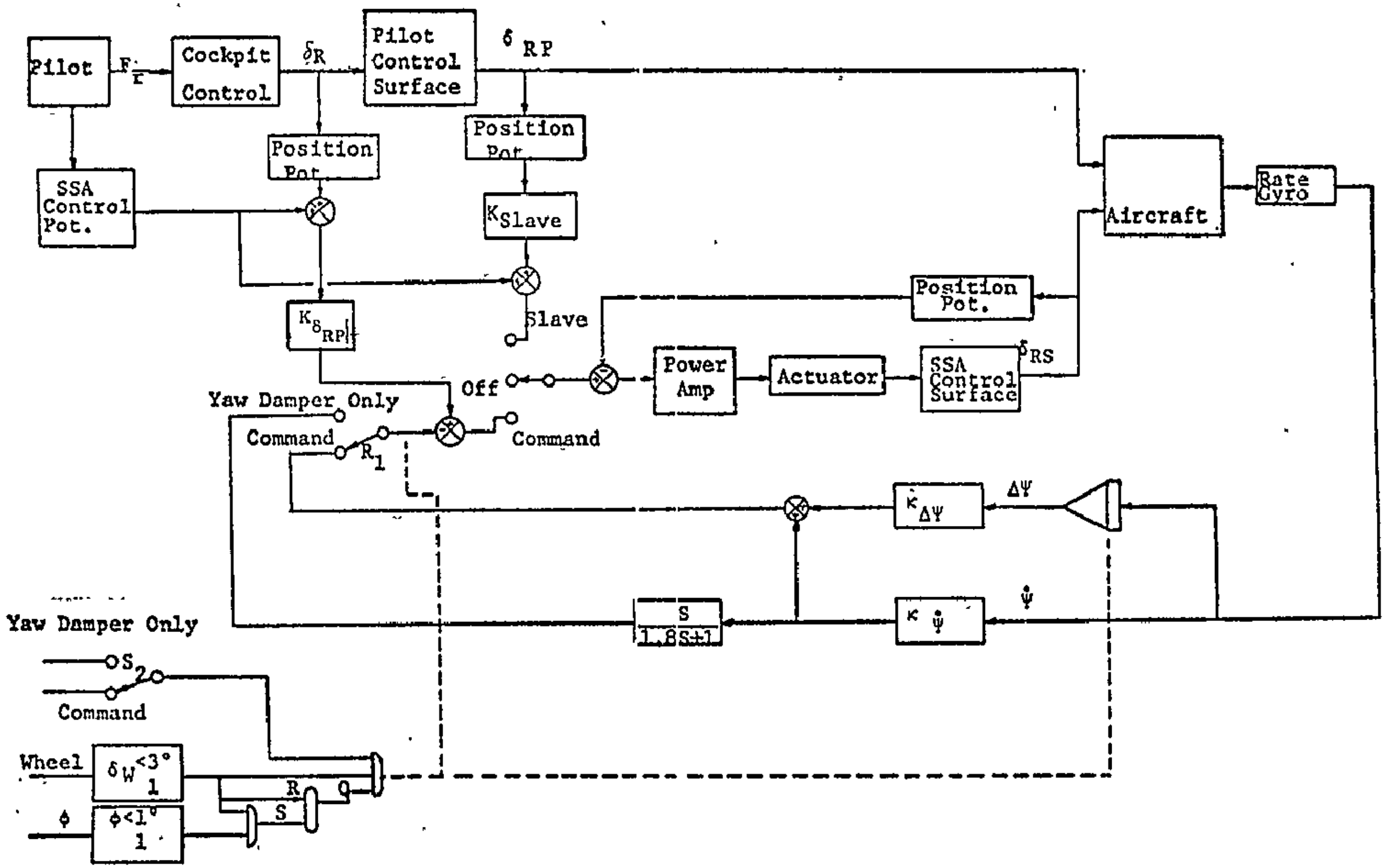



FIGURE 3.4 Block Diagram - Yaw Axis

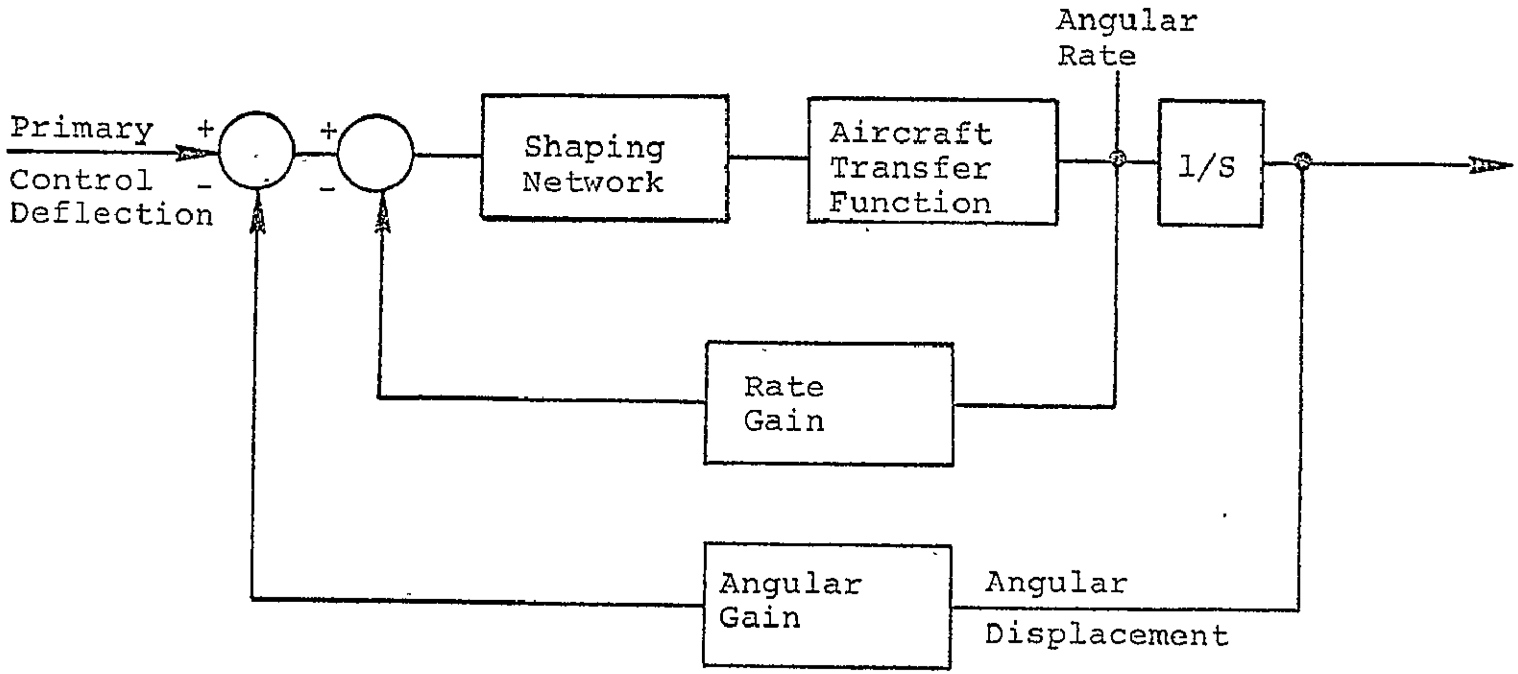



FIGURE 3.5 Simplified Block Diagram of Attitude Command Control System

trimmed the aircraft until the separate surface elevator position returned to approximately zero.

The auto-trim system also fulfilled a second purpose. The automatic trimming increased the authority of the basic attitude command system to a full $\pm 10°$ of pitch about any pitch attitude.

The auto-trim system was incorporated into an existing aircraft system, the standby trim system. The Beech Model 99 is designed with a main electric and a back-up or standby trim system. The main system is controlled by a thumb operated switch on the pilot's and co-pilot's control wheels. This system operates at approximately three times the speed of the standby trim system which allows the pilot to override a standby trim system failure. The standby trim system is normally operated by a two position on-off toggle switch and separate up-down trim switches. The auto-trim system was wired into the aircraft standby trim system by way of the standby trim on-off switch. Provided this switch was in the "off" position, the auto-trim system controlled the aircraft mounted standby trim relays which controlled the standby trim motor. If the pilot selected standby trim "on", the auto-trim system was disabled. For a complete description of this system see Reference 5, page 27.

3.2.3.2 Gyro Erection Cut-Out - The SSSA System obtained the roll and pitch attitude information from a vertical gyro. This gyro automatically erected itself relative to the normal acceleration force that it experienced. In straight and level flight this reference point was the vertical position. However, in a turn, when the aircraft experienced accelerations other than gravity, it erected to a reference different than the vertical position. If this occurred the gyro would provide an erroneous signal to the control system. To eliminate this the bank angle was monitored and the system automatically cut out the erection circuit whenever the roll attitude exceeded a pre-set value. For a complete description see Reference 5, page 29.

3.2.3.3 Pitch Reference - Figure 3.5 graphically describes that the pilot's input to the attitude command system is primary control deflection. However, the pilot must physically overcome the aerodynamic forces generated when the primary controls are deflected. This does not present a problem in the roll and yaw axes because the pilot normally does not fly for extended periods with large lateral or directional control deflections. However, the pilot is required to sustain long duration elevator deflections. To relieve this load in a conventional aircraft the pilot is provided with a longitudinal trim system.

The SSSA system utilized the aircraft trim system in the same fashion that the conventional aircraft utilizes it; it traded primary elevator position for stabilizer position. This was accomplished by monitoring the pilot's main trim switch position. Any time this switch was in the trim up or down position a time varying signal was generated which replaced the primary elevator position signal in the attitude command control system. For a complete description see Reference 5, page 22.

3.2.3.4 Heading Hold Implemented by Roll or Yaw Command - The heading hold was actually a portion of the basic attitude command control system. It was included in the sub-system section of this report because there are two methods for implementing heading hold: (1) roll axis control, and (2) yaw axis control. The two methods were incorporated to evaluate which axis would provide the most effective heading hold. The two systems were not designed to be used simultaneously.

The system operation was as depicted in Figures 3.2 and 3.4. A heading error signal was generated which produced a control deflection in the roll or yaw axis depending upon which had been selected. For a complete description see Reference 5, page 12.

# CHAPTER 4

## SSSA MODEL 99 INSTRUMENTATION PACKAGE

### 4.1 PCM Data Acquisition System

The SSSA Model 99 was equipped with an 80 channel Pulse Code Modulation (PCM) digital data acquisition system that was supplied, connected and calibrated by NASA-DFRC.

Each of the 80 channels was scanned at a high frequency and the results stored on a magnetic tape. This tape, when reduced, yielded a quasi-continuous time history of the recorded parameters. No data telemetry was used in this program.

The parameters recorded and their identifications and channel numbers are listed in Table 4.1. The variable name is an abbreviation of the parameter required for the Boeing computer data analysis. The parameter identification name appears on all data and plots generated by the Boeing Company.

It should be noted that there are two sets of angular displacement and angular rate gyros. NASA-DFRC supplied the second set of gyros to obtain an independent source of aircraft performance. The SSSA system gyros are identifiable by a -gyro suffix on the parameter identification name.

### 4.2 Turbulence Intensity Measuring System

The SSSA Model 99 was equipped with a Turbulence Intensity Measuring System (TIMS), manufactured by Meteorology Research, Inc. It consists of a high frequency dynamic pressure sensor coupled to a TIMS computer which filters the transducer signal and generates a DC voltage ranging from 0 to 5 volts. The TIMS computer filter network incorporates a 6 Hz to 20 Hz bandpass filter (i.e. passes frequencies from 6 to 20 hertz). Reference 6 indicates that this filter adequately removes the aircraft response to both control inputs and turbulence from the turbulence intensity measurement. The

Table 4.1. List of Recorded Parameters

| Channel | Parameter | Parameter-ID |
|---|---|---|
| 01 | Normal Acceleration | ZACC |
| 02 | Lateral Acceleration | YACC |
| 03 | Longitudinal Acceleration | XACC |
| 04 | Angle of Attack | ALFA |
| 05 | Angle of Sideslip | BETA |
| 06 | TIM - Turbulence | TIM-TUR |
| 07 | TIM - Airpseed | TIM-A/S |
| 08 | TIM Transducer | TIM |
| 09 | Altitude Coarse | ALTI |
| 10 | Altitude Fine | ALTIFINE |
| 11 | Airspeed Coarse | VIAS |
| 12 | Airspeed Fine | VIASFINE |
| 13 | Primary Elevator Position | PELE |
| 14 | Primary Right Aileron Position | PAILRIGHT |
| 15 | Primary Left Aileron Position | PAILLEFT |
| 16 | Primary Rudder Position | PRUD |
| 17 | Aileron Trim Position | AIL-TRIM |
| 18 | Rudder Trim Position | RUD-TRIM |
| 19 | Stabilizer Position | STABPOS |
| 20 | Left Throttle Position | THROLEFT |
| 21 | Right Throttle Position | THRORGHT |
| 22 | Flap Position | FLAP |
| 23-1 | Pitch Axis Status | PITCSTAT |

Table 4.1 (cont.)

| Channel | Parameter | Parameter-ID |
|---|---|---|
| 23-2 | Roll Axis Mode | ROLLCOMM |
| 23-3 | Pitch Axis Mode | PITCCOMM |
| 23-4 | Yaw Damper - Heading Hold | YAWDONLY |
| 23-5 | Roll Axis Status | ROLLSTAT |
| 23-6 | Roll Heading Hold | ROLLHH |
| 23-7 | not used | |
| 23-8 | Yaw Axis Mode | YAW-COMM |
| 23-9 | not used | |
| 24-1 | Yaw Axis Status | YAW-STAT |
| 24-2 | not used | |
| 24-3 | not used | |
| 24-4 | Heading Hold Logic | HH--LOG |
| 24-5 | Event Marker | EVENMARK |
| 24-6 | Tape On | TAPEON |
| 24-7 | not used | |
| 24-8 | not used | |
| 24-9 | not used | |
| 25 | Secondary Elevator Position | SELE |
| 26 | Secondary Right Aileron Position | SAILRIGHT |
| 27 | Pitch Angle | TETA |
| 28 | Roll Angle | PHI |
| 29 | Secondary Left Aileron Position | SAILLEFT |
| 30 | Secondary Rudder Position | SRUD |
| 31 | Aileron Error Signal | AIL-SIGN |

Table 4.1 (cont.)

| Channel | Parameter | Parameter-ID |
|---|---|---|
| 32 | Rudder Error Signal | RUDDSIGN |
| 33 | DC Voltage Monitor | DC--VOLT |
| 34 | Yaw Angle | PSI |
| 35 | not used | |
| 36 | Pitch Rate | Q |
| 37 | AC Voltage Monitor | AC--VOLT |
| 38 | not used | |
| 39 | not used | |
| 40 | Roll Rate | P |
| 41 | Pitch Acceleration | QDOT |
| 42 | Yaw Rate | R |
| 43 | Roll Acceleration | PDOT |
| 44 | Yaw Acceleration | RDOT |
| 45 | Rudder Actuator Current | AMP-RUAC |
| 46 | Elevator Actuator Current | AMP-ELAC |
| 47 | Right Aileron Actuator Current | AMP-RAAC |
| 48 | Left Aileron Actuator Current | AMP-LAAC |
| 49 | Yaw Rate Gyro | R---GYRO |
| 50 | not used | |
| 51 | $\theta$ Command | TETACOMM |
| 52 | $\phi$ Command | PHI-COMM |
| 53 | $\psi$ Command | PSI-COMM |
| 54 | $\Delta\psi$ Command | DPSICOMM |
| 55 | Elevator Error Signal | ELERSIGN |

Table 4.1 (cont.)

| Channel | Parameter | Parameter-ID |
|---|---|---|
| 56 | Heading Hold-Yaw Demod | HH-YDEMO |
| 57 | Pitch Vertical Gyro | TETAGYRO |
| 58 | Pitch Rate Gyro | Q---GYRO |
| 59 | Rudder Actuator Voltage | VOLTRUAC |
| 60 | Elevator Actuator Voltage | VOLTELAC |
| 61 | Right Aileron Actuator Voltage | VOLTRAAC |
| 62 | Left Aileron Actuator Voltage | VOLTLAAC |
| 63 | Roll Vertical Gyro | PHI-GYRO |
| 64 | Roll Rate Gyro | P---GYRO |
| 65 | not used | |
| 66 | not used | |
| 67 | Alternate Localizer | ALT-LOC |
| 68 | Alternate Glideslope | ALT-GLID |
| 69 | ILS Localizer Deviation | LOC |
| 70 | ILS Glideslope Deviation | GLID |
| 71 through 76 | not used | |
| 77 | Outside Air Temperature | OAT |
| 78 | Sync-code 000 000 011 | |
| 79 | Sync-code 001 100 101 | |
| 80 | Sync-code 101 011 111 | |

TIMS computer filter network is designed so that a full scale output of 5 volts is equal to 1.33 meters (4.36 feet) per second equivalent gust velocity. Assuming a linear relationship between the TIM computer output and equivalent gust velocity, the following conversion factor can be used to convert TIM output to equivalent gust velocity:

1 volt = 0.266 m/sec (.872 ft/sec) equivalent gust velocity.

In addition, Table 4.2 can be used as a "rule-of-thumb" relation between equivalent gust velocity and subjective turbulence level.

Table 4.2. Relationship Between Subjective Turbulence Level and Equivalent Gust Velocity

| Equivalent Gust Velocity m/sec (ft/sec) | Subjective Turbulence Level |
|---|---|
| 0.305 (1) | light |
| 0.61 - 0.76 (2 to 2.5) | moderate |
| 1.22 - 1.33 (4 to 5) | severe |

A complete theoretical description of TIMS and its application to the SSSA Model 99 can be obtained from References 6, 7 and 8.

## CHAPTER 5

## INTRODUCTION TO THE FLIGHT TEST PROGRAM

### 5.1 Flight Test Objectives and Proposed Schedule

The objectives of the flight test program were to optimize and evaluate the performance of the SSSA Model 99 in order to determine whether the handling and ride qualities of the aircraft were improved by SSSA. The proposed schedule, designed to accomplish this objective, is shown in Figure 5.1. The remainder of this section will define briefly the terms used in the proposed schedule. Chapters 6, 7, 8 and 9 of this report will cover the most important aspects and results of the flight test program in detail.

### 5.2 Definition of Terms

Envelope expansion: Determination of the stall speed, minimum control speed, and flutter envelope of the SSSA Model 99.

Functional Checks and Tuft Study: Verification of correct operation of all three SSSA axes in both slave and command mode; and an investigation of the flow pattern around the control surfaces.

Problem Definition Meeting and Memo: A meeting to discuss any problems encountered to date and proposed solutions to those problems in Memo form.

SSSA System Optimization and NASA Evaluation: Selection of the feedback loop gains to obtain optimum aircraft performance and subsequent evaluation of the performance by NASA pilots.

Quantitative Evaluation: Determination of the aircraft performance in both slave and command modes as defined by the following:

1. Static longitudinal stability;
2. Dynamic longitudinal stability;
3. Dynamic lateral-directional stability; and
4. Aircraft responses to step control inputs.

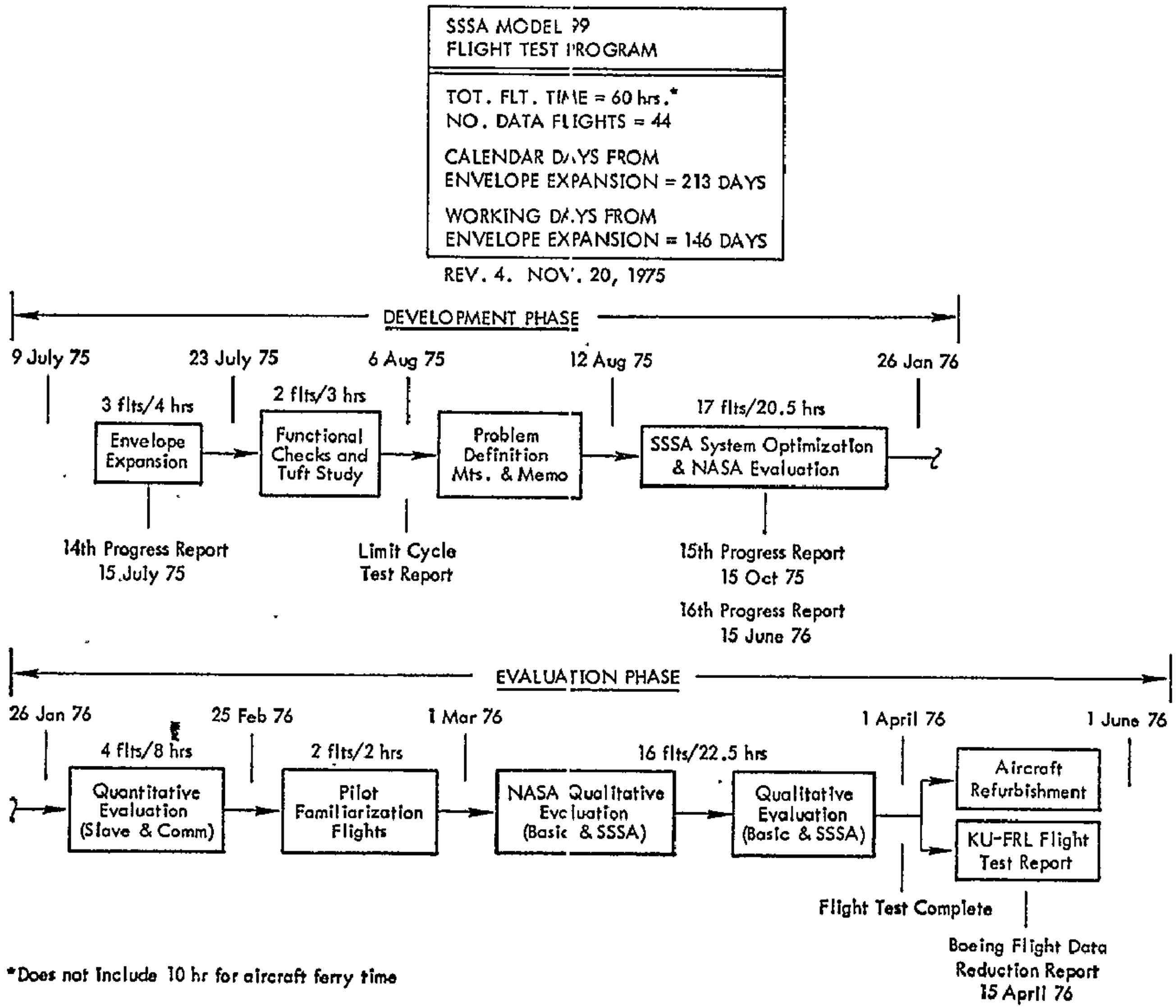



FIGURE 5.1 Proposed SSSA Model 99 Flight Test Schedule

Pilot Familiarization Flights: Flights by the evaluation pilots designed to familiarize them with SSSA attitude command and Model 99 characteristics.

NASA Qualitative Evaluation: NASA pilots' performance of the qualitative flight profile in both slave and command modes and subsequent rating of the aircraft using the Cooper-Harper pilot rating scale. The qualitative flight profile is described in Figure 5.2 and the terms used are defined in Table 5.1. The Cooper-Harper pilot rating scale is outlined in Figure 5.3 and the terms used are defined in Table 5.2.

Qualitative Evaluation: Evaluation pilots performance of the qualitative flight profile in both slave and command modes and subsequent rating of the aircraft using the Cooper-Harper pilot rating scale.

Aircraft Refurbishment: Restoration of the aircraft to its original Model 99 configuration.

## 5.3 Actual Flight Test Schedule

The actual flight test schedule differed slightly from the proposed schedule due to SSSA system gyro malfunctions and a program contract renegotiation. The actual flight test schedule including the number of flights and hours flown in each phase of the program is included in Reference 9.

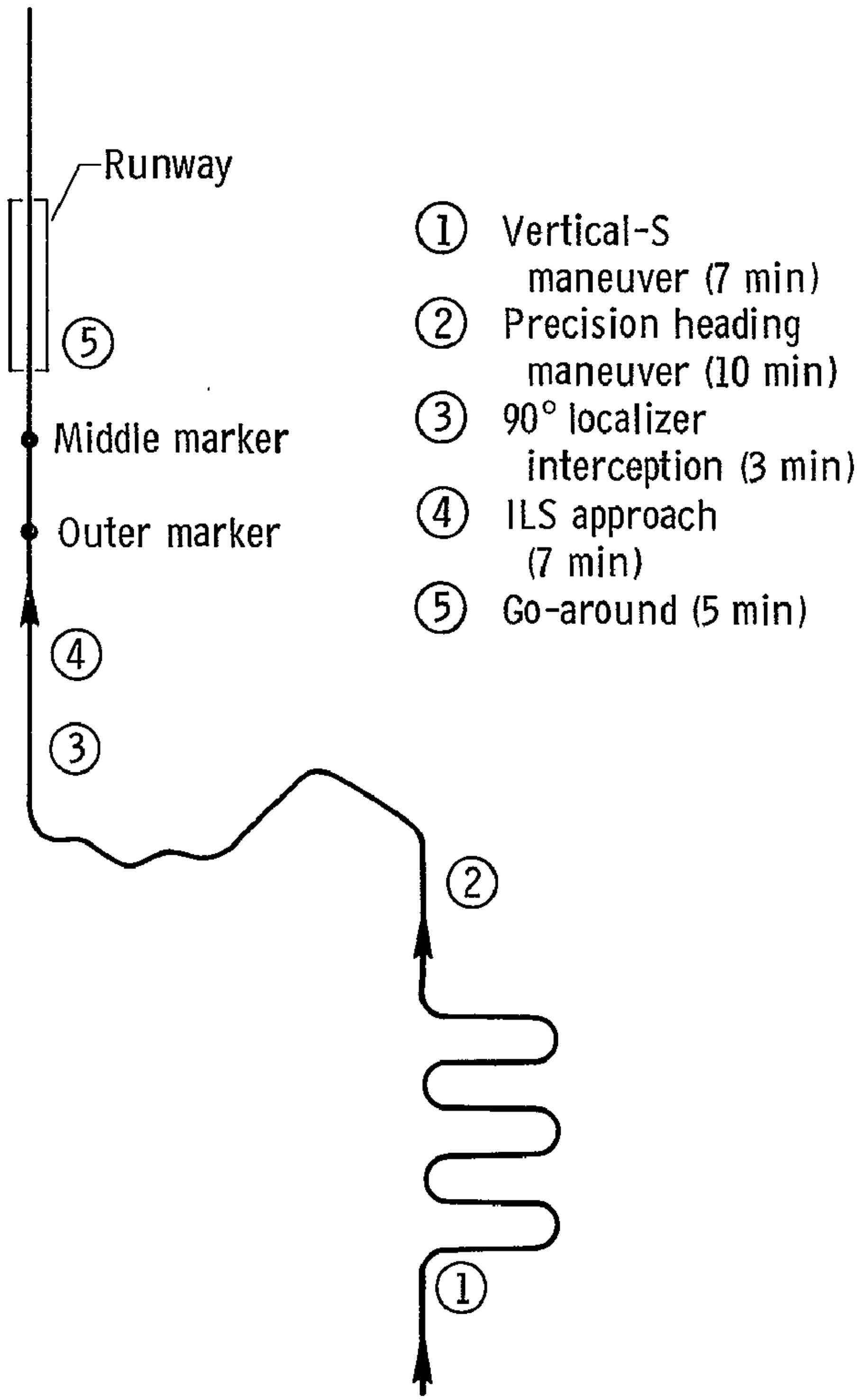



FIGURE 5.2 Typical Qualitative Flight Profile

Table 5.1. Definition of Terms Used in Qualitative Evaluation Profile

TASK 1:

Vertical S

Maintaining a 152 m/min (500 ft/min) rate of climb in a steady banked turn for 305 m (1000 ft) climb, then converting to a 152 m/min (500 ft/min) rate of descent in a banked turn in the opposite direction for 305 m (1000 ft) descent.

TASK 2:

Precision Heading

Maintaining a given heading as accurately as possible.

TASK 3:

ILS Intercept

A 90° intercept of the localizer approximately 9.6 km (6 miles) from the outer marker.

TASK 4:

ILS Approach

Performance of a Standard Instrument Landing System approach.

TASK 5:

Go-Around

An acceleration and climb following a missed approach - incorporates retracting gear and flaps.

TASK 6: (Optional Test)

Precision Heading

Maintaining a given heading as accurately as possible after the go-around.

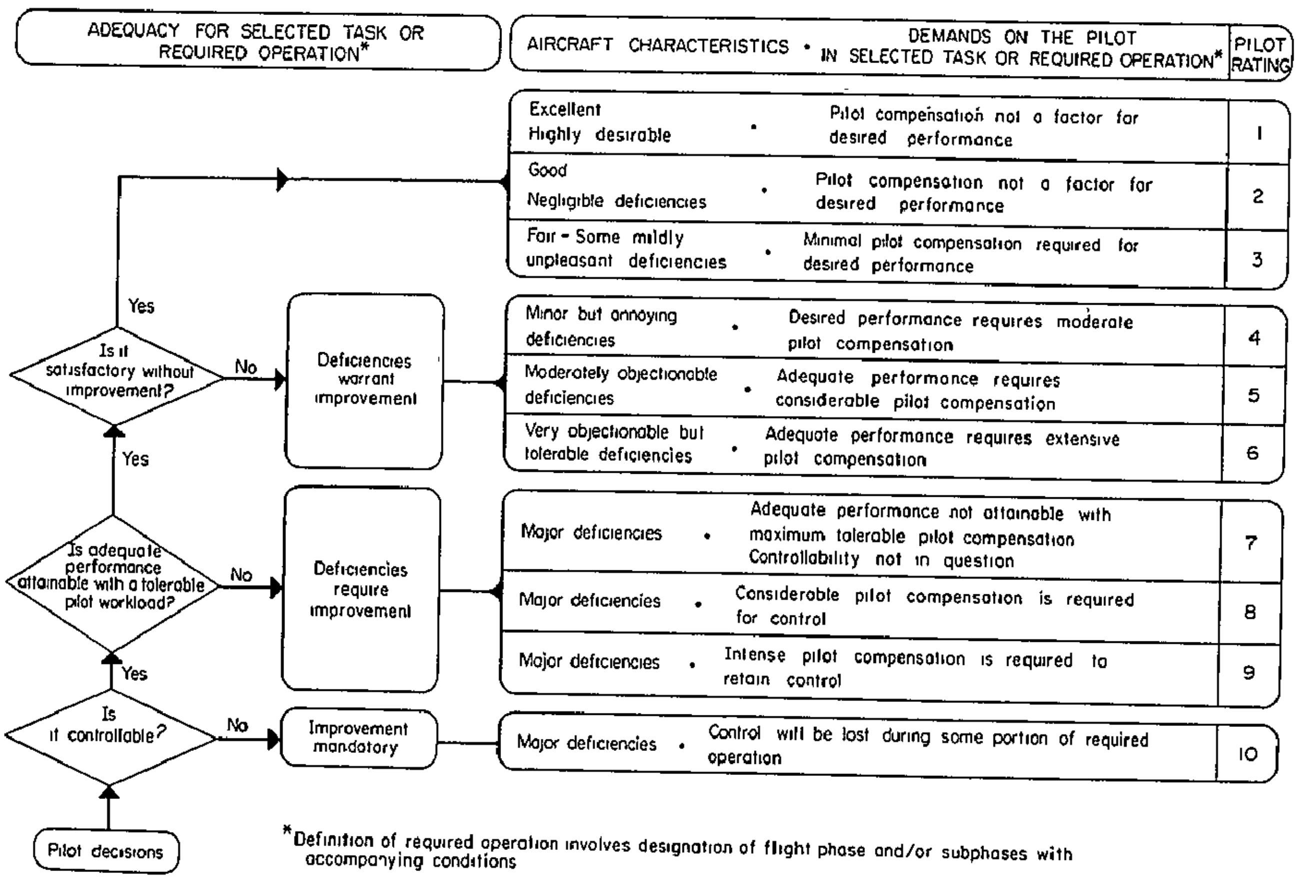



FIGURE 5.3 Cooper-Harper Handling Qualities Rating Scale

Table 5.2. Definitions of Terms Used in Cooper-Harper Pilot Rating Scale

<u>Compensation</u>

The measure of additional pilot effort and attention required to maintain a given level of performance in the face of deficient vehicle characteristics.

<u>Handling Qualities</u>

Those qualities or characteristics of an aircraft that govern the ease and precision with which a pilot is able to perform the tasks required in support of an aircraft role.

<u>Mission</u>

The composite of pilot-vehicle functions that must be performed to fulfill operational requirements. May be specified for a role, complete flight, flight phase, or flight subphase.

<u>Performance</u>

The precision of control with respect to aircraft movement that a pilot is able to achieve in performing a task. (Pilot-vehicle performance is a measure of handling performance. Pilot performance is a measure of the manner or efficiency with which a pilot moves the principal controls in performing a task.)

<u>Role</u>

The function or purpose that defines the primary use of an aircraft.

<u>Task</u>

The actual work assigned a pilot to be performed in completion of or as representative of a designated flight segment.

<u>Workload</u>

The integrated physical and mental effort required to perform a specified piloting task.

# CHAPTER 6

# ENVELOPE EXPANSION AND TUFT STUDY

## 6.1 Introduction

The objectives of this flight test program did not warrant an extensive envelope expansion program. An abbreviated expansion program was performed with the major emphasis on the flutter characteristics. The minimum control speed and the stall speed were investigated for one center of gravity location - approximately 28% of the mean aerodynamic chord. Additionally, the separate surface controls were tufted for flow visualization. The purpose was to determine if any unusual aerodynamic cross coupling occurred between the primary and separate surface controls during maneuvering.

## 6.2 Stall Speed

The installation of the SSSA controls did not alter the basic aerodynamic characteristics of the Model 99. As a consequence, the stall speed of the modified aircraft was identical to that of the basic aircraft. The area that was affected was the control characteristics during the stall. Consequently, these characteristics were subjectively evaluated for the slave (basic aircraft), off (SSSA controls free floating), and command modes.

In the slave mode the stall control characteristics were identical to those of the basic Model 99.

The off mode was somewhat different from slave. Because of the reduction in the available pitch control power, the stall recovery rate was reduced from that of the basic aircraft. The aircraft was completely recoverable; however, pitch control was obviously degraded. The roll and yaw control was not noticeably degraded because of the lack of basic aircraft excursions in these axes and consequently the lack of demand on roll and yaw control.

The command mode stall was also quite straightforward. There were no unusual characteristics. Initially, some concern was expressed concerning the effect of auto-trim on the stall. This system tends to trim the aircraft into the stall. However, this proved to be an insignificant consideration because the pilot retained complete authority of the main trim system. The roll attitude command provided some improvement due to the tendency to keep the wings level. This advantage was provided with the roll heading hold system off. With the roll heading hold on there was a low frequency, approximately 0.5 Hz, oscillation in roll below 90 knots. This oscillation was very similar to the heading hold oscillation that occurs with most auto-pilots at low airspeed.

### 6.3 Minimum Control Velocity, $V_{MC}$

The minimum control velocity was calculated for the modified Model 99 using an incremental change in control power by assuming two separate surface rudder failure conditions:

1. Separate surface rudder faired (unpowered),
2. Separate surface rudder hardover in adverse direction (powered).

These calculations were made at aft center of gravity, 38.4% MAC. The results of these calculations were 90 knots for the unpowered, faired condition and 111 knots for the powered, hard-over condition in adverse direction. This corresponded to an increase of 12 and 23 knots in $V_{MC}$, respectively.

During the envelope expansion phase of the flight test program, $V_{MC}$ was evaluated for the unpowered, faired condition at a center of gravity at 27% MAC. This evaluation revealed a $V_{MC}$ of 90 knots. The hard-over condition was not evaluated due to the apparent accuracy of the faired condition calculations.

## 6.4 Flutter Envelope Expansion

Definition of the flutter envelope was accomplished in three phases: 1) Analytical definition of flutter speed using SSSA control laws, 2) ground vibration test to verify elastic modes in analytical analysis, 3) flight evaluation to define the actual flutter speed. Results of phase 1 and 2 are on file at KU-FRL, and results of phase 3 are included in Reference 10.

The results of the analytical evaluation revealed that the roll axis, command mode was the limiting axis. Both the pitch and yaw axes had flutter boundaries that far exceeded the operational requirements for this program. However, the roll axis did reveal an instability that was strongly affected by roll axis feedback gain. As a consequence, prior to the first flight the analytical flutter envelope was defined as shown in Figure 6.1.

The flight evaluation was conducted by investigating the nominal and 1.5 times the nominal roll axis gain. For the nominal gain a sustained roll oscillation occurred at 215 knots at an altitude of 3050 meters (10,000 feet) pressure altitude. At 1.5 times the nominal gain at 1800 meters (5900 feet) pressure altitude, the oscillation occurred at 220 knots. The oscillation occurred at a frequency of 6 Hz with all motion confined to the roll axis. No cross coupling between axes was detected.

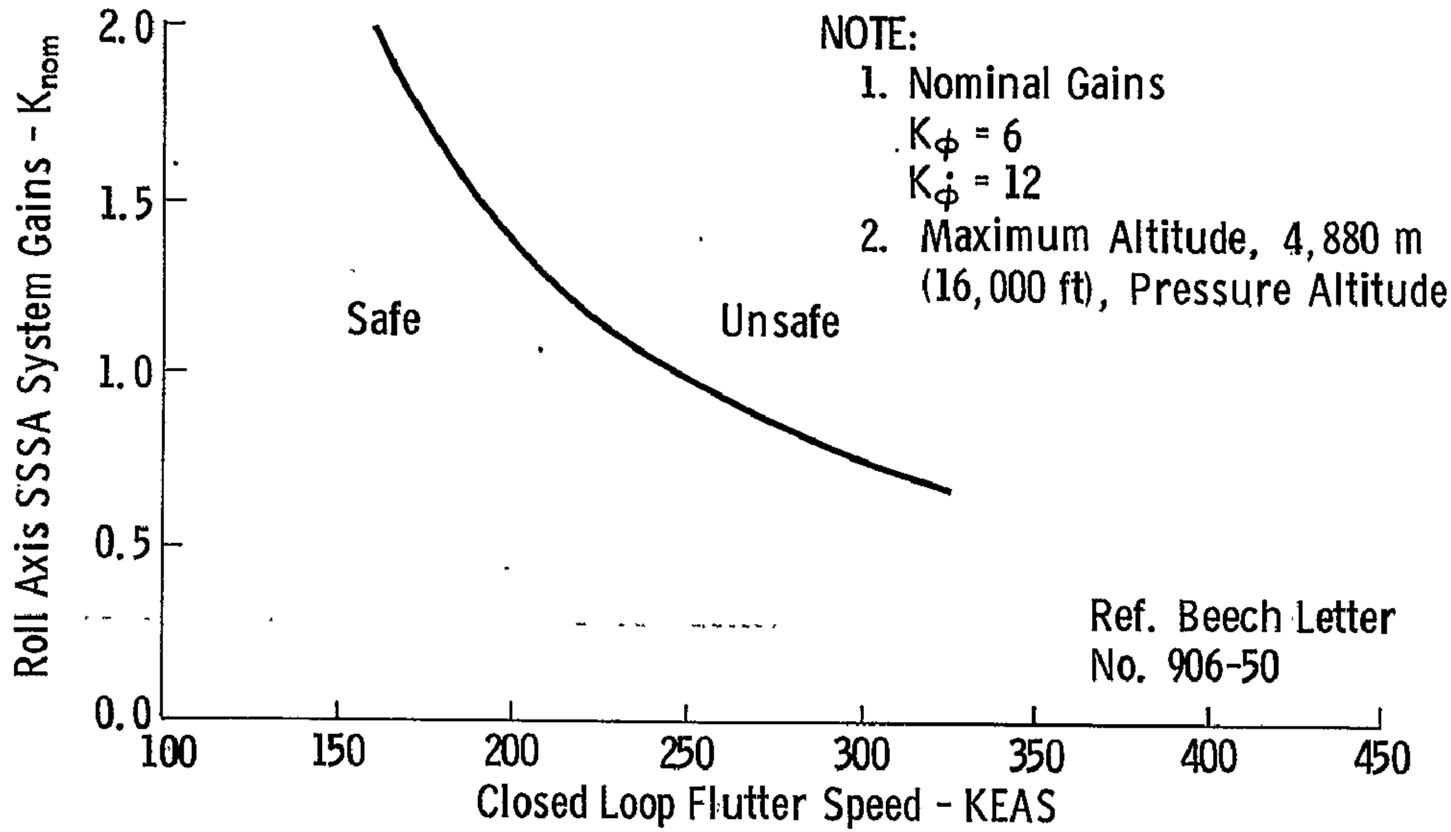



FIGURE 6.1 Analytical Flutter Speed Predictions

# CHAPTER 7

## SSSA SYSTEM OPTIMIZATION

### 7.1 Introduction

The purpose of the system optimization portion of the flight test program was to identify and solve any developmental problems encountered, and to optimize the SSSA Model 99 feedback loop gains to obtain peak performance from the system.

### 7.2 Developmental Problems

Prior to and during the system optimization portion of the flight test program several developmental problems or system malfunctions occurred. In all cases the source of the problem was either SSSA system gyro malfunction, inadequate electronic design, or improper sizing of the SSSA system feedback loop gains. A discussion of each problem encountered, its cause and its solution is given in the following sections of this chapter.

7.2.1 Roll Asymmetry. On the first flight of the SSSA Model 99 it was determined that the roll response obtained from a primary aileron deflection was not the same to the left and right. Electronic trouble-shooting of this problem determined that there was a zero position off-set in the roll rate gyro. The zero position offset was counteracted by adjusting the SSSA roll trim potentiometer, but this adjustment induced an electronic saturation of an amplifier in the roll computer leading to the asymmetric roll response.

Initially, a new roll rate gyro was installed in the aircraft but it also had a zero position offset. In order to eliminate the asymmetric roll response without replacing the gyro, the roll axis gains were redistributed in the SSSA electronics to reduce the impact of the SSSA roll trim potentiometer adjustment and eliminate amplifier saturation in the roll computer. For a detailed discussion of the electronic modifications necessary see Reference 11.

7.2.2 Pitch Oscillation. A sinusoidal oscillation of the pitch attitude of the SSSA Model 99 was noticed on flight one. The amplitude of this oscillation varied with airspeed and was caused by a sinusoidal oscillation of the separate surface elevator of amplitude ranging from $\pm 1°$ to $\pm 6°$ at a frequency of approximately 1.25 hertz. The pitch attitude oscillation resulting from this separate surface movement was not detectable on the instrumentation, but a pitch rate oscillation of amplitude $\pm 3°$/sec could be observed.

Adjustment of the feedback loop gains in the pitch computer changed the amplitude of the separate surface elevator oscillation, but did not eliminate it. Further troubleshooting indicated that the pitch angle signal from the vertical gyro was oscillating in flight with the SSSA system off. This indicated a gyro malfunction, and subsequent replacement of the vertical gyro eliminated the pitch axis oscillation.

7.2.3 Bank Angle Overshoot and Settling Time. Once the asymmetric roll response problem was solved on the fifth flight of the SSSA Model 99, it was realized that the bank angle overshoot and settling time were greater than predicted in Reference 2. The bank angle overshoot ($\phi_{OS}$) is defined as the difference between the maximum and steady state bank angles ($\phi_{SS}$). The settling time (Ts) is defined as the length of time required to reach and maintain 95% of the steady state bank angle. Figure 7.1 is given to help clarify these definitions.

A program to redefine the roll axis gains in an attempt to minimize the bank angle overshoot and settling time using flight test results was begun. An analysis of the SSSA Model 99 roll axis (Appendix A) indicated that the bank angle overshoot and settling time were functions of $K_\phi$, $K_{\dot\phi}$ and $K_{\delta_{AP}}$. $K_\phi$ and $K_{\dot\phi}$ were fixed at $K_\phi$ = 9 deg/deg and $K_{\dot\phi}$ = 18 deg/deg/sec due to the flutter evaluation detailed in chapter 6. An increase of $K_{\delta_{AP}}$ from 15 deg/deg to 60 deg/deg yielded satisfactory roll performance with no measurable overshoot and minimum settling time.

It should be noted that at $K_{\delta_{AP}}$ = 60 deg/deg the separate surface aileron saturates in the following direction. This saturation

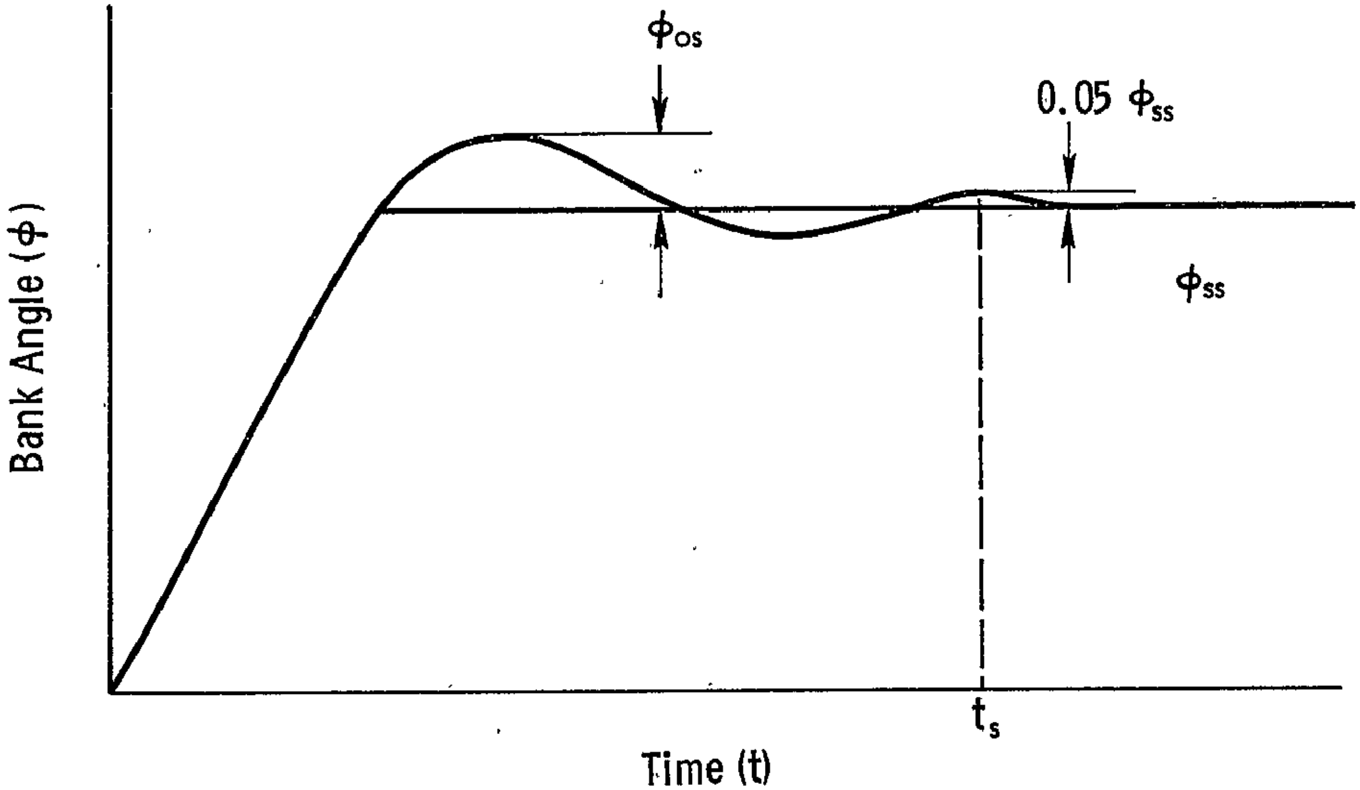



FIGURE 7.1  Definition of Bank Angle Overshoot and Settling Time

invalidates the linear analysis of Appendix A and the bank angle overshoot and settling time then become functions of the magnitude of primary aileron deflection as well as of $K_\phi$, $K_{\dot\phi}$ and $K_{\delta AP}$.

Flight test roll responses for the approach configuration included in Appendix B indicate that separate surface aileron saturation does not noticeably affect the bank angle overshoot; however, it does significantly affect the settling time as shown in Table 7.1.

Table 7.1. Effect of Separate Surface Aileron Saturation on Settling Time

| $\phi_{SS}$, deg | $T_{Sat}$, sec | $T_S$, sec |
|---|---|---|
| 14 | 1.0 | 1.4 |
| 24 | 1.2 | 2.4 |
| 26 | 1.3 | 3.2 |

7.2.4 Excessive Aileron Forces. An inherent problem in the SSSA attitude command concept is that a constant aileron deflection is required to fly a constant bank angle. The wheel force required to maintain a constant bank angle is directly proportional to the primary aileron deflection. The amount of primary aileron deflection required is a function of the forward loop gain $K_{\delta_{AP}}$; for large values of $K_{\delta_{AP}}$, less primary aileron (and therefore less wheel force) is required to fly a steady state bank angle. It should be noted that large values of $K_{\delta AP}$ also make the aircraft very sensitive to primary aileron inputs and change the roll response as discussed in section 7.2.3. $K_{\delta_{AP}}$ = 60 deg/deg was chosen to minimize control forces required to fly a constant bank angle, and still not make the aircraft too sensitive to primary aileron inputs. Figure 7.2 shows the steady state wheel force as a function of bank angle with SSSA system gains of $K_\phi$ = 9 deg/deg, $K_{\dot\phi}$ = 18 deg/deg/sec and $K_{\delta_{AP}}$ = 60 deg/deg.

7.2.5 Pitch Trim Overshoot. After the fourth flight of SSSA Model 99, the pilots indicated that the aircraft had a pitch trim overshoot problem. When the pilot commanded a new reference attitude with a pilot

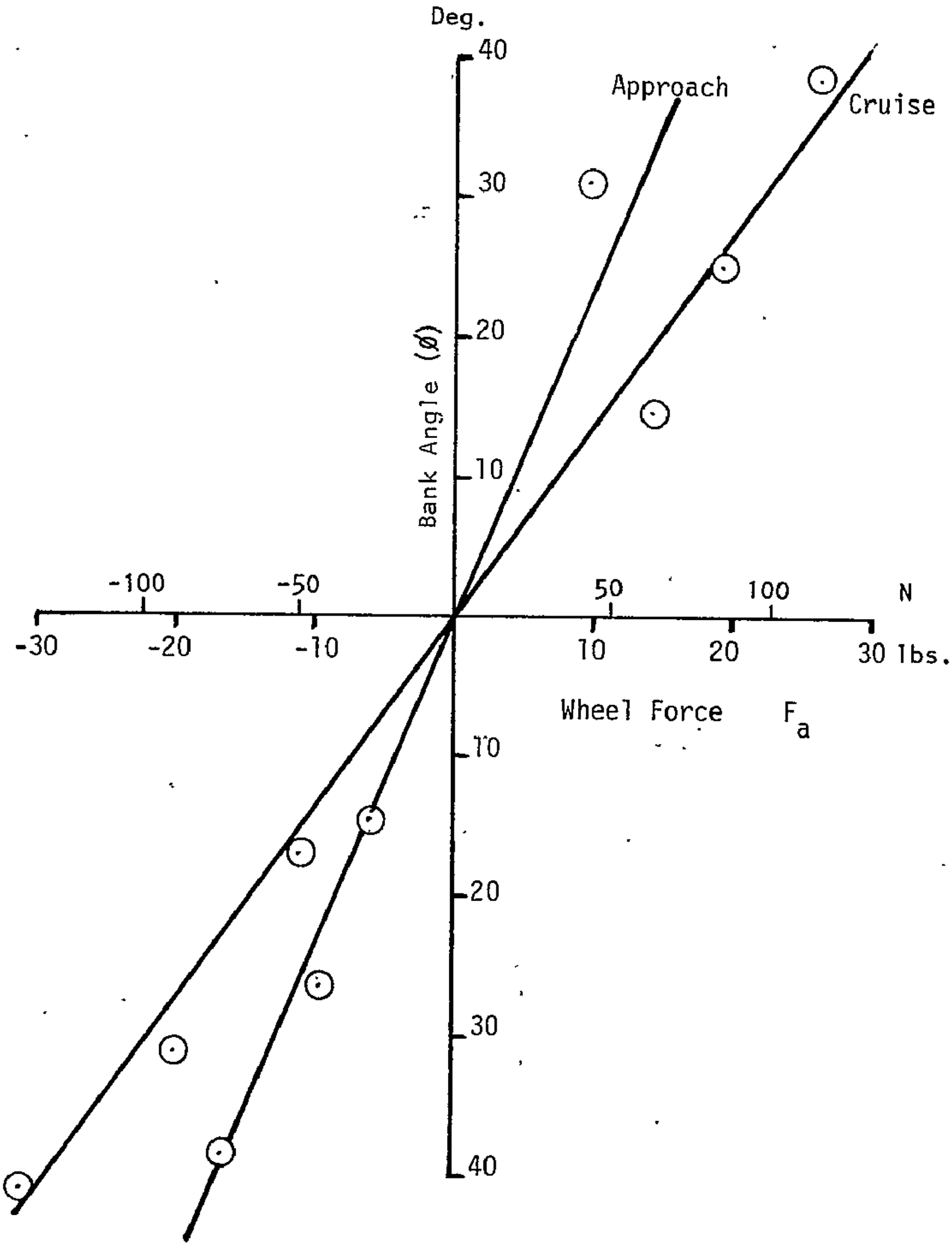



FIGURE 7.2 SSSA Model 99 Aileron Control Forces

trim input the aircraft overshot the commanded attitude and then gradually returned. This overshoot made it very difficult for the pilot to reach a desired attitude with the pilot trim.

The overshoot was caused by improper sizing of the primary elevator gain ($K_{\delta_{EP}}$) in the SSSA electronics. When the primary elevator gain was initially sized, the aircraft response to trim inputs was not considered. As a result of a pilot trim input, the attitude commanded by the SSSA computer was much less than that attained by the aircraft. Consequently, the separate surface would saturate trying to oppose the aircraft motion and the pitch attitude would overshoot the commanded attitude. The auto-trim system would eventually trim the aircraft back to its commanded attitude. The problem was solved by increasing $K_{\delta_{EP}}$ so that the commanded attitude matched the basic aircraft response to a pilot trim input. For a complete technical description of this problem and its solution refer to Reference 12.

7.2.6 Go-around Pitch Transients. Comments following the first NASA evaluation flight indicated that the pitch attitude performance of the SSSA Model 99 in a go-around acceleration was unsatisfactory. The basic Model 99 has very large pitch trim transients during configuration changes. These transients, represented by elevator control forces required to maintain a constant pitch attitude during configuration changes, are summarized in Table 7.2. The SSSA system as originally designed would lighten these forces. However, due to its limited authority, the separate surface elevator became saturated, which resulted in the loss of pitch attitude command. As can be seen from Table 7.2, the largest factor contributing to pitch attitude changes on the Model 99 is flap retraction.

The approach taken to eliminate the loss of pitch attitude during a go-around was to allow the auto-trim system enough time to prevent separate surface elevator saturation by slowing the flap retraction speed. The flap retraction speed was slowed by the "flap interrupt modification". This modification was designed to interrupt the flap retraction any time the separate surface elevator exceeded a preset limit of $\pm 5°$. Then the auto-trim system would reposition the

Table 7.2. Basic Model 99 Trim Characteristics

| Configuration Change | Elevator Push Wheel Force Required to Trim $F_e$ - N (Lb) |
|---|---|
| Gear Up → Down | 33 ( 7.5) |
| Flaps Up → Down | 222 (50.0) |
| Half → Full Power | 80 (18.0) |

separate surface elevator to within ±.5°, and the flaps would continue retracting. By proper adjustment of the separate surface elevator deflection limits the flap retraction time was minimized for the go-around conditions. This modification increased the flap retraction time from 15 seconds to 25-30 seconds. The aircraft response to a go-around acceleration before and after installation of the flap interrupt modification is shown in Figures 7.3 and 7.4 respectively. It should be noted that this modification also changed the flap extension time.

7.2.7 Electronic Design Problems. Two electronic design problems were encountered during the system optimization portion of the flight test program. First, uncommanded high frequency movement of the separate surface controls appeared on flight fourteen. This problem was called the electronic "glitch" and was caused by an excess current demand from the SSSA actuators which induced electronic noise on the 28 volt DC bus. This problem was eliminated by capacitive filtering of the SSSA power amplifiers. The details of the solution are given in Reference 9.

The second electronic design problem was in the switching network of the yaw attitude command system. Due to the sensitivity of the digital electronics used in the heading hold function, the aircraft often selected an erroneous heading. This problem was also solved by electronic filtering which once again is described in detail in Reference 11.

7.2.8 SSSA System Gyro Malfunctions. Part of the original SSSA design concept was to use inexpensive gyros. This concept was justified because overall system cost was of major importance. Since the aircraft was controllable, even in the event of a hard-over failure, expensive

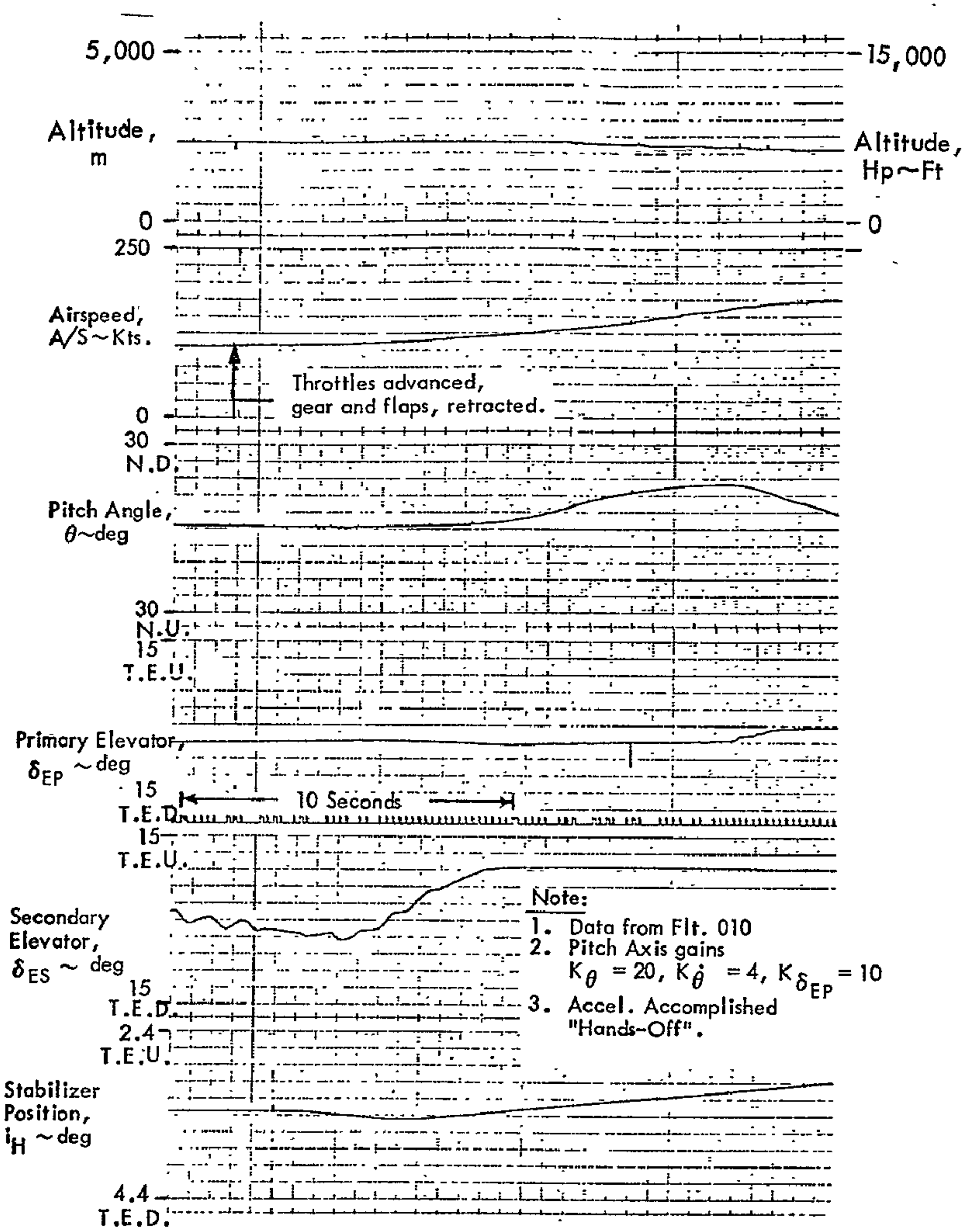
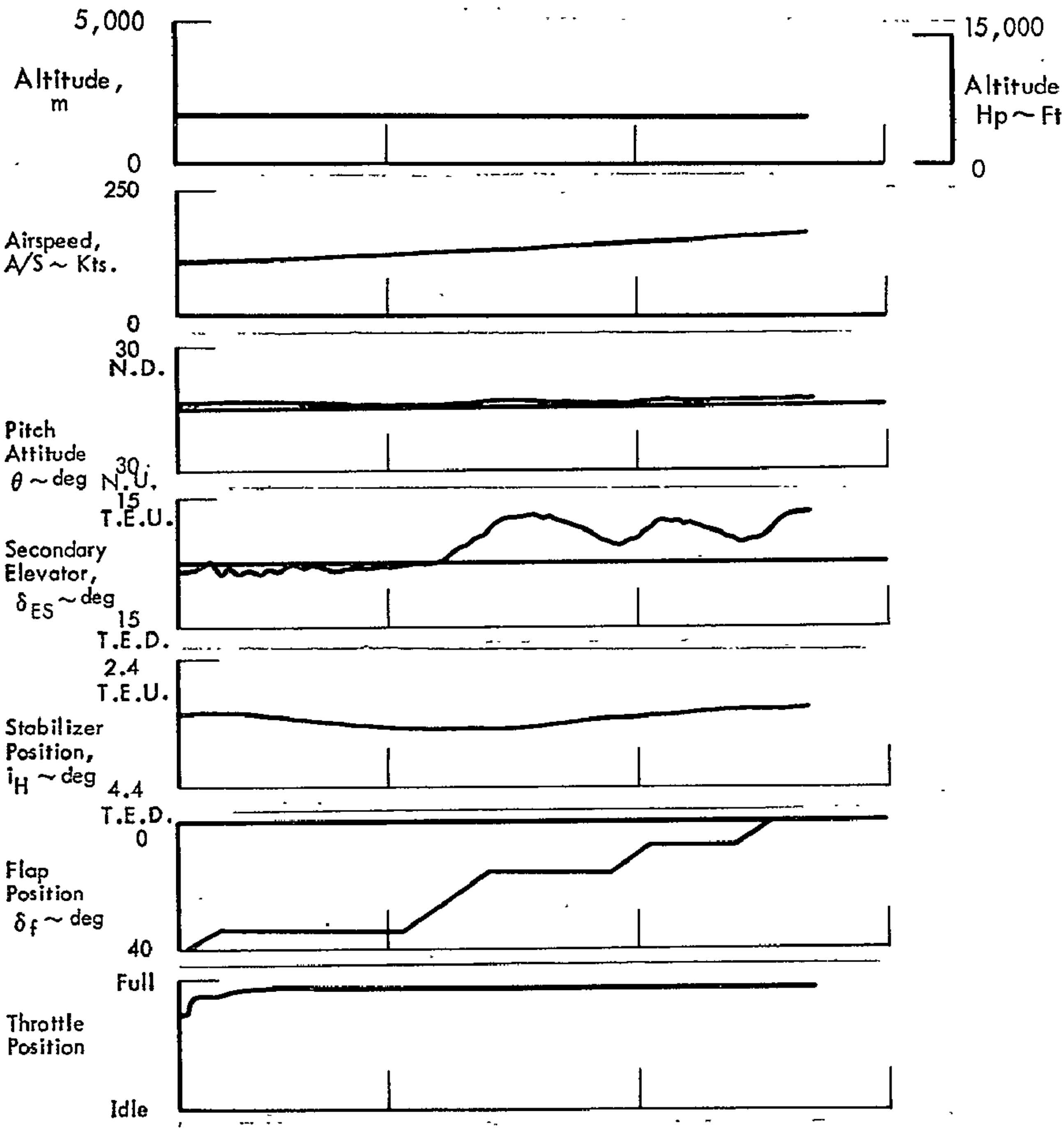



FIGURE 7.3 Aircraft Response to Go-Around Acceleration (Flap Interrupt Mod. Not Installed)




Note:

1. Data from Flt. No. 014
2. Pitch axis gains —— $K_\theta = 20$, $K_{\dot\theta} = 4$, $K_{\delta_{EP}} = 24$
3. Accel. accomplished "Hands-Off".

FIGURE 7.4 Aircraft Response to Go-Around Acceleration (Flap Interrupt Mod. Installed) gyros were not required from a safety of flight standpoint. Several developmental problems are directly related to the use of inexpensive gyros.

The roll asymmetry discussed in section 7.2.1 was directly related to a zero-position offset of the roll rate gyro. The pitch oscillation discussed in section 7.2.2 was caused by a faulty vertical gyro. Finally, the SSSA system directional gyro had an intermittent heading drift which seriously degraded the optimization and performance of the yaw attitude command system. In retrospect, it would have been less expensive to have purchased higher quality, better precision gyros than to have expended the flight time and manpower required to solve gyro related problems.

## 7.3 Summary of Optimum SSSA System Gains

The optimum forward and feedback loop gains for the SSSA Model 99 as determined by flight tests are given in Table 7.3. These gains were selected to minimize Euler angle overshoots and obtain aircraft performance desired by NASA, Beech and KU flight test personnel while staying within the flutter envelope. Aircraft performance obtained with these gains will be discussed in Chapters 8 and 9 of this report.

Table 7.3. Optimum SSSA System Gains

| Aircraft Axis | Parameter | Optimum Gain | Units |
|---|---|---|---|
| Roll | $K_{\delta_{AP}}$ | 60 | deg/deg |
| | $K_{\phi}$ | 9 | deg/deg |
| | $K_{\dot{\phi}}$ | 18 | deg/deg/sec |
| Pitch | $K_{\delta_{EP}}$ | 28 | deg/deg |
| | $K_{\theta}$ | 20 | deg/deg |
| | $K_{\dot{\theta}}$ | 4 | deg/deg/sec |
| Yaw | $K_{\delta_{RP}}$ | 1 | deg/deg |
| | $K_{\psi}$ | 4 | deg/deg |
| | $K_{\dot{\psi}}$ | 6 | deg/deg/sec |

# CHAPTER 8

# QUANTITATIVE FLIGHT TEST RESULTS

## 8.1 Introduction

The quantitative flight test program was performed to define the static and dynamic responses of the SSSA Model 99 in the attitude command mode, and to compare those responses with the basic Model 99. The quantitative flight test program consisted of step control responses in the pitch and roll axes; phugoid, short period and dutch roll dynamic responses, and a static longitudinal stability test. To save time during the flight test program the basic aircraft responses described in Chapters 8 and 9 were obtained with the SSSA system in the slave mode. This eliminated the problem of bolting the primary and secondary surfaces together and making separate flights to evaluate the basic aircraft. The only difference between the basic aircraft and the slave mode was a reduction in control forces caused by the reduced primary control surface areas.

All tests were done in both the slave and command modes, and in both the approach and cruise configurations. The approach configuration is defined as gear down and flaps 40° down at 110 knots indicated airspeed. The cruise configuration is defined as gear and flaps up at 170 knots indicated airpseed. The center of gravity was approximately 28% MAC for all flight conditions. All computer generated plots referred to are contained in Appendix B and were generated by the Boeing Company, Wichita, Kansas.

## 8.2 Roll Axis Response

The responses of the basic Model 99 (slave mode) and the SSSA Model 99 (command mode) to step aileron inputs in both the approach and cruise configurations are given in Appendix B, section 1. Sample roll responses are given in Figures 8.1 and 8.2. The important things to notice are that the Model 99 responds as a rate command system in the

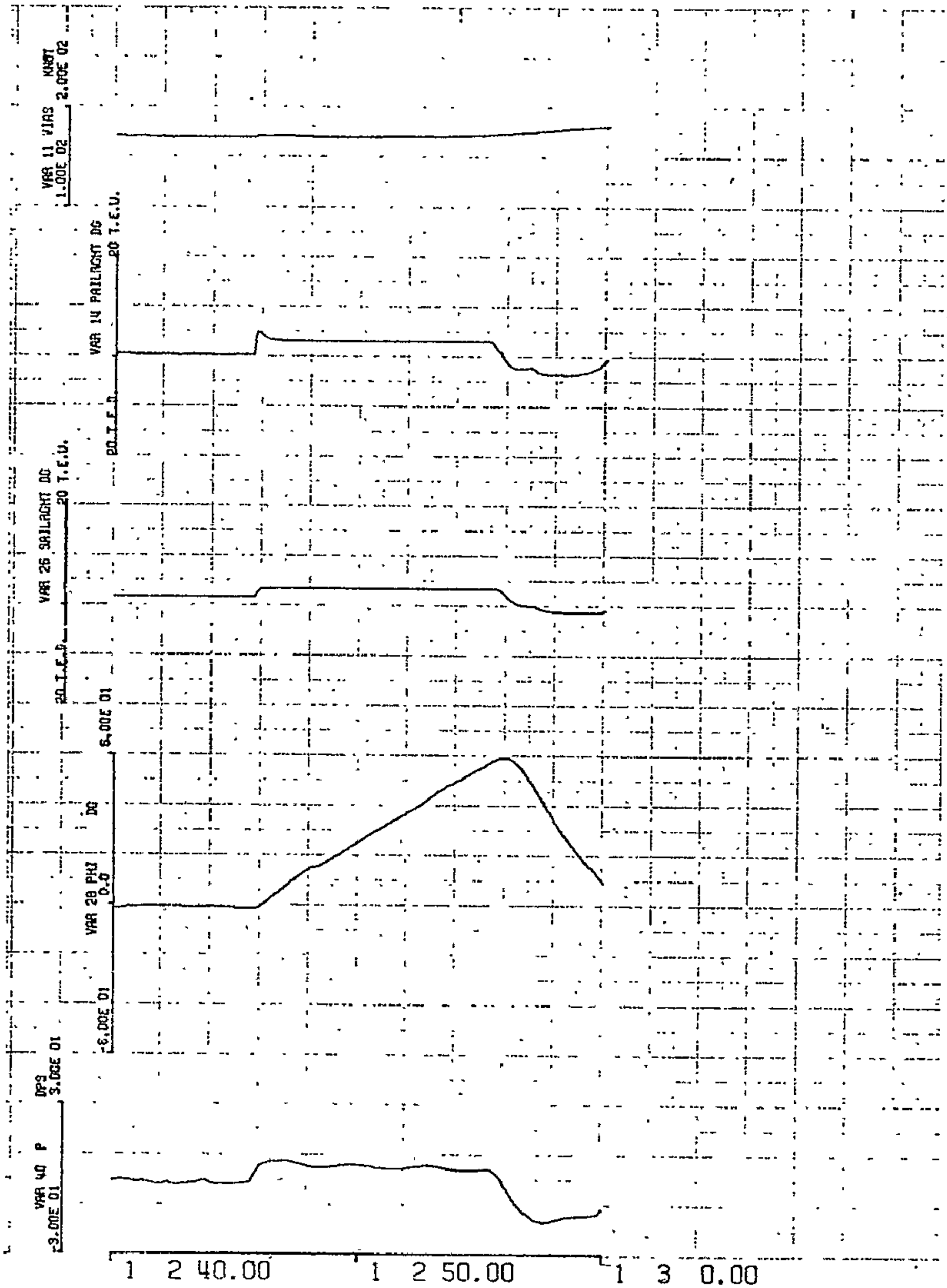



FIGURE 8.1 Basic Model 99 (Slave Mode) Roll Response Due to a Step Aileron Input

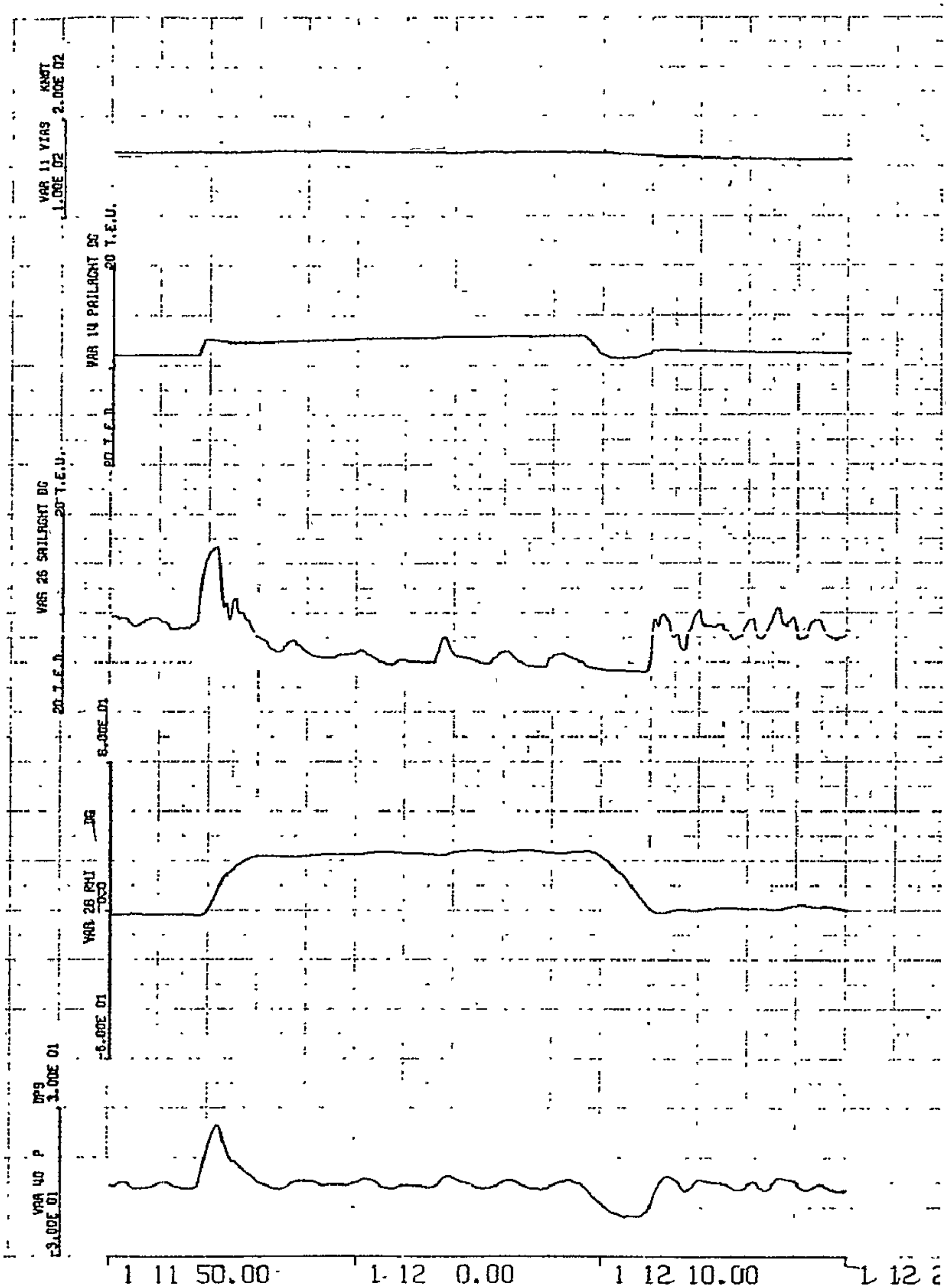



FIGURE 8.2 SSSA Model 99 (Command Mode) Roll Response Due to a Step Aileron Input

slave mode, and as an attitude command system in the command mode. Also, in the command mode the bank angle overshoot is not measurable and the settling time is a function of separate surface aileron saturation as discussed in section 7.2.3. The reader is reminded that the variables plotted by Boeing are labeled with their parameter identification names and can be translated using Table 4.1.

## 8.3 Pitch Axis Response

The responses of the basic Model 99 (slave mode) and the SSSA Model 99 (command mode) to step elevator inputs in the approach and cruise configurations are given in Appendix B, section 1. Sample pitch responses are given in Figures 8.3 and 8.4. Once again notice the attitude command performance of the SSSA Model 99 (command mode).

## 8.4 Dynamic Responses

Time history responses for the phugoid, short period and dutch roll modes of motion are given in Appendix B, section 2. The tests were run on the basic Model 99 (slave mode) and the attitude command Model 99 (command mode). The short period test was performed in the approach configuration only. The phugoid and dutch roll tests were performed in both the approach and cruise configurations. The phugoid response was initiated by an elevator deflection with the aircraft trimmed at the specified configuration. The elevator deflection was held until the airspeed decreased 10 knots and then released. The aircraft response was then recorded with no further pilot inputs. The short period response was generated by an elevator doublet with the aircraft trimmed at the specified configuration. The dutch roll response was generated by a rudder doublet with the aircraft trimmed at the specified configuration.

Tables 8.1 and 8.2 are given to summarize the dynamic responses of the various modes of motion of the basic and SSSA model 99 by giving their damping ratios and undamped natural frequencies. These values were calculated using the subsidence ratio method described in Reference 13.

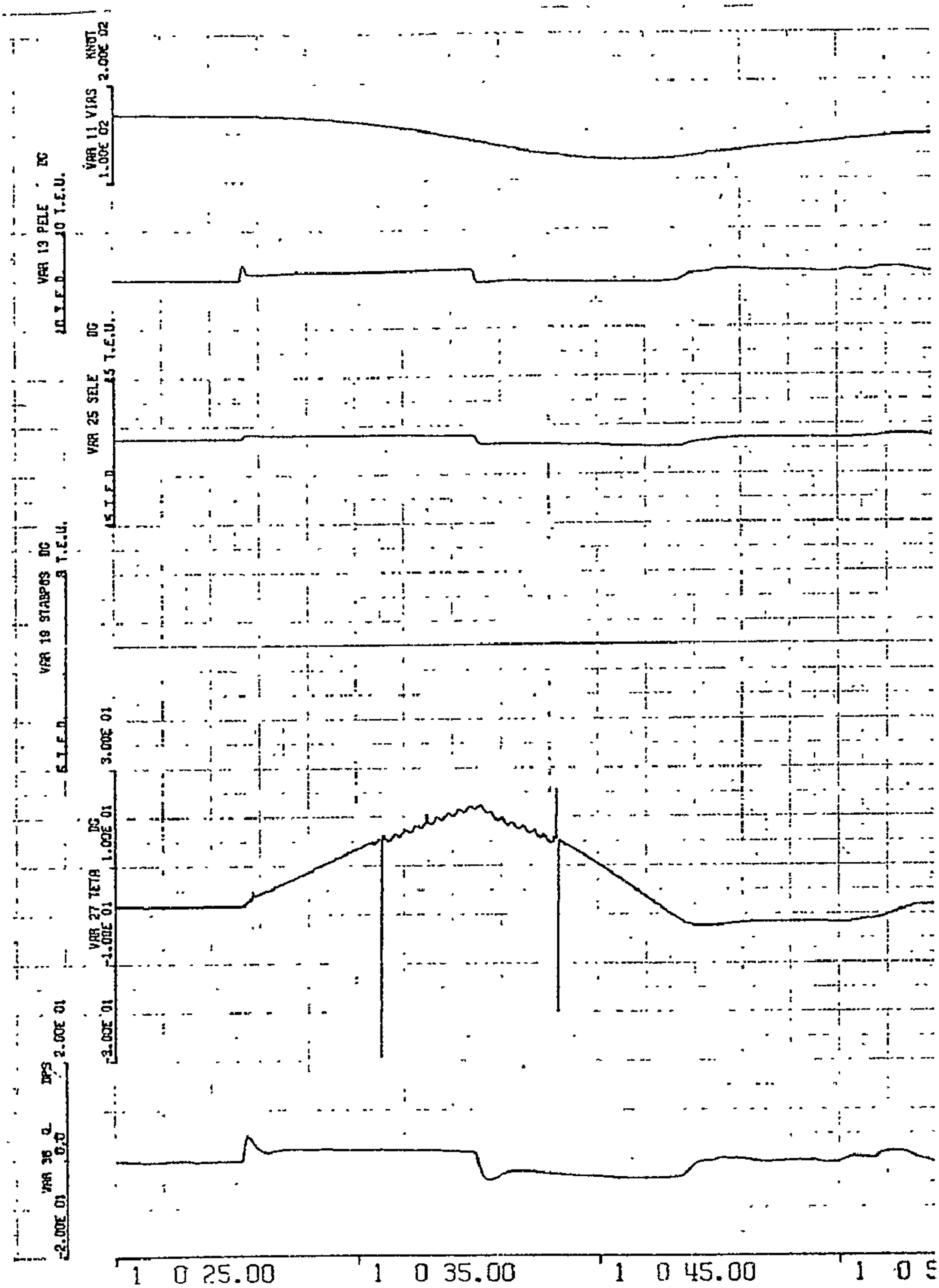



FIGURE 8.3 Basic Model 99 (Slave Mode) Pitch Response Due to a Step Elevator Input

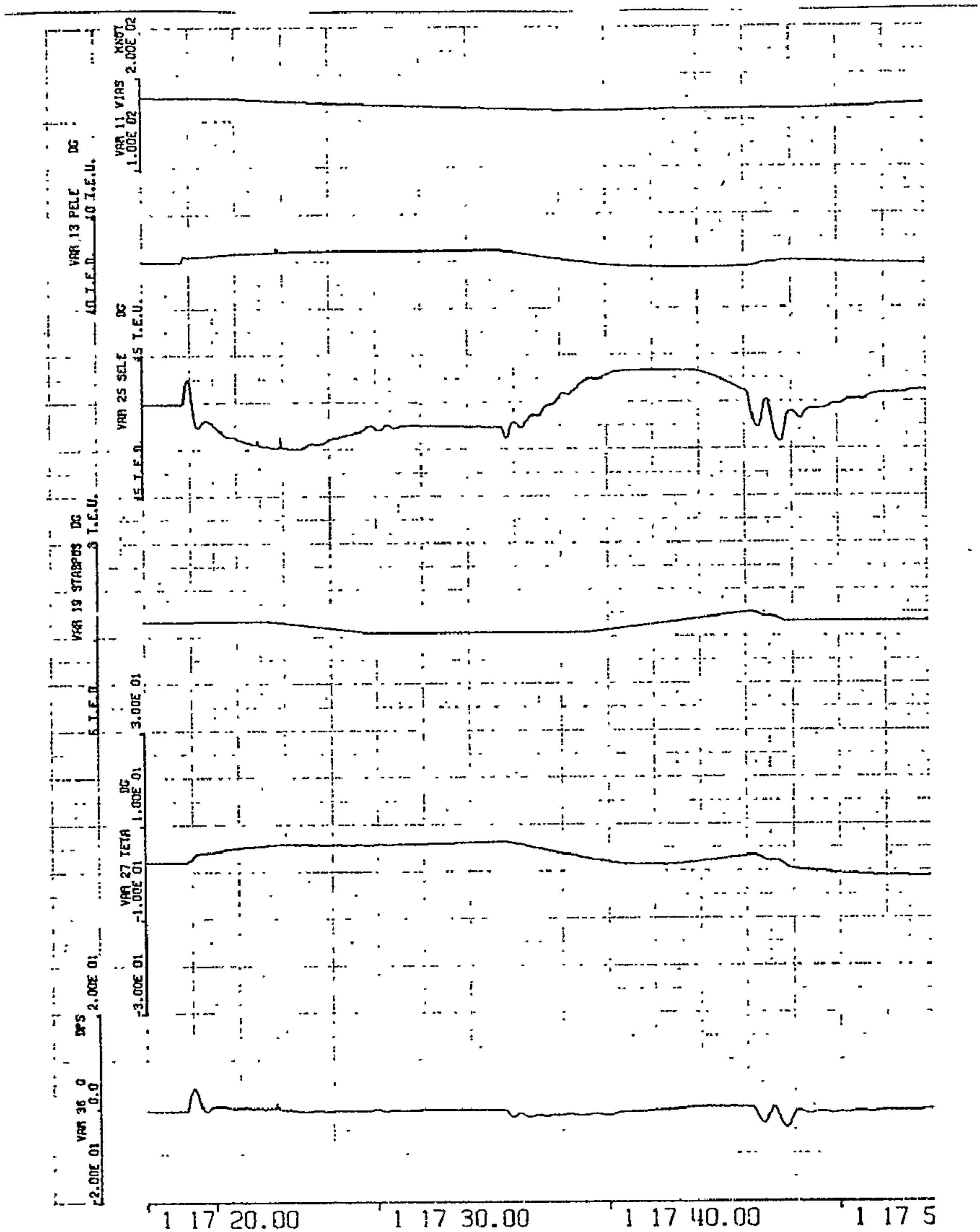



FIGURE 8.4 SSSA Model 99 (Command Mode) Pitch Response Due to a Step Elevator Input

The command mode phugoid responses and the short period responses were difficult to analyze due to the high damping and therefore should be considered approximate values. The short period response in cruise was not available. The important thing to notice from Tables 8.1 and 8.2 is the improved phugoid and dutch roll damping in the attitude command mode.

## 8.5 Static Longitudinal Stability

The static longitudinal stability of the basic Model 99 (slave mode) and SSSA Model 99 (command mode) was determined for both the approach and cruise configurations. The test was performed by changing the airspeed from the specified trimmed conditions with an elevator input, and then measuring the stick force required to maintain the new airspeed. The results of these tests with the primary elevator gain at $K_{\delta_{EP}} = 28$ deg/deg are given in Figures 8.5 and 8.6. The effect of varying $K_{\delta_{EP}}$ is shown in Figure 8.7. This figure shows that the static longitudinal stability can be adjusted as a function of $K_{\delta_{EP}}$, independent of aircraft center of gravity.

Table 8.1 Dynamic Responses in the Approach Configuration at 635 kg (1400 lb) Fuel

| Response | SSSA Mode | Damping Ratio | Undamped Natural Frequency |
|---|---|---|---|
| Phugoid | Slave | .14 | .176 |
| | Command | .54 | .480 |
| Short Period | Slave | .54 | 1.58 |
| | Command | .63 | 2.24 |
| Dutch Roll | Slave | .15 | 1.60 |
| | Command | .31 | 2.76 |

Table 8.2 Dynamic Responses in the Cruise Configuration at 635 kg (1400 lb) Fuel

| Response | SSSA Mode | Damping Ratio | Undamped Natural Frequency |
|---|---|---|---|
| Phugoid | Slave | .16 | .127 |
| | Command | .50 | .260 |
| Short Period | Slave | Not Available | |
| | Command | | |
| Dutch Roll | Slave | .08 | 2.36 |
| | Command | .30 | 2.36 |

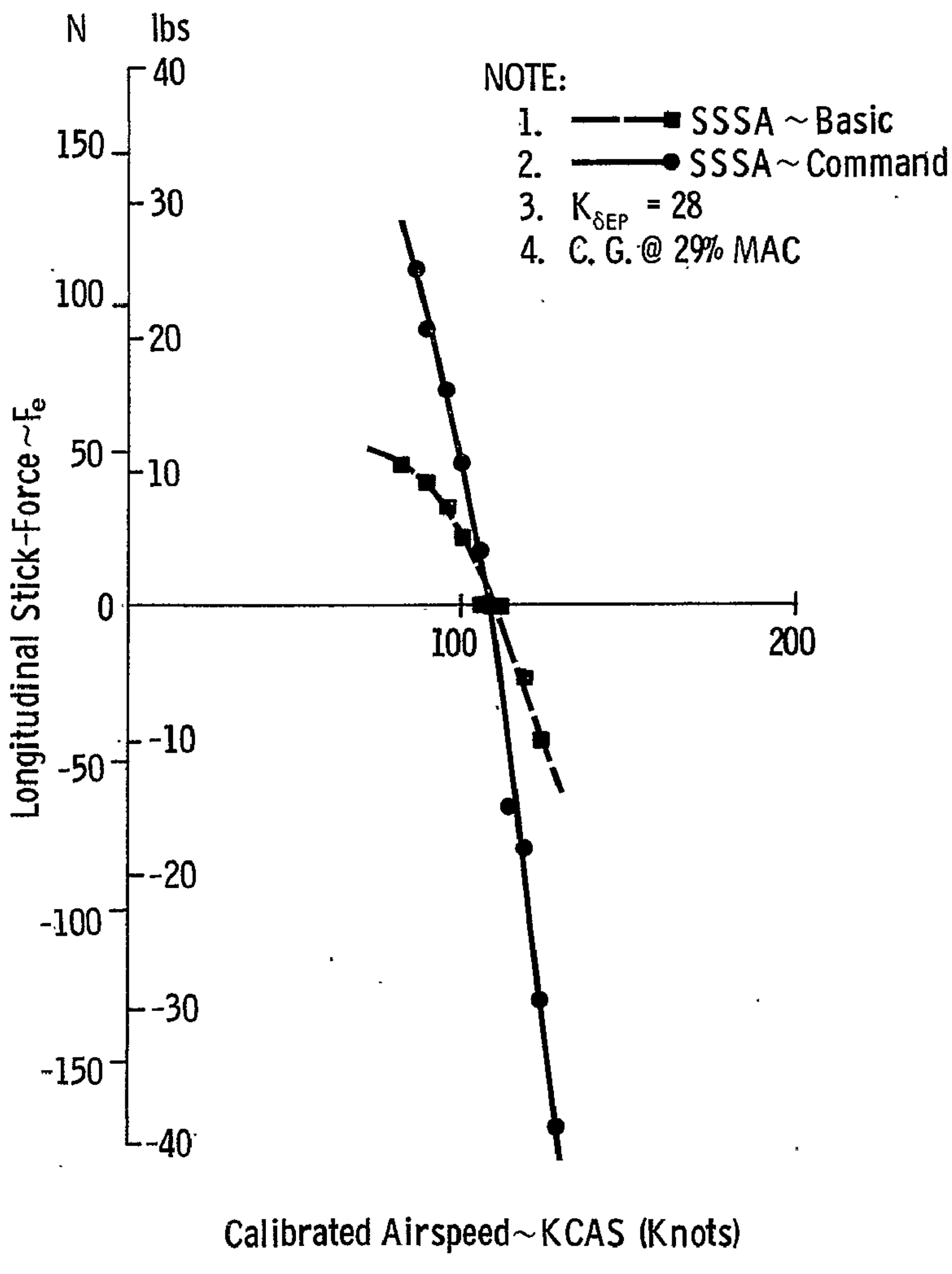



FIGURE 8.5 SSSA Model 99 Static Longitudinal Stability in the Approach Configuration

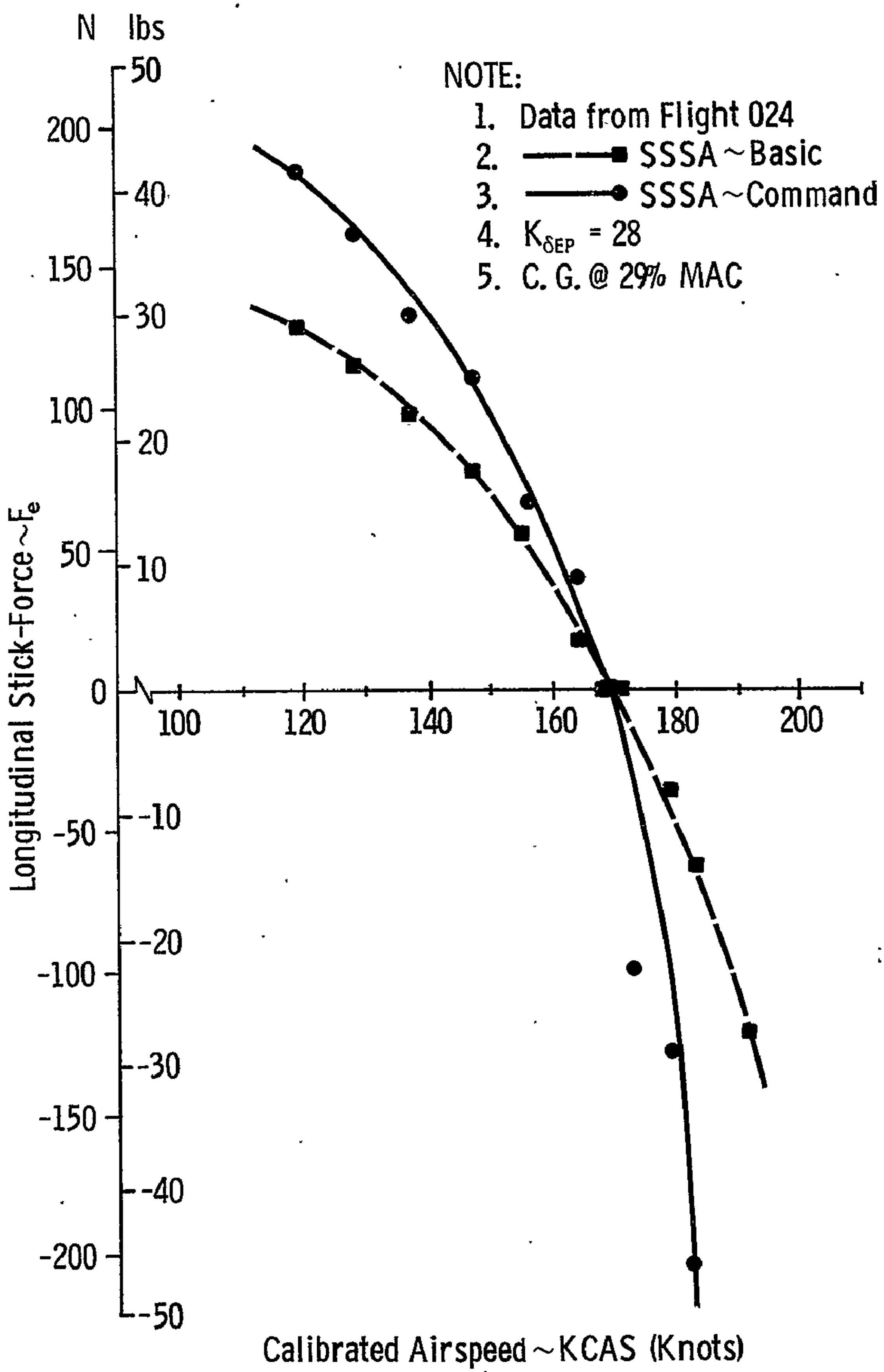



FIGURE 8.6 SSSA Model 99 Static Longitudinal Stability in the Cruise Configuration

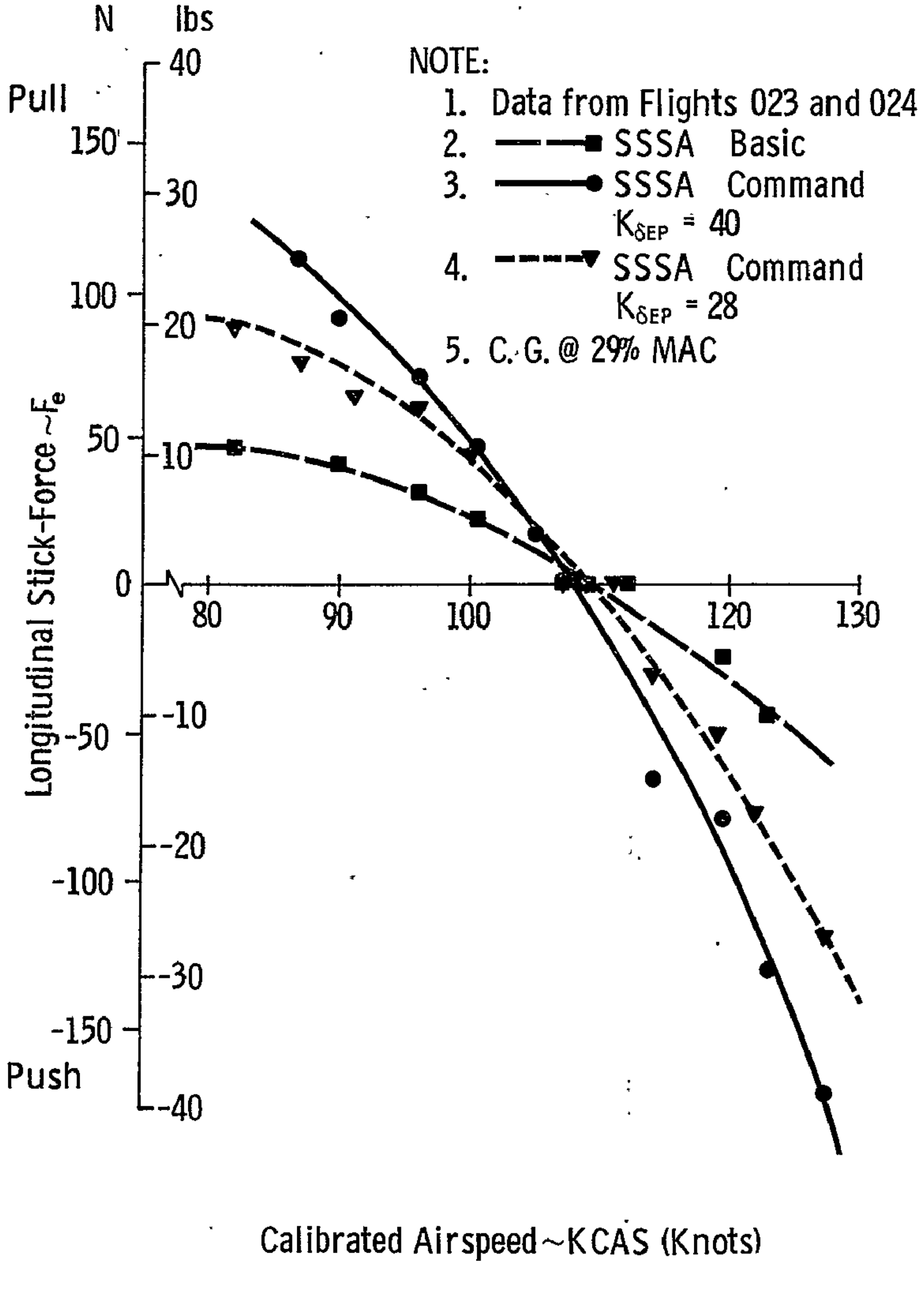



FIGURE 8.7 SSSA Model 99 Static Longitudinal Stability as a Function of $K_{\delta EP}$ in the Approach Configuration

CHAPTER 9

# SSSA MODEL 99 QUALITATIVE EVALUATION

## 9.1 Introduction

The qualitative evaluation phase of the flight test program was performed to determine whether the handling and ride qualities of the Beech Model 99 were improved by implementation of the SSSA attitude command control system. The primary objective of the evaluation program was to generate subjective pilot opinions of the handling and ride qualities of the Model 99 while performing a simulated IFR (instrument flight rules) mission. The mission was designed to test the operational characteristics of the aircraft and pilot and is described in Figure 5.2 and Table 5.2.

Prior to the evaluation flights the primary evaluation pilots attended an "Evaluation Pilot Seminar". This seminar accomplished the following objectives:

1. Described the philosophy of qualitative flight evaluations and specifically described the Cooper-Harper pilot rating scale and its usage.
2. Described the attitude command control theory and how it was implemented on the Model 99 using SSSA.
3. Described the evaluation profile and the purpose of each task.

Following the seminar each evaluation pilot flew a 1 to 1.5 hour familiarization flight to acquaint himself with the Model 99 characteristics and the evaluation profile. After the familiarization flight, each evaluation pilot flew the qualitative flight profile in the basic Model 99 (slave mode) and gave a Cooper-Harper pilot rating; then each pilot flew the same profile in the SSSA Model 99 (command mode) and gave another Cooper-Harper pilot rating. The second profile was flown immediately after the first to allow as nearly identical atmospheric conditions as possible. The two Cooper-Harper ratings were then used as a relative measure of aircraft handling qualities. In addition, all parameters described in Chapter 4 were recorded and analyzed as a quantitative measure of pilot performance and aircraft handling and ride qualities.

## 9.2 Evaluation Pilot Experience Summary

Three primary evaluation pilots and three NASA evaluation pilots participated in the program. The three primary evaluation pilots' resumes are given in Table 9.1. None of these pilots had any previous experience with the Beech Model 99, or the attitude command control system.

The three NASA pilots' resumes are given in Table 9.2. None of these pilots had previous experience in the Model 99; however, two of the pilots had flown the NASA PA-30 attitude command system extensively and the third was very familiar with attitude command.

## 9.3 Qualitative Evaluation Results

The SSSA Model 99 handling and ride qualities are a function of the atmospheric turbulence level. The six evaluation pilots flew a total of eight flights at various turbulence levels. Each evaluation pilot was asked to give his opinion of the turbulence level during the flight. Figure 9.1 relates the pilots' subjective measure of turbulence to the actual turbulence level recorded by the TIMS system.

9.3.1 Pilot Rating Summary. Figure 9.2 shows the relationship between Cooper-Harper pilot rating and RMS turbulence level for the basic Model 99 (slave mode) and the SSSA Model 99 (command mode). Figure 9.3 shows that the pilot rating in the attitude command mode was improved by an average 1.12 pilot rating points. Figure 9.4 shows a least squares curve fit to the data points.

9.3.2 Summary of Pilot Comments. After each evaluation flight, the pilots were debriefed on the performance of the aircraft in both slave and command modes. The transcripts of the entire pilot debriefings are included as Appendix C. Some specific comments related to the handling and ride qualities are included in Tables 9.3 and 9.4, respectively.

Table 9.1. Qualitative Evaluation Pilot Experience Summary

| Pilot Number | Affiliation | Ratings | Total Time | Total Light Twin Time | Total Instr. Time |
|---|---|---|---|---|---|
| 1 | Beech | Comm, ASMEL INSTR | 2300 | 430 | 300 |
| 2 | Beech | Comm, ASMEL INSTR | 4000 | 1500 | --- |
| 3 | Beech | Comm, ASMEL INSTR, ATR | 3600 | 1900 | 600 |

NOTE: A - Air
S - Single engine
ME - Multi-engine
L - Land
INSTR - Instrument rating
ATR - Airline transport rating

Table 9.2. NASA Evaluation Pilot Experience Summary

| Number | Affiliation | Ratings | Total Time | Total Light Twin Time | Total Instr. Time |
|---|---|---|---|---|---|
| 4 | NASA | Comm, ASMEL INSTR | 2800 | 175 | 370 |
| 5 | NASA | Comm, ASMEL INSTR | 6000 | 600 | --- |
| 6 | NASA | Comm, ASMEL INSTR | 6000 | 700 | --- |

NOTE: A - Air
S - Single engine
ME - Multi-engine
L - Land
INSTR - Instrument rating

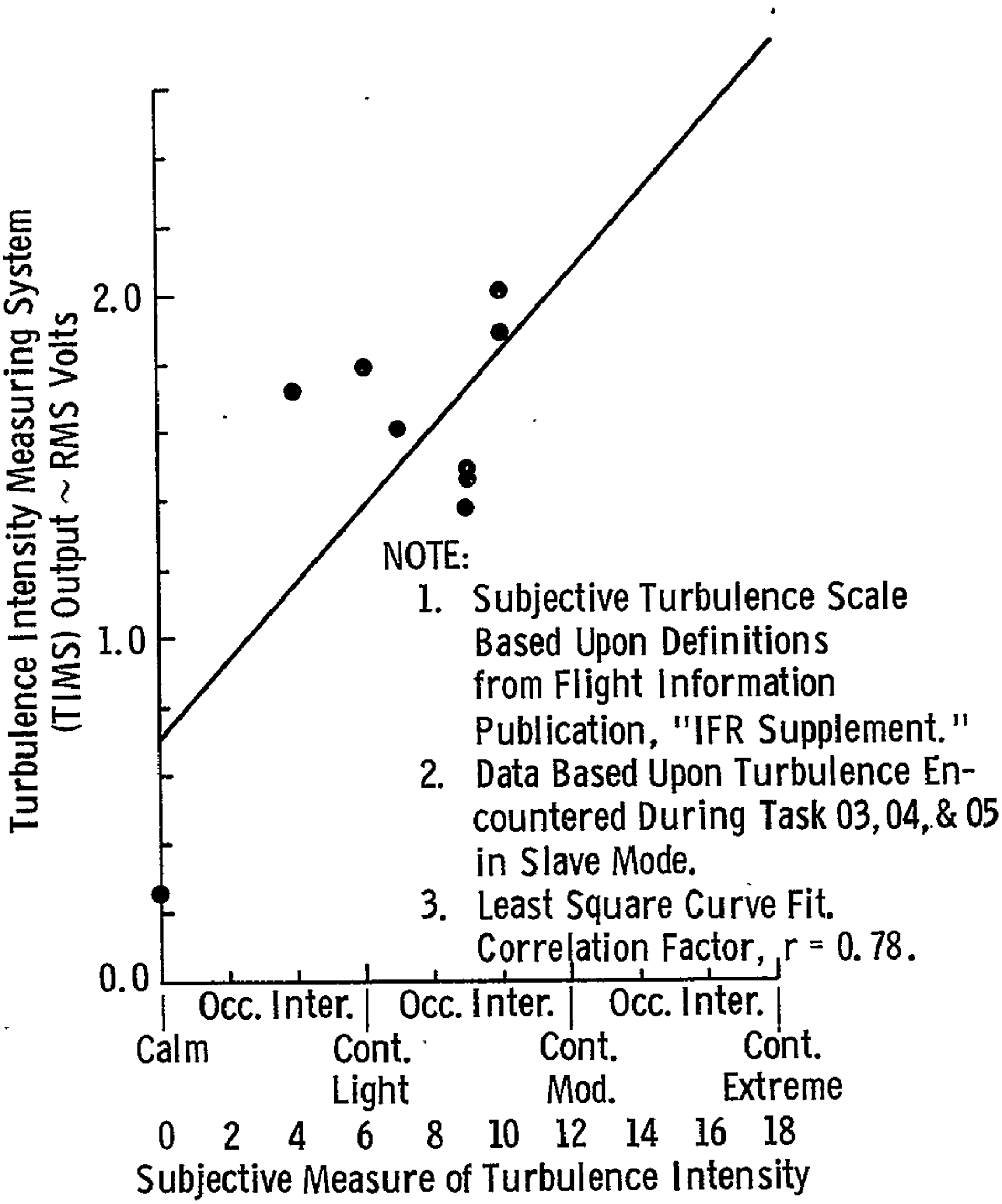



FIGURE 9.1 Relationship of the Pilots' Subjective Measure of Turbulence to the TIMS Output

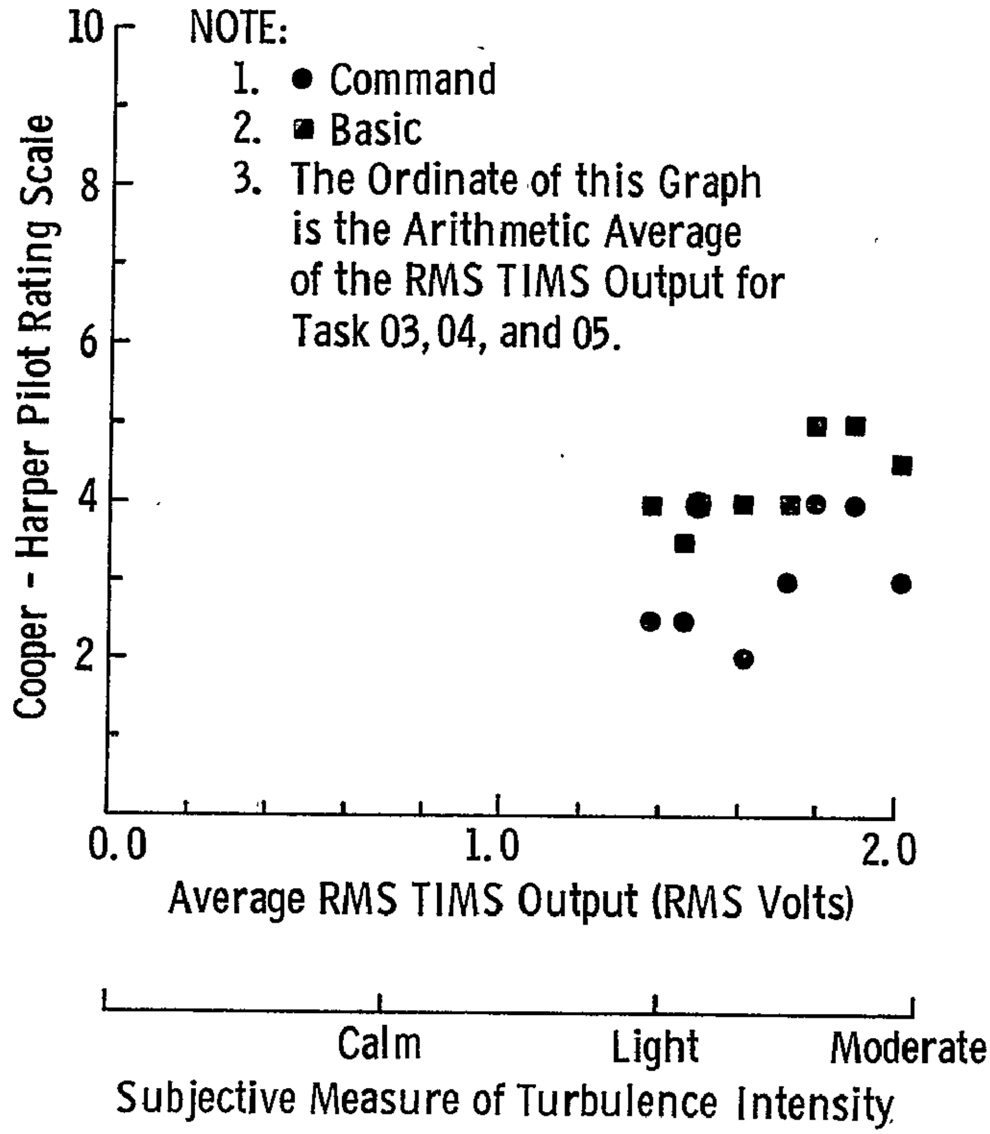



FIGURE 9.2 Cooper-Harper Pilot Rating as a Function of Average RMS TIMS Output

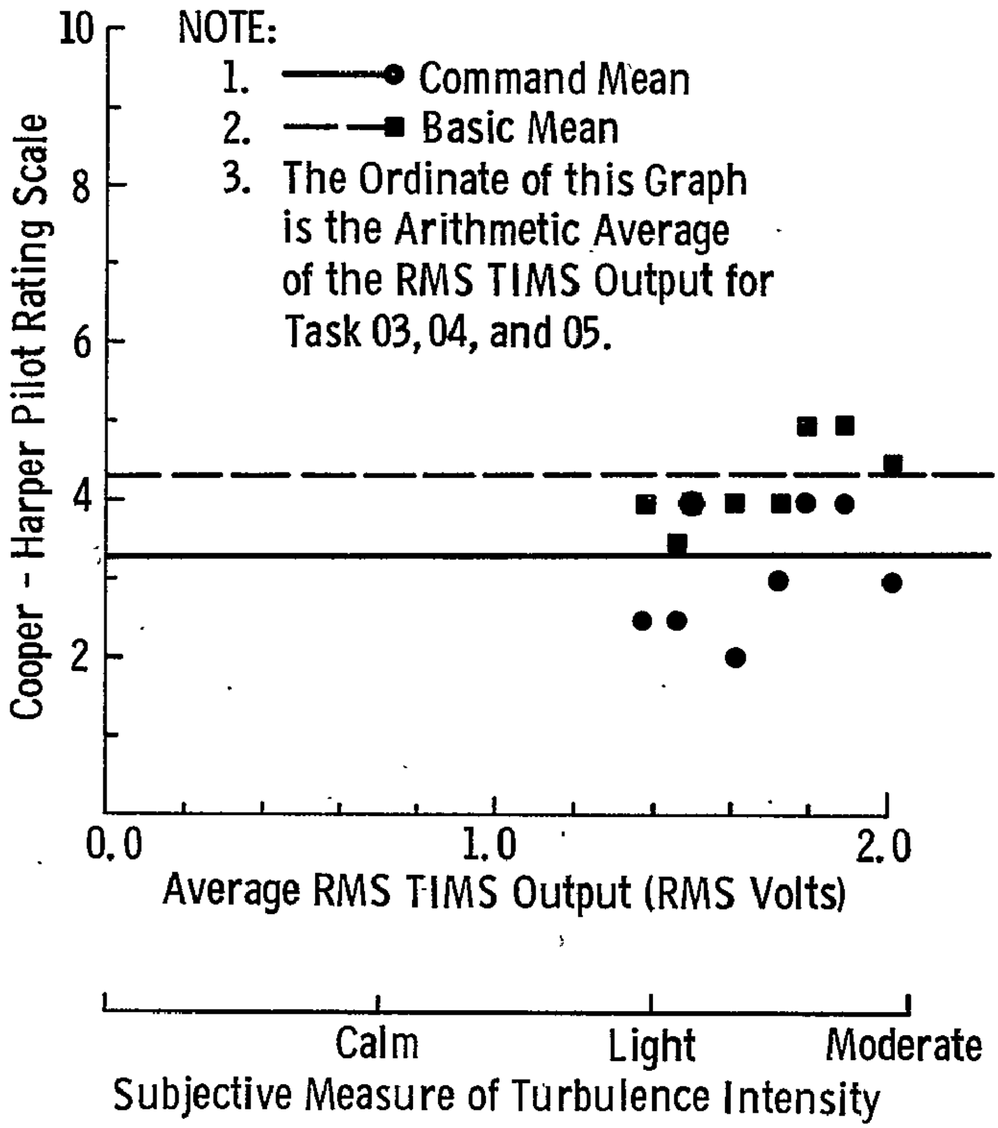



FIGURE 9.3 Average Cooper-Harper Pilot Rating as a Function of Average RMS TIMS Output

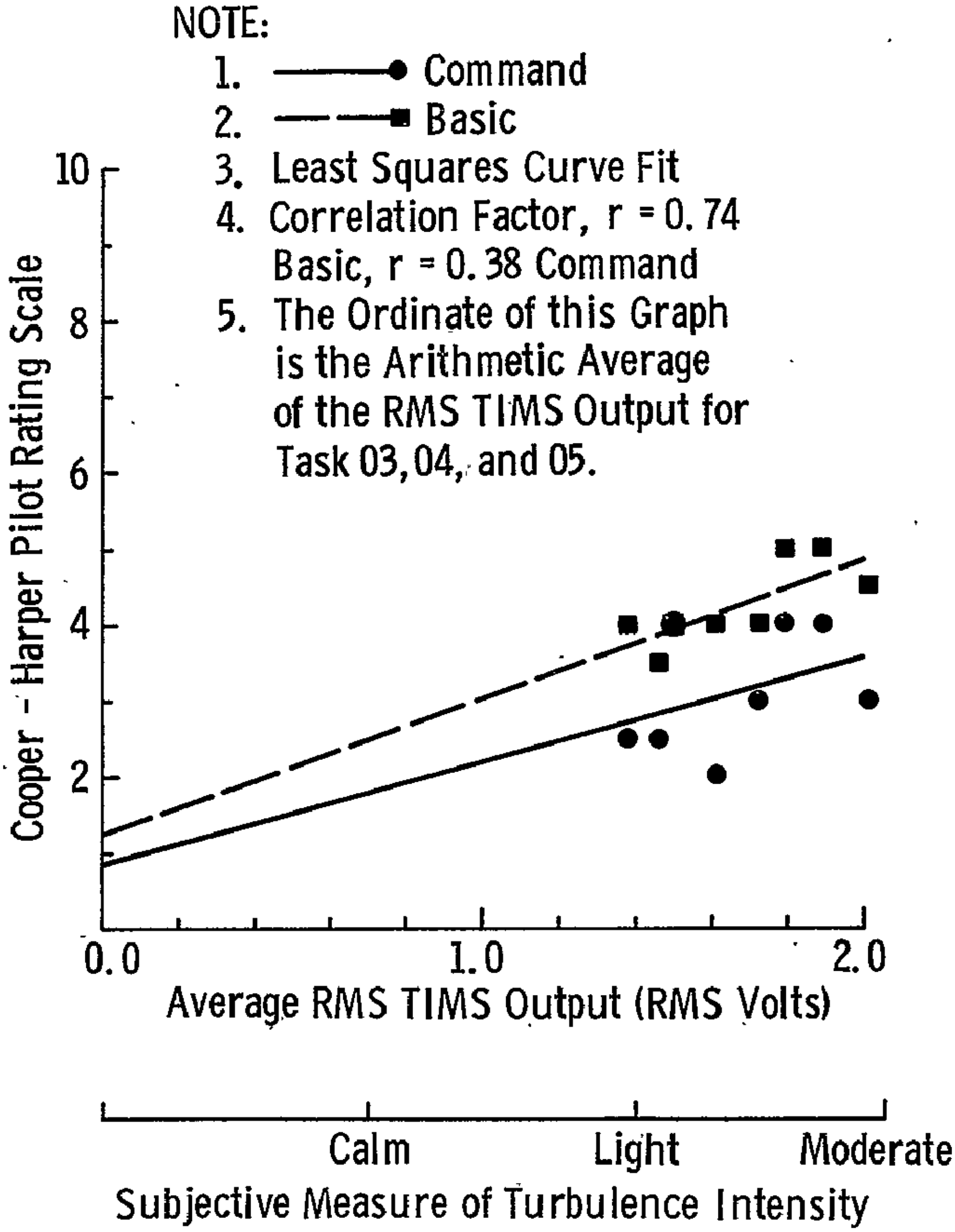



FIGURE 9.4 Least Squares Curve Fit to the Cooper-Harper Pilot Rating Scale as a Function of RMS TIMS Output

Table 9.3 Handling Qualities Comments

Pitch attitude command:

I liked the decoupling effect of being able to control the glide slope and the rate of descent with the pilot trim and the speed with power.

Glide slope was more positive with the system on.

Pitch attitude command is probably the biggest improvement that I see in that the attitude tends to be locked in.

Not much change in the pitch axis except for the gear and flap transients.

Missed approach much easier, aircraft well controlled.

When the go-around was executed, I was forced to establish a climb attitude. The basic aircraft would naturally pitch up with acceleration.

Roll attitude command:

The workload is much lower, especially in the roll axis; I felt much more confident of my ability to perform the mission.

The localizer was easier to maintain.

Heading hold:

The basic aircraft wallows around. It is difficult to hold heading. The aileron forces are high. When you turn your system on, it relieves the pilot workload, particularly when maintaining heading in turbulence. If turbulence knocks you off (the heading), the system brings you back to it.

Initially I was fighting the heading hold system; I wasn't turning loose and letting it settle down. I found out later if I flew almost hands off, heading hold was pretty good.

Table 9.4 Ride Quality Comments With Attitude Command System On

In all the axes, as soon as you turn the attitude command on it seems as if the turbulence decreases by half.

The ride is much smoother.

The airplane seems as if it is on a rail or track.

In summary, the pilots were favorably impressed with the elimination of control force transients that accompanied configuration changes. They also felt that their workload was greatly reduced for precision maneuvers such as glideslope and localizer tracking and heading hold. In general, the pilots felt more confident of their abilities to perform the IFR task in command mode. Most pilots felt that the ride qualities and turbulence response of the aircraft were improved by the attitude command system. Finally, the pilots did not like the necessity of holding aileron forces in turns.

## 9.4 Qualitative Flight Test Data Summary

The parameters described in Chapter 4 were recorded and analyzed for each evaluation flight in an attempt to support the subjective opinions of the evaluation pilots. A sample set of time-histories and statistical calculations for flight number 36 is given in Appendix D. Time-histories and statistical calculations for all evaluation flights are on file at KU-FRL.

The following sections summarize the pilot performance, pilot workload, and aircraft ride qualities during the evaluation flight profile. Care should be taken in drawing strong conclusions from these data. The following points should be considered when reviewing the statistical data summaries:

1. This program had a very limited number of data points which makes it difficult to make valid statistical calculations.
2. The evaluation profile was developed to generate qualitative or subjective pilot opinions, not quantitative data.

The data presented in this section is represented in three formats:

1. Data points with no curve;
2. Mean representation of the data points; and
3. Least squares curve fit with assumed data points at the origin.

The slope of the least squares curve fit line is strongly affected by the lack of data at low turbulence levels. Therefore, a data point at the origin was assumed in several cases and this assumption is noted and explained in the appropriate section.

9.4.1 Pilot Performance Summary. Three parameters were chosen to summarize pilot performance; heading deviation during the precision heading task, and glideslope and localizer deviation during the ILS approach. Figure 9.5 shows the standard deviation of aircraft heading as a function of RMS turbulence level during the precision heading maneuver. Figure 9.6 shows that the average heading deviation of the basic Model 99 (slave mode) and the SSSA Model 99 (command mode) was the same. Figure 9.7 shows a least squares curve fit to the data points with an additional point assumed at the origin. This assumption means that in the hypothetical case of no turbulence, or absolutely calm air, the aircraft will hold heading perfectly.

Figures 9.8 and 9.9 show the RMS localizer and glideslope signals as a function RMS turbulence level during the ILS approach. Figures 9.10 and 9.11 show that the average RMS localizer deviation was slightly higher in the SSSA Model 99 (command mode) but that the average RMS glideslope deviation was slightly less. Figures 9.12 and 9.13 show that least squares curves fit to the RMS localizer and glideslope signals as a function of RMS turbulence level. Points at the origin were assumed; the assumption means that in the hypothetical case of no turbulence, the pilot can fly a perfect ILS intercept.

The data contained in Figures 9.5 through 9.13 indicate that for the tasks selected the pilots' performances were not significantly improved by SSSA attitude command. However, the pilot's subjective opinions were that their performance was improved.

9.4.2 Pilot Workload Summary. Three parameters were chosen to summarize pilot workload: primary aileron activity during the precision heading task, and primary aileron and elevator activity during the ILS approach. Figure 9.14 shows the standard deviation of primary right aileron position as a function of RMS turbulence level for the precision heading maneuver. Standard deviation was chosen to represent workload so that any constant aileron deflection required to maintain wings level

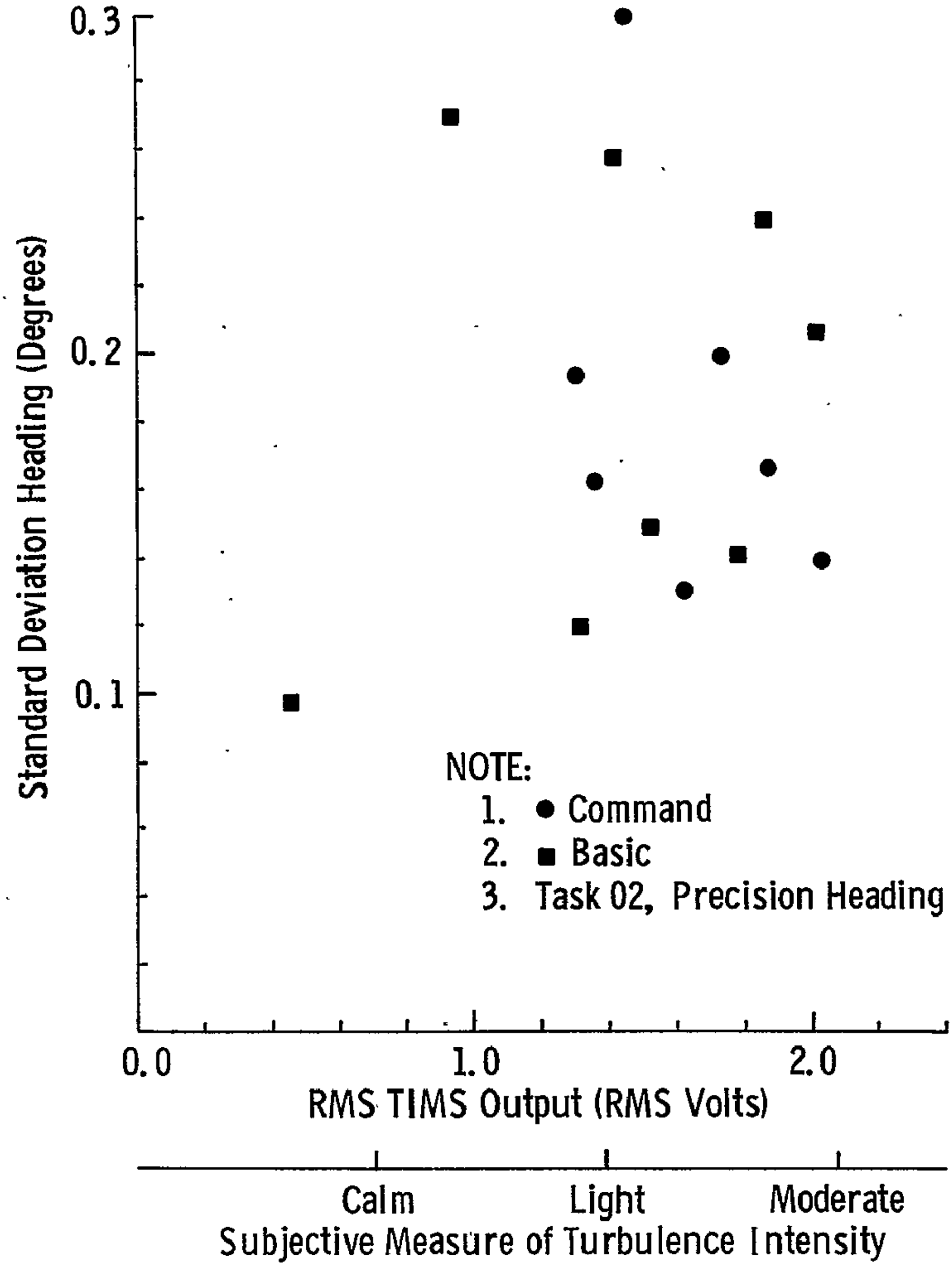



FIGURE 9.5 Standard Deviation of SSSA Model 99 Heading as a Function of RMS TIMS Output for the Precision Heading Task

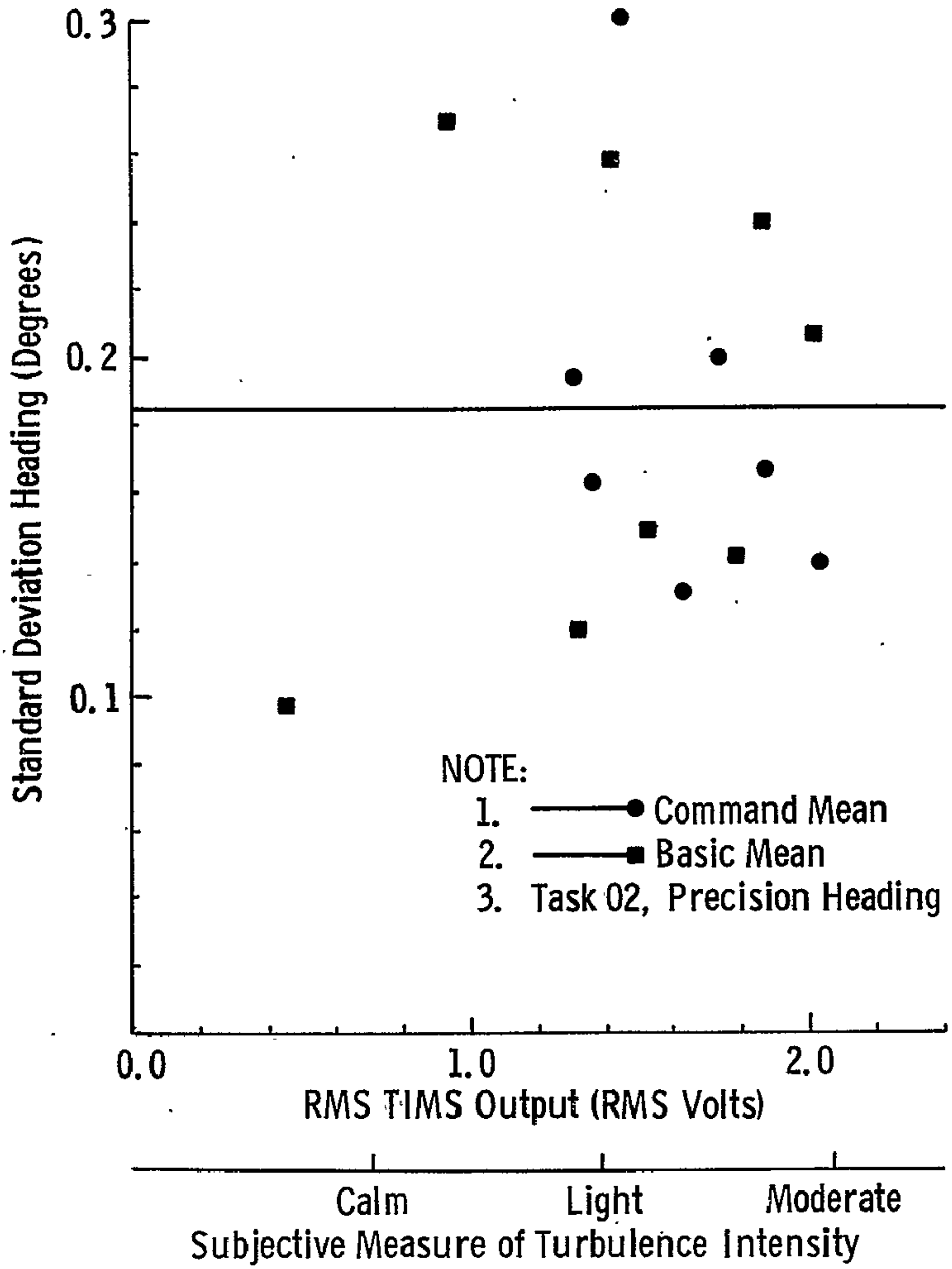



FIGURE 9.6 Average Standard Deviation of SSSA Model 99 Heading as a Function of RMS TIMS Output for the Precision Heading Task

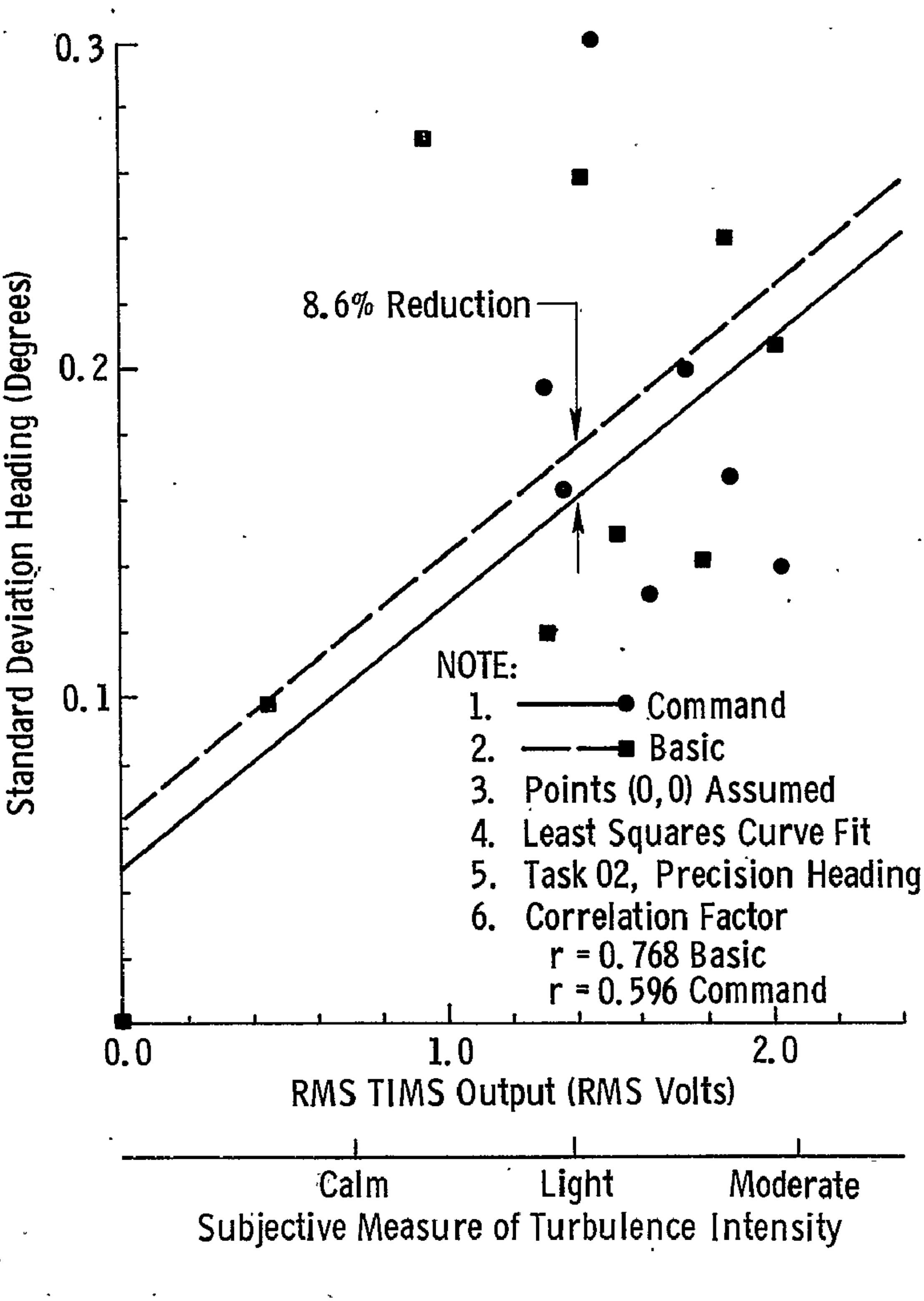



FIGURE 9.7 Least Squares Curve Fit to the Standard Deviation of SSSA Model 99 Heading as a Function of RMS TIMS Output for the Precision Heading Task

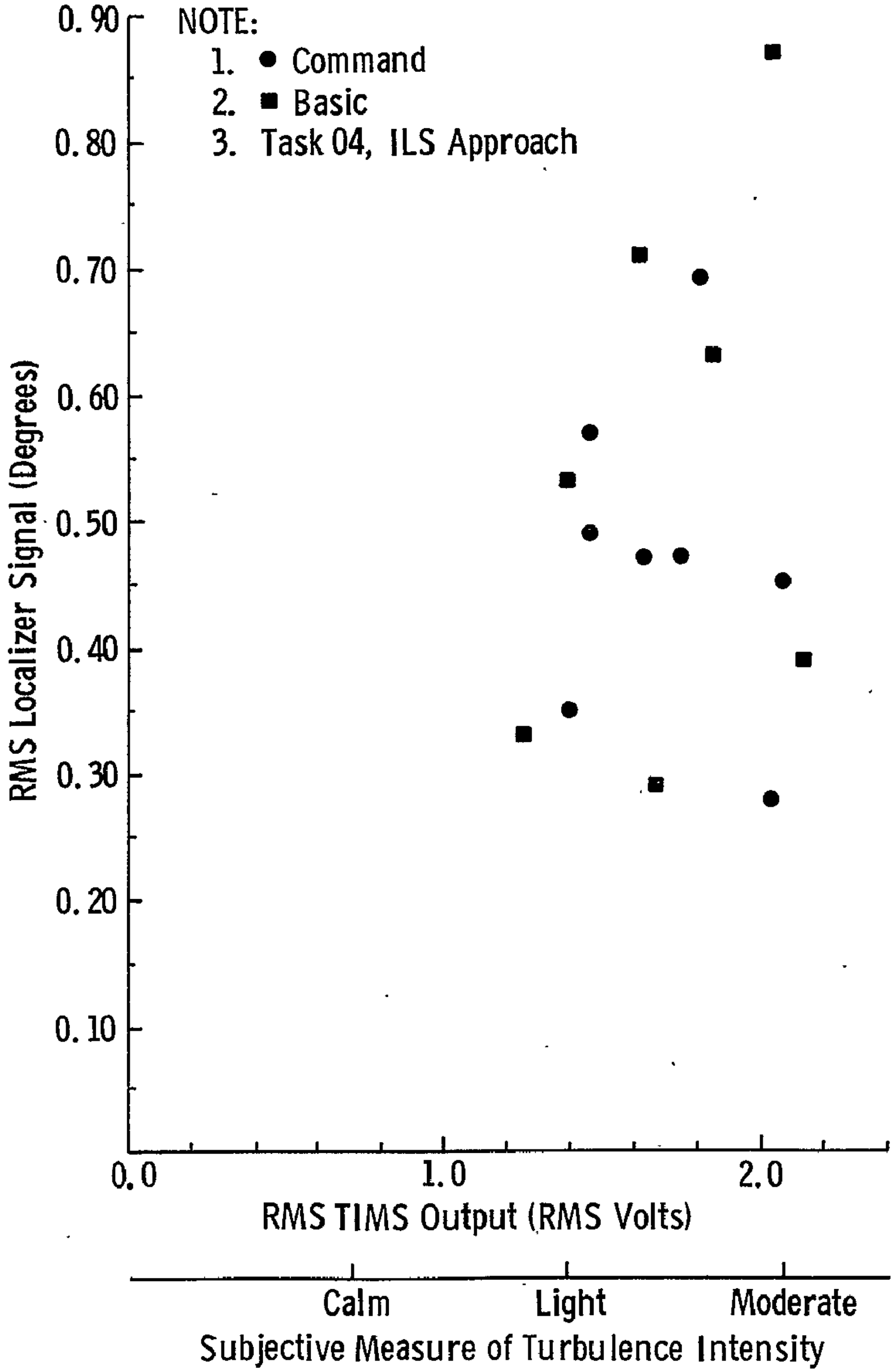



FIGURE 9.8 RMS Localizer Signal as a Function of RMS TIMS Output

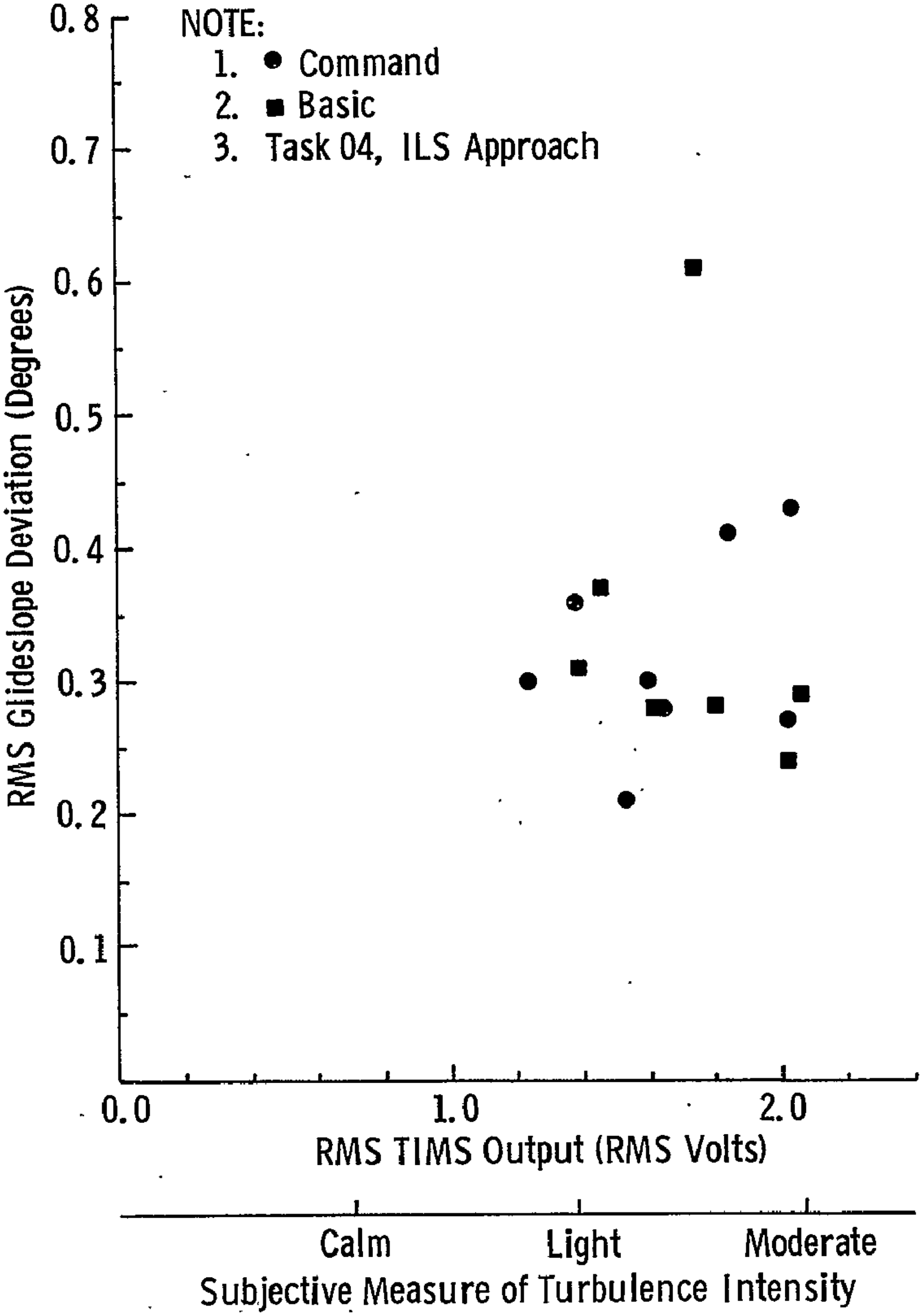



FIGURE 9.9 RMS Glideslope Signal as a Function of RMS TIMS Output

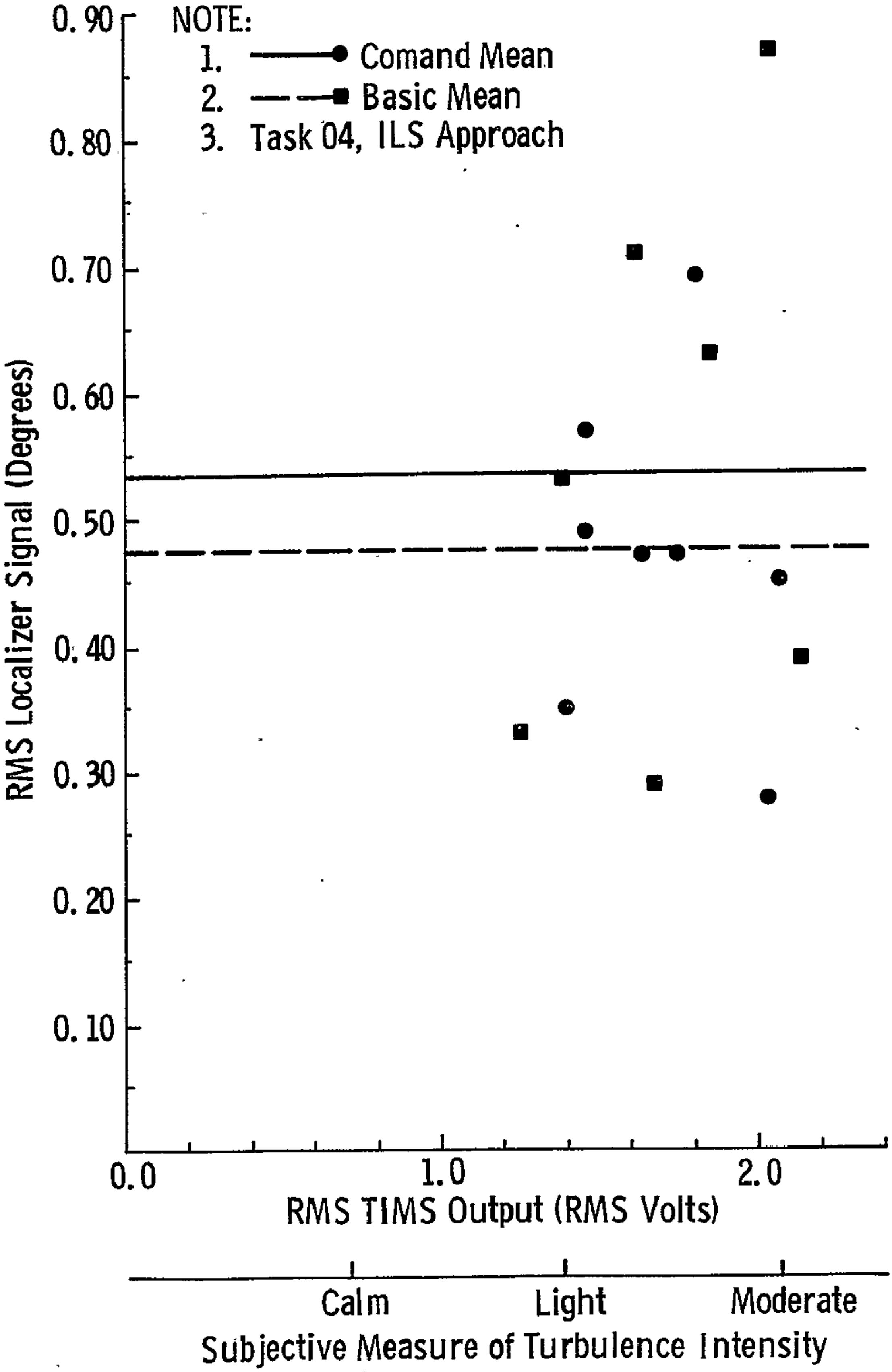



FIGURE 9.10 Average RMS Localizer Signal as a Function of RMS TIMS Output

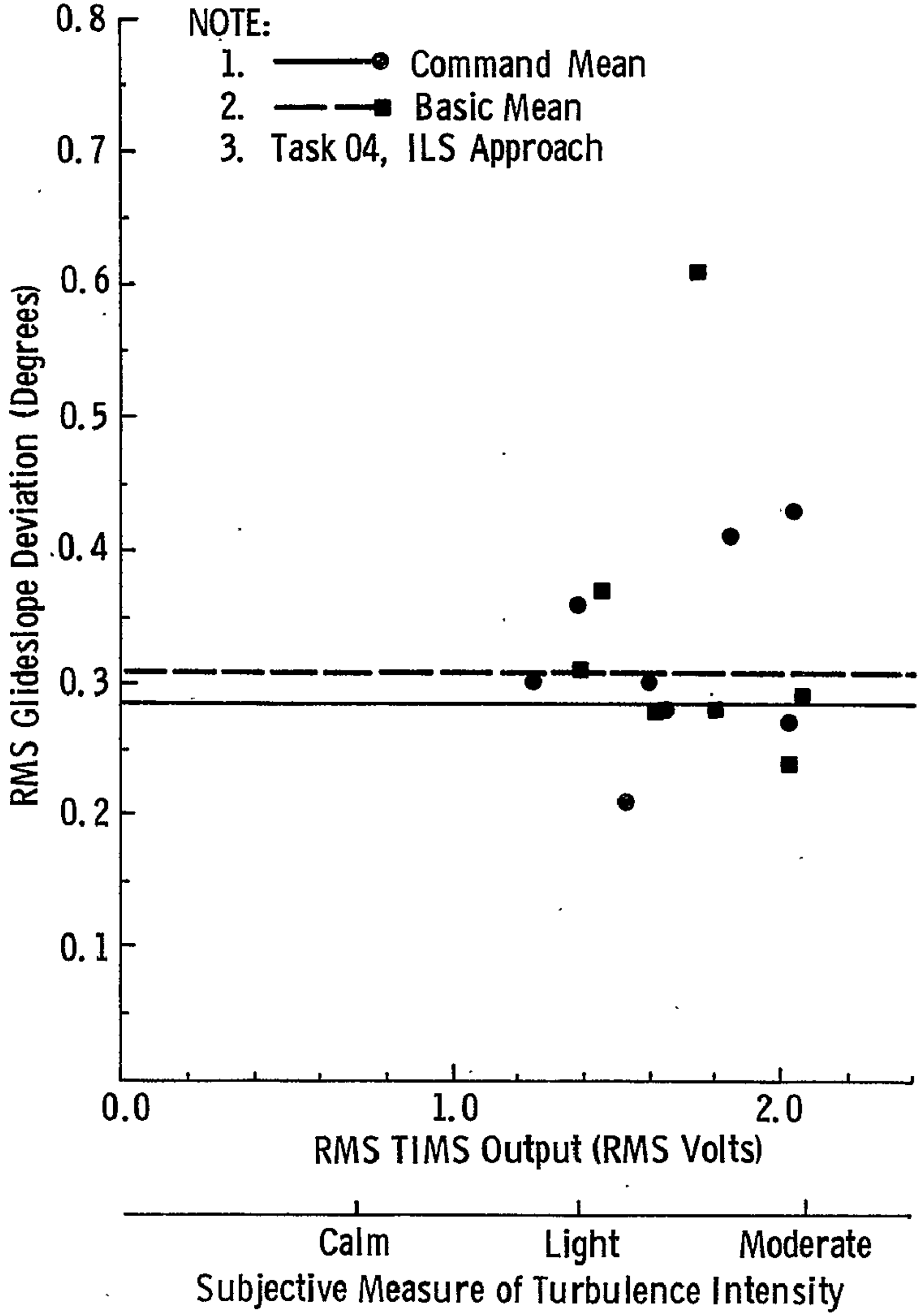



FIGURE 9.11 Average RMS Glideslope Signal as a Function of RMS TIMS Output

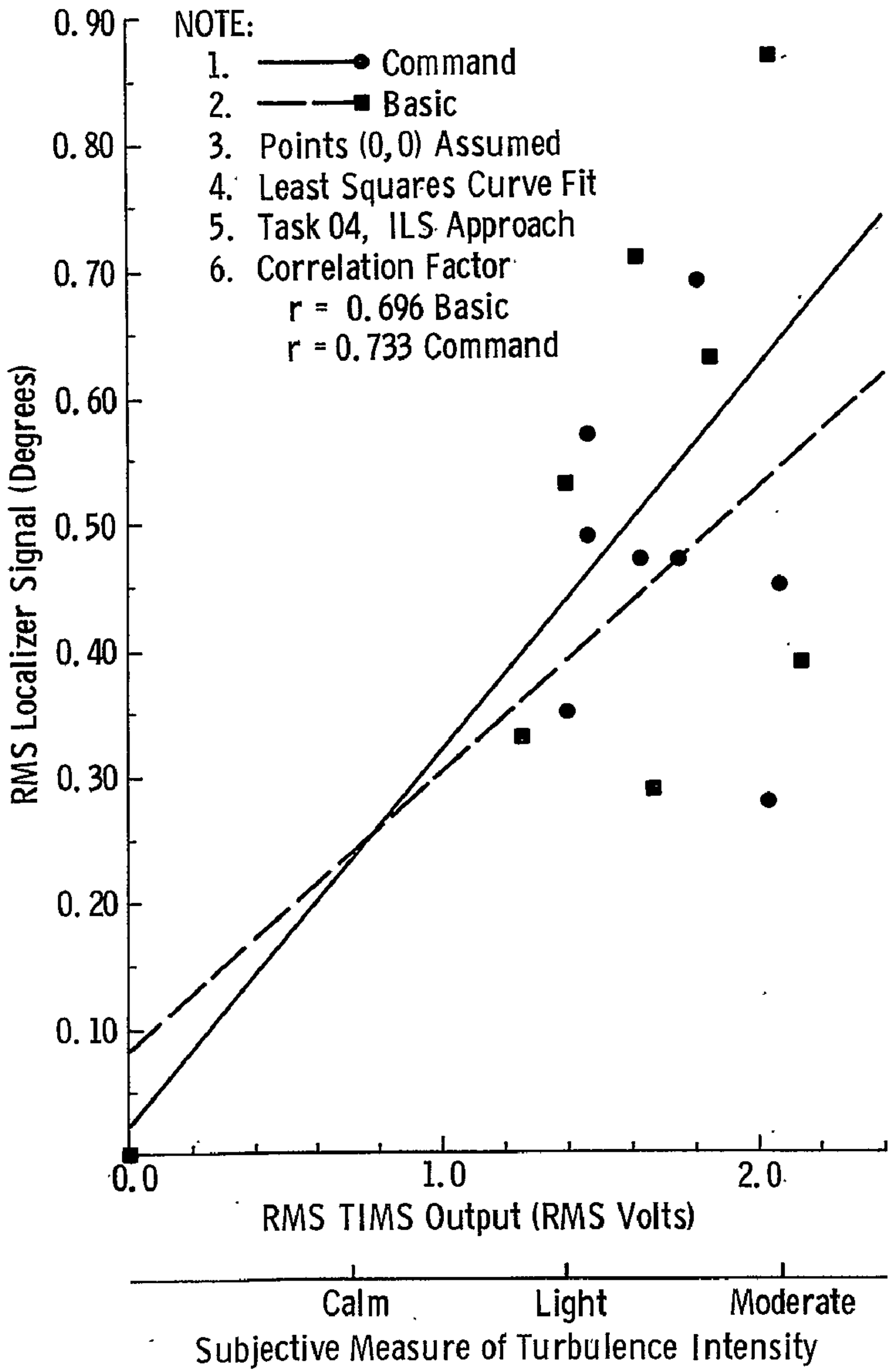



FIGURE 9.12 Least Squares Curve Fit to the RMS Localizer Signal as a Function of RMS TIMS Output

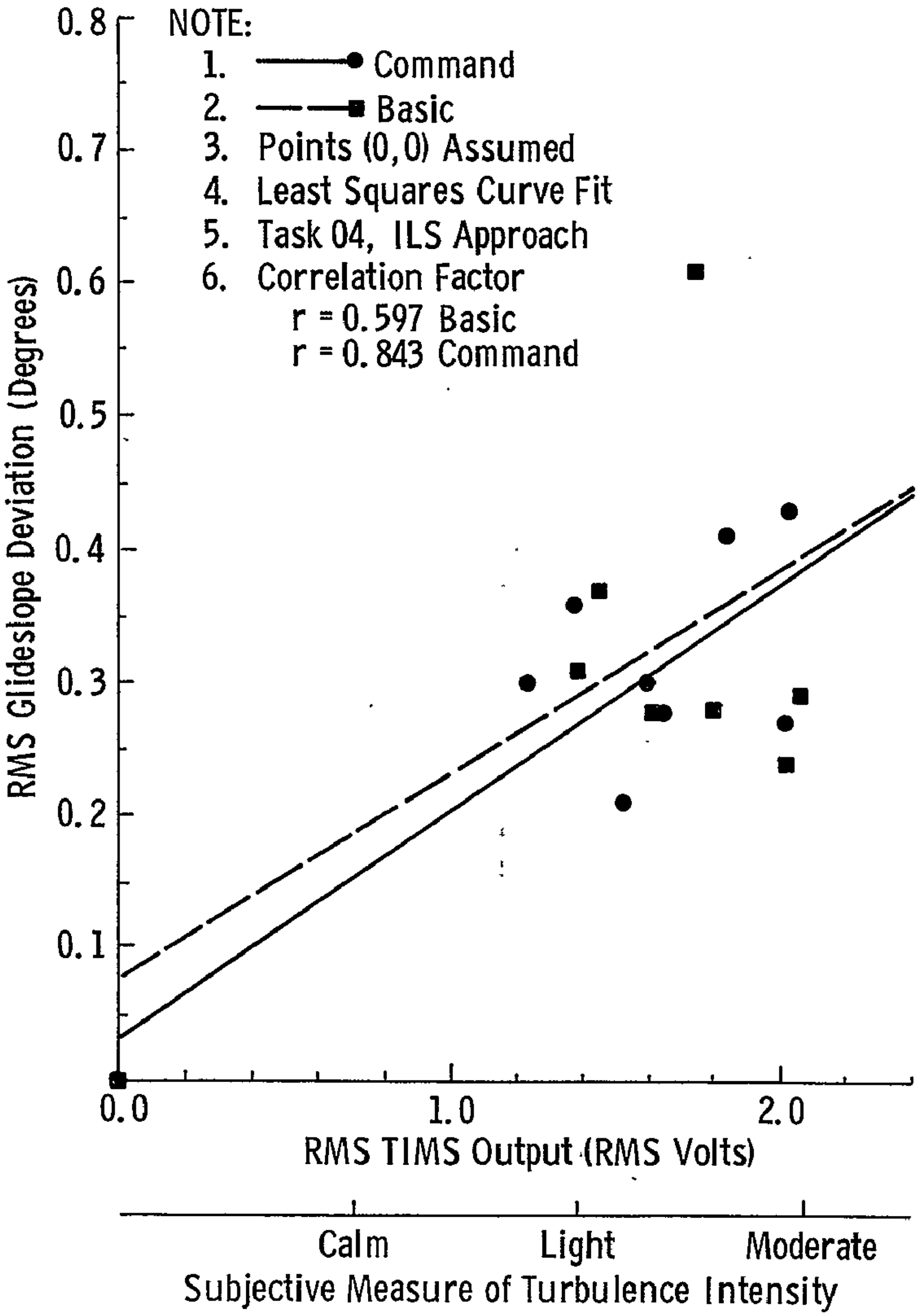



FIGURE 9.13 Least Squares Curves Fit to the RMS Glideslope Signal as a Function of RMS TIMS Output

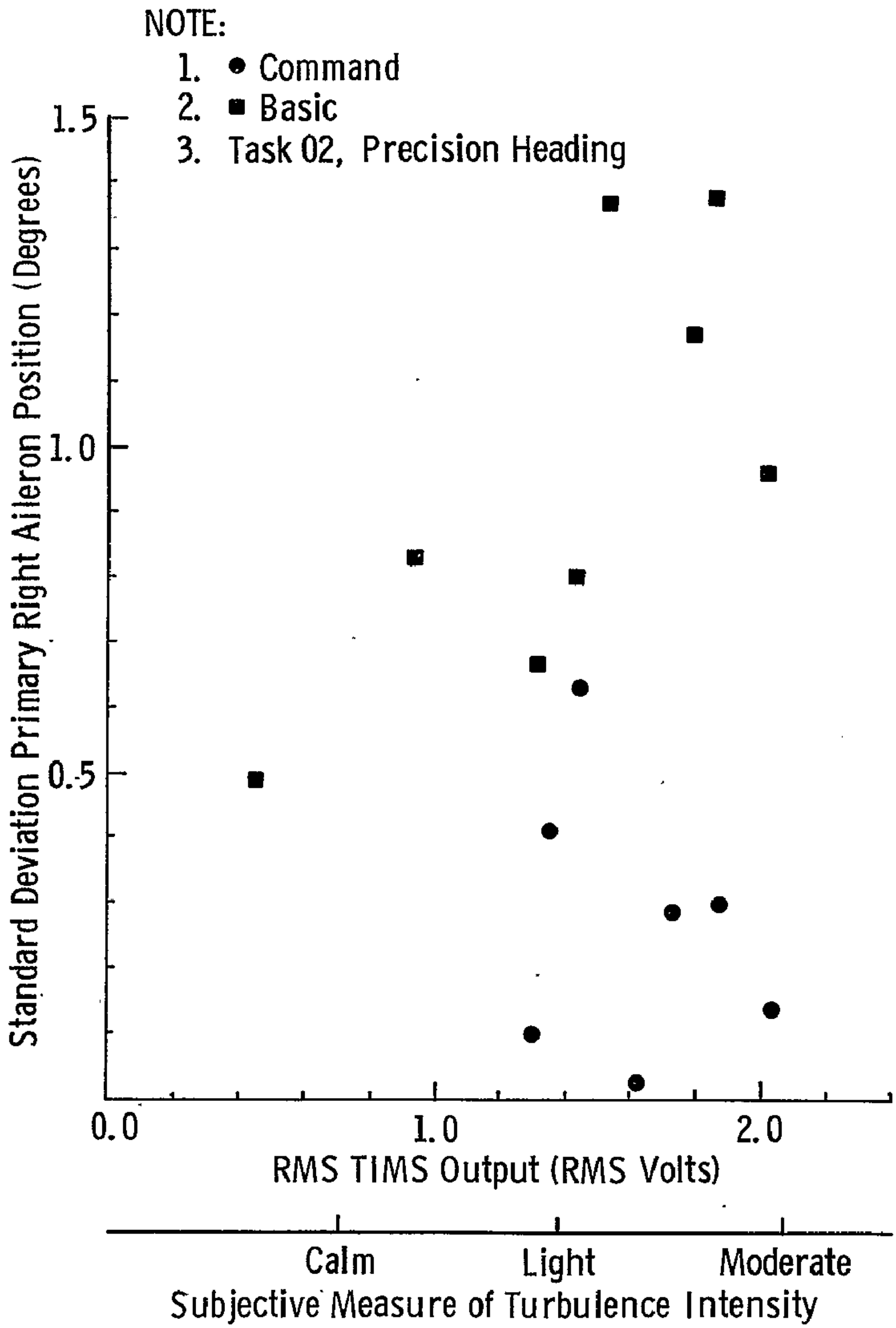



FIGURE 9.14 Standard Deviation of Primary Right Aileron Position as a Function of RMS TIMS Output for the Precision Heading Task

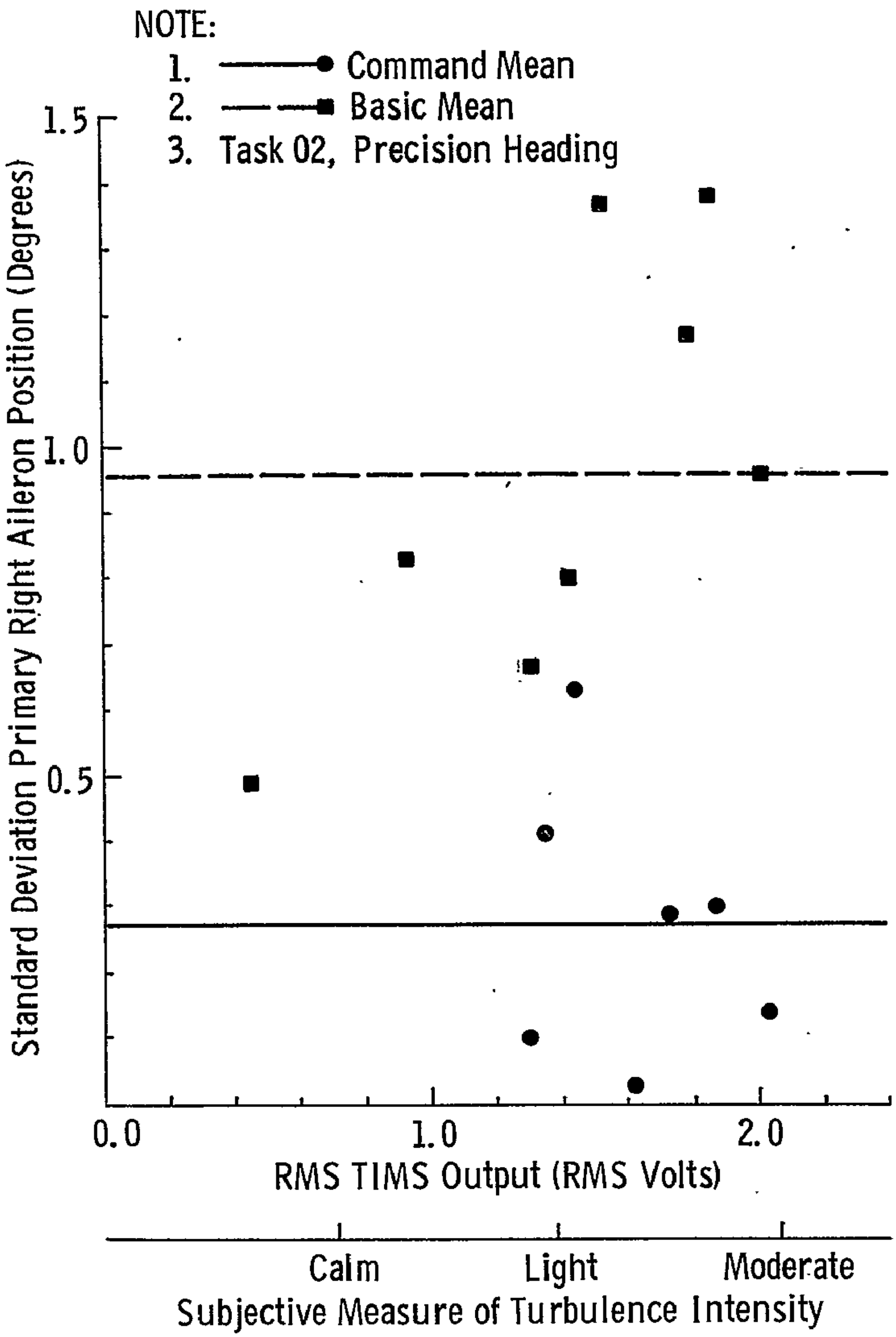



FIGURE 9.15 Average Standard Deviation of Primary Right Aileron Position as a Function of RMS TIMS Output for the Precision Heading Task

would not increase the measure of workload. Figure 9.15 shows that the average pilot workload was reduced 72% for the SSSA attitude command system. Figure 9.16 shows a least squares curve fit to the data. A point at the origin was assumed; the assumption means that in the case of no turbulence, the aircraft will hold heading with no pilot activity required.

Figure 9.17 shows the standard deviation of primary right aileron position as a function of RMS turbulence level for the ILS approach. Figure 9.18 shows that the average aileron workload was reduced 62% by the SSSA attitude command system. Figure 9.19 shows a least squares curve fit to the data. A point at the origin was assumed; the assumption means that in no turbulence, once the pilot was established on the localizer he would not have to change his position with an aileron deflection.

Figure 9.20 shows the standard deviation of the primary elevator position as a function of RMS turbulence level for the ILS approach. Figure 9.21 shows that the average elevator workload was increased by 21% by the SSSA attitude command system. Figure 9.22 shows a least squares curve fit to the data. A point was assumed at the origin, this assumption means that once the pilot was established on the glideslope, he would not have to change his attitude with an elevator deflection.

The data contained in Figures 9.14 through 9.22 indicate that the pilot's primary aileron workload was reduced significantly in both the precision heading and ILS approach tasks by the SSSA attitude command system. The primary elevator workload was increased slightly in the ILS approach.

9.4.3 Ride Qualities Summary. Three parameters were chosen to summarize ride qualities: normal and lateral acceleration during the precision heading task, and lateral acceleration during the ILS intercept. Figure 9.23 shows the standard deviation of normal acceleration as a function of RMS turbulence level for the precision heading task. Standard deviation of normal acceleration was chosen because the steady state value of normal acceleration is one g; the normal acceleration varies above and below this value; therefore, an RMS value would not be

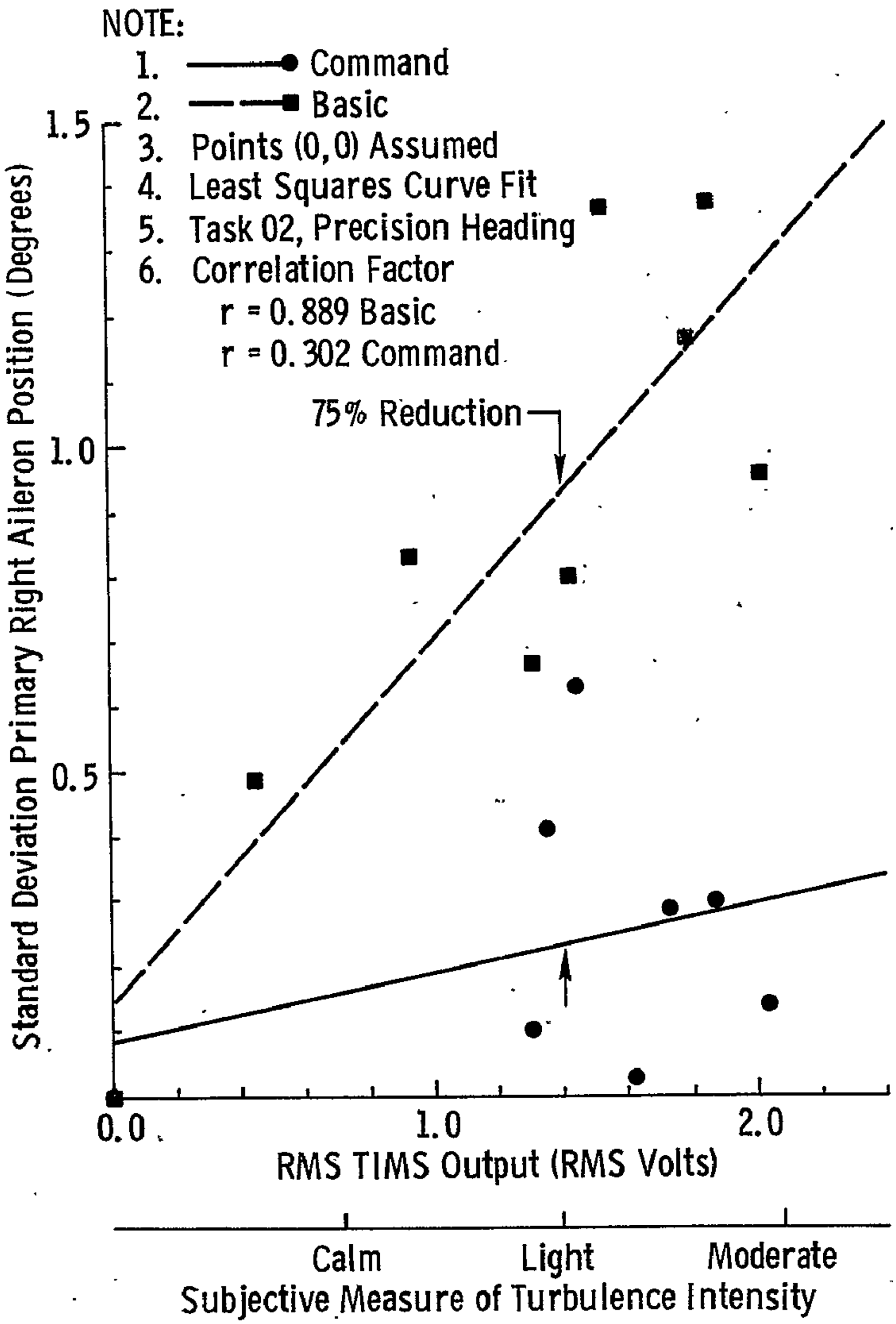



FIGURE 9.16 Least Squares Curve Fit to the Standard Deviation of Primary Right Aileron Position as a Function of RMS TIMS Output for the Precision Heading Task

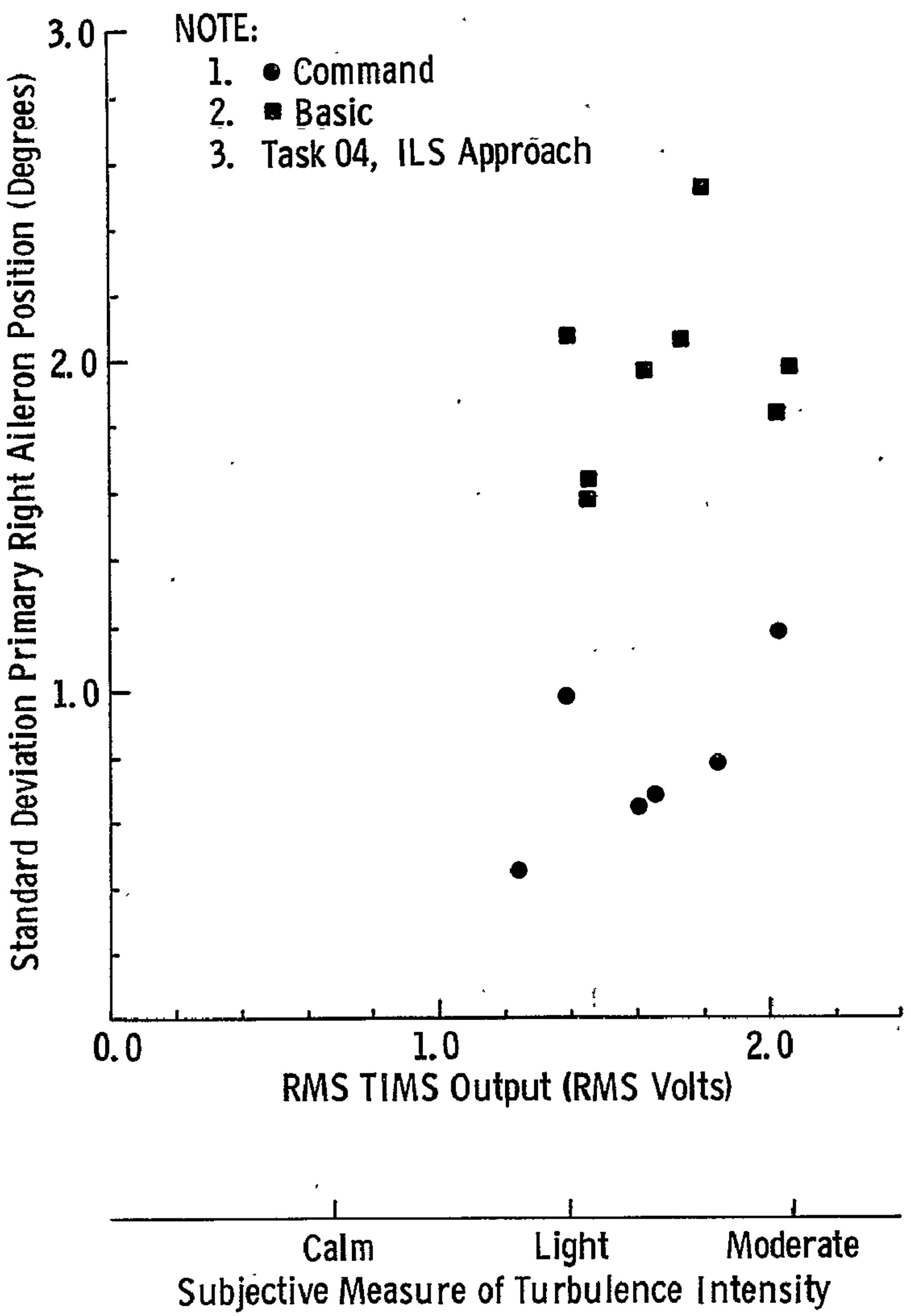



FIGURE 9.17 Standard Deviation of Primary Right Aileron Position as a Function of RMS TIMS Output for the ILS Approach

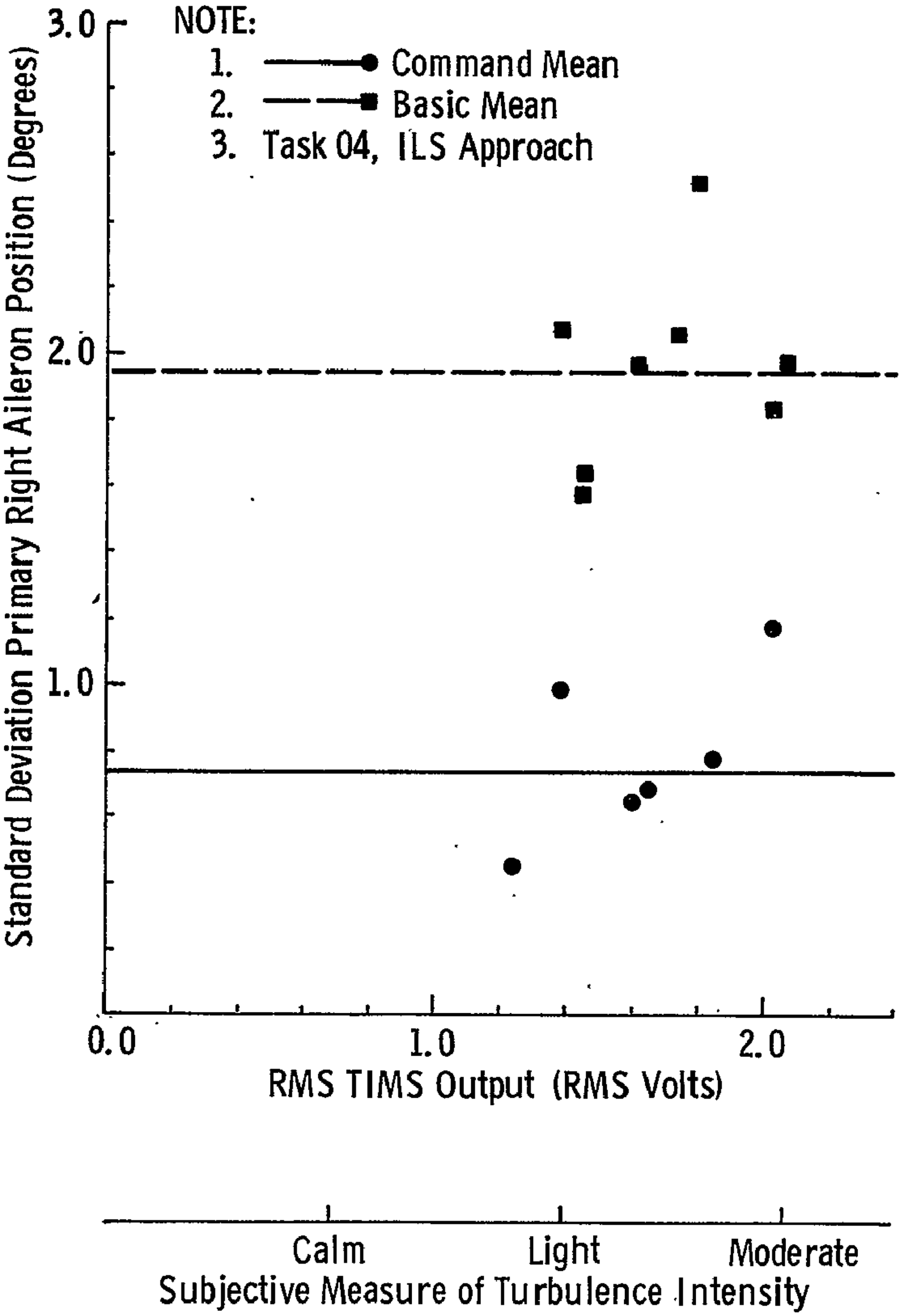



FIGURE 9.18 Average Standard Deviation of Primary Right Aileron Position as a Function of RMS TIMS Output for the ILS Approach

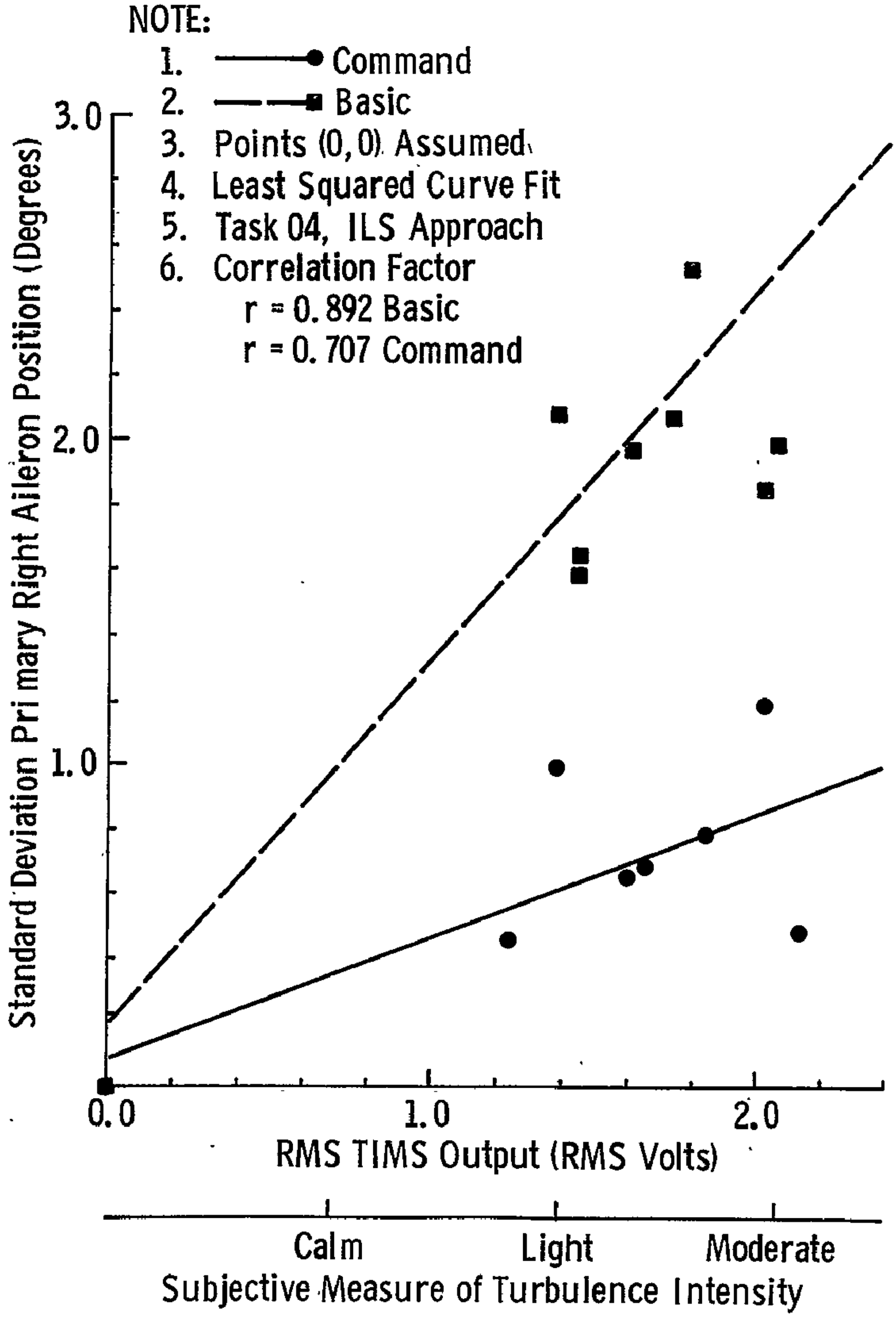



FIGURE 9.19 Least Squares Curve Fit to the Standard Deviation of Primary Right Aileron Position as a Function of RMS TIMS Output for the ILS Approach

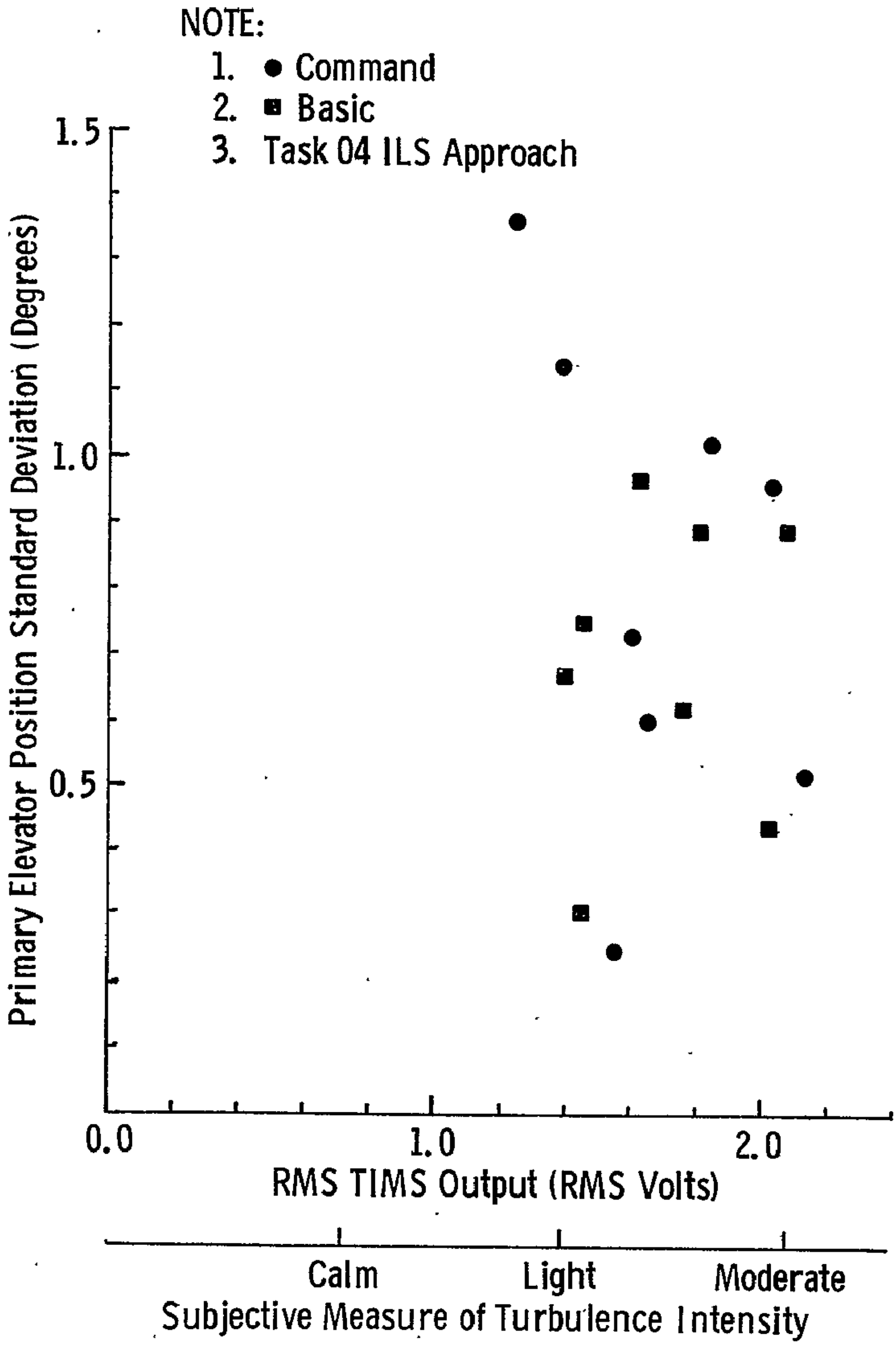



FIGURE 9.20 Standard Deviation of Primary Elevator Position as a Function of RMS TIMS Output for the ILS Approach

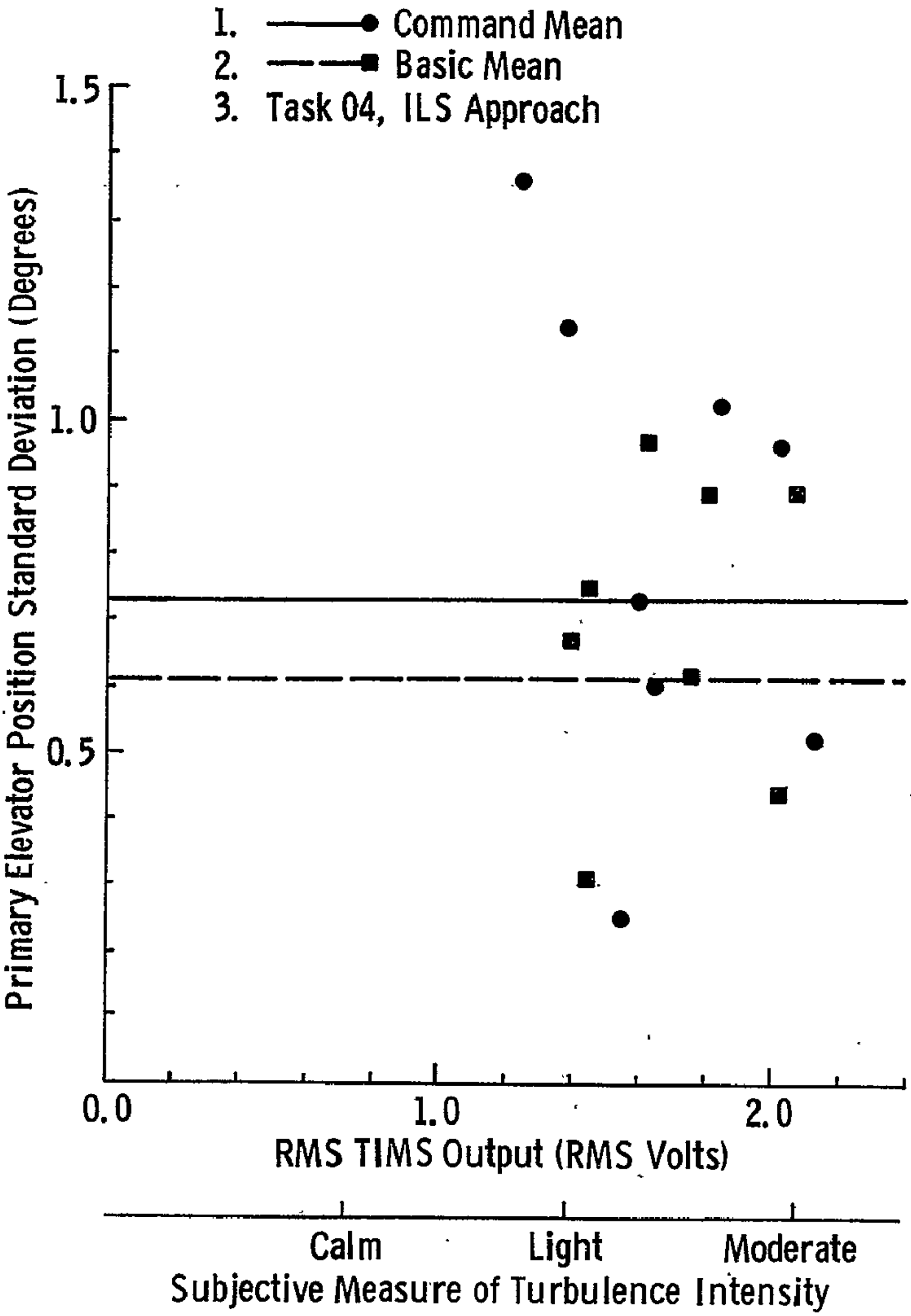



FIGURE 9.21 Average Standard Deviation of Primary Elevator Position as a Function of RMS TIMS Output for the ILS Approach

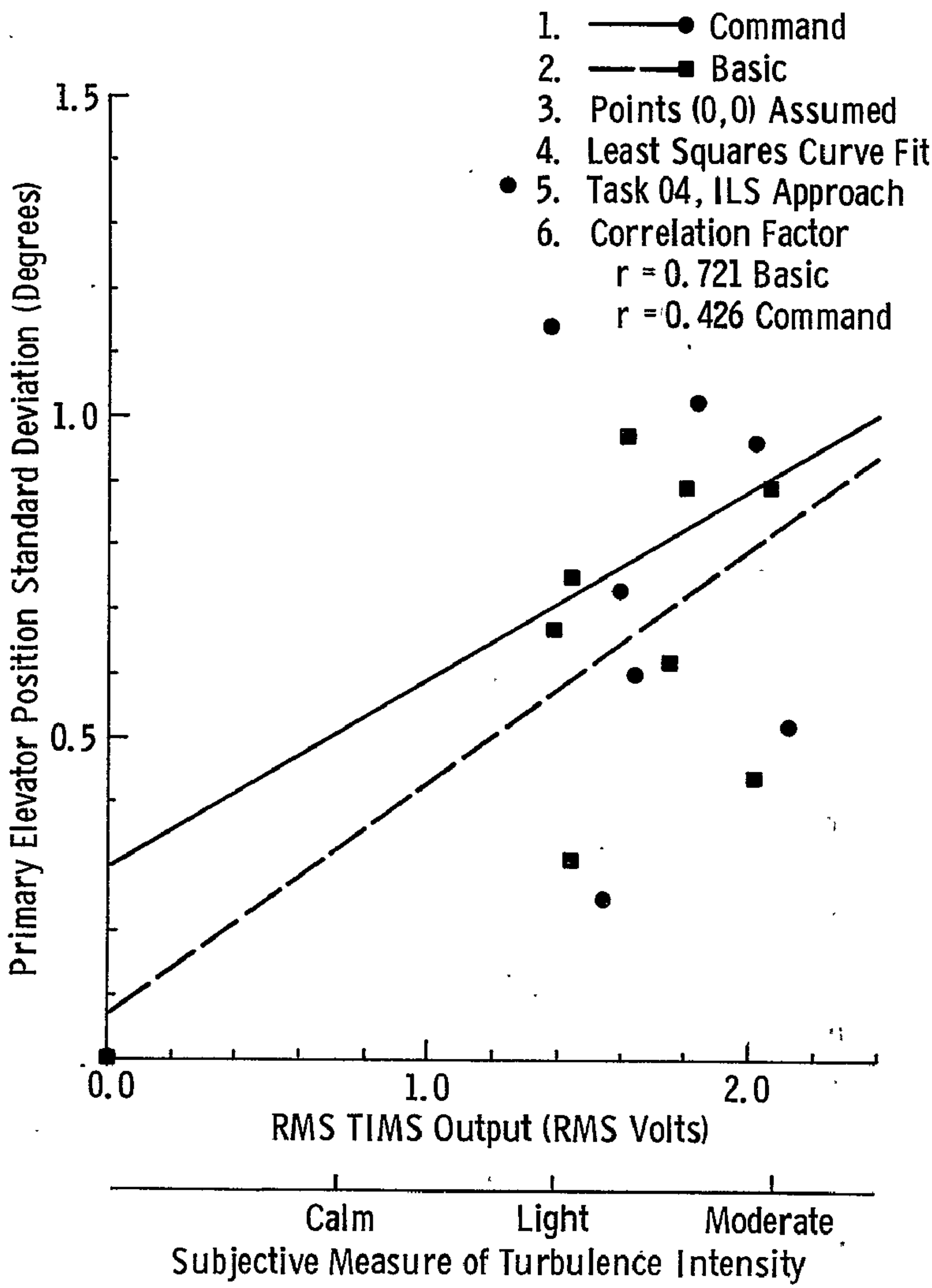



FIGURE 9.22 Least Squares Curve Fit to the Standard Deviation of Primary Elevator Position as a Function of RMS TIMS Output for the ILS Approach

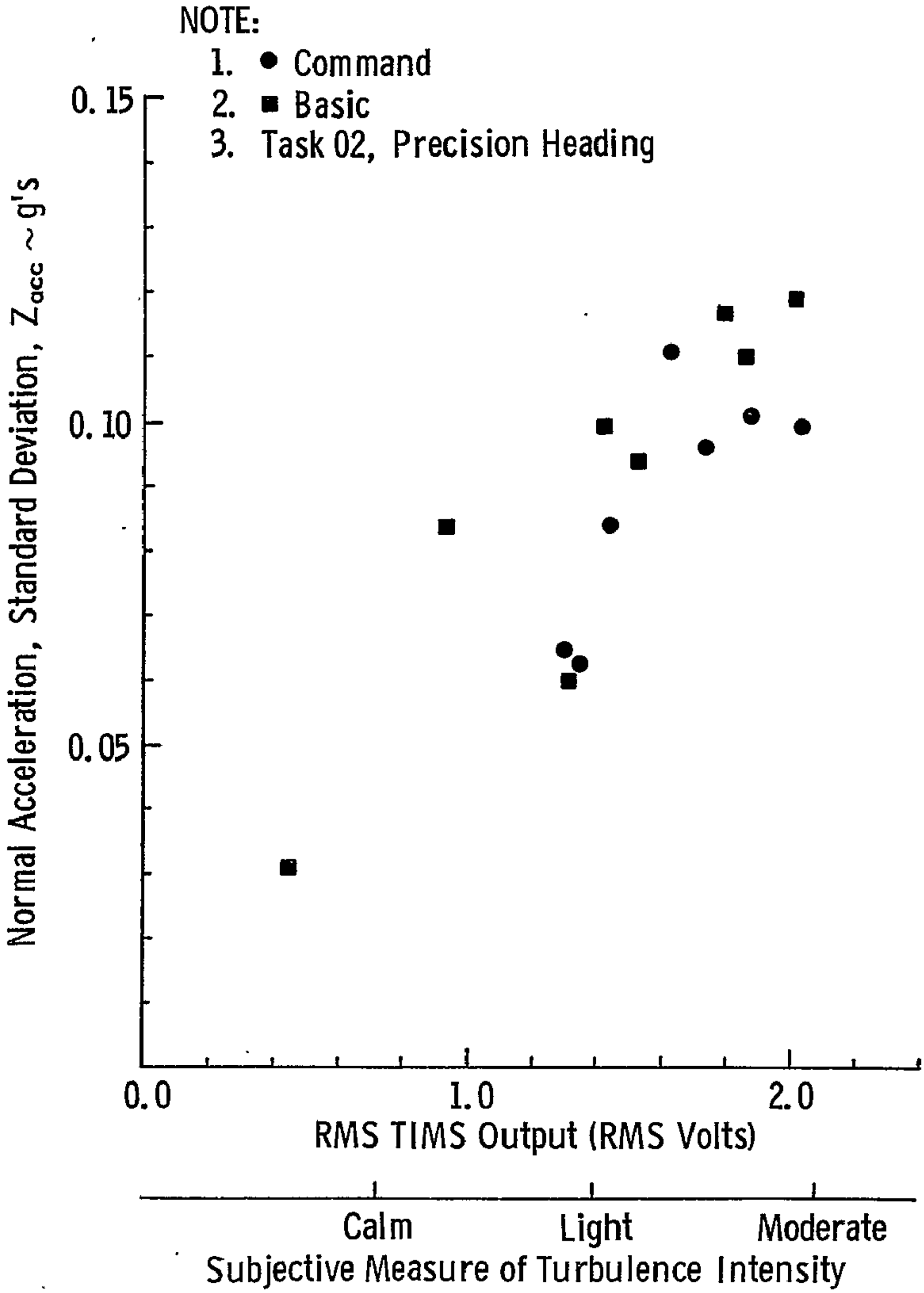



FIGURE 9.23 Standard Deviation of Normal Acceleration as a Function of RMS TIMS Output for the Precision Heading Task

an accurate measure of ride qualities. Figure 9.24 shows that the average value of normal acceleration standard deviation of the basic Model 99 (slave mode) is nearly the same as that of the SSSA Model 99 (command mode) for the precision heading task. Figure 9.25 shows a least squares curve fit to the data. A point at the origin was assumed; the assumption means that in the case of no turbulence, the normal acceleration on the aircraft is constant at one g during the precison heading task.

Figure 9.26 shows the RMS lateral acceleration as a function of RMS turbulence level during the precision heading task. Figure 9.27 shows that the average RMS lateral acceleration was increased 6% by the SSSA Model 99 (command mode). Figure 9.28 shows a least squares curve fit to the data. A point at the origin was assumed; the assumption means that in the case of no turbulence, the aircraft was subjected to no lateral acceleration in the precision heading task.

Figure 9.29 shows the RMS lateral acceleration as a function of RMS turbulence level for the ILS approach. Figure 9.30 shows that the average RMS lateral acceleration of the basic Model 99 (slave mode) was decreased by 11% by the SSSA Model 99 (command mode). Figure 9.31 shows a least squares curve fit to the data. A point at the origin was assumed; the assumption means that in the case of no turbulence the aircraft was subjected to no lateral acceleration during the ILS approach.

The data presented in Figures 9.23 through 9.26 do not indicate a significant improvement in ride qualities with the SSSA Model 99 functioning in the attitude command mode, However, the pilots indicated that they felt the attitude command system improved the aircraft ride qualities.

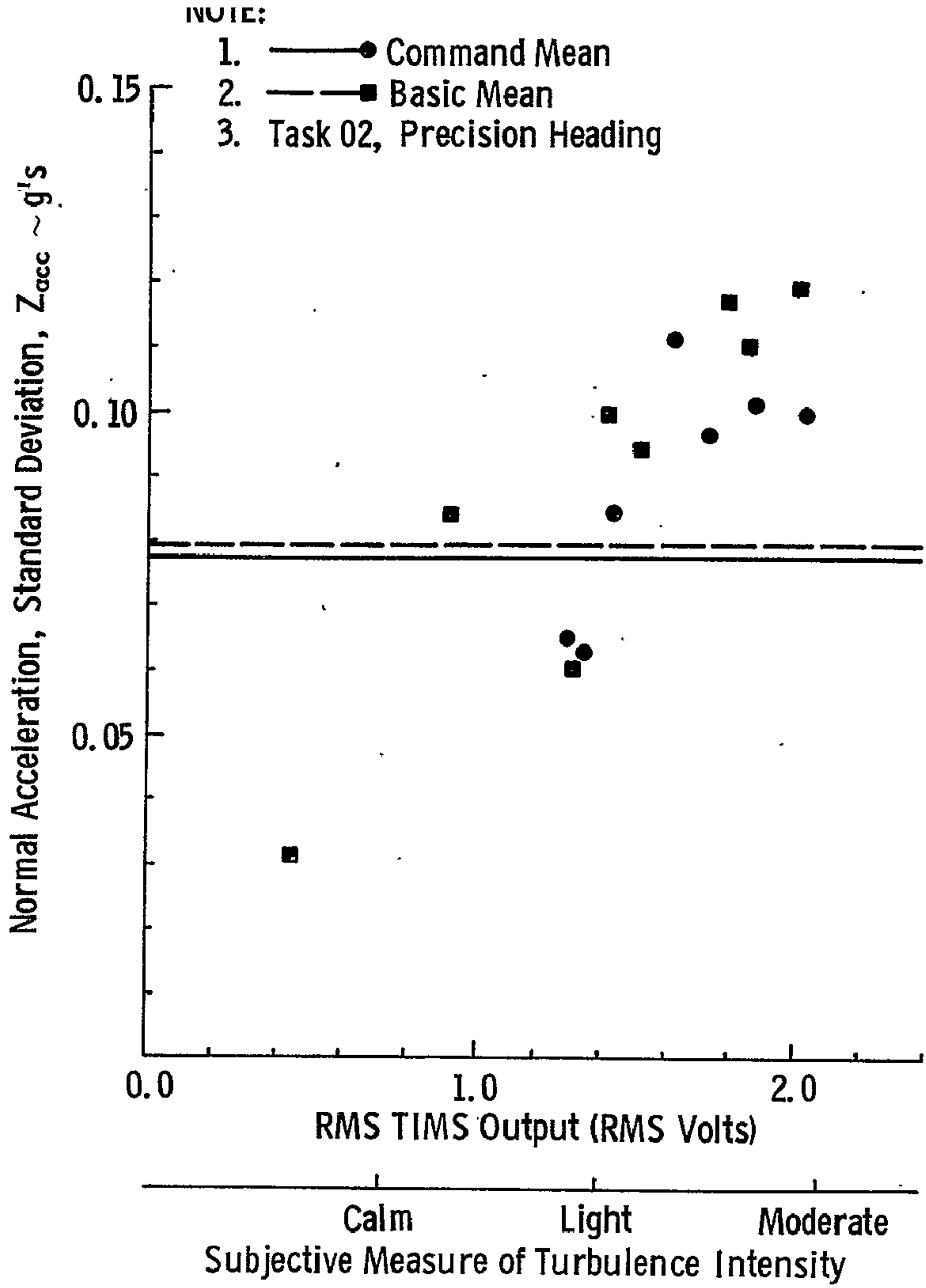



FIGURE 9.24 Average Standard Deviation of Normal Acceleration as a Function of RMS TIMS Output for the Precision Heading Task

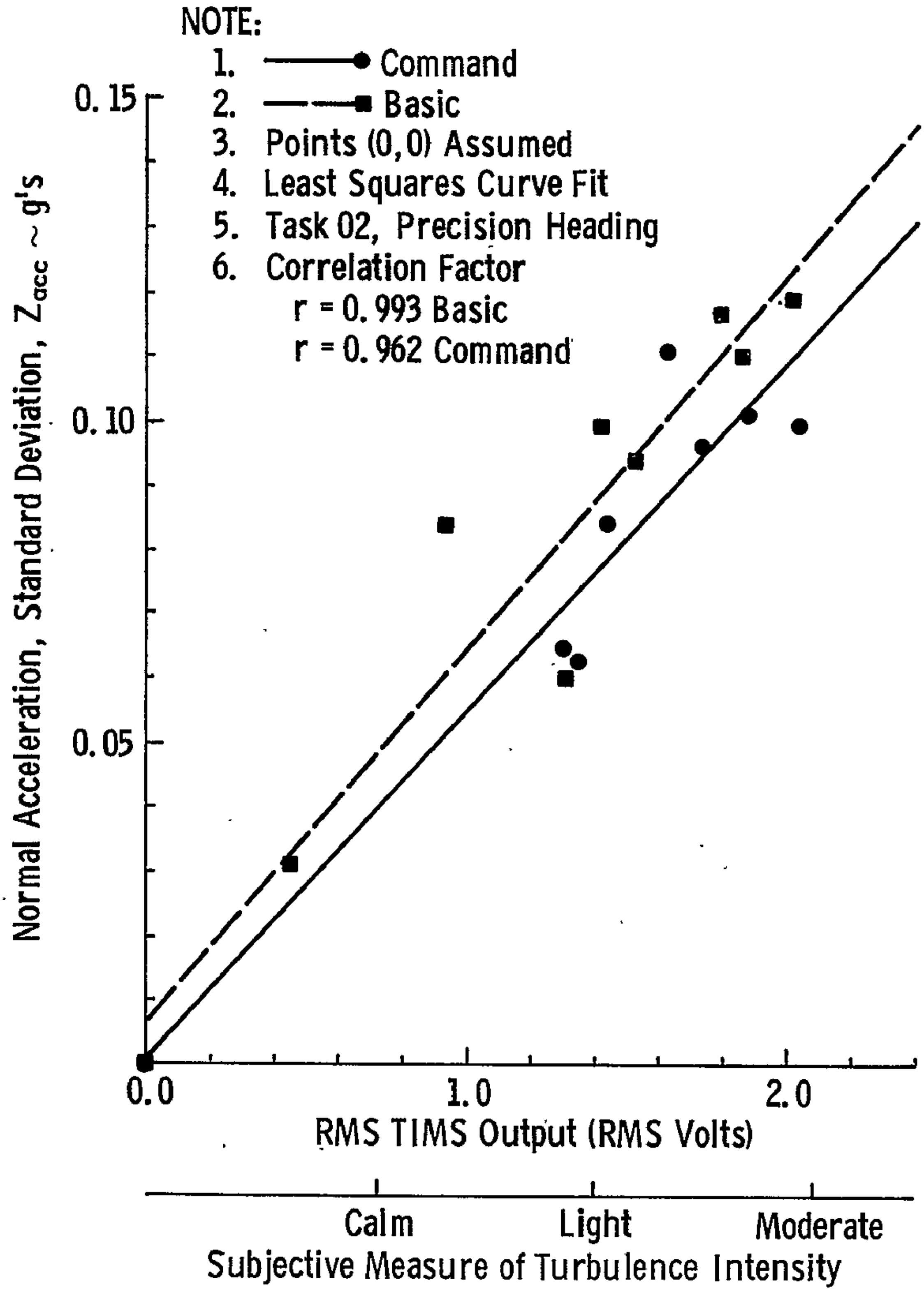



FIGURE 9.25 Least Squares Curve Fit to the Standard Deviation of Normal Acceleration as a Function of RMS TIMS Output for the Precision Heading Task

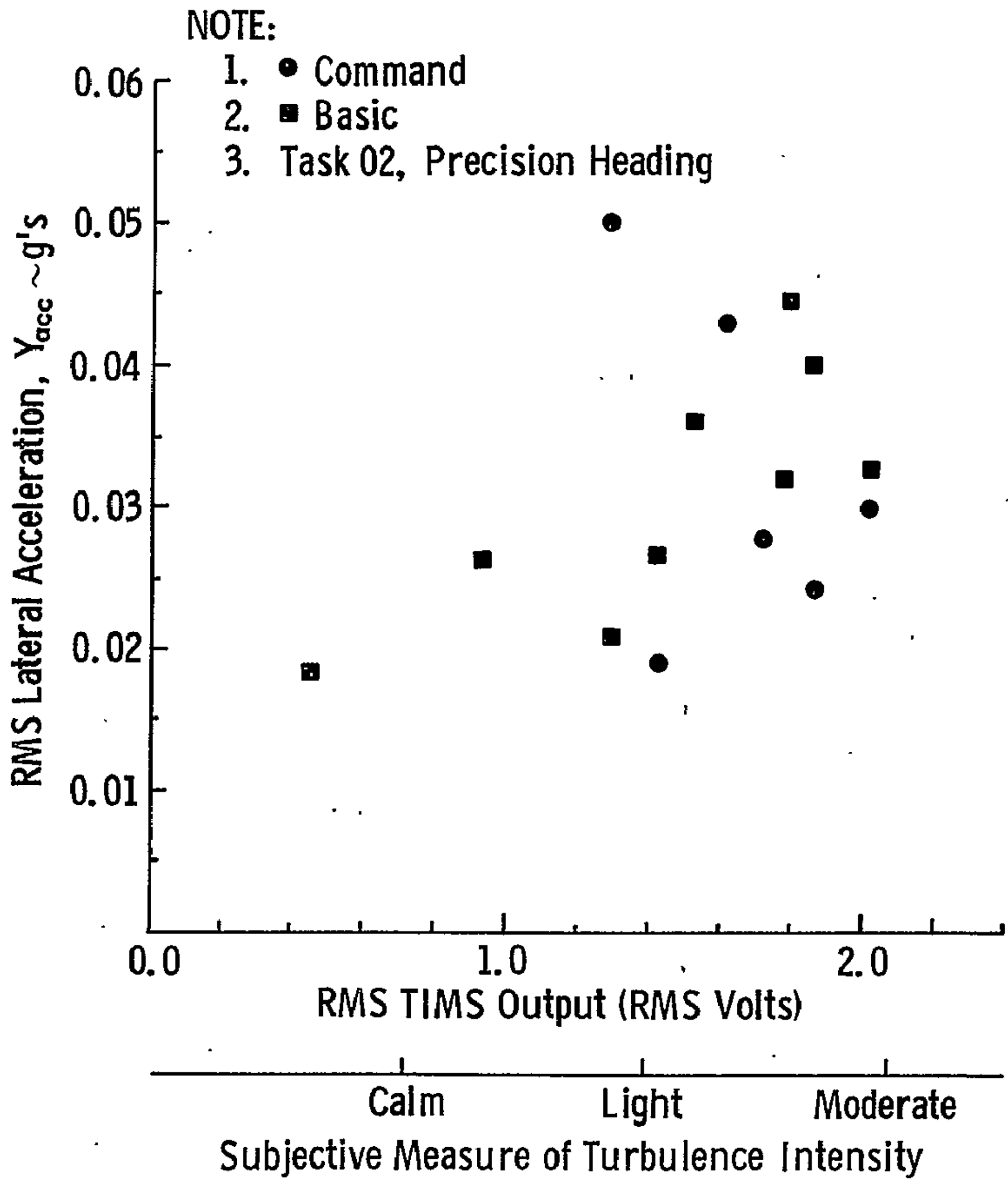



FIGURE 9.26 RMS Lateral Acceleration as a Function of RMS TIMS Output for the Precision Heading Task

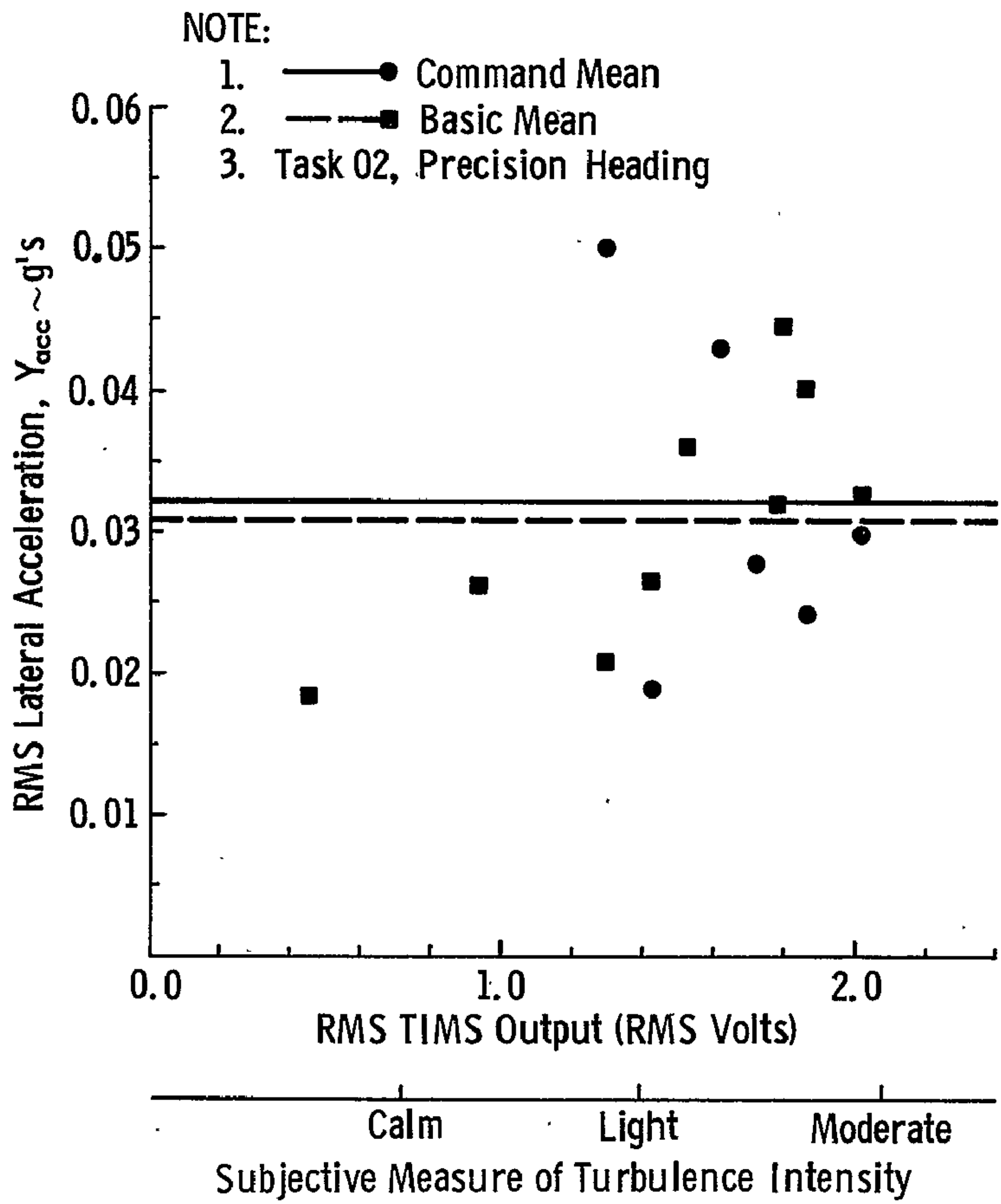



FIGURE 9.27 Average RMS Lateral Acceleration as a Function of RMS TIMS Output for the Precision Heading Task

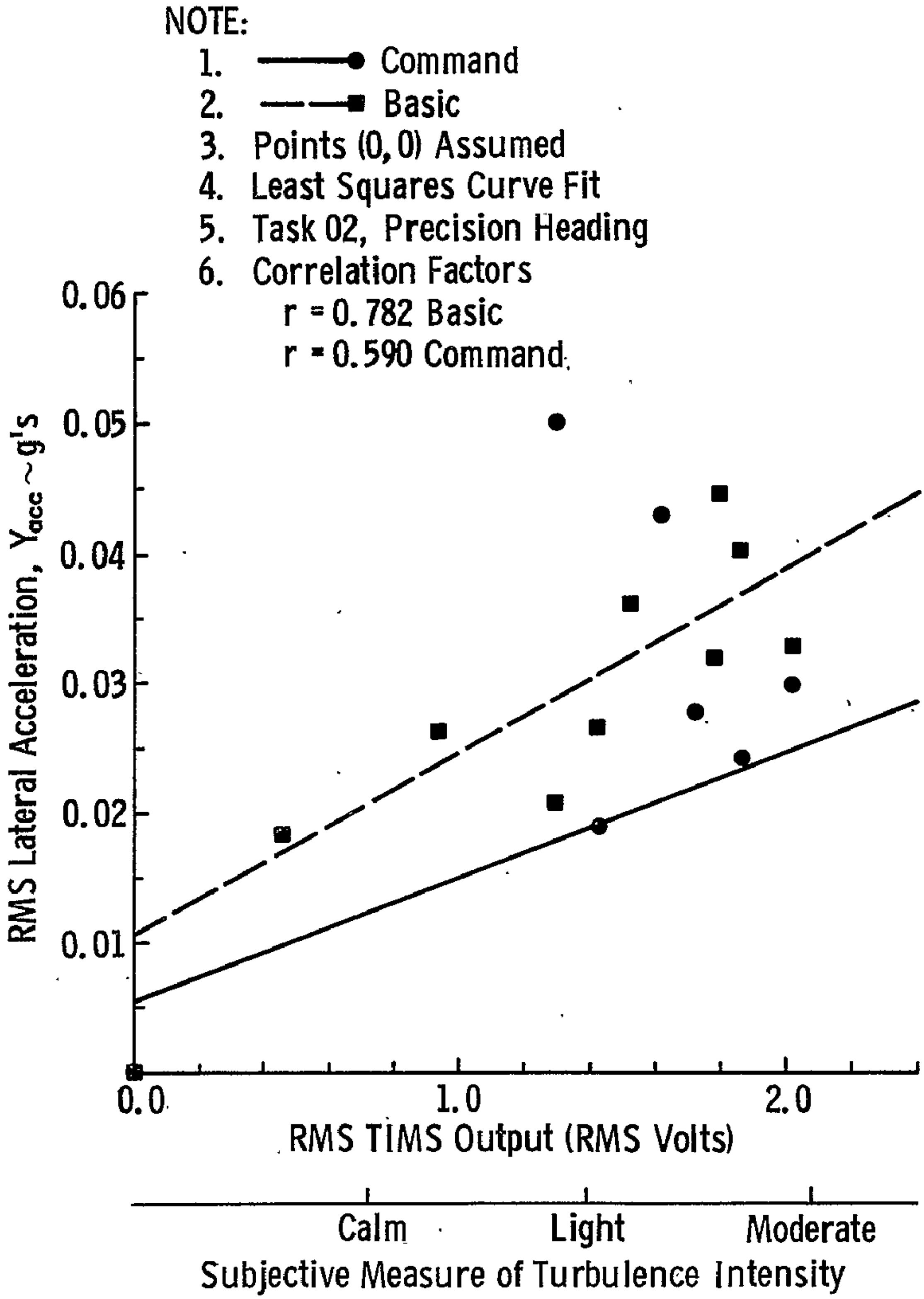



FIGURE 9.28 Least Squares Curve Fit to the RMS Lateral Acceleration as a Function of RMS TIMS Output for the Precision Heading Task

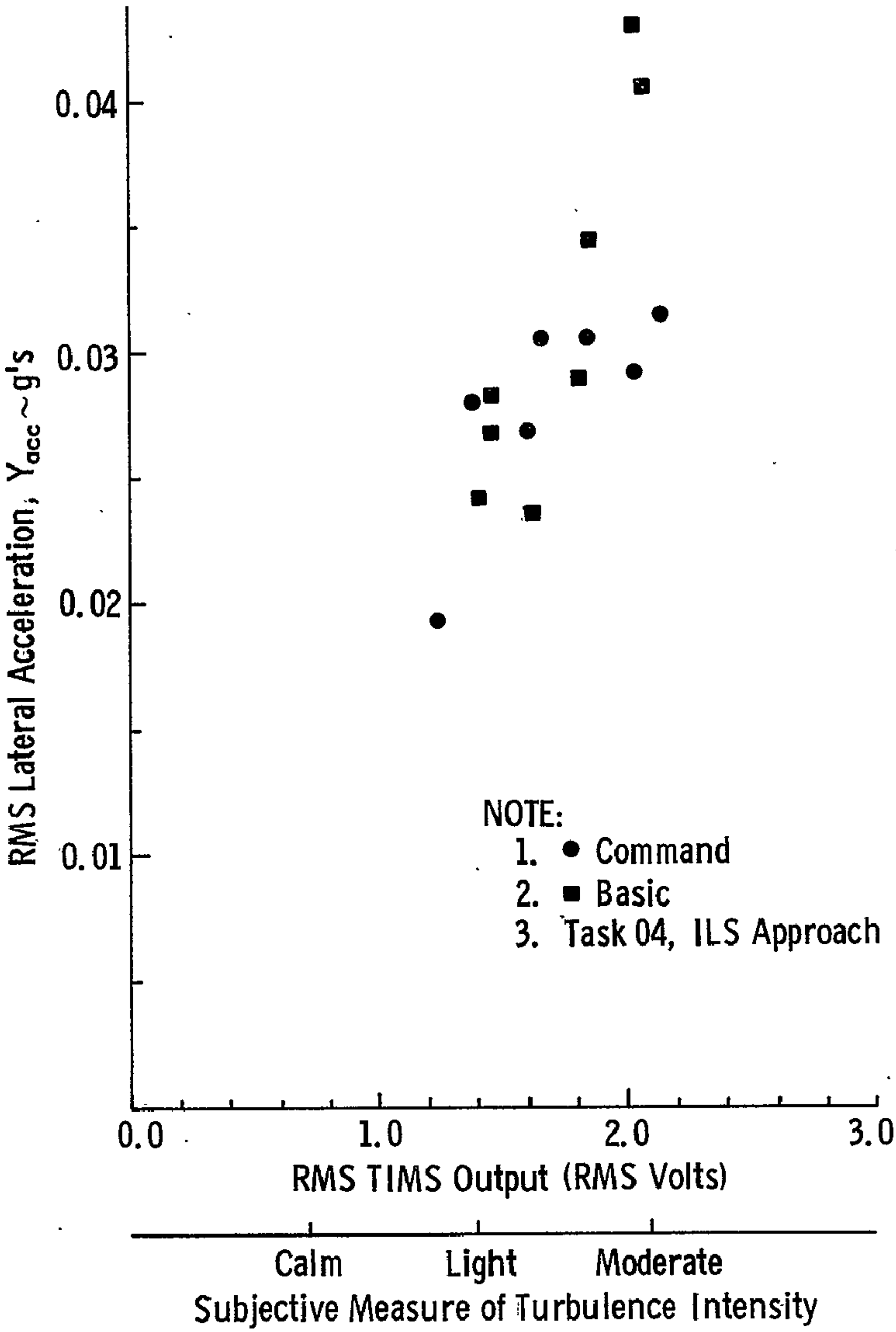



FIGURE 9.29 RMS Lateral Acceleration as a Function of RMS TIMS Output for the ILS Approach

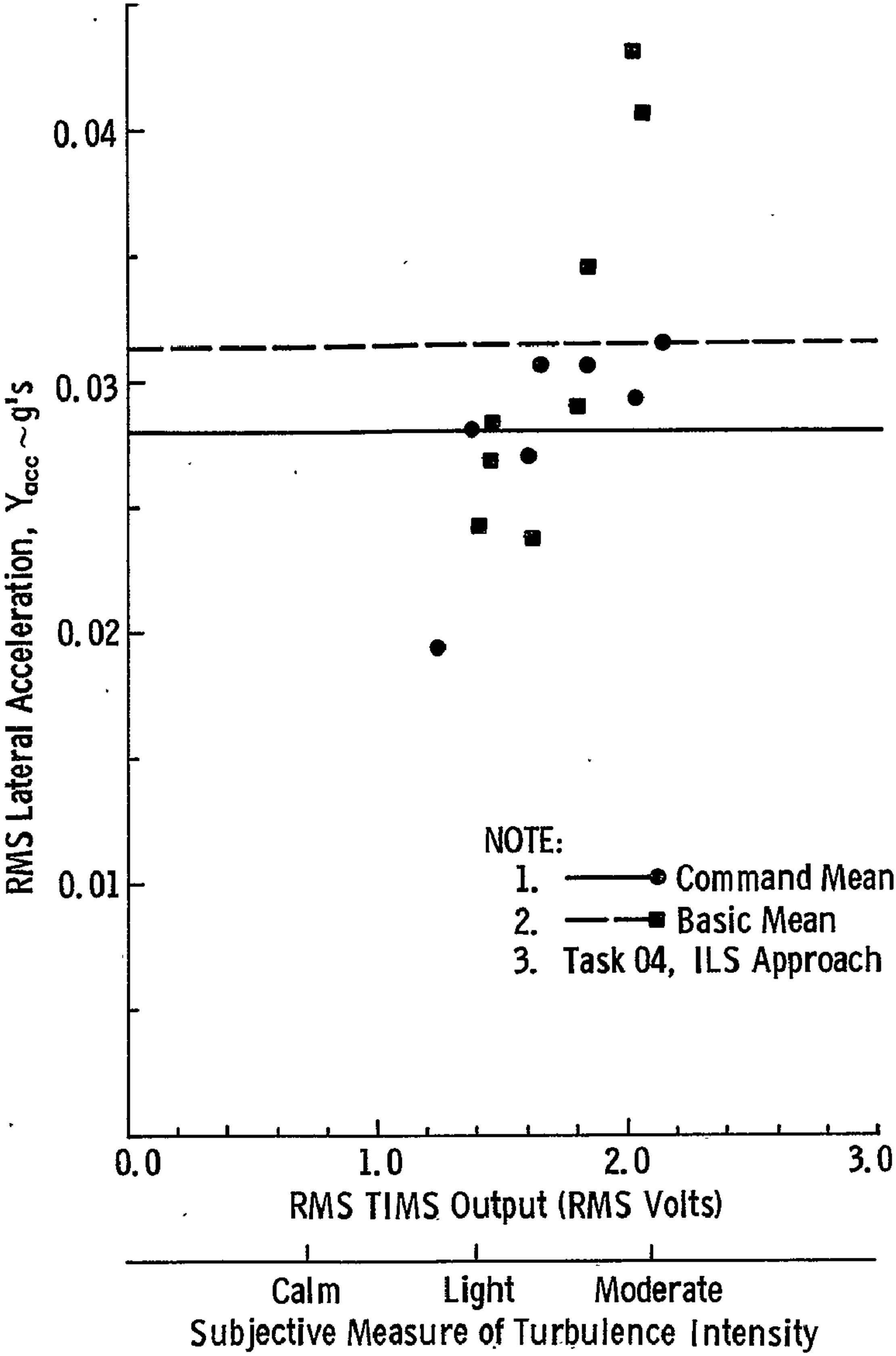



FIGURE 9.30 Average RMS Lateral Acceleration as a Function of RMS TIMS Output for the ILS Approach

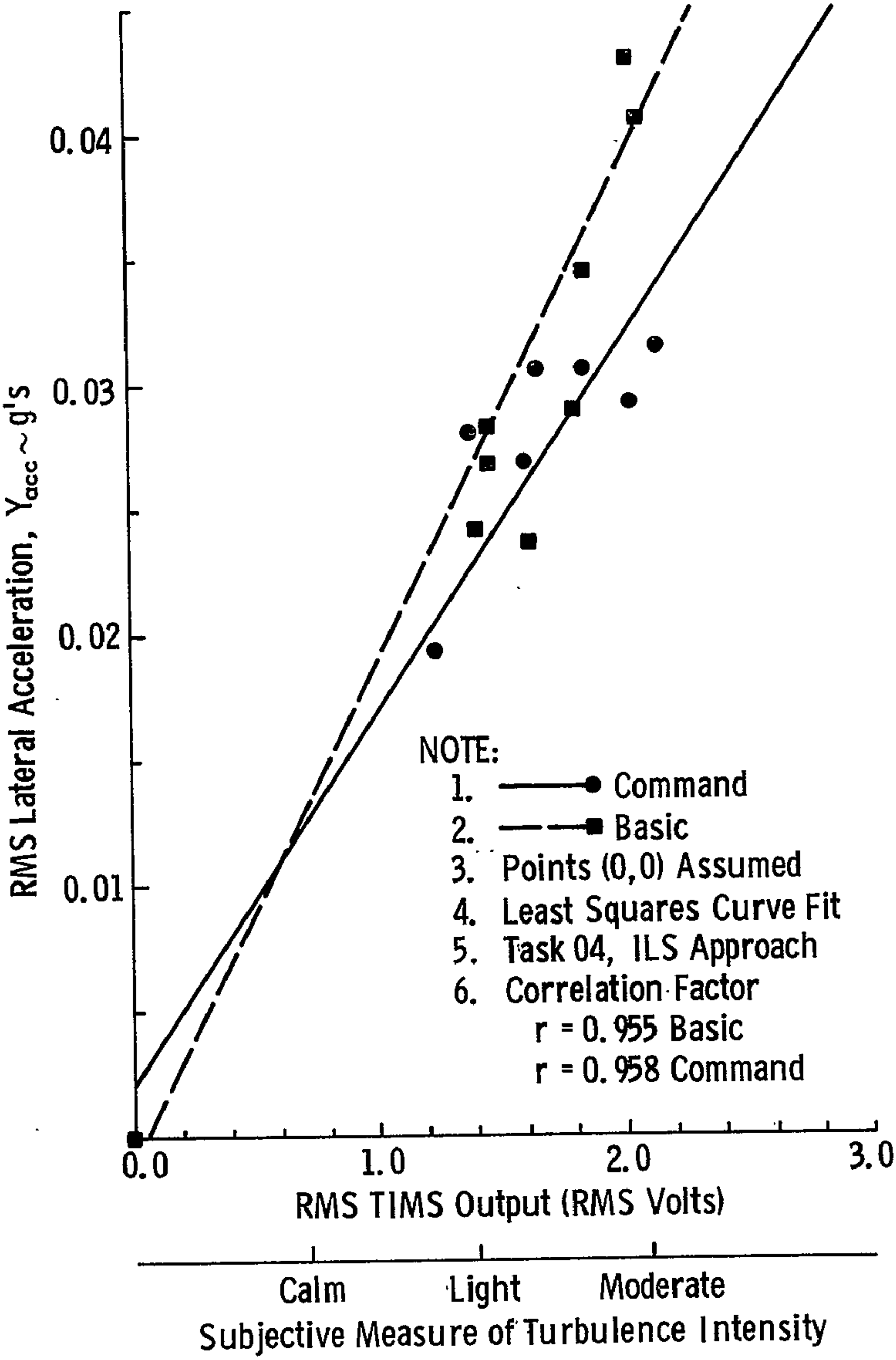



FIGURE 9.31 Least Squares Curve Fit to the RMS Lateral Acceleration as a Function of RMS TIMS Output for the ILS Approach

# CHAPTER 10

# CONCLUSIONS AND RECOMMENDATIONS

## 10.1 Conclusions

The flight test program on a Beech Model 99 has demonstrated that Separate Surface Stability Augmentation (SSSA) can adequately provide attitude command and improve the handling and ride qualities of the aircraft without control force feedback to the pilot. SSSA also has the capability of performing less demanding augmentation tasks such as yaw damping, wing leveling, and auto-pilot functions. Additionally, this program supports the conclusions of a NASA Dryden Flight Research Center PA-30 program: attitude command improves the handling qualities of an airplane while performing an instrument flight rules (IFR) task in turbulence. The Cooper-Harper pilot rating was improved by an average of 1.12 points for the mission flown. The maximum improvement on an individual pilot basis was 2.0 points and the minimum was 0 points of improvement.

The improvement in pilot rating can be related to the reduction in pilot workload in performing the IFR task. Reductions in aileron activity and pitch trim transients are the most prominent areas of improvement. Another area that can be related to the improvement in pilot rating is apparent improvement in ride qualities. The evaluation pilots subjectively felt an improvement in the ride qualities.

The aspect of the system that tended to degrade the pilot rating was the necessity to hold aileron force for a banked turn. Even though the forces were minimized, the pilots generally objected. Additionally, the apparent static longitudinal stability was increased significantly by the SSSA system which made the aircraft feel very stiff in pitch. The rationale for this change was that while flying attitude command the pilot should make attitude changes with the pilot's trim. However, the evaluation pilots still wanted to make small pitch attitude changes with elevator inputs. Consequently, the increased forces tended to degrade the pilot rating. (It should be noted that this problem could be eliminated by incorporating separate forward loop gains for the primary elevator and pilot trim inputs.)

## 10.2 Recommendations

1. Based upon the results of this program, attitude command in the roll axis is not acceptable without an easily accessible trim system in bank. The most logical system would be an electric trim mounted on the pilot's control wheel. The most desirable system would be rate command/ attitude hold in the roll axis.
2. Adaptation from a conventional rate command system to an attitude command system requires a significant amount of familiarity (5 - 10 hours) before the full advantage of the system is attained. Therefore, additional familiarity should be given to the evaluation pilots.
3. Separate Surface Stability Augmentation should not be viewed as merely a means for implementing attitude command. It should be viewed as the name implies, as a viable method of stability augmentation.
4. Several of the aircraft step response problems are related to separate surface control saturation. The problems were solved adequately for this program; however, a complete analytical description of the effect of control saturation is lacking. This description should be developed.

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# APPENDIX A

## DETERMINATION OF THE FACTORS AFFECTING BANK ANGLE OVERSHOOT AND SETTLING TIME

Appendix A contains a theoretical determination of the factors contributing to the SSSA Model 99 bank angle overshoot and settling time.

The SSSA Model 99 roll axis block diagram can be expressed as shown in Figure A.1. The .61 and .39 terms represent the control power percentage of the primary and separate surface ailerons respectively. The $\varepsilon_1$ and $\varepsilon_2$ represent intermediate signals in the electronics and are used to simplify the block diagram algebra. The $\phi/\delta_A$ transfer function is the basic airplane $\phi/\delta_A$ transfer function and is represented in this analysis by the single degree of freedom roll approximation of reference 3.

$$\frac{\phi(S)}{\delta_A(S)} = \frac{L_{\delta_A}}{S(S-L_p)}$$

Therefore applying block diagram algebra:

$$\varepsilon_1(S) = .61\ \delta_{AP}(S) + .39\ \delta_{AS}(S)$$

$$\delta_{AS} = \varepsilon_2(S)\ [\frac{9.5}{S+9.5}]$$

$$\varepsilon_2 = K_{\delta_{AP}}\ \delta_{AP}(S) - (\frac{S+1}{3S+1})\ (SK_{\dot{\phi}}+K_{\phi})\ (\phi(S))$$

$$\phi(S) = \frac{\phi(S)}{\phi_{AP}(S)}\ \varepsilon_1(S)$$

substituting for $\delta_{AS}$ (S) in the $\varepsilon_1$ expression:

$$\varepsilon_1 = .61\ \delta_{AP}(S) + .39\ [\varepsilon_2\ (\frac{9.5}{S+9.5})]$$

substituting for $\varepsilon_2$:

$$\varepsilon_1 = .61\ \delta_{AP}(S) + .39\ [\ (\frac{9.5}{S+9.5})\ (K_{\delta_{AP}}\ \delta\ (S) - (\frac{S+1}{3S+1})$$

$$(SK_{\dot{\phi}}+K_{\phi})\ (\phi(S)\ )\ ]$$

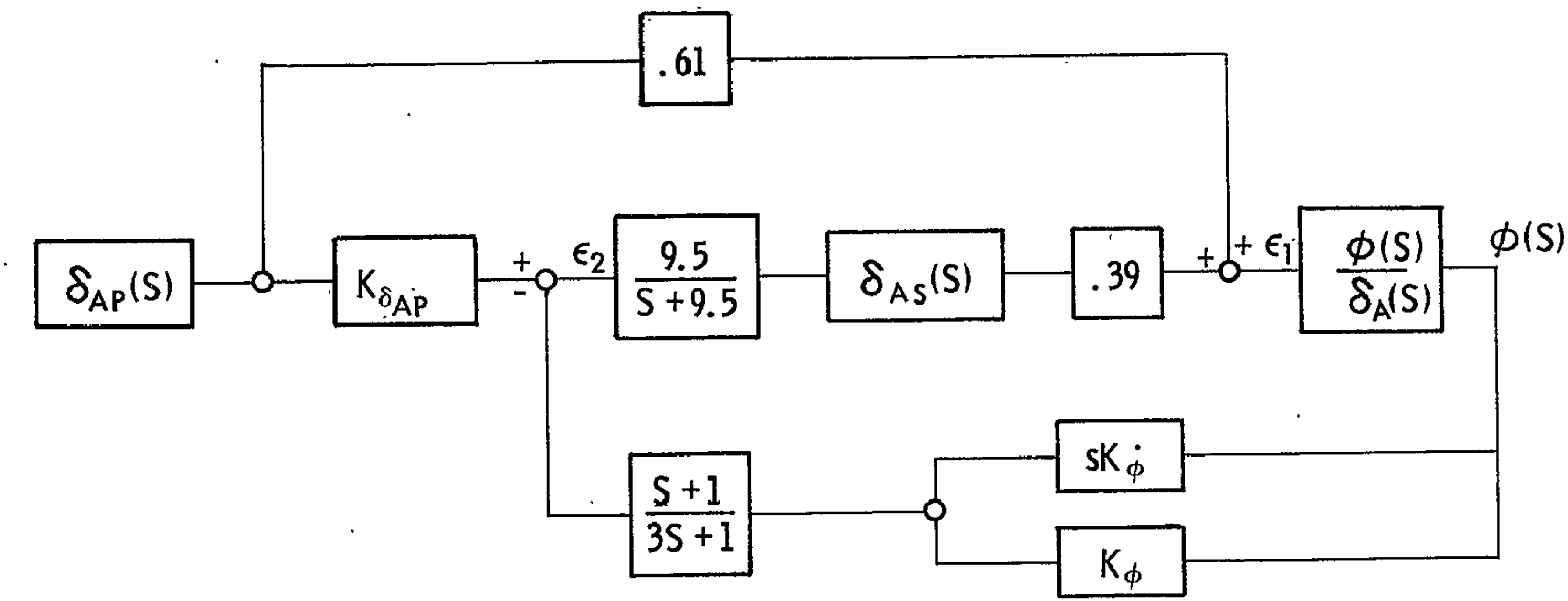



FIGURE A.1 Roll Axis Block Diagram

from block diagram algebra:

$$\phi(S) = \frac{\phi(S)}{\delta_A(S)} (\varepsilon_1)$$

$$\phi(S) = \frac{L_{\delta_A}}{S(S-L_p)} (\varepsilon_1)$$

substituting for $\varepsilon_1$ and simplifying leads to:

$$\phi(S) = \left[\frac{L_{\delta_A} (3S+1)\ [.61\ (S+9.5) + .39\ (9.5)\ (K_{\delta_{AP}})]}{S(S-L_p)\ (S+9.5)\ (3S+1) + L_{\delta_A}\ (.39)\ (9.5)\ (S+1)\ (SK_{\dot{\phi}}+K_{\phi})}\right]$$

$$\delta_{AP}(S)$$

This equation indicates that the dynamic response (represented by bank angle overshoot and settling time) of the SSSA Model 99 to a step aileron input is a function only of $K_\phi$, $K_{\dot{\phi}}$, $K_{\delta_{AP}}$, $L_{\delta_A}$ and $L_p$.

In the case of the SSSA Model 99, $L_{\delta_A}$ and $L_p$ are fixed and $K_\phi$, $K_{\dot{\phi}}$ and $K_{\delta_{AP}}$ can be varied to change the roll axis dynamic response.

It should be noted that this is a linear analysis and assumes no saturation of the separate surface controls. If the separate surface controls saturate the analysis is no longer valid. Also, due to the negative feedback loop and the SSSA electronic sign convention of a positive control deflection yielding a positive Euler angle, the sign of $L_{\delta_A}$ should always be positive.

APPENDIX B

QUANTITATIVE DATA

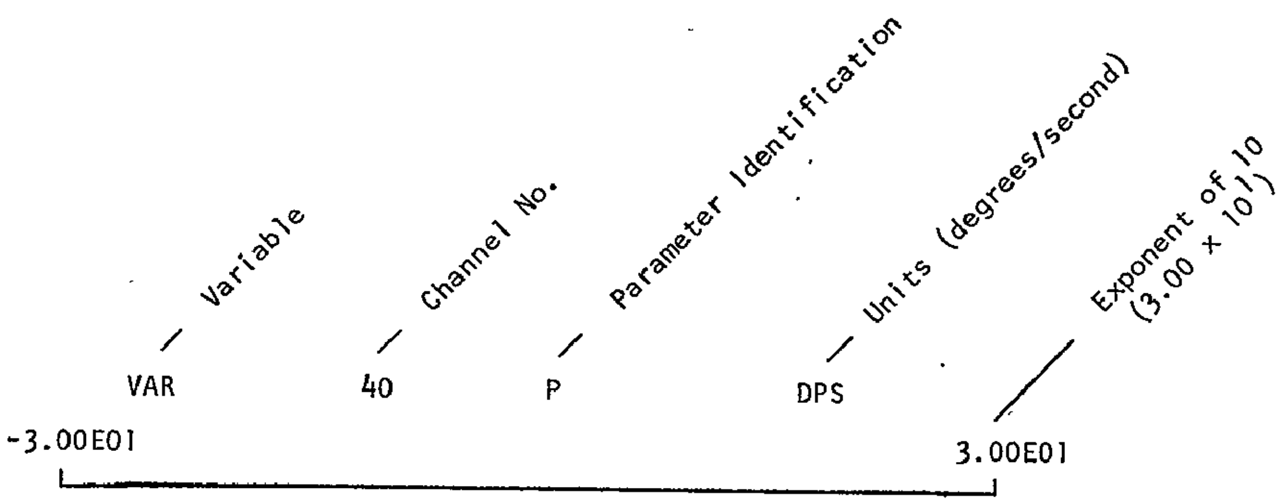
Appendix B contains the time-history plots generated during the quantitative flight test program. Section 1 contains aircraft responses to step control inputs in the roll and pitch axes, and section 2 contains aircraft dynamic responses. All plots were generated by the Boeing Company, Wichita, Kansas, at the request of KU-FRL.

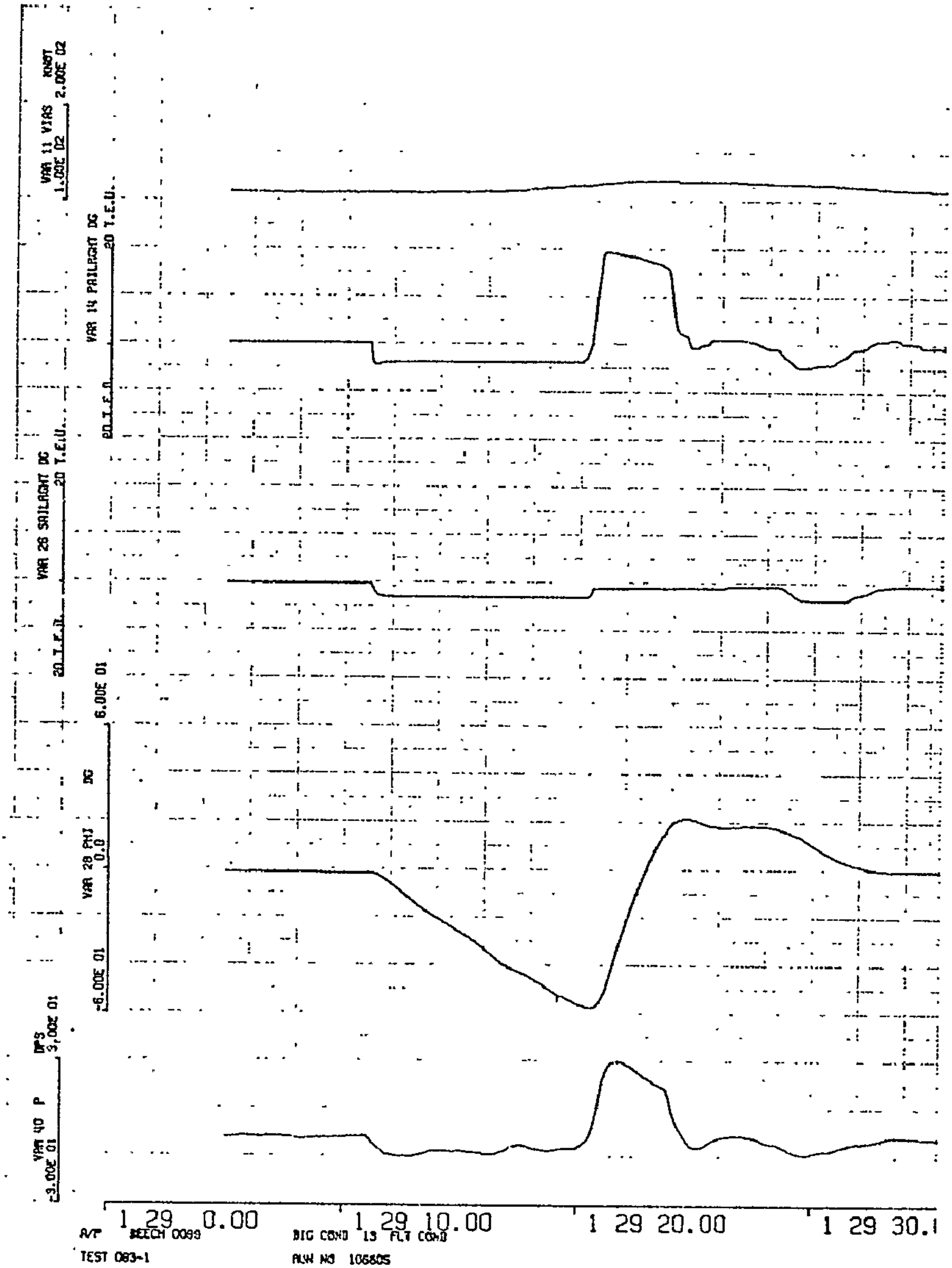
APPENDIX B - SECTION 1

AIRCRAFT RESPONSE TO STEP CONTROL INPUTS

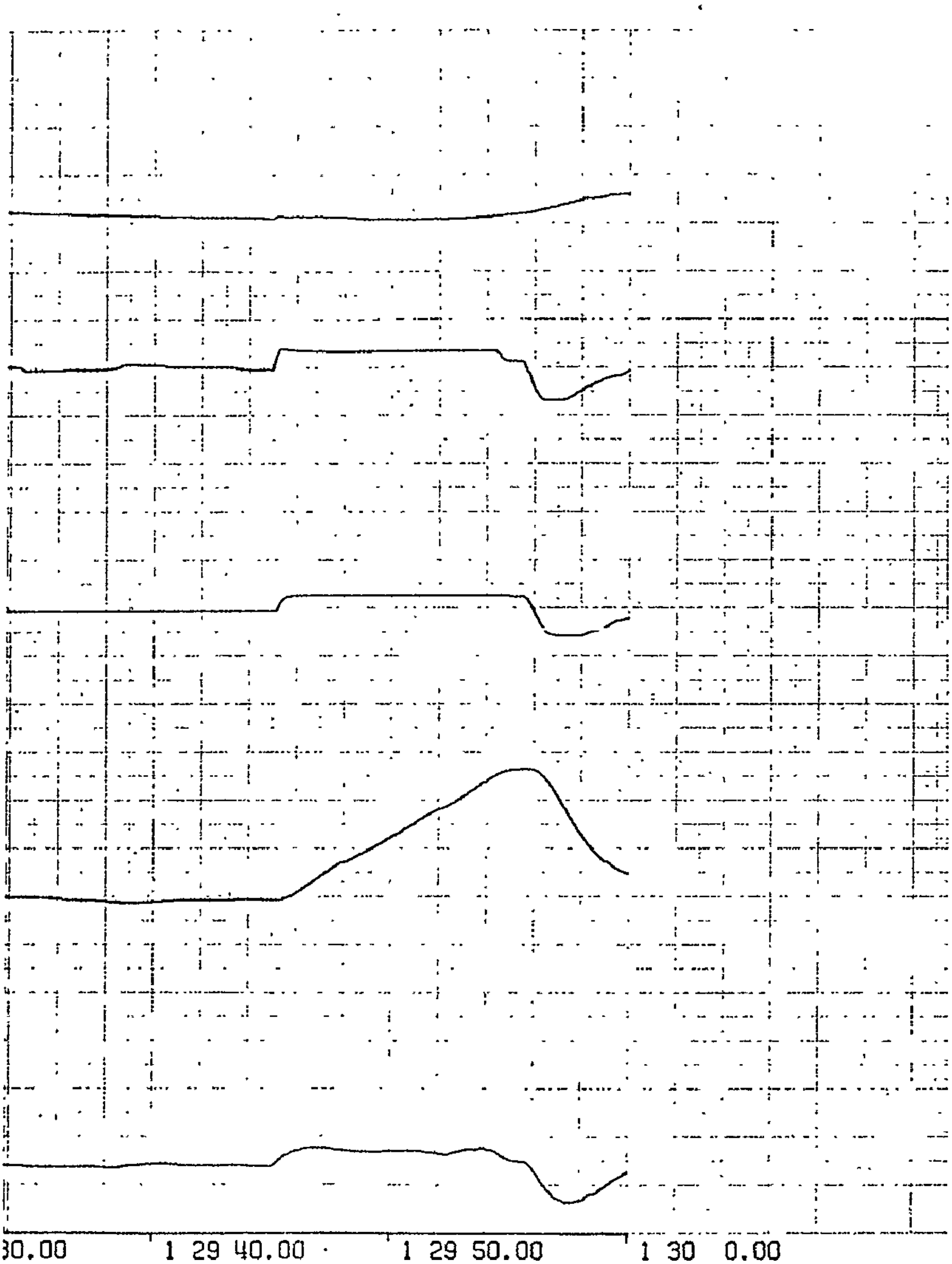
See Table 4.1 for parameter identification.

Computer printout scales may be read as follows:






Roll Response-Approach-Basic



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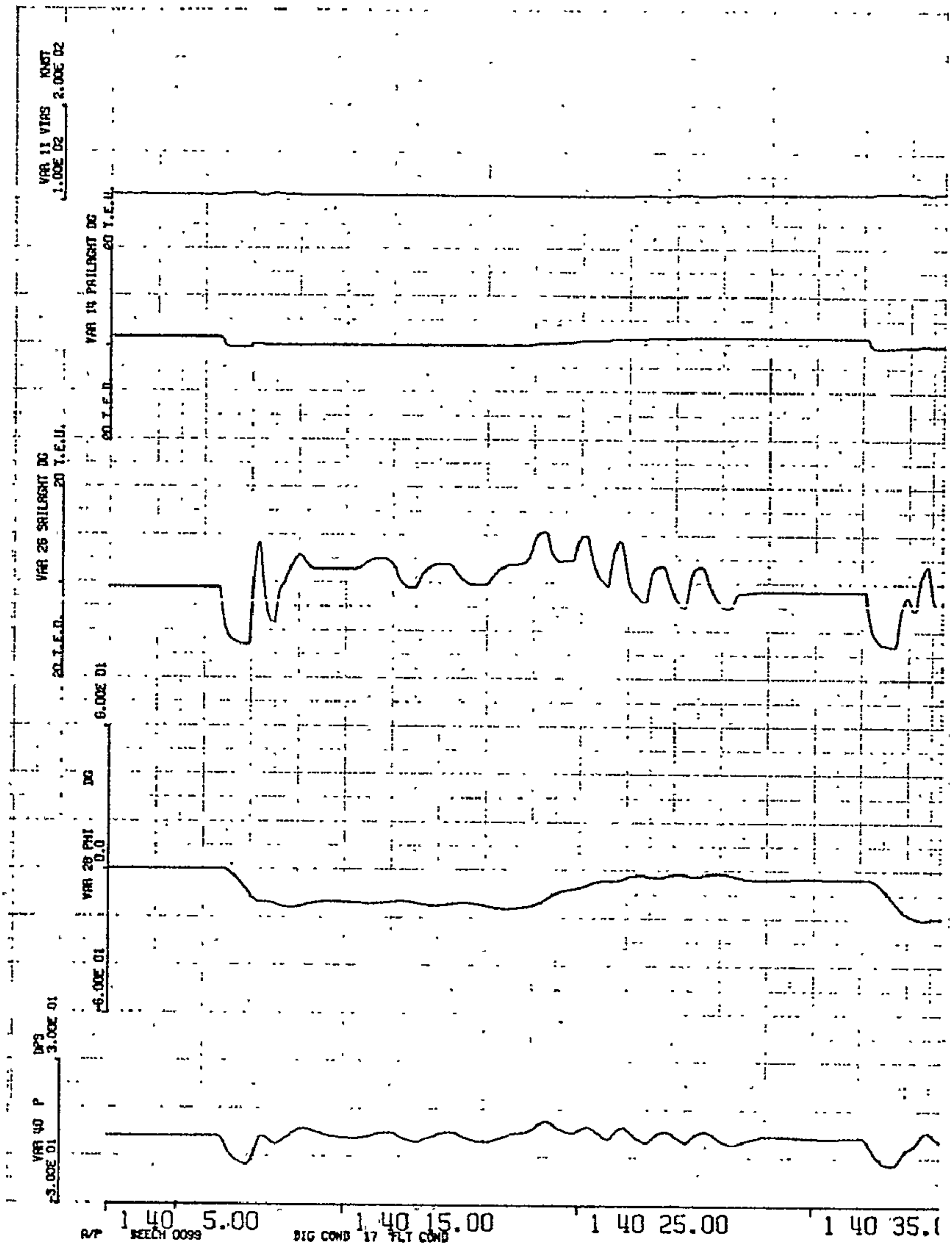
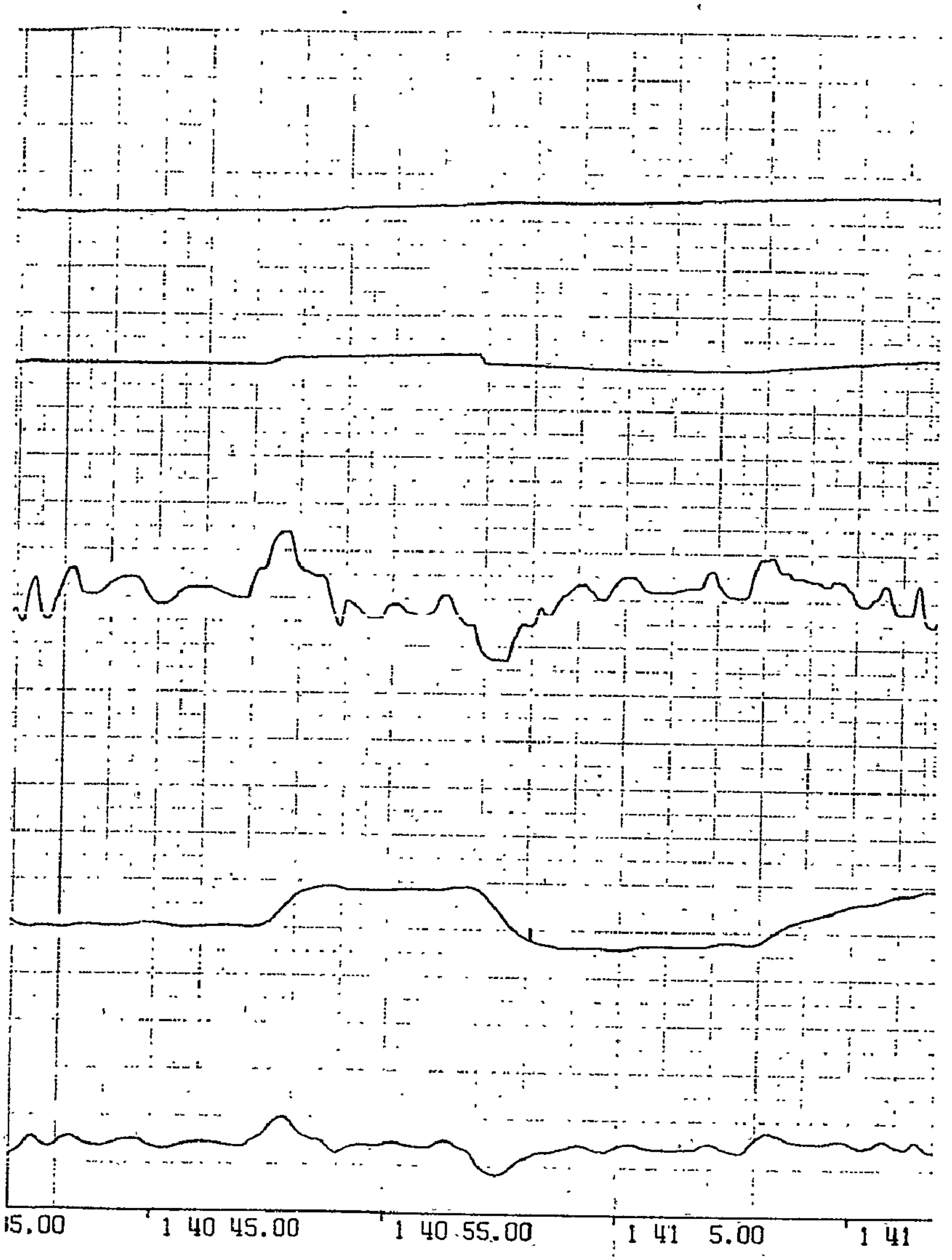



Roll Response-Approach-Command



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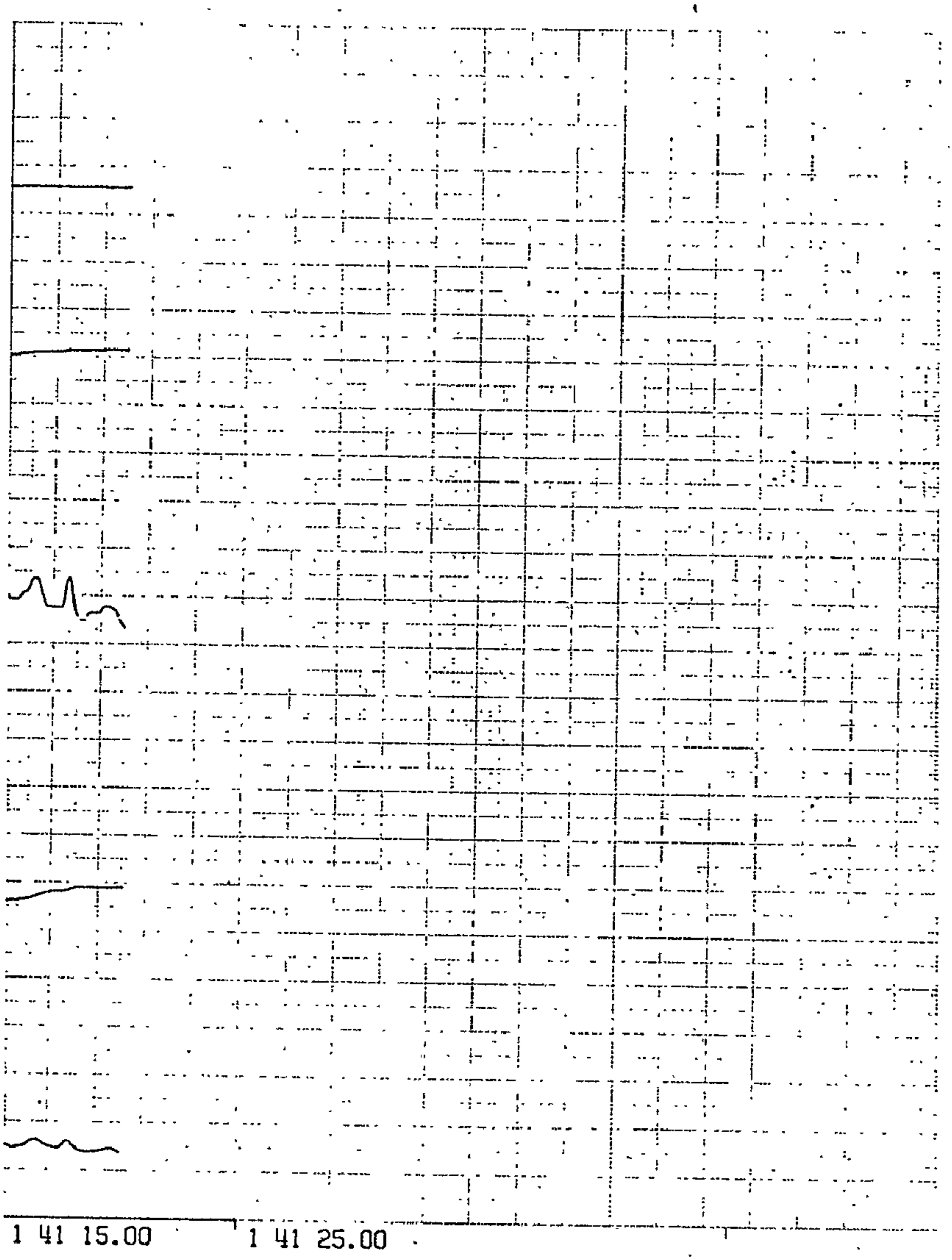
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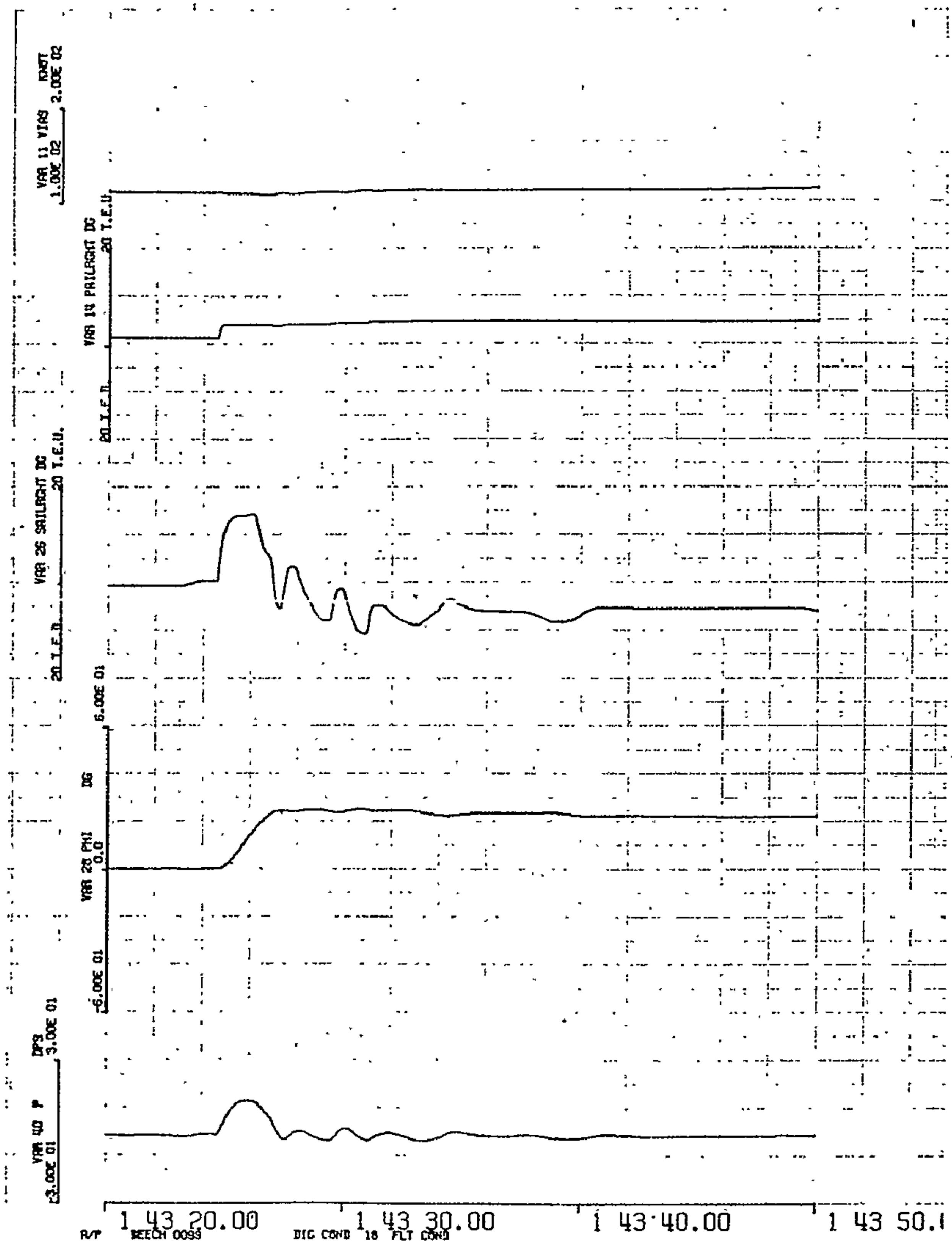
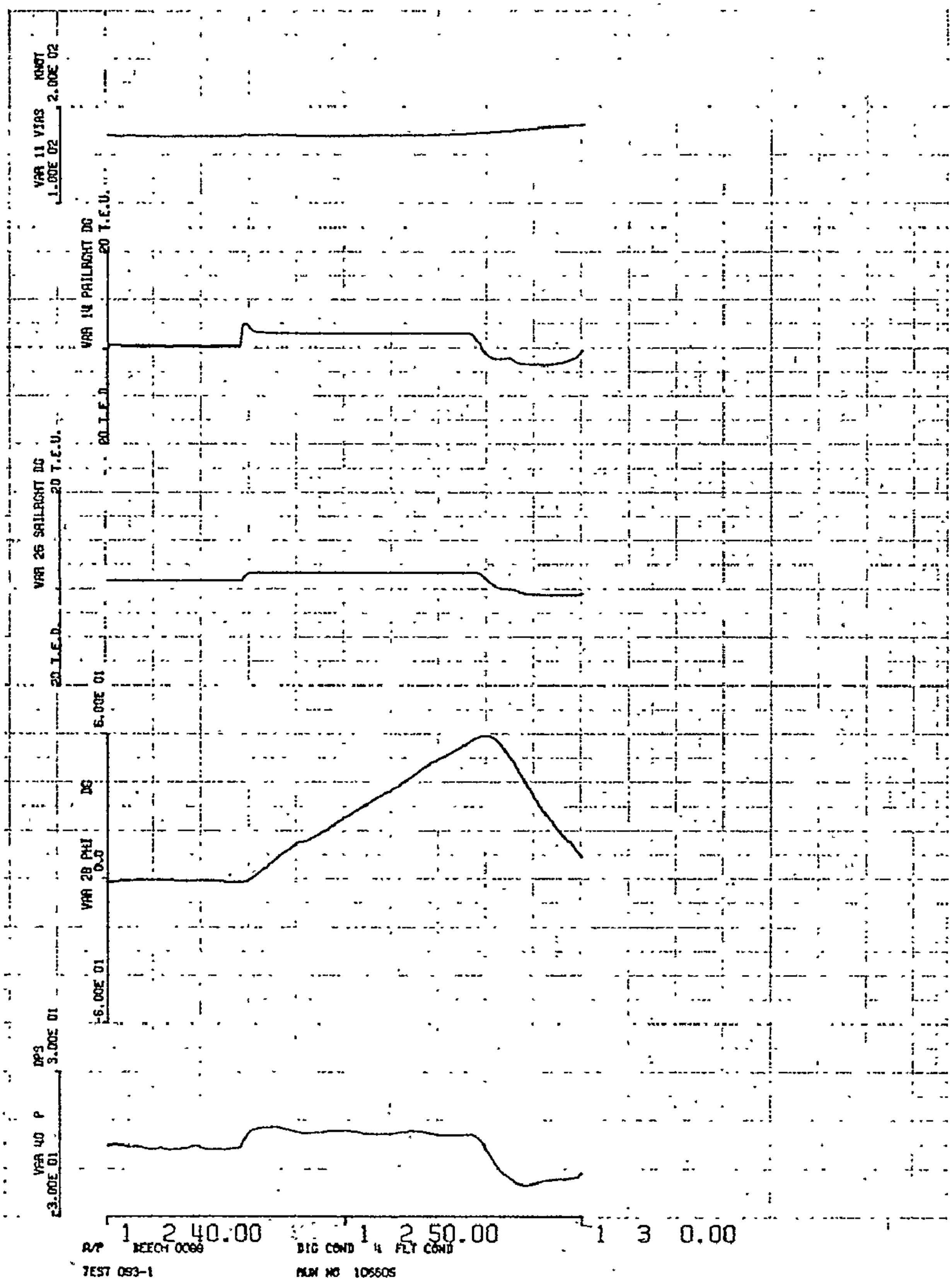
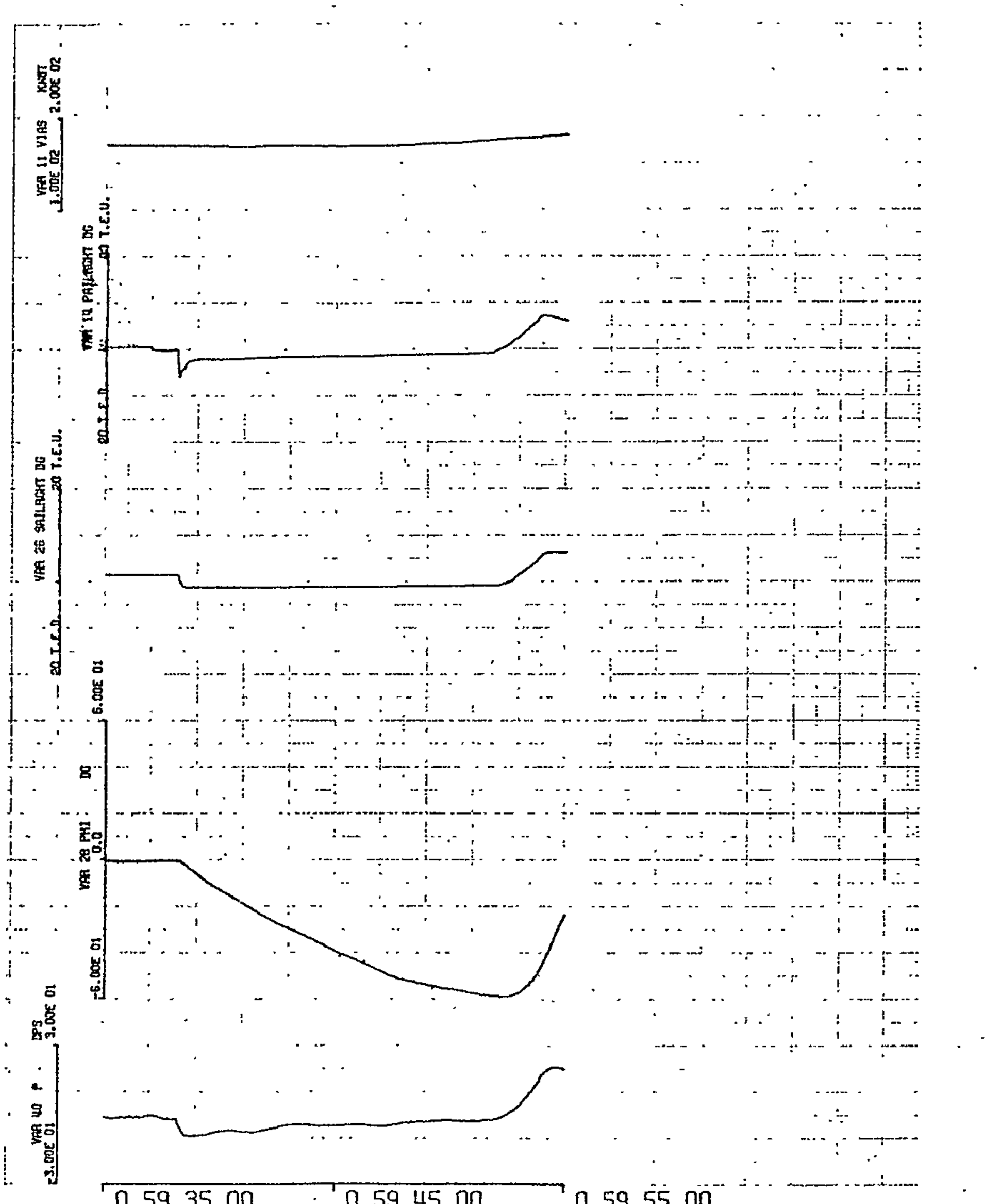



A/P BEECH 0033 DIG COND 18 FLT COND
TEST 003-1 RUN NO 106606
Roll Response-Approach-Command PLOT FORMAT 15




Roll Response- Cruise-Basic

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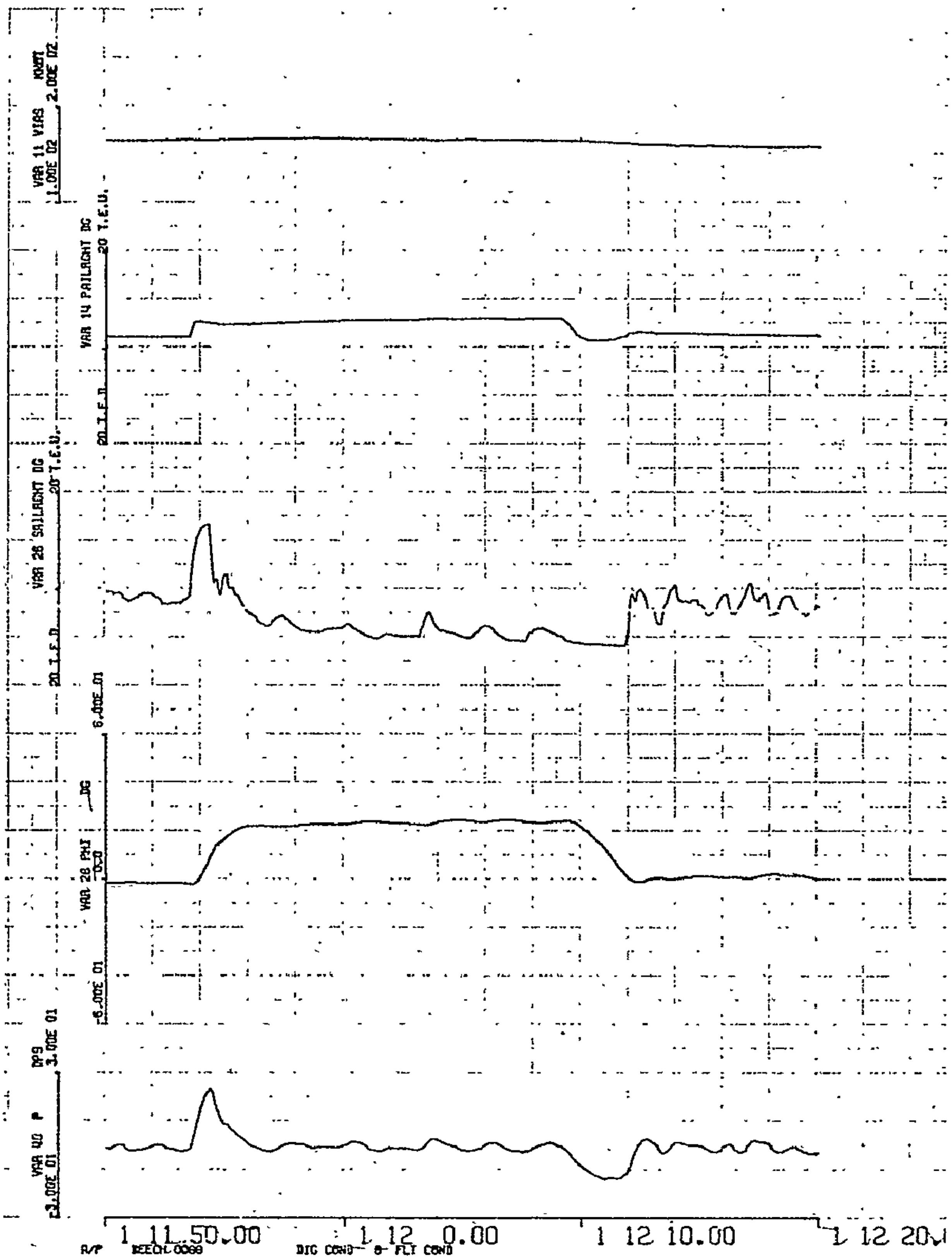
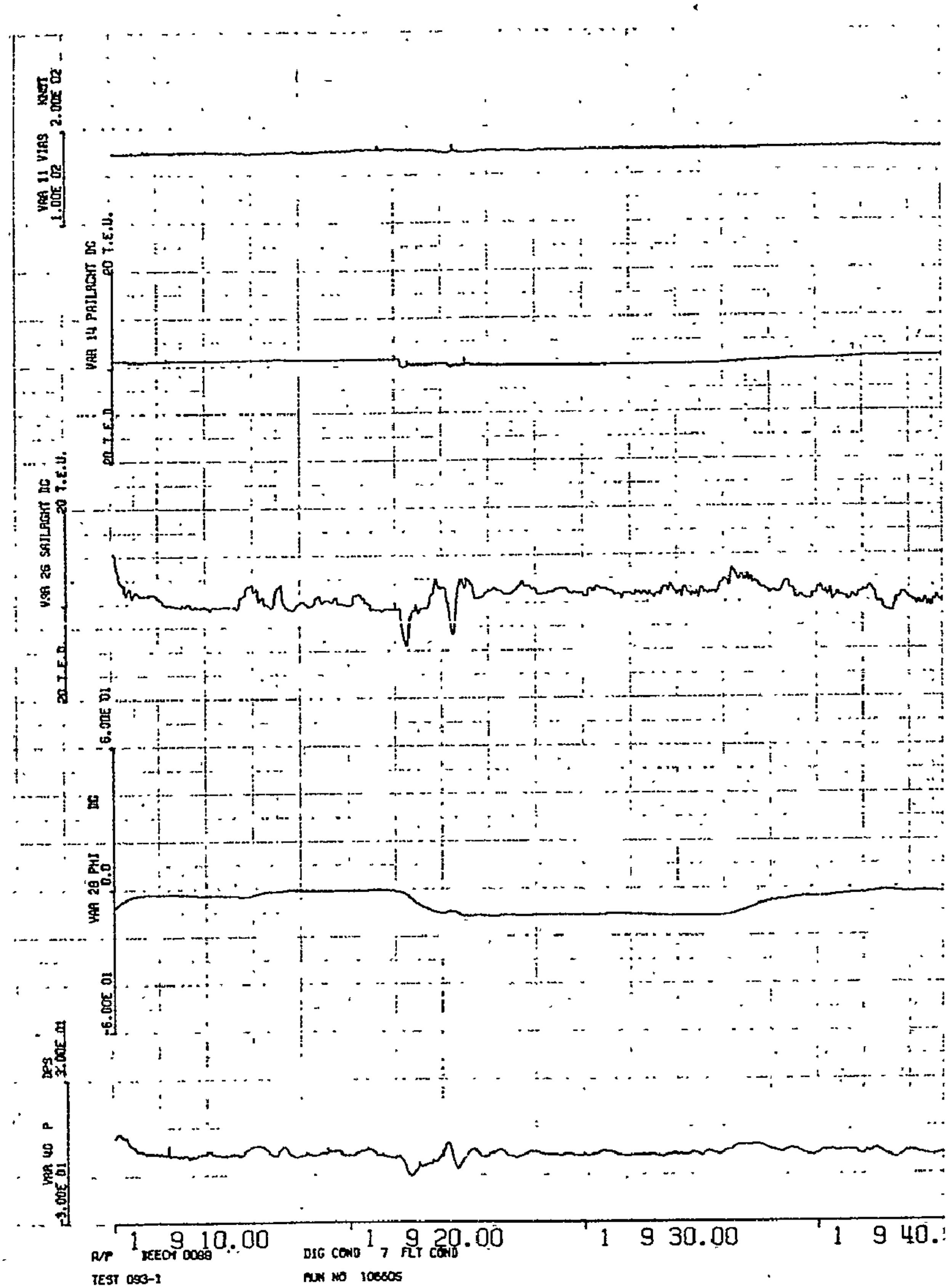
TEST 093-1 RUN NO 10660S

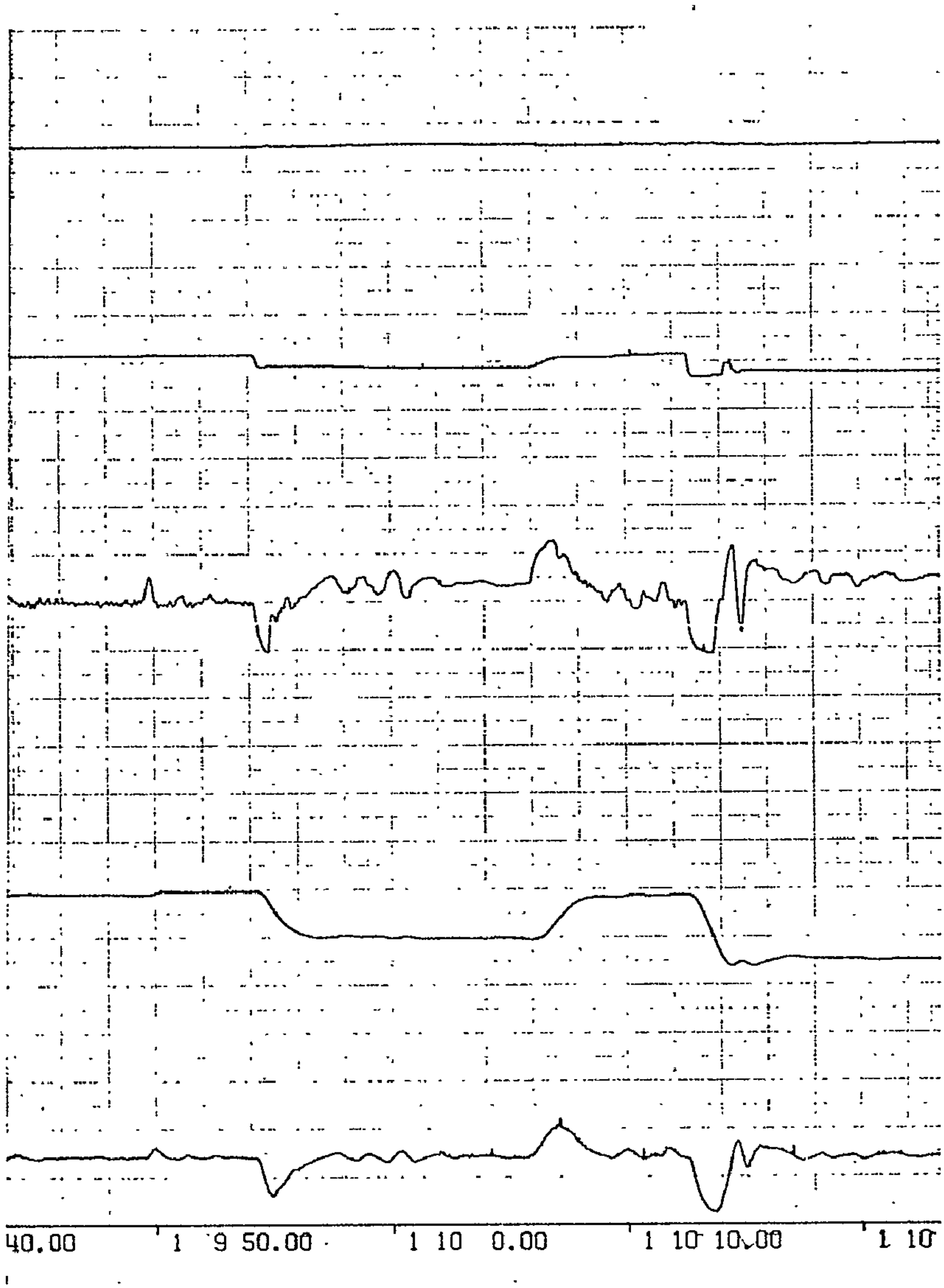
Roll Response-Cruise-Basic PLOT FORMAT 15



A/P BEECH 0088 DIG COND 8 FLT COND
TEST C93-1 RUN NO 10660S
Roll Response-Cruise-Command PLOT FORMAT 15




Roll Response-Cruise-Command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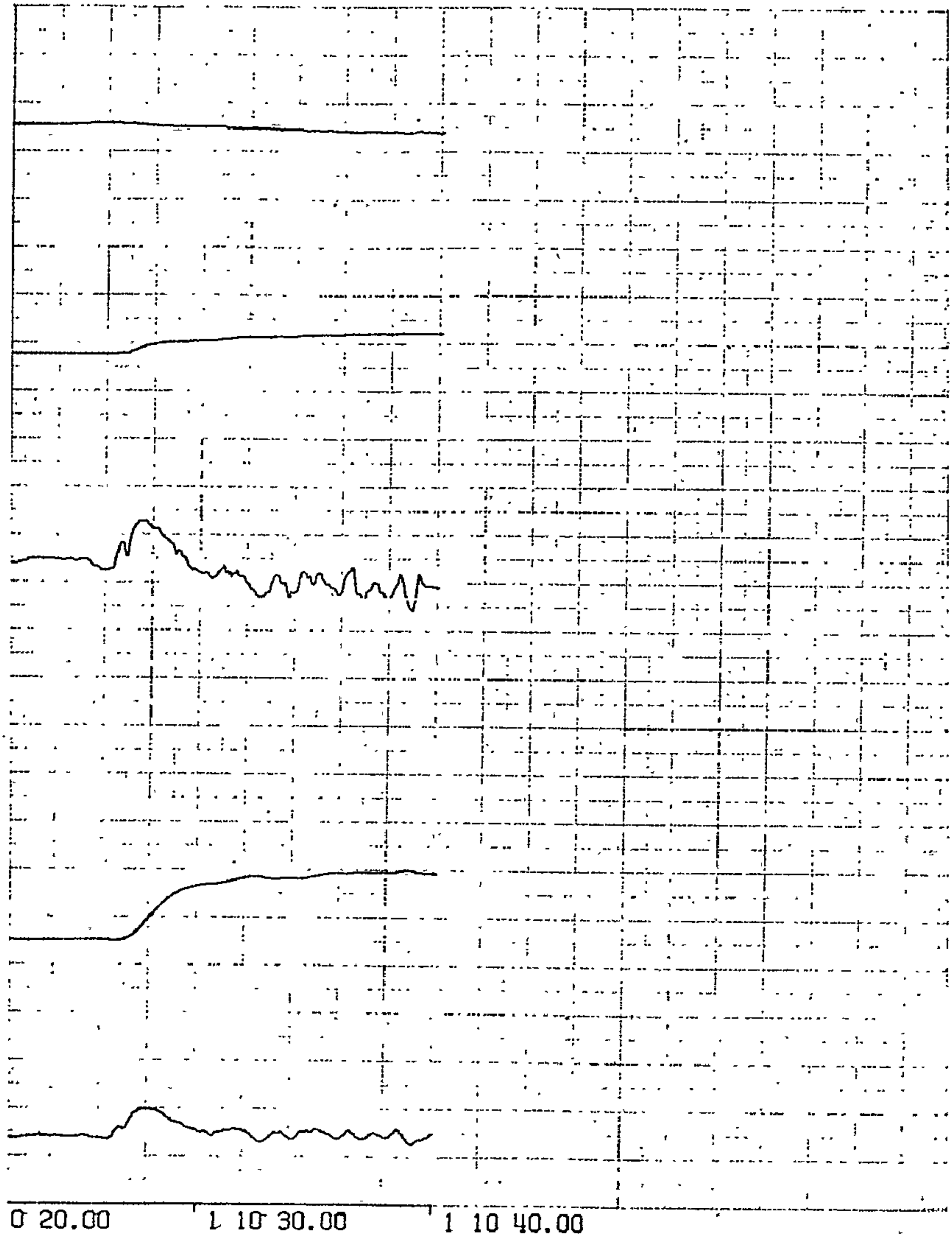
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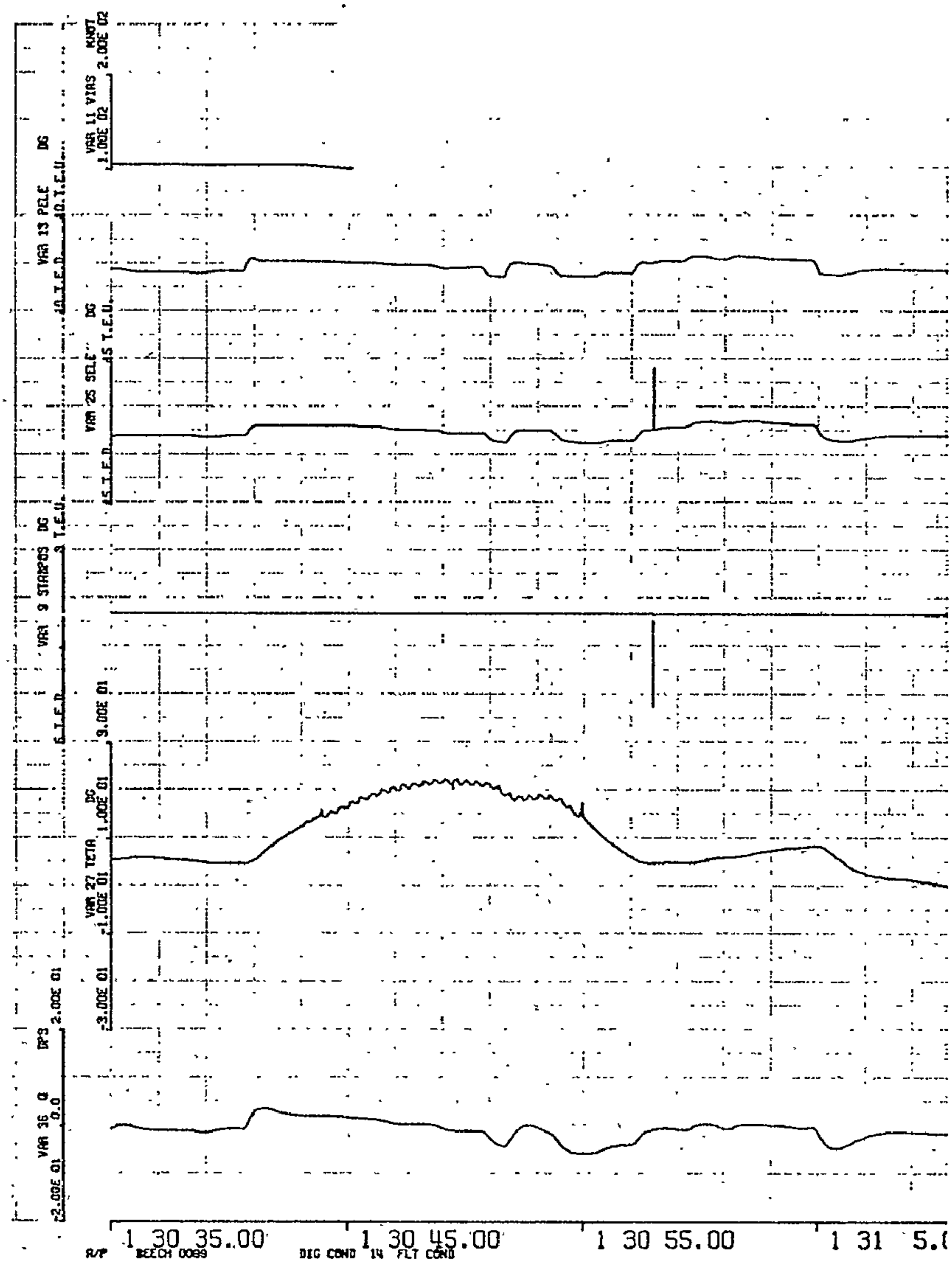
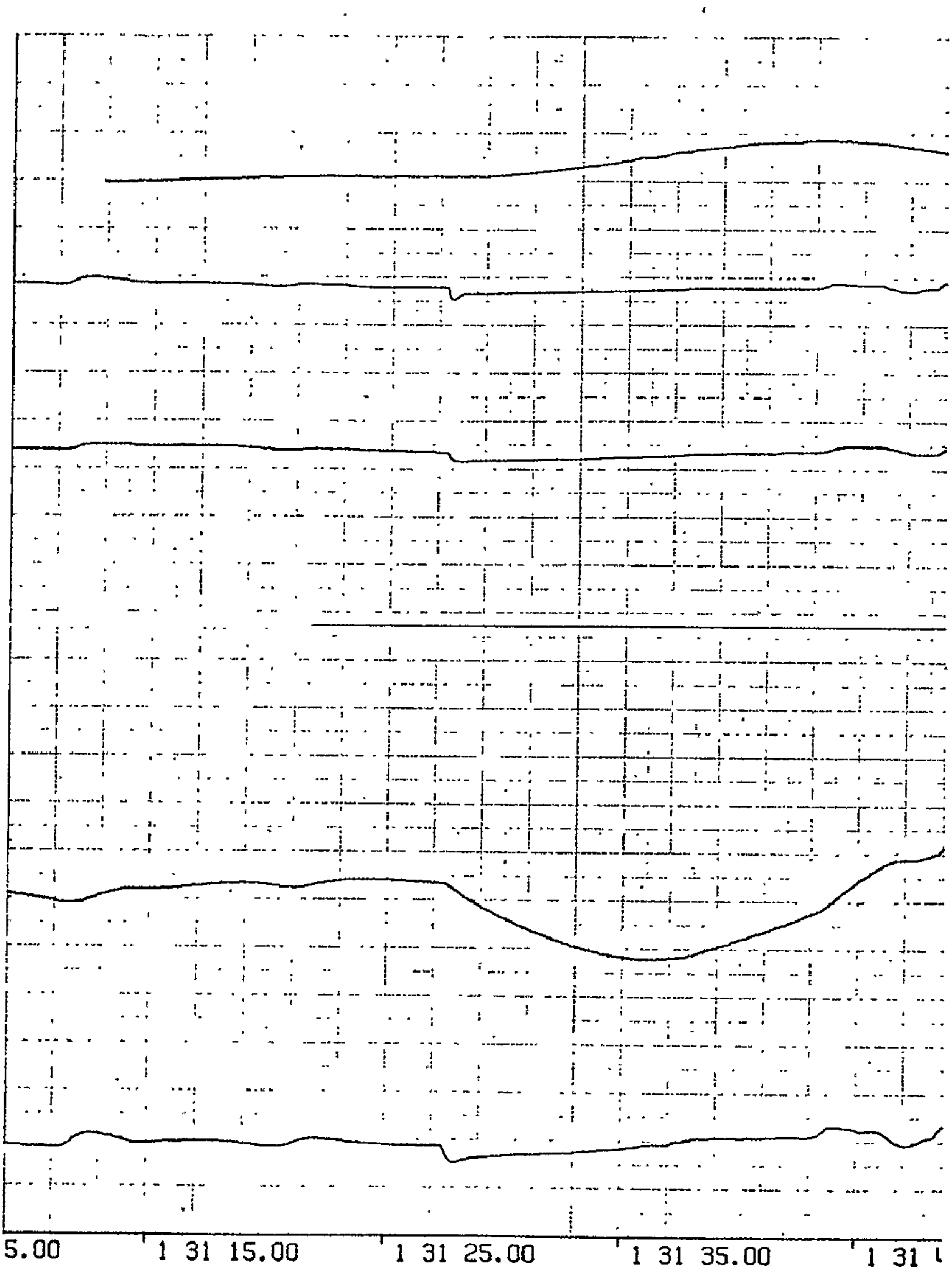


Elevator Step-Approach-Basic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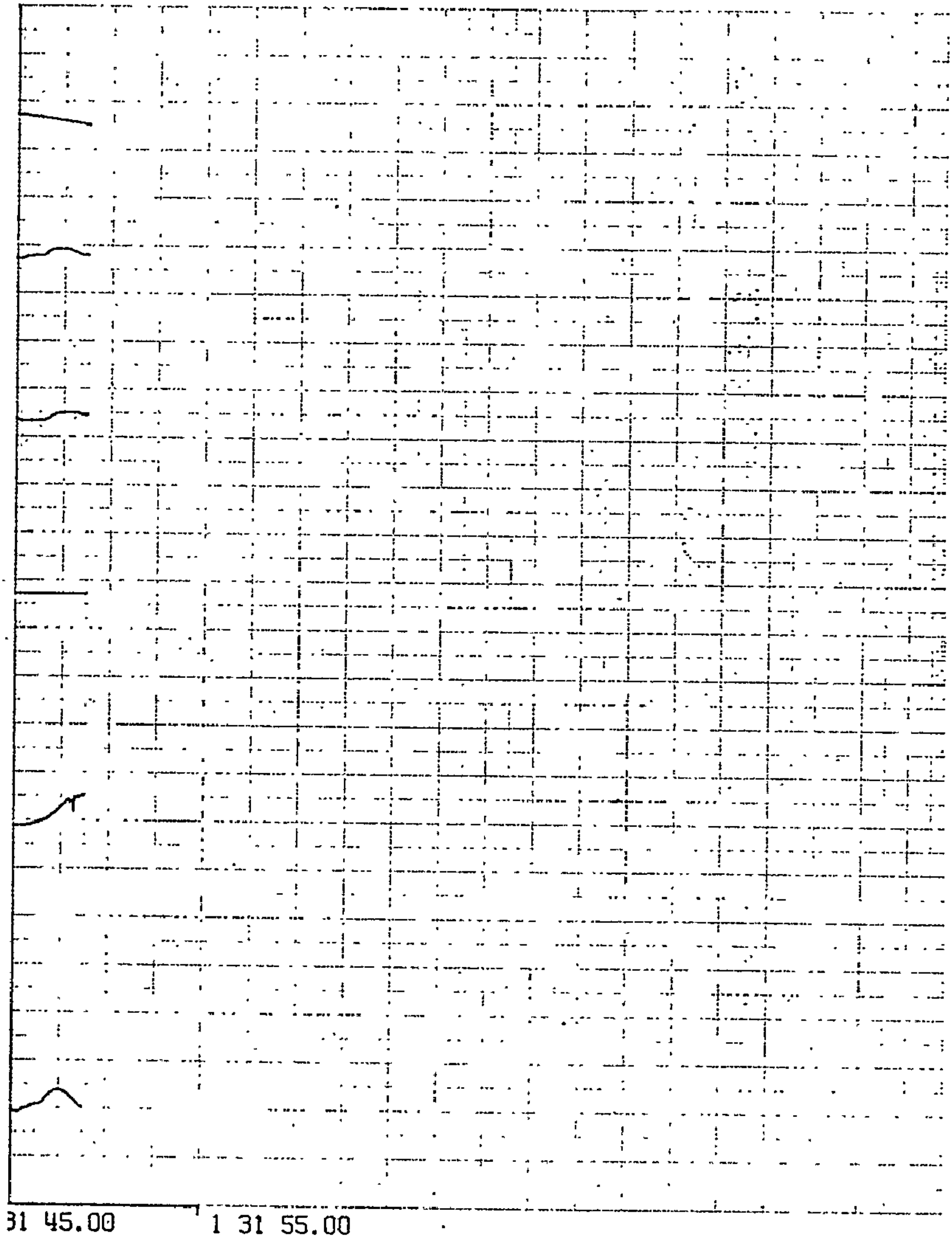

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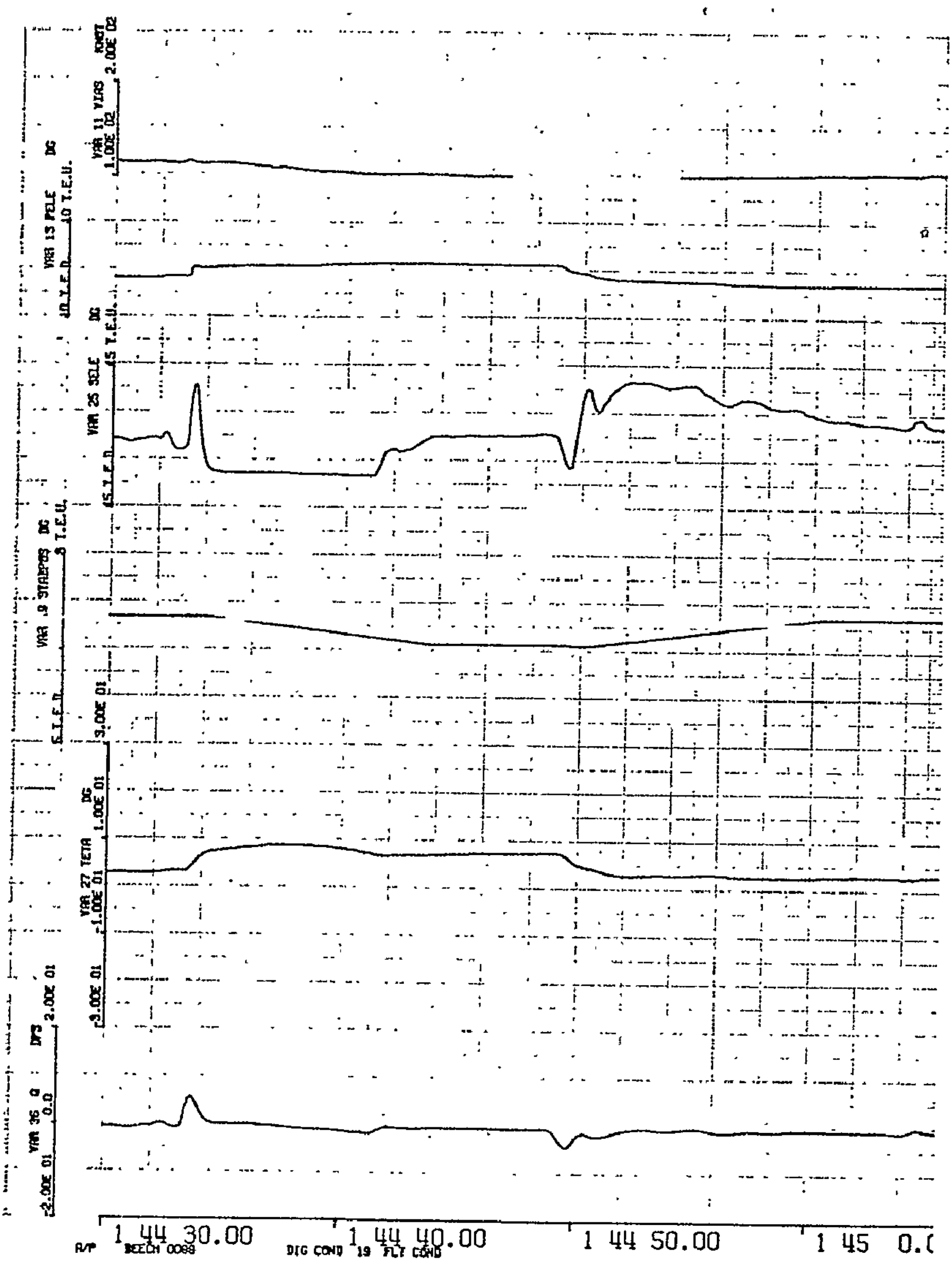
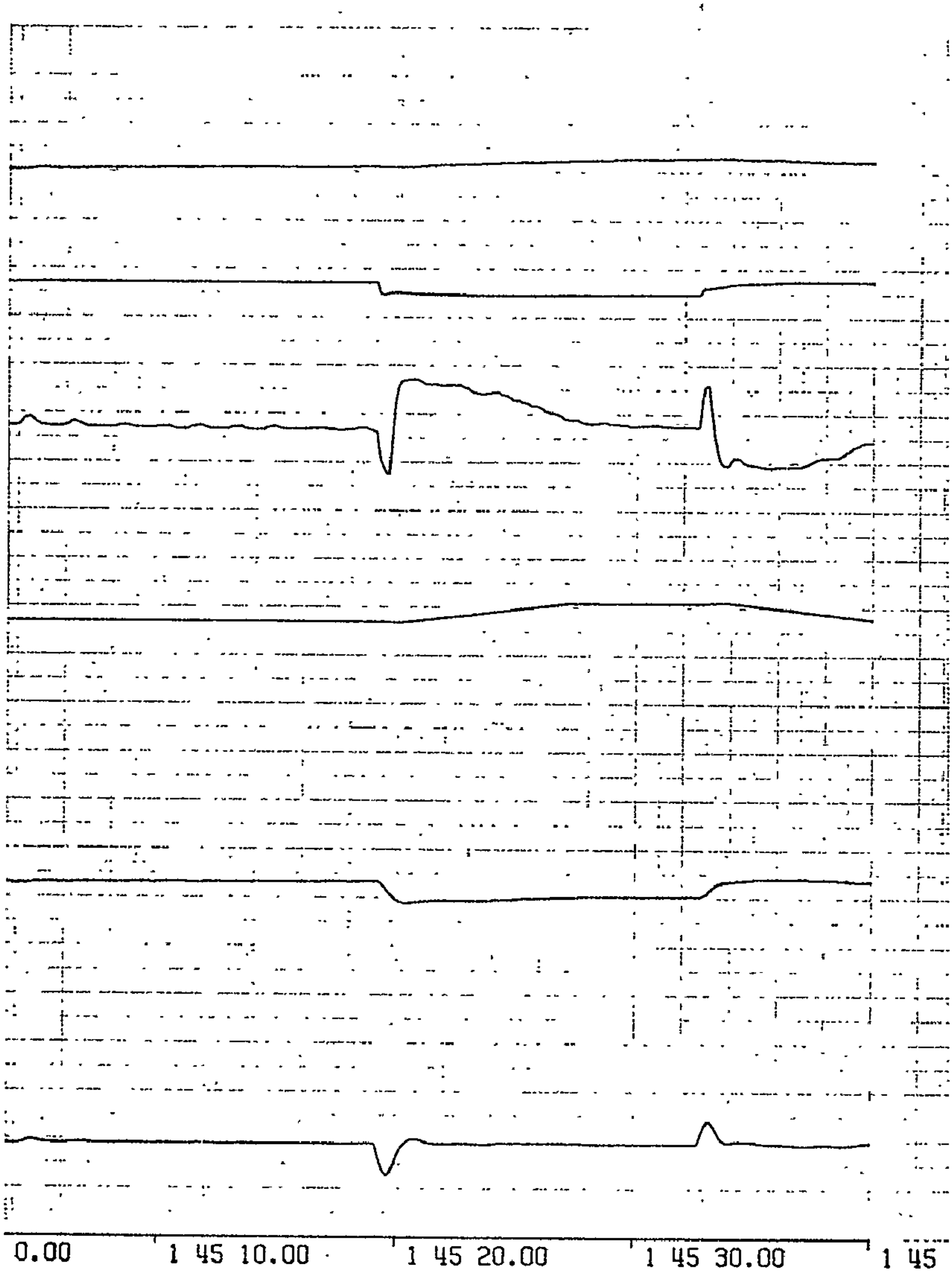



A/P BEECH 0089 DIG COND 19 FLT COND
TEST 083-1 RUN NO 108508
Elevator Step-Approach-Command PLOT FORMAT 14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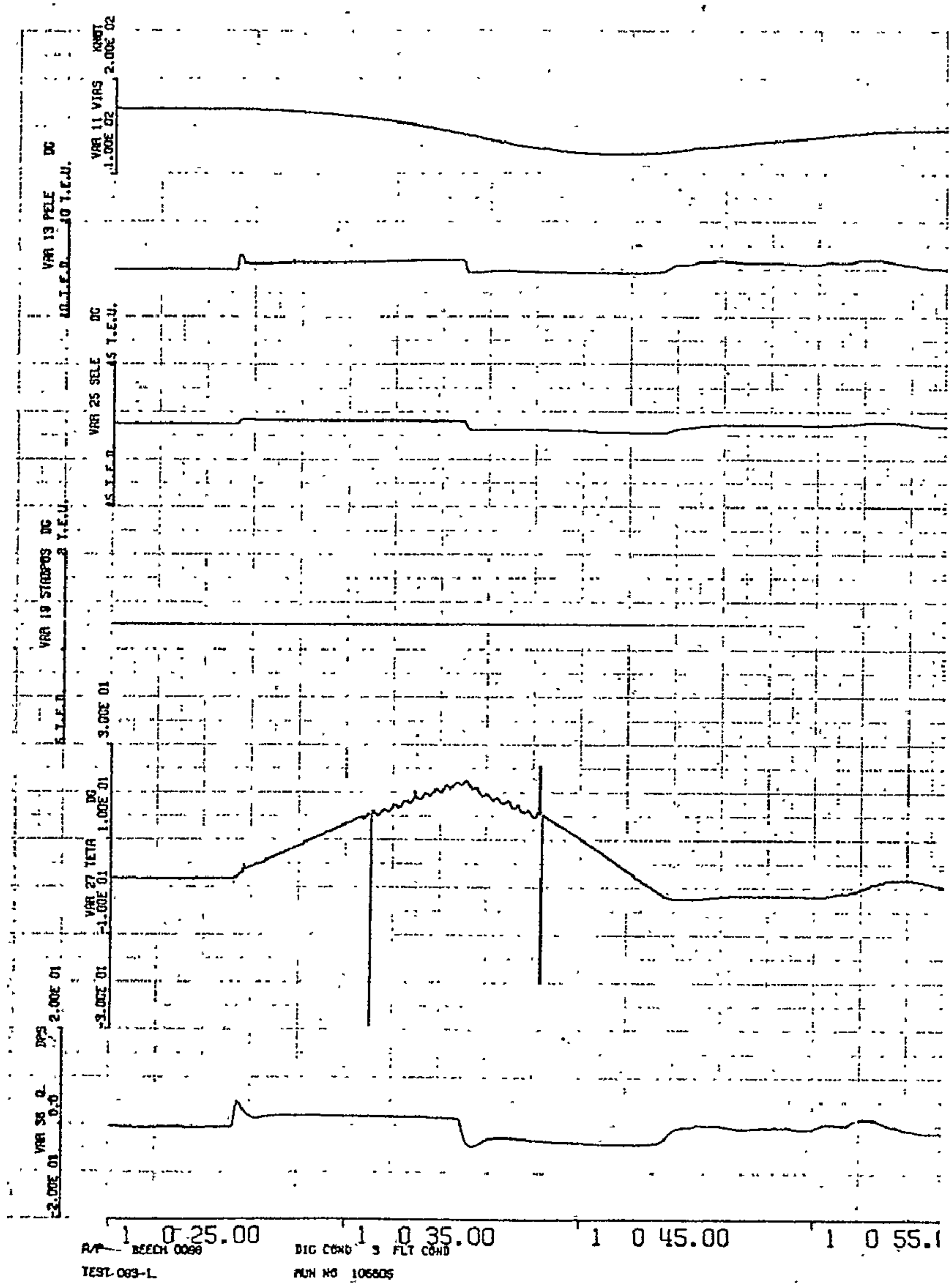
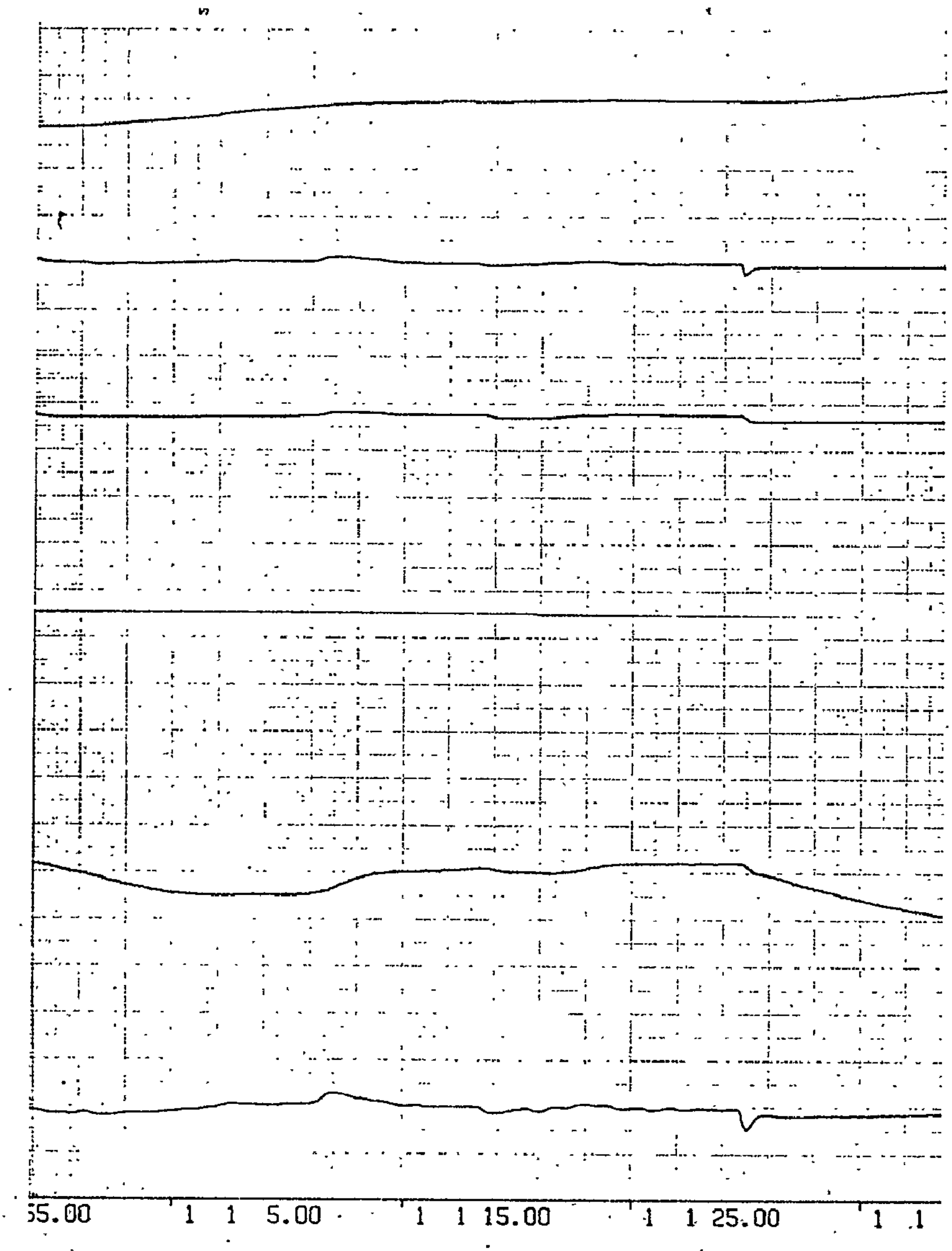


El evator Step Response-Cruise -Basic



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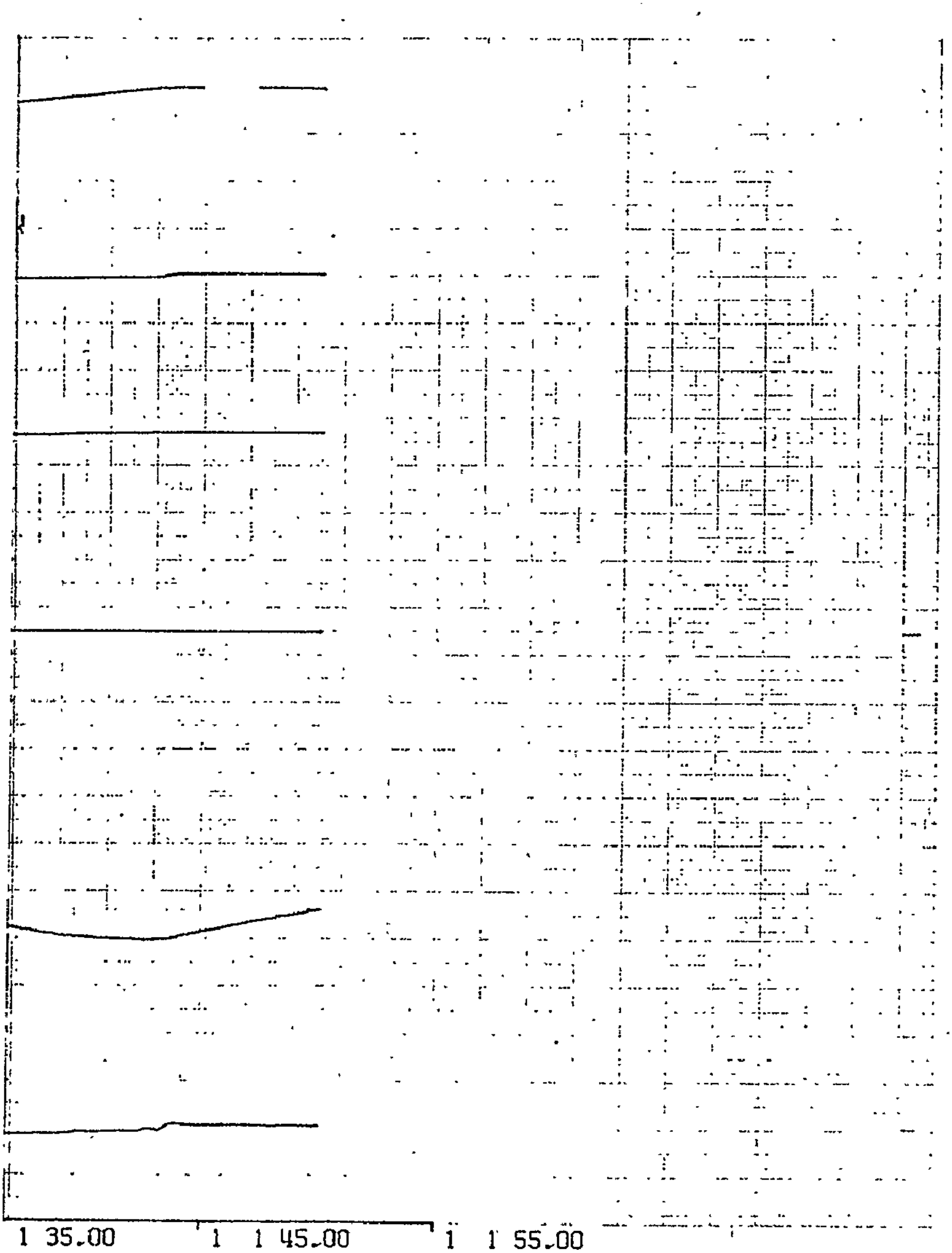
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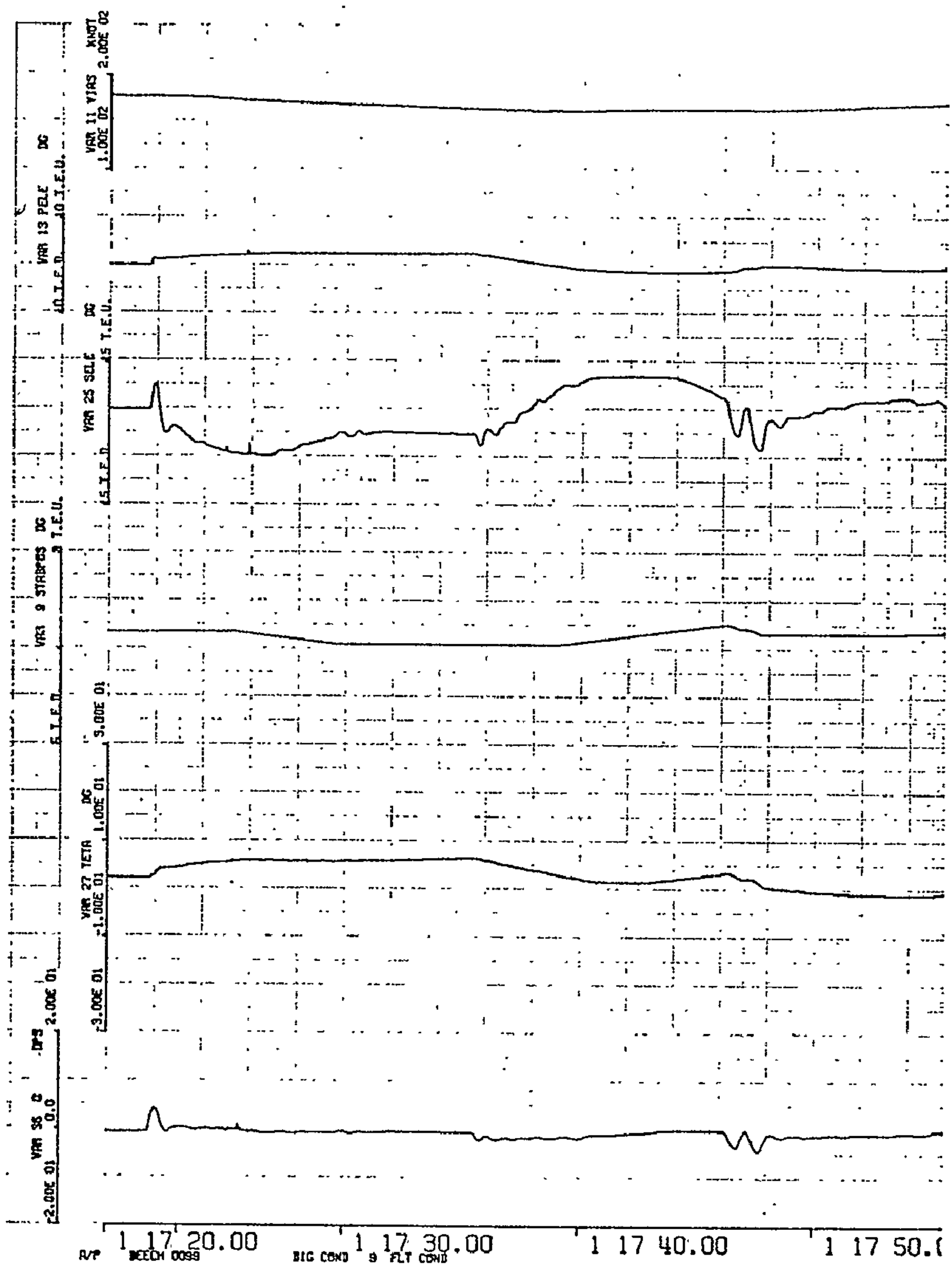
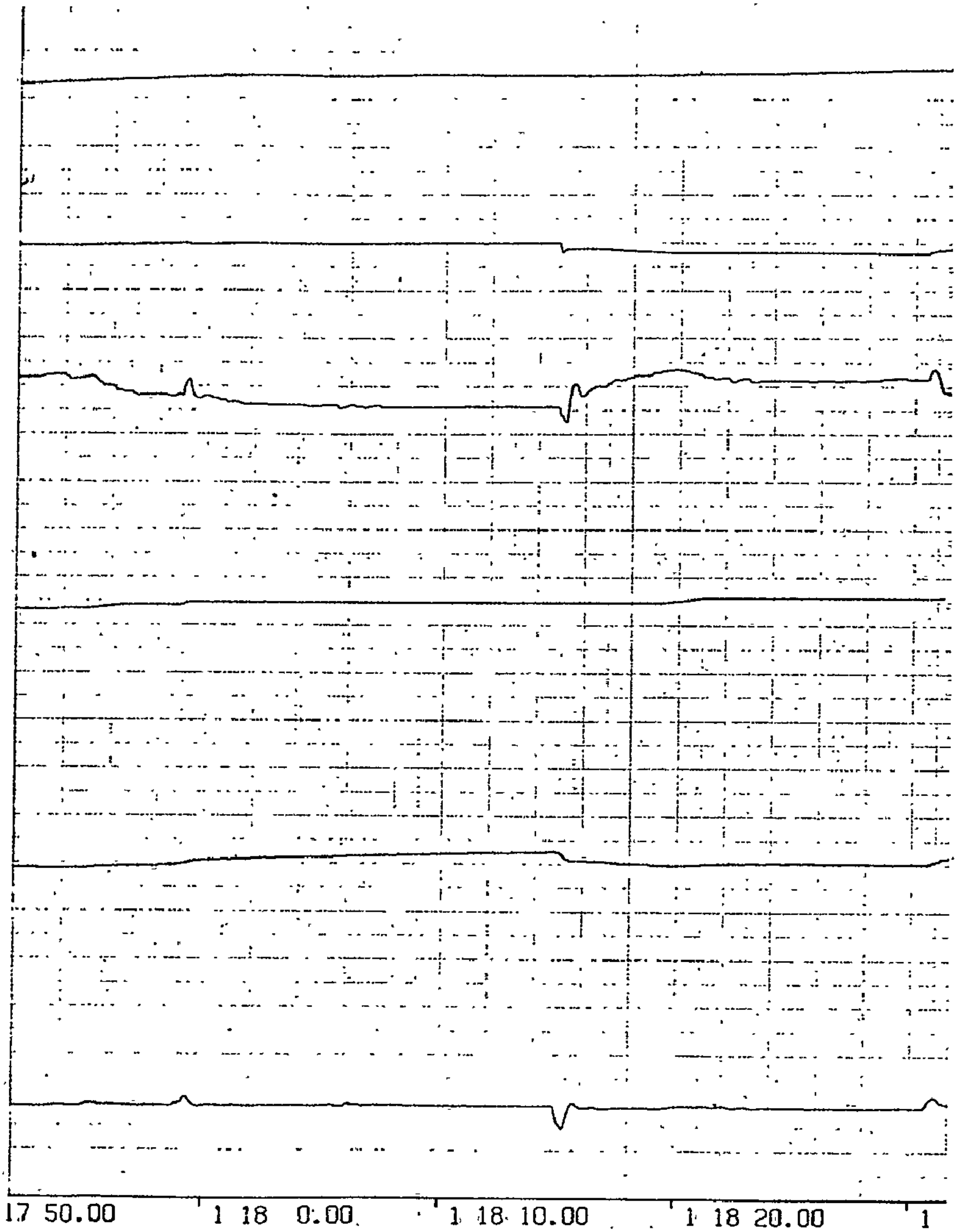



A/P BEECH 0099 BIG COND 9 FLT COND

TEST 093-1 RUN NO 10660S

Elevator Step-Cruise-Command PLOT FORMAT 14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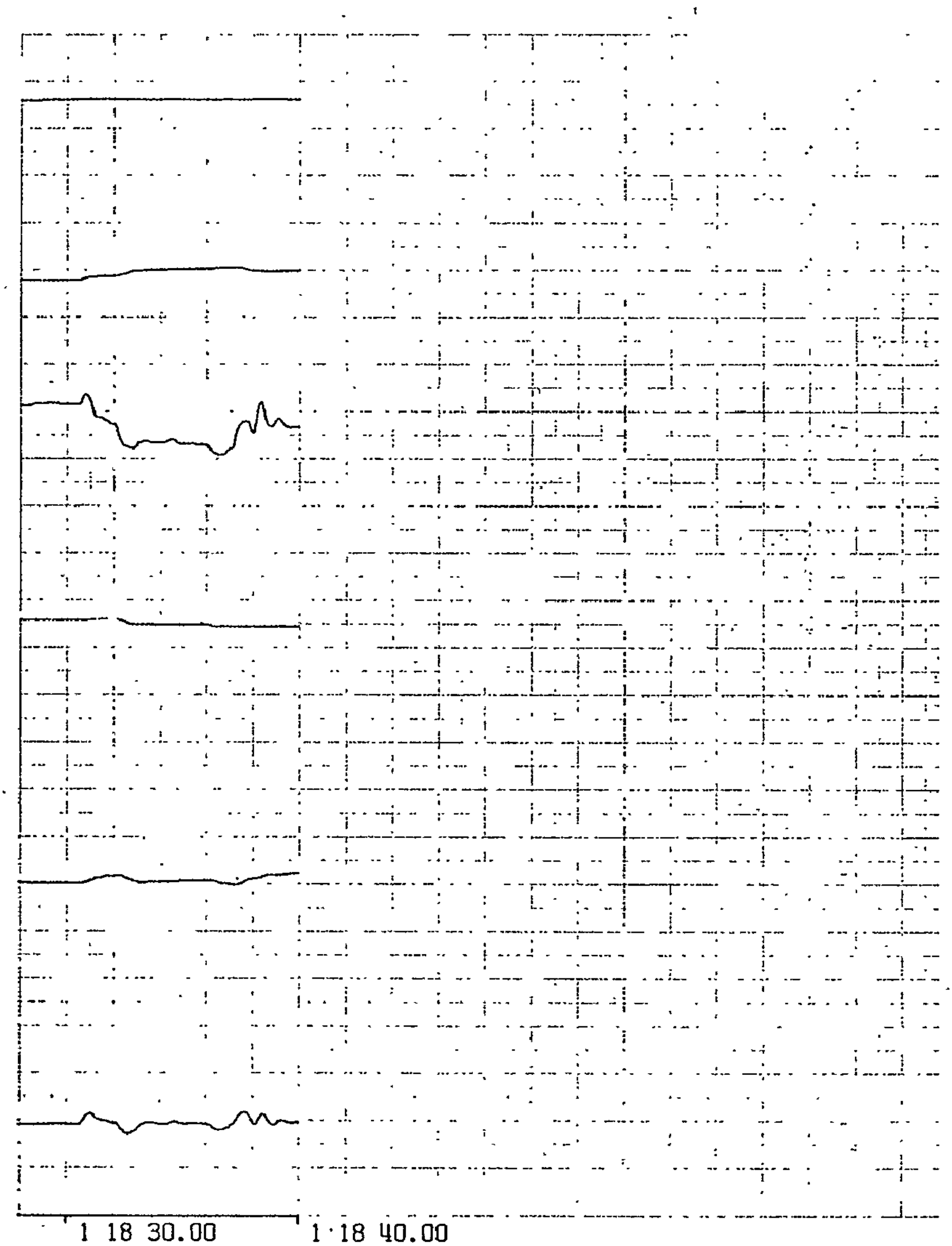
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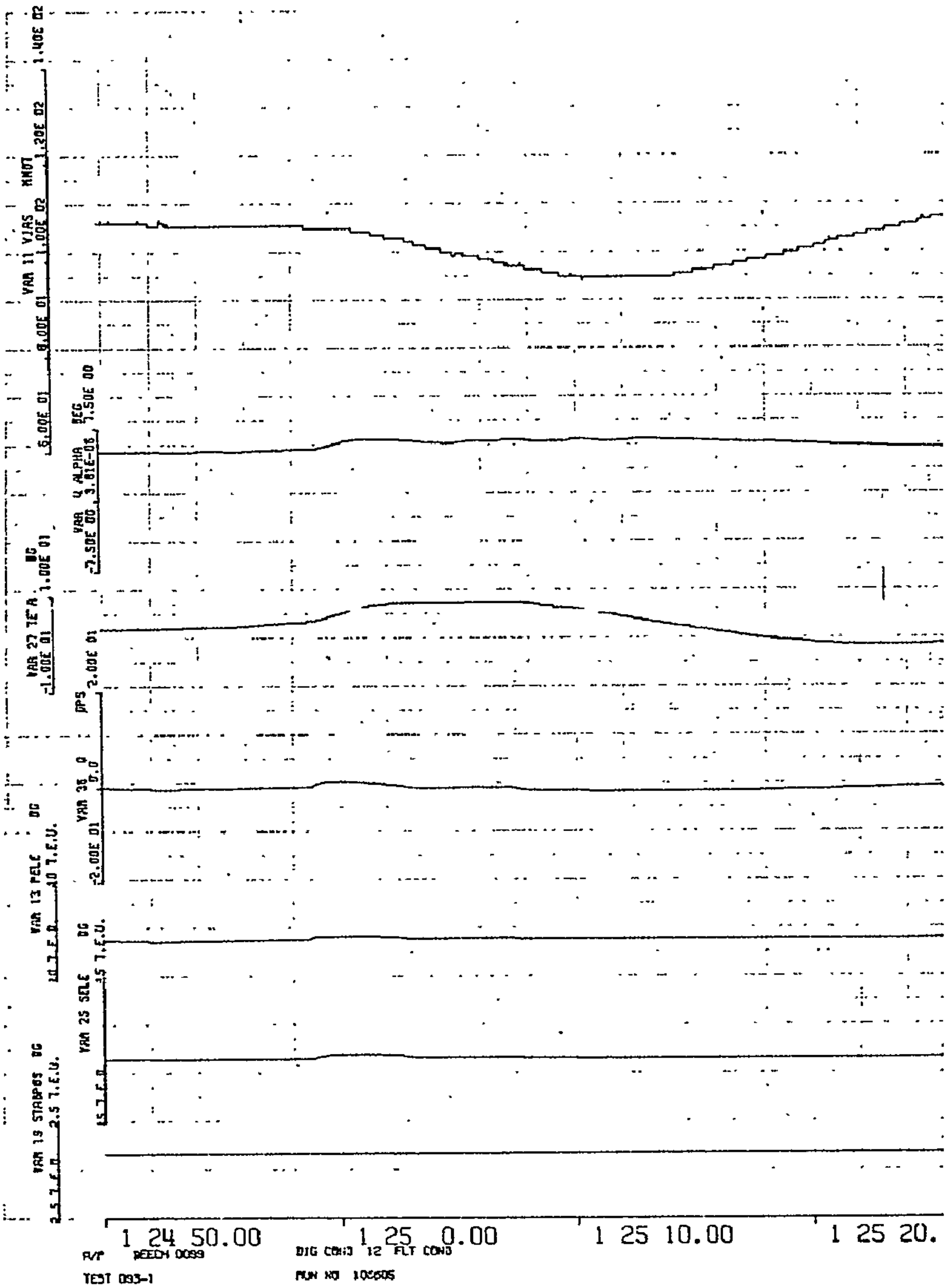
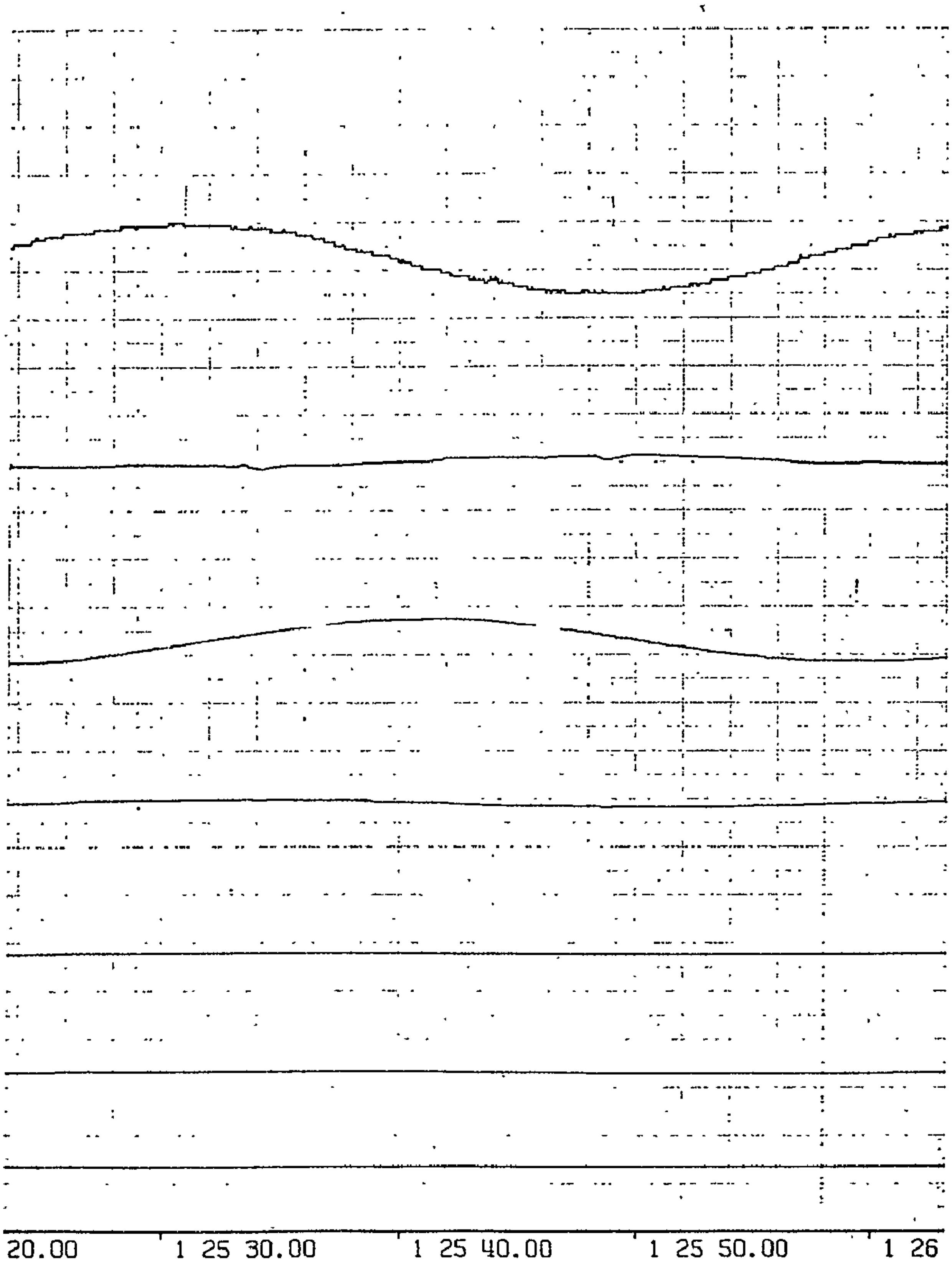
APPENDIX B - SECTION 2

AIRCRAFT DYNAMIC RESPONSES



Phugoid-Approach-Basic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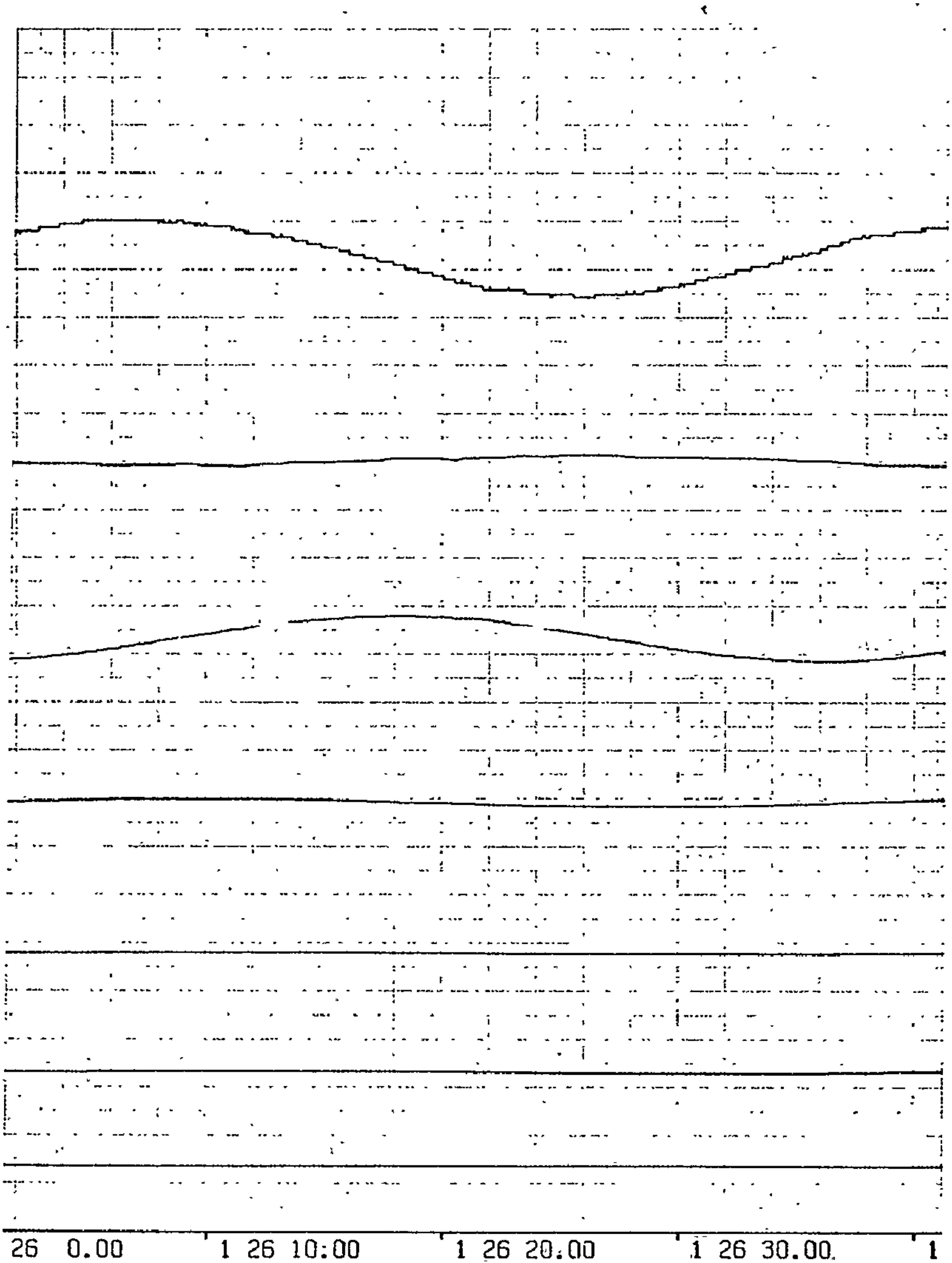
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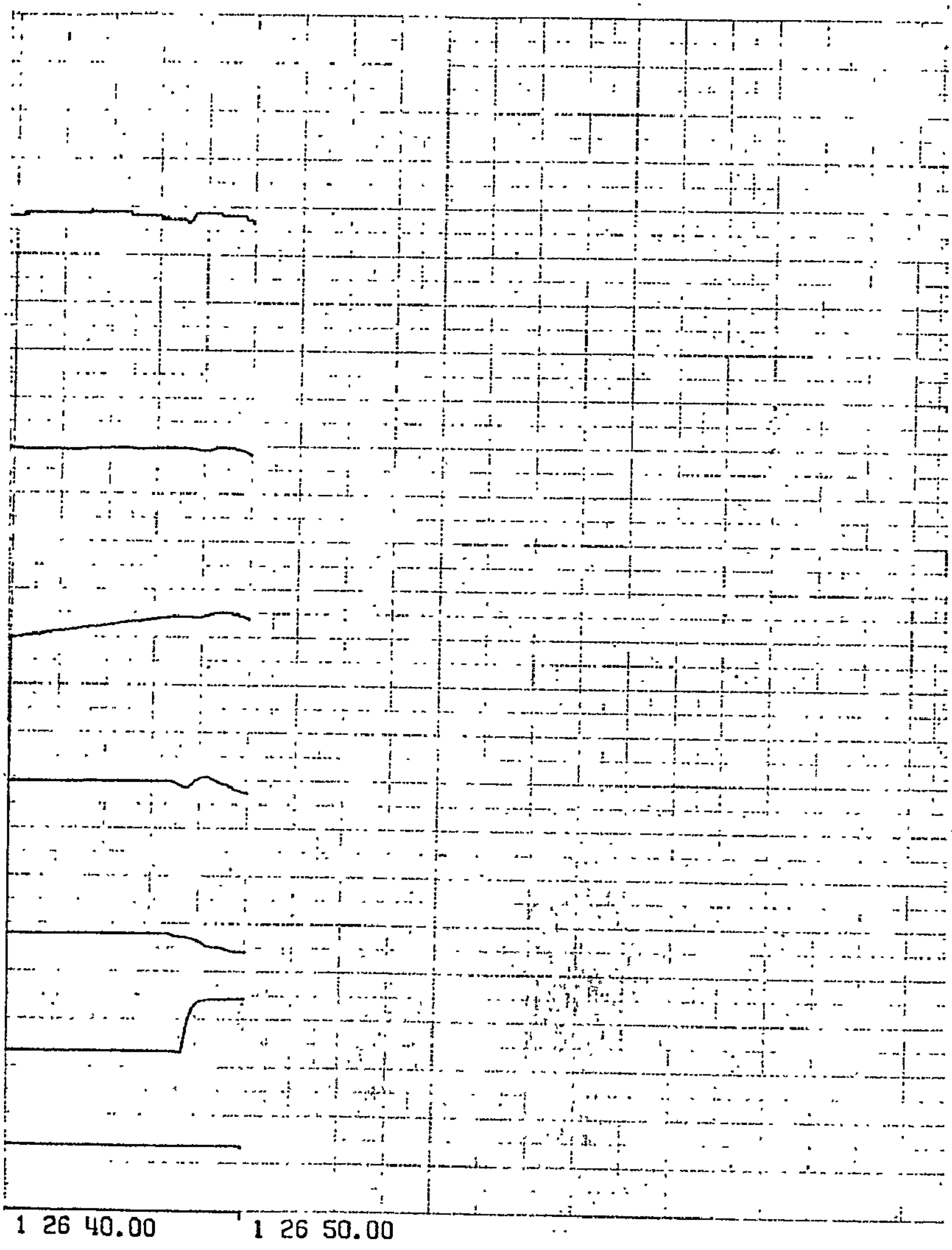
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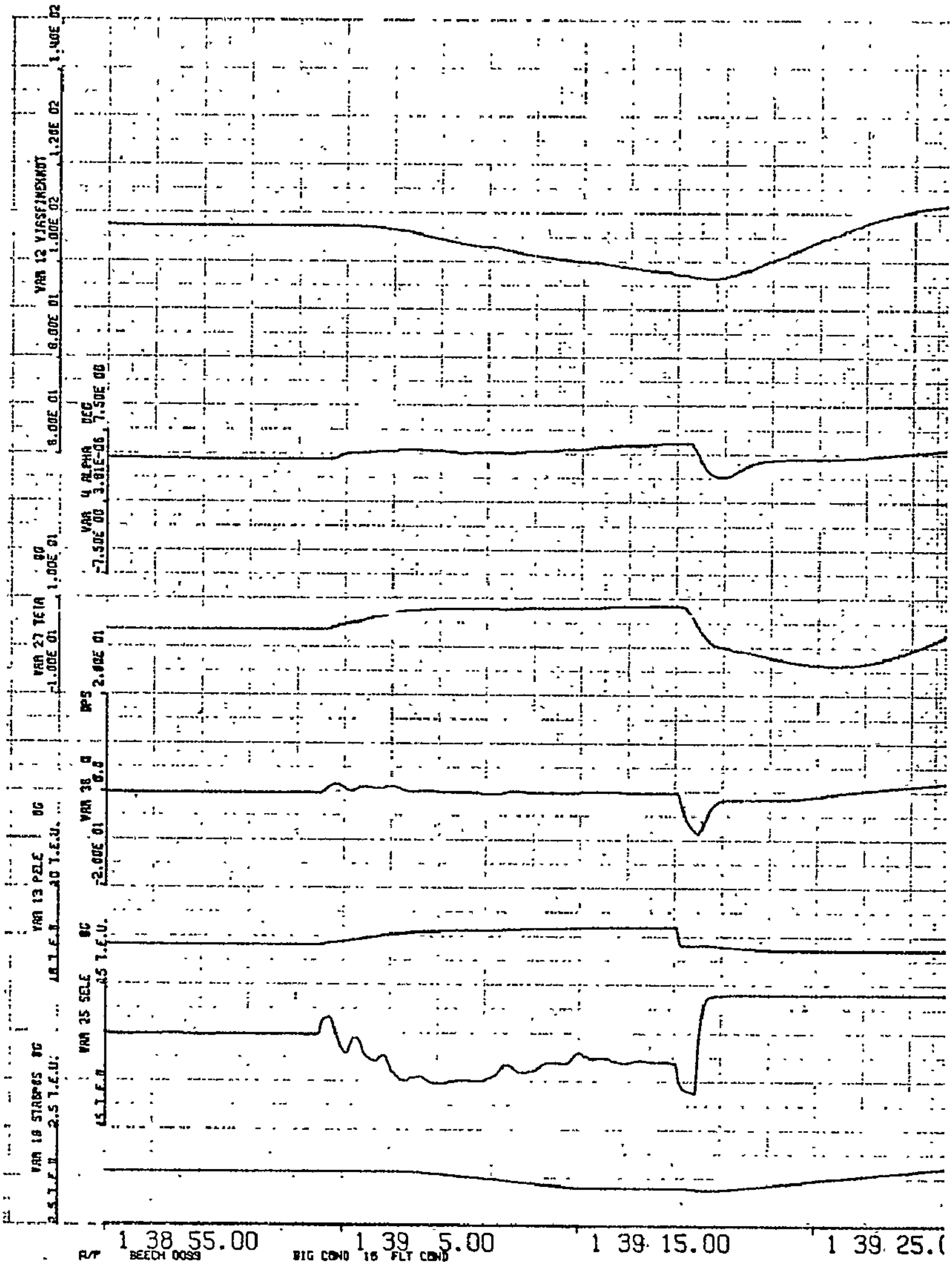
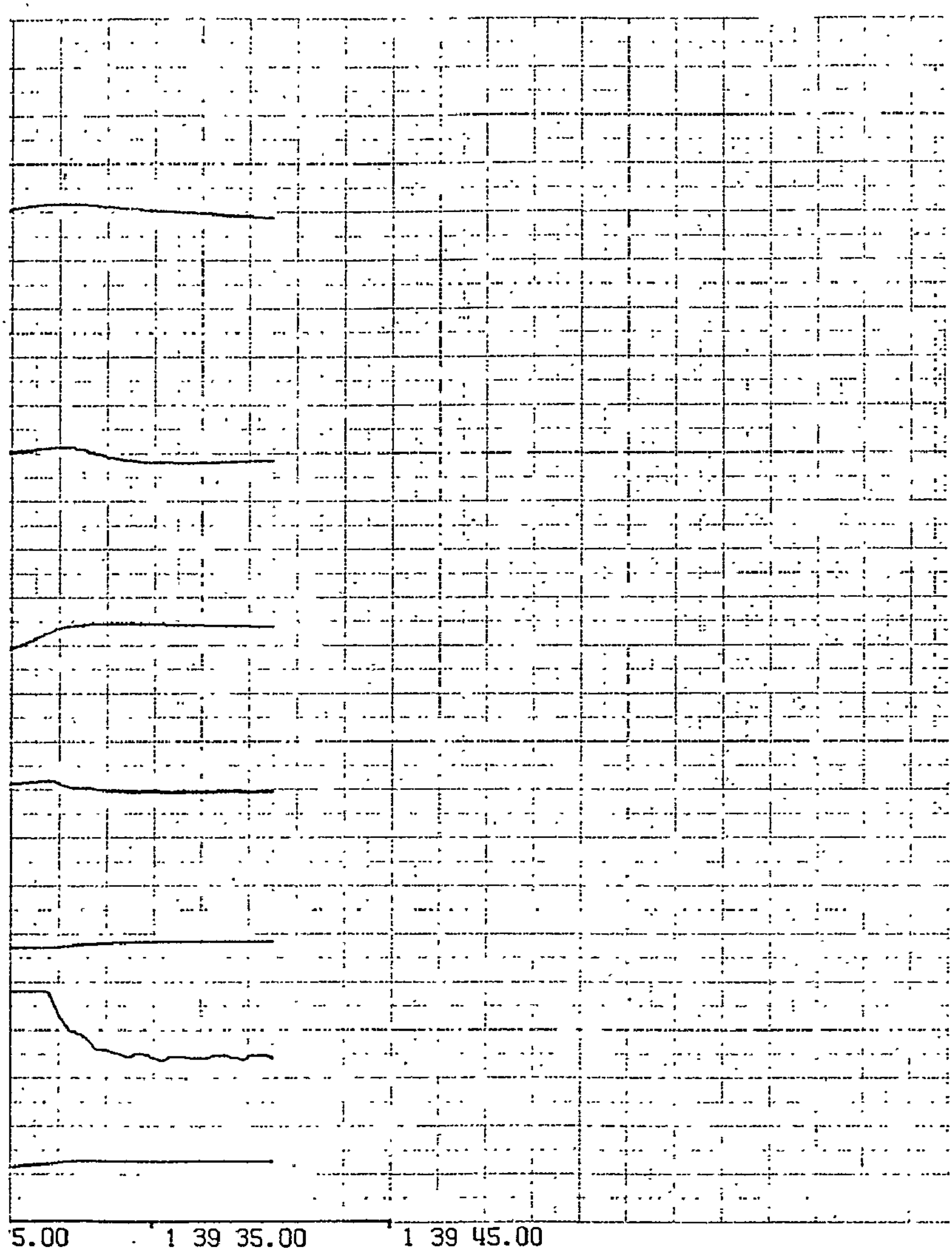



A/P BEECH 0099 BIG COND 16 FLT COND

TEST 093-1 RUN NO 10660S

Phugoid-Approach- Command PLOT FORMAT 01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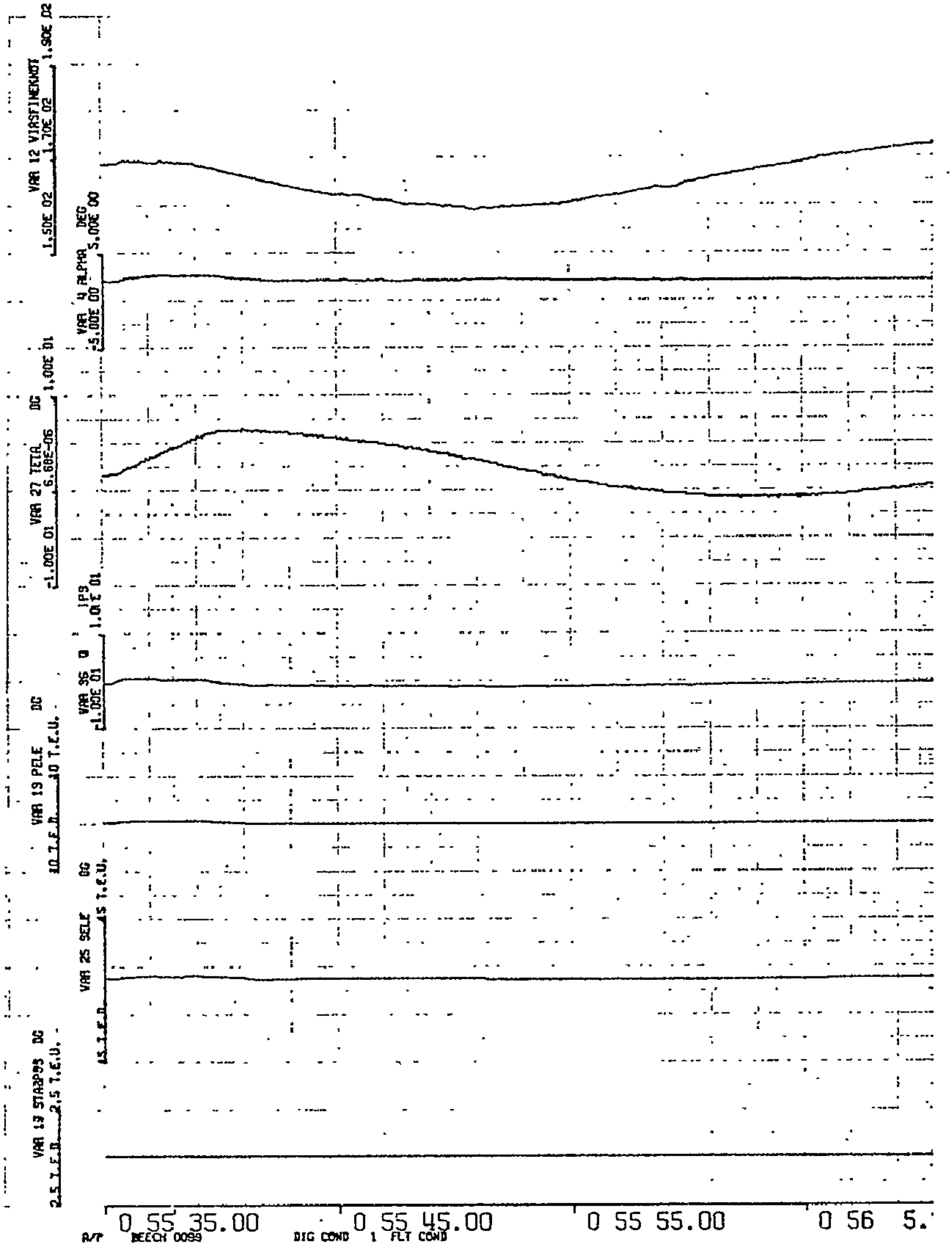
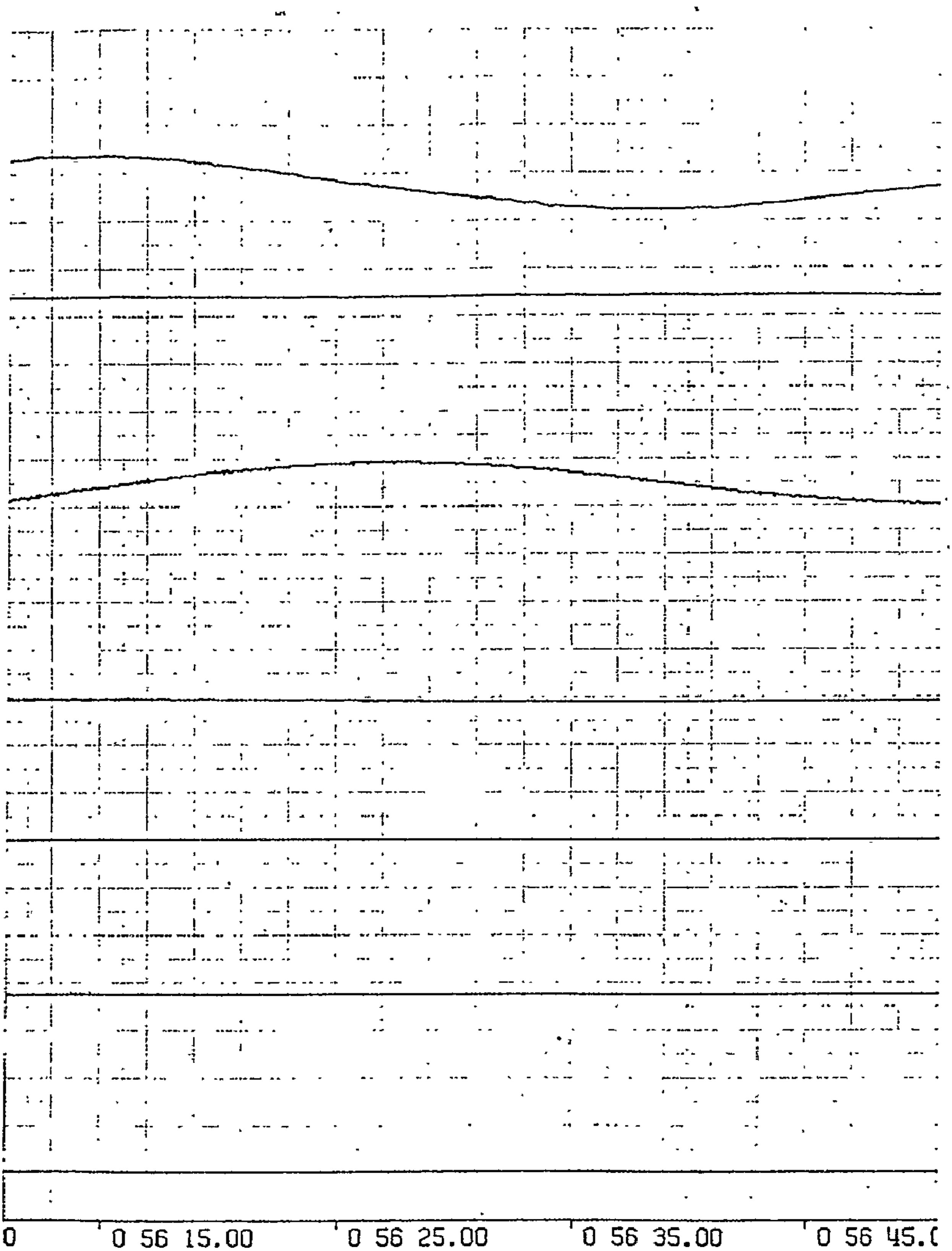



A/P BEECH 0099 DIG COND 1 FLT COND

TEST 093-1 RUN NO 106605

PLOT FORMAT 13

Phugoid-Cruise- Basic



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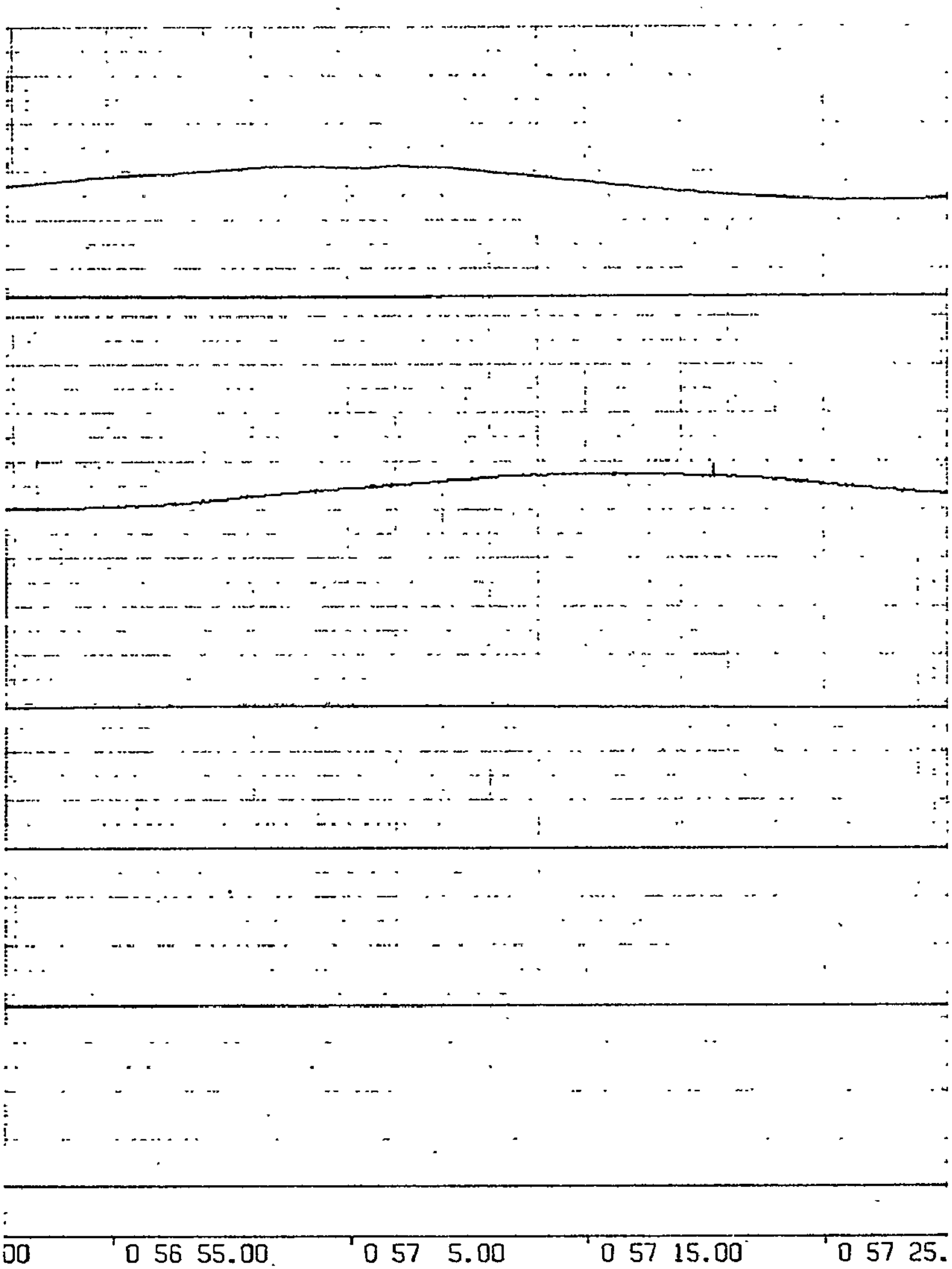
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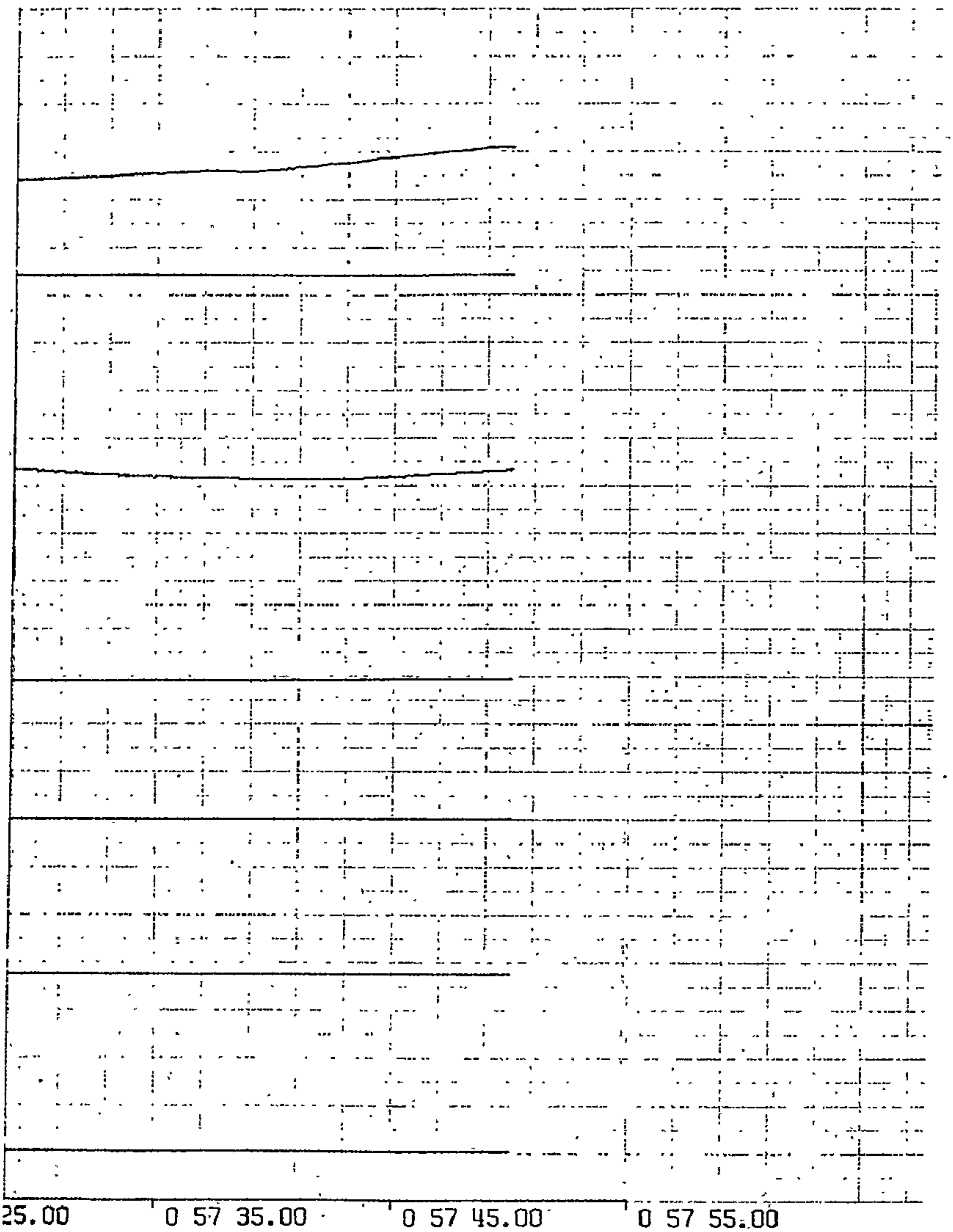
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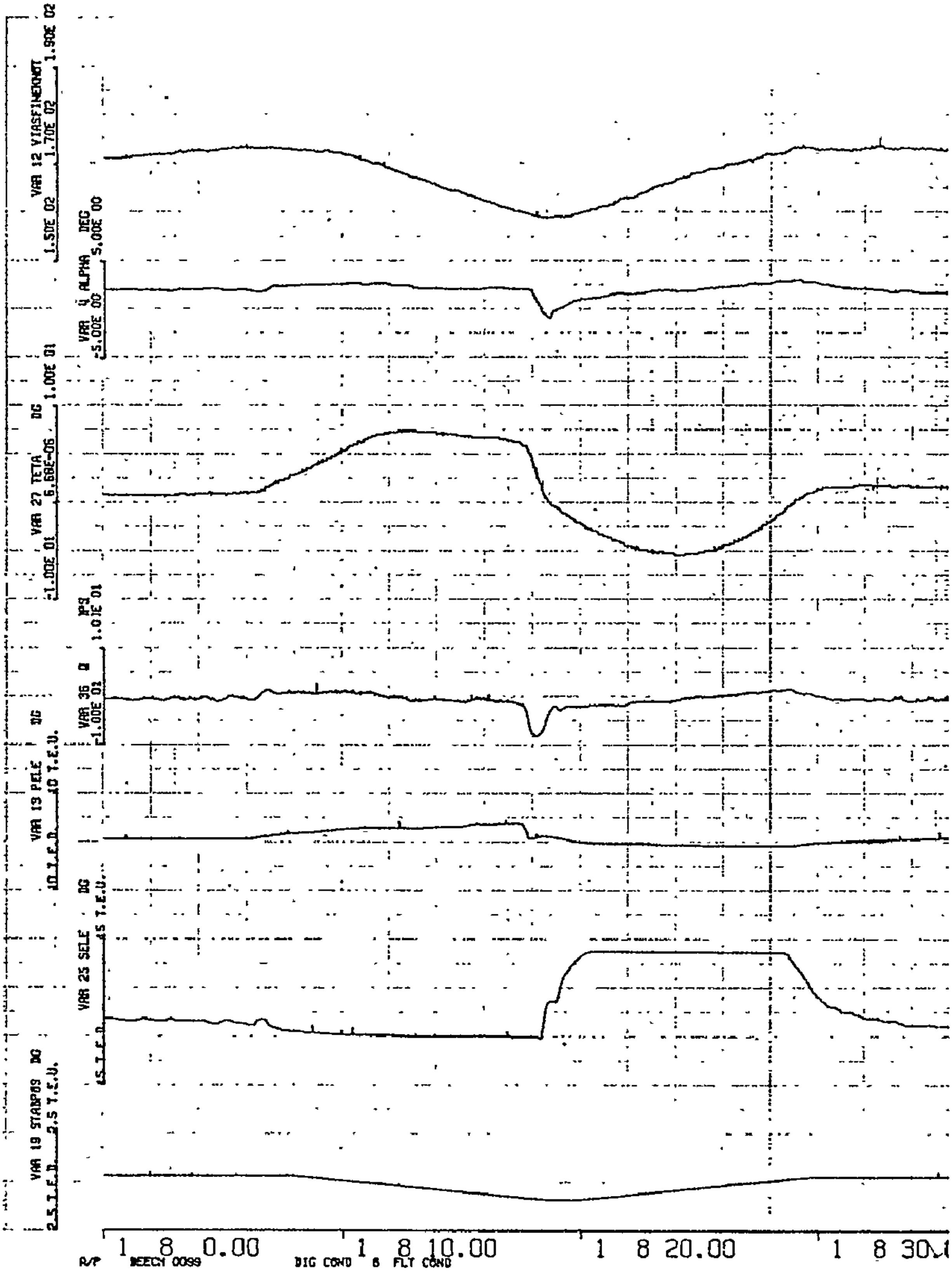

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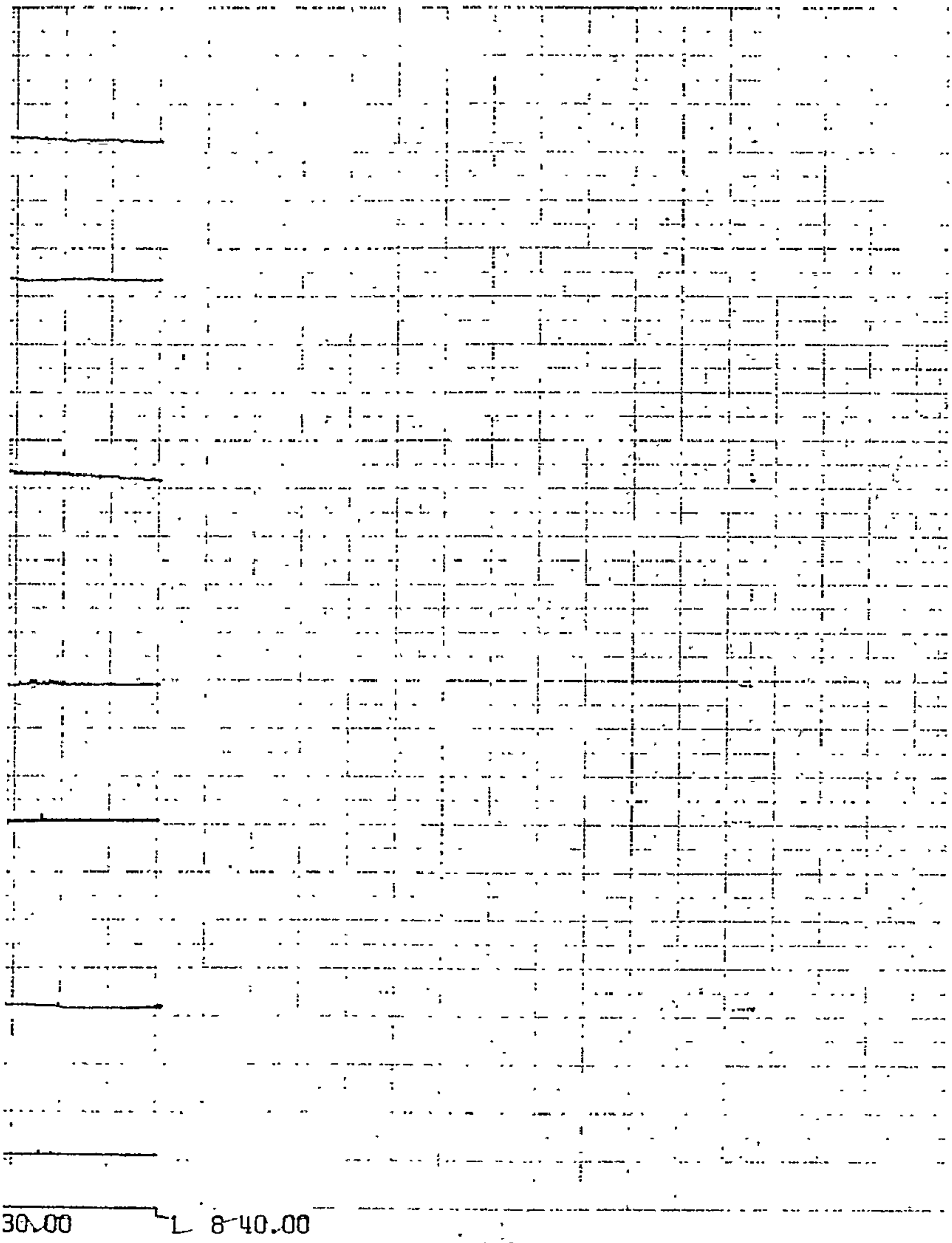
TEST 093-1 RUN NO 106605

Phugoid-Cruise-Command PLOT FORMAT 13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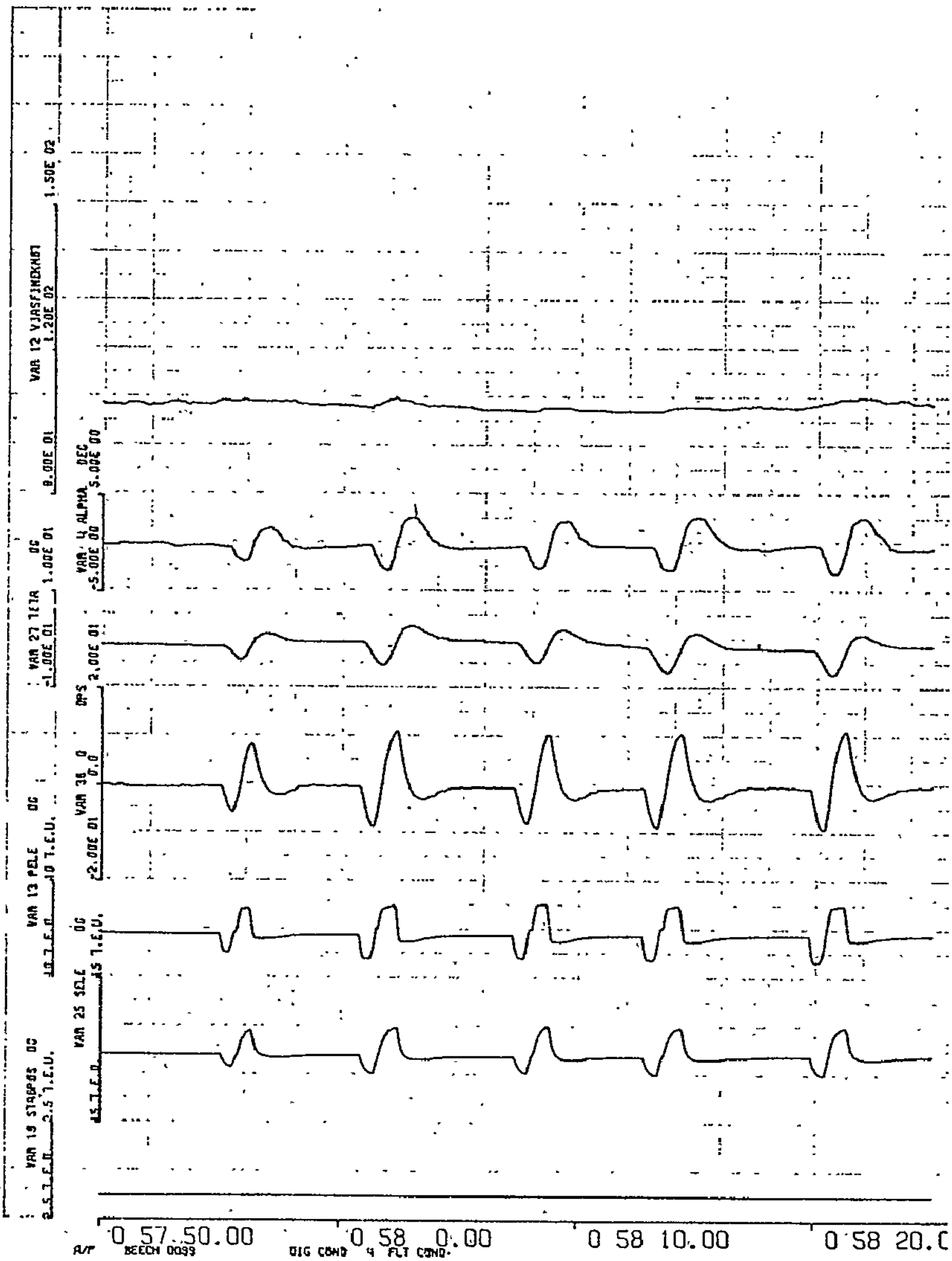
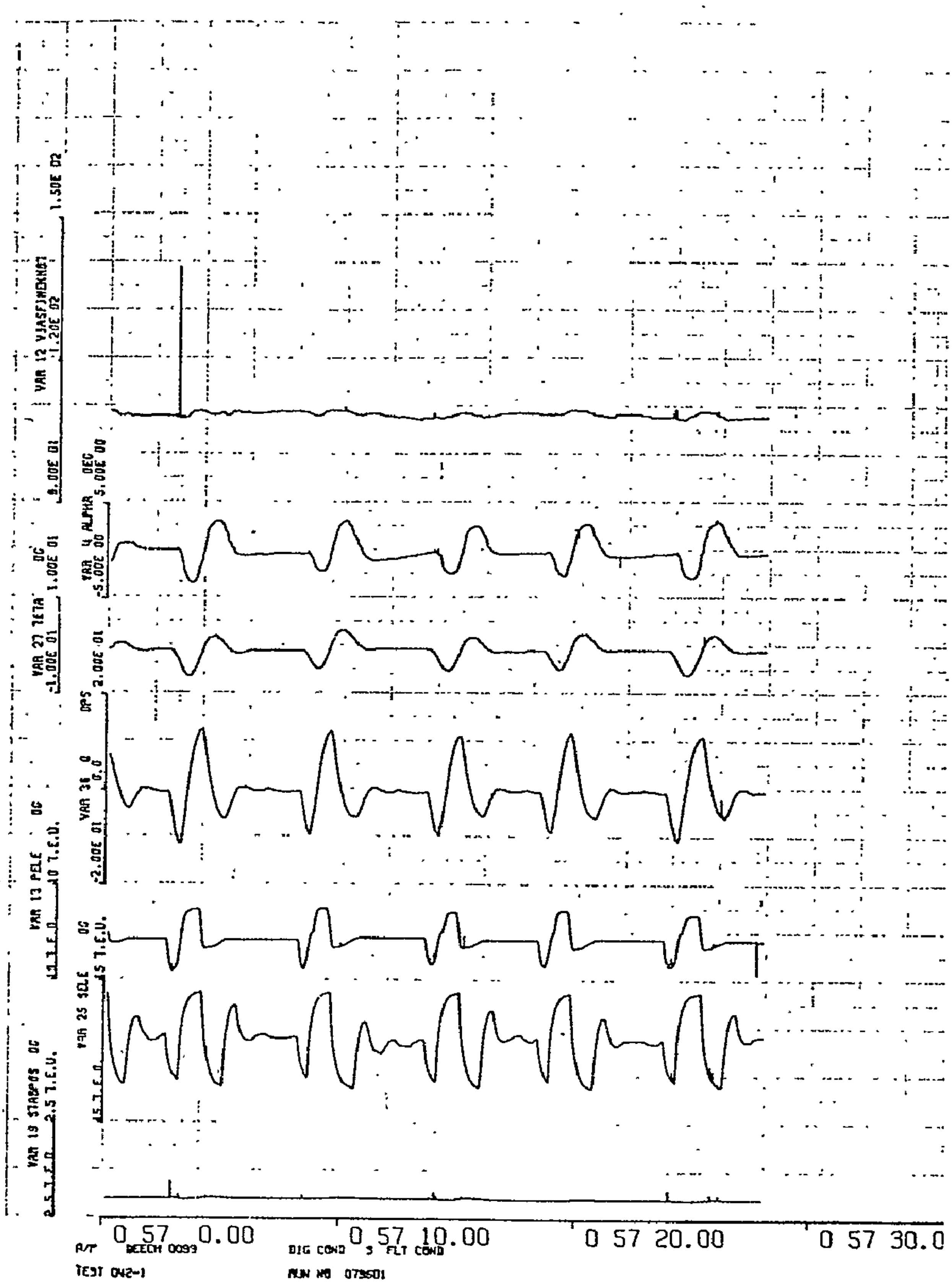


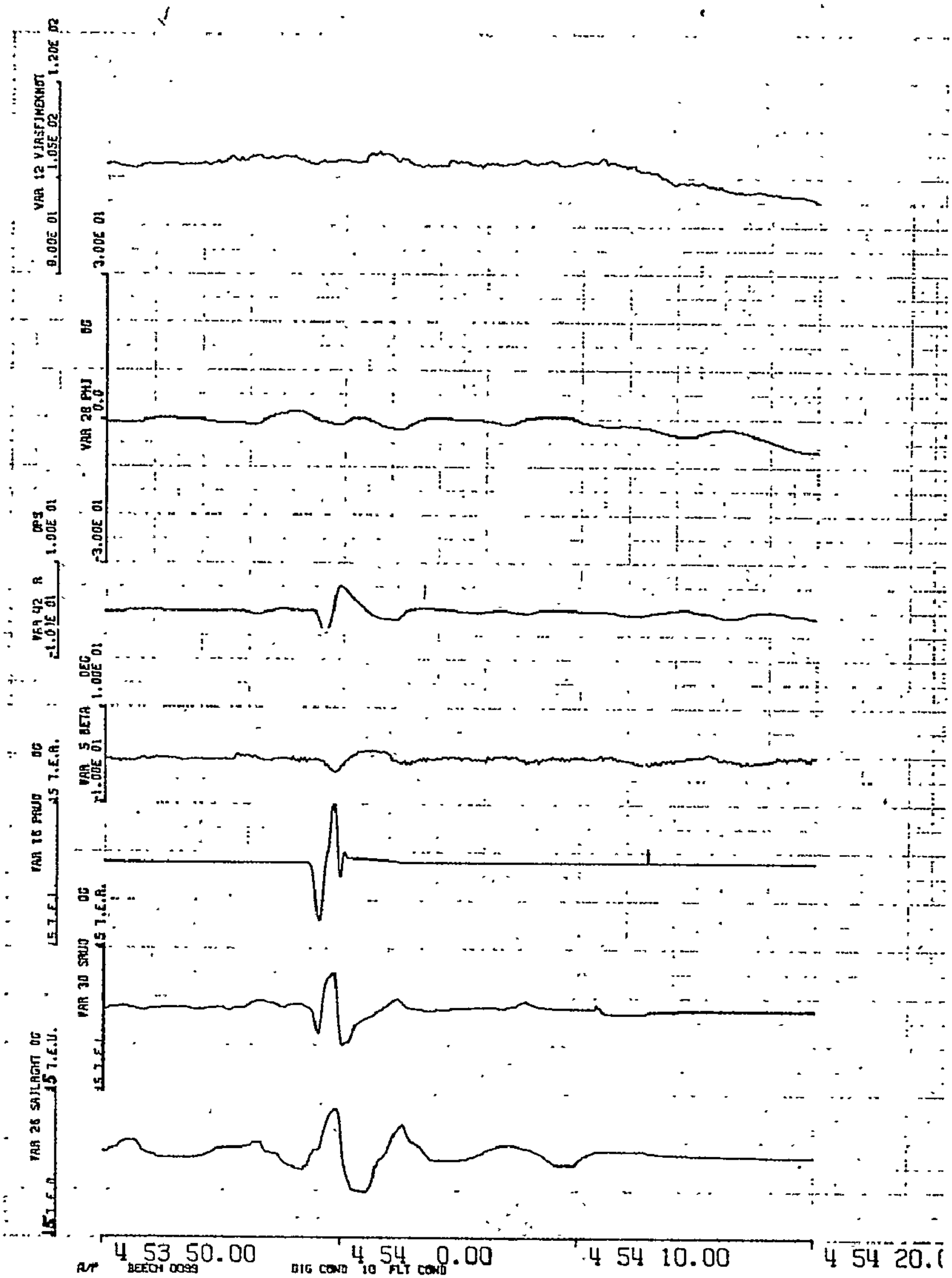

A/P BEECH 0099 DIG COND 4 FLT COND.

TEST 042-1 RUN NC 079601

Short Period-Approach-Basic PLOT FORMAT-01




Short Period-Approach-Command

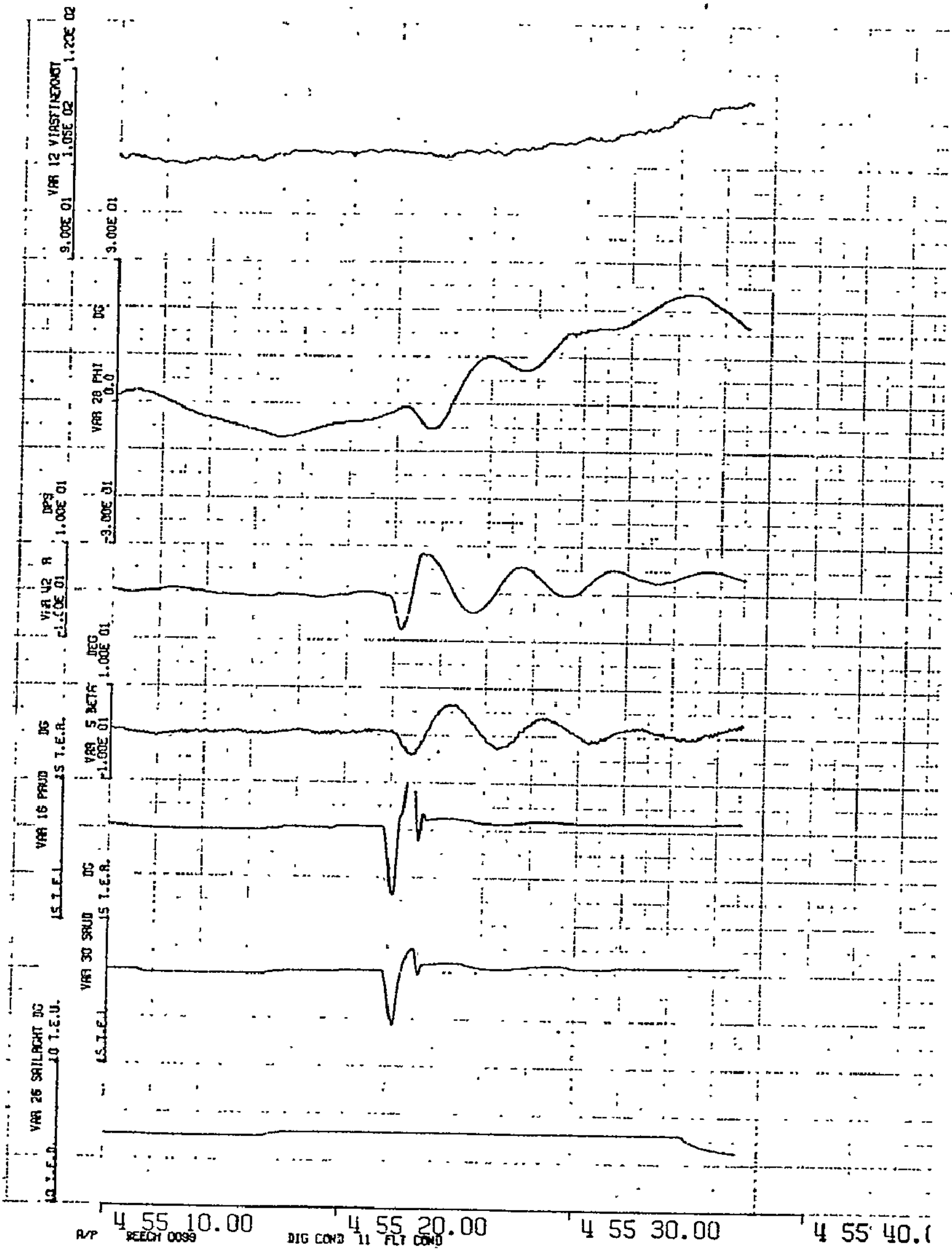



A/P BEECH 0099 DIG COND 10 FLT COND

TEST 069-1 RUN NO 098603

Dutch Roll-Approach-Command

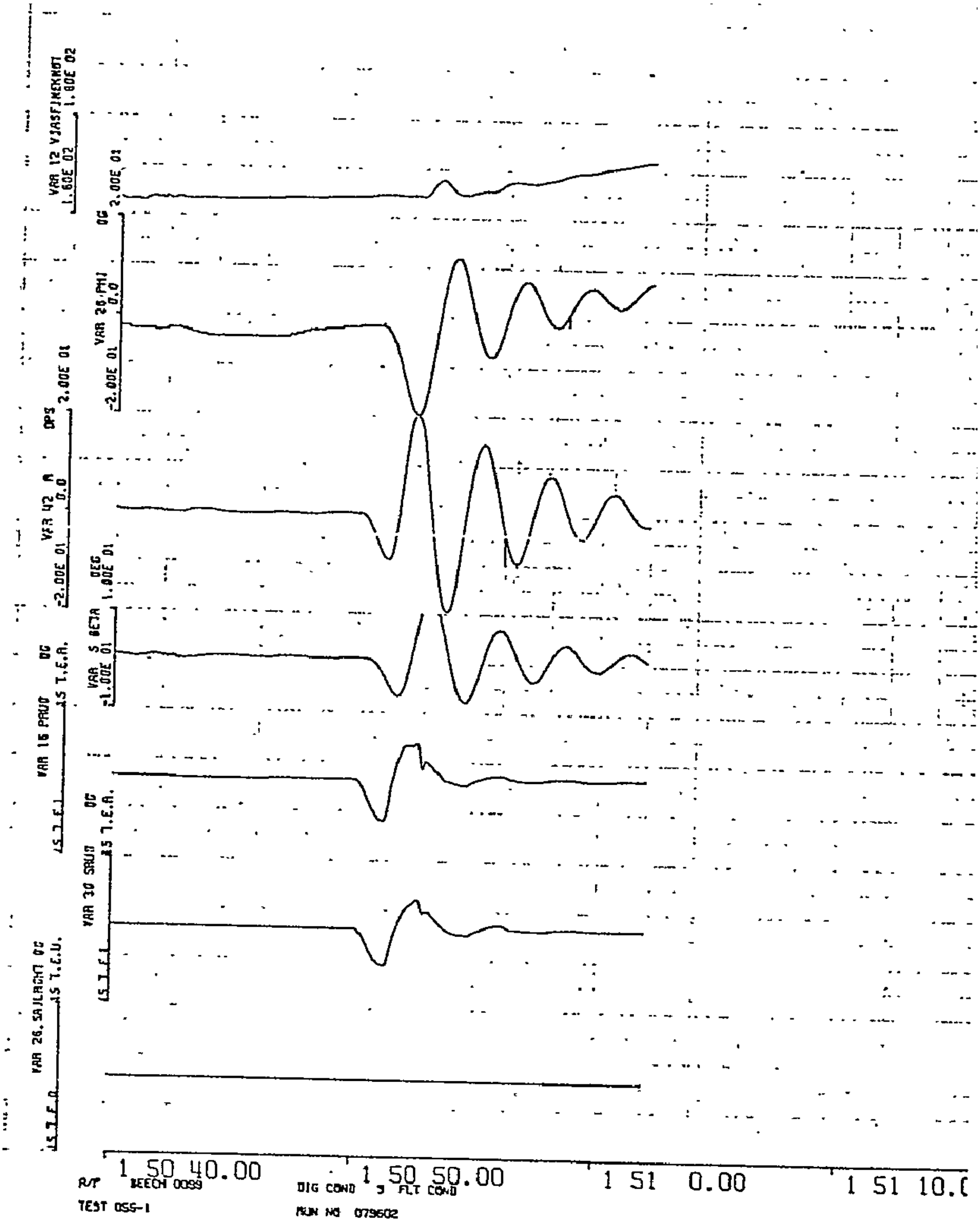
PLOT FORMAT 12



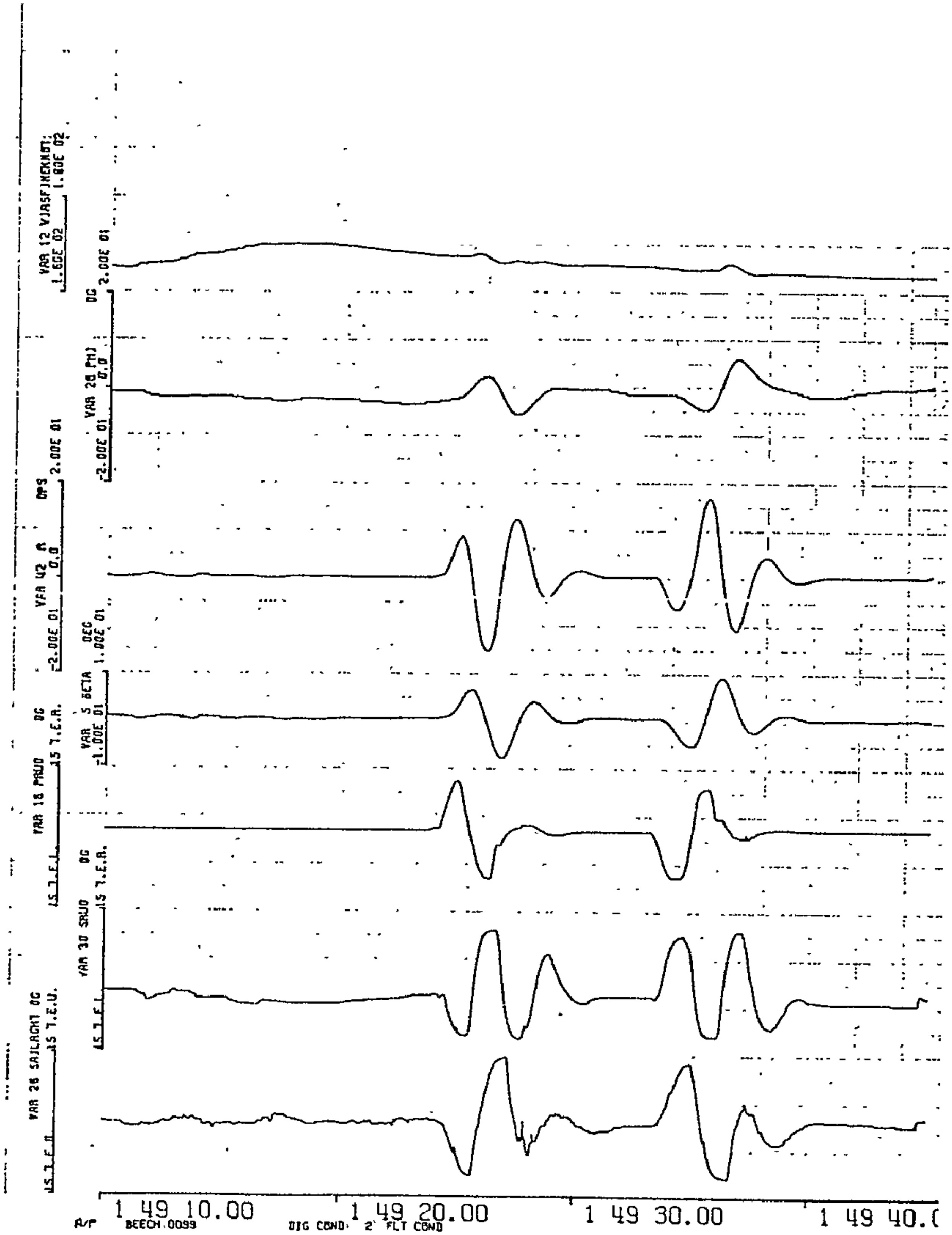

A/P REECH 0099 DIG COND 11 FLT COND

TEST 069-1 RUN NO 124620

Dutch Roll-Approach- Basic PLOT FORMAT 12




Dutch Roll-Cruise-Basic



A/P BEECH 0099 DIG COND 2 FLT COND
TEST 055-1 RUN NO 079602
Dutch Roll-Cruise -Command PLOT FORMAT 03

# APPENDIX C

## PILOT COMMENT TRANSCRIPTS

Appendix C contains written transcripts of the evaluation pilots' comments. The comments were recorded during the debriefing session after each evaluation flight.

Date: Feb. 25, 1976 | Flight: 026 | Takeoff: 1527

Pilot number: 5

SSSA mode: Command, heading hold roll on, heading hold yaw on

Pilot rating: 3.0

Turbulence level: Intermittent light

Task 1

Wheel forces are a bother. Seems to increase workload. Rate of climb, $\dot{h}$, control seems to be poor due to gyro precision.

Pilot rating = 3.0

Task 2

Heading hold is good for an accuracy of ±2° to ±3°. However, if you need to fly heading ±1° the workload is as great as the slave aircraft.

Pilot rating = 3.0

Task 3 & 4

Heading corrections seem to be slow, i.e. the aircraft seems to respond slowly to heading command. The first ILS approach was too close to the O.M. Could not get established well on ILS. Second approach was better but not much. As a consequence the system was downgraded overall by approximately 1 pilot rating.

Pilot rating = 4.0

Task 5

Missed approach was much easier. The aircraft was well controlled without being hurried.

Pilot rating = 3.0

Date: Feb. 25, 1976 | Flight: 026 | Takeoff: 1527

Pilot number: 5 | SSSA mode: Slave (basic airplane)

Pilot rating: 4.0 | Turbulence level: Intermittent light

I'll talk about the vertical S's first, here. OK. There isn't anything specific. I'll just say it requires a lot of work, continuous high workload, and I'll give it a pilot rating of 4 but I think the basic thing that makes it hard to do are the facts that gusts upsets and the fact that if you are not perfectly trimmed it just drifts away from the commanded attitude. Also, 150 knots is particularly flat on the speed power curve and airspeed tends to drift a lot and it takes a lot of throttle motion to keep it somewhere in the general ballpark. It does make it quite a lot easier if you know what power settings to use for the climb and the descent. It looks like about 1,100 foot-pounds torque for the climb and about 400 or 500 for the descent worked out about right.

Small heading changes—the airplane is really fairly nice for that—not too much workload and it is fairly easy to make small heading changes. About a 3 for the pilot rating on that. Does require fairly continuous attention or else the heading does drift off. I think a 3 probably covers the pilot rating there OK. I will mention that there is slight turbulence, slight intermittent turbulence throughout the evaluation. There is one little nuisance factor and that is that the vertical index on the attitude indicator is hard to see with the goggles on and it is hard to hold a 30° bank because it is hard to actually see the 30° index. OK.

The ILS itself—I wouldn't have any particular objections to it but the overall workload is high and I think I would give it a pilot rating of 5. But I must say that the approach actually worked out a little better than I thought it would. But the workload is high and continuous. I was satisfied with the pattern and the procedure we used.

I think the level of performance achieved was adequate for the goaround and I would give that about a 5 also; it wasn't quite as difficult to deal with as I thought it would be. And I think the performance was adequate although it was during a critical part of the workload that I had to add power and I really didn't have enough attention span to set the power adequately. I just pushed on a lot of power and then controlled aircraft attitude. The overall result was pretty good except that the safety pilot had to watch what I did with the throttles there to keep from overboosting.

Date: Mar. 9, 1976 Flight: 028 Takeoff: 1140

Pilot number: 6 SSSA mode: Slave

Pilot rating: 4.0 Turbulence level: Light to moderate

Separate surfaces seem to lag the primary surfaces quite a bit.

Roll and yaw axes are very difficult to control in turbulence.

Date: Mar. 9, 1976 | Flight: 028 | Takeoff: 1140

Pilot number: 6

SSSA mode: Command, yaw damper only

Pilot rating: 2.5

Turbulence level: Light to moderate

Trim change with gear and flaps is very nice.

Workload is definitely much less with the system in command. The roll axis attitude command is very helpful; it lightens the workload a lot.

The heading hold function is not tight enough to suit me. Heading hold switching is good! The aircraft localizer is not really sensitive enough. I noticed on Einar's flight that it lags quite a bit.

Overall I had much more confidence in my ability to perform the mission in the command mode.

The biggest improvements are in the roll and yaw axes. Outside of gear and flap transients, there is not much change in pitch axis.

Date: Mar. 9, 1976 | Flight: 028 | Takeoff: 1140

Pilot number: 6

SSSA mode: Command, heading hold roll on, heading hold yaw on

Pilot rating: 2.5

Turbulence level: Light to moderate

The heading hold functioned much better with the yaw axis engaged.

I feel that the pitch trim response is too sensitive while the primary elevator pitch response is not sensitive enough.

I suggest doing both a long turn in and a short turn in on the ILS approaches. I think the pilot can better evaluate all aspects of the system on the long turn-ins.

The wheel forces needed for sustained maneuvers (especially banked turns) are objectionable. I suggest some sort of roll axis trim on the control wheel.

The heading hold drift is annoying, but it's still much better than the basic aircraft.

Date: Mar. 17, 1976 | Flight: 031 | Takeoff: 1450

Pilot number: 3 | SSSA mode: Slave

Pilot rating: 3.5 | Turbulence level: Very light

Task 1 — Once you get set up, it's very easy to perform these vertical S's. You don't have to do anything.

Task 2 — The heading is not difficult to maintain with basic aircraft.

Task 3 — I was very busy trying to perform this maneuver. I thought I was going to be much closer to the outer marker, but as it turned out I had plenty of time to set up on the glideslope.

Task 4 — No problem, I fly the localizer by maintaining a heading.

Task 5 — There were very large trim changes with gear and flaps and as a result it was difficult to trim to a nose up attitude.

Task 6 — I could maintain heading very well.

In general, the trim changes were the most detrimental factor in the basic aircraft performance.

Date: Mar. 17, 1976 Flight: 031 Takeoff: 1450

Pilot number: 3 SSSA mode: Command, heading hold roll on, heading hold yaw on

Pilot rating: 2.5

Turbulence level: Light

Task 1 — The wheel forces required to maintain a sustained bank angle were very objectionable. I liked the basic aircraft performance in this maneuver better because of this. I want to note that the pitch axis performance does not seem to be much different than the basic airplane.

Task 2 — It is easier to hold a heading with the augmented airplane.

Task 3 — I couldn't read the DME very well on the slave approach, but overall I couldn't tell much difference between the two on the turn-ins.

Task 4 — Glideslope control was not much different, but it may have been a little more positive with the augmented airplane. The localizer was easier to maintain with the augmented airplane, probably because of the heading hold.

Task 5 — The goaround was much better. There were no trim changes with gear and flaps and a trim input gave immediate nose-up attitude. I would say this is the biggest area of improvement over the basic aircraft.

Task 6 — The heading was more difficult to maintain here. I couldn't control it within ±5°. I don't know why, I just can't explain it.

Pilot rating — I would give the augmented airplane a 2.5 if an electric roll trim switch could be implemented. If not, I'd have to give it a 4.5 because those wheel forces are very objectionable.

Date: Apr. 6, 1976 Flight: 30

Pilot number: 2 SSSA mode: Slave/command

Pilot rating: Turbulence level: Continuous light
Slave — 4.0
Command — 4.0

First thing that I am going to make a note of here is that we got a lead and lag in the altimeter which is bouncing the altimeter around anywhere from -25 to -30 up to a +50. It is probably going to show up in the vertical S maneuvers. I didn't mention it yesterday but the gyro wings level marker isn't quite on. In other words it's very slight right wing down position for wings level flight apparently, if you put in the center on the gyro it tends to drift a little bit. I've retrimmed the airplane now so that I seem to get a wings level condition. The airplane needs retrimming here. Still getting the glare in the turns that gives me some trouble as far as sight of the instruments is concerned. [End of second day.]

Today I still have a little bit of trouble with chasing the rate of climb on this thing getting the airplane trimmed, to give me the rate of descent that I want and to keep it constant. It's really smooth out today I really shouldn't be having any particular trouble with it. I still have the tendency with the basic airplane to overshoot the heading slightly. The needle and ball and the trim on the airplane don't all go together. We've got, at 3,000 feet we've got an occasional shear that gives a bump that's not what you would call a continuous light turbulence situation but an occasional shear type turbulence. Turbulence is now becoming a consistent light chop. In this light chop I've got the same thing again, I've got to chase the rate of climb just slightly more than I would like to be real comfortable. It's difficult to tell with small changes in the altitude because the altimeter is still fluctuating some without the rate of climb indicating anything, sort of just a bounce on the needle of the altimeter. In answer to your question about vertical S maneuvers, I was having some trouble with chasing the rate of climb and it was a little bit tricky because the altimeter fluctuates a little to a -25 to a +50 fluctuation. Still I feel on the basic airplane I've got to chase it some on pitch trim. I made a comment on tape to that respect. Also, made a comment on the tape that the turn and bank indicator, that the ball is not really centered up and the needle is not really centered when the airplane is trimmed for level flight so that also tends to give you the sensation of carrying the wing all the time. But other than that I didn't note any particular dislikes on the transitions to climb and glide. The airplane is a little slow to get going up again. It seems to trim over pretty well but it's a little more tricky to trim for a climb attitude with the power setting. In response to the question of precision heading, I didn't seem to have too much trouble today as far as precision heading was concerned related to basic functions of the airplane. The pitch trim is still a little bit difficult to come by to keep a nice level attitude that you would want to take your hands off of. After Mike got through with it, it was trimmed up so that I didn't have much trouble with wings level as long as I kept into account what the needle ball configuration was. In relation to the 90° intercept I tried to pop it over a little quicker today. I went to about 30° to 35° bank and kept the altitude a little better; however I still didn't get it trimmed over for the flaps. The basic system has got a lot of pop up on the nose with gear and flaps and you've got to be aware of it and lead that and I still don't have a good hold on that. I still am behind the airplane as far as getting the trim in for that pop up on the nose. Other than that I had no particular problems on the intercept; I had one and a half overshoots till I was on course and then a slight trim in the rudder trim setting and as soon as I got that down, even with the light occasional turbulence we were getting, I didn't have much trouble with the glideslope from there on in. I agree that a light chop is a good evaluation of the turbulence. On the missed approach and goaround, here again when you pull the gear and flaps even with the torque set at red line torque you have a real sensation of the basic airplane sinking. It's indicating zero rate of climb and it's slow to transition to a climb but you have a sensation in the airplane that you haven't established a climb yet and you really tend to watch the airspeed closely because you get this feeling of sinking quite a while before you really get a rate of climb going. After I had the rate of climb going and had turned to the given heading of 060 I didn't have any particular trouble other than what I mentioned before in the vertical S maneuvers (it was somewhat touchy and you had to work at it to trim an attitude on pitch). In relation to the Cooper-Harper handling quality rating scale, the airplane is controllable and it certainly is well within the average pilot's capability. Capability on performance for pilot tolerance is satisfactory. The controls are a little bit heavy and it's a little bit of a nuisance to have to fight the pitch trim quite as much as you have to but it's still satisfactory. I would say the airplane is satisfactory without improvement. Let's put it this way; some improvement would be desirable but is not something that would necessarily be required. Looking over to the side now, the ratings of 1 through 6, which is the level that I have gotten to, I better go back to the without improvement and say that it has a minor shortcoming in longitudinal trim. It's a nuisance and I would put it in on, probably on, a 4 rating. It's a minor but annoying shortcoming in the pitch axis. Probably a 4.

Still have a little difficulty keeping the airplane over in attitude according to gyro position. Need just a little more trimming. I am having some difficulty right now with big changes in pitch attitude. Little slow getting the nose over there, it's more of a deal of trimming it over a little faster than anything else. The turn is set to the right now. Seem to feel a little pressure on the rudder that I didn't feel yesterday—maybe it's just my imagination. Now I am getting the nose trimmed into position for descent, I'm about 350 feet behind my altitude in my turn. Behind and trim it over just a little more and now it's coming down better. Now this heading and altitude is just about right. Let's steepen it up a little bit. That's better—a little smoother. The airplane seems to kick back and forth a little more than I would like it to on ailerons. It's hitting and engaging and disengaging the system. Thing was chasing the ailerons in left turn and was more my fault than anything else. Just getting used to it again. I got up and transitioned to descent of 500 feet a little better that time. Turns and everything came out about the same, together. It was a better transition on that change from climb to a glide. I'm not having as much trouble this time with the aileron. Still get something that feels like I'm getting some help on the ailerons which doesn't seem to be from turbulence. With the SSSA, I'm working the level stuff on this trim system a lot better today. I find the feel of the grip and the less I fiddle with it the better it stays where it's supposed to be put. It does have some drift in the heading hold with hands off; however, it is not bad. It still isn't tremendously stable; you got to fiddle with that but not as much as I did the basic airplane. When you get a turbulence bump, though, it doesn't come back together and it's a light touch almost hands off wings trimmed for 310 and drifting to the right a little increasing the heading but it's 800 foot per minute rate of descent a little turbulent and it's holding well. It's a little solider hold on the trim system. Would probably be a real neat arrangement. It's gotten up to about 170 there as I'm coming down toward altitude. So I got up a little fast. Seem to affect as much as you stay with the trim. It's kind of nice if used to help on the longitudinal pitch from power change although it's not a very significant power change. That's nicer on the longitudinal trim in the gustier air. I can feel it working against it on the ailerons and on the pitch trim. Holding up about 165 here so will reduce the power a little and let it slow down. We're on final heading before intercept on 220 here headed for the ILS. I got to chase the aileron thing a little bit trying to get the wings to level out I tend to over control that and messing with that and I overshot my localizer again by quite a bit of degrees and 100 feet headed in and corrected it back so we didn't go too far off. The system works a lot better if I don't touch it. Tend to fight the rudder a little bit here; it seems to want to run the ball out to the right. Putting in the rudder seems to be trimming it, and it takes quite a bit to keep it that way—to try and keep the ball in the center. We won't fight it, let it run a little ball out to the right 'cause I think I remember Jerry saying that it was an acceptable thing.

In reply to the question about the vertical S's. On power changes on the climb of the vertical S, after I finally started letting the system do more of the work instead of trying to chase it on the second vertical S. The first one was kind of sloppy but I was working the system and it was working against me. The second vertical S I was letting the trim system do more of its own thing. I found that I didn't have as much trouble with the aileron beating back and forth as I did on the first vertical S and consequently I could regulate my turn a little better. I still had trouble with the pitch trim changes on this. However, I don't think that it takes as much to get to an attitude. But when this gets bumped away from an attitude it doesn't come back real well. In other words it takes more fiddling to work it back to its trim position than it does getting there initially. That was my impression on the climb. On the descent in it, it seems to be a lot more stable there in the pitch trim mode, and the second one was a lot more comfortable than the first one.

Pitch trim in the descent it was easier to transition to it and it was a lot more stable in the descent as far as being pitched out of the thing and getting it back on trim again. That probably has something to do with power effects on it; I don't know, the difference in speed, et cetera.

In reply to the question on the initial precision heading, there again I was fighting the system. In other words I wasn't turning loose and letting it settle down. I found a little later on that if I flew an almost hands off situation that heading was pretty good. It drifts some, but it's not fast and it seemed to be continually to the right so I could correct it back. Also by doing this I got away from fighting the microswitches on the yoke. However, the wheel is still loose and sloppy. On straight level headings and so forth, you play with the things on pitch trim almost as much as you do as with the basic airplane but you don't have the heaviness in the controls with the system on that you do with the basic airplane. You got more force in the ailerons, it's heavier to handle laterally with the trim system on than it is in the basic airplane. Ninety degree intercept, by that time I was getting a little more familiar with letting the controls do more, although I didn't get around as fast as I did with the basic airplane. I found that it's heavy on ailerons to hold over at 30°; that is pretty good heft there and that's kind of a nuisance— that's something that you'd want to correct. I didn't get around as fast so it took me two and a half overshots as compared to one and a half getting it back on. But there again I wasn't keeping quite as much angle of bank because it was heavy on the aileron. But once I got it around and got it on the heading, by going almost hands off again, it was doing a good job of keeping me going where I wanted to, on the azimuth. I'm still chasing the rate of climb on the thing but I don't think I was having to do as much trimming on the glideslope with this as I did with the basic airplane plus the fact that I could definitely feel this control system. There wasn't as much pitch on the wings against the ailerons with the trim system on as there was on the basic airplane so I was getting some benefit from the aileron corrections against the turbulence on the glideslope. In fact more so on the glideslope than I noted in level flight. It was damping it more than there, particularly before we got in close. The last few minutes weren't quite as bad for us but earlier in the approach it was choppier. The basic airplane, I didn't do any hands off. Now you know I'm not really familiar with getting this thing all trimmed up but I flew it quite a bit hands off for just real light touch on the second approach on the SSSA system approach. However, on the approach whenever I got turbulence that exceeded the capability of the system I had to chase the attitude. Okay, now go ahead and finish the remarks on the glideslope thing. When I got to a point where I had to take hold and get back to a trim position it was a little shaky. The controls are a little heavier and it's a little touchier to control movements and trim. Getting it settled back down took a little concentration which was a little bit of an annoyance. I flew the localizer with a lot more hands off; that's what I was talking about on the approach after I got set up on the glide path and on the heading. It was a lot easier to fly it as long as I was within the trim situation of the airplane and as long as it didn't get a bump from turbulence and get out of the trimmed attitude. When I did pitch it that way then I was having a little difficulty getting it back on trim again so I could take my hands off. It was a real nice relaxed approach when it was doing its thing. Except for the turbulence condition. The missed approach straight out was a lot more comfortable with the system on (but then I rotated and got into a climb attitude a little quicker and Mike mentioned that). Consequently, I didn't get that sinking feeling so I wasn't playing with the airplane quite so much; however, I did notice that when I did that the airspeed was slow and I had to do quite a bit of trimming till I got the pitch at a position that it would stay at. In other words for 2 or 3 seconds there the nose continued to come up and I didn't have enough trim in and I had to trim quite a bit to finally get it to settle down for climb attitude. Once I did that it was all basically light, hands off, for the rest of the climbout and it did real well. It has a slight tendency to drift off heading and seems to be to the right most of the time and it does have a tendency, if it's pitched off its basic attitude, not to come back by itself to that original attitude. It's more nose up than it is nose down. Nose down seems to do better than nose up coming back. There again I was more familiar with the system at that time and basically if you set it up, as long as you don't get bumped out of it, it does real well. Probably the two most annoying things about the system are (1) the extra weight on the ailerons when you are making turns or trying to correct headings and (2) trying to let the rudder do its own thing. The ball wanted to be out at the right side and I put in right rudder and put it to the center and the system would push it on out again. I had to get up to a point that I had a lot of rudder pressure. A lot more than you would like to have. Like maybe about 40 pounds before I could override and keep the ball toward the center without it going ahead and pushing its own way out. I got the feeling the system was working against me on that. When I turned the rudder loose and just let it do its thing it just went ahead and held the heading pretty well and I didn't have to bother. But there was almost a full ball out to the right on the rudder. That kind of correlates with what I was doing with the vertical S's. I was having to trim in a little bit of right rudder on those. I didn't want to do that because I remember Jerry saying that if you don't trim the rudder the system would handle it okay.

The system was definitely controllable and I didn't have any trouble with it at all. I'd say it was satisfactory (as adequate performance and tolerable pilot load). If you got to a situation where you had to spend an hour in holding pattern with the system having as much force as there is on the ailerons you probably would get tired of that. I think we can probably move it up into the next category without any hesitation. Okay, I think I would have to call it back into the box on "improvements" for two things. First of all, it probably could handle the aileron situation without quite as much heft on the ailerons. In other words lighter force on the ailerons (that would be tiring in a long flight, you would have trouble with that). The second thing would be the rudder system for low power settings situation. I don't know, it seems to me to be contrary to basic pilot technique to let the ball float out to the side that way and yet when you tried to put it in you felt that you wanted to crank in rudder trim. I know now, for a fact, if I crank in rudder trim that I am just fighting the system. That is an undesirable trait.

I remember Jerry mentioned that saturation thing so I let it do its own thing. Another thing is that pitch trim situation if you get bumped out of the limits of the system or if you get bumped out of a particular attitude. I think that I would still have to go along with just the one I had with the basic airplane, "Its designed performance requires moderate pilot compensation". And on this one rudder and aileron are a problem. On the basic ship it's more pitch.

Date: Apr. 9, 1976 Flight: 39

Pilot number: 1 SSSA mode: Slave/command

Pilot rating: Turbulence level: Light
Slave — 5.0
Command — 4.0

Basically, I felt that my original comments from the first flight will apply to this flight. On this flight, basically I confirmed what I suspected before but could not remember due to devoting most of my attention to flying the airplane. That is that with the system slaved it provides or reduces the pitch changes with configuration quite a bit. It makes glideslope intercept or configuration changes upon interception of localizer much easier, and with the system slaved I gained hardly any altitude at all. With it unslaved I gained 200 to 300 feet in configuration changes. So, in command, stick forces and the configuration changes were much less than in the slave position. Heading hold, the maintaining heading maneuver, was essentially the same as I commented before; in the command mode it was very easy to maintain heading in turbulence, required very little pilot attention, the workload was very small whereas in the slaved position constant pilot attention was required to maintain heading. Vertical S's. This time I trimmed out aileron as suggested by Jerry Jenks, whereas before I did not—on the first flight I did not trim out the forces. On this flight I did and find that method unacceptable. I found it overall more difficult to fly the vertical S's by trimming out the aileron than I did on the previous flight when I didn't trim it out. I still maintain my previous position that trimming out ailerons with the wheel down there where it is now in the normal position would not be good pilot procedure. Putting the aileron trim on the yoke may provide a better response. Now it just takes too much time, particularly where, now once you get it trimmed up in the vertical S, you trim the aileron in and trim the pitch trim and you are just sitting there adjusting power to maintain your airspeed and your rate of climb with the pitch and that is very nice, but it's the transition that's the problem. That's what flying is, mostly the transition when you are trying to control the airplane rather than the steady state condition, straight and level, or turning, or climbing. So I didn't find that satisfactory in the vertical S maneuvers, although as I said during the steady state portion in the steady bank, steady climb, that it maintained it fairly well and reduced workload during that period. The transitioning, you just had your hands full, trimming aileron, trimming pitch but even if you put it on the wheel you would have to trim and pitch, trim and aileron at the same time in the transition vertical S, changing heading, changing pitch and you have no hand left for your throttle. Power is quite, on the vertical S, is critical during the transition whether command or slave. ILS, in the slave position again, the heading was slopping all over the place, it was difficult to maintain heading, additional workload was created with the airplane because when you put the gear and flaps down or just gear, probably the gear, you get a large change in rudder trim which you have to trim out in addition to the other workload. Again, as I mentioned before, the large stick forces with configuration changes—putting the gear and flaps down—and of course when you have something like this, you get vertigo effects on the pilot, like when your pitch is changing radically, trying to get it back messes everything up. It's not a favorable aircraft response. Again, the basic flaw of the aircraft during the ILS in the slave mode is wandering in the heading and the pilot workload to correct the heading, that is high aileron forces primarily high aileron forces, rudder isn't too bad. The aileron, you almost have to use two hands.

In the slaved the primary problem was with heading. Go around again you have stick forces generated with power application which are fairly significant.

On the command, it seemed like the ailerons were more sensitive this time. I had a slight problem with heading hold like we discussed that was probably primarily due to the aileron not trimmed to neutral. I remember after the goaround I did trim out some aileron. I noticed that we got into smoother air that the ailerons were not trimmed up. Obviously, if I had noticed this on the ILS I would have trimmed it, but with the turbulences either I didn't notice that they weren't trimmed or I was not sensitive enough to the situation to recognize it. When you have turbulence it is difficult to trim either in pitch or laterally because it is difficult with all the turbulence to tell what is going on with everything bouncing around like that. This may be a shortcoming in the system. Again in command, on the ILS, the pitch changes or stick forces generated with configuration changes were negligible and I gained only 50 feet or so as I recall on the interception when I put the gear and flaps down. I had more trouble this time with the heading and we have discussed the possible cause of that. Goaround, I noticed no problem there with the power application or configuration changes on the missed approach. Overall rating, I wouldn't change my rating from what it was before which I think was a 5 in the slave and a 4 in the command.

Date: Mar. 22, 1976 Flight: 033 Takeoff: 1240

Pilot number: 1 SSSA mode: Command, heading hold roll on, heading hold yaw on

Pilot rating: 4.0 Turbulence level: Light to moderate

I think the most obvious advantage is that it's much easier to maintain heading in the command mode.

I also thought that the ride was much smoother.

The aileron forces were objectionable in sustained banked turns.

The pitch transients during configuration changes were reduced.

Overall, I felt it was much easier to perform the ILS in the command mode, with a noticeable lightening of pilot workload.

Flight test engineer comment: The dutch roll seemed to be much less annoying from a passenger standpoint on this ILS approach.

Date: Mar. 22, 1976    Flight: 033    Takeoff: 1240

Pilot number: 1    SSSA mode: Slave

Pilot rating: 5.0    Turbulence level: Light to moderate

The aileron forces were very high.

The heading was difficult to maintain and it was necessary to use the rudder to make small heading changes.

The pitch transients with configuration changes were very large.

[The following discussion concerns the same flight.]

Jenks: Here are your comments from the slave mode. I guess really the only thing I wanted to do is to go through the comments again and see if you had any more detail or any more thoughts that may have been generated afterwards. The comment here . . . the aileron forces were high. Is this particularly objectionable during the vertical S's themselves?

Pilot: Slave, now is that when the system is on?

Jenks: No, that's system off.

Pilot: No, it . . . of course when you are doing vertical S there is no aileron force.

Jenks: Right, just the normal input.

Pilot: Just turning, the reason that is in my mind now is that we are doing aileron tests for a lot of different airplanes so I am particularly sensitive to that particular adverse characteristic.

Jenks: On the heading comment down here, the day that you flew this thing do you recall what type of turbulence inputs they were? Yesterday we flew it and we had a lot of lateral gusts.

Pilot: No. He asked me what the turbulence level was and I think I called it moderate, but I'm not sure.

Jenks: Yes, we've got it written down here. Light to moderate.

Pilot: You know as if whether they were vertical or lateral gusts.

Jenks: On your comment here that you made your small heading changes with rudder, how do you normally do that? Just rudder input then follow it with aileron?

Pilot: I don't know really. Maybe you could say primary rudder and secondary aileron. Then for very small by the time you throw aileron in it's too late.

Jenks: So that would cover pretty much the precision heading task. How about the localizer intercept? Did you notice . . . how did you feel about the transition to the approach configuration? In other words, gear and full flaps and speed reduction?

Pilot: This is one fallacy of your test technique. The [inaccuracy in the] first approach was probably 70-percent pilot error, straight pilot error. I just didn't execute the approach right, in other words I didn't maintain aircraft control. It was just lousy. If you look on the tape where I say "Okay, dummy, do it right this time," you might see a big improvement which is not necessarily due to the two systems. I'll talk about that later.

Jenks: The thing we are really looking for right now as our primary data source is going to be the subjective comments and the quantitative data that goes along with it is going to be a supportive sort of thing. In some instances, in our data analysis we might be coming along and taking the data and trying to support what the subjective comment was and then in another instance we might turn around and say well, no, in this instance it is detracting and that sort of thing. So, our real assessment as to the improvement in this system isn't necessarily going to be generated just from the performance itself.

Pilot: As I recall there was a lot of pitch change with gear and flaps intercepting the localizer, which added to the difficulty. As I told Rick, I was trying to think after I had the system on whether it was any better. I think I told him it was probably better but I just can't remember specifics—whether it was 5 better or 10 better—because I was primarily flying the airplane. Pilots, having a problem with ego, you try to fly the airplane and do a good job. When it is new your mind is only keyed to one thing rather than somebody who had a lot of time in the airplane, he could . . . he is not paying attention to flying the airplane . . . I just can't remember, but I do remember that the very last approach I made with the thing in the command mode was much easier and so undoubtedly there was less pitch change due to gear and flaps. If I fly it again, being more used to everything I can devote more of my time to feeling forces and my mind won't be 100 percent occupied with trying to fly the airplane.

Jenks: It is valuable to find out what the learning curve is on the control system because it is somewhat different and we can't deny that so it seems like there are two barriers that we have to get through. The first barrier is just as you say, familiarity with the airplane in general, whether it is slave or command, just location of throttles and power response, pitch response and things like that. Then we have to get through the barrier of the difference of the two control techniques. That is what we hope to do by being able to get another flight and possibly even at a higher level of turbulence. Yours I know was at a fairly low level of turbulence today. During the ILS approach itself in the slave mode, did you have . . . could you perceive any problems with maintaining the glideslope, good glideslope track, in other words being able to set up a good positive . . .

Pilot: It was practically nonexistent the first time. Probably no more than I normally have, considering I was flying a new airplane.

Jenks: Then the goaround, the thing we were looking for there, of course, was a look at the pitch transients due to configuration changes due to the power, gear and flaps.

Pilot: I don't remember anything about that.

Jenks: The rating at that time for the basic airplane was a 5; and the rating of 5 says moderately objectionable shortcomings for aircraft characteristics and adequate performance requires considerable pilot compensation. One of the things you might consider is the difference between a 4 and a 5—minor but annoying shortcomings versus moderately objectionable shortcomings. Can you be specific? Have you thought about it enough or do you have anything specific that you recall that would differentiate it between a 4 and a 5?

Pilot: In the 5, in the basic airplane, it was just sloppy. It just wallows around like a big moose or an elephant or something. It was difficult to hold heading, aileron forces were high, just based on the ideal airplane it was just crummy. Now then when you flip your system on and the one reason, the only reason I rated it to be 4 was that it relieved the pilot load, particularly in turbulence, of maintaining heading, which was bad in the basic configuration. Because the pseudo autopilot effect of returning it back to neutral was a significant improvement on heading hold.

Jenks: Made the cross check a little less critical.

Pilot: If the turbulence knocks you off, the system brings you back. I thought it was significant enough to increase the rating. Now, for the ideal airplane the aileron forces are still too high and this I'm sure could be corrected. As it stands now . . .

Jenks: Yes, that's precisely what we want to do. We want to rate this airplane as it stands.

Pilot: The aileron forces are much too high. You can do it with one hand but it's tiring.

Jenks: The one thing that we didn't do with any of you guys was to actually talk about any of the control techniques, this is in the command mode itself, and that was different than what we did yesterday with Phil. What we did yesterday during the familiarization flight was to actually talk about techniques because it seemed that we did indeed have a technique problem where things were simplified with technique. Yes, even more specifically than that, yesterday we pointed out to Phil that if he desired he could use the pilot's trim for bank angle. Then you don't have to hold the force. You can just crank it off to the bank that you want and let her set. The other thing that seemed helpful, to Phil, anyway, was that again in the command mode, my perception of the control system has been that it tends to decouple the pitch axis. What it does is to give you throttle for speed control and give you trim for altitude control. It effectively decouples the two. In other words you can for a fairly long period of time—4, 5, 6 or maybe 10 seconds—you can make power changes and not change the vertical descent. Whereas in the basic airplane, the minute you make a power change you immediately get a pitch transient, which means you have to get an immediate trim change, and that immediately causes a descent. With the system the only descent change you get is due to the fact that when you shove the power up you go faster and it . . . The descent rate is just the sin of the descent angle—sin of gamma times the velocity so that effectively decouples for a long period of time. That proved helpful to Phil so we hope to be able to point all those things out on your next flight so you might get a little more familiarity. Now these are just the comments then on the command mode. The most obvious advantage is that it is much easier to maintain heading in the command mode, also the ride was much smoother. Where did you perceive the ride's being smoother? Was it in the lateral response or in the g response, the $\dot{z}$ type response do you think?

Pilot: I would probably think it would be the lateral response, although I really can't distinguish between the two. I just felt that the airplane seemed to ride smoother, at least in the pilot's compartment.

Jenks: I have perceived the same type of feeling. Looking out in front of the airplane it is not uncommon to see a gust hit you and hit two complete overshoots with the nose, with the system off. However with the system on you just see the initial gust input and bang . . . We have already talked about the aileron forces' being objectionable in a sustained bank. The pitch transients during configuration change were reduced. I guess in the vertical S maneuvers, we want to bank up here a little bit . . . In the vertical S maneuvers with the system in command, yesterday when we were talking with Phil, his initial perception was flying the vertical S system on and system off he didn't feel that there was much improvement and that was when we got into this discussion about the technique of using throttle for speed control and trim for pitch control for $\dot{h}$ control and we fooled around with it some more and it completely changed his opinion. He said, oh, I see what you mean, that works much better. Then he said he thought the system was quite impressive in the vertical S. I'm not trying to influence you or change your comment. The thing I am trying to do is see if you encountered the same thing. In other words, you may have had a more conventional airplane sort of technique, where you were shoving the throttle and pulling back on the yoke or trimming something in.

Pilot: When I did them I really couldn't tell the difference in doing the two maneuvers. But when I was doing them they said don't worry about airspeed. That's vertical S's, that part of it, airspeed and then towards the end I was kind of doing it myself but I wasn't required to maintain a constant airspeed. That relieves your workload 50 percent. Just let that airspeed slop around wherever it wants to within reason. I had a constant power setting. I set one for climb and he said that was about right for descent and I would pull it back for the descent.

Jenks: What type of airspeed deviations do you think you encountered?

Pilot: Twenty knots at least. One hundred fifty maybe, I mean 20 total. When I was climbing, it may have gone from 155 down to 140. Some of the last ones I tried to do the way I preferred to. I was fiddling more with the power . . . The way I did them I couldn't really tell much difference between the two systems.

Jenks: In the unaugmented airplane did you do the same thing? Did you fly the slave airplane the same way as far as airspeed was concerned?

Pilot: Yes.

Jenks: Aileron forces objectionable in sustained bank turns, pitch transients during configuration changes were reduced. That is more or less the comment you probably had on the localizer intercept. It was undoubtedly reduced but you couldn't really feel it. How about on the ILS itself? Did you detect any improvement in the pitch trim response at all there? Did you ever reach a point on the ILS where you felt you had the airplane trimmed up and locked on to the localizer? Where you could take your hands off?

Pilot: Just about through all of them. But as far as breaking it down into that much detail, I couldn't make any comments other than what I made before in that the last ILS (the fourth one, fourth total, in the command mode) seemed to be much much easier than any of the others. Of course you've got a learning curve there. But even so it can't be all learning curve. There is some difference in the two modes. It can be pitch, heading, all combined in there, and power response, I'm sure.

Jenks: The thing is, you see, all the data we're taking is being compared, not just your data but also the data of everybody else. Everybody who is evaluating the airplane is basically being subjected to the same profile. They are experiencing the same learning curve process, in other words they are getting through familiarity with the airplane and the profile and stuff like that such that we can to a certain extent normalize it so the thing we are going to say is if you perceived a bigger improvement than someone else or the same delta then we have to conclude then that perhaps that we are gaining some advantage from the control system. How about the missed approach, the goaround? Any additional comments on that?

Pilot: No, I can't . . . there again you are talking about power and pitch response and I don't remember.

Jenks: So, the overall rating was a 4, the minor but annoying shortcomings, I think you have already mentioned that is probably the aileron forces. Do you think . . . How do you think your opinion would be changed if you consistently used the trim knob?

Pilot: I wouldn't do that. I don't like that. Pitch is fine, trim is fine in pitch but not in bank. In the normal turns you make it's . . . If I understand the system right, if you trim it into a bank, you've got to untrim it when you roll out, although you could override it. It's not a satisfactory method . . .

Jenks: How would you feel about it if you had an electric trim, a coolie hat trim on the wheel for ailerons?

Pilot: I don't know. It might, I would say I still wouldn't do it. But here you have ingrained habits just like going from a stick to a wrist control. I know I'll never like that. You don't really know until you try it.

Jenks: Do you feel that way because you feel it's unsafe to be trimmed into a bank?

Pilot: Yes, that's probably got something to do with it. If you are turning, the pilot more likely needs to change direction rather than pitch as you are maneuvering, say to get out of somebody's way or to change headings from command on the ground or wherever you are going. Bank is probably more than pitch. I just like to be in control of it all the time and to be able to put my own yanking and banking in there. If you had one conveniently on the stick where you just flip the thumb, it might be satisfactory. To move your hand down and crank a wheel . . . I might try it next time just to see.

Jenks: It's pretty close in convenience, it doesn't take too many turns, it goes 1, 2, 3 and you're at a 30° bank turn, about 10° a wrist flip.

Pilot: If you are right handed, most pilots fly with their right hands, it means this business . . .

Jenks: I normally fly with the left because I have my right over on the throttle. Except during takeoff or something like that. Then I normally fly with two hands.

Pilot: That airplane you've got to fly with two hands.

Jenks: Did you notice any problems with the control sensitivity in the ailerons? Did you find it difficult to fly in a banked turn or did you find yourself giving the PIO to the airplane?

Pilot: There was probably a little sensitivity but I didn't find it objectionable. You could tell it was . . .

Jenks: Probably initially when you first started.

Pilot: It wasn't nearly as bad as a T-33 for example. But it was no problem. If you put somebody in a T-33 the first time he couldn't fly it, probably. This one you could tell was sensitive but it was no problem.

Date: Apr. 1, 1976 Flight: 036

Pilot number: 3 SSSA mode: Slave/command

Pilot rating: Turbulence level: Occasional light
Slave — 4.0
Command — 2.0

Pilot: . . . Tuck to transition smoothly in pitch during the vertical S's, that was in the command mode.

The whole thing as we all know is modified by the fact that I've been flying a straight airplane all my life, so I am a little more adept at making it smooth than I would be with the new system. From the first time I flew it, which was a couple of weeks ago, I had the same problem with the slave mode—holding the aileron—and I don't like that.

Jenks: With the control system in command?

Pilot: Right, command and holding the ailerons in the vertical S can be a real pain. For two reasons - (1) It's pressure you have to hold in but (2) it's difficult to hold the same amount of pressure for a length of time. Consequently your accuracy is degraded. So with the suggestion of trimming it out, once I had it in it was like an autopilot. That was good. So that just gives basis to my original suggestion of the electric coolie hat trim. Because if you can electrically trim that would be fine. The real problem though is if you try to do it manually. It's when you're transitioning from a right turn to a left turn or from the ILS to a goaround or something, you have a lot to do without having to sit down and manually trim an aileron. That could really be a hazard if you had it manually but with an electric trim that would all take care of itself and that could be a real nice system. There was a very distinct advantage once I got it trimmed up, but the transition into it was somewhat awkward due to the lack of the electric trim. The straight airplane is fairly stable to start with, so once I got it into the maneuver without the command system it still held it pretty well, but I had to monitor it more than I did the command system once I got it trimmed, but without the trim I had to have a bunch of force on the aileron. You could trim the pitch but I could trim the pitch in the straight airplane too. So without the electric trim it was an inferior system to the straight airplane. With it trimmed up though it was a better system than the straight airplane.

Jenks: How about the transitioning on the bottom and the top of your vertical S. Did you notice any difference there between the basic and the . . .

Pilot: No, not really. I normally trim an airplane with the button anyway and so it really doesn't make that much difference to me. Other than the fact that we noted on the way home that if I was trimming a straight airplane I would hold the wheel to where I wanted it and trim off the pressure whereas on this system it is difficult to do that so you just more or less trim it with the button and it seems to set up an oscillation that is damped out very rapidly but especially on a long fuselage such as the 99 the guy in the back seat would really feel it, which obviously wouldn't work for an air carrier because he would get everybody sick in the back.

Jenks: How about turbulence today?

Pilot: [While] we were doing the vertical S's it was smooth. [When] we got down below about 4,500 feet we started getting into the haze layer or the inversion layer, and it started getting bumpy, but really I noticed it when we started into it but I didn't really notice it on . . . . I would have to say light would be the overall . . .

Jenks: Light turbulence is turbulence that momentarily causes slight erratic changes in altitude and/or attitude. Light turbulence as opposed to chop, which is usually considered the bumpy road sort of criteria.

Pilot: Not for the whole flight, though. Just in the lower realm.

Jenks: At the higher altitudes, during the vertical S maneuvers, then we're talking about smooth, and at the lower altitudes where we did the precision heading and the rest of the profiles then we are talking about light turbulence.

How about the reporting term, occasional, intermittent, or continuous. Occasional is less than a third of the time, intermittent is one-third to two-thirds, and continuous is more than two-thirds.

Pilot: Well, I would have to say occasional, because I didn't really consciously think about that. Once I got on the ILS I was more concerned about the wind shear that we got in a little bit close than I was about the turbulence. I didn't think we were bouncing around that much.

Jenks: So smooth and occasional light?

Pilot: Yes.

Jenks: How about the precision heading task with the basic airplane?

Pilot: In theory, the command should be a whole lot better and in past experience it was, but today it didn't seem to be. On the ILS it was but not on the precision heading, but I can't explain why because it should be like an autopilot. Today I held, I think the tapes will prove me out, I held my heading better, raw data, than I did with the command system, but I cannot explain why.

Jenks: Do you recall any change in technique or anything at this time?

Pilot: No. The one thing that wasn't on the tape, where it was really the worst, was in that descent, but we were descending on the straight airplane. Before, I might have gotten a couple of degrees off but I don't think I got more than 2° or 3° off. Where this one I looked down and I was 10° off. So I don't know how to explain that. Just from my knowledge of what I've flown in the past, I would have to give the command system the nod on precision, because it tends to hold like an autopilot and you can direct your attention to other areas. You don't really have to stay on top of it as you might. But, again, the airplane is fairly stable, so we don't have too much trouble even with a straight airplane if you have it trimmed up.

Jenks: How about the localizer intercept?

Pilot: Today, I noticed a lot bigger change than I did the last time I flew it. I wasn't all that aware of it when we were flying a straight airplane. I overshot the localizer a little bit. I thought I was in closer than I was and I took a little bit bigger heading just to get back on it and then I didn't quite catch it. I think I was on it by the time I got to the marker okay. But I noticed that my altitude varied probably 200 feet. We entered at about 3,000 and I think it got as low as 2,800 maybe 2,750 at the lowest. So what's 200 feet, no big deal, but it wasn't as precise as I think the tapes will show that I was on the command because the command held the altitude almost perfectly and I was able to monitor the airspeed and the heading much closer. Consequently, I was on the localizer within . . . my heading went through the localizer course inbound. I think it went to 090 . . . and the inbound is 129 but the course only overshot maybe half a needle. By the time I started coming back I was into a 30° angle bank the other way and I really locked it on right there. I was on it pretty much the rest of the way in so that was a great advantage. I'm not sure why I didn't notice that when I flew it 2 weeks ago but I didn't. I couldn't tell any difference. Today, I noticed a distinct difference. I noticed a good difference on the ILS too. I set up that rate of descent. And I set up the heading and it was almost like an autopilot approach. I think the tapes will show I was a lot closer to the localizer on the second approach than I was on the first. We did have some kind of wind shear out there which played a little havoc with my first approach. I didn't notice it as much on the second, but it might have been that I was chasing the needle more and I just didn't . . . I don't think I got more than half a needle without on the first approach either. The fact of the matter is that my workload was a little higher on the straight airplane. Getting back to the vertical S's, my airspeed control was much better on the vertical S with the command system trimmed. The aileron trim I could almost go hands off and I was pegging everything right where I wanted it, whereas on the straight airplane I had trouble maintaining the airspeed. I was getting the rate of descent and the standard rate turn but I wasn't maintaining the airspeed as well. On the other when I was not trimming out the aileron I had as much trouble as I did with the straight airplane, but once I got the aileron trimmed out it really held the profile better. That would be an advantage there too. After the ILS and into the goaround the same thing applies although I was a little more aware of the airplane this time than I was last, as you know I don't have any time in a 99 other than in this program. The first time I flew the profile, 2 weeks ago, I was surprised how much trim it took to change from a descending ILS attitude to a climbing out, missed approached attitude. What happened there was I gave it the power, gear and flaps up and gave it a bunch of trim forgetting that the 99 and our 100 models are quite similar. It takes a lot of trim just to take care of the gear and the flaps and I found that I was in accelerating level flight but I wasn't climbing. This time I was aware of that and I was monitoring closer and I put in enough trim to get me climbing, but I did have to put in a bunch of trim. Whereas with the command system it takes care of your gear and flaps automatically. Any trim that you add is actually climb trim, and that is a big advantage for somebody that has a heavy workload. I figure probably some accidents are caused where the guy thinks he is climbing where he really isn't. There is such a big change, especially in that airplane, there is such a drastic change from full flaps to climbout. Probably 6° or 7° in trim, I would imagine.

Jenks: We have measured the force—it is around 65 pounds. It is the trim change force on the elevator.

Pilot: I don't doubt it. This is the worst airplane we make for that. Out of 200, you probably won't find 10 pounds of change if it's 65 on the other because it's about that much better. It's overpowered, too, so when you get all the power going you are climbing whether you've got everything down or not. So that would make a difference too, and we were grossed out today too, which would have another effect. I would have to give the command system the nod again on the goaround. The climbing out and the precision heading again would be the same as my other comments.

Jenks: Why don't we walk through the basic airplane then. As I say, I think the idea here is not to feel compelled at all to come up with the reading that you came up with the last time. Again, we are evaluating this airplane on this day based upon your own perceptions today. So, the first question of course is, is it controllable?

Pilot: Obviously, it is.

Jenks: Is adequate performance attainable with a tolerable pilot workload?

Pilot: I think so.

Jenks: Is it satisfactory without improvement?

Pilot: Yes, I would have to say the straight airplane probably is satisfactory without improvement, although certain things like trim change and so on, I don't know what you would do to change that. It would be nice if we didn't have such a big trim change.

Jenks: This question always seems to present some difficulty when you get to this point, so let's just kind of ignore this for the moment and look at aircraft characteristics and the demands on the pilot. If you had answered that question no, obviously for aircraft characteristics at the top of that block is minor but annoying shortcomings. Middle is moderately objectionable shortcomings, very objectionable but tolerable shortcomings. We are referencing this thing to the amount of workload that you as a pilot, today, under these conditions could actually tolerate. We are saying that at the top of the block—of course, desired performance requires moderate pilot compensation versus considerable versus extensive.

Pilot: We are also doing it for the whole flight, not just one . . .

Jenks: That's right. That's the entire profile of the entire mission. This is supposed to be indicative of possibly a cruise portion followed by vectors to a descending altitude followed by approach giving the vectors to the localizer and missed approach. We are indeed talking about the entire profile.

Pilot: Trim changes would be, especially since the command system is so much better than the aileron, and the other thing is the rudder on the command system chases the ball, it seems like a little bit and that's somewhat aggravating. Especially if you have been taught all your life that the ball ought to be in the center. You try to do that and it's all over. I would have to say minor but annoying shortcomings for the straight airplane, which is about a 4.

Jenks: Now for the modified airplane.

Pilot: For this airplane without the electric trim I say it would be almost objectionable shortcomings in a turn—you know, the vertical S maneuver and so on. When you once get it straightened out like in localizer approach or precision heading or something like that, then that portion would be eliminated because it holds it well.

Jenks: You are saying that the aileron forces, if you have to hold them, during any period are very objectionable . . .

Pilot: Yes, almost objectionable, but tolerable. About a number 6. If you can trim those out where those aren't a factor any more, you increase the system completely as far as I am concerned and almost get it up into good but negligible—2. I think it would change it that much because for somebody, especially somebody that is used to a straight airplane where you can put it in, take out the forces, and it's there and then you get in there and have to hold it in there it's aggravating and also after a while you forget about it and if you have another workload, taking a clearance or changing a radio, in the meantime your standard rate turn has gone to pot. So, I think that would be objectionable, tolerable shortcoming, but if you can trim it out I say the airplane is probably good with negligible detractors because everything else, the localizer, monitoring the altitude while you are changing your heading and so, the goaround, heading hold, all those would be good characteristics that would pan out but that one shortcoming, obviously it seems like it could be changed without too much trouble.

Jenks: So we are talking about a 2 then with the stipulations that we have already talked about.

Date: Mar. 30, 1976 — Flight: 4

Pilot number: 4 — SSSA mode: Slave/command

Pilot rating:
Slave — 4.5
Command — 3.0

Turbulence level: Intermittent moderate

Pilot: I wasn't fully aware of the function of the controls with the system on as in relation to the basic control of the aircraft. In essence I was utilizing them in combination as always, but still in more or less the same manner in which I would use the controls if the system weren't on. In other words, in a conventional airplane rate command sort of way. I'm talking principally about pitch axis because roll axis was an axis which I largely ignored other than occasionally cross scanning the attitude gyro to see that I had about the right bank angle. That axis I really short changed and didn't make a real tight closure on that at all. We are talking mainly about pitch. My initial comments with the system off were based on a technique which is relatively conventional, and once we had the discussion about the throttle being principally a controller of airspeed and elevator being principally a controller of $\dot{h}$, things fell into place. However, along with that philosophy of control usage it is extremely important to combine timely use of the trim system to control the elevator, because without timely use of the trim system even with the proper manipulation of the controls in relation to $\dot{h}$ and speed. . . . I think it would be less effective, much less pleasing, if we didn't use the trim system when it was appropriate in timely fashion.

Jenks: Timely, meaning getting input in rapidly enough as opposed to delaying for some time and then . . .

Pilot: What I'm talking about really is minimizing yoke force in the elevator shaft. Because the force gradient is I think unacceptably high. I think the thing that makes the system acceptable is the fact that you have a trim system. I think it would be much nicer if you didn't have to trim so often. If the gradient were lower and didn't require the use of the trim so often but the trim, as long as you know to use it, it's still reasonably nice. I think an incremental improvement would be to lower the gradient, but I realize that you have other problems.

Jenks: The thing is, we can do that quite simply. That's not that big a deal. We can get it to the point where even with the existing system right now without making any modifications to the system, we can change that digital clock and optimize for the pitch trim response and also get the static longitudinal stability back down to a more nominal level. So that is possible.

Pilot: Forewarning to use the pitch trim immediately upon initiating or realizing that you are going to initiate elevator position movement takes care of the problem. It's something you have to be forewarned about and you have to do it a couple of times just to make sure that it becomes second nature. Do that whenever you want to move the elevator.

Jenks: I think that is probably the reason that I haven't appreciated the problem very much. I've gotten to the point where when I want a new attitude I don't even pull on the yoke, I just hit the trim.

Pilot: That's how I was flying the airplane later on in the day, since I normally like to fly an airplane that way anyway if it has an electric trim. Normally, meaning if it works out well, and if I don't excite the phugoid or something like that. For instance that's a good way to fly the F-4 and F-8 airplanes, especially if you are trying to be a smooth formation lead. Fly it with trim. I am accustomed to doing that. I like to do it that way. I didn't object particularly to flying it to trim. It is just a matter of realizing by trial and error procedures that you do in fact have to do it that way. The previous undesirable comments were based on first of all and primarily on flying the airplane by trying to control speed principally through elevator position and principally through throttle manipulation. Of course, there is always a mixture of the two, but those are the principal techniques I was using to start with. Then when I changed they changed. They became more accurate and . . . I was using the . . . My performance was better. It was significantly better with even less workload than before. I was trying as hard as I could.

Jenks: This is going to be the evaluation in the slave mode and we have already talked quite extensively about the vertical S's and . . .

Pilot: I wanted to say a few more things about the recorded runs we made after you left the airplane. On the first several runs, what I am essentially saying, task 1, the vertical S maneuver, there was a lot of degrading in performance due to the fact that I was wearing the glasses and the sun was coming through the windshield and hitting the glasses. It was extremely difficult to see. Later on I realized that there was a sun visor up there. I realized what the problem was and I put the visor in between myself and the glass but your visual acuity was just miserable. It was very difficult to see things and it definitely detracted from performance. It was just hard to read the gauges. You couldn't see them peripherally well at all. So my performance was very much worse than it had been when I had been flying without them even though when I was flying without them I had been ignoring the horizon. The conditions as far as having a horizon were for all intents and purposes the same but I had a lot better . . . I could see the instruments themselves much much better. The performance on the vertical S maneuver, the first run especially, was very very poor. I had a very high workload on that task, but in spite of that, in spite of all the effort I put into it, I found it difficult to perform the task accurately. In fact, [I found it] impossible to perform it very accurately. I was generally very dissatisfied with the performance. I did it quite a few times. I probably have about 8 or 9 180° turns because I wanted to continue and see if I could dampen out those deviations. Especially when I first put on the glasses, that screwed things up. I had some real bad turns. I was working very hard and there were a lot of upsets from the turbulence that were causing me to work . . . a lot of pitch upsets that were disturbing me. I was getting speed fluctuations of ±15 knots. I just couldn't get things squared away very well. In spite of all the work and along with the pitch upsets . . . there was a lot of thermal activity. I was getting extreme deviations on $\dot{h}$ too. I was working real hard and I let $\varphi$ go entirely on that one. I think that at some time I was probably in 30° to 32° of bank, sometimes I was in a 15° bank because I was trying to close the loop tighter on $\dot{h}$ control and speed. With the system on it was much much much better. It was very . . . we will come back to that. I want to go into the heading maneuver. On this task I was getting . . . I found that I was able to hold heading at about ±4° and there were frequent deviations, right and left. I could correct them but in just a few moments, it was just a matter of a few seconds, I would have an upset that would send me back off. . .

Jenks: I noticed today that it seemed the turbulence, the nature of the turbulence was getting a lot of yaw inputs, predominantly a roll but occasionally we would get a yaw input.

Pilot: Right, I was getting some yaw inputs up there too. That is about all I have to say on that. I characterized my level of effort as moderate in terms of frequency with which I had to be active in the loop. I would guess there were periods of 2 or 3 seconds where I was completely inactive. Then the upset . . . there was nothing I could do to compensate for the upset, really, while it was going on. It was a fairly quick event in periods of time. It would just be a matter of flying the airplane back to the right heading. In a period in which again it was relatively quick as a matter of having a sequence of steps or squarewave where every now and then you would get just the top of the squarewave . . . nothing and then all of a sudden an input, short duration input then another one later on. That is about all I have to say right now about precision heading. On the intercept . . . the intercept task which I flew without the system was the last of two approaches. It so happened that my technique in flying it was different and the results were better. Namely, as soon as the needle started to move I used about 45° or 50° of bank, which produced less overshoot. I had the gear down a little bit sooner and the flaps down a little bit sooner and I got steady on the localizer much earlier but it was not so much due to the fact that I didn't have the system on, it was just a matter of the initial procedure when the needle started to move and I don't think it is significant in terms of system characteristics. It is only significant in the fact that I happened to make a better initial guess where to start and what to do. It would have been a little bit extreme for most people's liking and on the other hand a 90° intercept I guess depends on how far out you are. I would do it right away if I were the only one in the airplane. I wouldn't do it that way if I had somebody on board because I would be trying to make a more gradual smoother procedure out of it. So, anyway, the localizer performance with the system off is going to look better because I just happened to do the right thing that time and got squared away on the localizer.

Jenks: How did you feel about the workload during the transition? Did you notice the pitch transients with gear and flaps and power?

Pilot: With me the transition is kind of an open loop procedure where you make the turn and you drop the gear and you drop the flaps and you put the power up. I already had approximate numbers for the power and it just turned out about right. While these things are going on simultaneously I am not doing much of anything except trying to control altitude in a gross sense. If you change to 75 feet, it doesn't bother too much and of course the flaps coming down and everything it could very well happen. I think again in this case I probably had a better transition too with the system off than with the system on. But again I don't know without doing it a number of times, just doing the transition itself with configuration change and the turn and the intercept and altitude control I don't know, I can't tell that the system's being off or on was particularly significant. Again I feel it is kind of like an open loop task where I just throw everything down and I wait to see what happens. I'm not really active here particularly. And everything I do is a guess, not everything, but things are largely a guess or maybe they are coming through at a lower level in terms of accelerations . . . When I feel a heave my natural tendency is to start trimming forward because I know that I'm ballooning, I know I'm gaining altitude. I do that regardless of whether the system is on or off, I think. I was flying the system later on in the flight, in fact once I started using the trim I used it in both configurations pretty consistently rather than moving the wheel. I moved it with the trim to . . . Because that is the way I normally fly an airplane. I don't know if that was the intent or not but I guess you want whatever techniques seem to be . . .

Jenks: That's right. We haven't been dictating at all because we didn't want to cause any greater deviations than we had to from the guy's normal techniques. If the guy is accustomed to poking in elevator then we wanted to see what the effects were. I think that is valuable sort of data that if a control system like this is indeed implemented the guys that fly with a lot of elevator may indeed have some trouble.

Pilot: That's what I did so I was about equally active . . . but when I felt I needed to move the elevator I normally did it by use of the trim. The approach itself with the system off was probably, the performance might be a little better for maybe the first two-thirds of it because again I did have an easier task and my overshoot wasn't so much. I would guess maybe at least in pitch attitude I was working a little bit harder than I was later on. I found it to be . . . there was some thermal activity that caused some pretty significant deviations during the approach and required let's say a moderate to high level of activity in terms of control inputs. On the goaround, again that was pretty much an open loop type task to me. Open loop in this respect has a limit on the amount of power I could use. The gear was going to come up. There is no bank input particularly necessary. Again I considered it more or less a loop maneuver and I know what the maximum torque is, the flaps coming up, the gear coming up, the only task that I really have is to try to stay in sufficiently above VMC and try to maintain a positive rate of climb. I really needed to do, to sort of separate things out on this goaround, I should have done probably two or three or four of them just as I should have done two or three or four localizer intercepts by themselves to look at them because there was lot going on in a hurry there. One of the things that is disconcerting about the system off goaround is the great pitch change when you bring the flaps up. It is hard to keep your positive rate of climb. It requires a concerted effort. Not being familiar with the rate of flap retraction, it came as a little bit of a surprise to me each time how much I had to pull back and how much I had to really get on the trim. I was anticipating it. It was a high workload task in that there was an amount of stress that was associated merely with an unanticipated pull force, a combination of a pull force sort of lack of the body cues that sense that you are in fact climbing, that you are transitioning to a climb and then the altimeter confirmed that in both cases or in case of the system off first, I didn't lose any altitude but I sure didn't gain much. That bothered me a little bit because I like to be able to power up there and set up the gear and thing. It bothered me a little bit because I like to be able to have a little more positive missed approach profile in that . . .

Jenks: Ten degrees up and positive climb?

Pilot: It was not a positive climb for some period of time and due largely to the fact the flap retraction was something I didn't really anticipate very well and I was concerned about decelerating too because in the full flaps configuration even when you pull the gear up, even when you go up to 1,250 torque you aren't climbing a whole lot. And the airspeed is still bleeding off and it is not real . . . I think it is something that you need to go out and be able to have a sense for in terms of time of control manipulation so you can do an open loop relatively open loop and have good results.

Jenks: I think one thing you said here is real consistent with the comment you made with the vertical S maneuvers. You said that you found that it was very important to be very timely with the trim. I think because you recognized this you didn't feel the most drastic effects that could have occurred in the goaround on the basic airplane because I found that if you don't get right on the trim, and I assume that is probably the technique you used . . . In other words, when you start trimming or when you start changing configuration on the trim, if you delay that just a little bit, if you try to use the elevator in order to hold the attitude then the system gets away from you. Even by the time you get to the point when you say, oh, I need some trim, you are still sitting there with 50 pounds of force on the wheel trying to trim it off. I feel that I've noticed that with some of the goarounds that I . . .

Pilot: I wasn't as timely on the trims or configuration changes as I was on the S maneuvers because I practiced the S maneuvers much much more than I practiced the goaround maneuvers. I really didn't have it figured out. The forces did build up each time on the goaround maneuver to an uncomfortable point which to me I noted as gut feeling, I'm really working, it got a lot of my attention. Because of the fact that I don't like to fly with a lot of control force on the controls, I have to have it trimmed up.

My reaction to this [turbulence rating] chart is that it depends on wind load. You were talking about airspeed. I would say judging from this, call it moderate. Food service and walking would be difficult if you were in the airplane, there is no doubt about that. What I was noticing principally was the airspeed changes. You were getting airspeed fluctuations at times in the neighborhood of ±4 or 5 knots. We were definitely getting attitude and altitude changes; especially after you get out and you start operating over there, there was a good bit of heaving in the airplane in the thermal activity.

Jenks: Consider it turbulence as opposed to chop?

Pilot: Yes, I would say turbulence opposed to chop.

Jenks: How about the reporting term? Occasional, intermittent, or continuous?

Pilot: It was not continuous. I would say it was intermittent. It weighted toward the high end of intermittent.

Jenks: We are going to evaluate the control system, starting with the vertical S.

Pilot: With the system on I got much better, with an exclamation mark. I flew it without using the aileron trim wheel. I can't say that with the blue glasses on, and I was probably trying a little bit harder, I can't say that I could ignore the control force, the lateral force. Especially when I was making a left input just the geometry of the situation was such that it was more uncomfortable for me to hold a sustained force at the left the way my arm was situated on the armrest. It seemed to be heavier to the left, I think just because of the fact that my geometry and my arm and the wheel was different. However, I didn't find it particularly annoying to the right. I found it mildly annoying to the left and I went ahead and flew that way on some of the maneuvers just to do it—to see how annoying it would be. I was able to control the airplane much much better with a moderate to moderately high degree effort compensation. The performance differences, the values of the excursions, were roughly half of what they had been with the other system. I think the nice thing about the system is that it gives you better starting points. Initially your best guess is sort of an open loop process to start with and then a guess iterative process.

Jenks: Guesses to power and pitch attitude?

Pilot: Right. My guesses with the system on were much better and then it was also obvious that the turbulence was upsetting the airplane much less. That was a very obvious result of having the system on. In general it was just much much easier to fly with the system engaged. My only derogatory comment would be mild and that deals with aileron force.

Jenks: How did you feel about the aileron sensitivity with the forward loop gain? Did you notice any problem at all?

Pilot: I noticed no problem at all. I say that with the understanding between the two of us that my attention to bank angle was less than the attention given to speed and attitude but there seemed to be much less to do because it seemed to be held reasonably well by the system. In fact in some runs I did trim $\varphi$ and it held very nicely. What was the question you asked again?

Jenks: I was asking whether or not you noticed any problems with the control sensitivity—in other words, a tendency to overcontrol.

Pilot: No, I noticed no problems at all. Again, some of it may have been obscured by the fact that turbulence upsets were getting past the system to a certain extent, but they were mild and I couldn't see any limit cycle or oscillatory behavior, no pilot induced sort of thing being out of phase with it. That didn't show up at all. It wasn't obvious to me. It may in fact exist but with the conditions we had today it wasn't obvious and I liked it. The only thing I didn't like was the force. On the precision heading maneuver I thought it was really great. It held, in fact what I did was take my hand off the wheel entirely, off the yoke and I put it in the center of the wheel so if I needed to I could tweak the elevator a little bit and then I tried just resting it very lightly over it so. If I needed to tweak the elevator I could do it with trim. It did a beautiful job of heading hold. Every now and then there would be an excursion or an upset that the airplane couldn't handle. It didn't appear to drift and it was holding heading for a period of time—maybe 10 or 12 seconds, something like that—right on and then there would be a small excursion that I would make a correction for.

Jenks: Did you find the yaw inputs due to the separate surface rudder inputs objectionable? In other words, did you feel the lateral acceleration due to the yawing of the airplane?

Pilot: I didn't find it to be objectionable at all. On the other hand I was desensitized to a certain extent to it then, due to the fact that we were getting lateral turbulence anyway with the system off. I found the ride to be better, really nicer, insofar as I can remember, with the system on, even in terms of lateral acceleration. I don't know that the records will show it but my perception was that it was nicer, the y accelerations were less objectionable with the system.

Jenks: Could you detect the difference in the yaw damper? I've got an opinion here and I was just wanting to draw it out of you.

Pilot: I don't know the cause-effect relationship. All I'm trying to describe is the effect. The effect was that the yaw rates, the excursions and the yaw both, the total yaw experienced as well as the rates were considerably down.

Jenks: I think that was the sort of thing I was looking for. I noticed that I've seen lateral gusts that hit you and we end up with the system turned off without the yaw damper. Typically you'll hit a lateral gust and you'll end up with two overshoots, at least two overshoots with the nose sweeping across the horizon, and an amplitude of about 5°. I noticed with the yaw damper on you get the initial gust excursion and then it's right back on. The frequency seems to be a little higher, the amplitude is somewhat less.

Pilot: Today we had always the yaw damper on when the system was on.

Jenks: There is no time when we're in command that you don't have yaw damper on.

Pilot: I found it to be really great in the precision heading task. I thought it did a real good job. There were occasionally excursions but they weren't very frequent. The fact that they appeared less frequently would lead me to conclude since they are appearing more frequently before that it was handling a large percentage of the excursions without my even noticing it. Of course the ones that got through were big ones. The localizer intercept we've talked about. Again, I consider it kind of an open loop thing. My localizer intercept with the system on was pretty lousy. I overshot more, much more, and it took me longer to get back to some nominally centered localizer position. As far as the control of the aircraft, though, in terms of pitch axis, I felt that it was much improved over the system off. I liked the decoupling effect of being able to control the glideslope, the rate of descent with the elevator, and the speed with the power. I think that made it a worthwhile improvement to the ease of flying the approach. Again, the records will probably show, except maybe in closer, that the system-off approach was better, but again the primary reason was that I got squared away earlier on it with the system off than I did with the system on. I still feel on the basis of the approaches we shot before we taped the last two approaches that there is a definite improvement with the system on over the performance with the system off.

Jenks: Do you have a feel specifically where you think the improvement's coming? Do you think that it's the fact that the pitch transients are trimmed out or is it in the roll performance?

Pilot: It's not in the roll. I don't think that roll was a particular factor, again because of the fact that I didn't really have enough time to psyche out a real accurate heading to maintain localizer track. As far as pitch, I can't think real specifically it made airspeed control and control easier. It's not too definitive but it may . . . I think that one of the things, again because of the thermal activity, there were a couple of points when glideslope maintenance required a fairly high level of activity, and it was easier, it is characteristically easier, I feel, with the system on than it is with the system off. I sort of hate to use the two approaches we made because I would like it if the other ones . . . I don't think that's what they show. I don't feel that what they are going to show is going to be consistent with my opinion.

Jenks: I think that's really all right. The approach we are taking on this stuff is our primary data, in other words, the primary data source we are generating on this program is your subjective opinion. Then the quantitative data that goes along with that is going to be merely tagalong. If it supports, fine, if it doesn't fine. The real idea is that we are going from your subjective comments, we are going to be able to substantiate why the performance is what it is in the strip charts. I am not particularly concerned about that right now.

Pilot: The goaround again I feel like that was pretty much an open loop thing and we have already talked about precision heading. I don't really have much more to say about that.

Vertical S's with the system on, I think the performance was satisfactory without any improvement. I think due to the fact that there was aileron force required without the trim for . . . either you had to trim the ailerons or you had to maintain some force into the turn. I would say there was . . . the aircraft characteristics were between good and fair. However, I didn't feel that compensation is the appropriate term in terms of lead lag type relationship. If you are talking about pilot compensation in terms of . . . it is kind of like a static gain you need to maintain as opposed to some dynamic quantity. There is a certain annoyance that comes in from the fact I guess that your skeletal muscles are tensed up to a certain thing and it makes the task more difficult. It is kind of a bone head thing as opposed to something that you feel you have to psyche out. It's just something that is annoying you. In that respect I would have to say that the description which says that pilot compensation is not a factor is not quite appropriate. I would say that there is some compensation required for the desired performance and I think that it would fall somewhere between a 2 and a 3, let's say a 2.5. Let me change that again, after looking at the wording. The aircraft characteristics description here . . . says "some mildly unpleasant". I think mildly unpleasant characterizes the nature of the task or the subtask which involves holding an aileron force or trimming. I would say that trimming is less unpleasant as long as you don't have something else to do with your right hand such as write down a clearance or something of that sort. Trimming is less unpleasant than holding the force. I would rather do it that way because the trim is close at hand and it is very convenient and easy to reach . . . put your hand down and keep it in that vicinity. On the whole I would say it is mildly unpleasant and I think a 3 would be probably most appropriate. On precision heading, again I thought it was really great. Aircraft characteristics, I wouldn't give it a 1 because something got through the system. I don't think pilot compensation was a factor for performance. I really thought that was really good. I think a 2 on that would be appropriate. The intercept we are leaving out on the approach.

Jenks: Again, for the same reason because you really thought it was kind of open loop like just a matter of configuring the airplane and waiting and watching what happens.

Pilot: With as little practice as I had, if I had repeated it a number of times I think I would have been able to perceive a difference. With the exposure I got I couldn't. I was still doing it open loop.

Jenks: Do you think if we change, of course I'm not talking about changing it now because I think that would negate a lot of our test data that we have at the present time. Do you have any recommendation on a change in the profile that might prevent this from being an open loop sort of task?

Pilot: No, I don't think it has to be an open loop. I was doing it open loop. I don't think it has to be. If I had repeated it enough times . . . I really wasn't scrutinizing the intercept as much on our practice pass as I was the other portion, such as the S maneuver and the precision heading and the ILS approach. I didn't really have a feel exactly for what I should be looking for there and then the practice didn't really generate any particular response. Because of the fact that at least task 1 and 2 I did over and over again. I had some experience. I started to be able to perceive differences. I don't think the profile needs to be changed. What I think you need to do or what I think would be nice would be to fly enough approaches so that somebody . . . of course maybe nobody else had the same impression. But for me I would need to fly enough approaches so that I could practice this maneuver more times than I did. The same thing with the goaround. On the ILS approach, performance I thought was much better. Due largely to the pitch axis control. I really . . . under the conditions today there was better compensation than needed to be used because of the turbulence do this to the basic airplane. I guess it's the response to turbulence. I think the aircraft and the system is satisfactory without improvement. I don't think it's great but I think it is satisfactory and I think the system helped it a lot. I'm . . . a little bit hung up now over pilot compensation being minimal or moderate. I hesitate to call it minimal. I think I would have to go to a 3 . . . I hate to do that across the range because then your improvement is desired. I think we'll let it go with a 3 on that.

Jenks: The type of compensation we are talking about is obvious or definite trim inputs to reestablish the vertical descent . . . up or down or whatever it might be.

Pilot: As an overall comment before we get to the overall comment rating, I thought the effects of turbulence were much reduced—the perceived effects were much reduced—by the system. Maybe it's like talking about noise. I felt that it was a lot better with the system on. I don't know what the accelerations were but to me it felt better. I thought it was significant.

Jenks: I think riding in the airplane, sitting in the back, I think I can perceive a difference and I never really noticed it before, in fact I had been asked several times as to whether we could detect an improvement in the ride qualities. I couldn't.

Pilot: You are sitting near the CG.

Jenks: Well, yes, I was normally involved in the stuff, and I just wasn't that perceptive. However, Rick and another one of the guys that works on the project, they were down and they flew on one of the evaluation flights. They had time to just sit back there just riding. They noticed a marked difference because it was fairly bumpy and the guys were flying along doing the vertical S maneuvers and Leland told me he started getting lumps in his throat pretty quick. But when they went to the command system, all of a sudden they noticed a big difference to the point that it was much more comfortable.

Pilot: I could almost get with the aileron trim. When we were doing our practice maneuvers, I could just about get the thing trimmed to fly hands off, at least for some period of time. Then we would get an upset that was large enough to get through the system and I would have to make a correction. I couldn't come close to doing that, not even remotely close to doing that with a basic airplane and I was continuously making . . . going through iterations to try to get what I needed to take care of the last upset in my trend before the upset occurred. I'm talking specifically about the S maneuvers. I like it now.

I think I would say that adequate performance is attainable with a tolerable pilot workload. Going to the next block, it was satisfactory without the improvements. Yes, I think it is satisfactory, but the only real objection I have to the system, and again it depends whether you use the trim wheel—whether I use the trim wheel or whether I try to override, is . . . This is a little bit dependent on the situation in which I am flying the airplane. Sometimes it is convenient to have your right hand free to do something else and on the other hand there aren't that many situations where you are making 180° turns. But if I were making a 180° turn or maybe even a 90° turn this sort of depends on the type of airplane. If I am going along at 280 knots and I am making a 180° turn you're talking about 200 indicated at 20,000 feet it takes a long time to make a 180° turn even if at 30° of bank. I definitely want to have a trim wheel. That would be very annoying to me to have to hold . . . it's time dependent to me. The amount of satisfaction I have when it goes up . . . it is just an integrated value. For the S maneuvers, I felt that it would really be nice to fly it that way or to take care of the force situation. Ideally, by lessening the forces or making a little more, I don't think it could be too much more convenient to trim. Maybe if you had a coolie hat trim switch . . . but there is something about a coolie hat . . . [I would] actually like a displacement control like these or like the F-8 has, where they just have wheels on the stick grip rather than a beeper for this type of thing. I prefer that over the coolie hat.

Jenks: It feels a little more vernier control as opposed to bank control?

Pilot: Right. You don't . . . you know you are.

Jenks: I find myself doing that, I say, well I'll take a short bleep or a long bleep or two long ones.

Pilot: I hate to take long ones. I like to have it high gated enough so maybe a couple little short ones . . . never know with the long ones . . . This is satisfactory without improvement. I think I'll have to go with the aircraft characteristics on the . . . under the fair category. Some mildly unpleasant, mildly unpleasant being the lateral aileron force situation. I think a 3 is what I would give it with the system on.

# APPENDIX D
# QUALITATIVE DATA

Section 1: Sample Flight Time-Histories

Section 2: Sample Flight Statistical Calculations

Appendix D contains the time-history plots and statistical analysis of a sample qualitative evaluation flight. Table D-1 relates the digital condition number on the plots to the flight maneuver. All material contained in this appendix was generated by the Boeing Comapny, Wichita, Kansas, at the request of KU-FRL.

# APPENDIX D - SECTION 1

## SAMPLE FLIGHT TIME-HISTORIES

QUALITATIVE EVALUATION

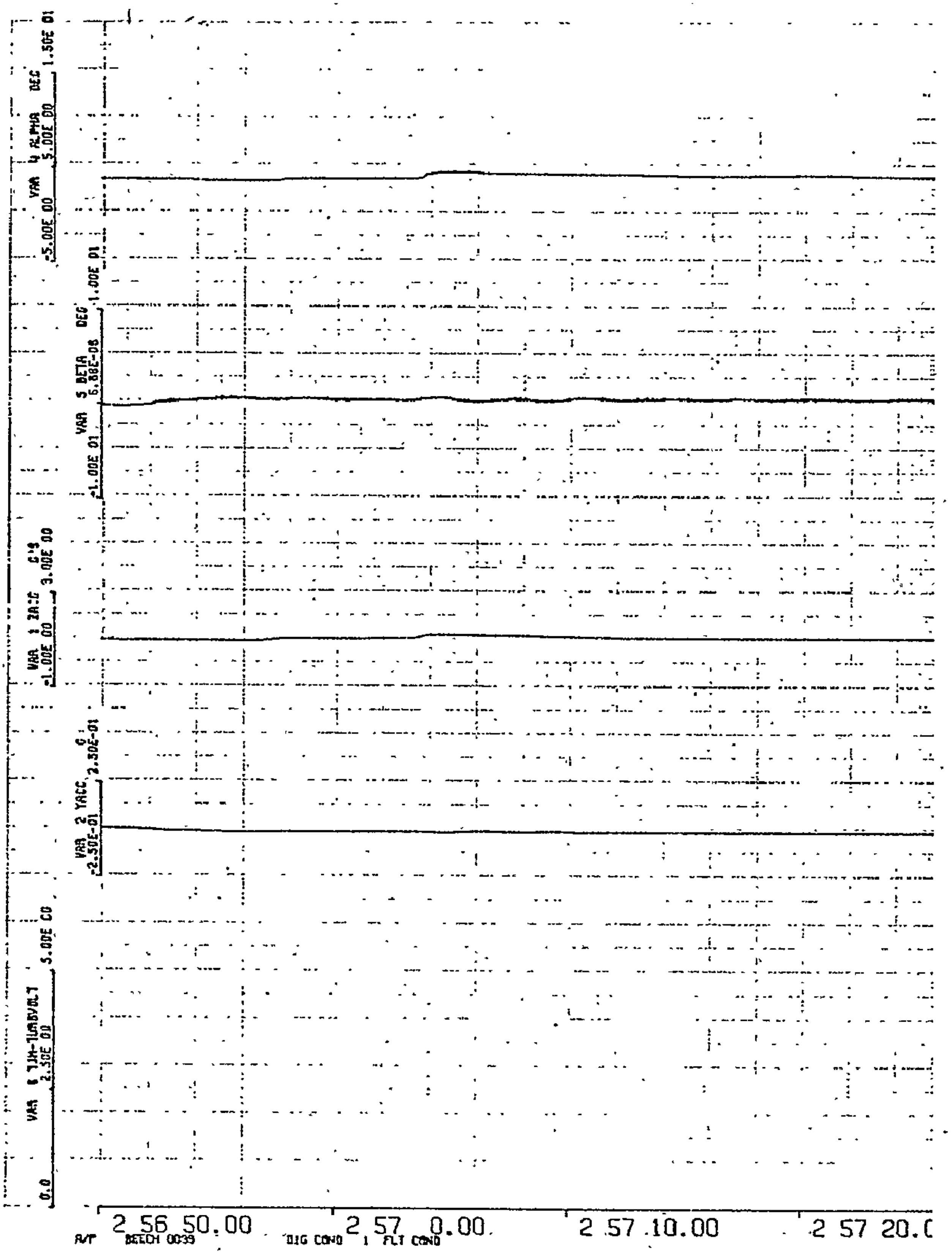
DIGITIZED DATA REQUEST FORM

Flt. No. 036 Pilot 3 Date of Flt. April 1, 1976

PCM Tape No. 092-1 Date of Request April 12, 1976

| Digital Condition No. | Task No. | Manuever | Start Time | Stop Time | Comments |
|---|---|---|---|---|---|
| 1 | 01 | Vertical-S | 025650 | 030000 | SLAVE |
| 6 | 01 | Vertical-S | 032520 | 033040 | COMM |
| 2 | 02 | Precision Heading | 030130 | 030320 | SLAVE |
| 7 | 02 | Precision Heading | 033720 | 033830 | COMM |
| 3 | 03 | Localizer Intercept | 031125 | 031320 | SLAVE |
| 8 | 03 | Localizer Intercept | 034050 | 034140 | COMM |
| 4 | 04 | ILS Approach | 031320 | 031530 | SLAVE |
| 9 | 04 | ILS Approach | 034235 | 034550 | COMM |
| 5 | 05 | Go Around | 031535 | 031650 | SLAVE |
| 10 | 05 | Go Around | 034550 | 034650 | COMM |

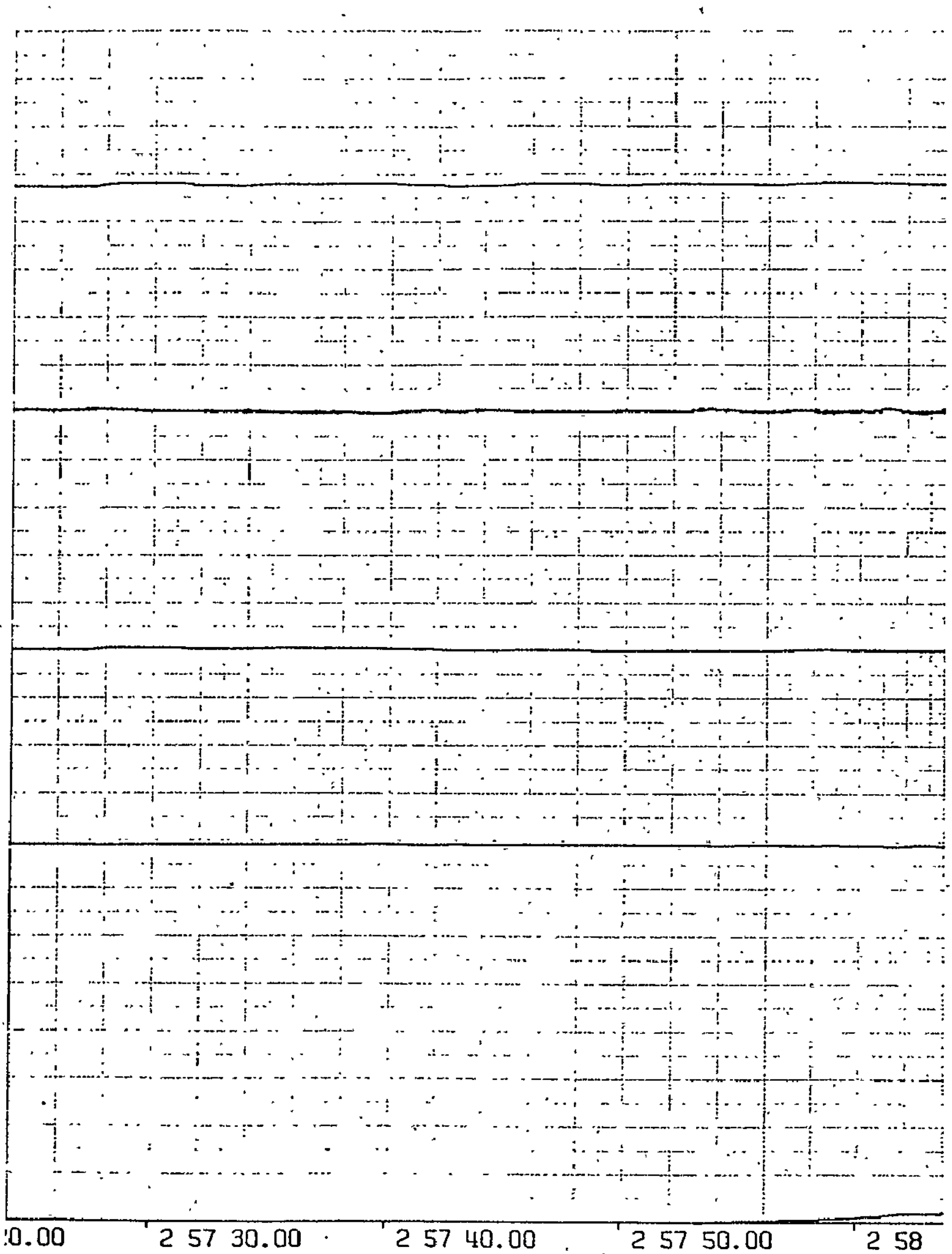
Table D-1 Qualitative Evaluation Data Request Relating Digital Condition Number to Flight Maneuver




A/T BEECH 0039 DIG COND 1 FLT COND

TEST 092-1 RUN NO 124616

RIDE QUALITIES - VERTICAL 5 PLOT FORMAT 0N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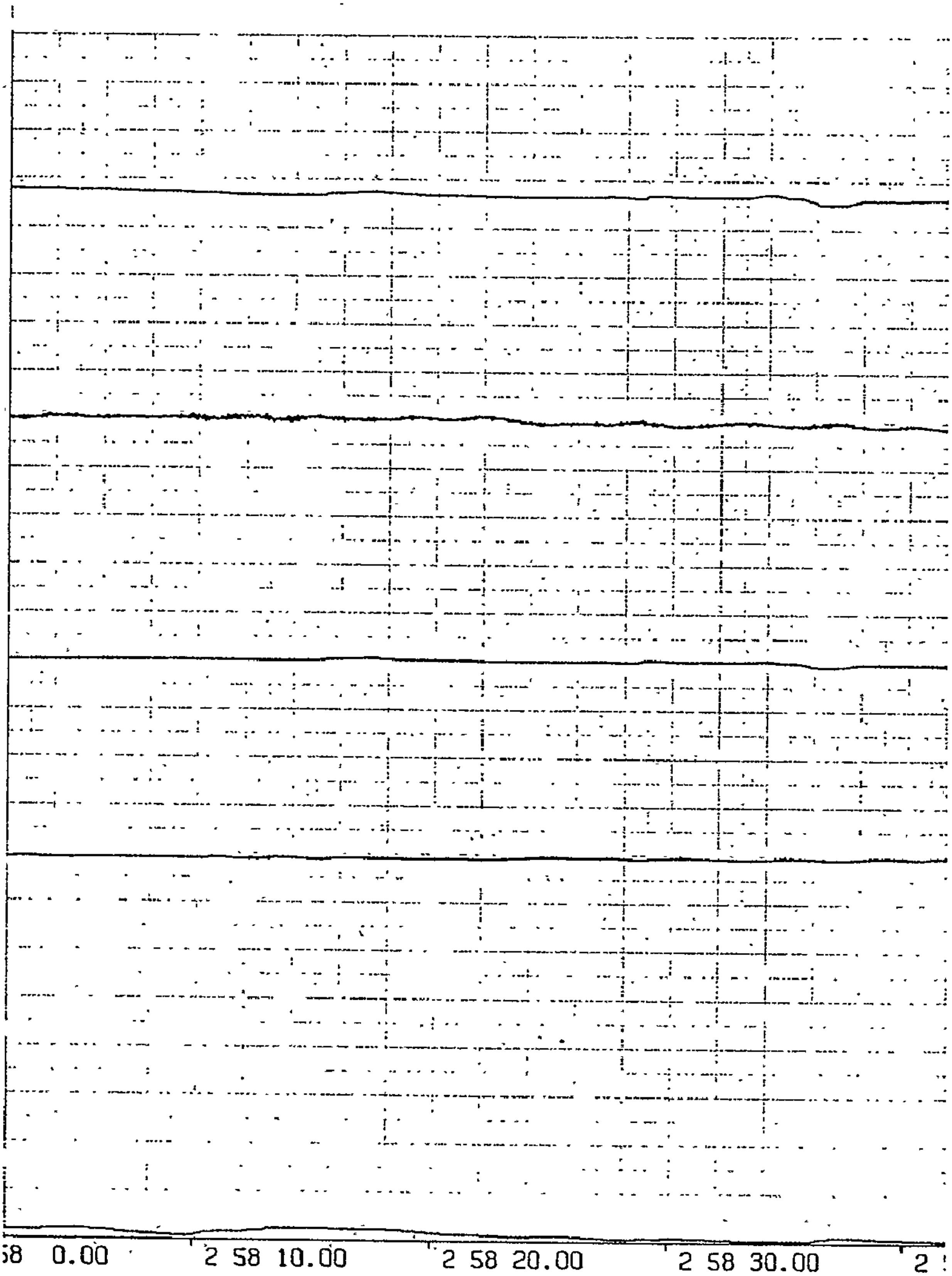
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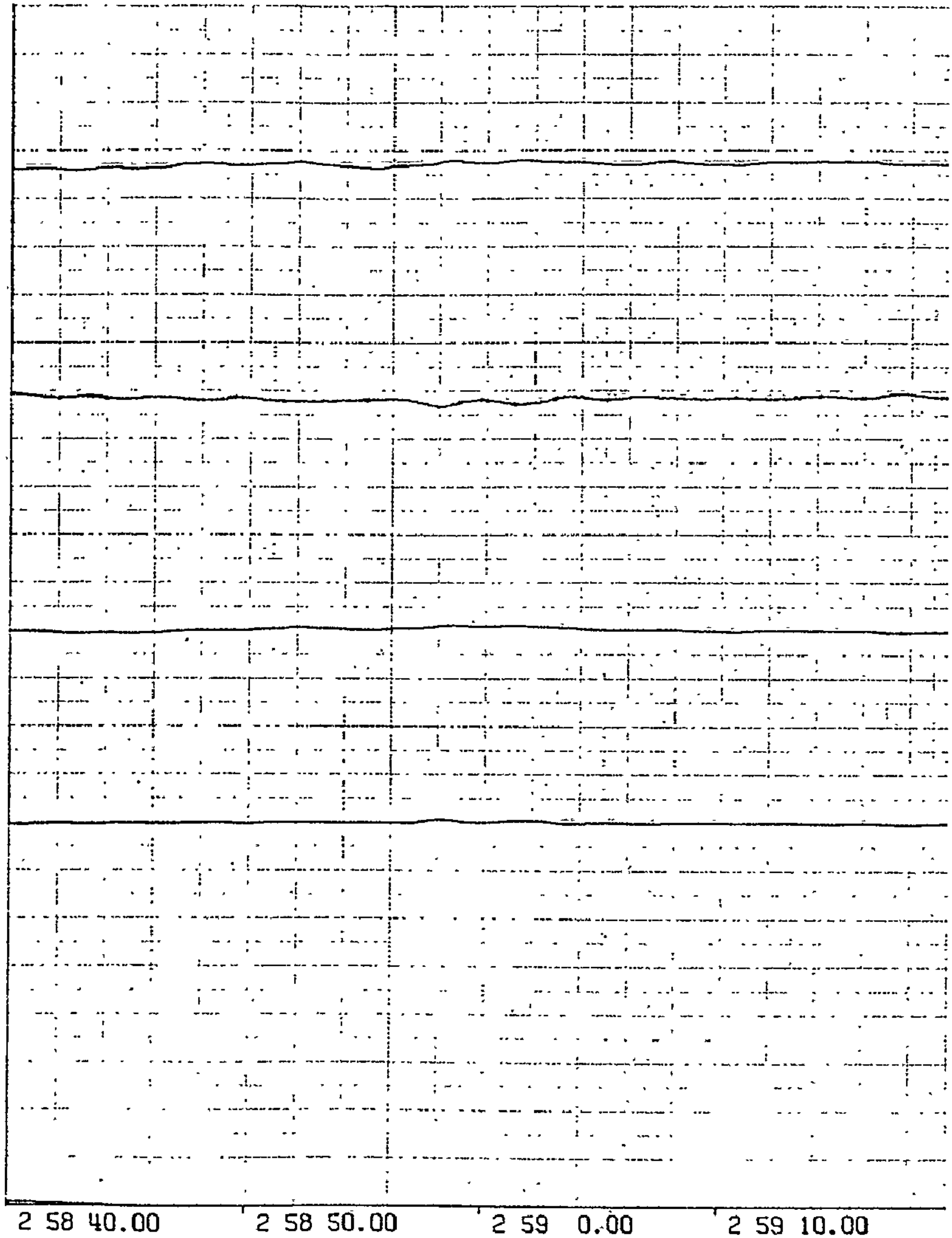
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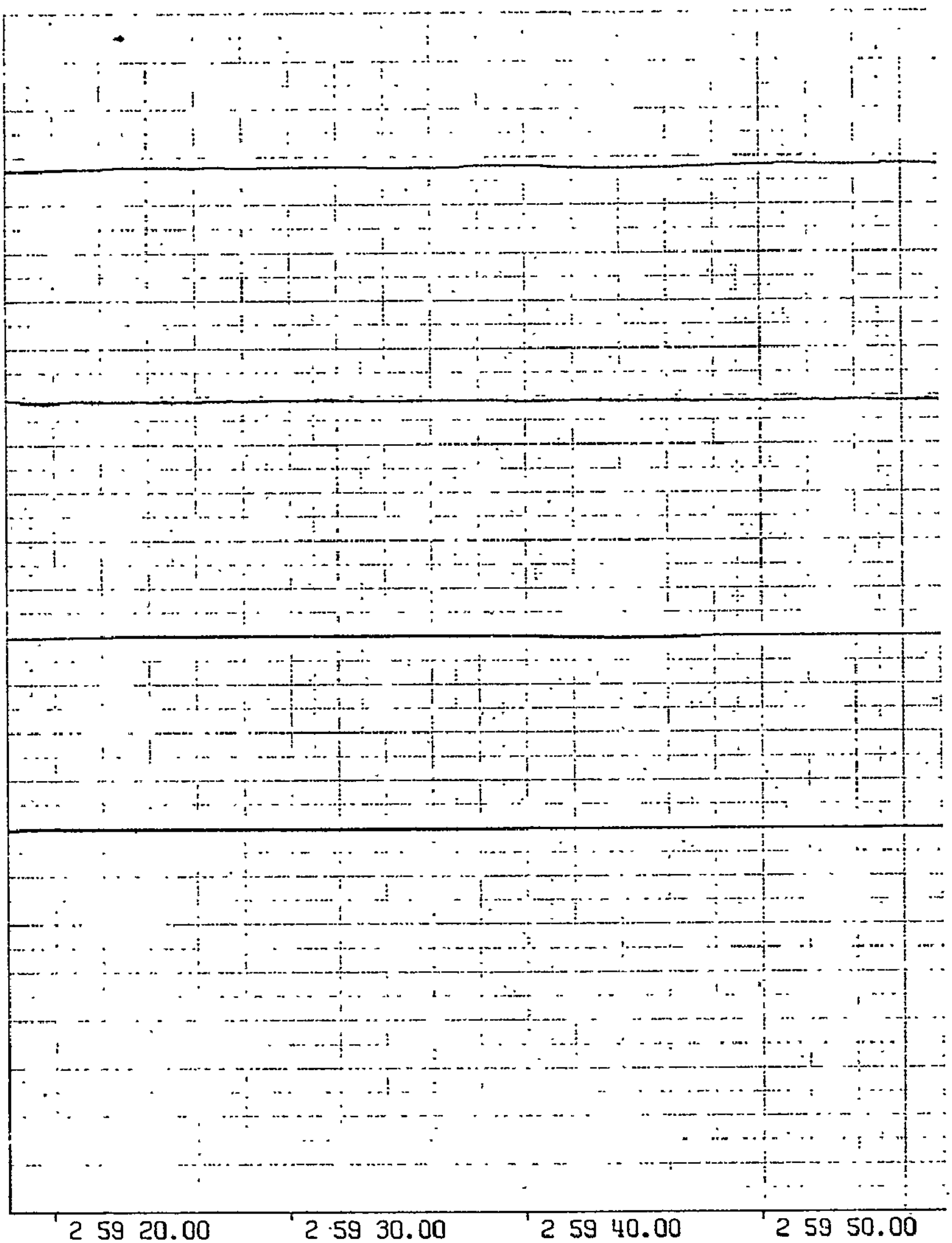
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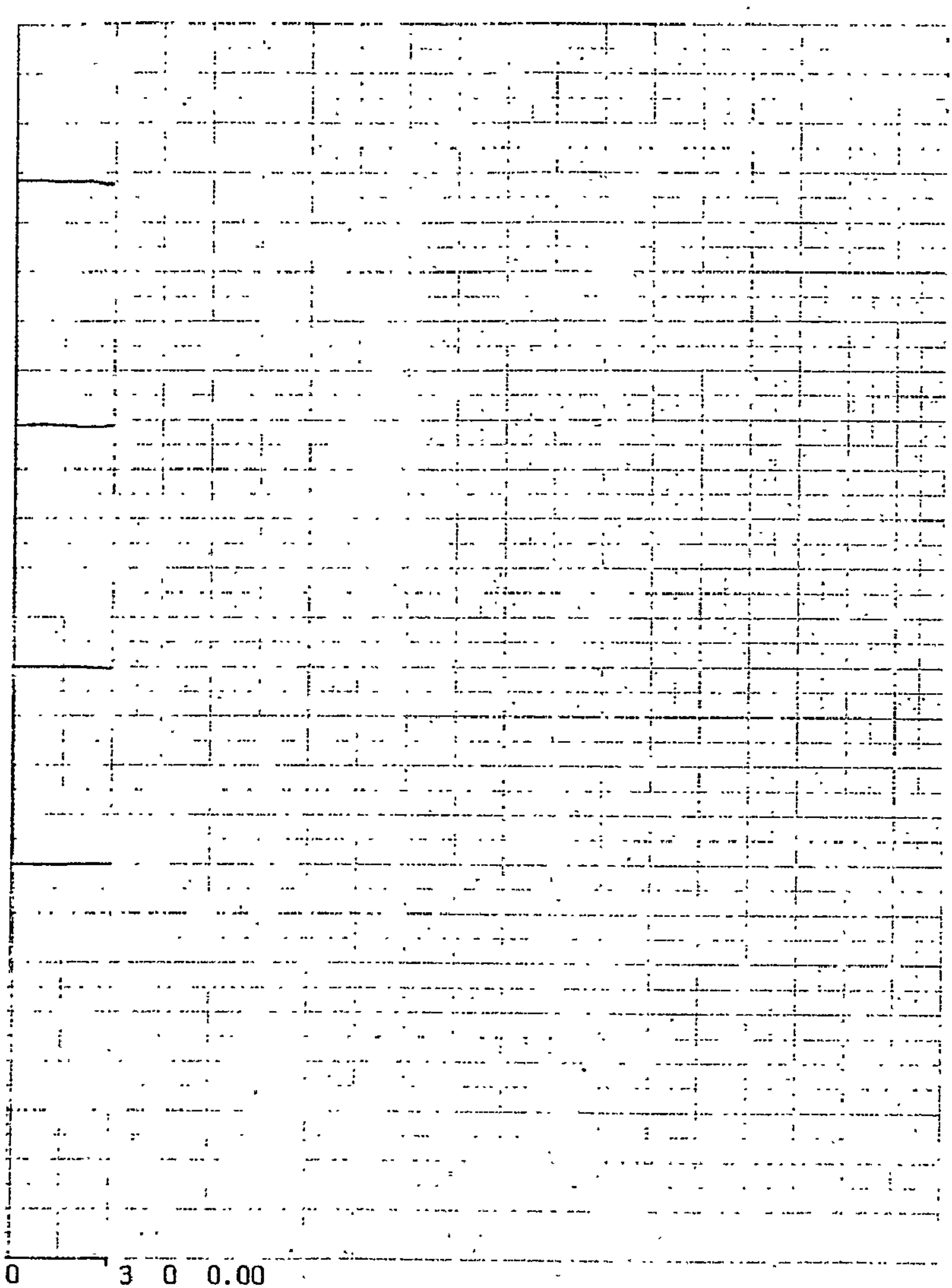
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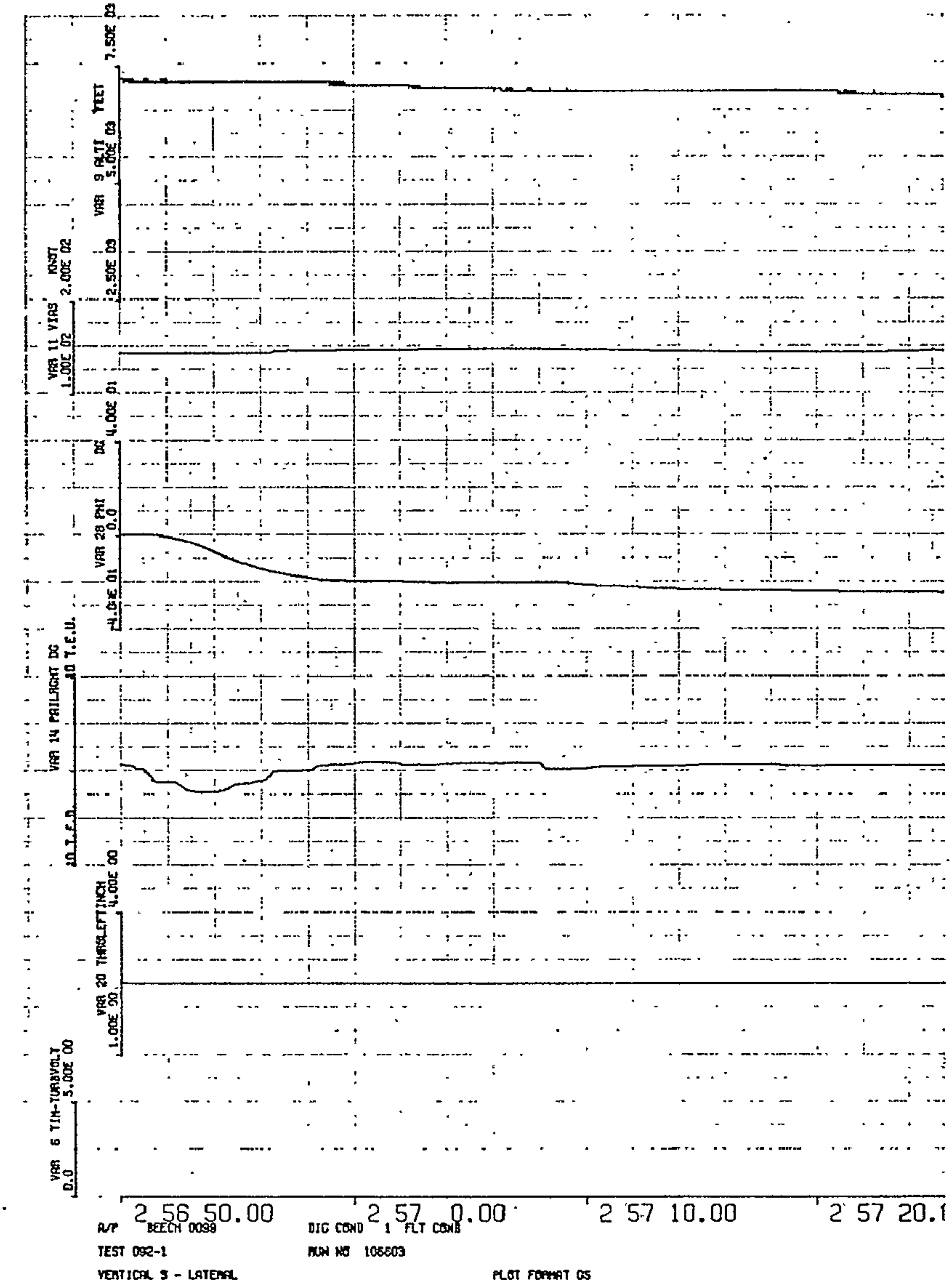
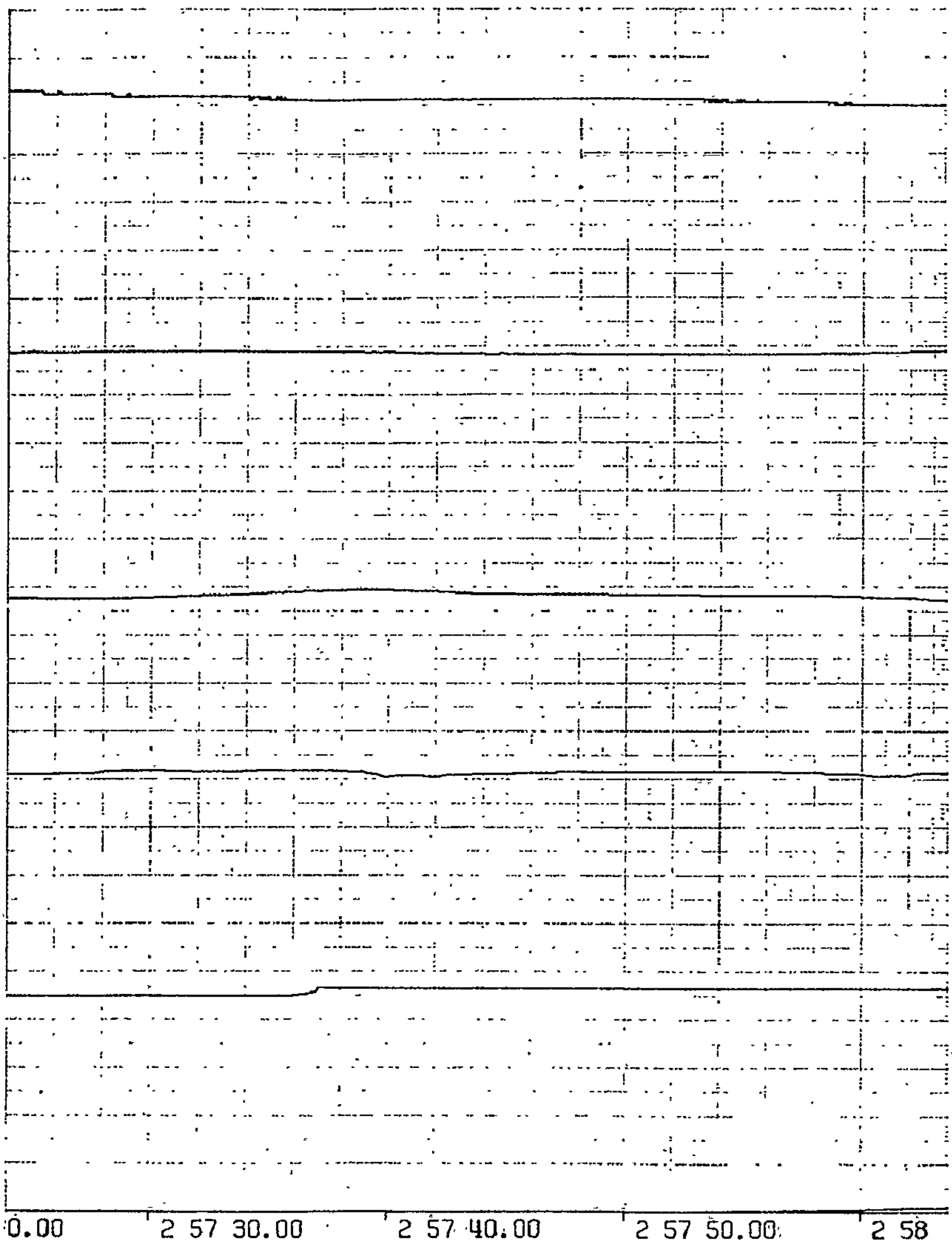
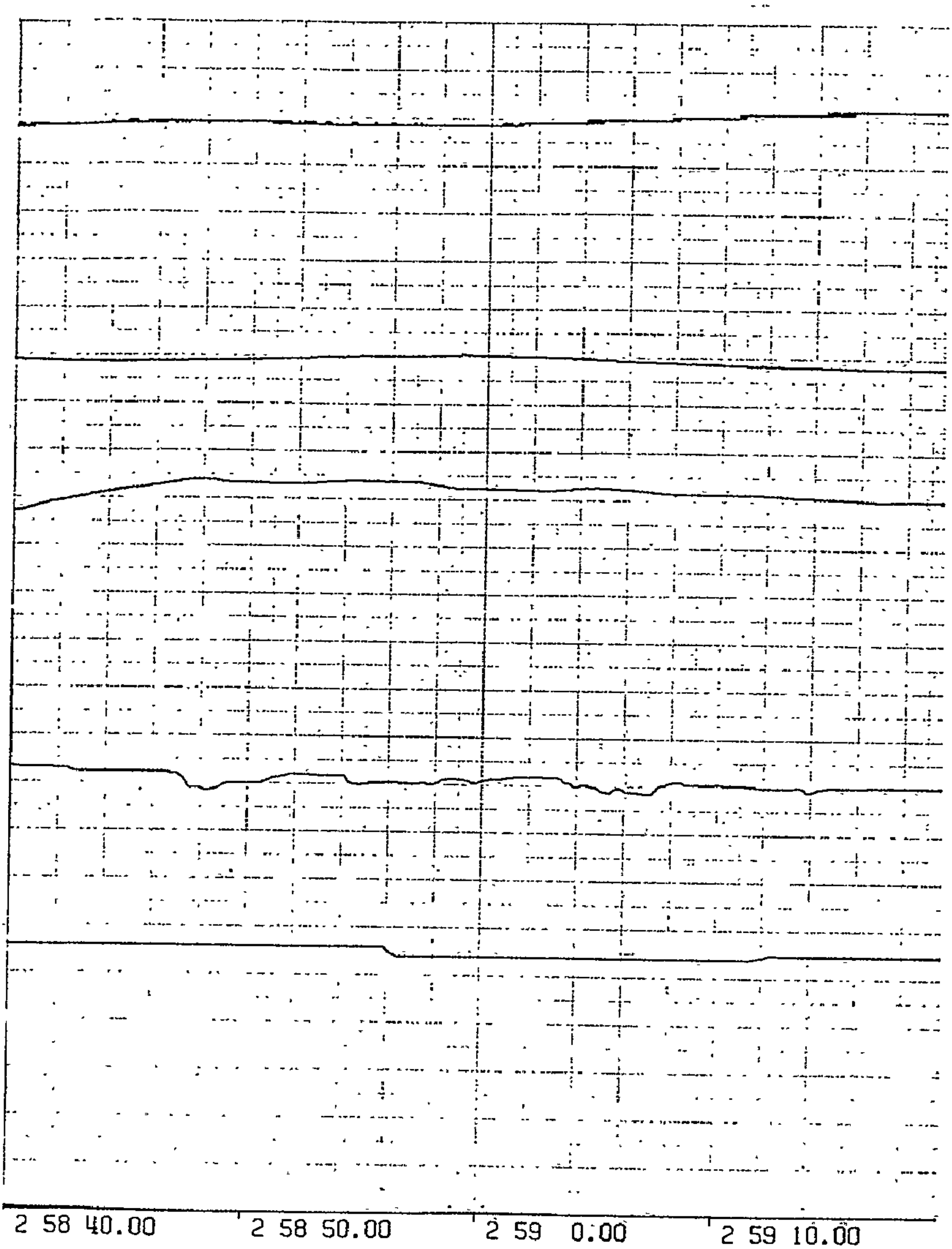
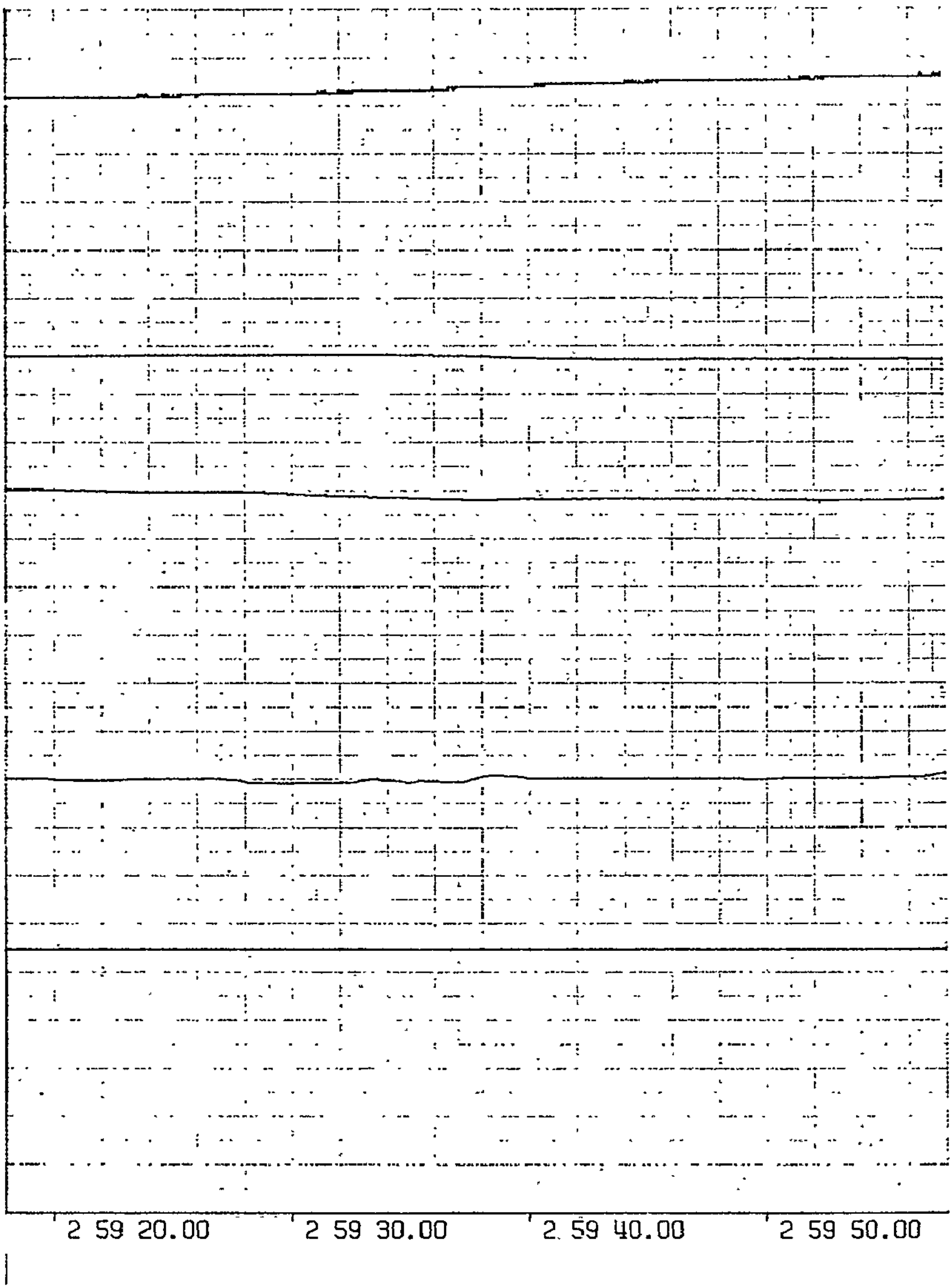


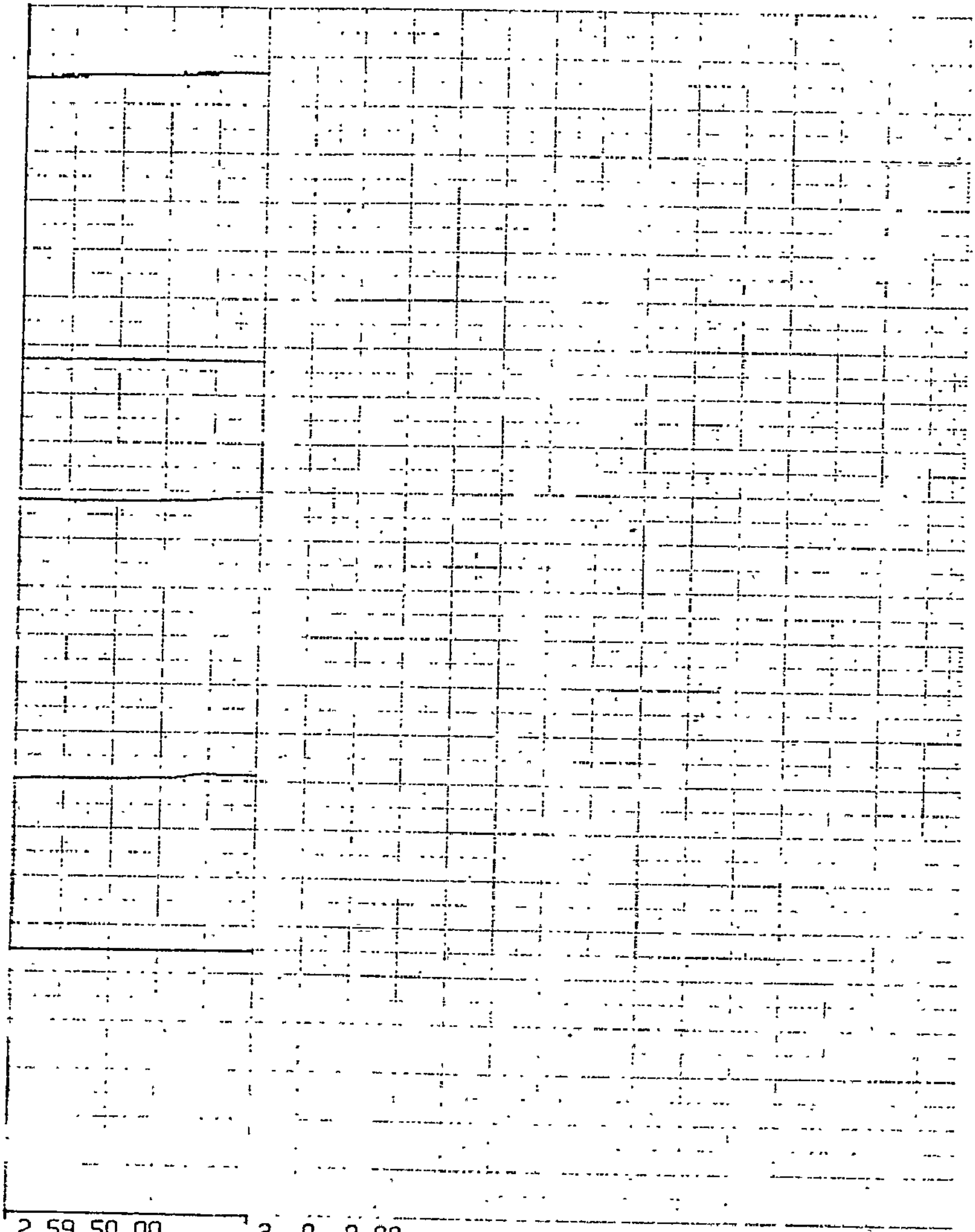
7.50E 03
VAR 9 ALTI FEET
5.00E 03
2.50E 03
KNOT 2.00E 02
VAR 11 VIAS
1.00E 02
4.00E 01
DG
VAR 28 PHI
0.0
-4.00E 01
10 T.E.U.
VAR 14 PAILRGHT DG
-10 T.E.U.
4.00E 00
VAR 20 THRSLEFTINCH
1.00E 00
5.00E 00
VAR 6 TIM-TURBVOLT
0.0
2 56 50.00
2 57 0.00
2 57 10.00
2 57 20.1
A/P BEECH 0099
DIG COND 1 FLT COND
TEST 092-1
RUN NO 105603
VERTICAL S - LATERAL
PLOT FORMAT 05

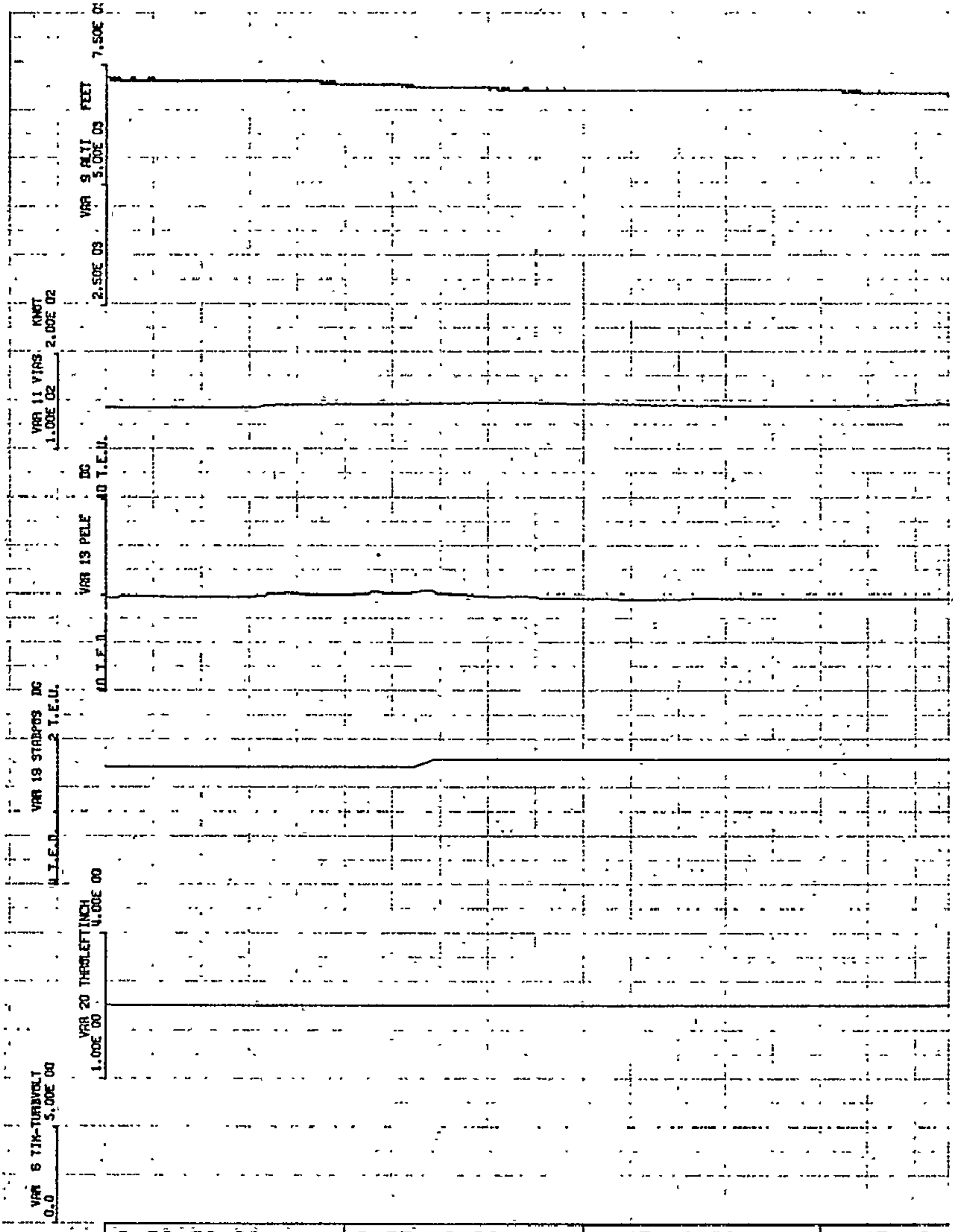

0.00
2 57 30.00
2 57 40.00
2 57 50.00
2 58


58 0.00
2 58 10.00
2 58 20.00
2 58 30.00
2

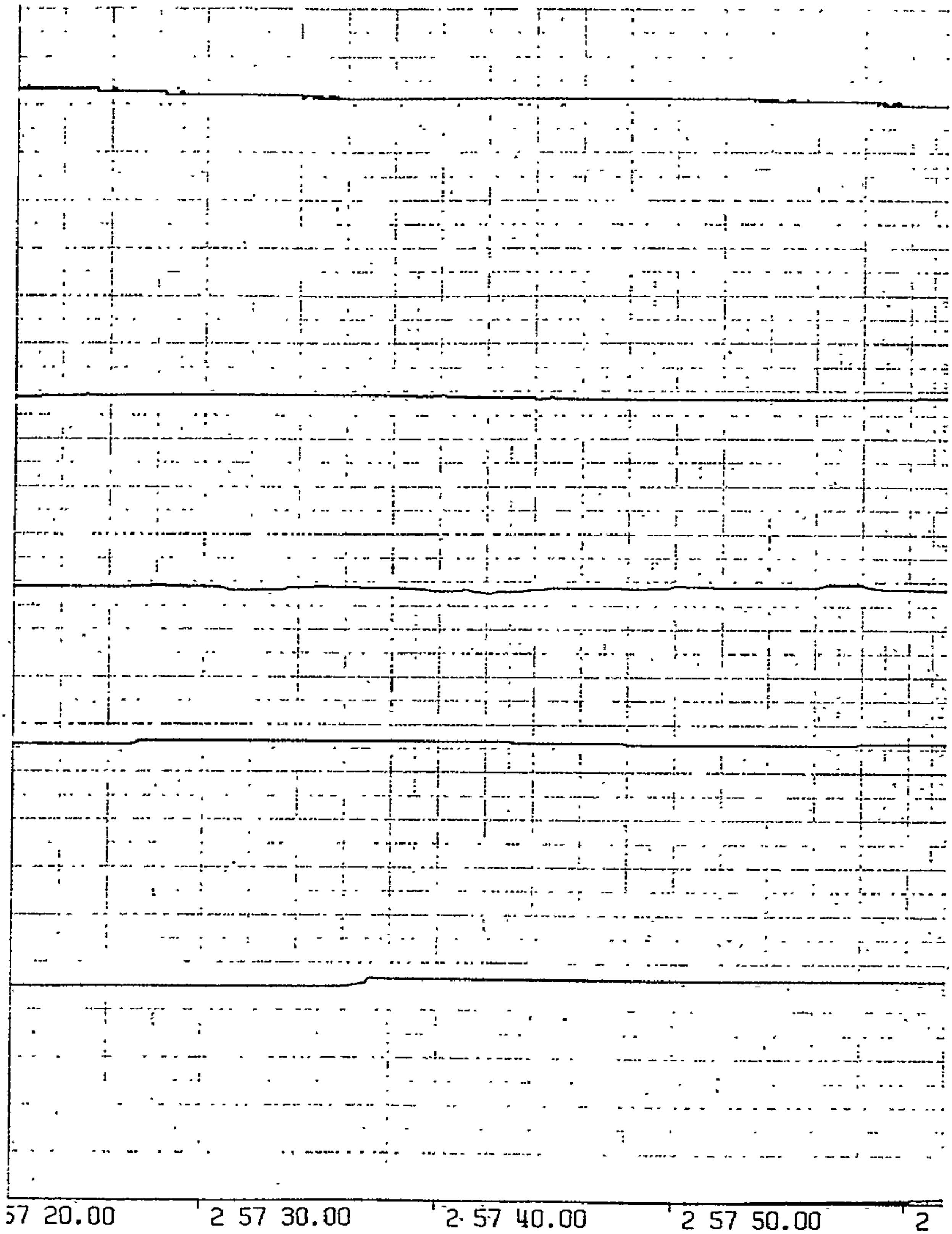

2 58 40.00
2 58 50.00
2 59 0.00
2 59 10.00

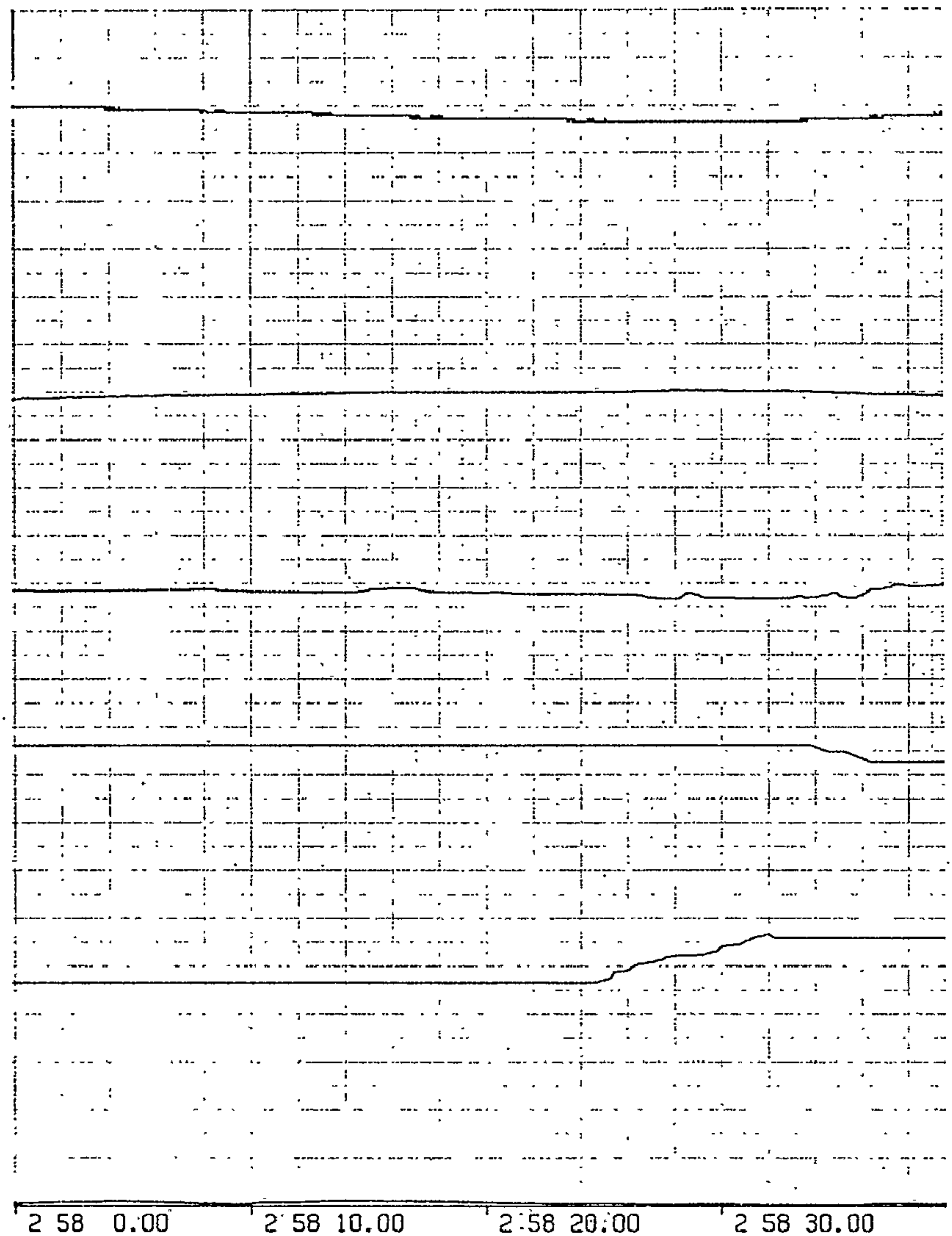

2 59 20.00
2 59 30.00
2 59 40.00
2 59 50.00

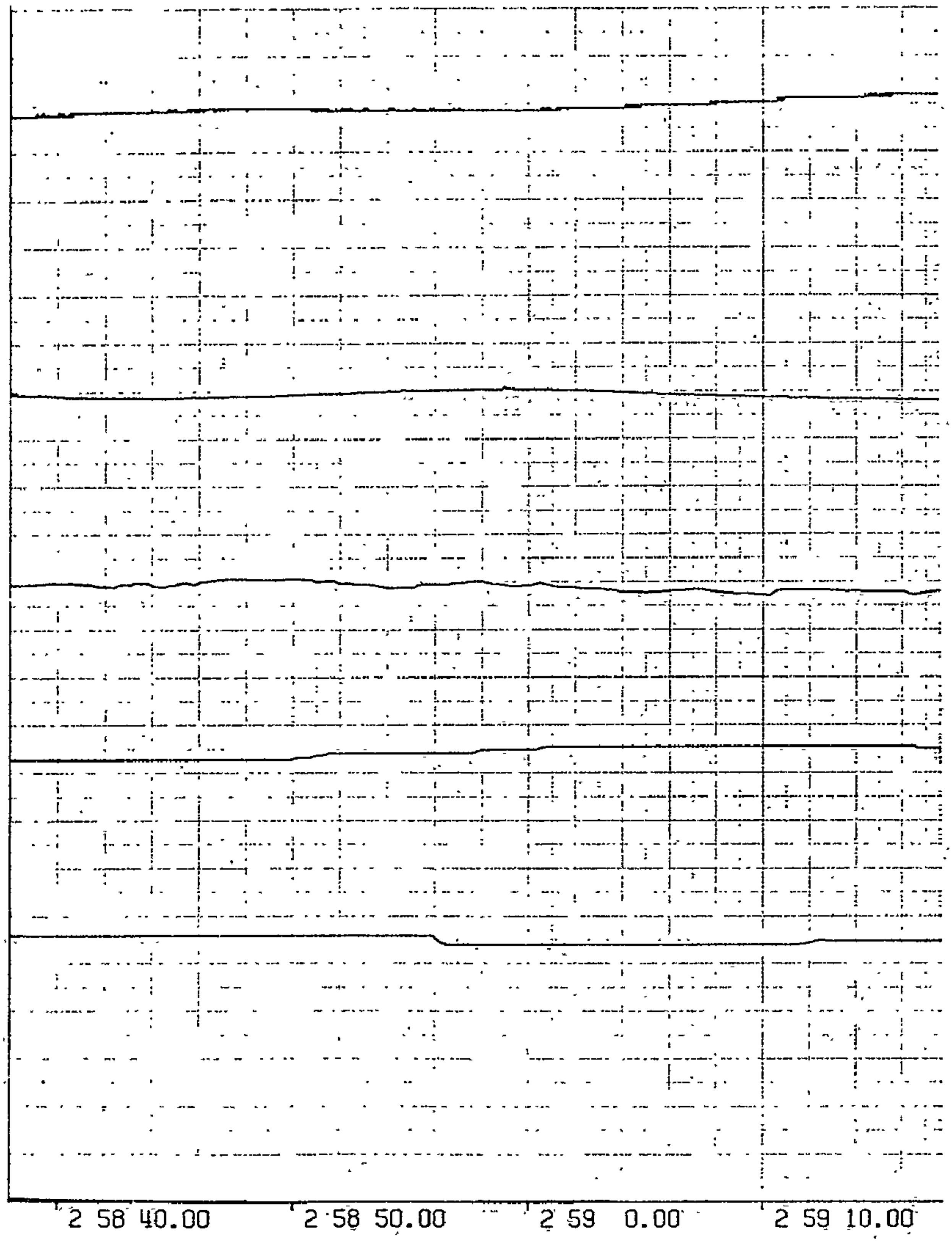

2 59 50.00
3 0 0.00

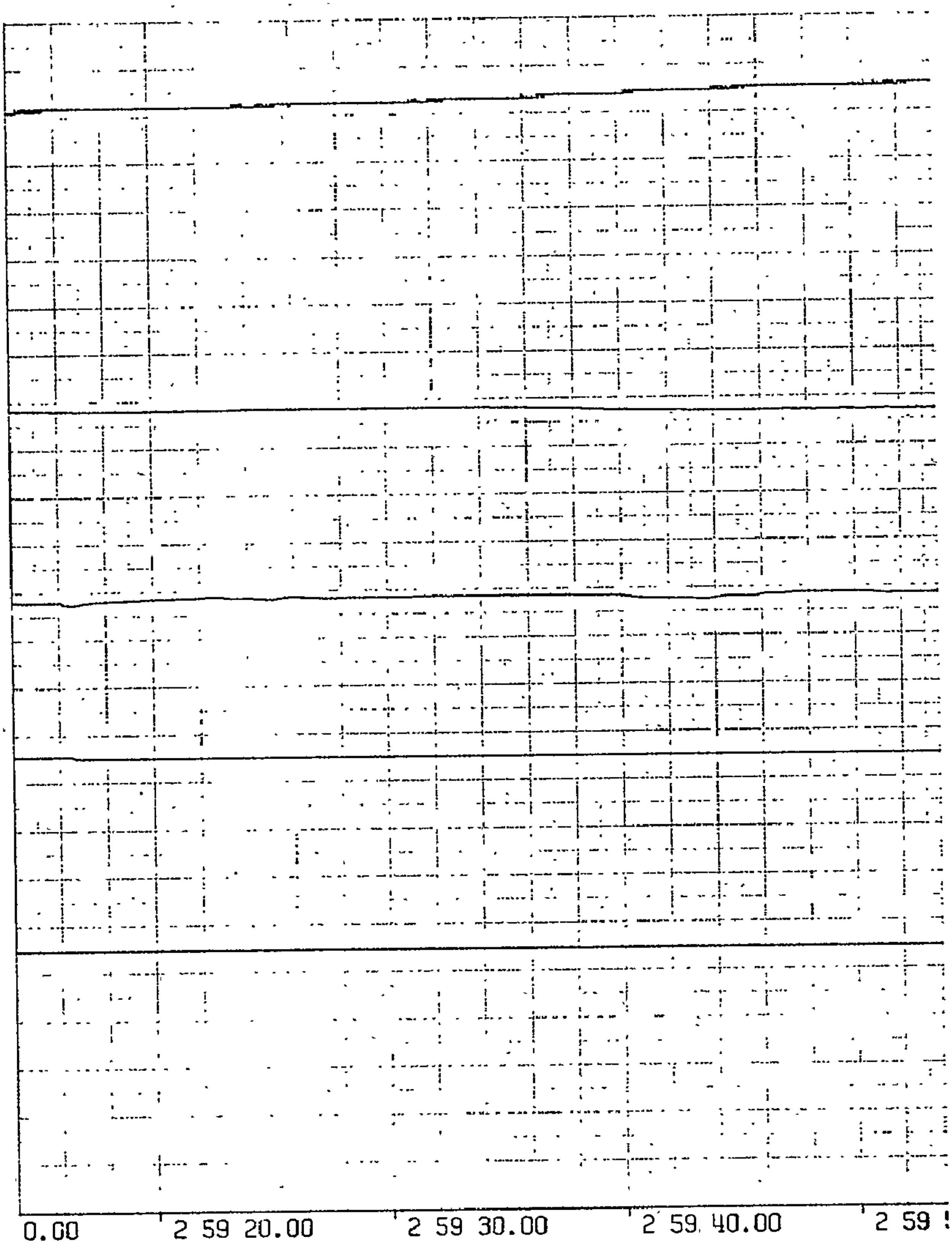


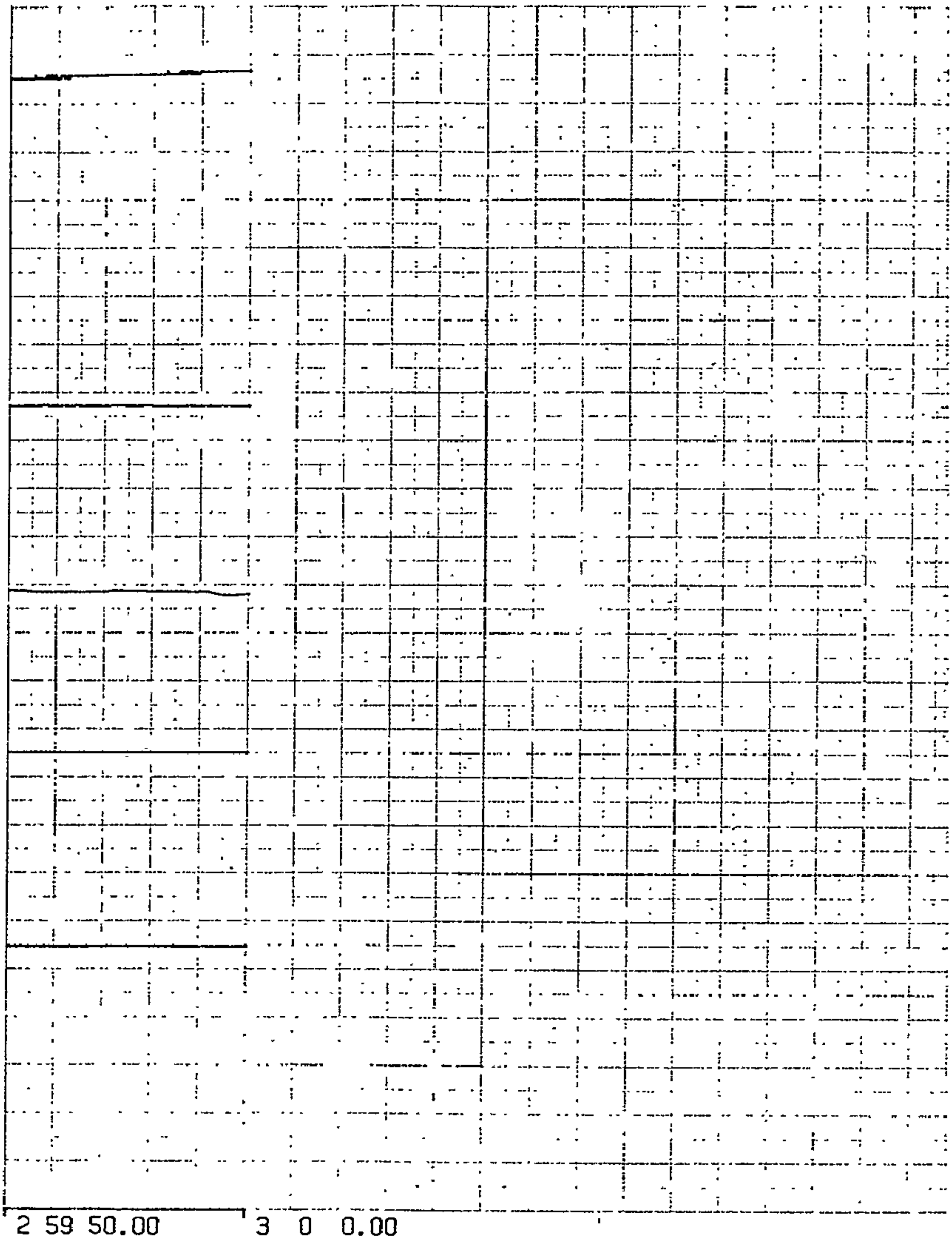

R/P BEECH 0099 BIG COND 1 FLT COND
TEST 092-1 RUN NO 106803
VERTICAL 3 - LONGITUDINAL PLOT FORMAT 06

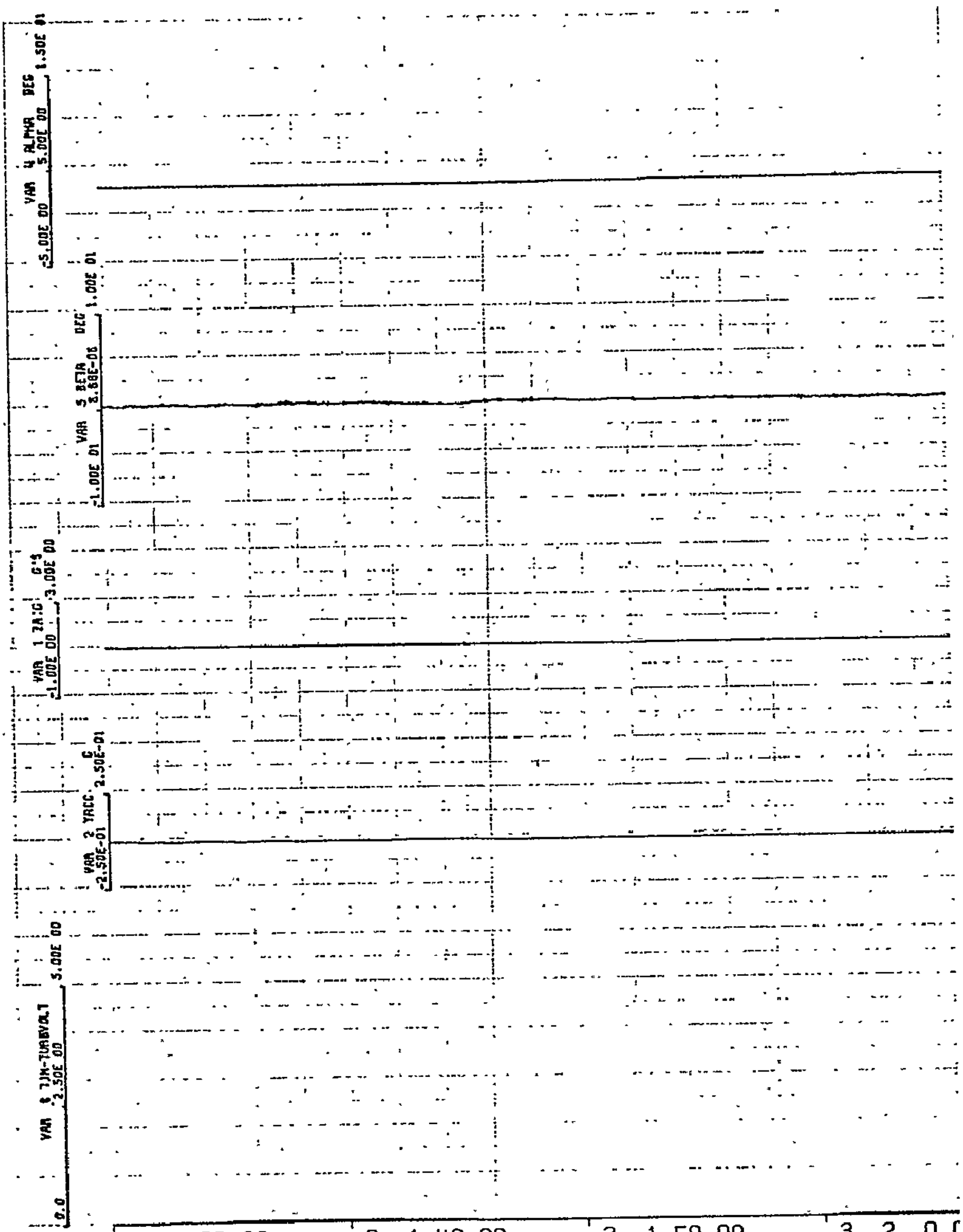

57 20.00
2 57 30.00
2 57 40.00
2 57 50.00
2


2 58 0.00
2 58 10.00
2 58 20.00
2 58 30.00


2 58 40.00
2 58 50.00
2 59 0.00
2 59 10.00


0.00
2 59 20.00
2 59 30.00
2 59 40.00
2 59

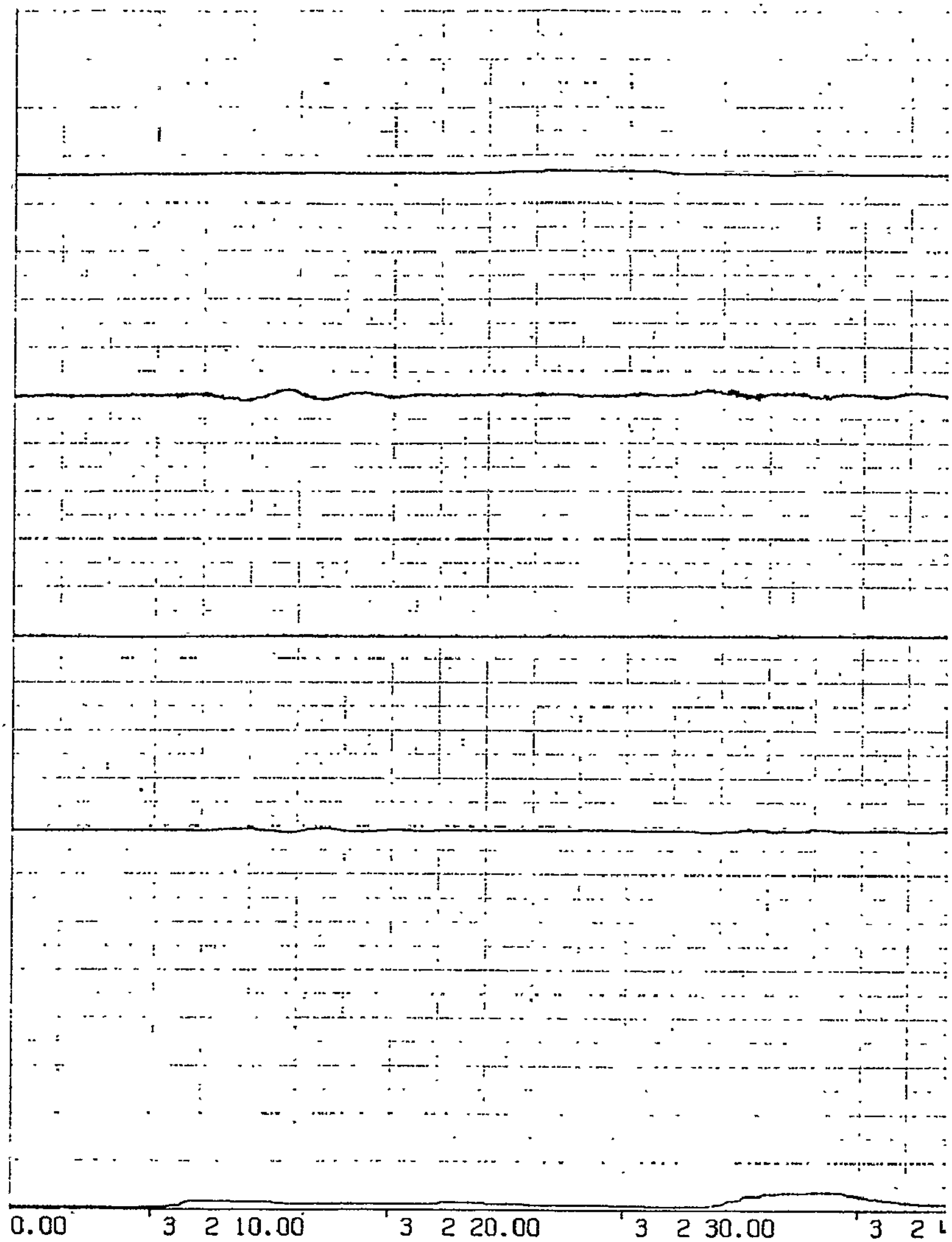

2 59 50.00
3 0 0.00



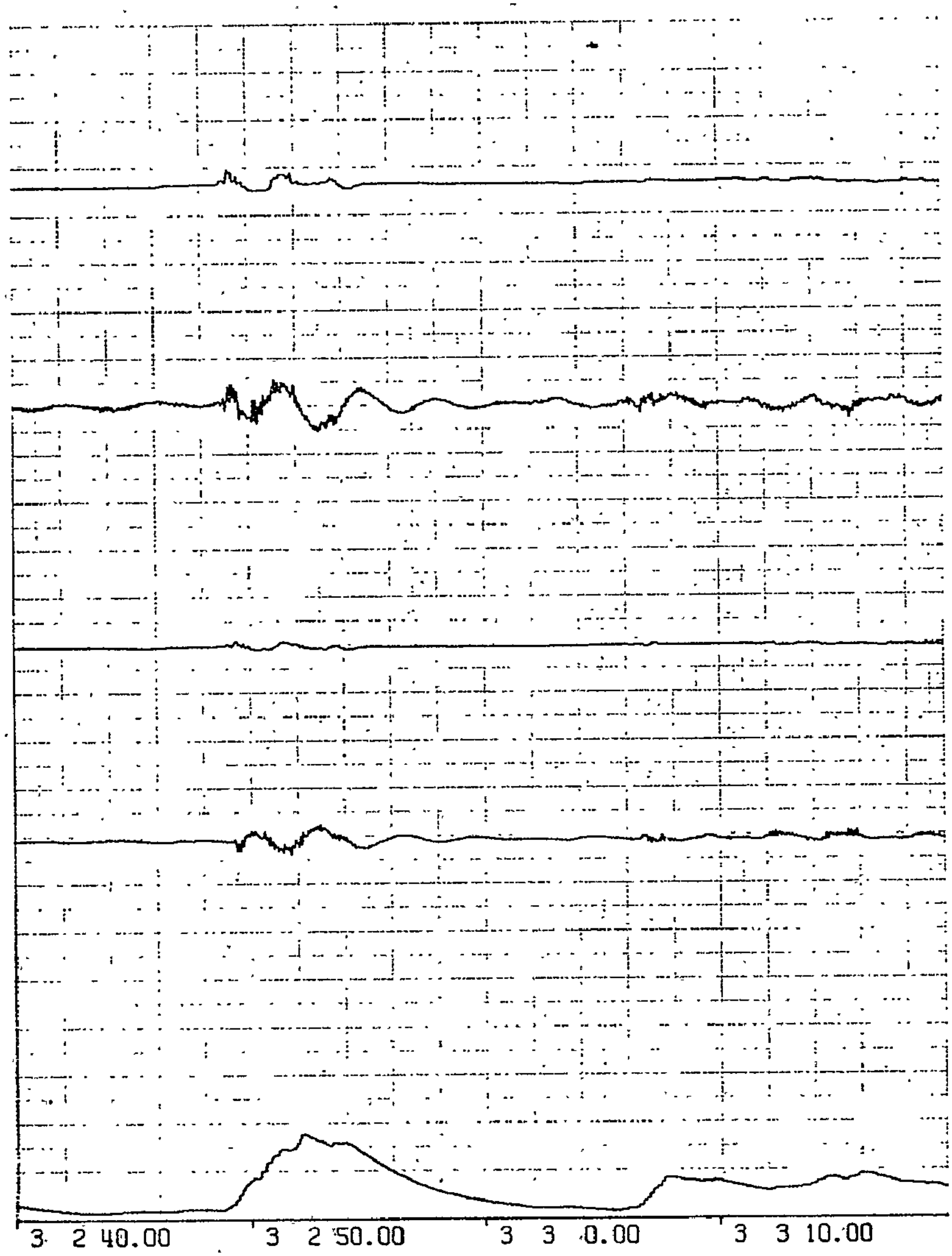

A/T BEECH 0099 DIG COND 2 FLT COND

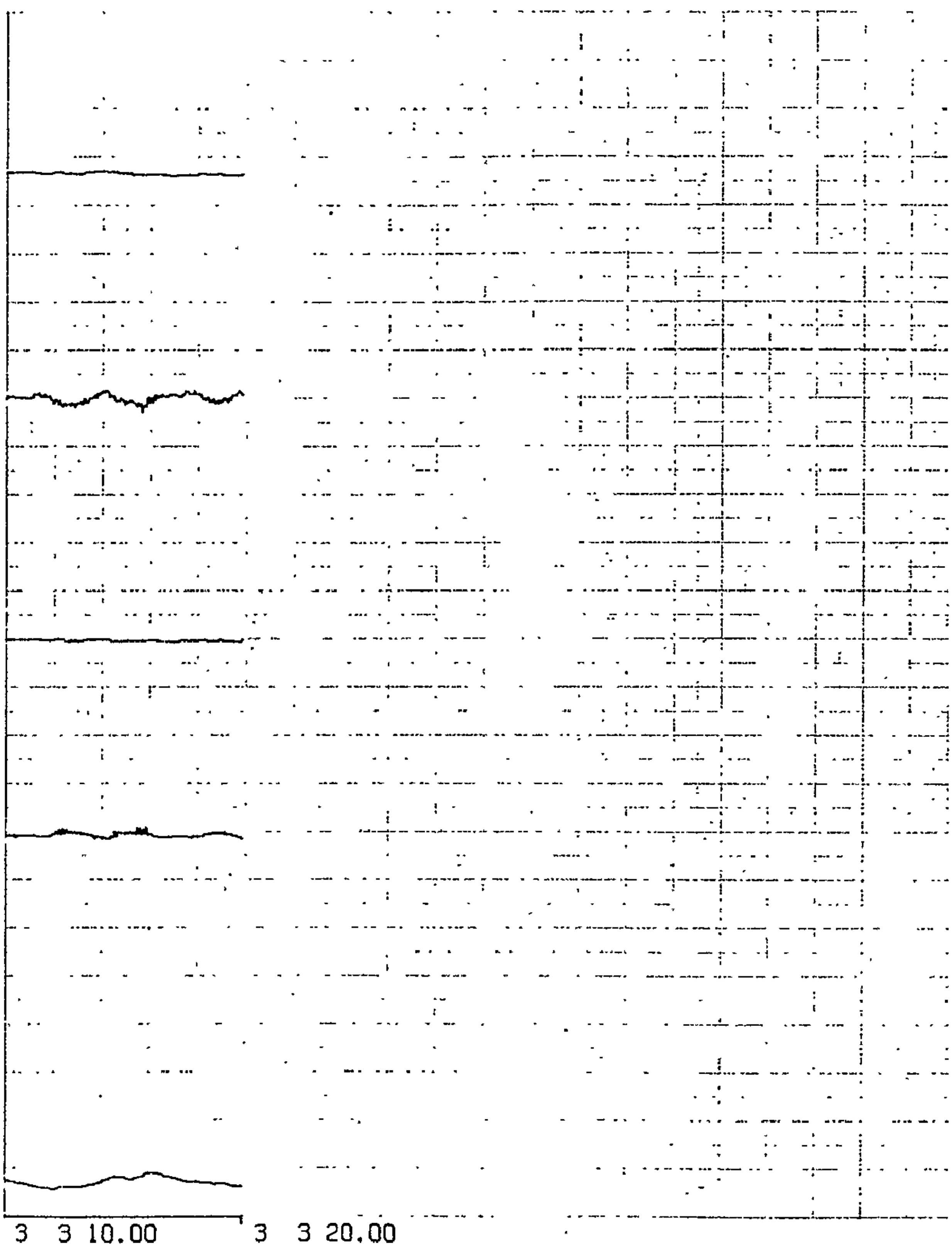
TEST 092-1 RUN NO 124616

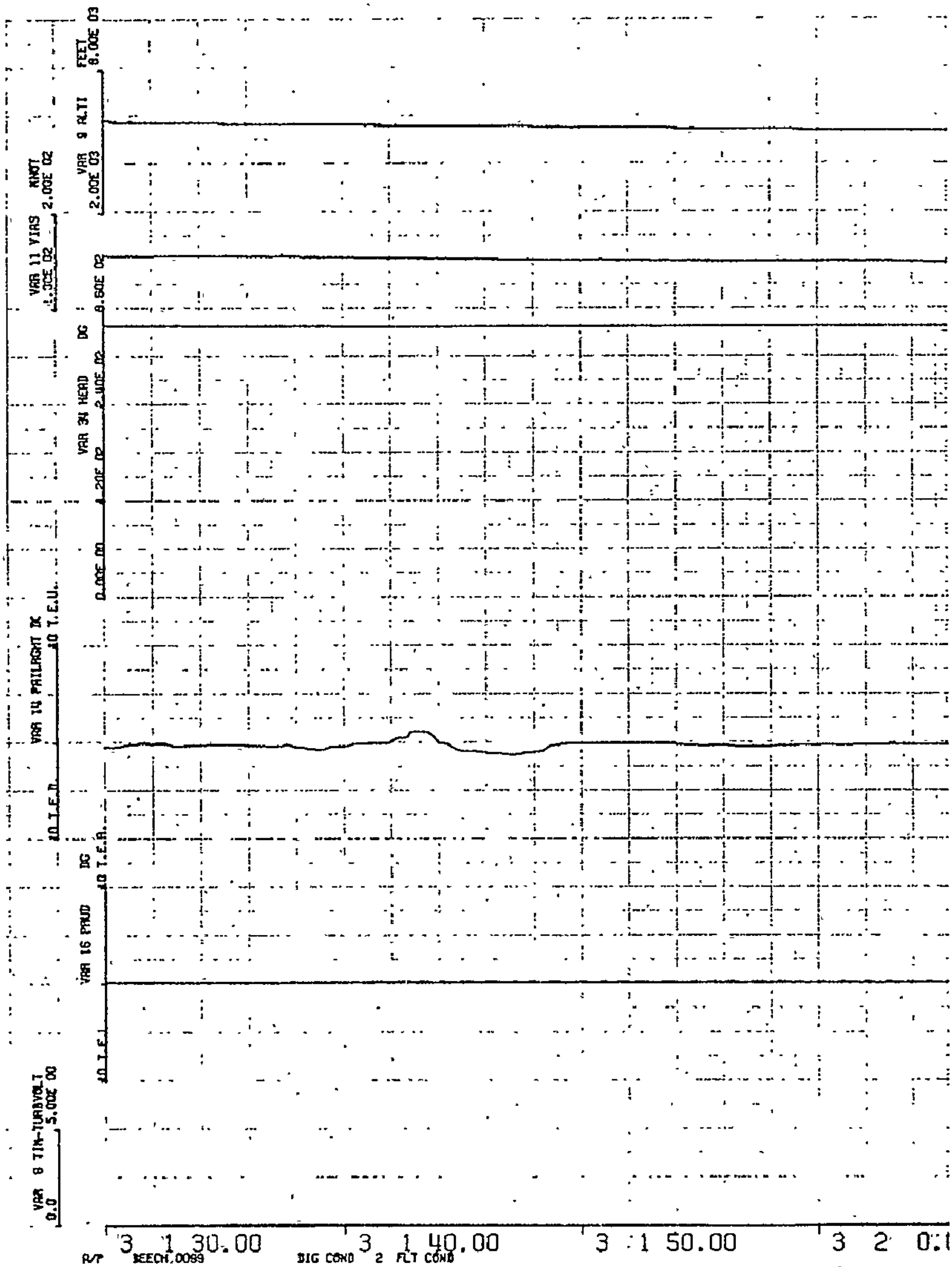
RIDE QUALITIES – PRECISION HEADING PLOT FORMAT 04



0.00
3 2 10.00
3 2 20.00
3 2 30.00


3 2 40.00
3 2 50.00
3 3 0.00
3 3 10.00

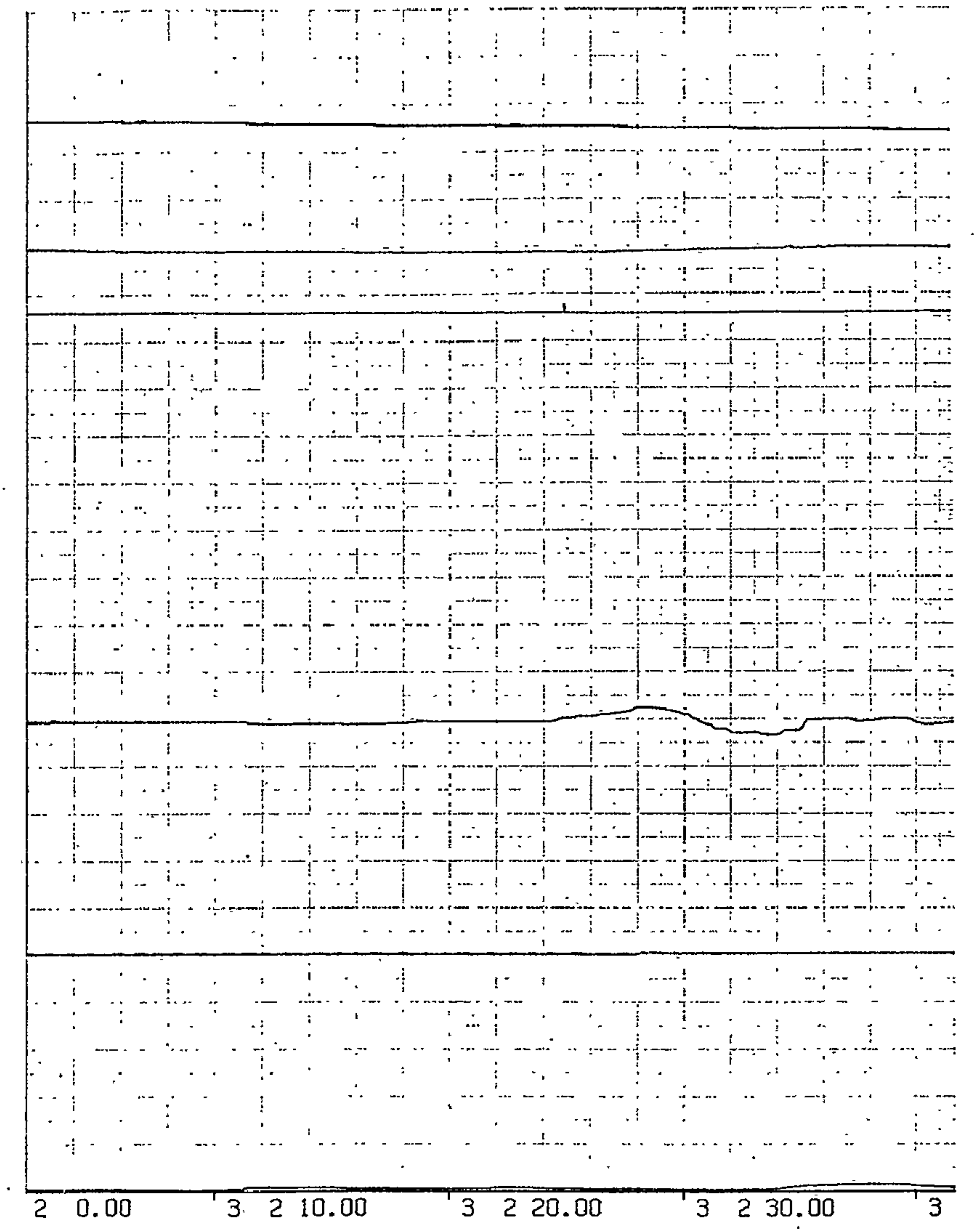

3 3 10.00
3 3 20.00

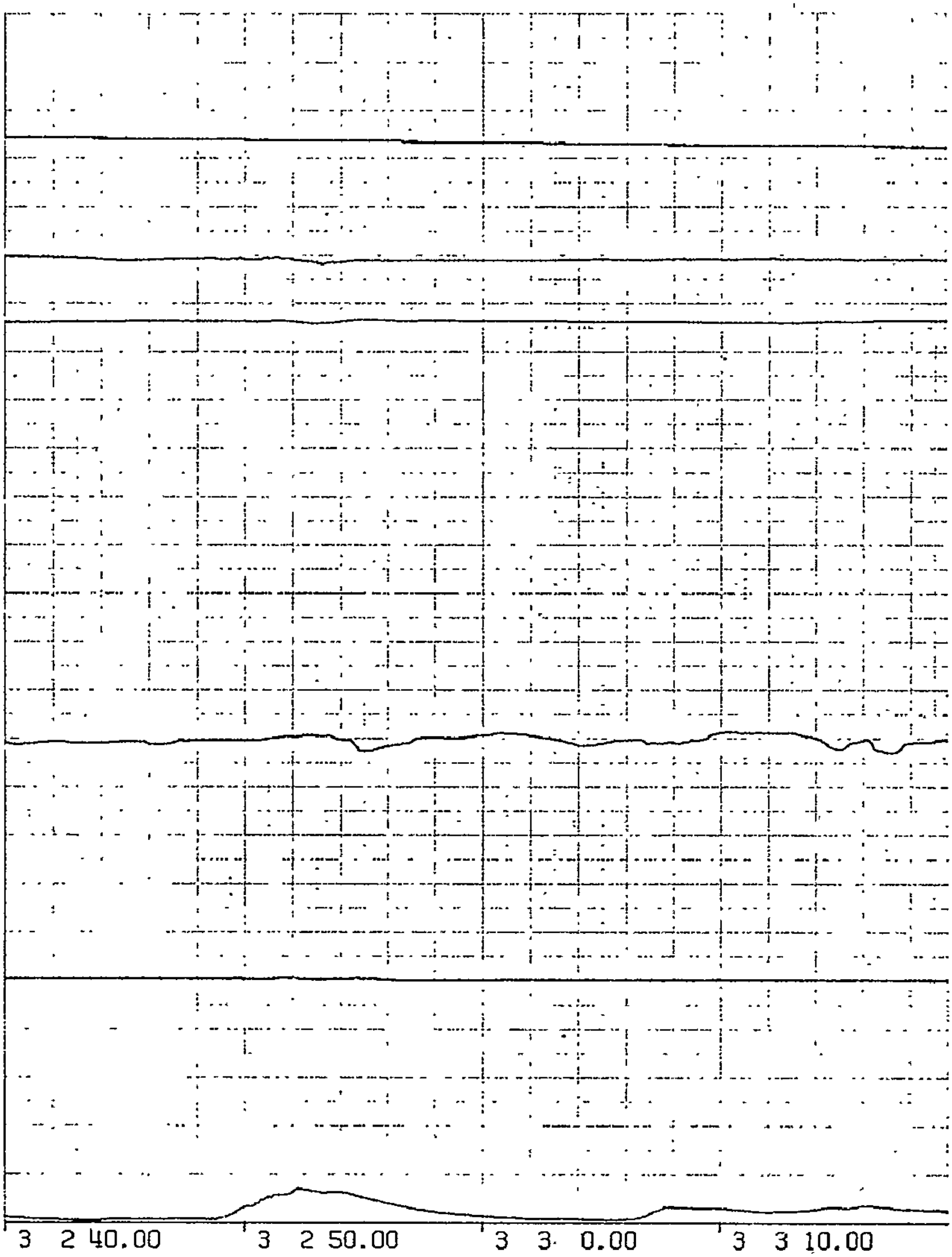


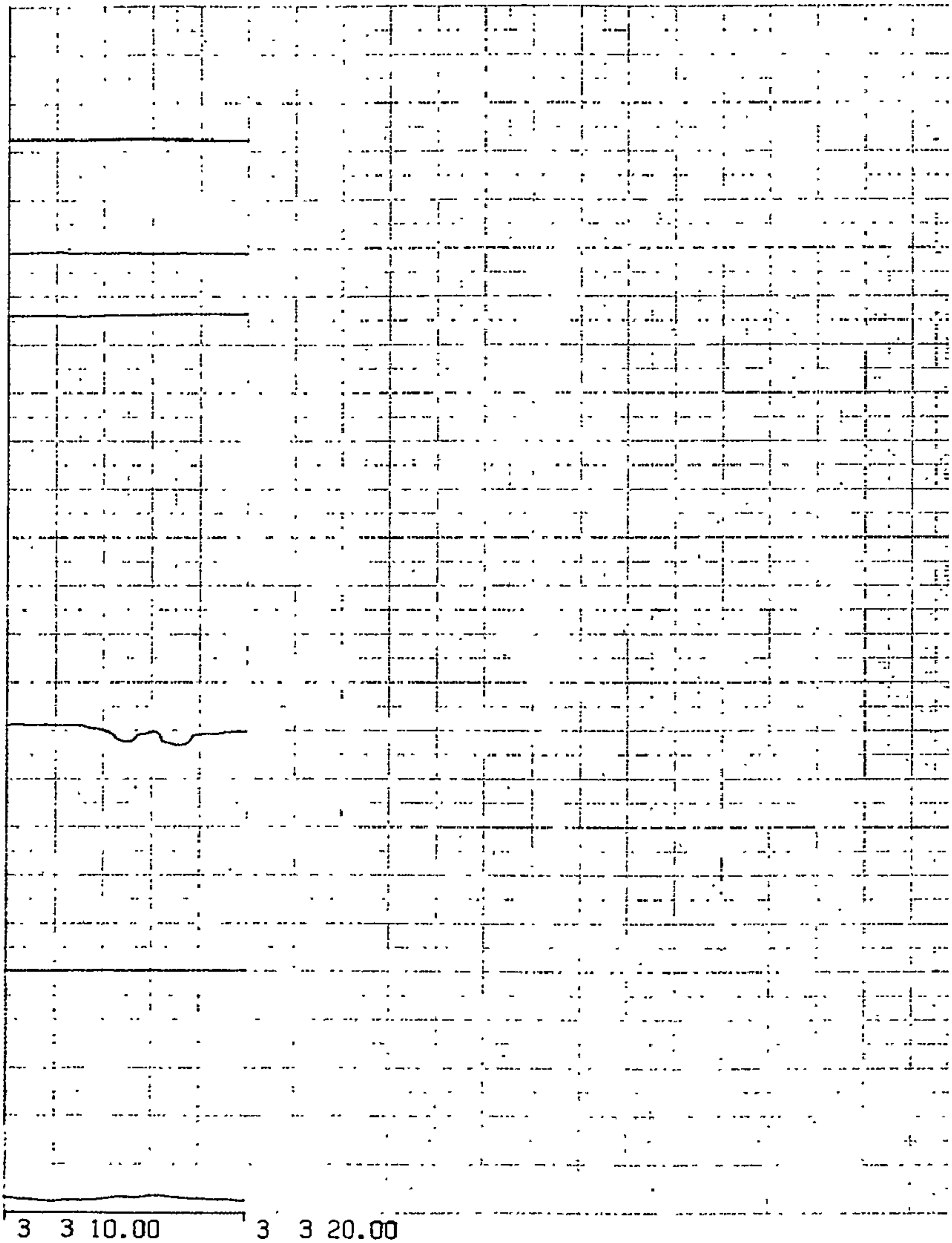

R/P BEECH.0099 DIG COND 2 FLT COND

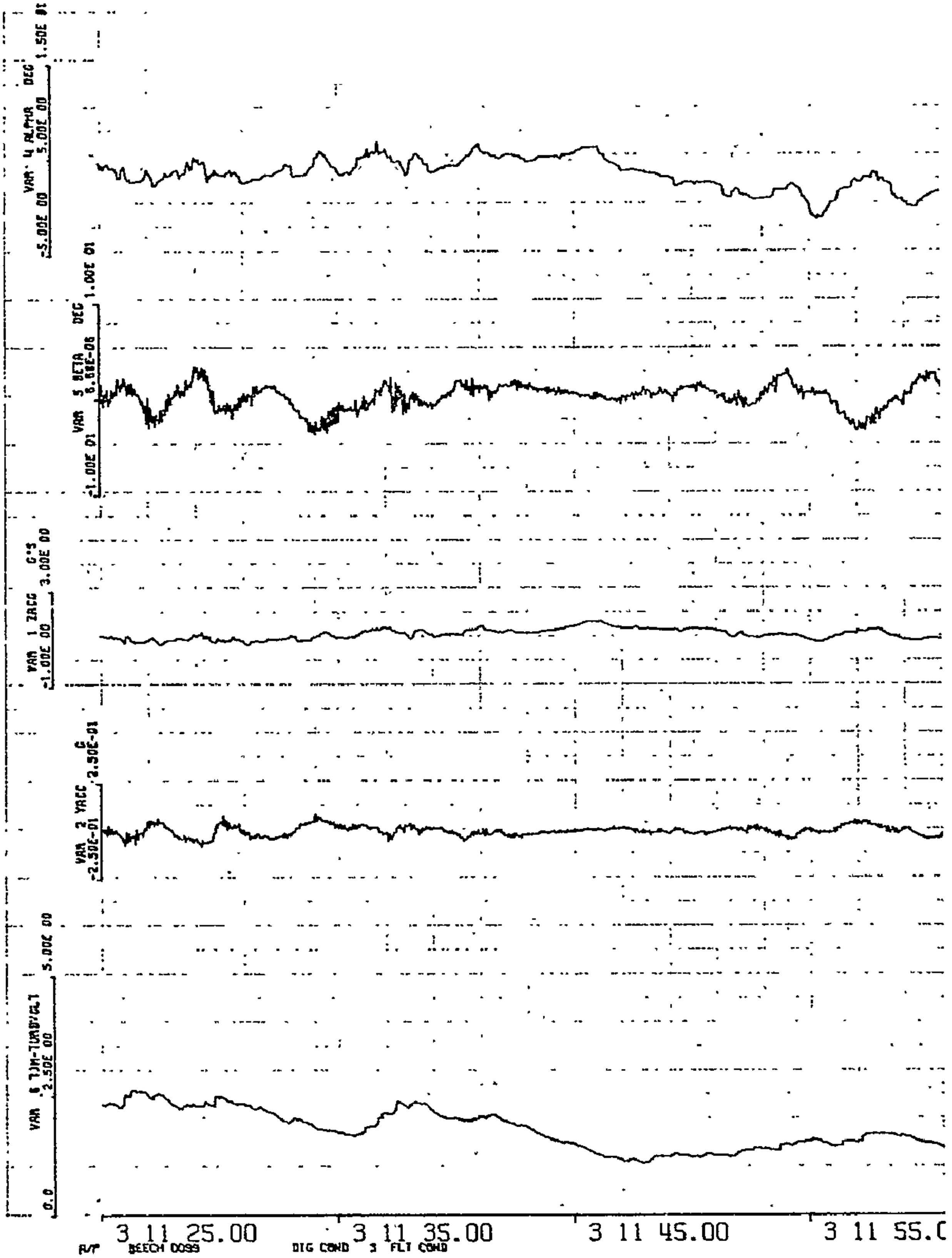
TEST 092-1 RUN NO 106603

PRECISION HEADING PLOT FORMAT 07


2 0.00
3 2 10.00
3 2 20.00
3 2 30.00
3


3 2 40.00
3 2 50.00
3 3 0.00
3 3 10.00

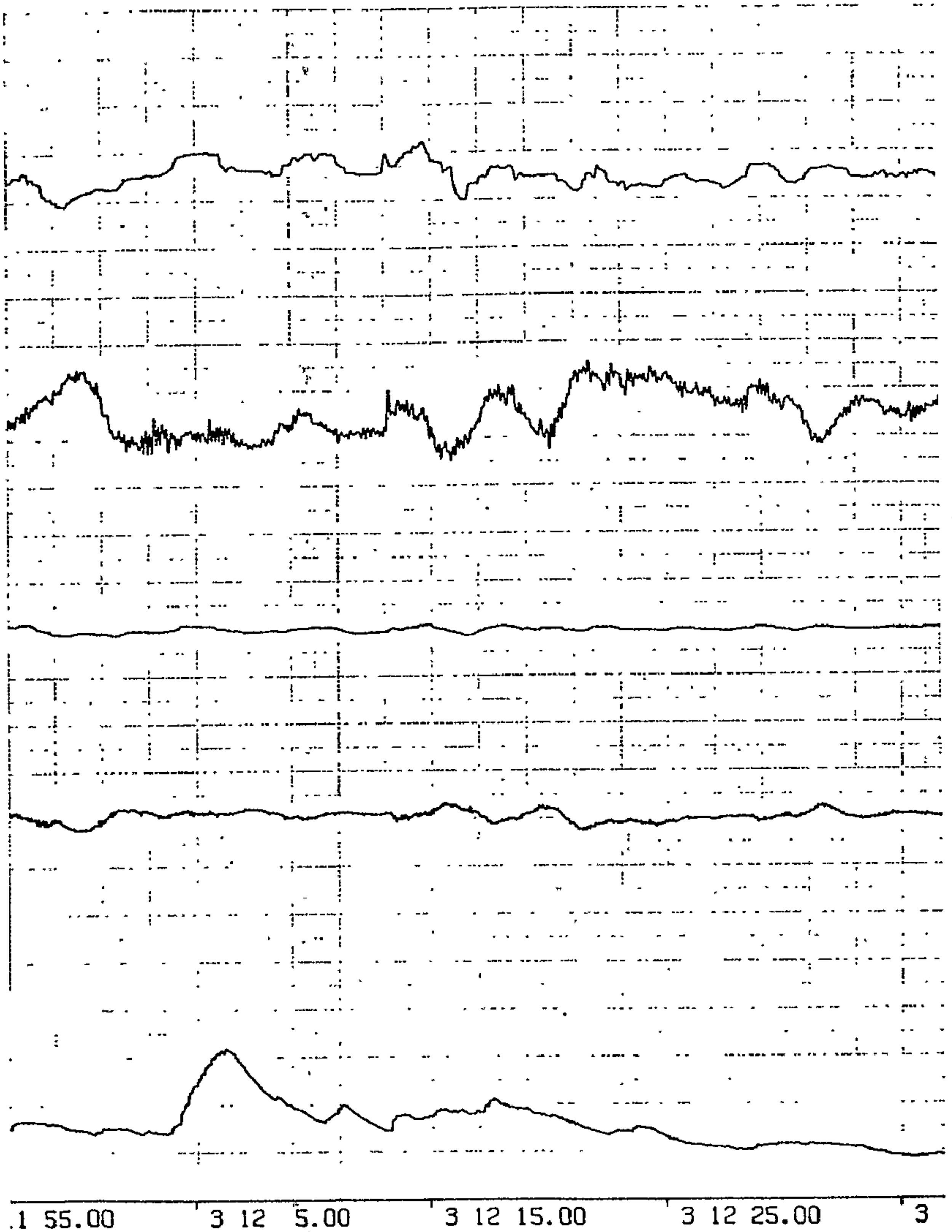

3 3 10.00
3 3 20.00

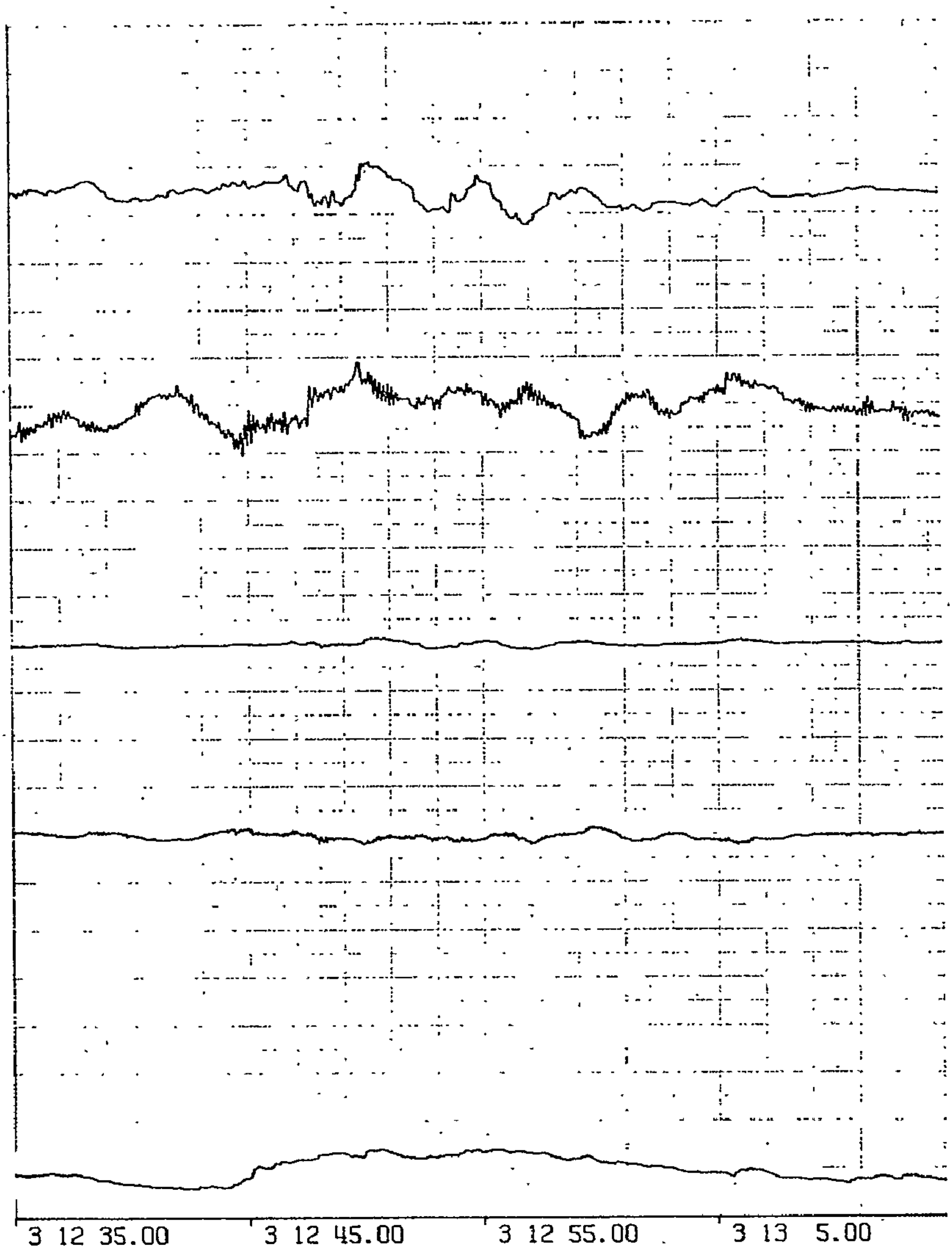


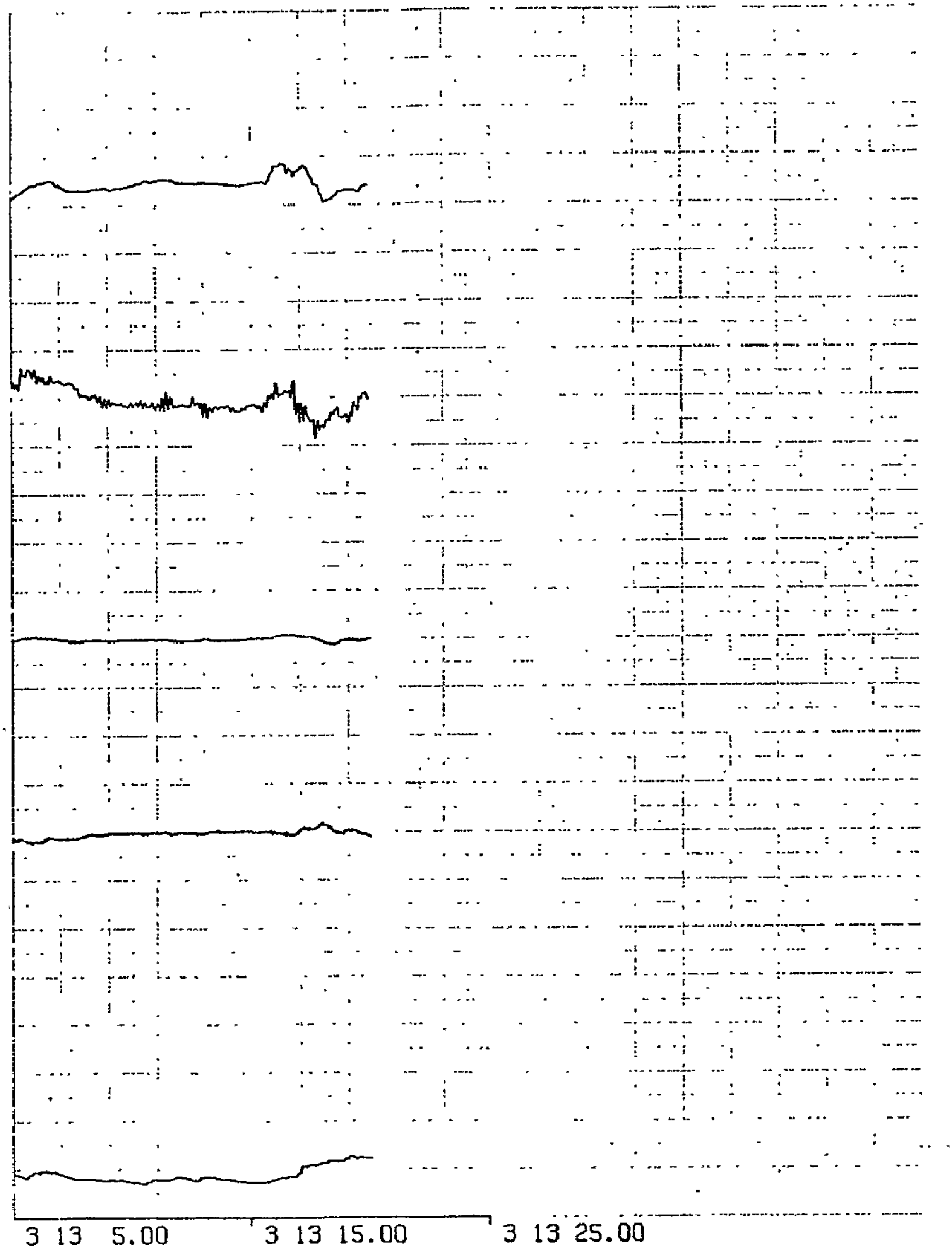

A/P BEECH D0S9 DIG COND 3 FLT COND

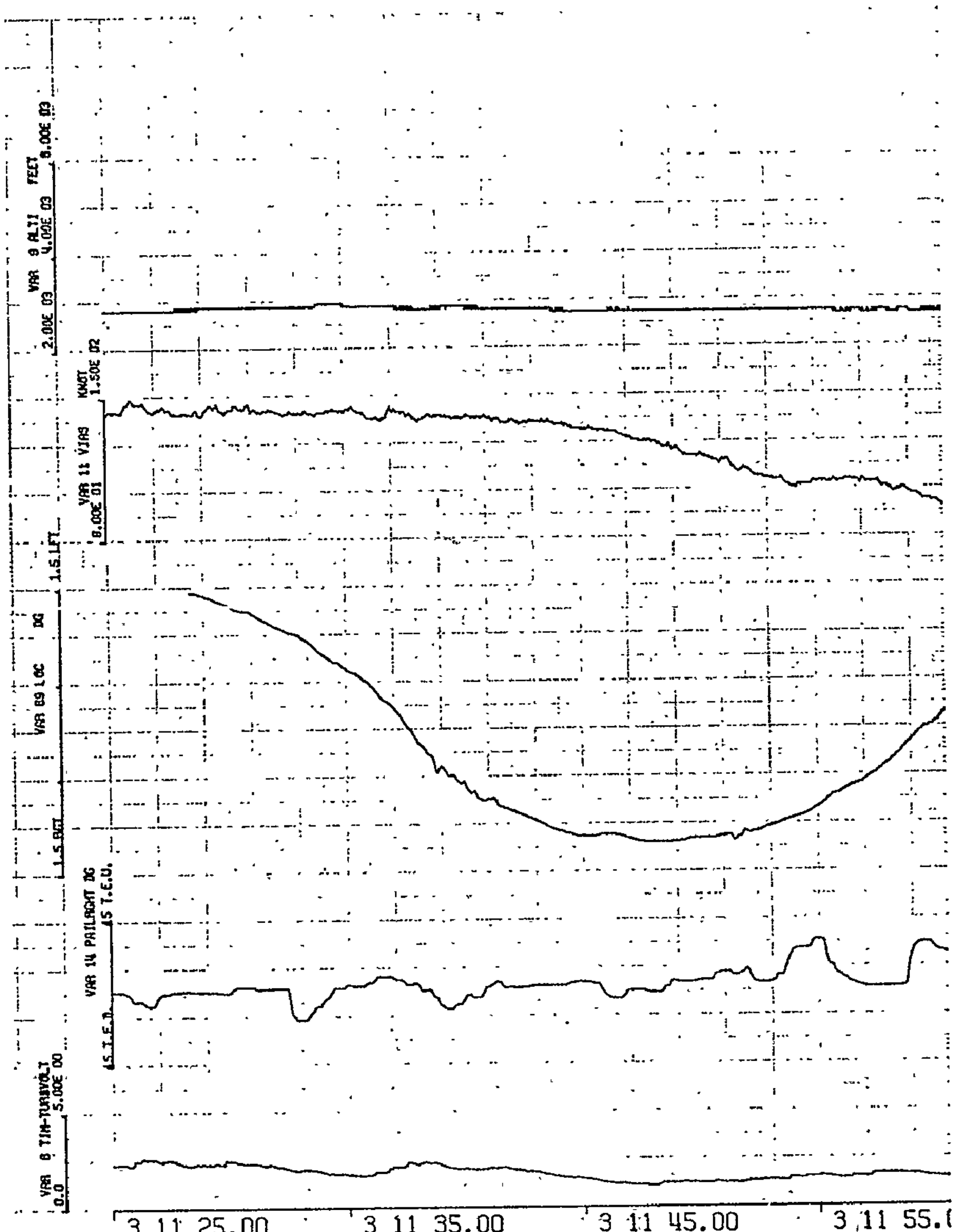
TEST 092-1 RUN NO 124616

RIDE QUALITIES - ILS INTERCEPT PLOT FORMAT 04

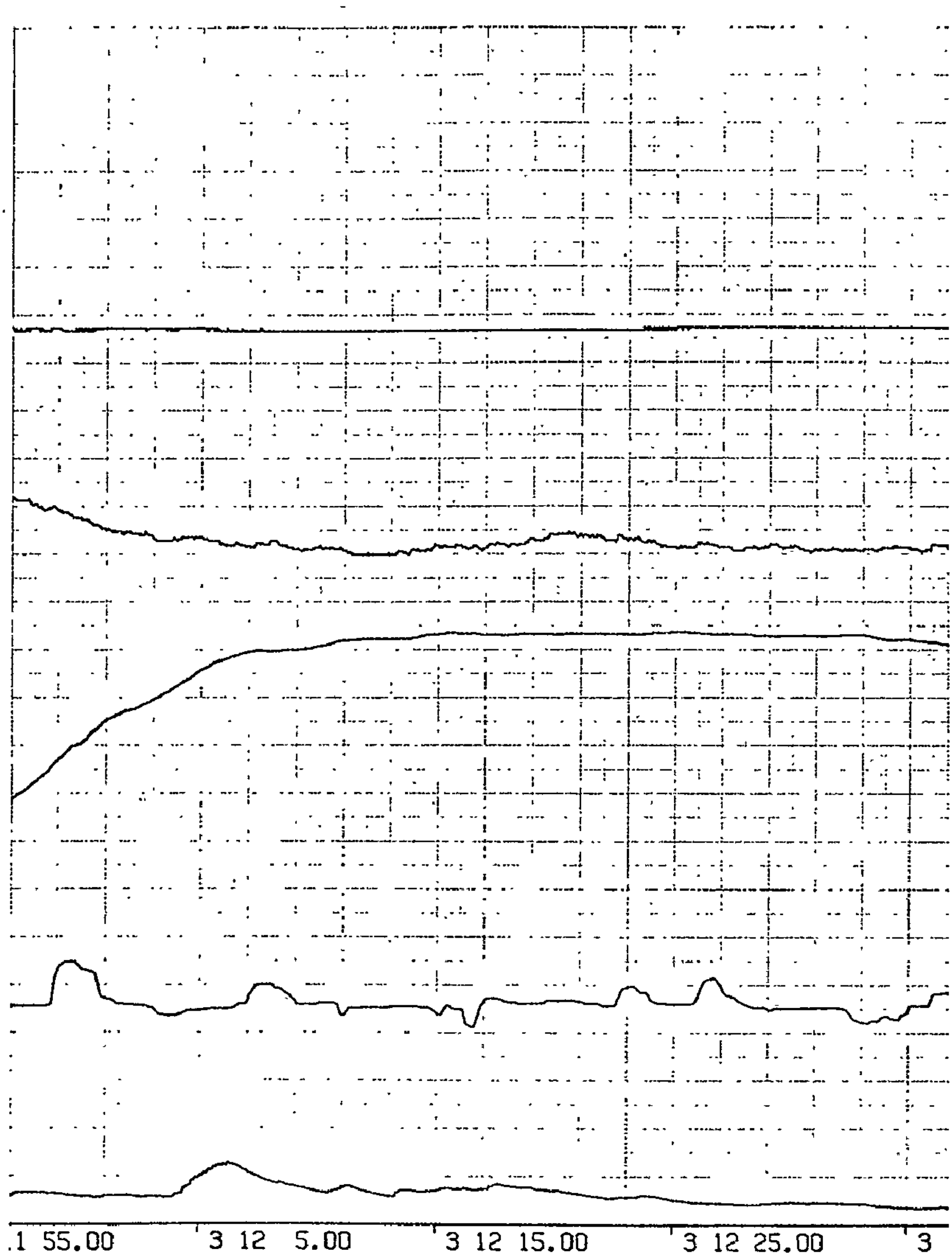

.1 55.00
3 12 5.00
3 12 15.00
3 12 25.00
3

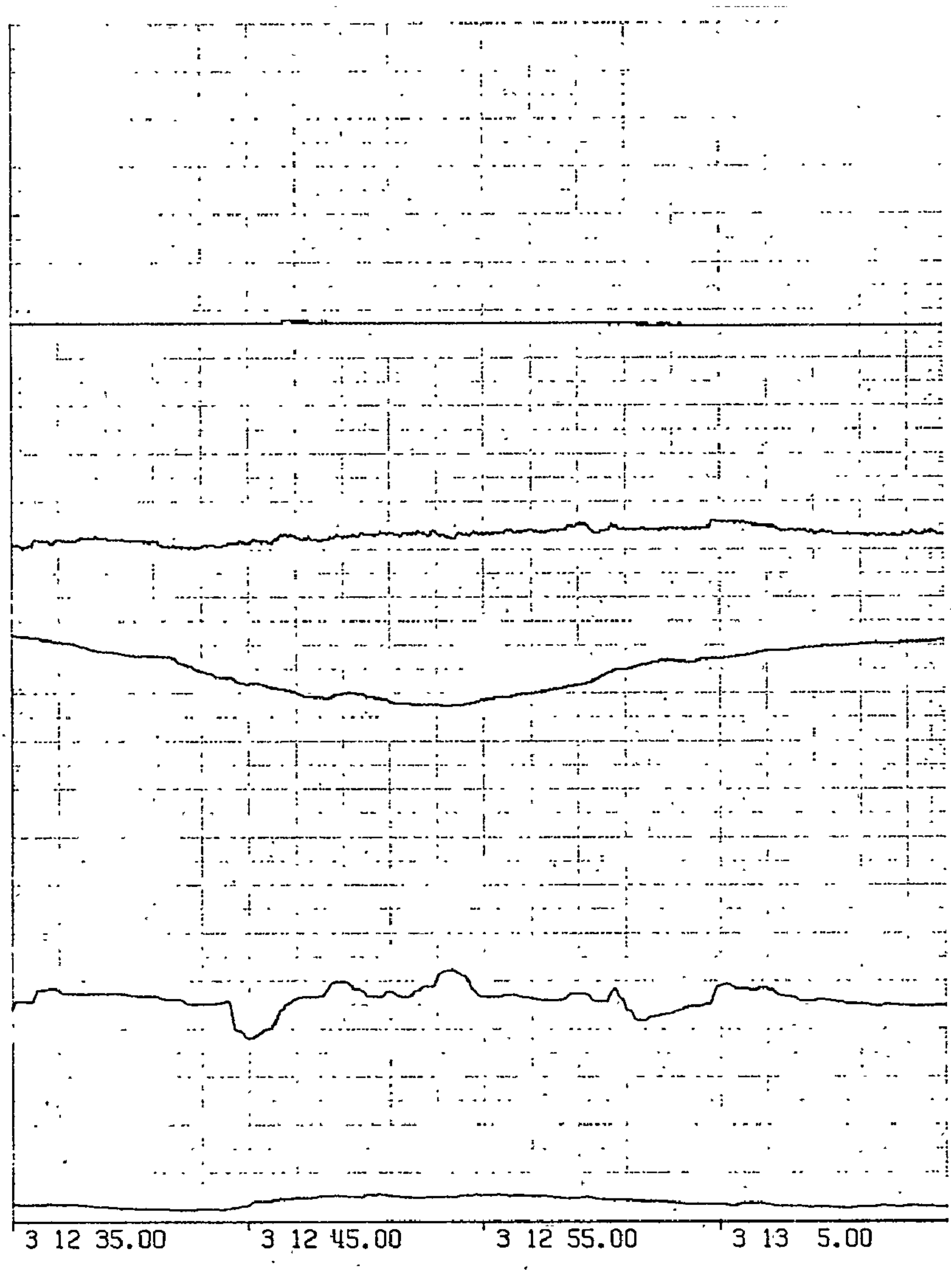

3 12 35.00
3 12 45.00
3 12 55.00
3 13 5.00

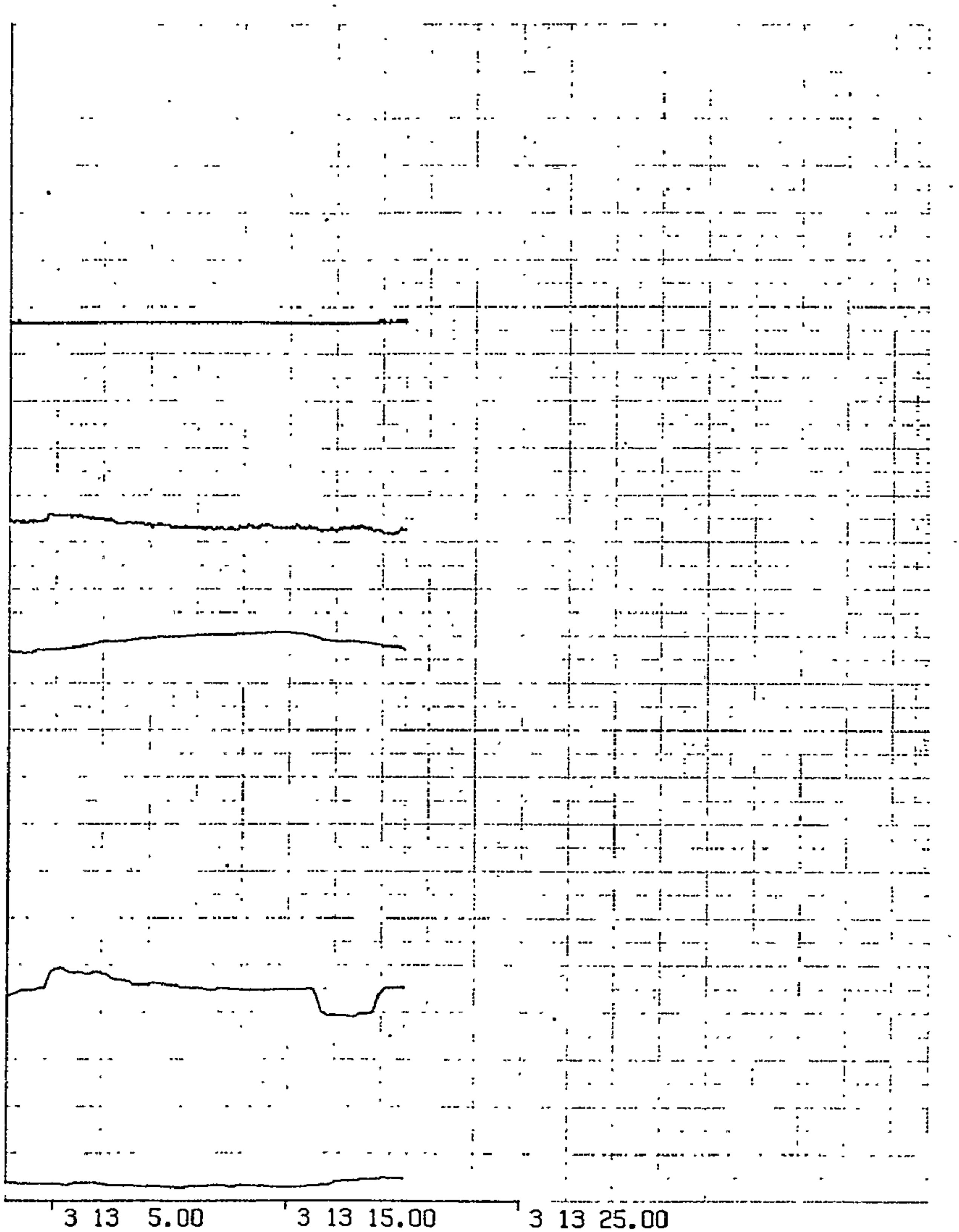

3 13 5.00
3 13 15.00
3 13 25.00

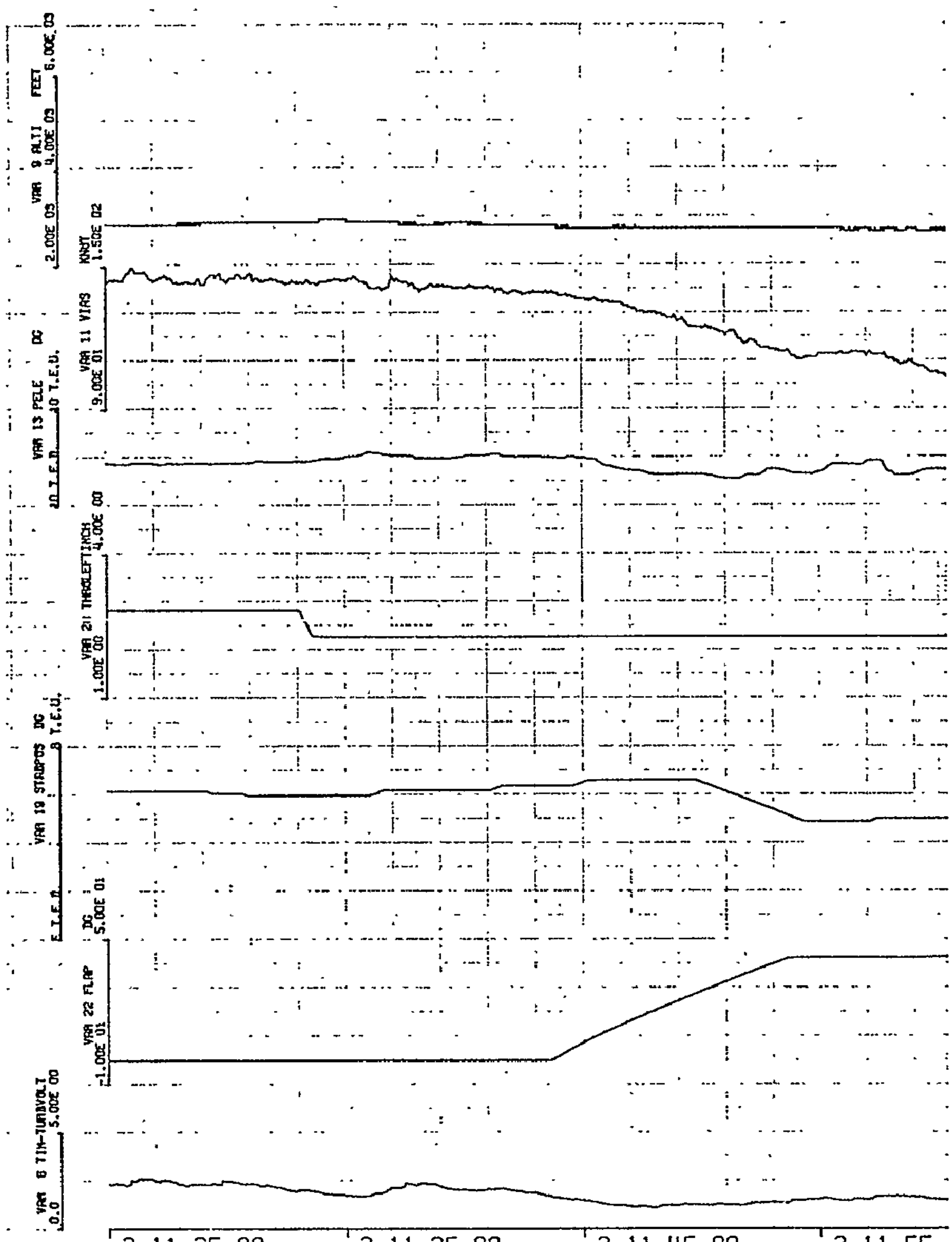



A/P BEECH 0093 DIG COND . 3 FLT COND
TEST 092-1 RUN NO 106603
ILS INTERCEPT - LATERAL PLOT FORMAT 08


.1 55.00
3 12 5.00
3 12 15.00
3 12 25.00
3


3 12 35.00
3 12 45.00
3 12 55.00
3 13 5.00

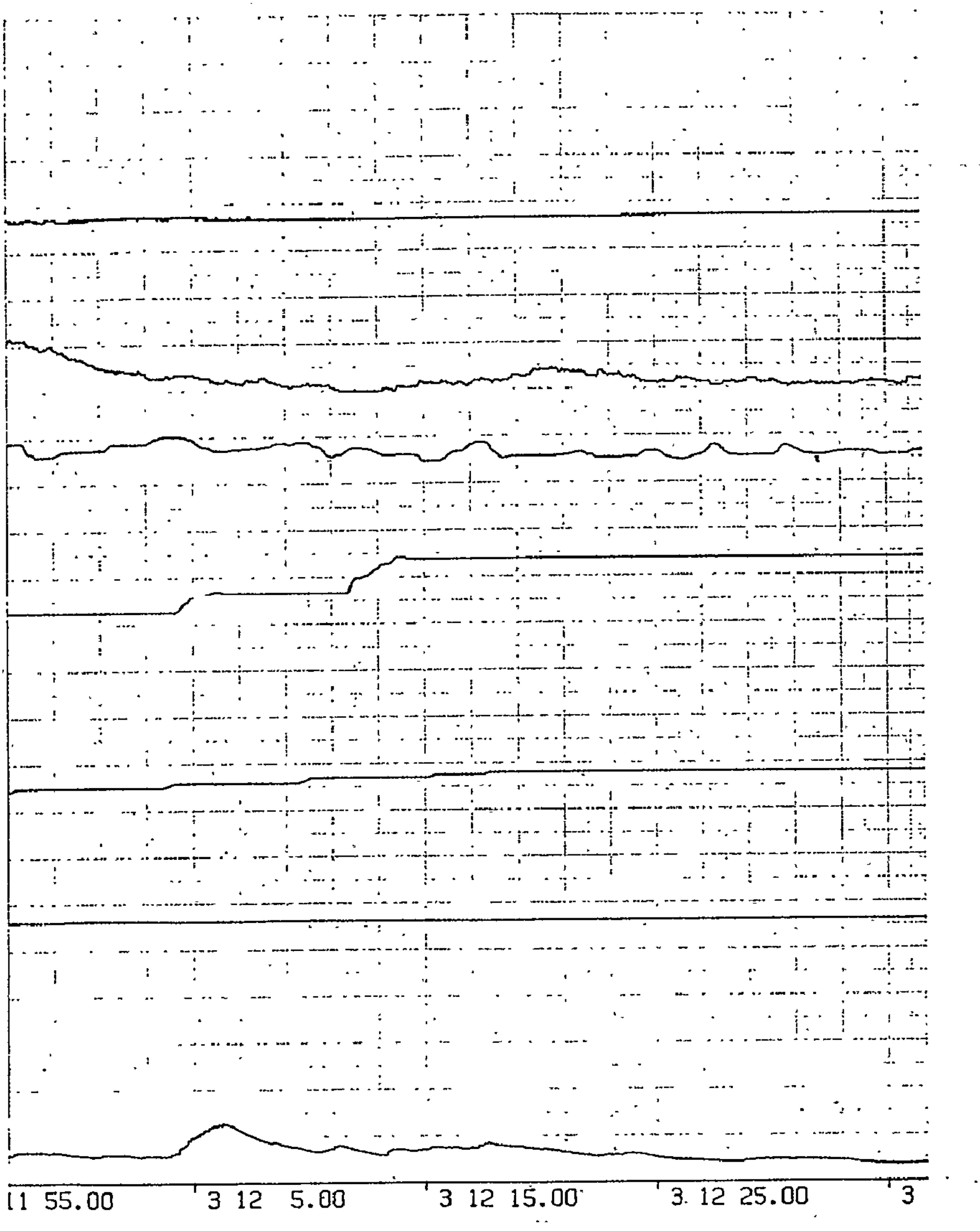

3 13 5.00
3 13 15.00
3 13 25.00

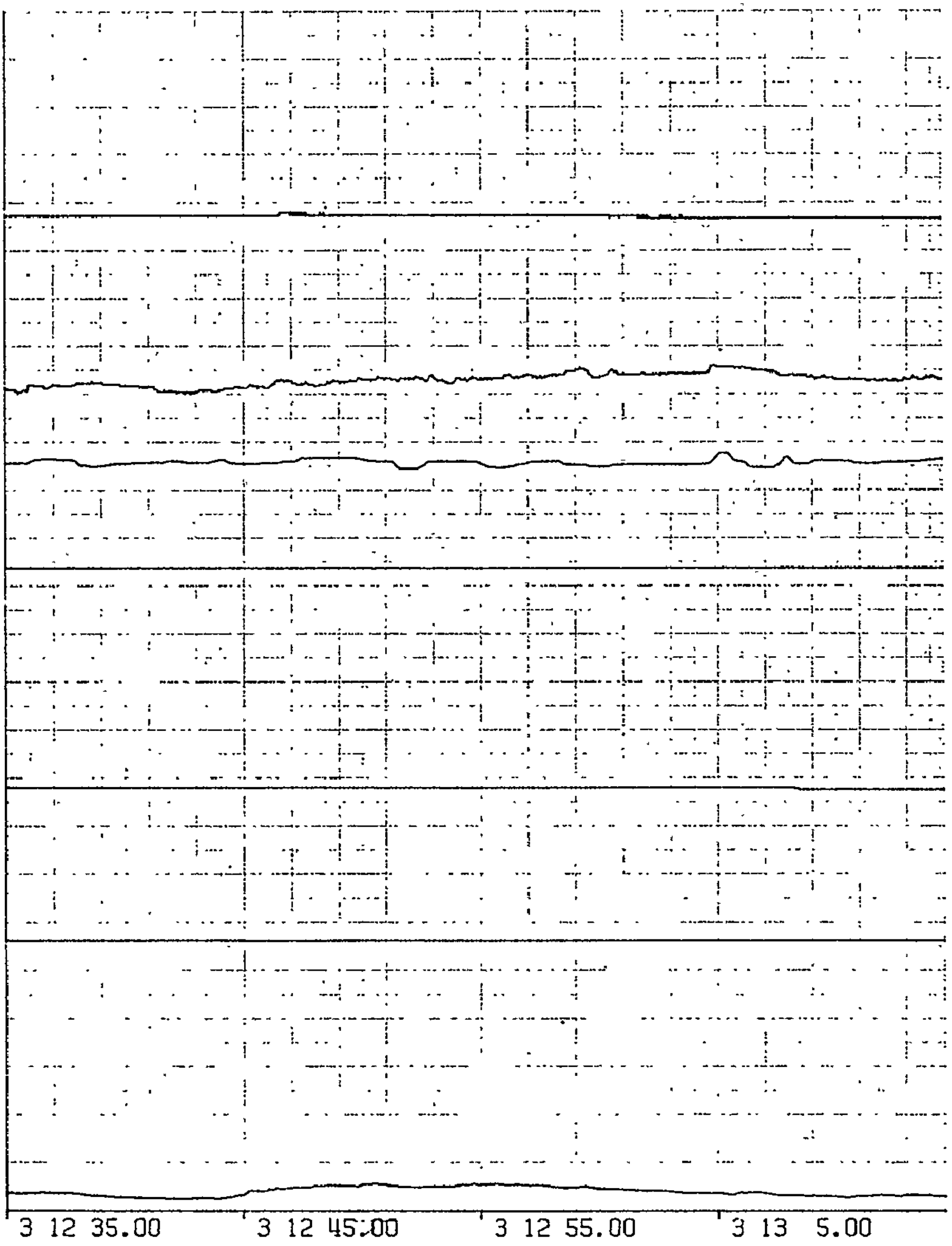


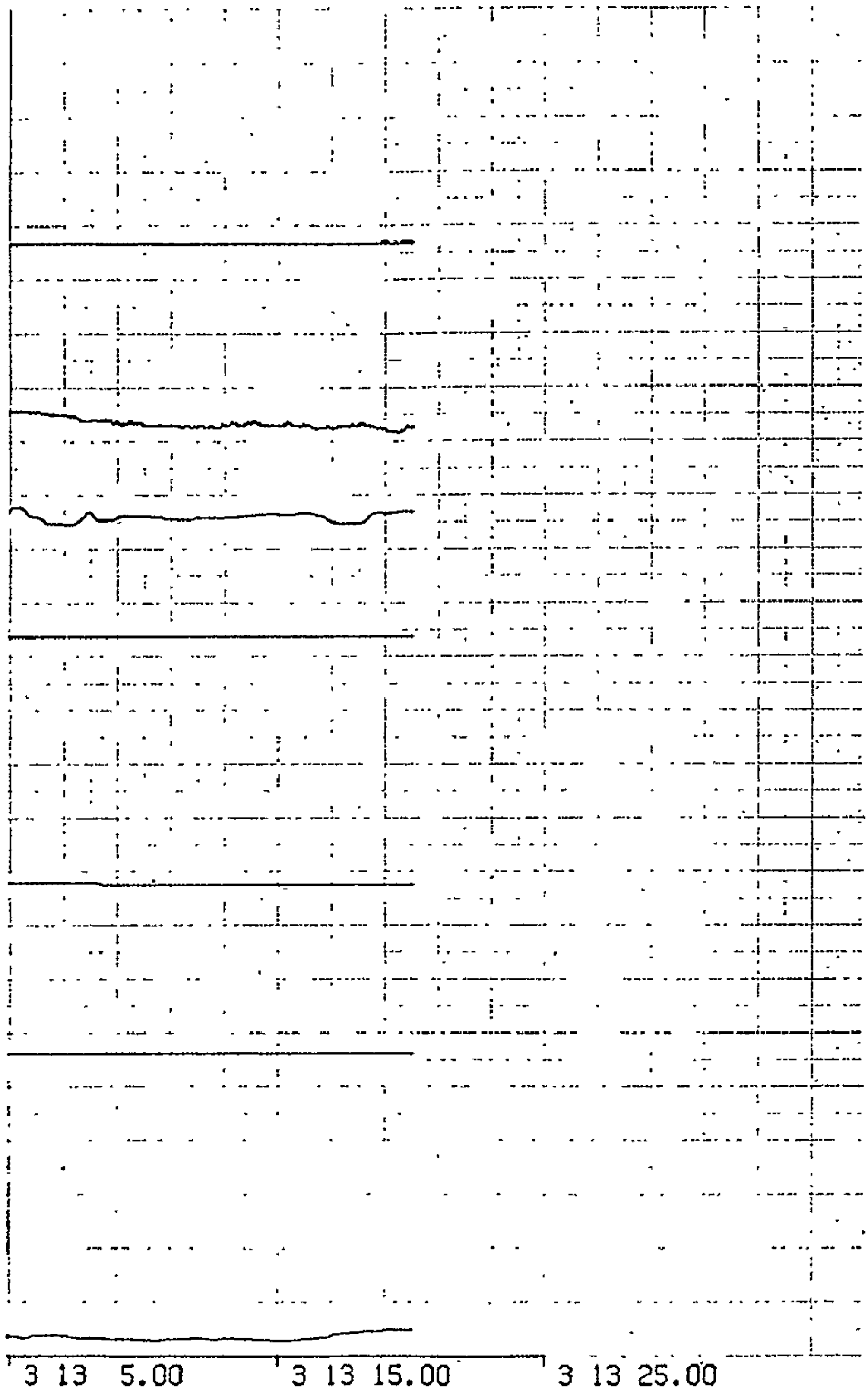

A/P BEECH 0099 DIG COND 3 FLT COND

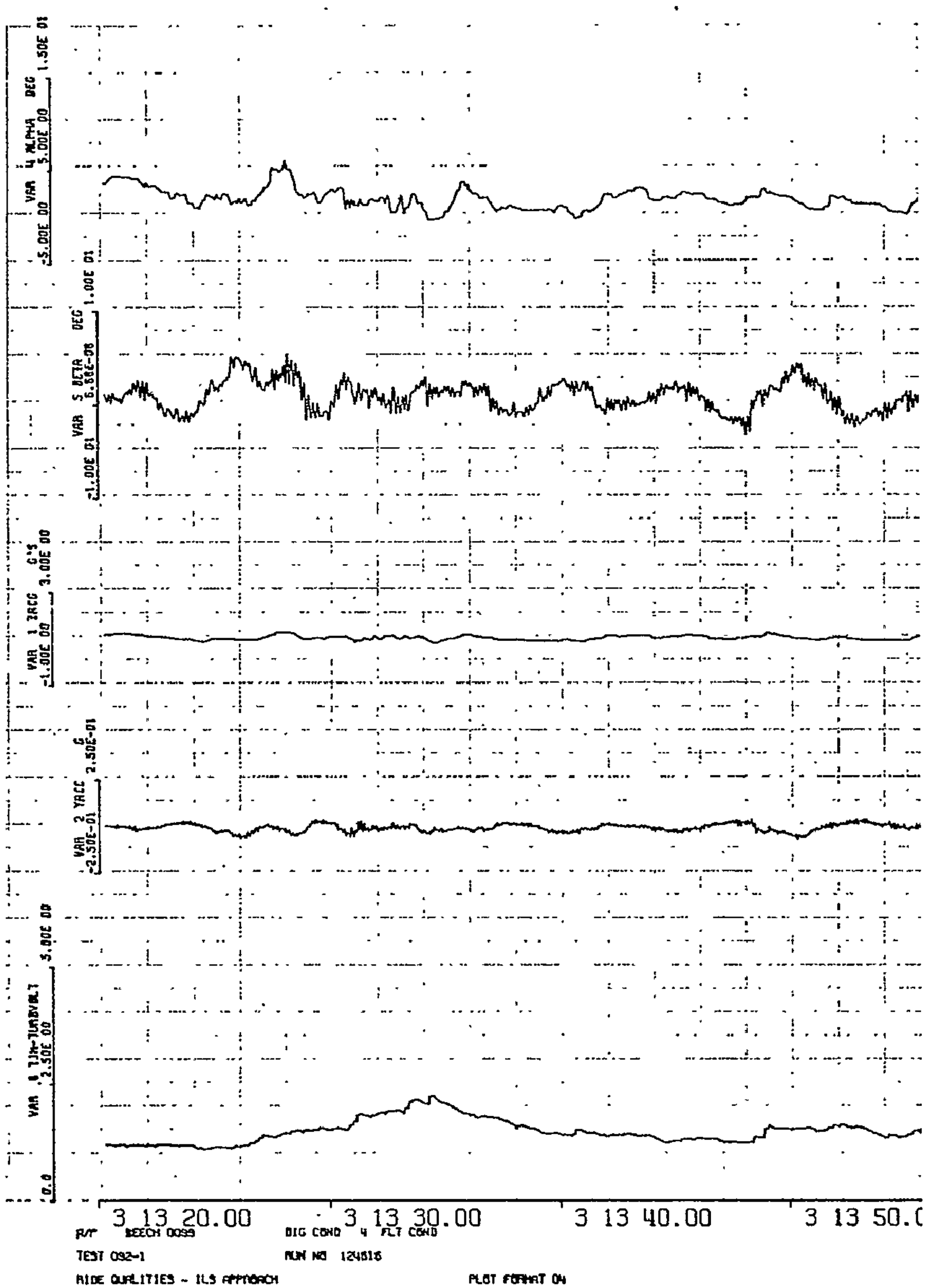
TEST 092-1 RUN NO 106603

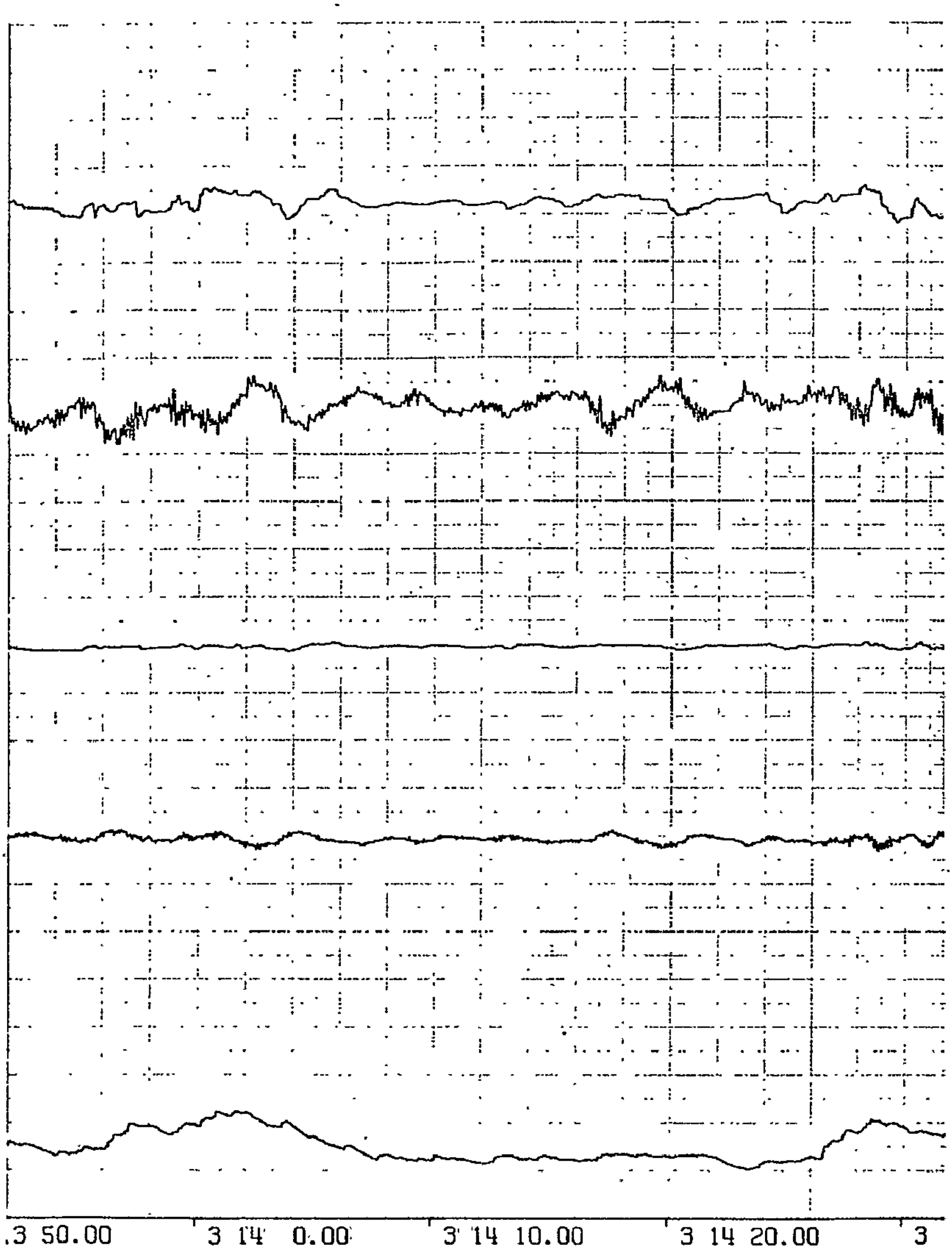
ILS INTERCEPT - LONGITUDINAL PLOT FORMAT 09

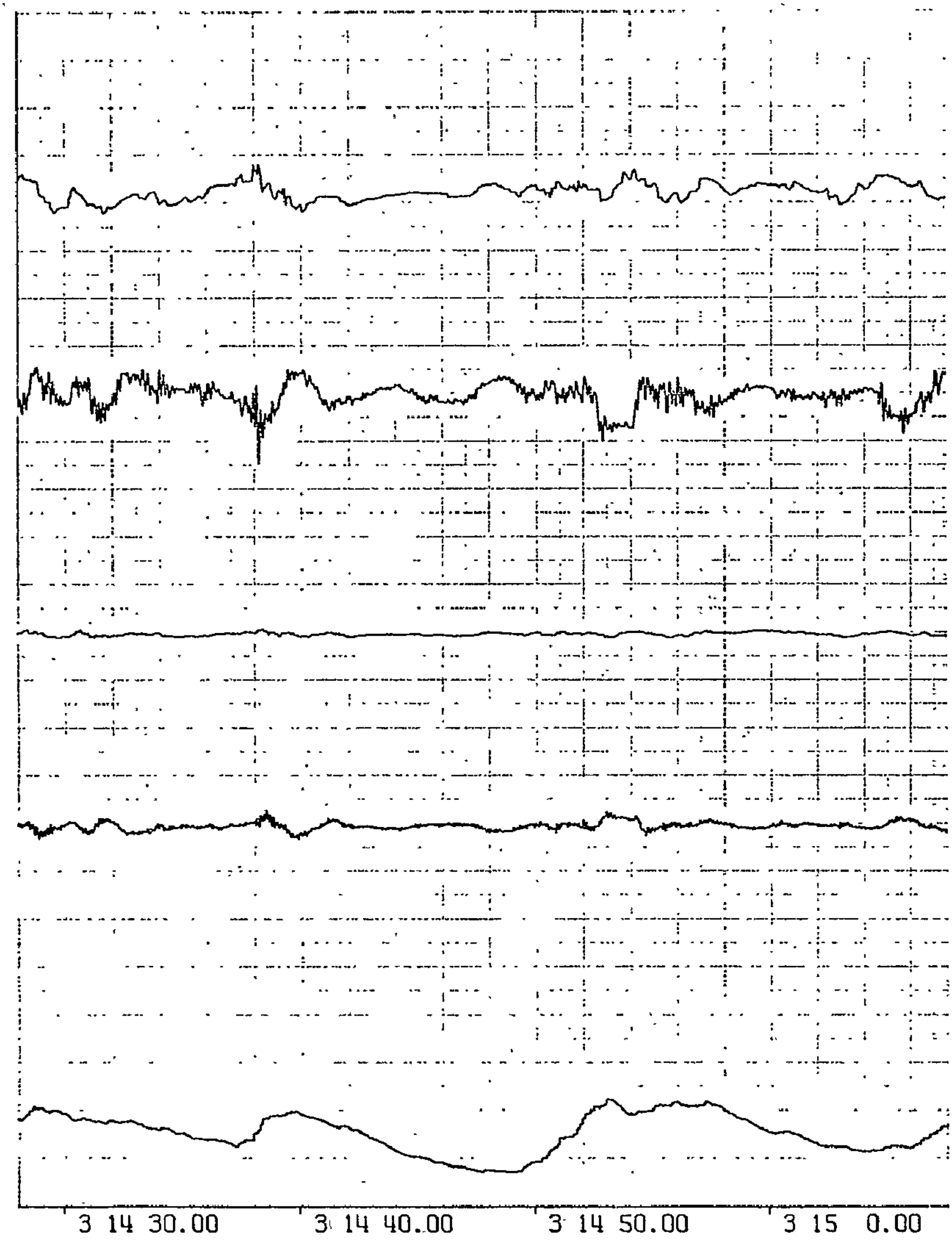

11 55.00
3 12 5.00
3 12 15.00
3 12 25.00
3

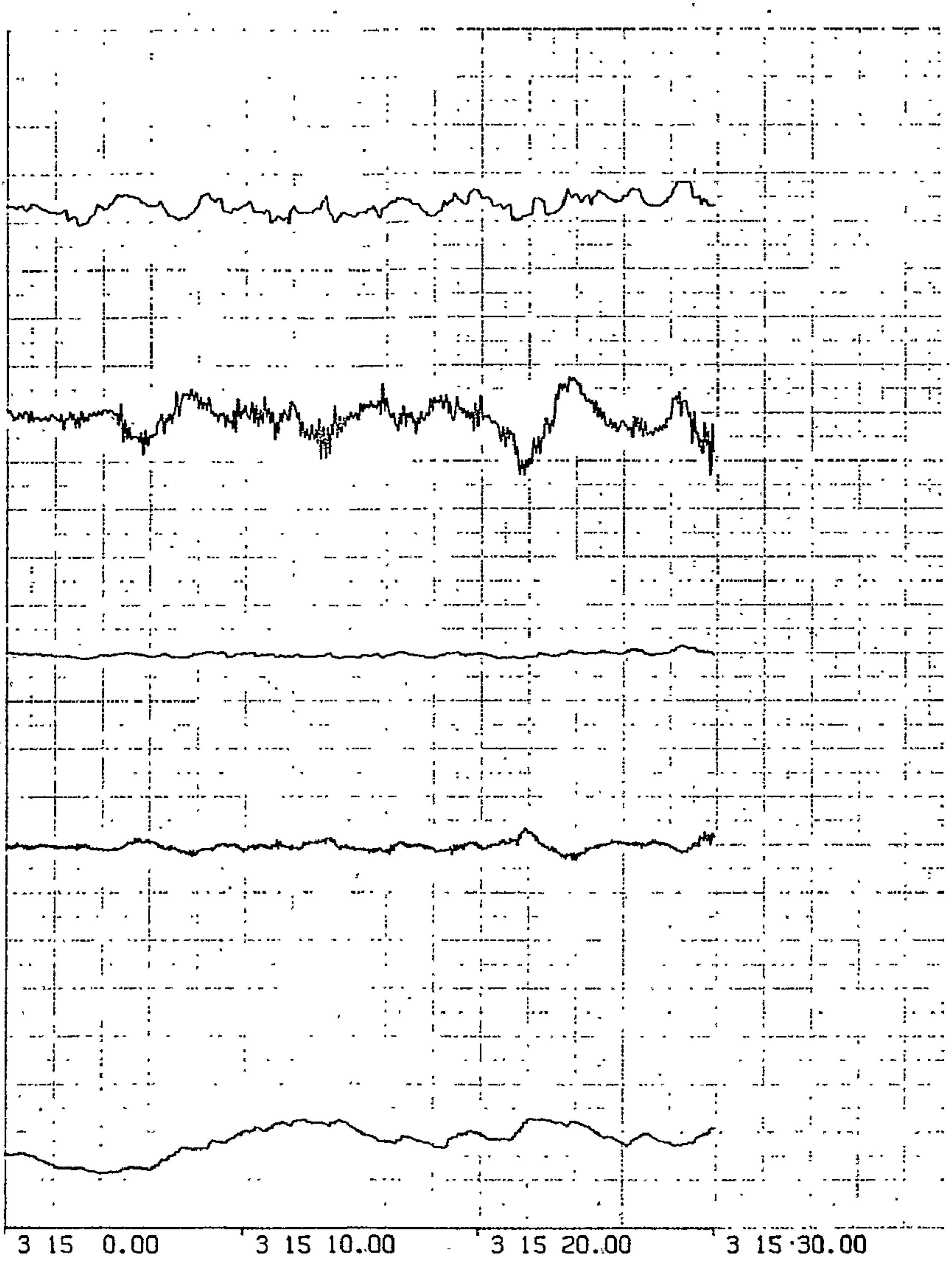

3 12 35.00
3 12 45.00
3 12 55.00
3 13 5.00

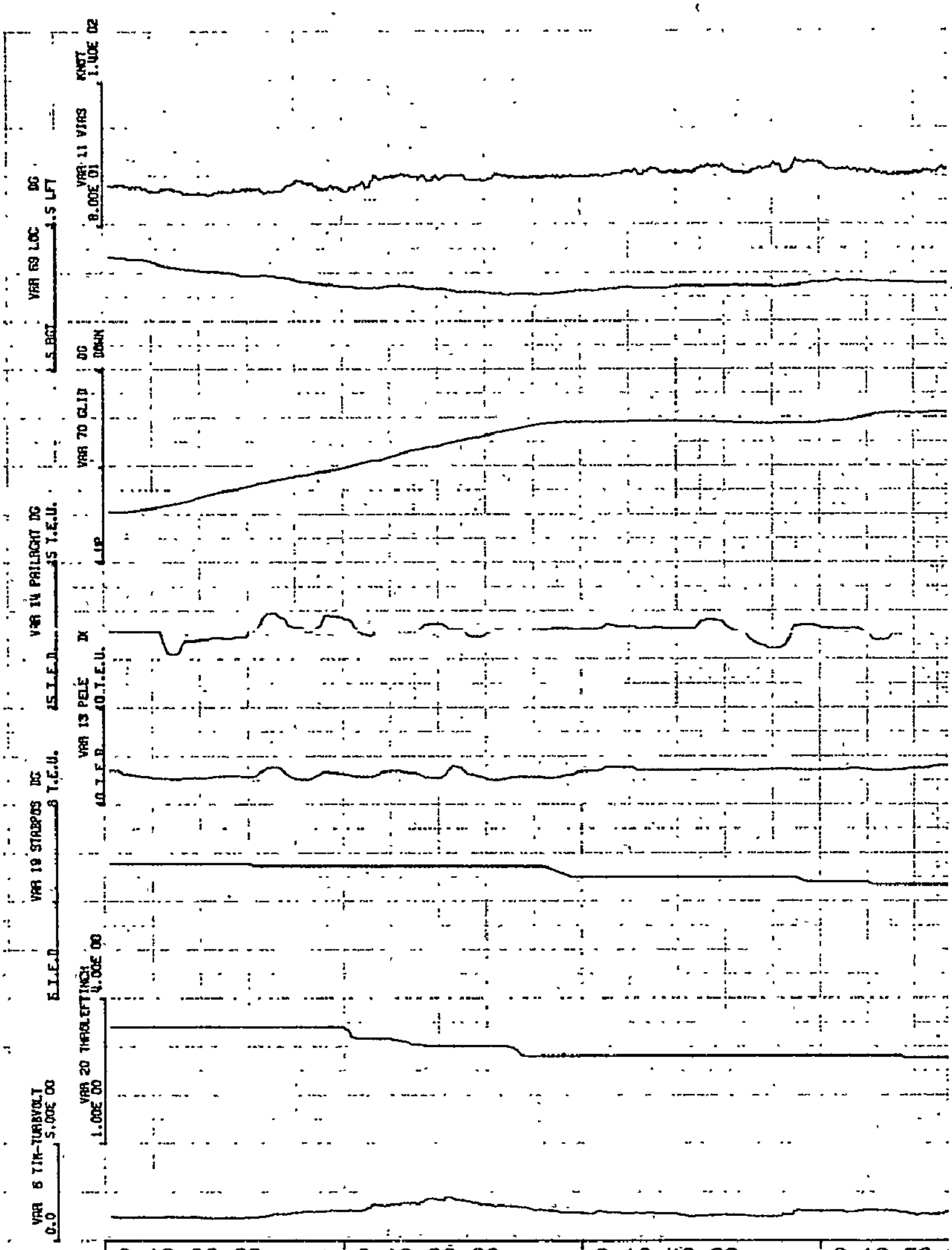

3 13 5.00
3 13 15.00
3 13 25.00


VAR 4 ALPHA DEG
-5.00E 00
5.00E 00
1.50E 01
VAR 5 BETA DEG
-1.00E 01
1.00E 01
VAR 1 ZACC G'S
-1.00E 00
3.00E 00
VAR 2 YACC G
-2.50E-01
2.50E-01
VAR 8 TJH-TURBVOLT
0.0
2.50E 00
5.00E 00
3 13 20.00
3 13 30.00
3 13 40.00
3 13 50.0
A/P BEECH 0099
DIG COND 4 FLT COND
TEST 092-1
RUN NO 124616
RIDE QUALITIES - ILS APPROACH
PLOT FORMAT 04


.3 50.00
3 14 0.00
3 14 10.00
3 14 20.00
3


3 14 30.00
3 14 40.00
3 14 50.00
3 15 0.00

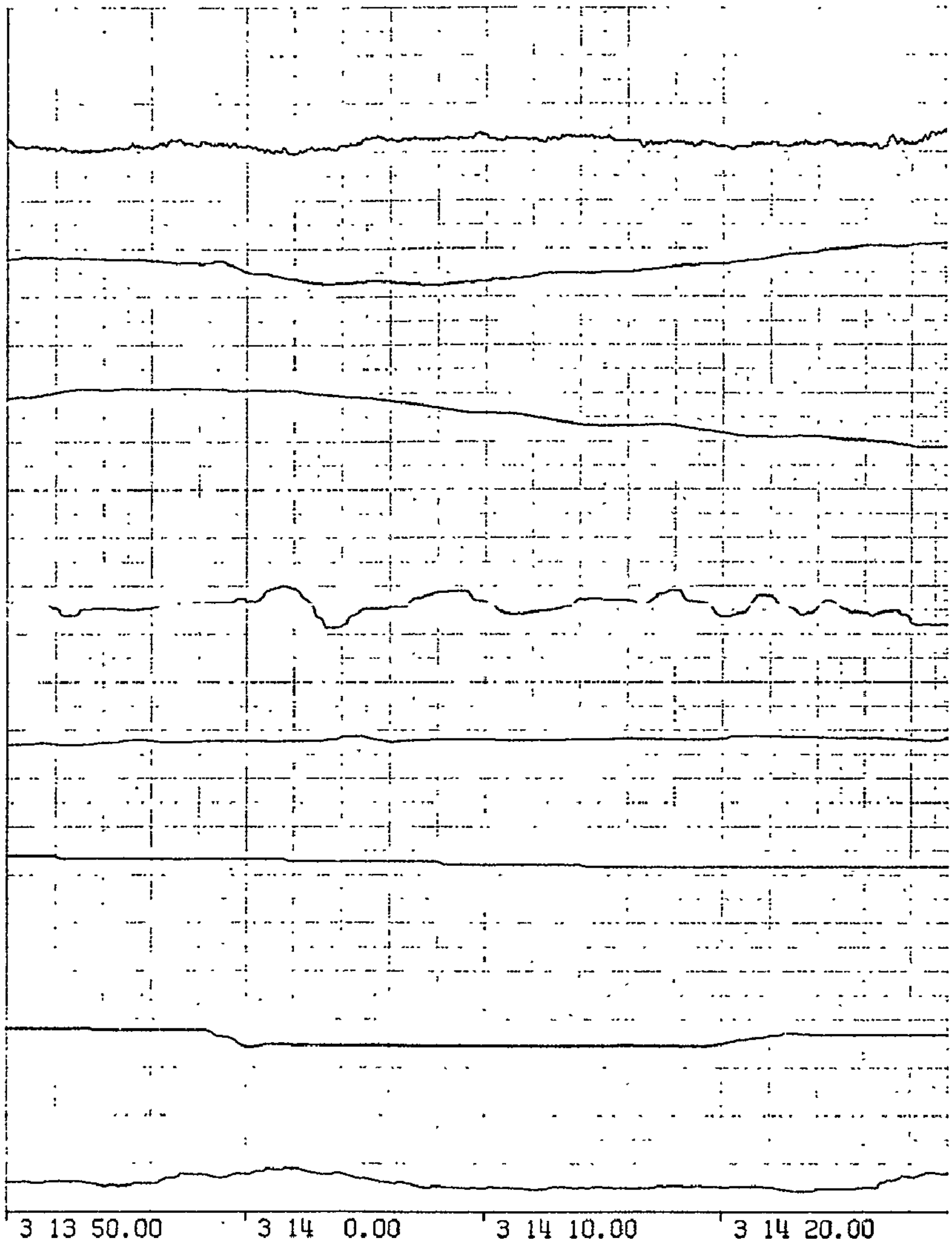

3 15 0.00
3 15 10.00
3 15 20.00
3 15 30.00

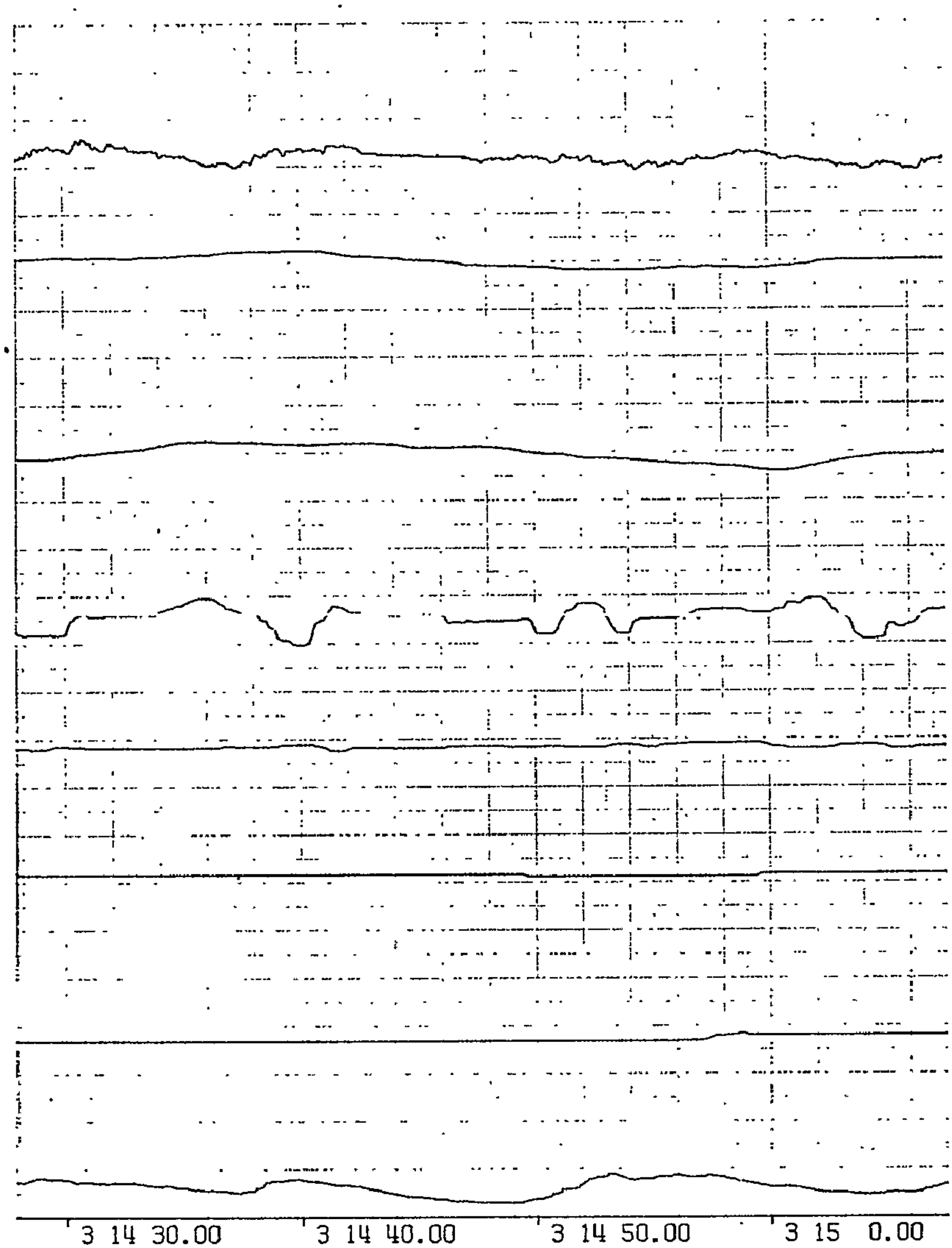


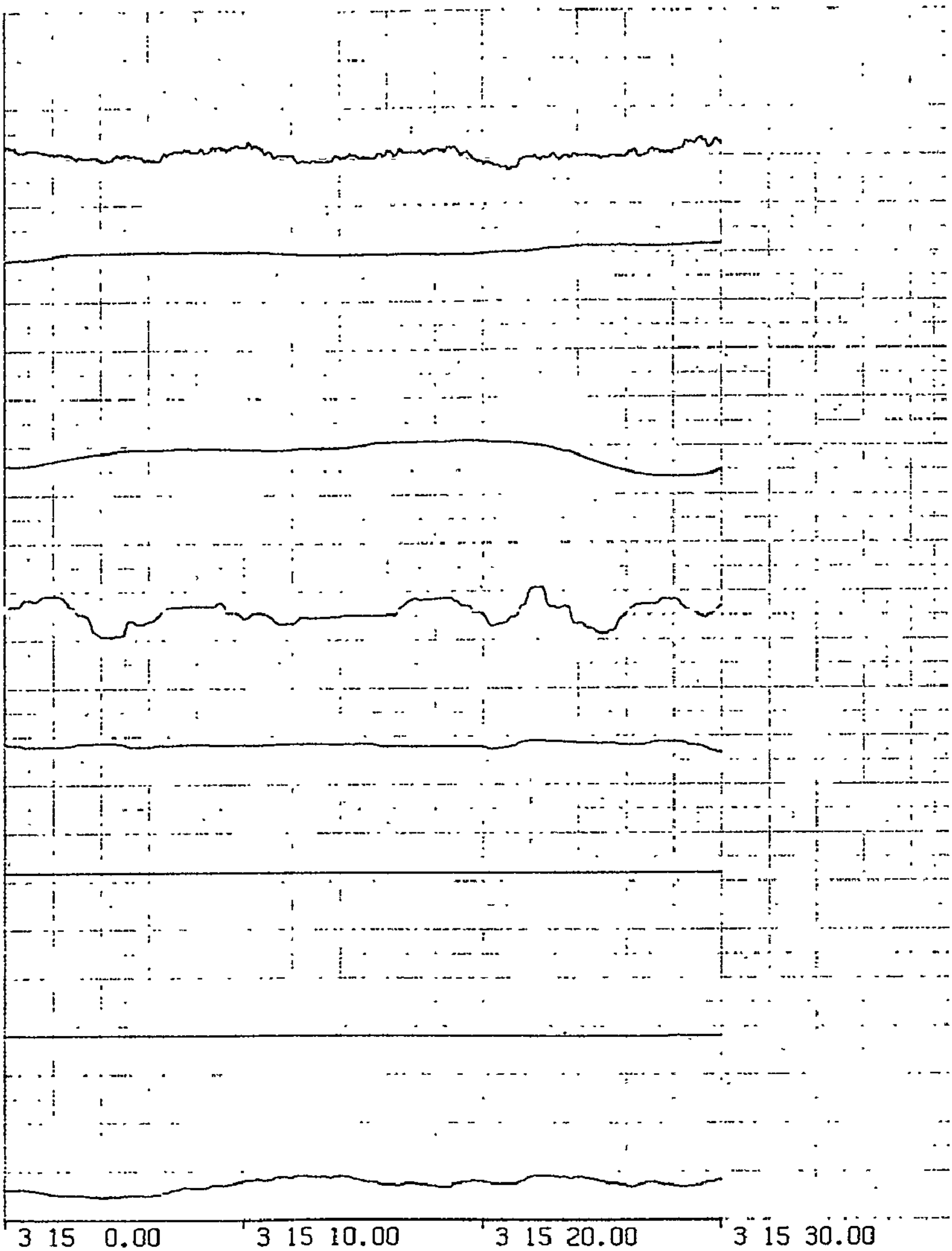

A/P BEECH 0099　BIG COND 4 FLT COND

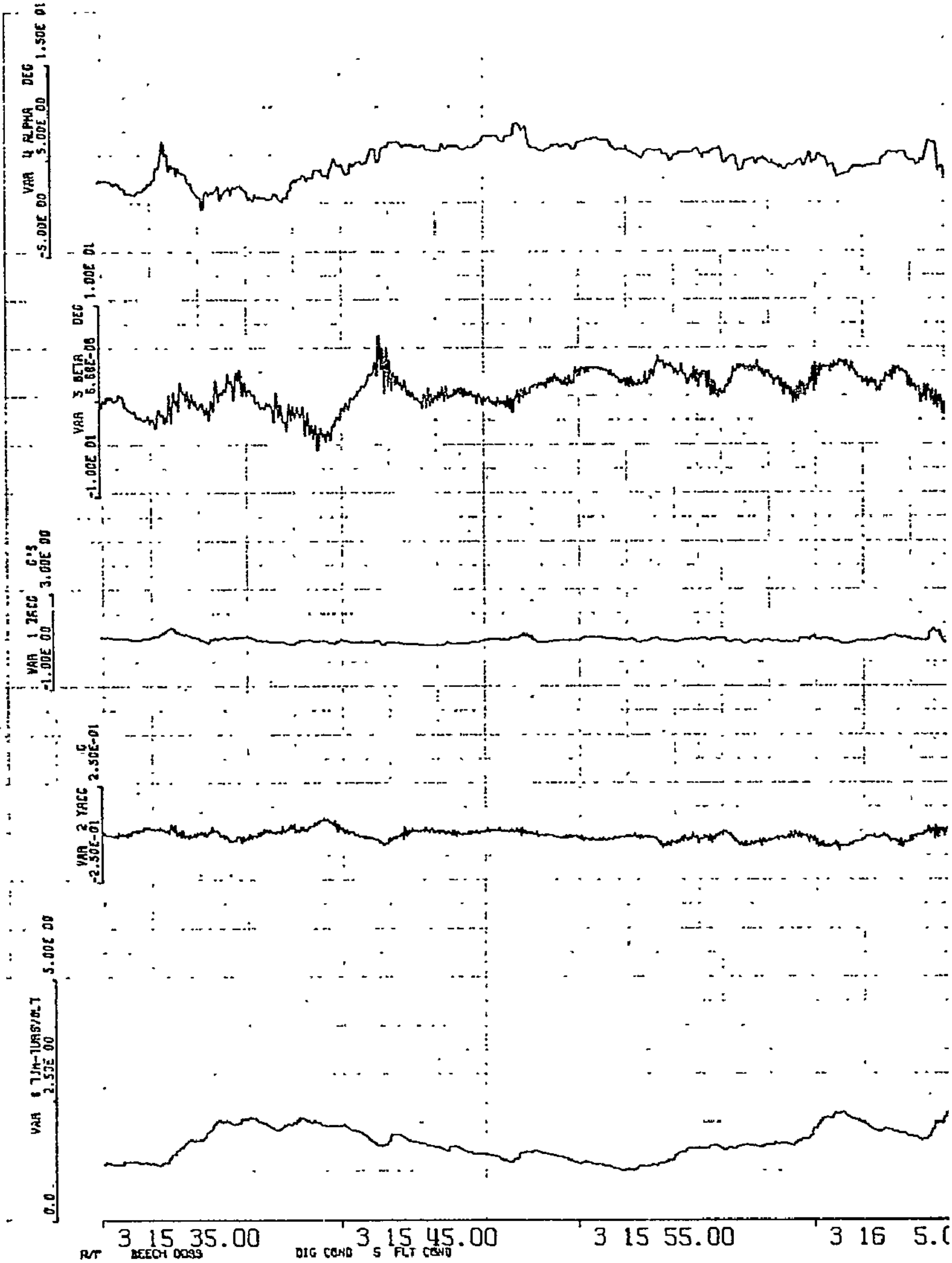
TEST 092-1　RUN NO 106603

ILS APPROACH　PLOT FORMAT 10

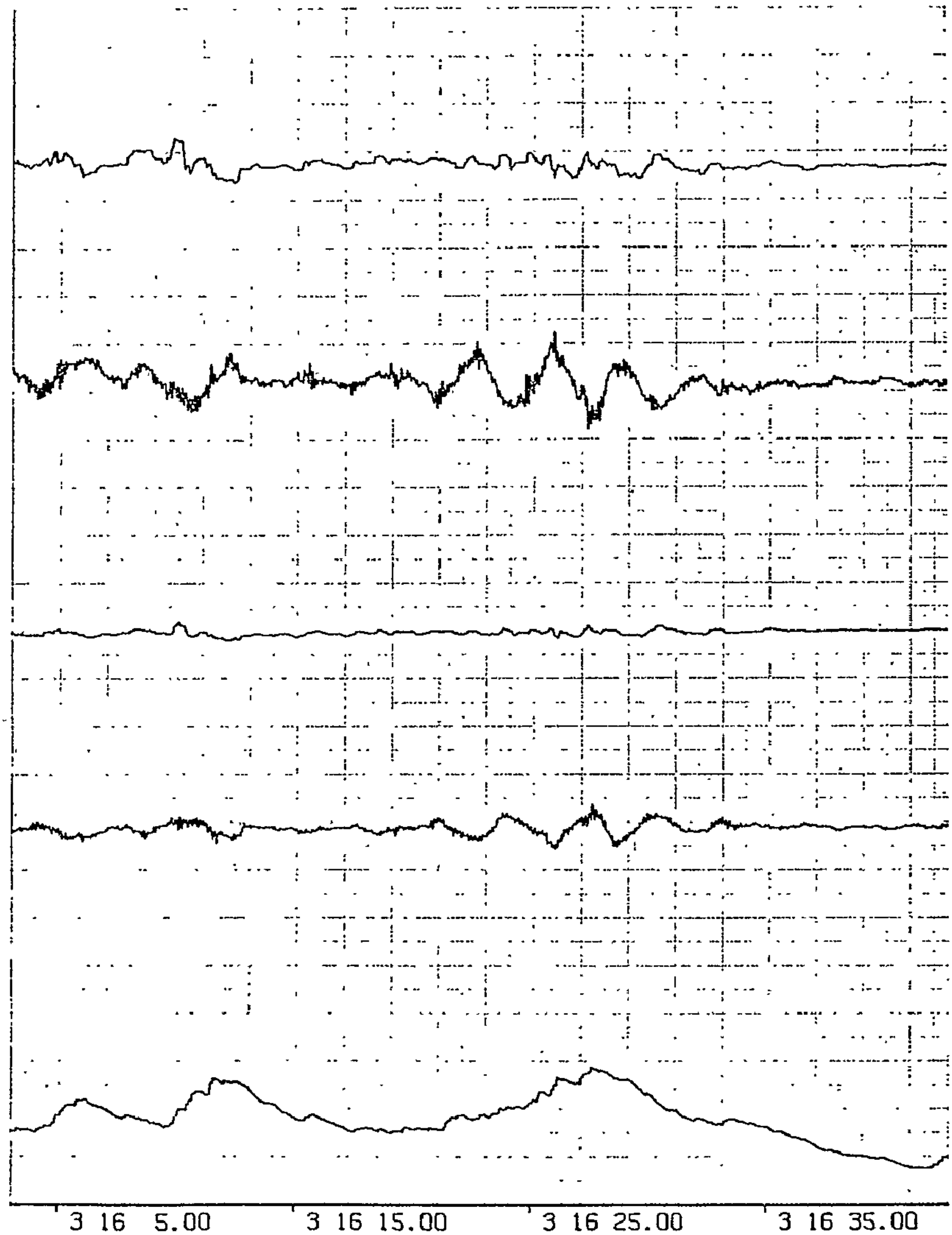

3 13 50.00
3 14 0.00
3 14 10.00
3 14 20.00

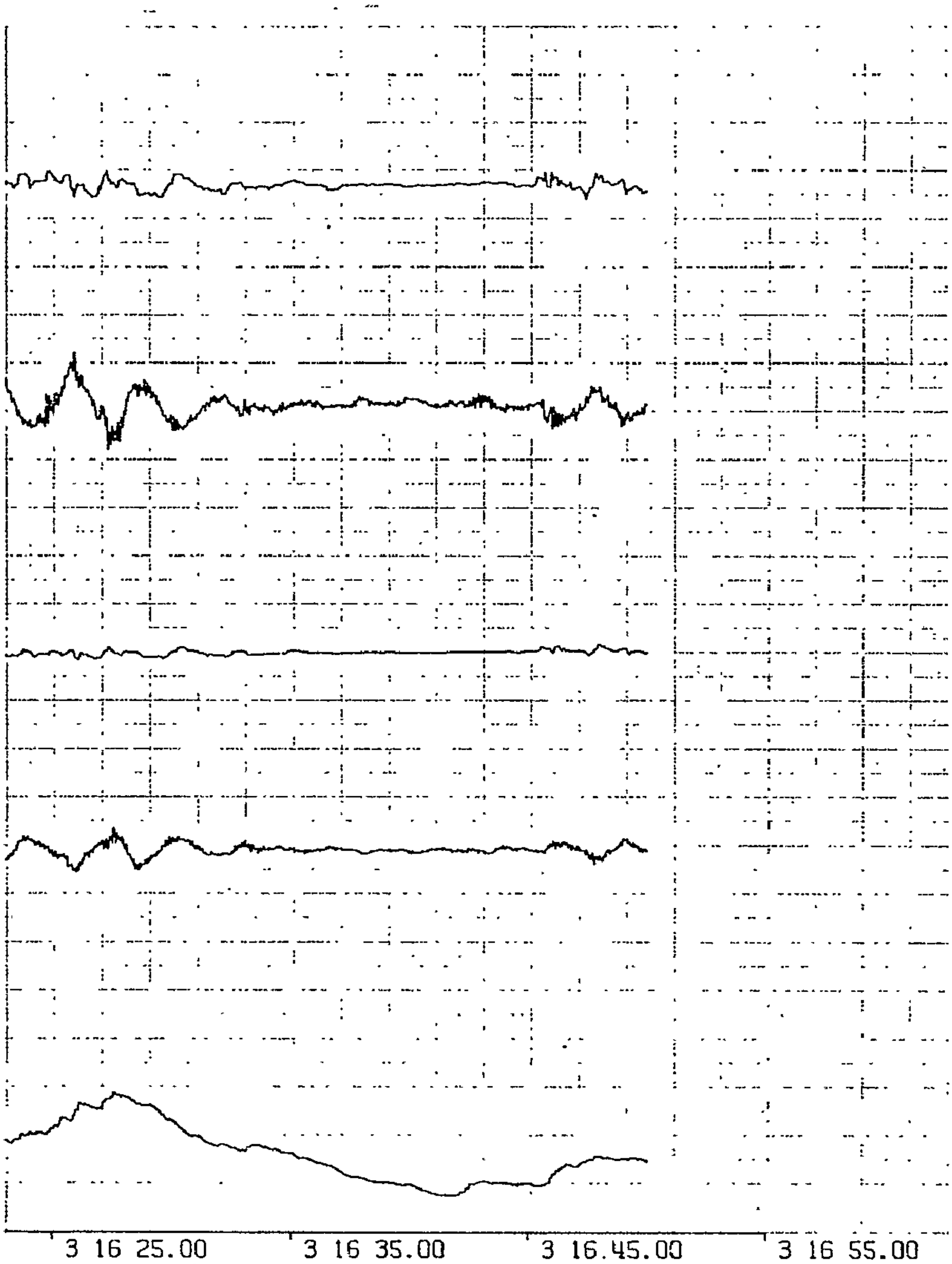

3 14 30.00
3 14 40.00
3 14 50.00
3 15 0.00

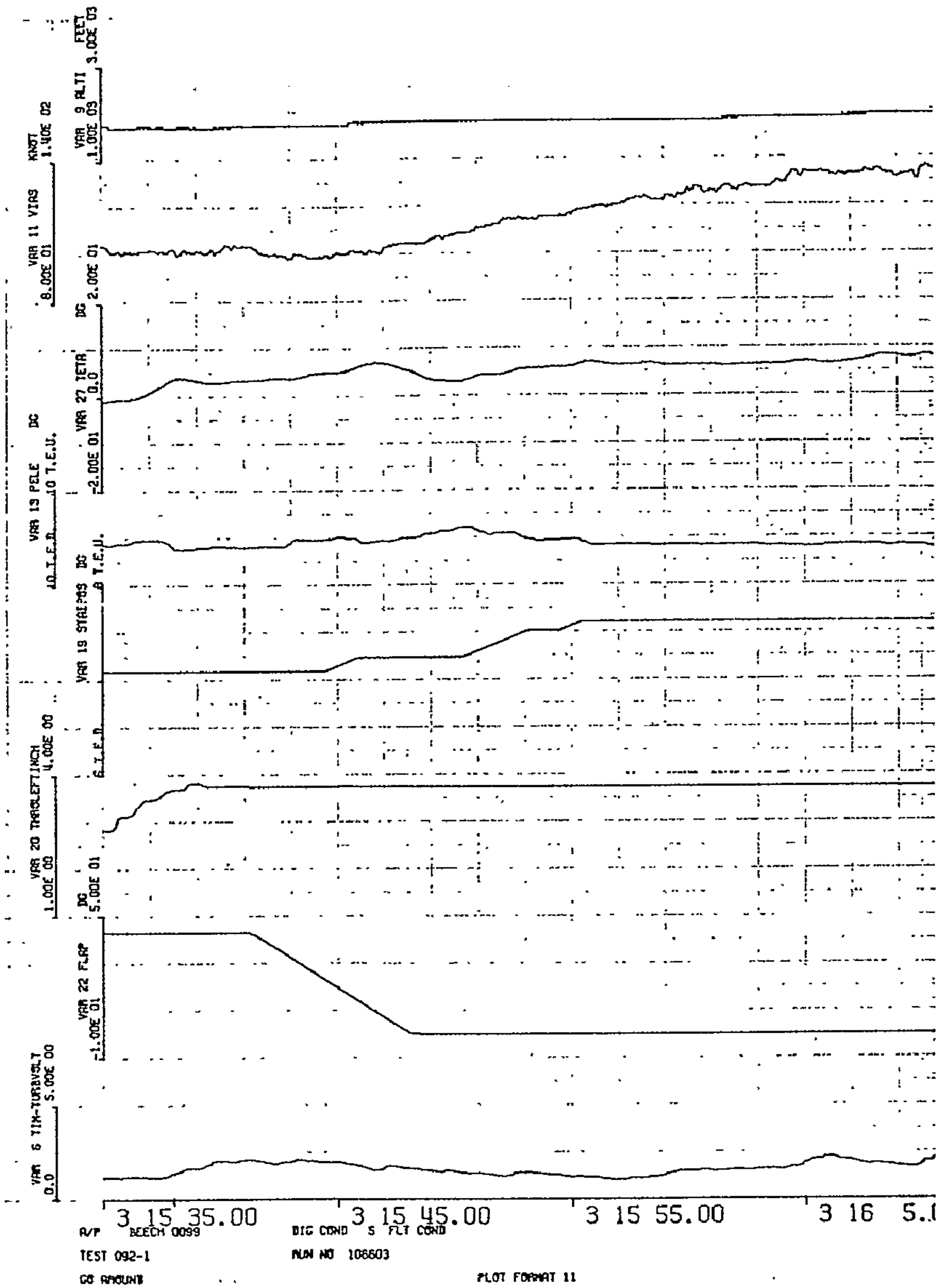

3 15 0.00
3 15 10.00
3 15 20.00
3 15 30.00

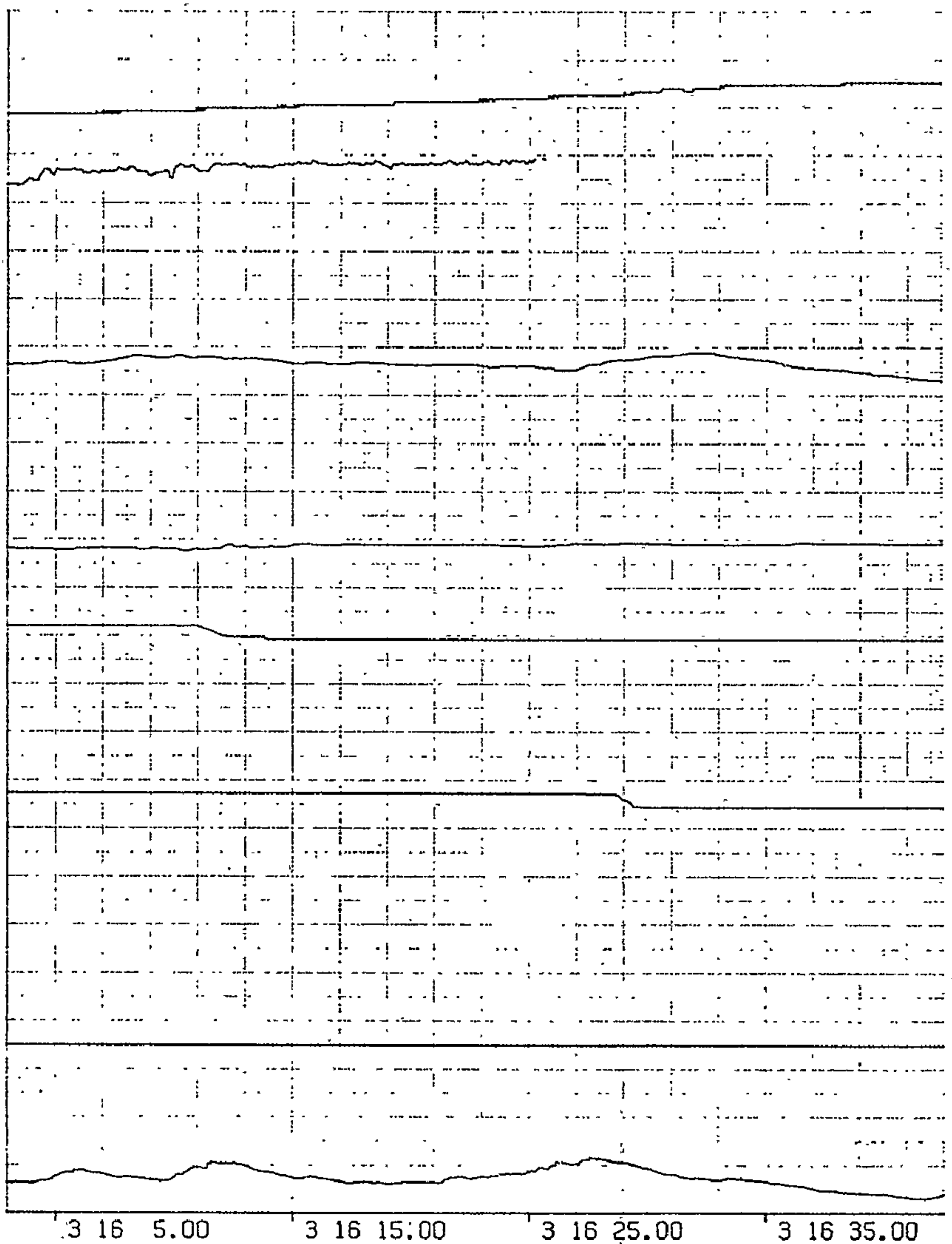


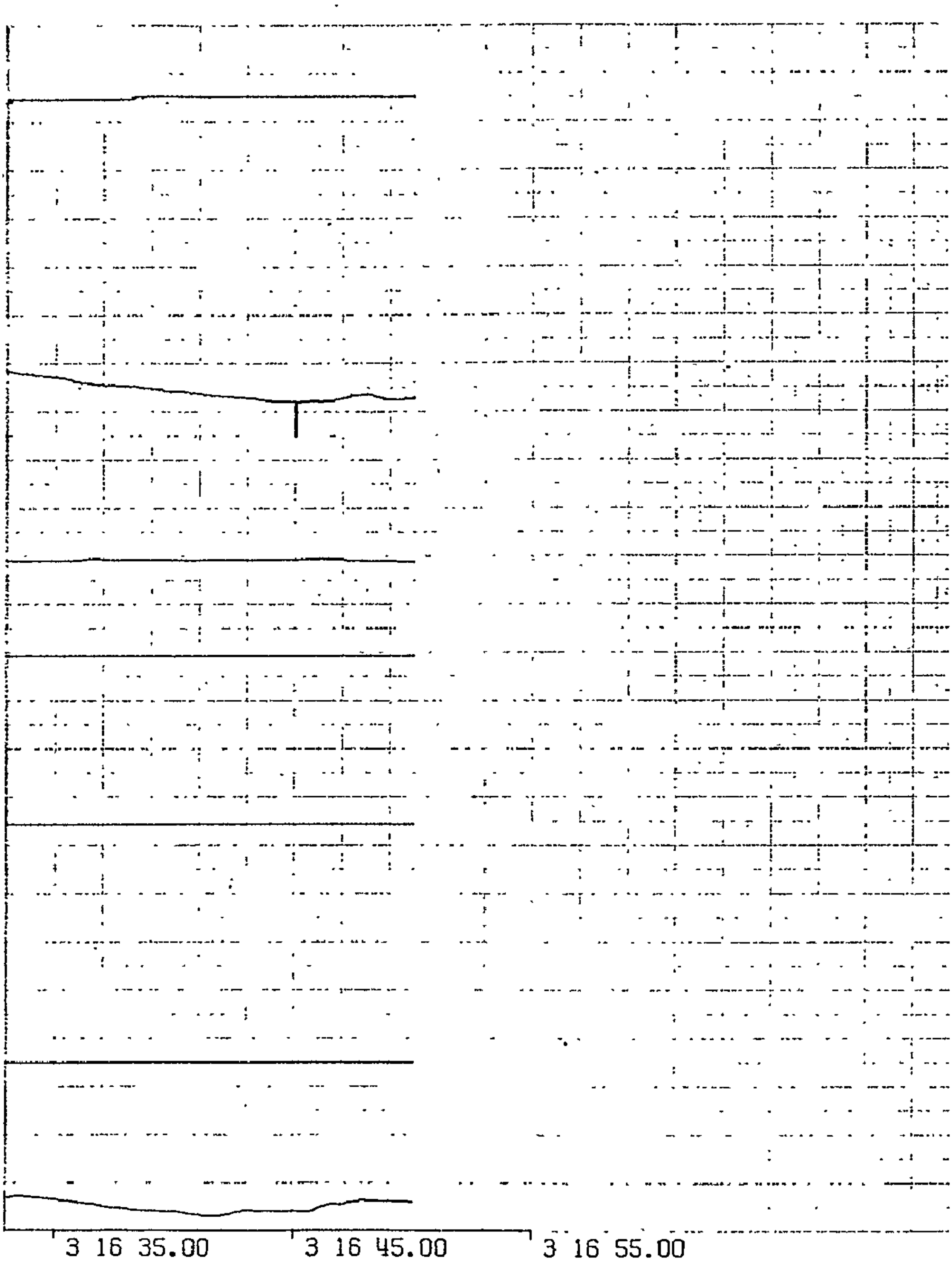

A/T BEECH 0039 DIG COND 5 FLT COND
TEST 092-1 RUN NO 124616
RIDE QUALITIES - GO AROUND PLOT FORMAT 04

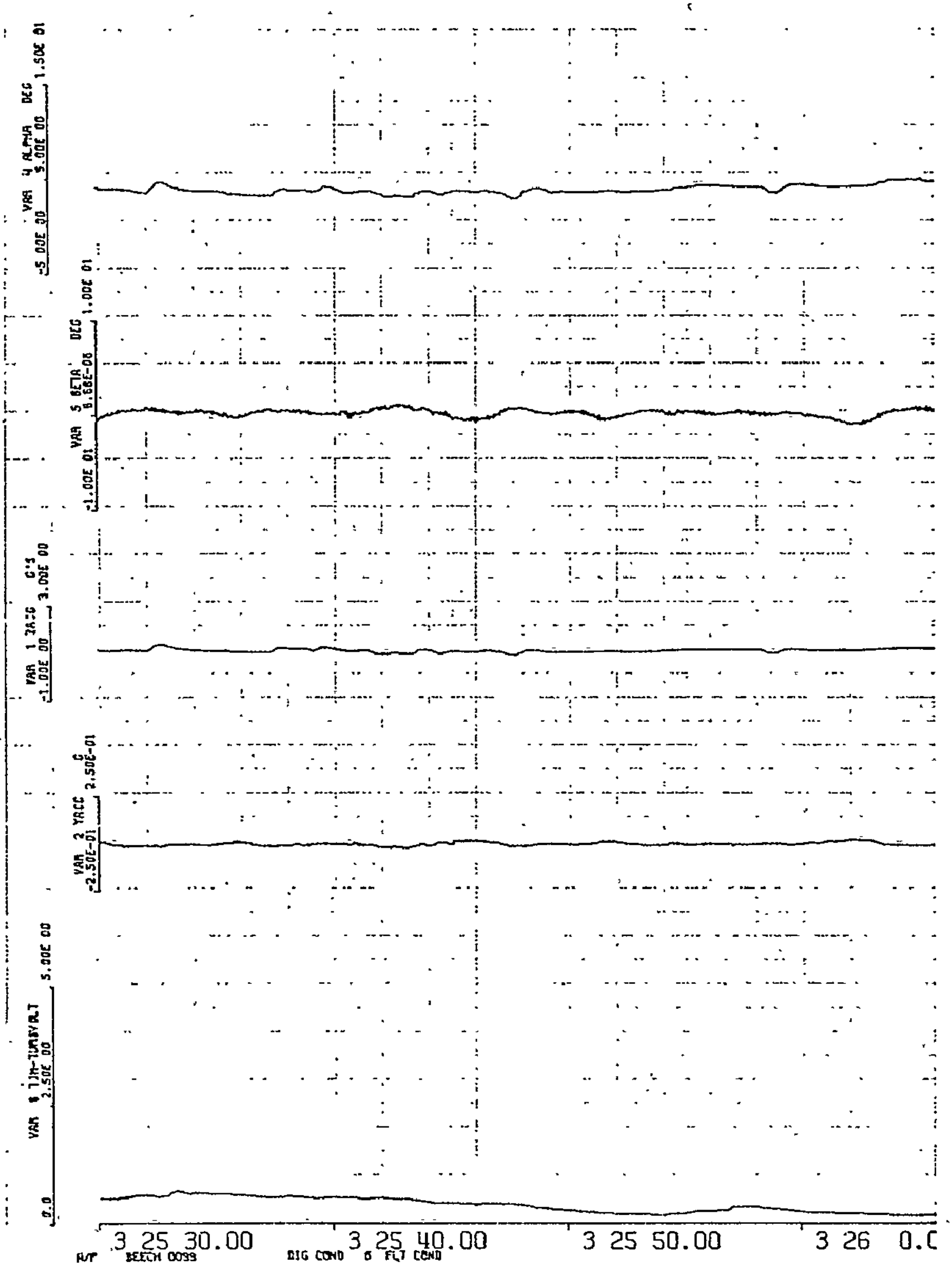

3 16 5.00
3 16 15.00
3 16 25.00
3 16 35.00


3 16 25.00
3 16 35.00
3 16.45.00
3 16 55.00


VAR 9 ALTI FEET
VAR 11 VIAS KNOT
VAR 27 TETA DG
VAR 13 PELE DG
VAR 19 STABPOS DG
VAR 20 THROLEFTINCH
VAR 22 FLAP DG
VAR 6 TIM-TURBVOLT
3 15 35.00
3 15 45.00
3 15 55.00
3 16 5.
A/P BEECH 0099
DIG COND 5 FLT COND
TEST 092-1
RUN NO 106603
GO AROUND
PLOT FORMAT 11


3 16 5.00
3 16 15:00
3 16 25.00
3 16 35.00

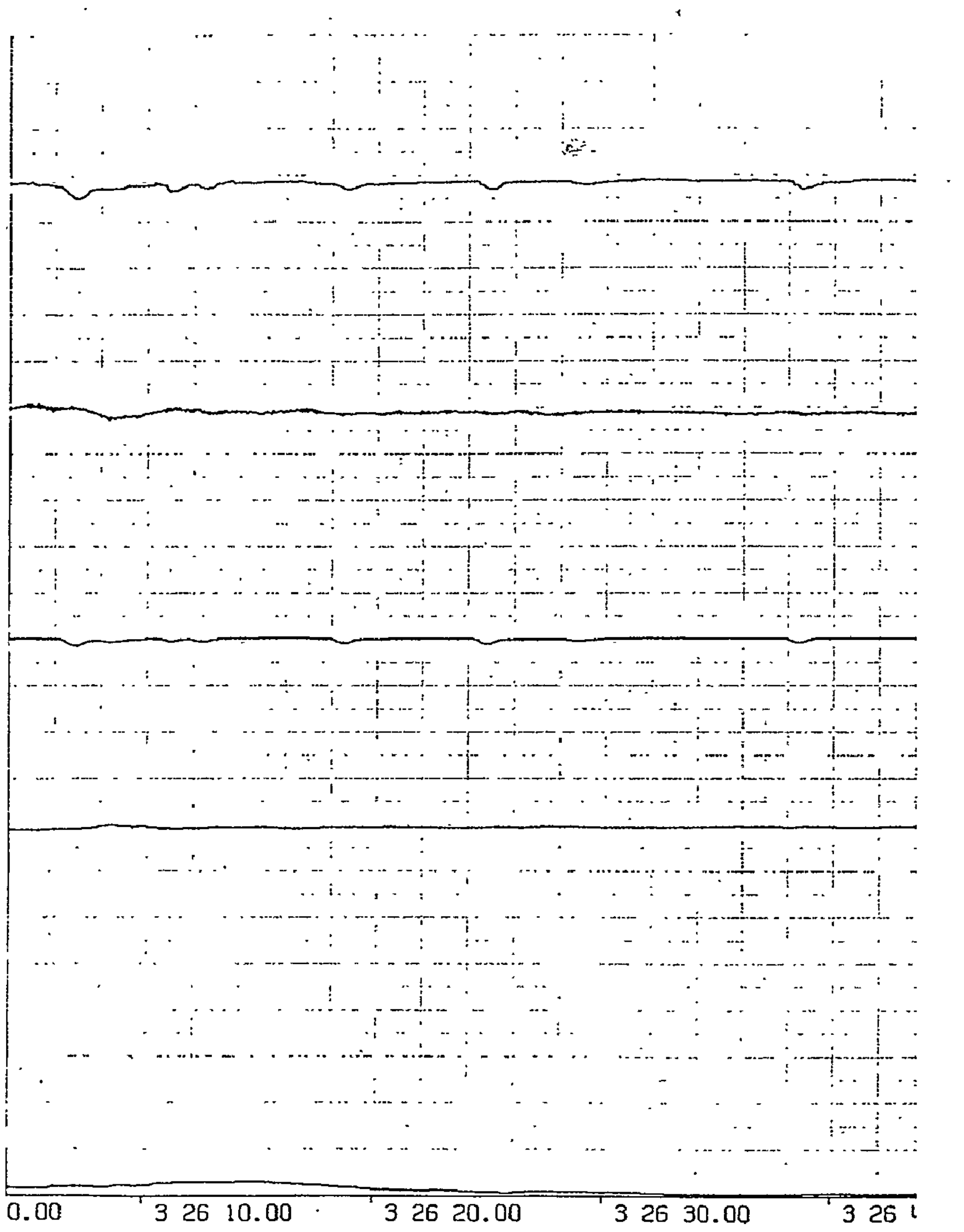

3 16 35.00
3 16 45.00
3 16 55.00

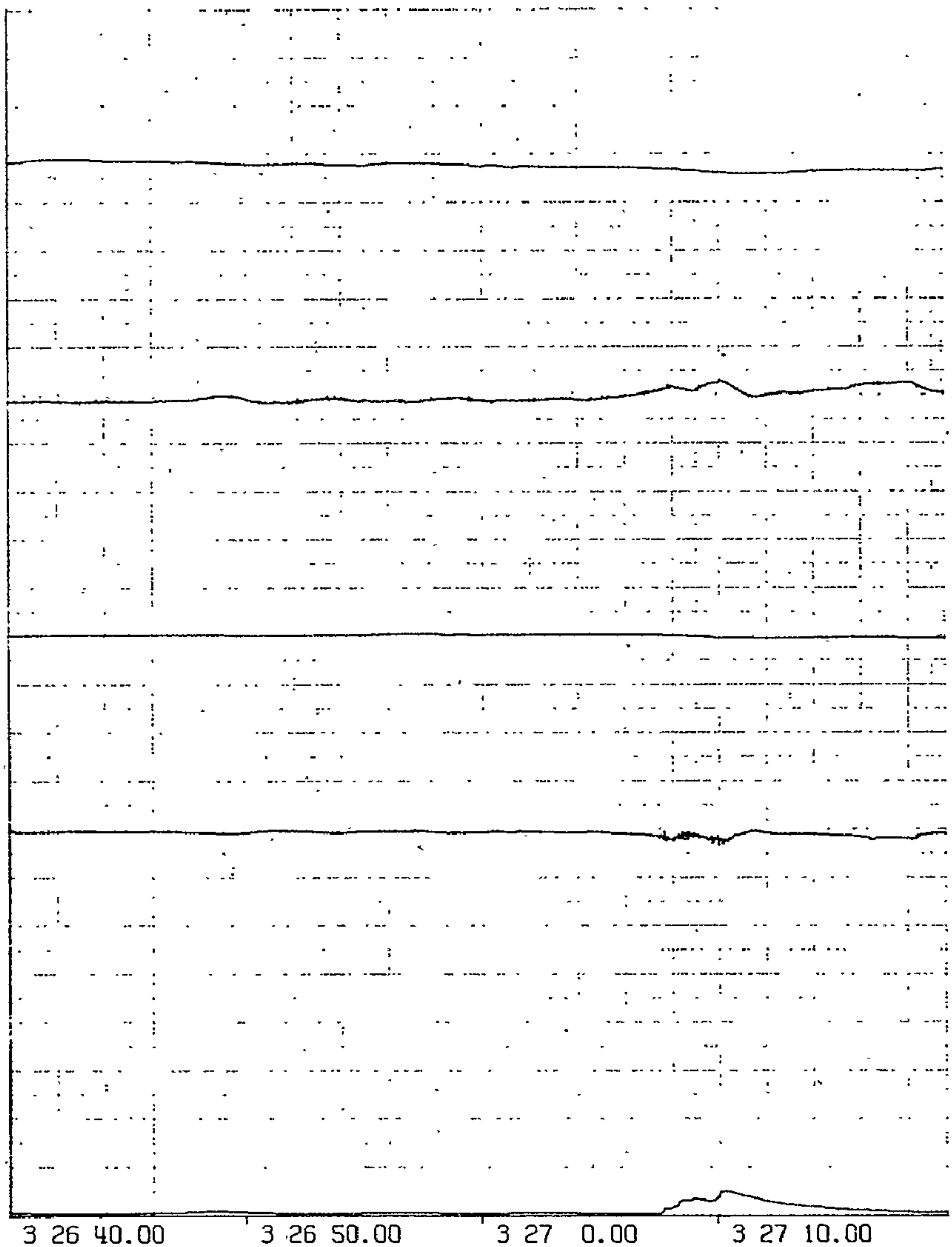


A/P BEECH 0099 DIG COND 6 FLT COND

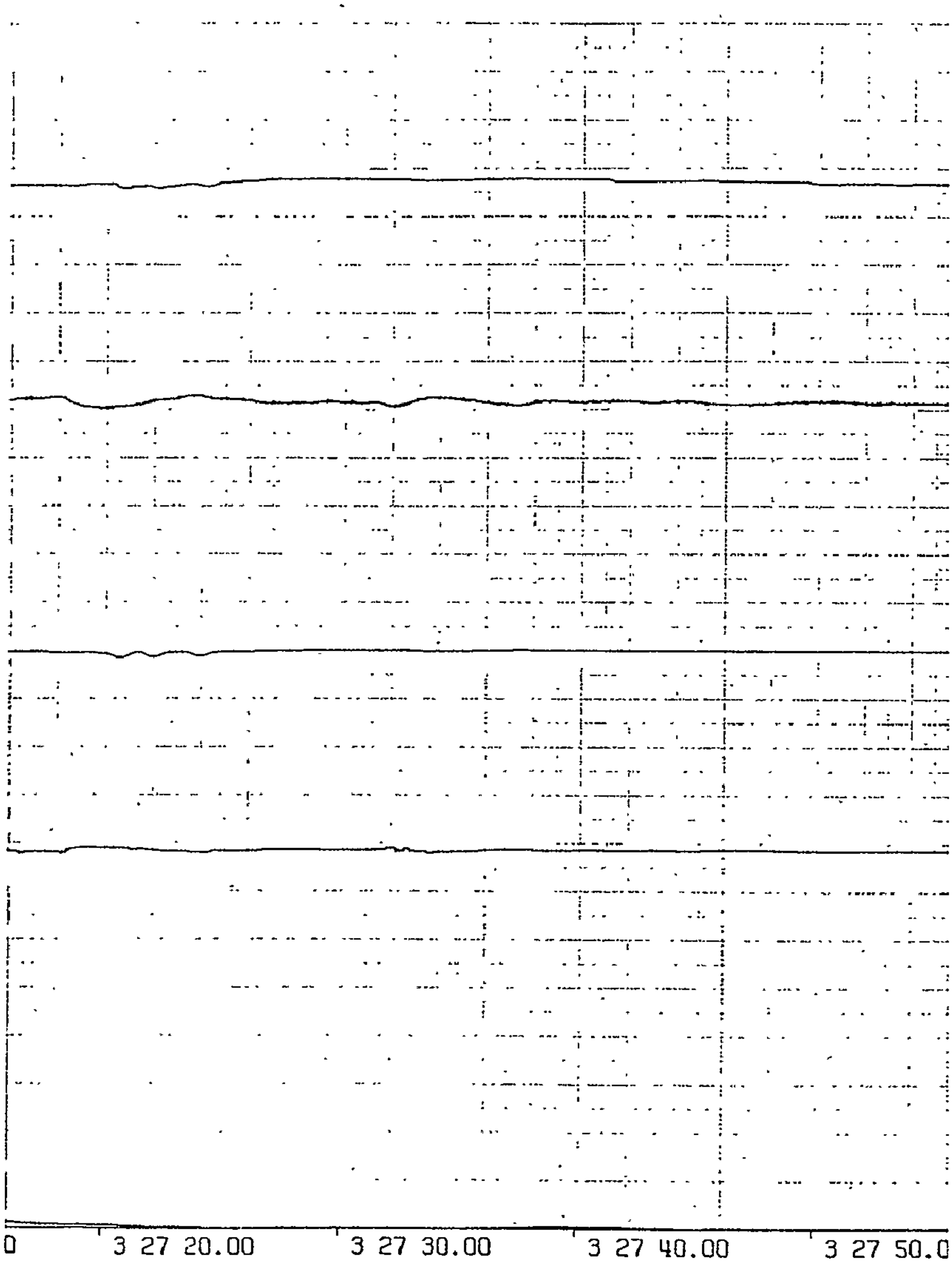
TEST 092-1 RUN NO 124616

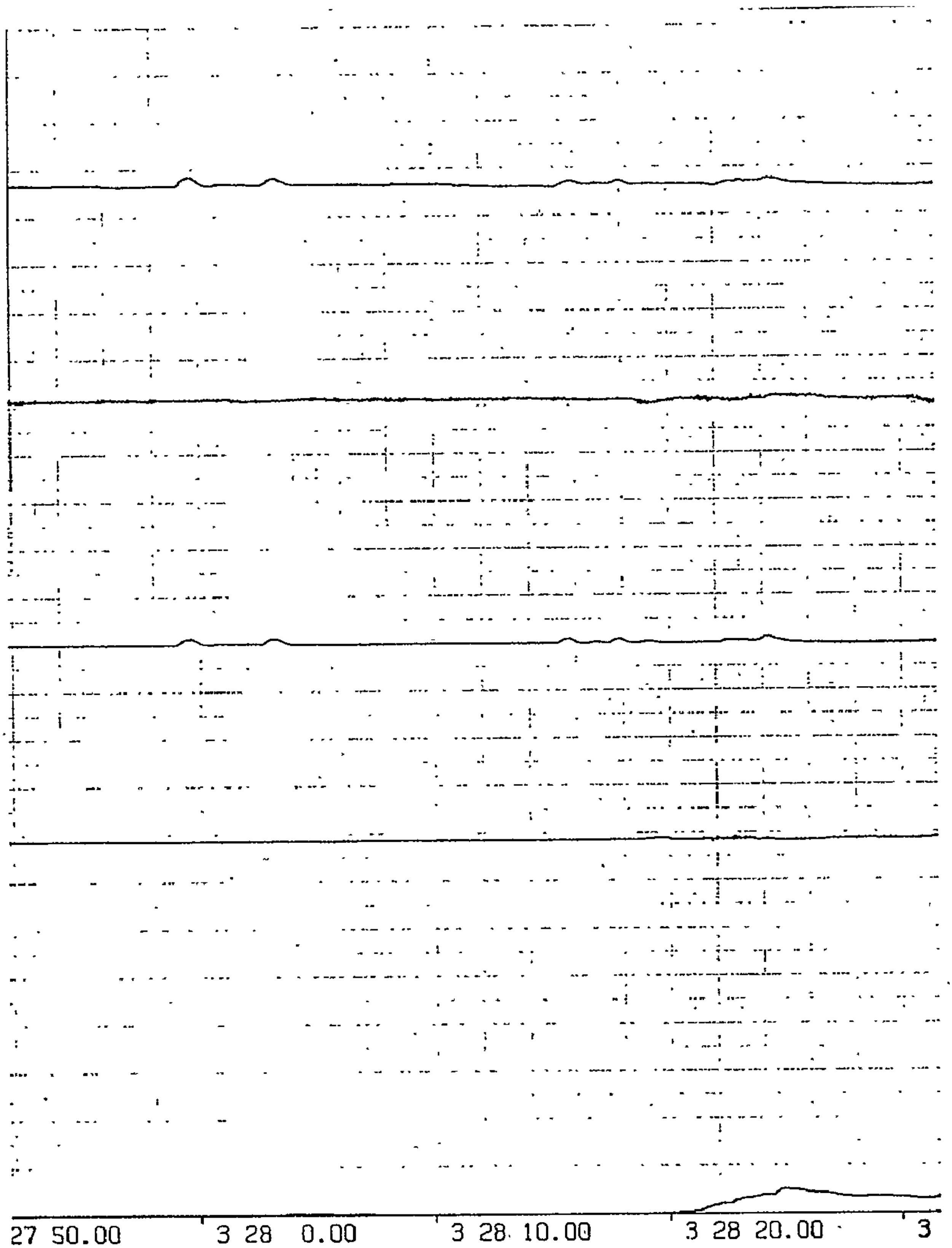
RIDE QUALITIES - VERTICAL 5 PLOT FORMAT CH

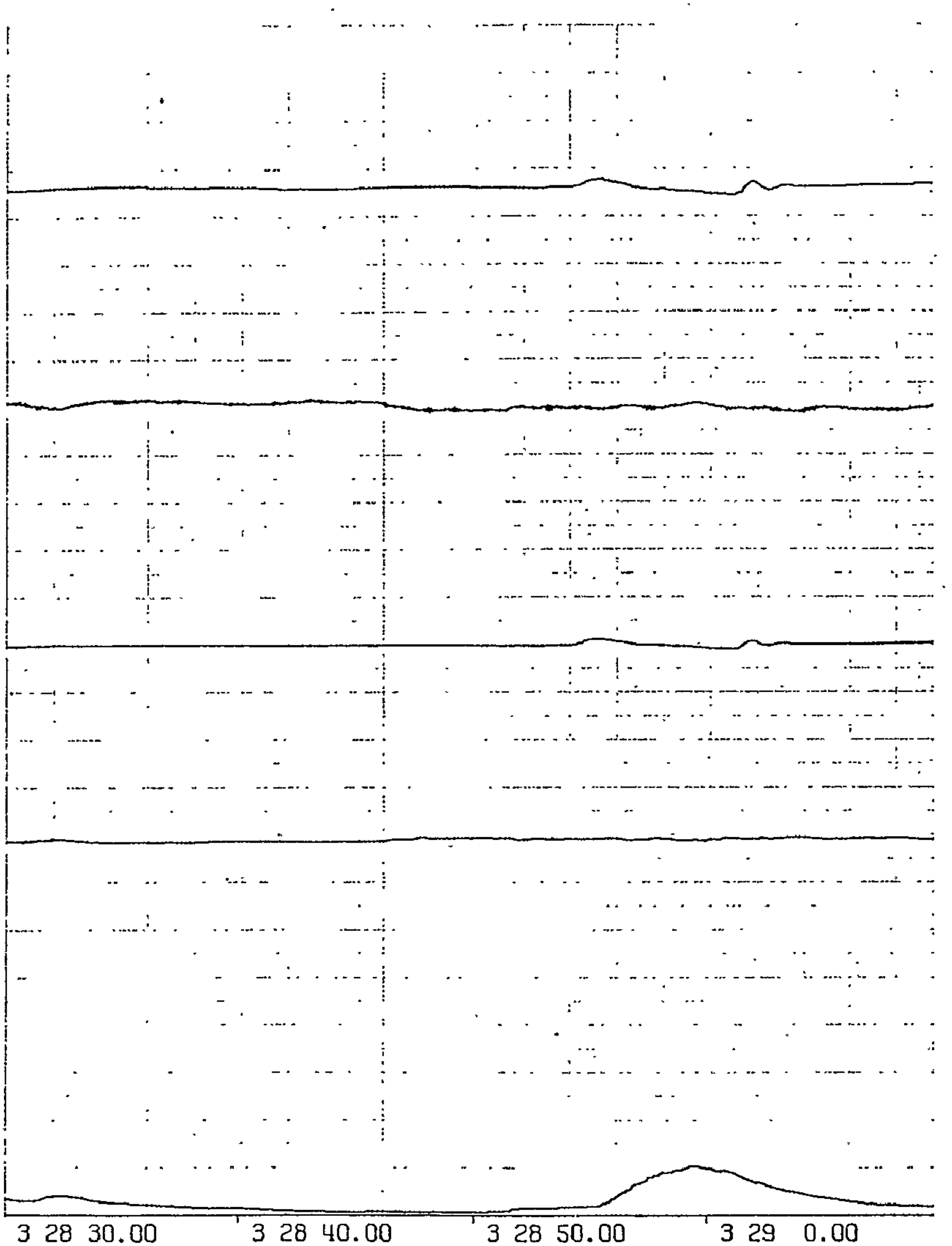

0.00
3 26 10.00
3 26 20.00
3 26 30.00
3 26

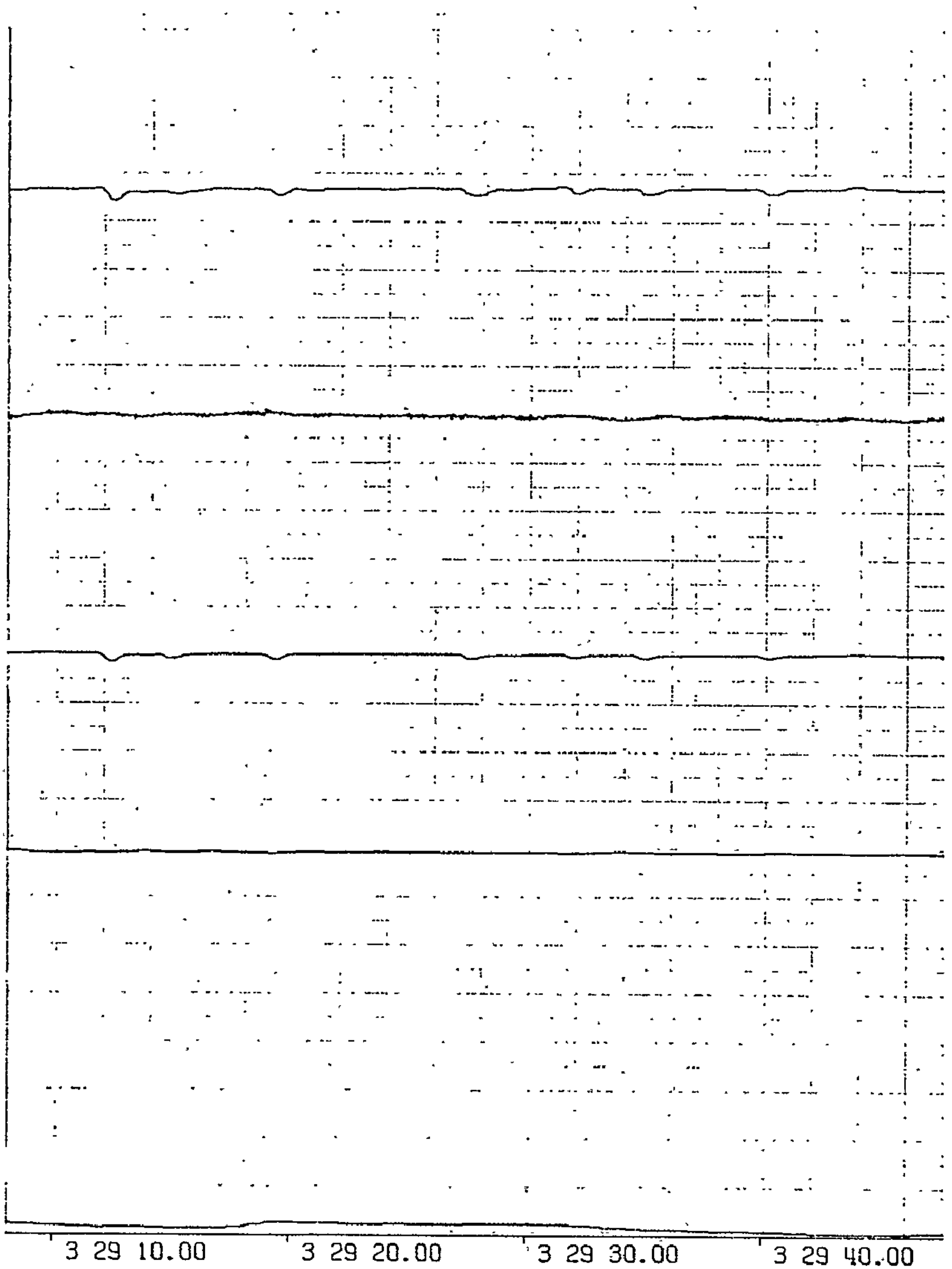


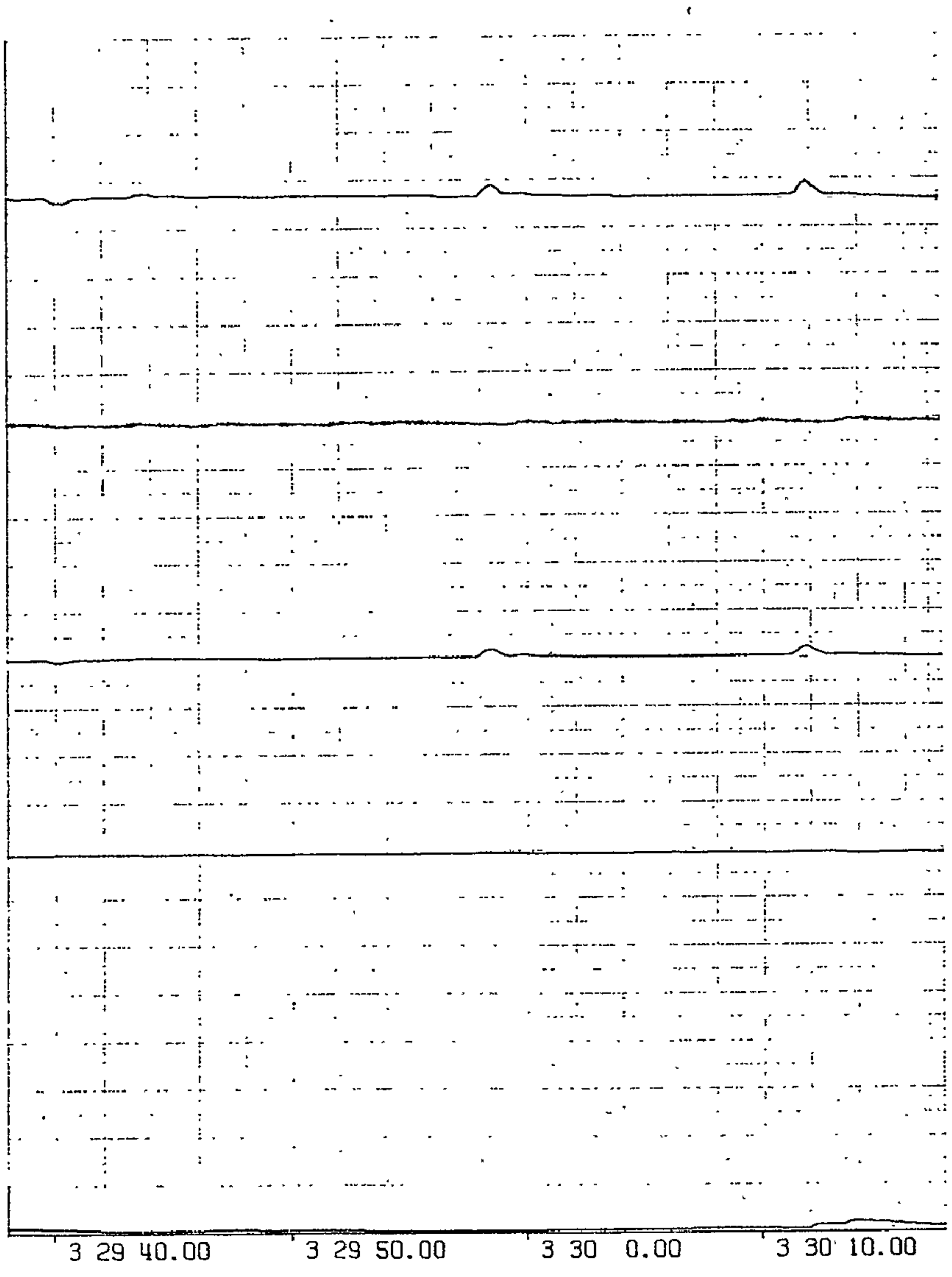
3 26 40.00
3 26 50.00
3 27 0.00
3 27 10.00

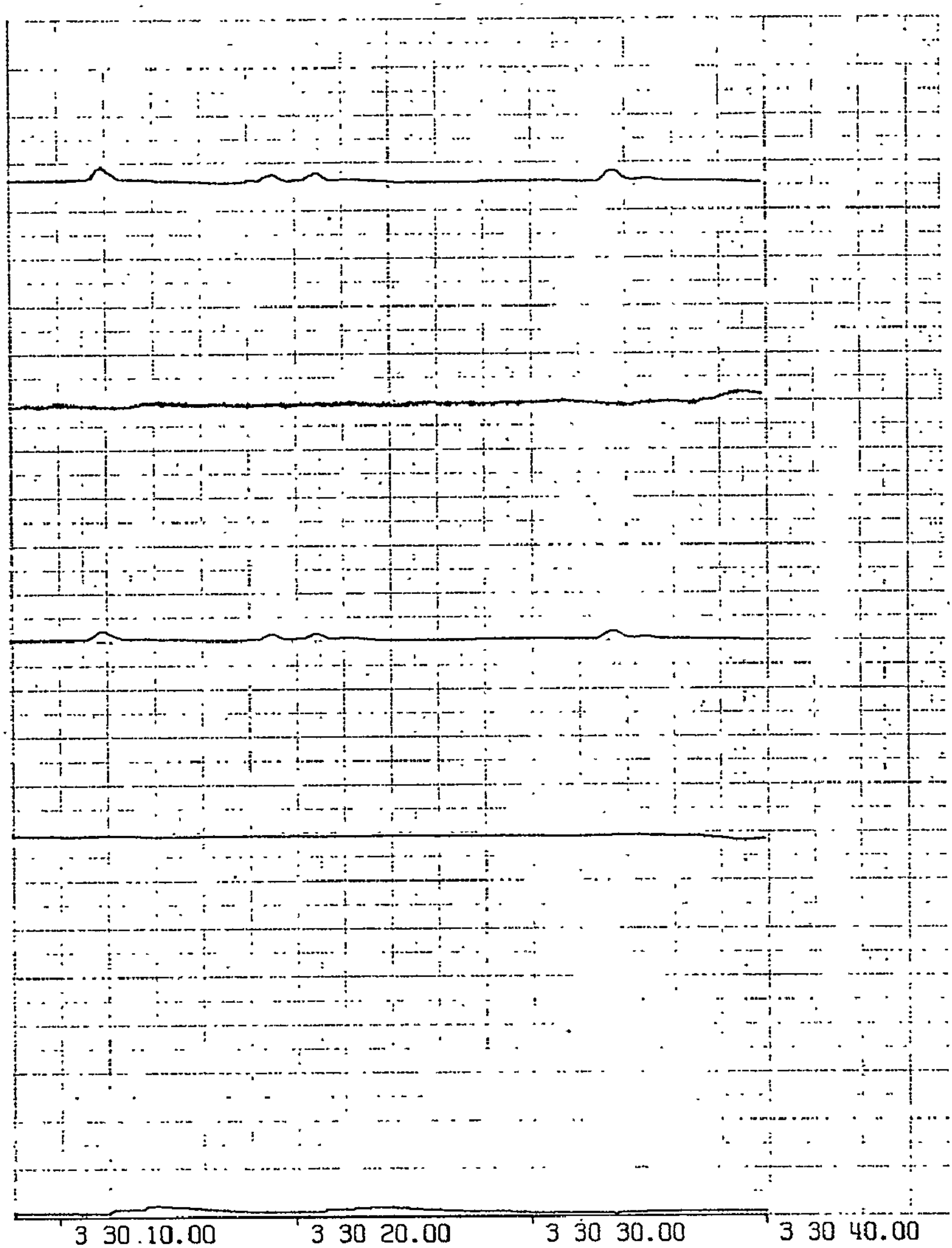

0
3 27 20.00
3 27 30.00
3 27 40.00
3 27 50.0

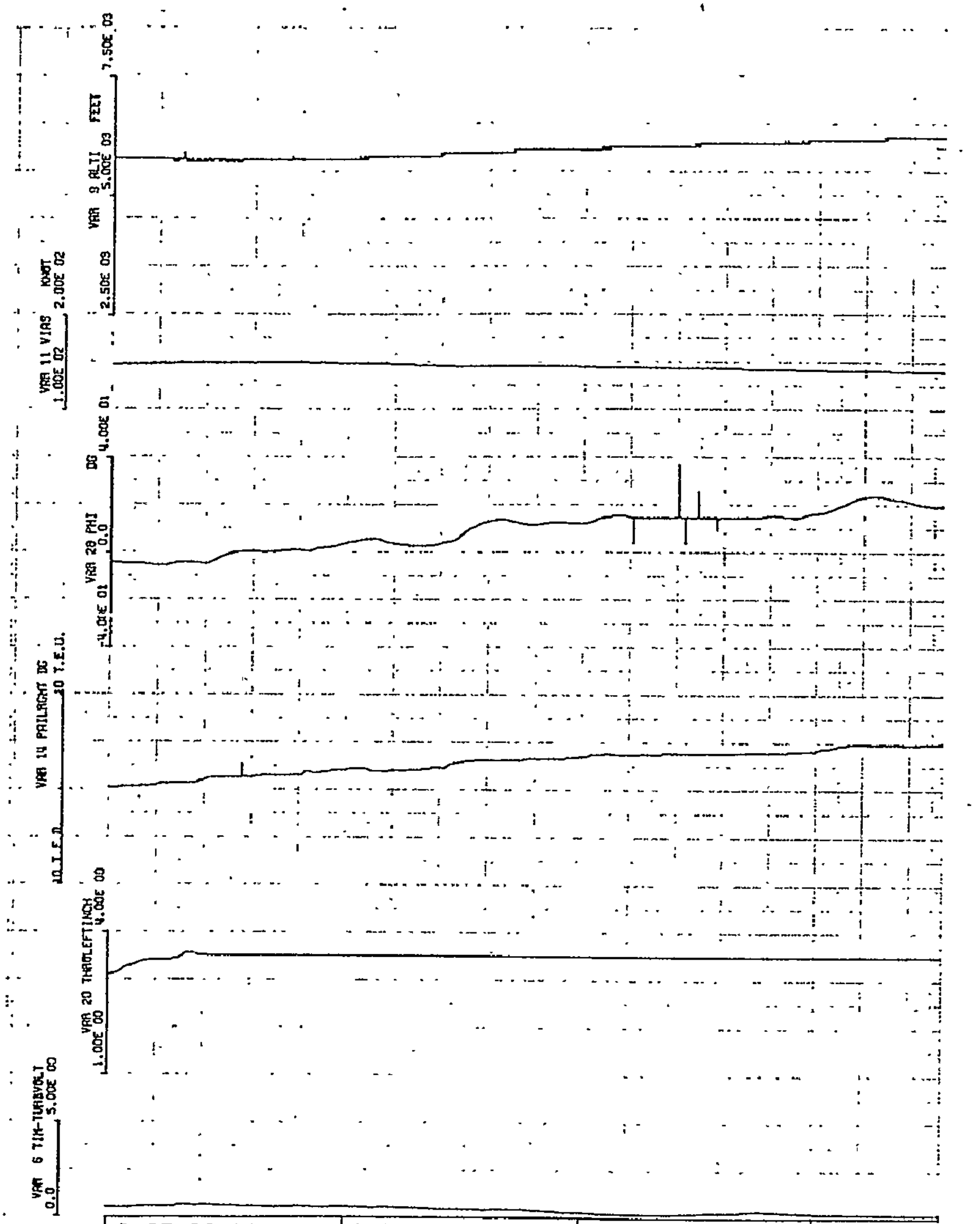

27 50.00
3 28 0.00
3 28 10.00
3 28 20.00
3


3 28 30.00
3 28 40.00
3 28 50.00
3 29 0.00

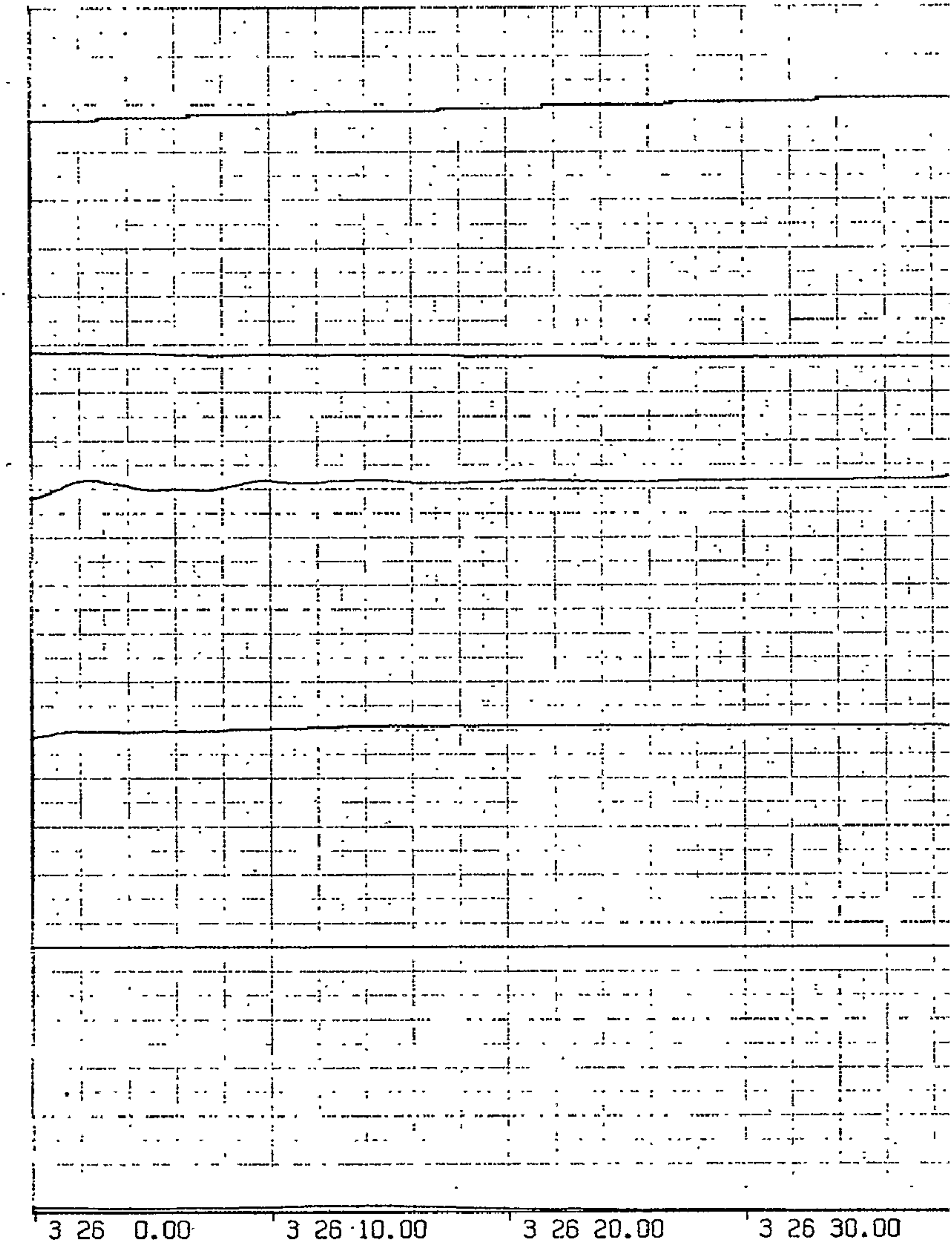

3 29 10.00
3 29 20.00
3 29 30.00
3 29 40.00

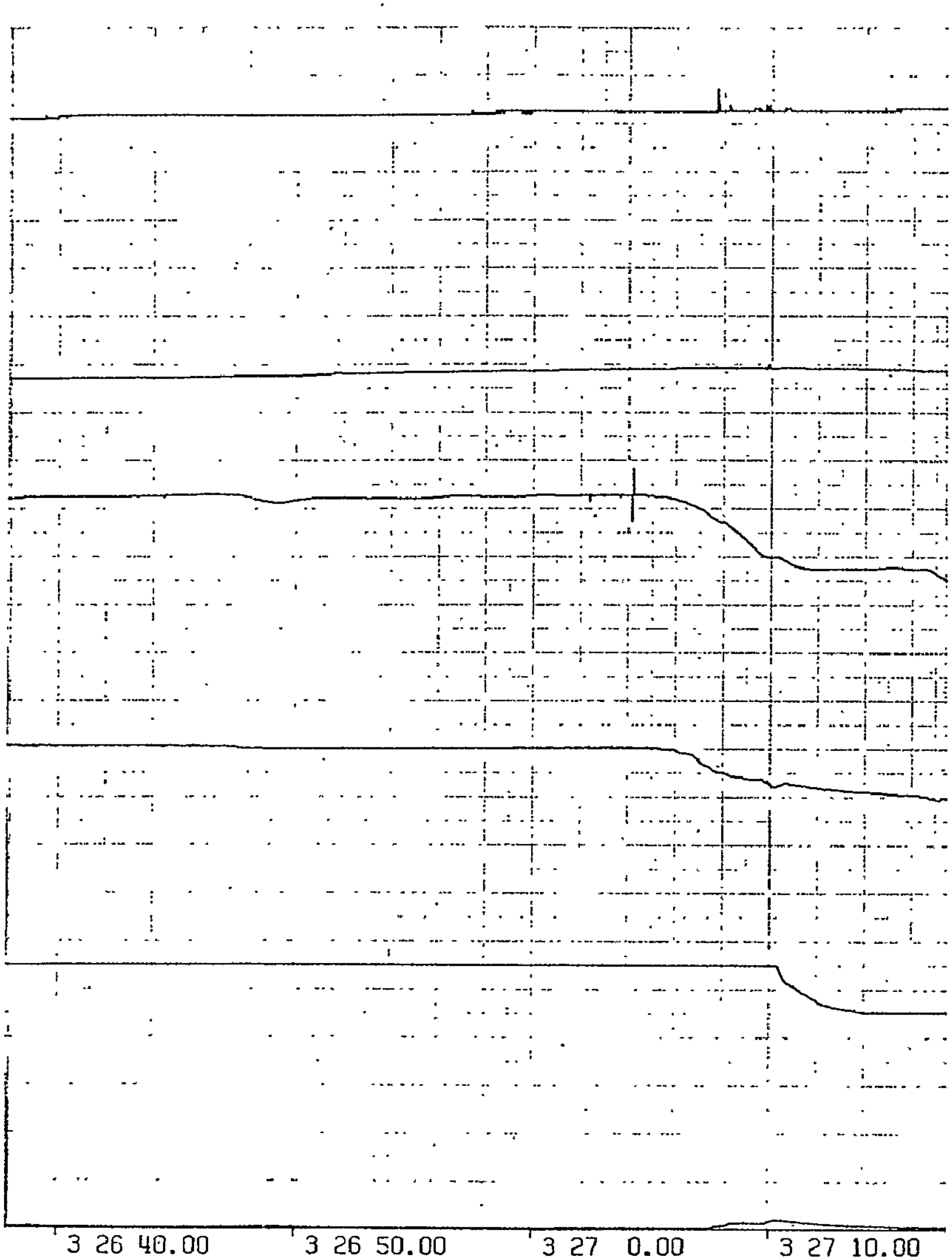

3 29 40.00
3 29 50.00
3 30 0.00
3 30 10.00

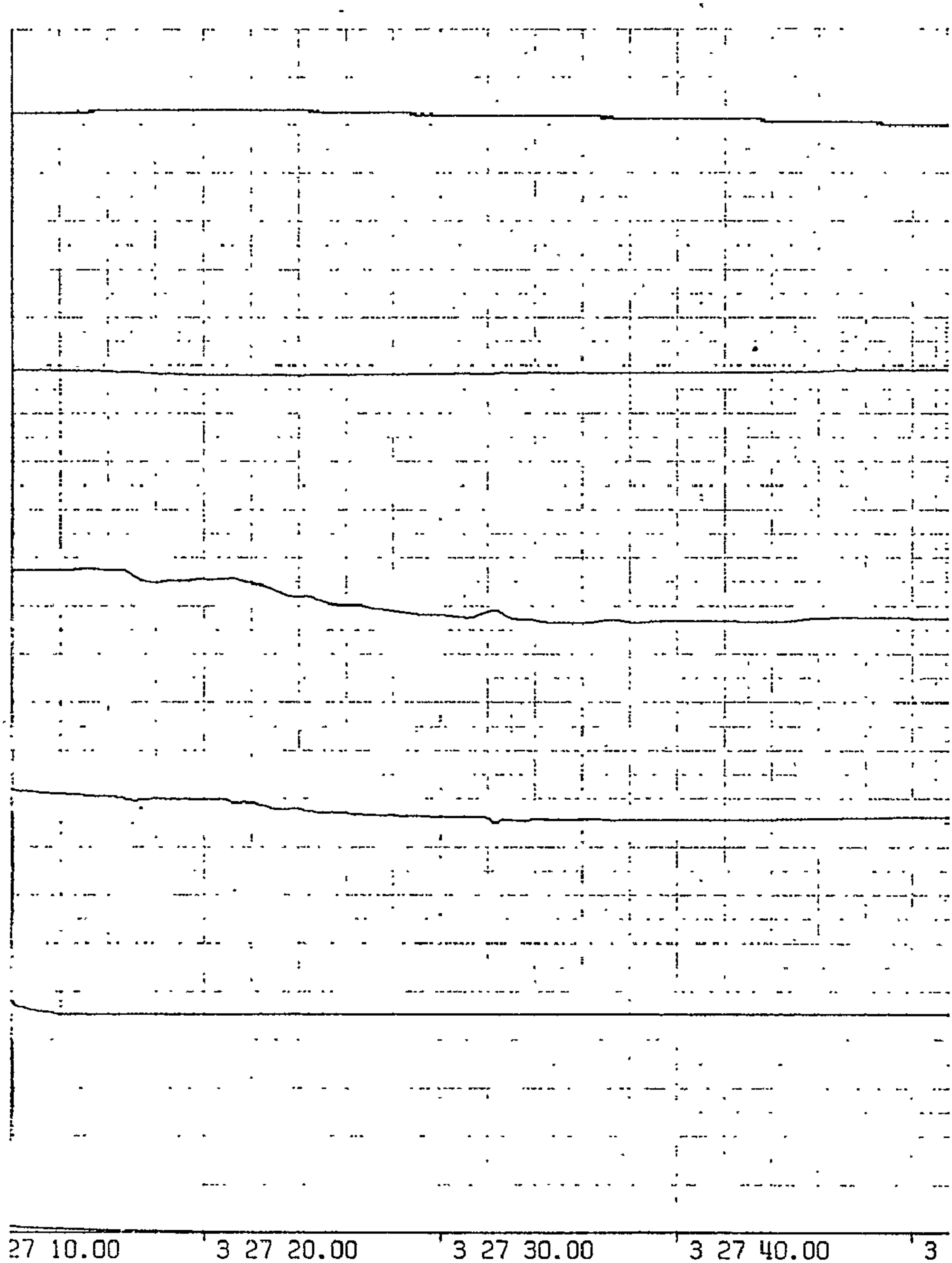

3 30.10.00
3 30 20.00
3 30 30.00
3 30 40.00

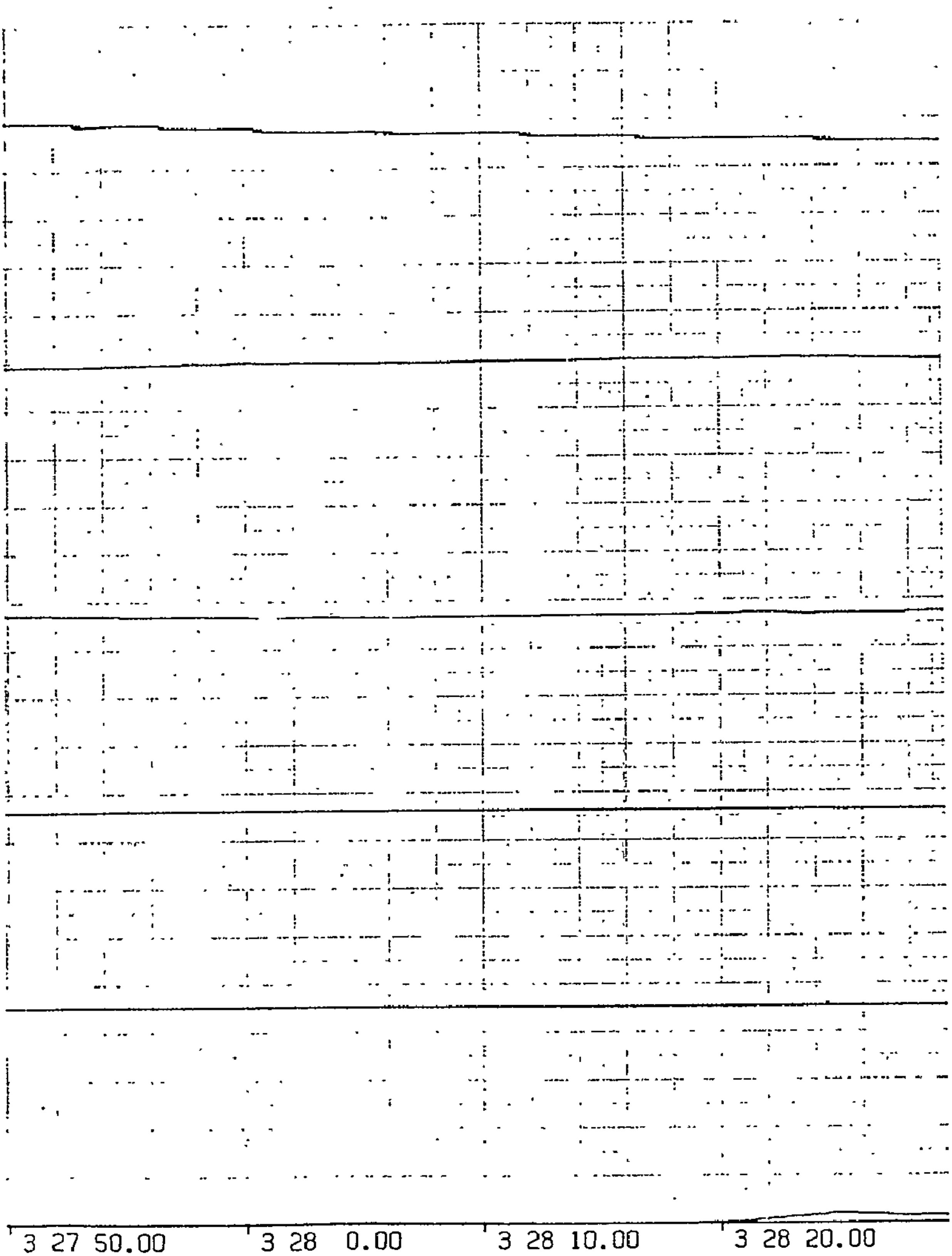


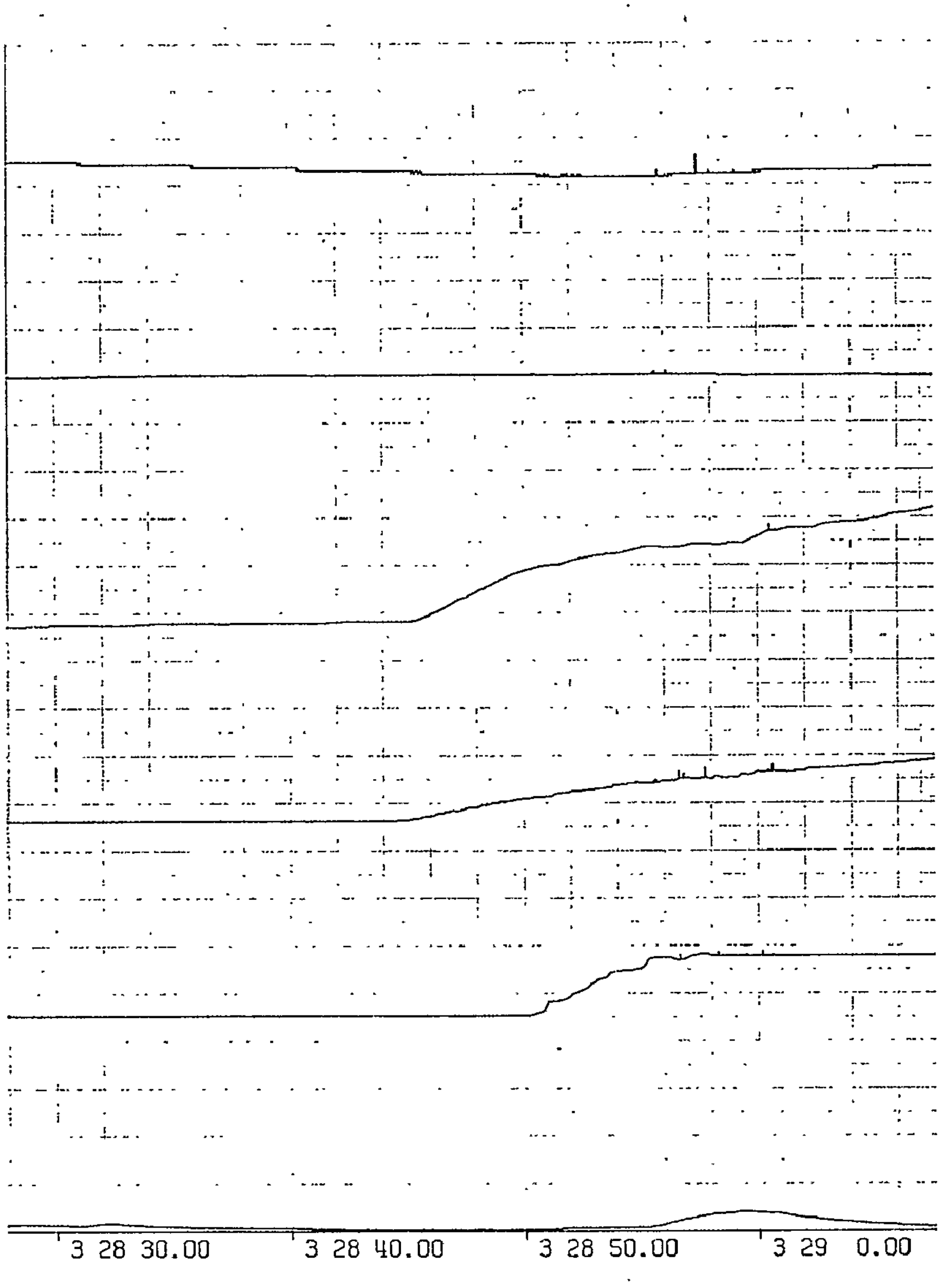

A/P BEECH 0099 DIG COND 6 FLT COND
TEST 092-1 RUN NO 106603
VERTICAL 5 - LATERAL PLOT FORMAT 05


3 26 0.00
3 26 10.00
3 26 20.00
3 26 30.00


3 26 40.00
3 26 50.00
3 27 0.00
3 27 10.00


27 10.00
3 27 20.00
3 27 30.00
3 27 40.00
3


3 27 50.00
3 28 0.00
3 28 10.00
3 28 20.00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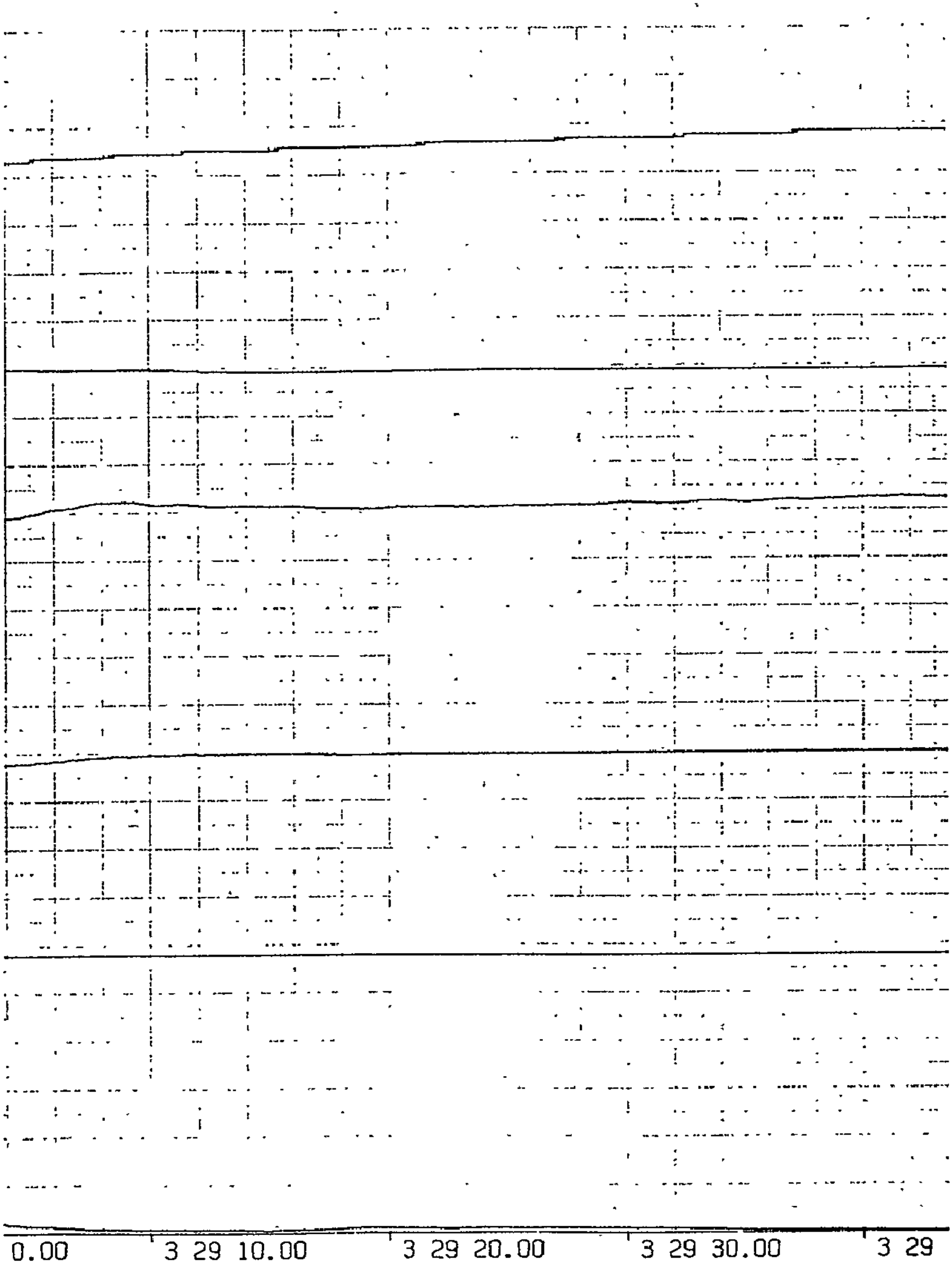
3 28 50.00
3 29 0.00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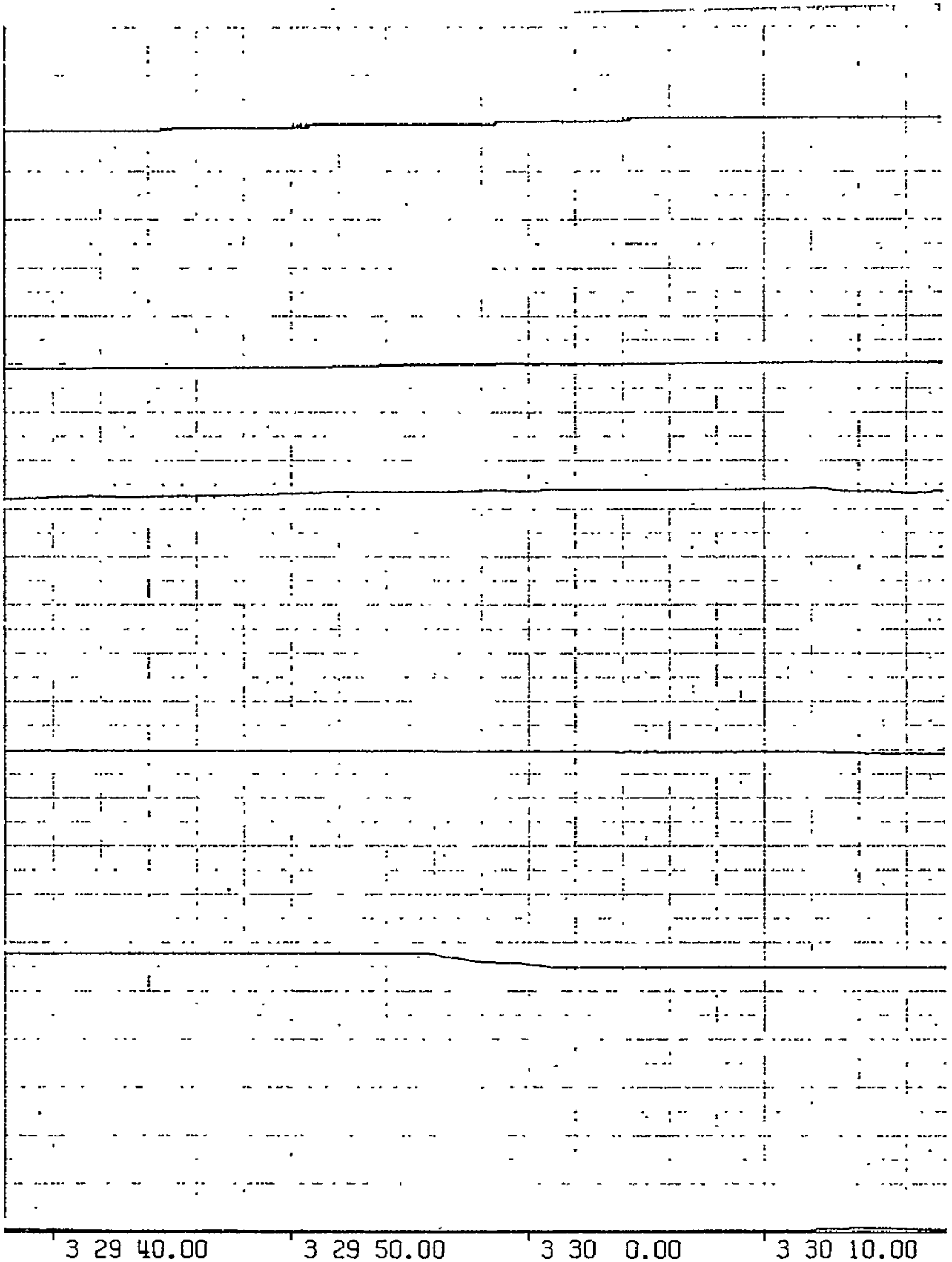
3 29 20.00
3 29 30.00
3 29


3 29 40.00
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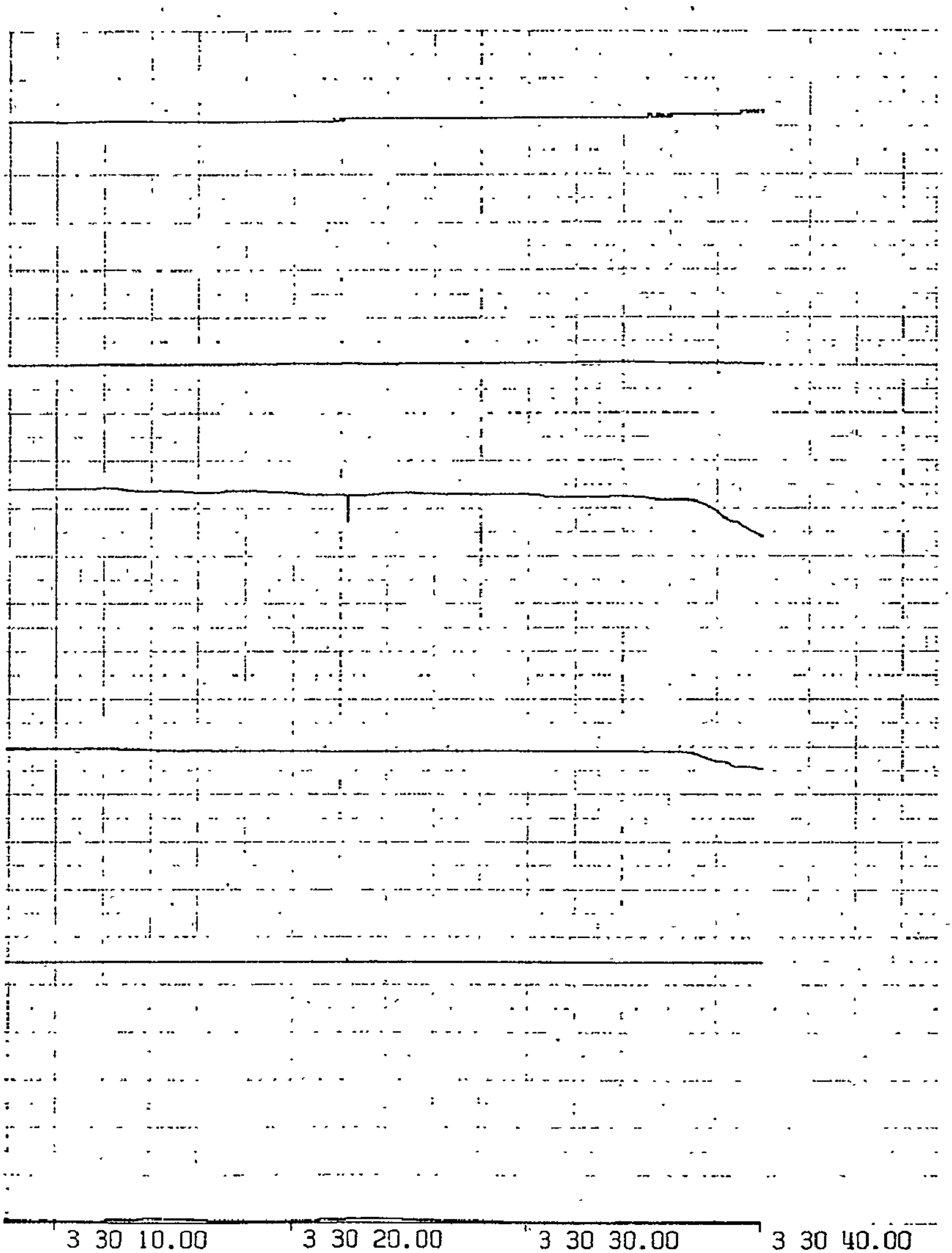
3 30 0.00
3 30 10.00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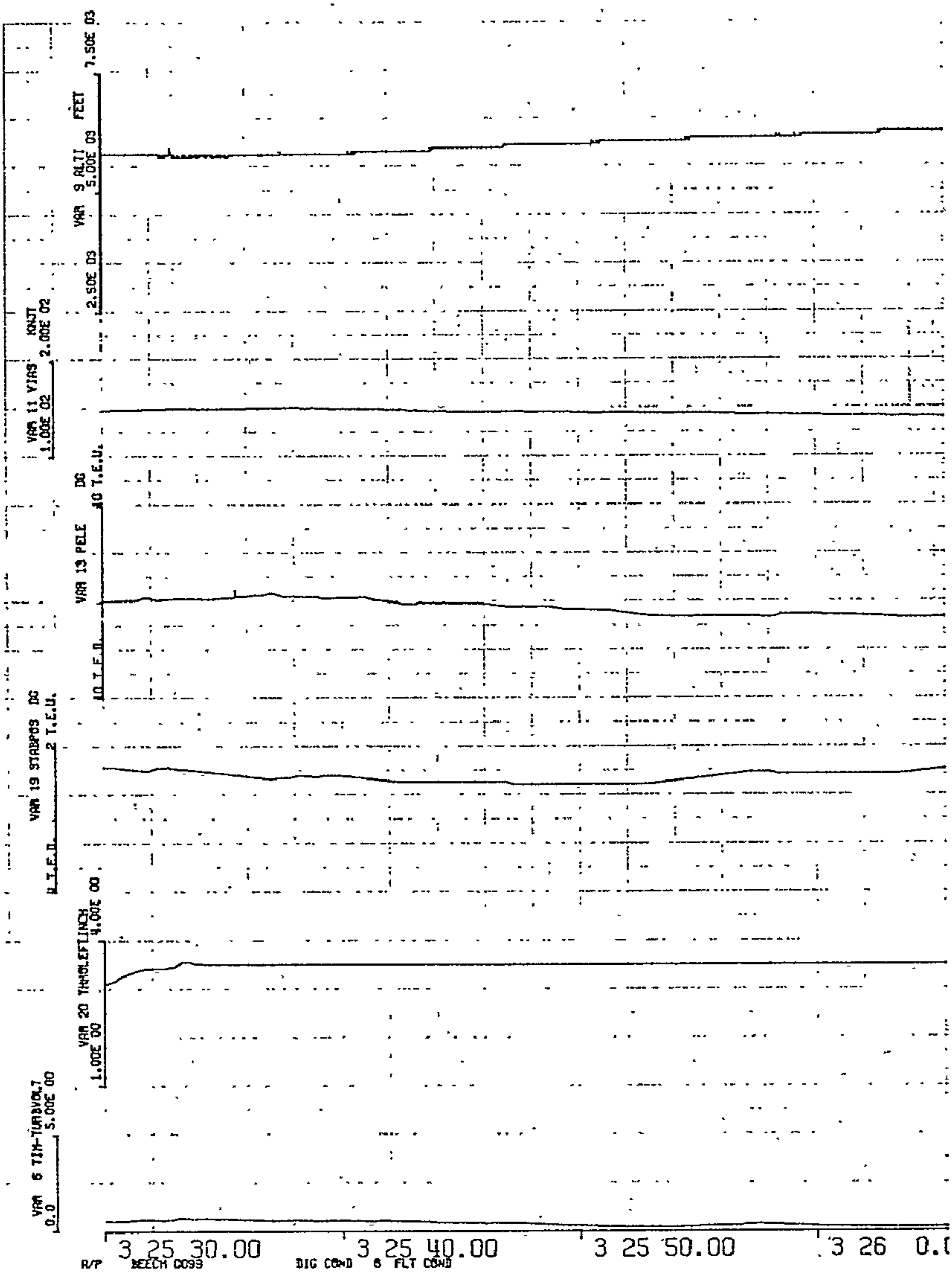
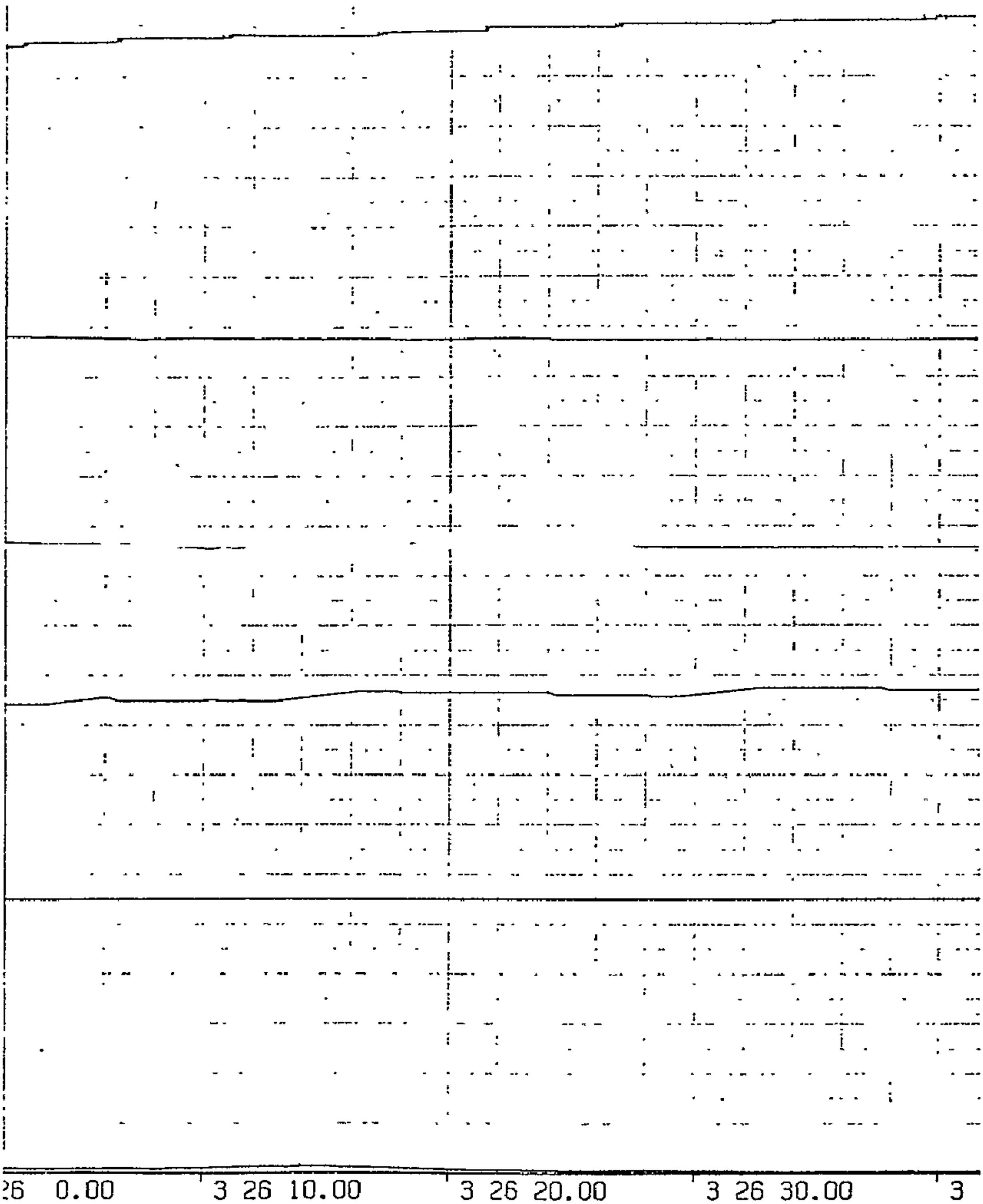
3 30 30.00
3 30 40.00

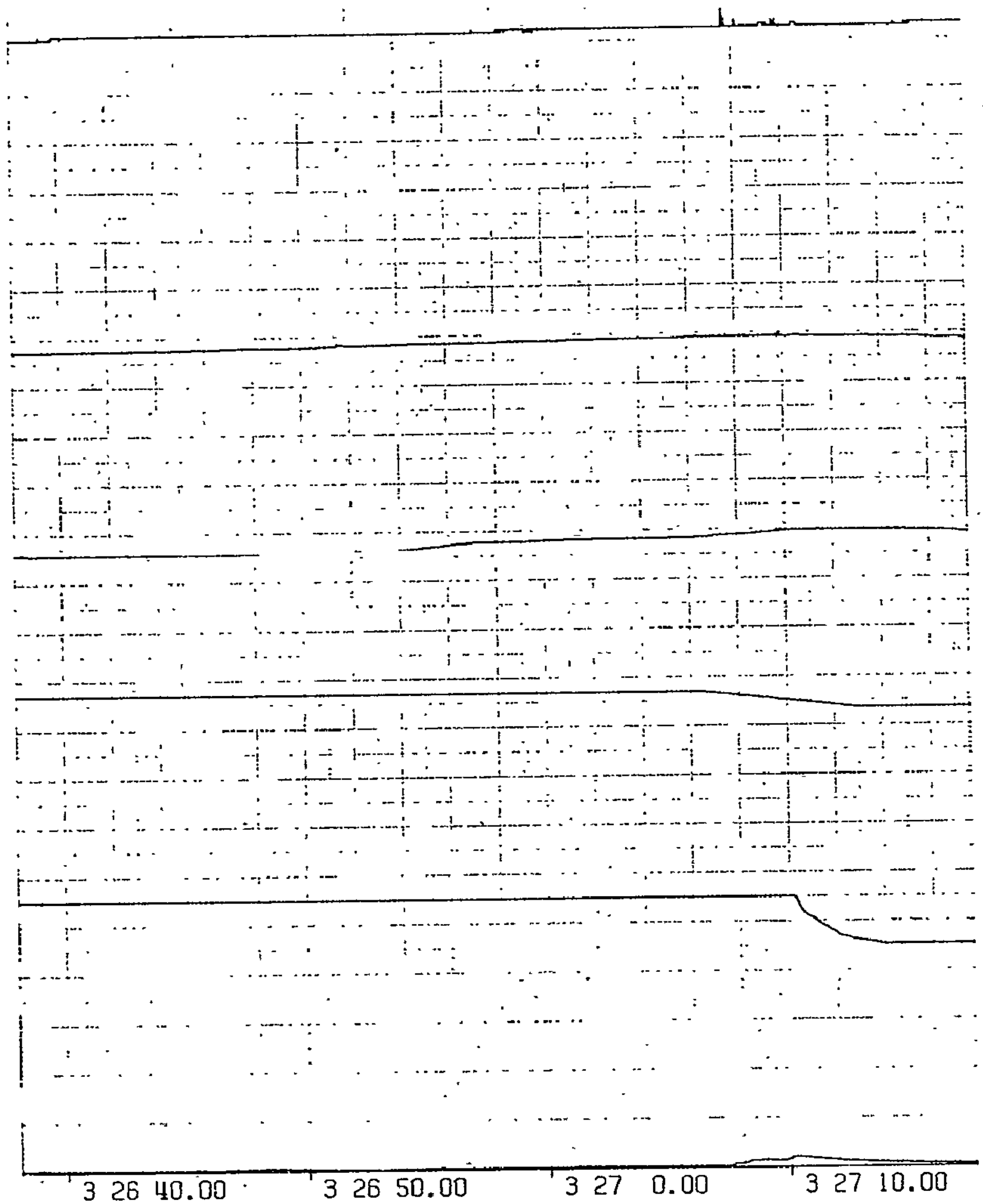


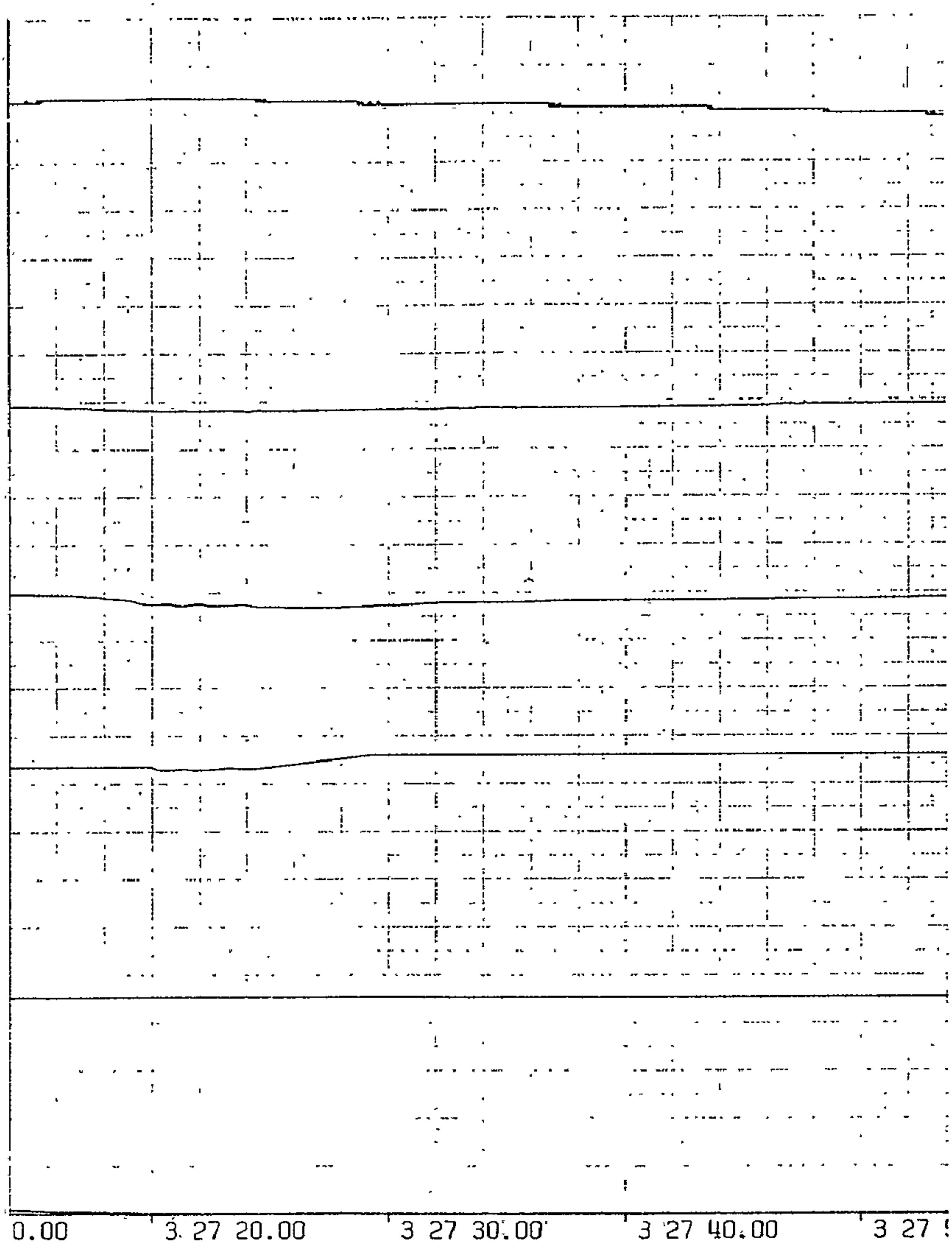

R/P BEECH C093 DIG COND 8 FLT COND

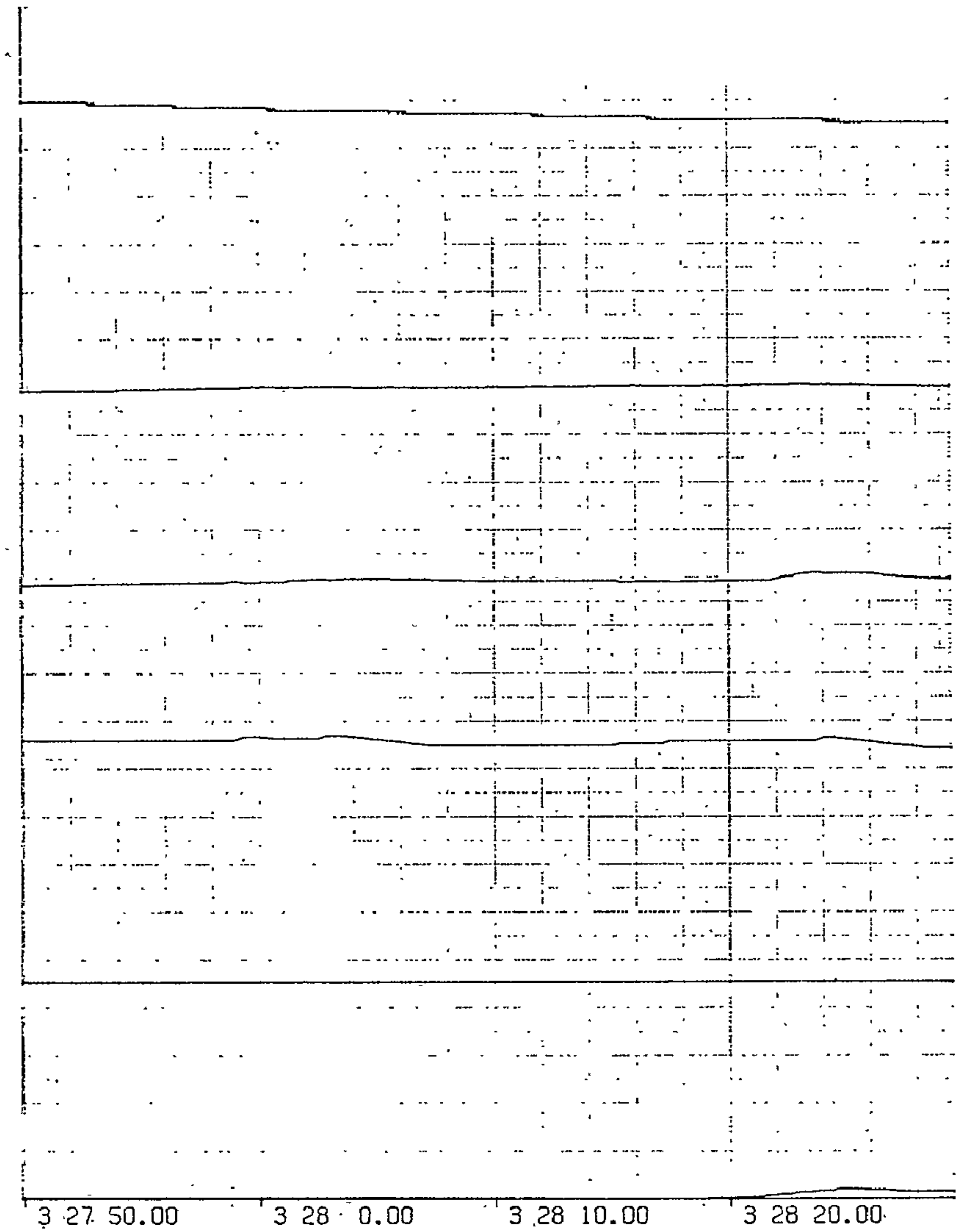
TEST 092-1 RUN NO 106803

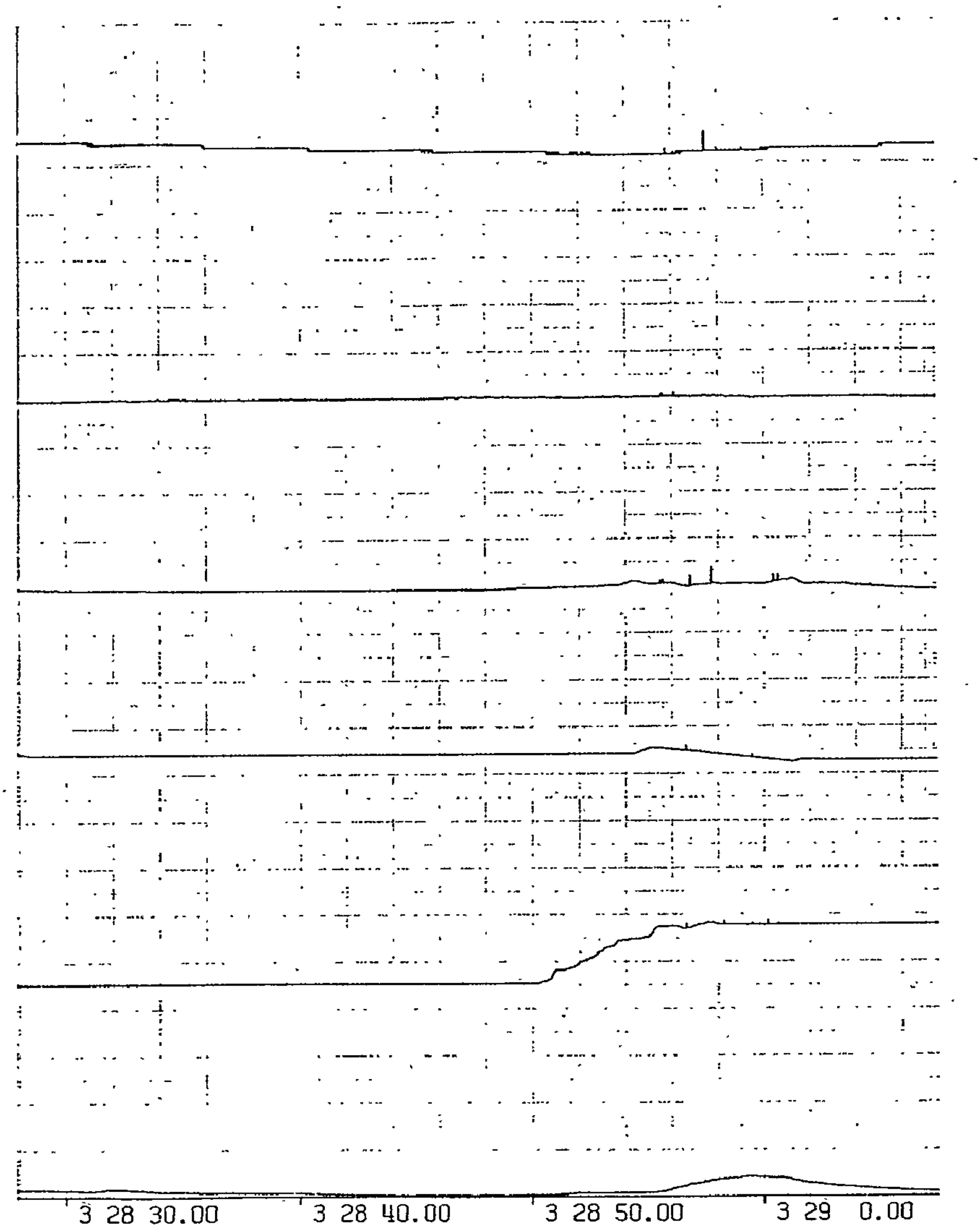
VERTICAL 5 - LONGITUDINAL PLOT FORMAT 06

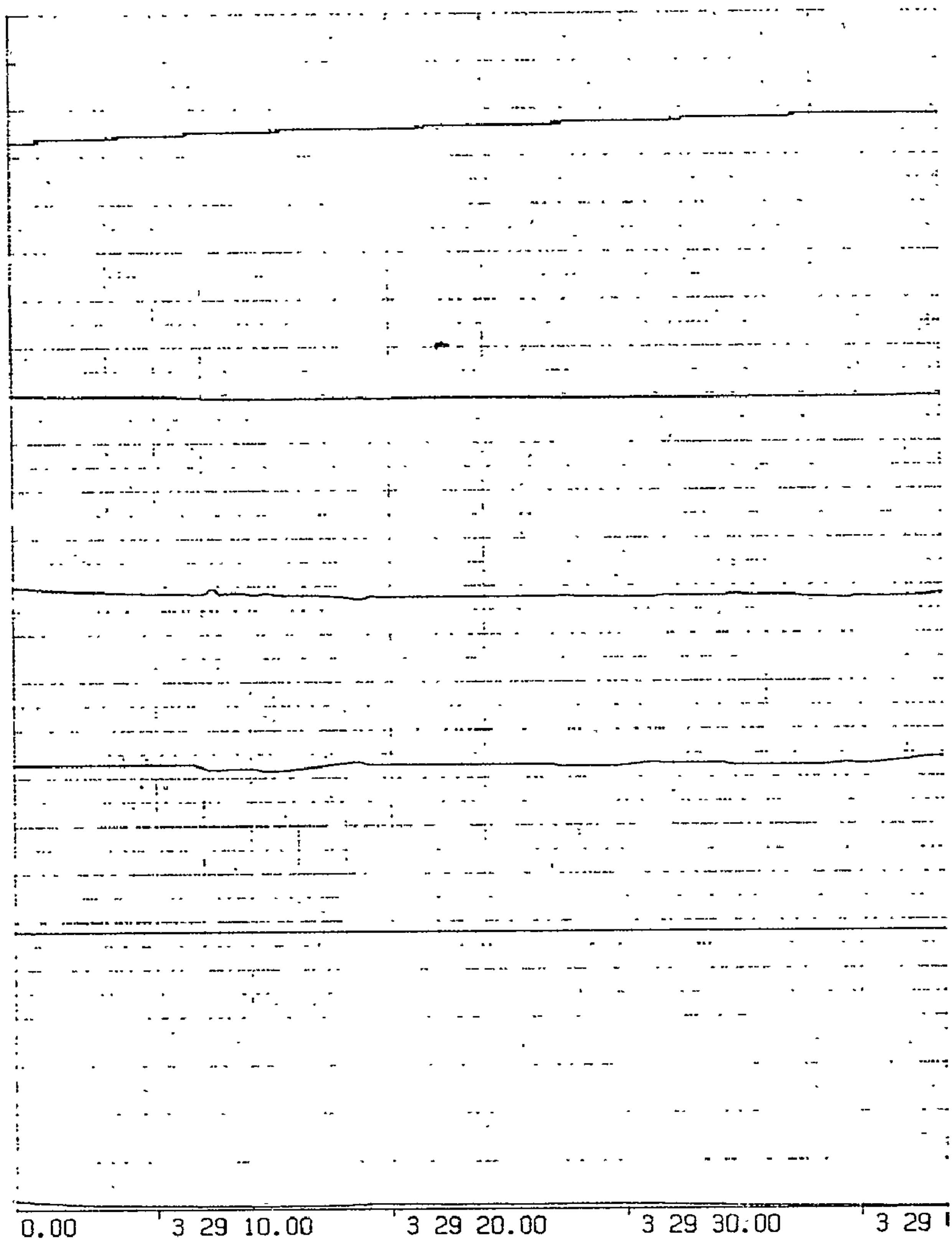

26 0.00
3 26 10.00
3 26 20.00
3 26 30.00
3

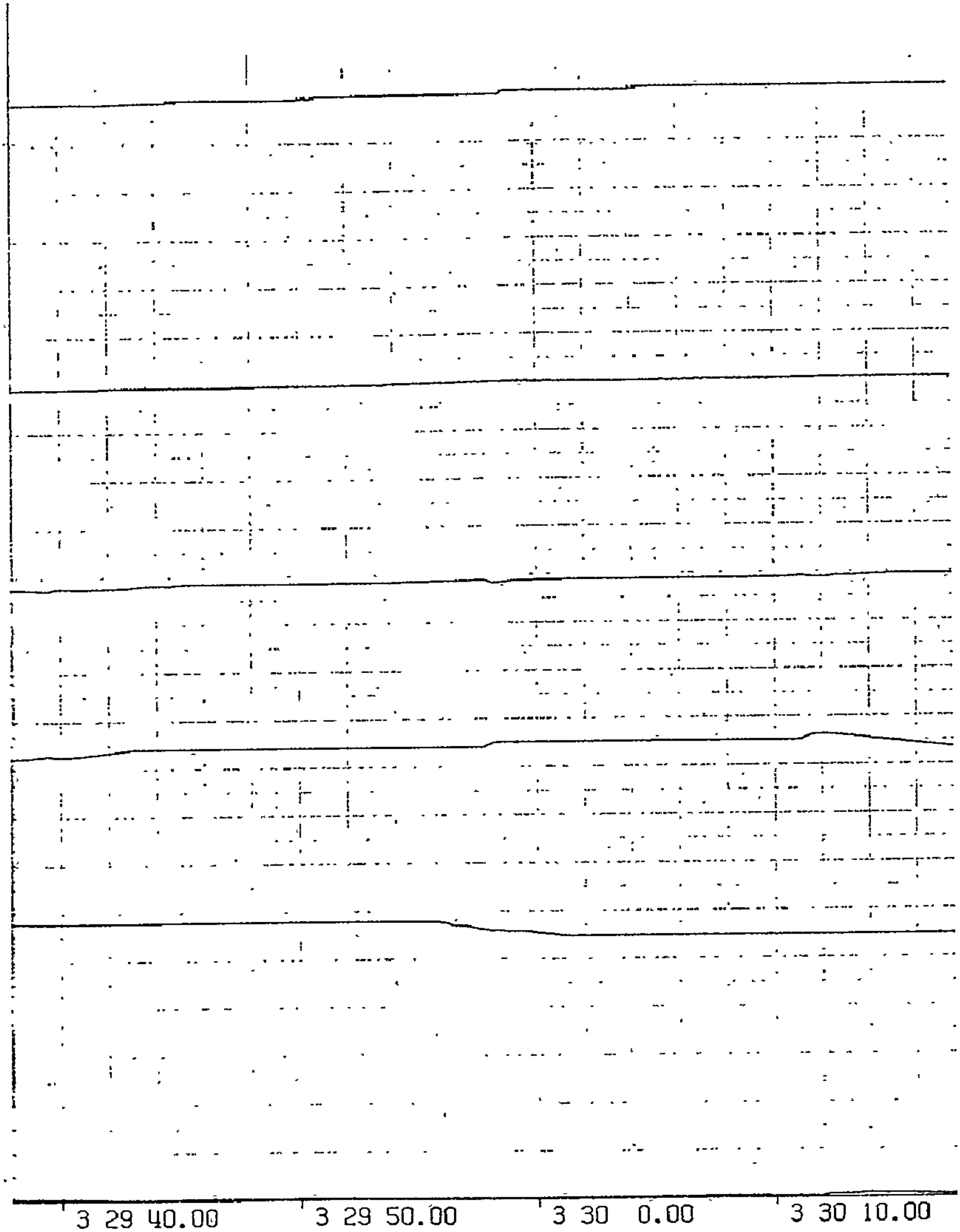

3 26 40.00
3 26 50.00
3 27 0.00
3 27 10.00


0.00
3 27 20.00
3 27 30.00
3 27 40.00
3 27 !

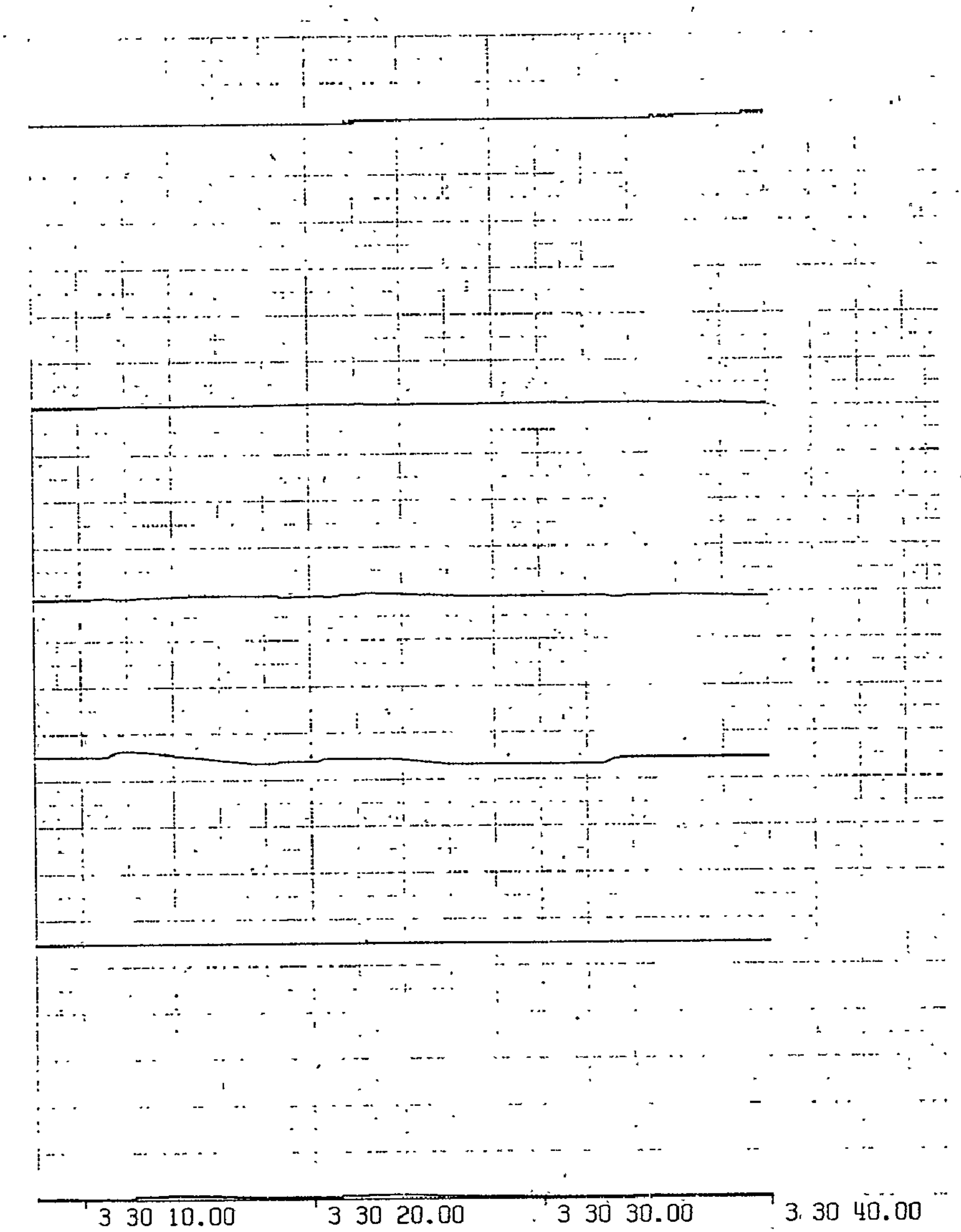

3 27 50.00
3 28 0.00
3 28 10.00
3 28 20.00

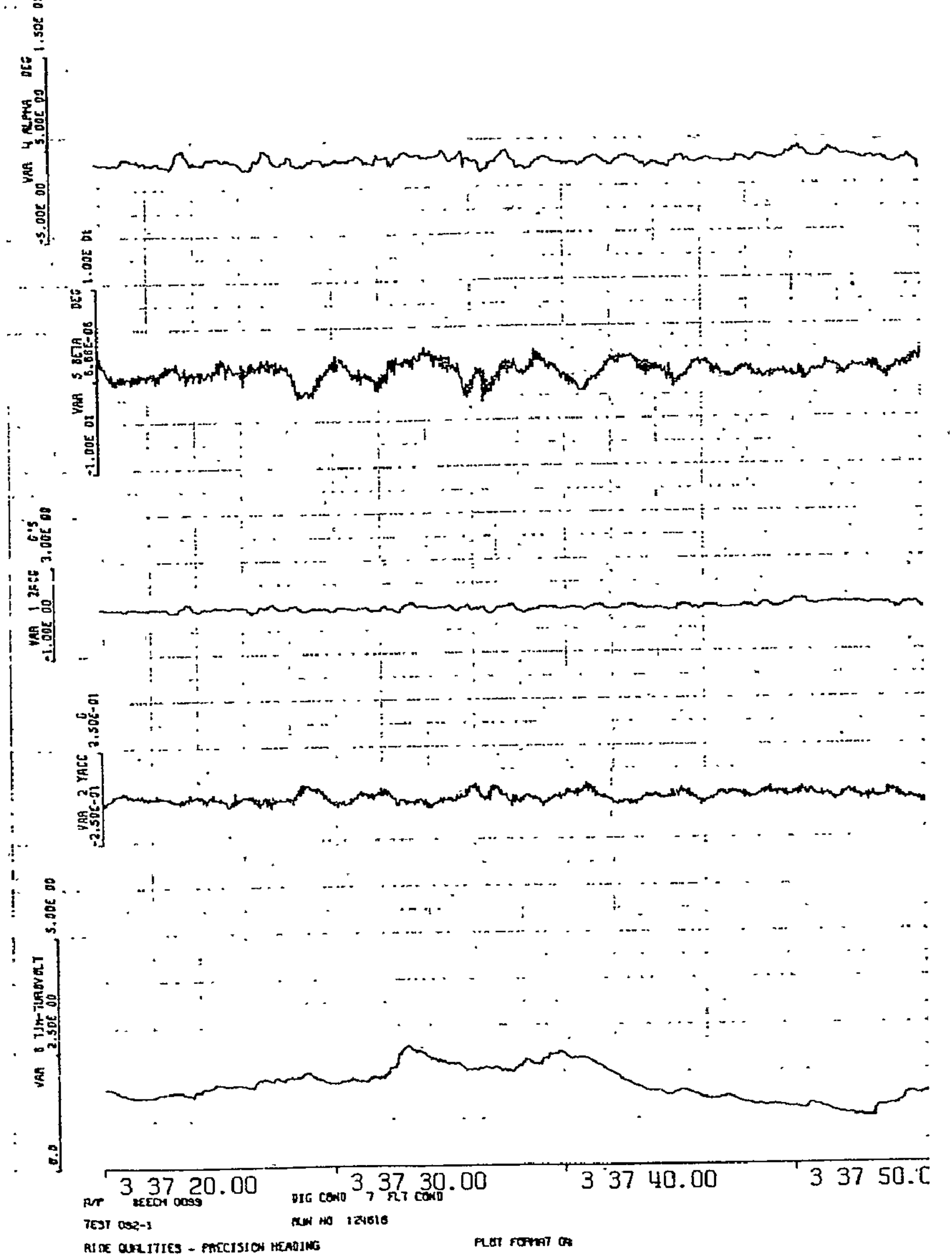

3 28 30.00
3 28 40.00
3 28 50.00
3 29 0.00

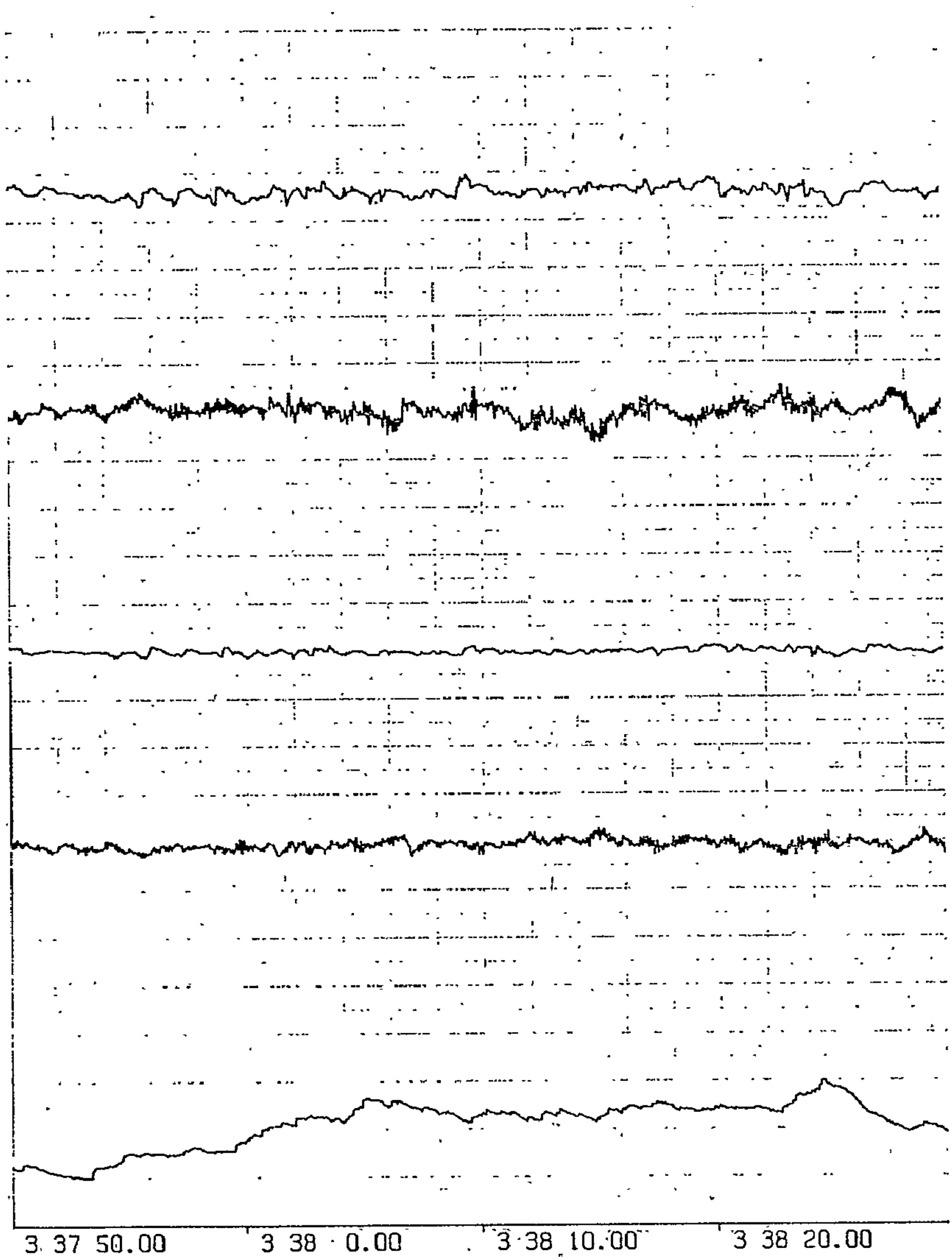

0.00
3 29 10.00
3 29 20.00
3 29 30.00
3 29

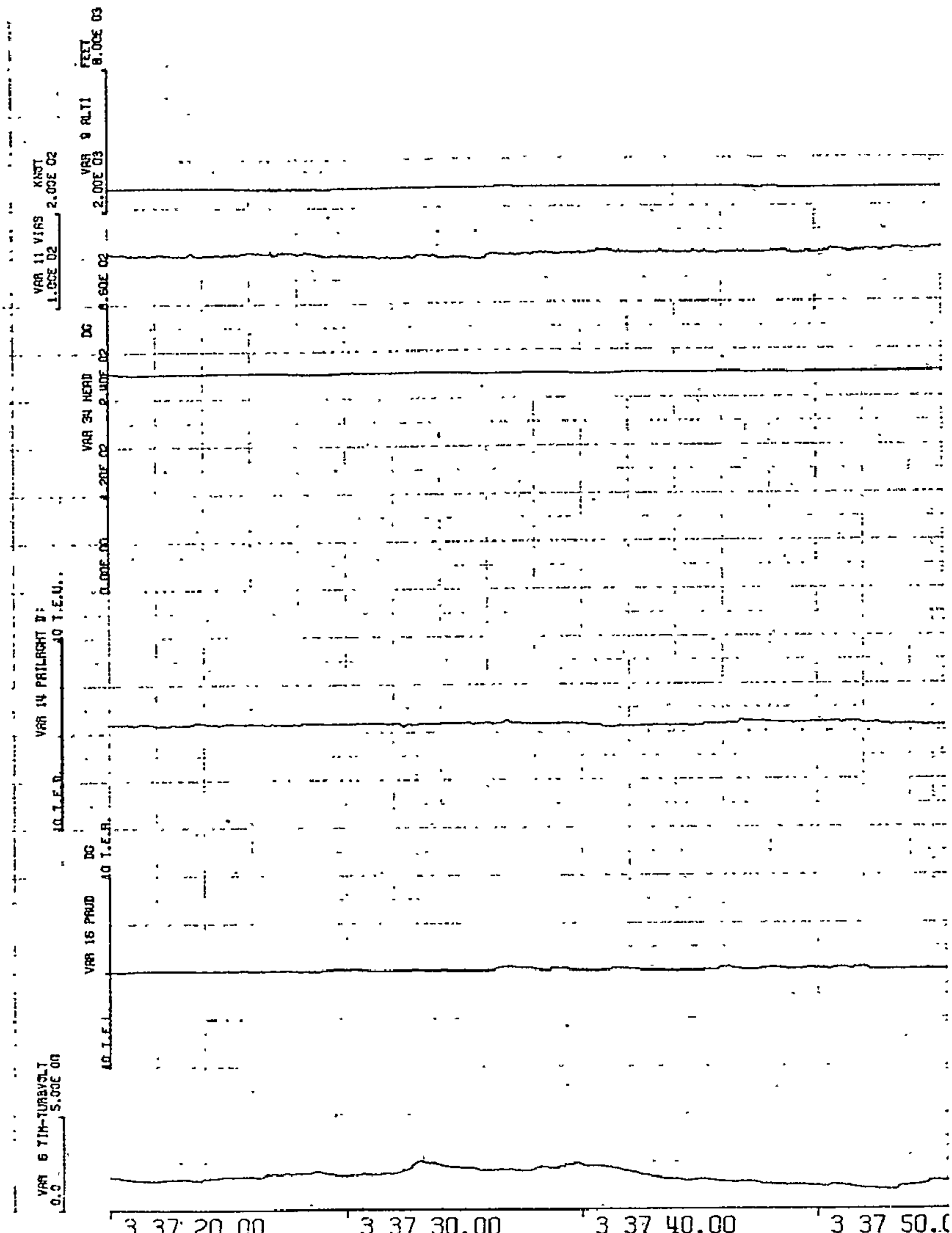



C-4
280


3 30 10.00
3 30 20.00
3 30 30.00
3 30 40.00


VAR 4 ALPHA DEG
VAR 5 BETA DEG
VAR 1 ZACC G'S
VAR 2 YACC G
3 37 20.00
3 37 30.00
3 37 40.00
A/P BEECH 0099
DIG COND 7 FLT COND
TEST 092-1
RUN NO 124616
RIDE QUALITIES - PRECISION HEADING
PLOT FORMAT 06

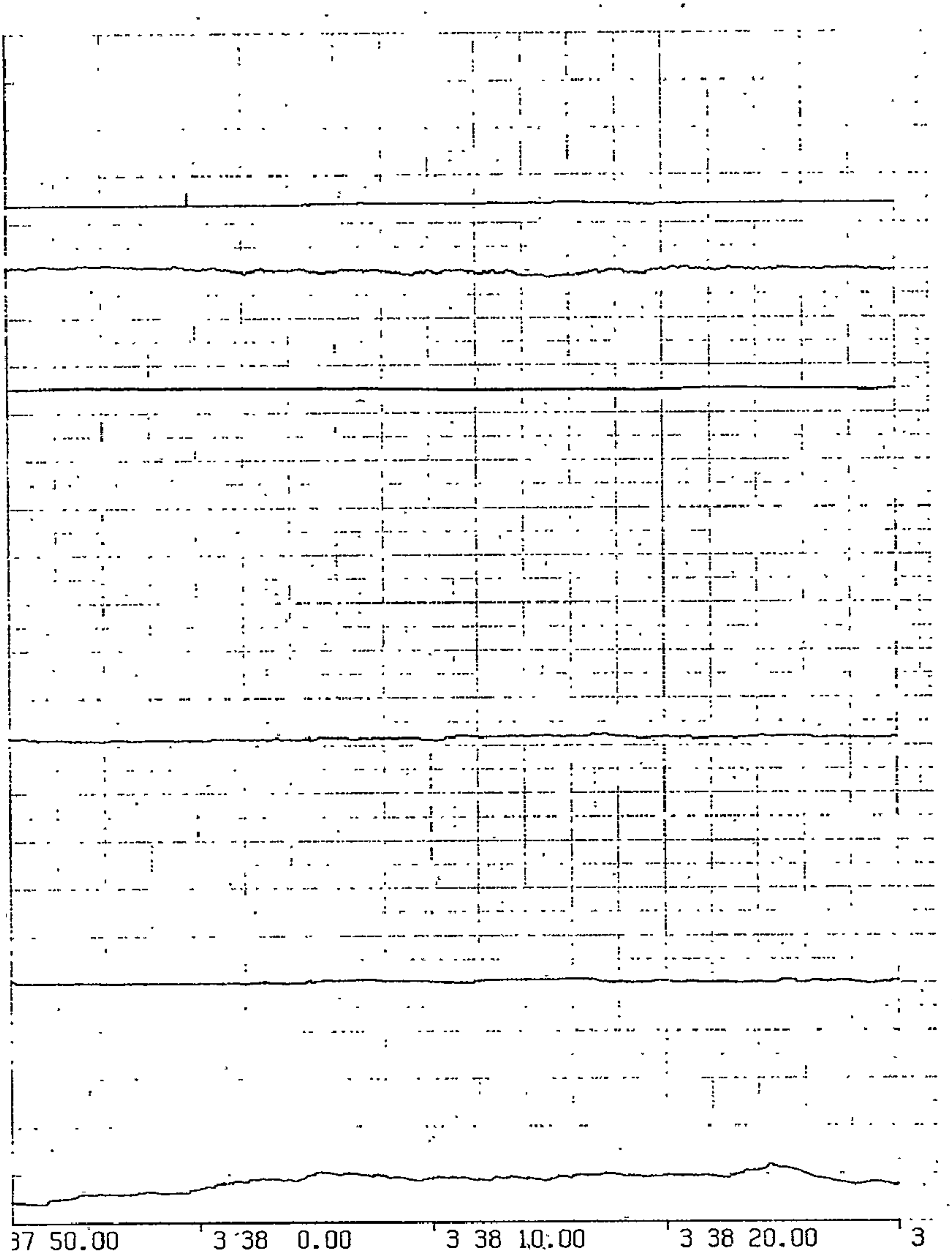

3 37 50.00
3 38 0.00
3 38 10.00
3 38 20.00

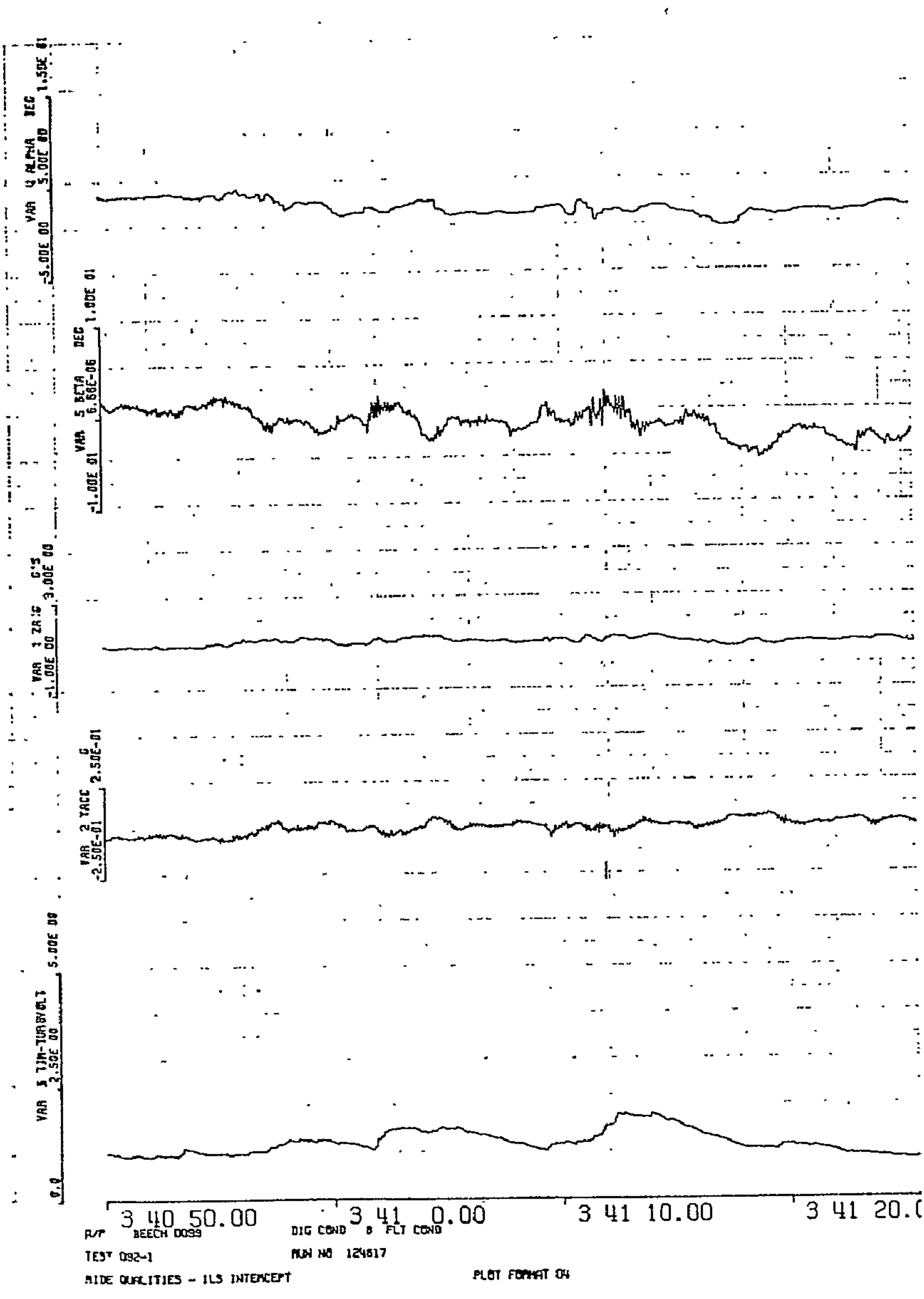



A/P BEECH 0099 DIG COND 7 FLT COND

TEST 092-1 RUN NO 106603

PRECISION HEADING PLOT FORMAT 07


37 50.00
3 38 0.00
3 38 10.00
3 38 20.00
3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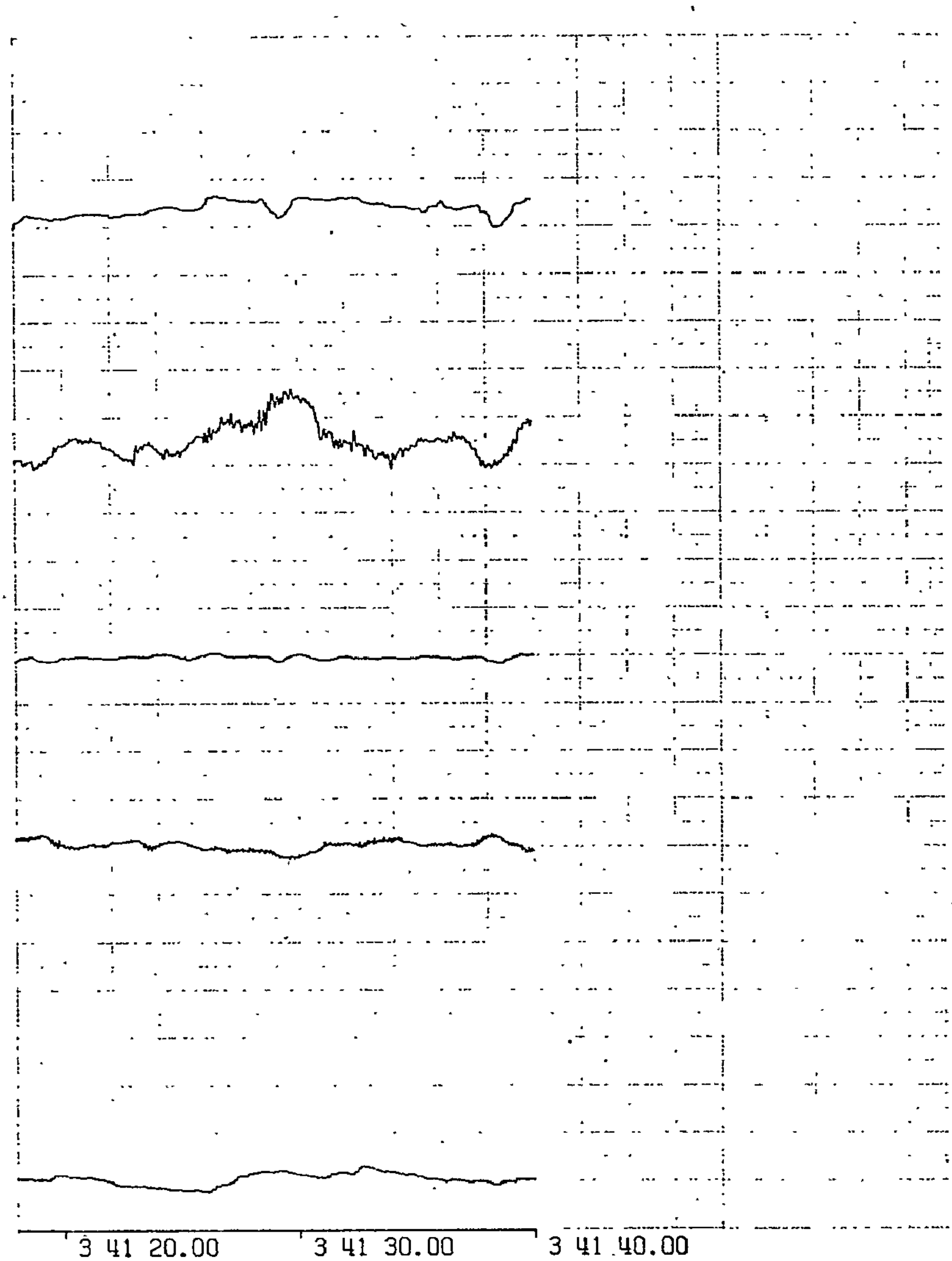
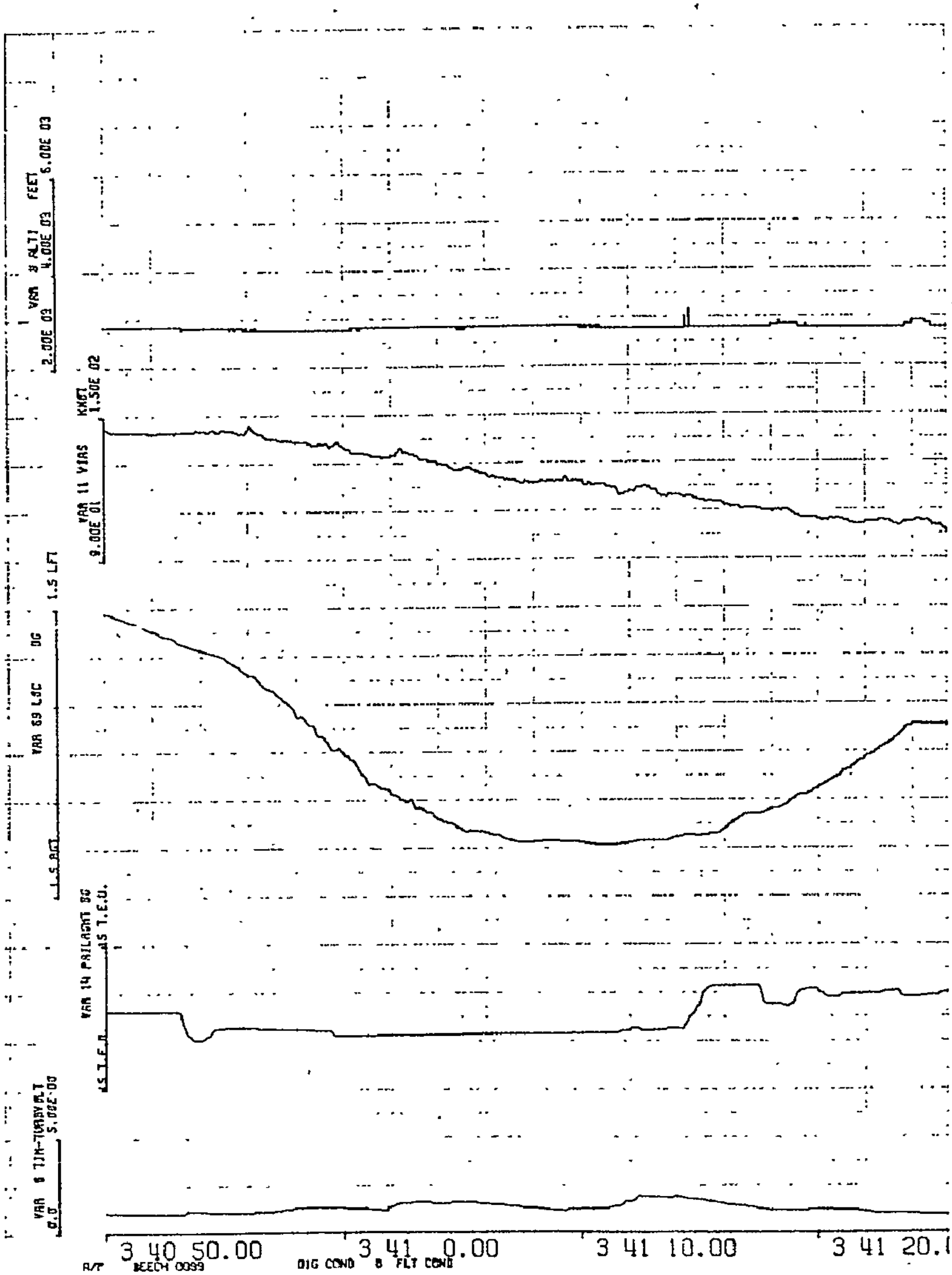
-5.00E 00
5.00E 00
1.50E 01
VAR 5 BETA DEG
-1.00E 01
6.68E-06
1.00E 01
VAR 1 ZA/G G'S
-1.00E 00
3.00E 00
VAR 2 YACC G
-2.50E-01
2.50E-01
VAR 5 TJM-TURB/GLT
0.0
2.50E 00
5.00E 00
3 40 50.00
3 41 0.00
3 41 10.00
3 41 20.0
A/P BEECH D099
DIG COND 8 FLT COND
TEST 092-1
RUN NO 124617
RIDE QUALITIES - ILS INTERCEPT
PLOT FORMAT 04

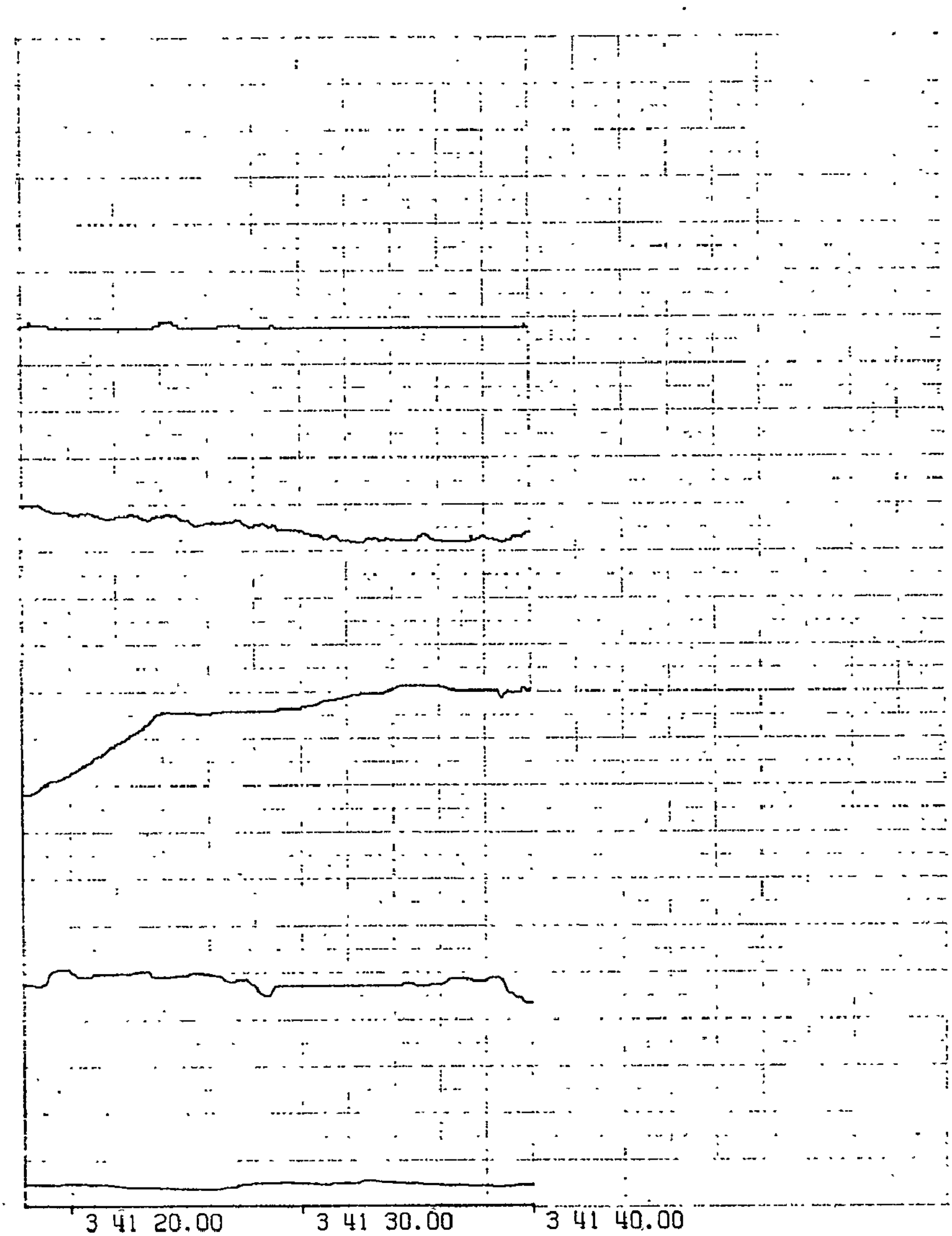

3 41 20.00
3 41 30.00
3 41 40.00

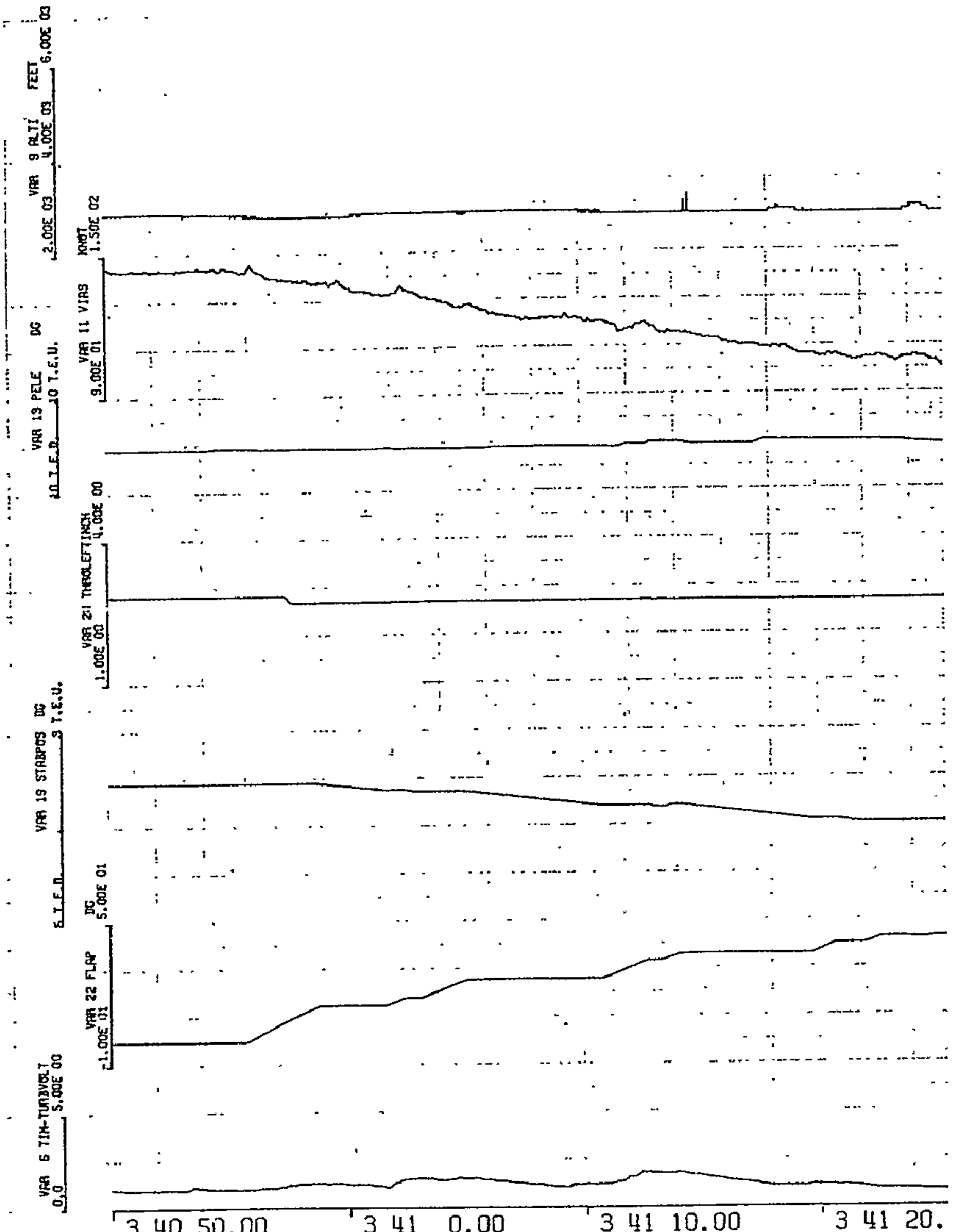



A/P BEECH 0099 DIG COND 8 FLT COND

TEST 092-1 RUN NO 106004

ILS INTERCEPT - LATERAL PLOT FORMAT 08

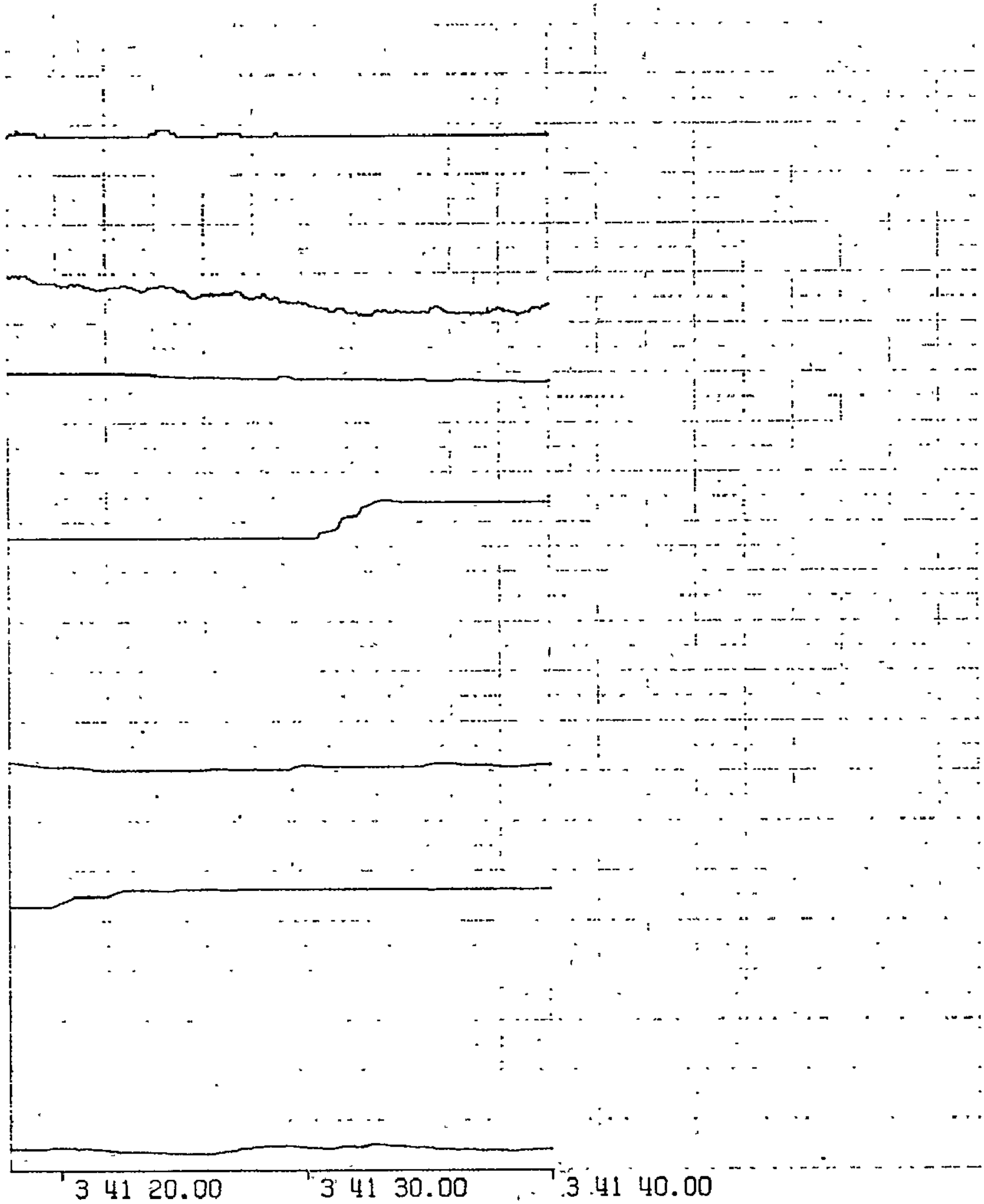

3 41 20.00
3 41 30.00
3 41 40.00

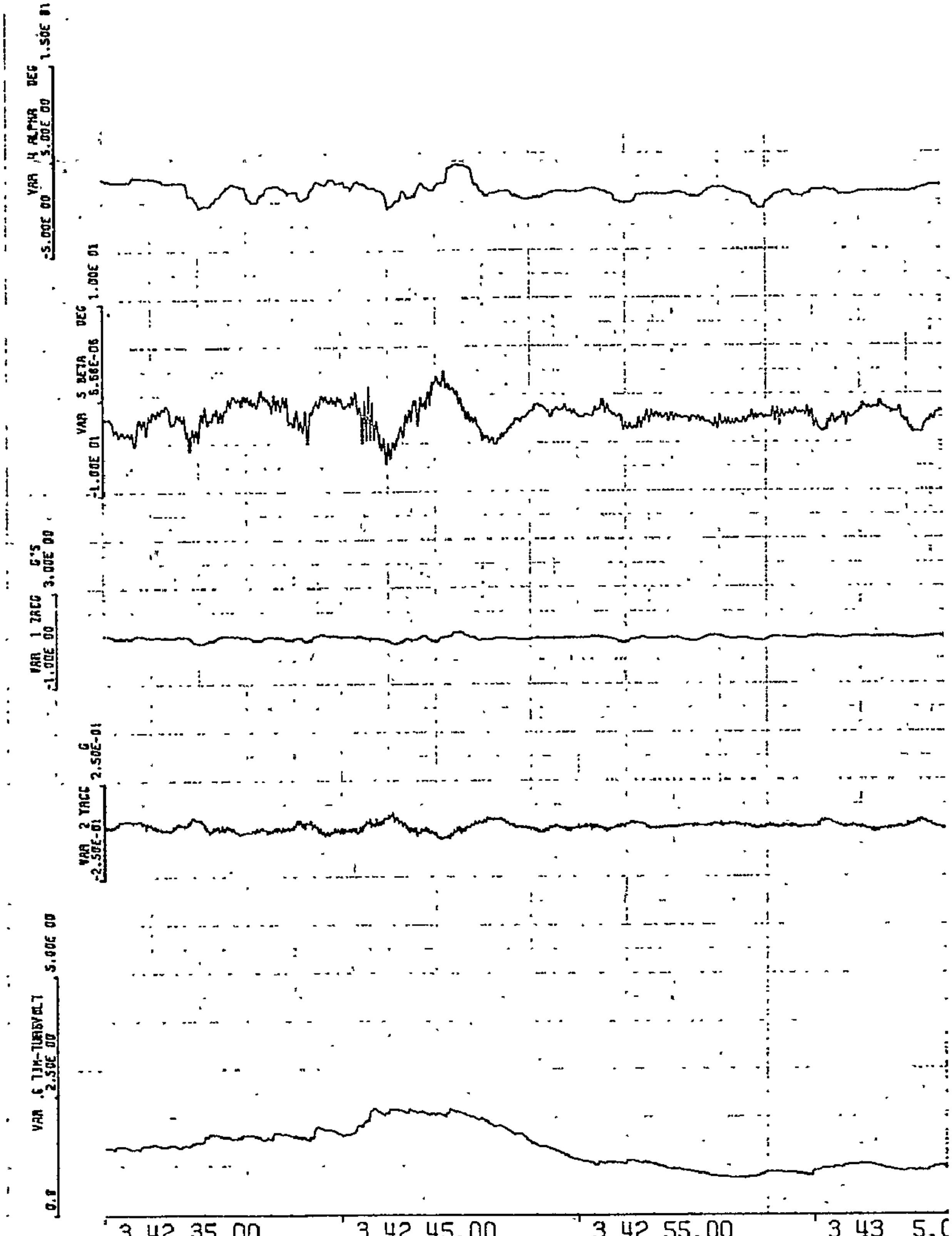



A/P BEECH 0099 DIG COND 8 FLT COND

TEST 092-1 RUN NO 106604

ILS INTERCEPT - LONGITUDINAL PLOT FORMAT 09

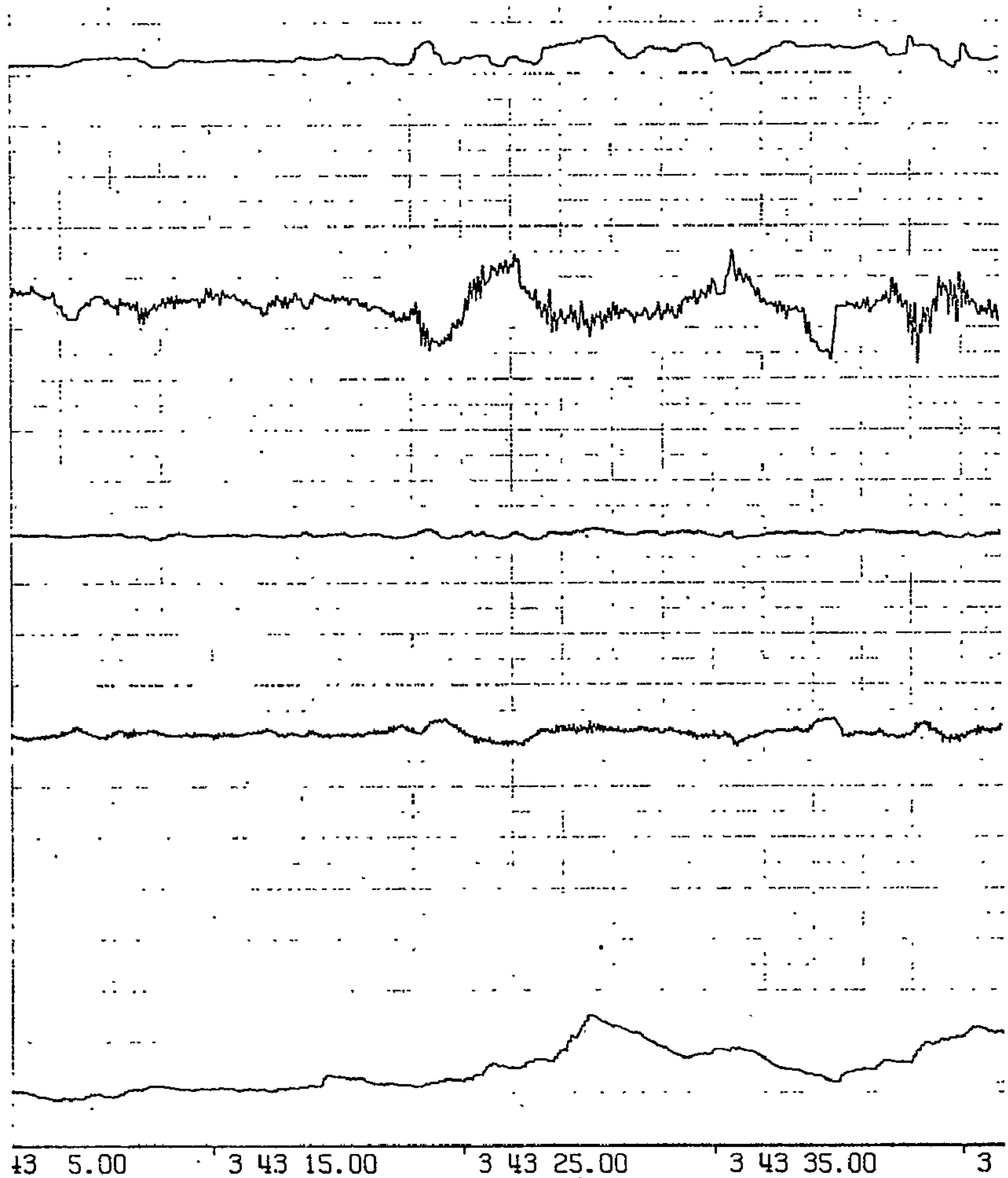

3 41 20.00
3 41 30.00
3 41 40.00

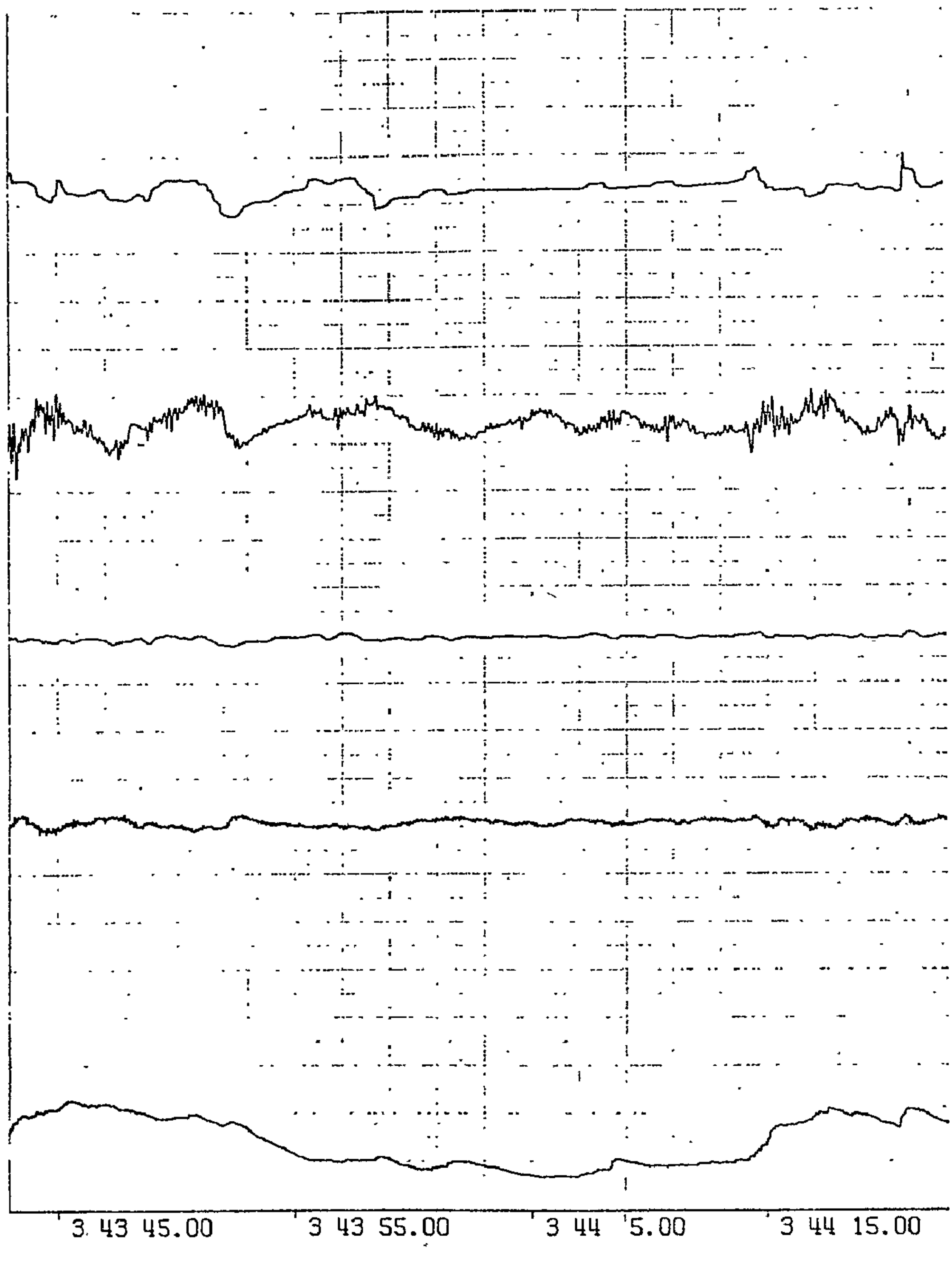


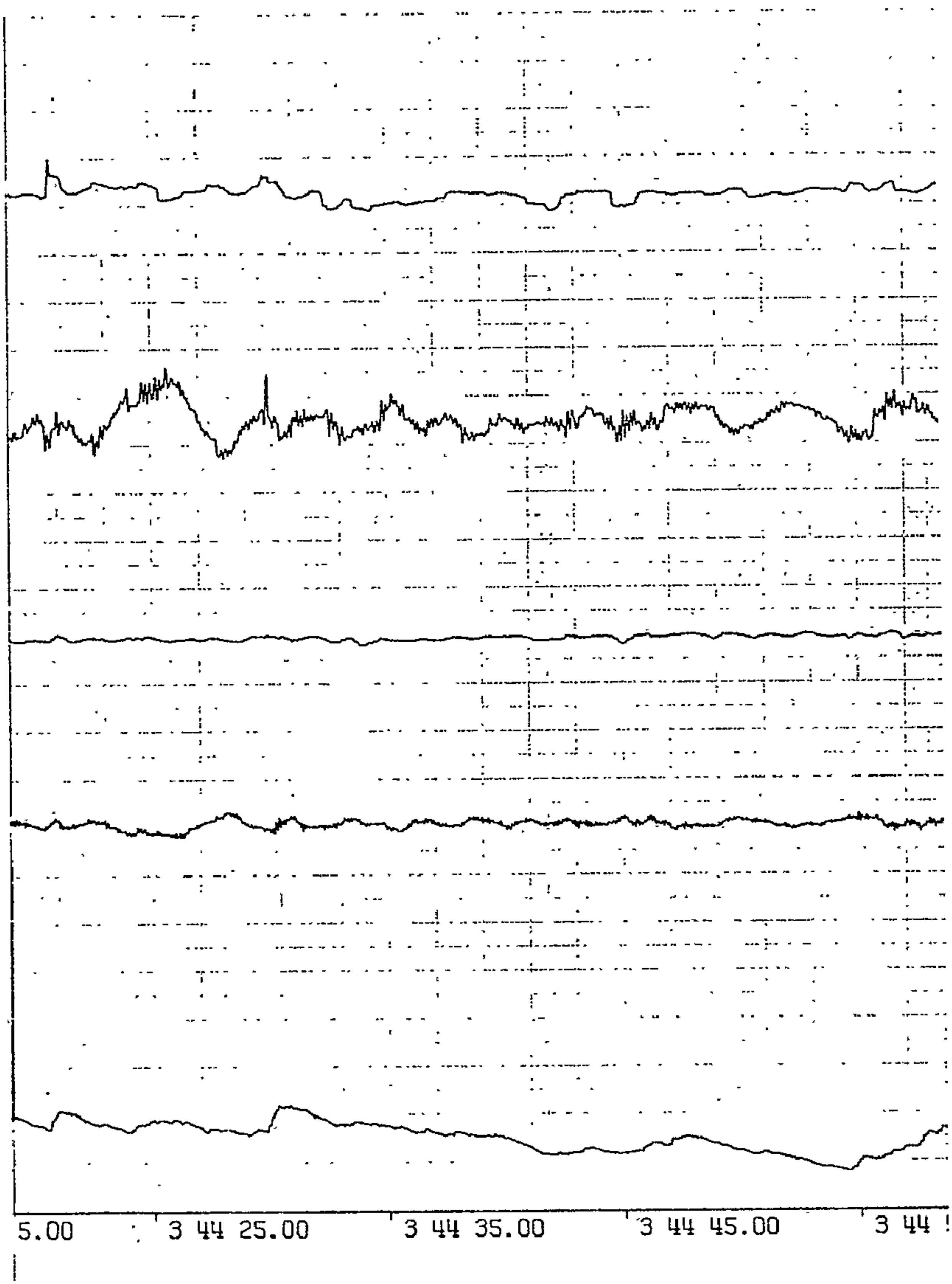

A/P BEECH-0089 DIG COND 9 FLT COND

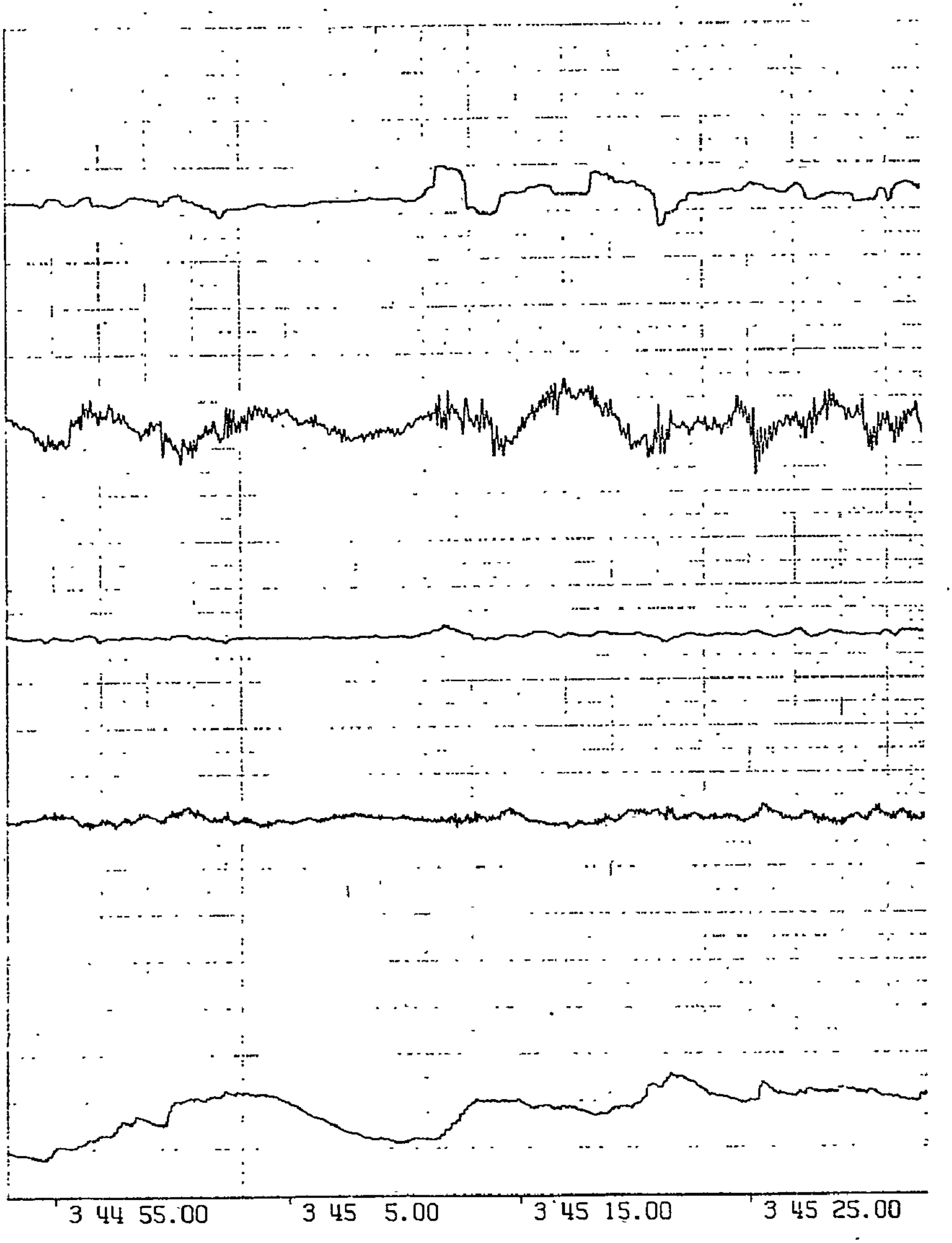
TEST 082-1 RUN NO 124617

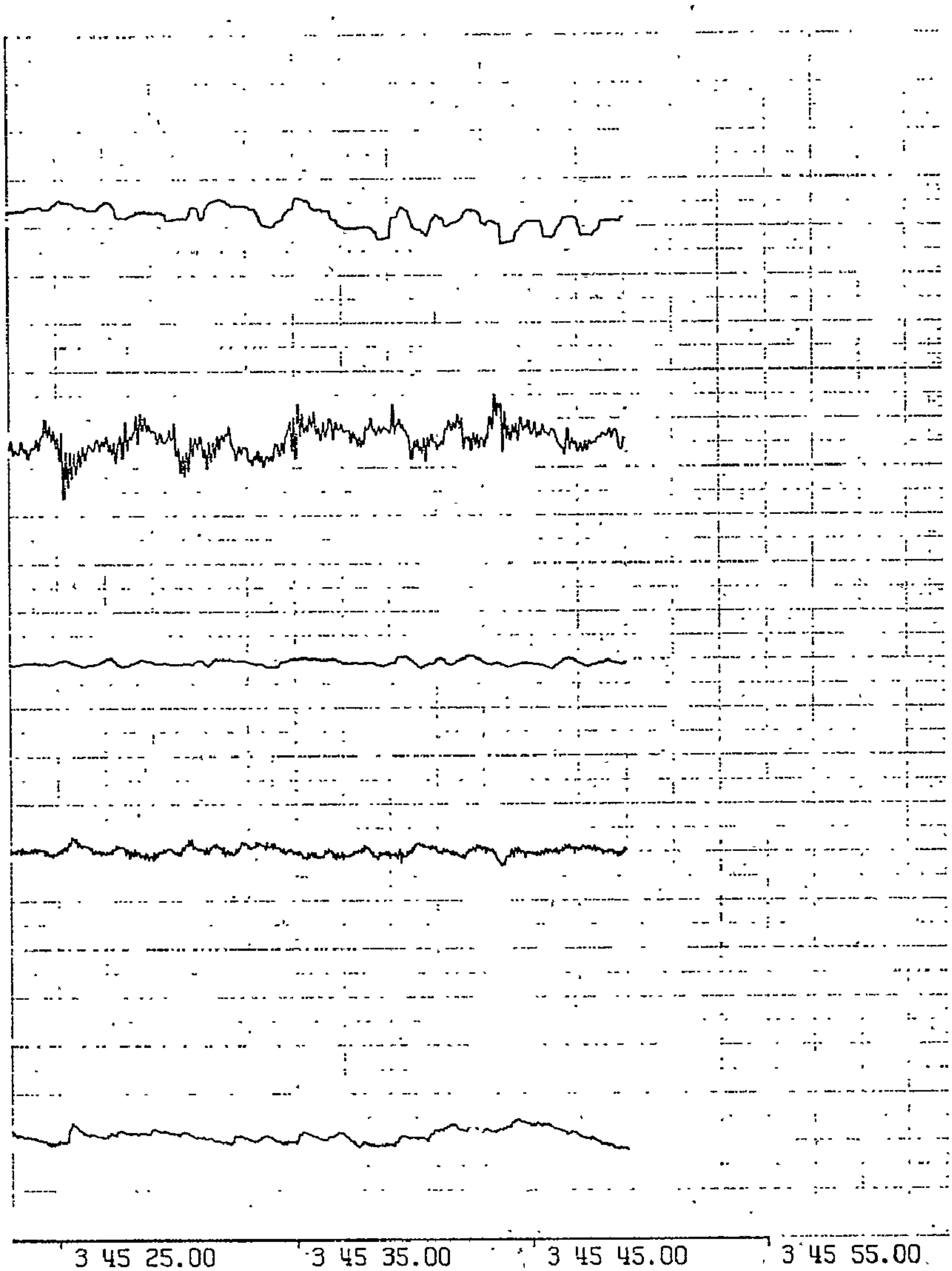
RIDE QUALITIES - ILS APPROACH PLOT FORMAT 04

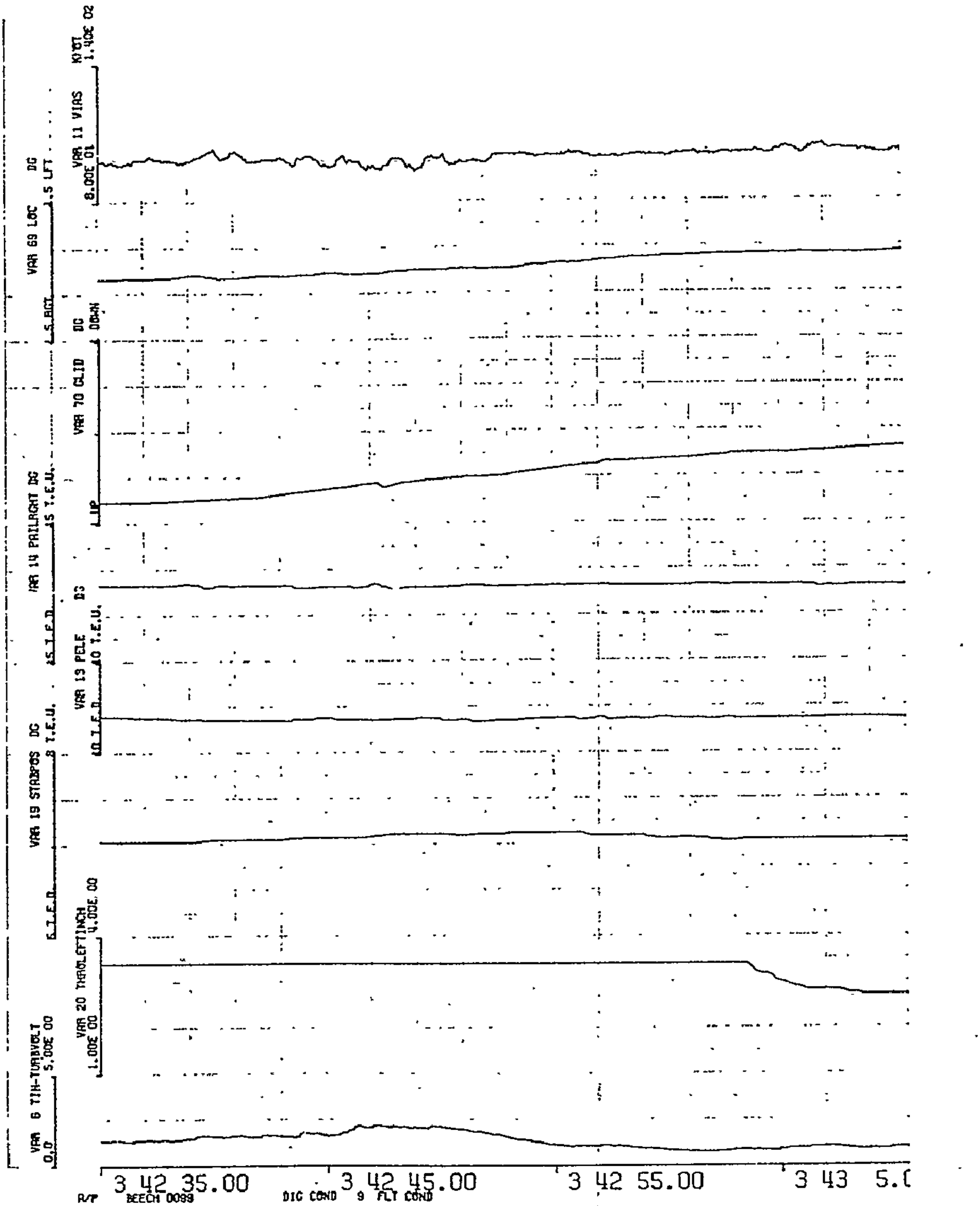

43 5.00
3 43 15.00
3 43 25.00
3 43 35.00
3


3 43 45.00
3 43 55.00
3 44 5.00
3 44 15.00


5.00
3 44 25.00
3 44 35.00
3 44 45.00
3 44 !


3 44 55.00
3 45 5.00
3 45 15.00
3 45 25.00

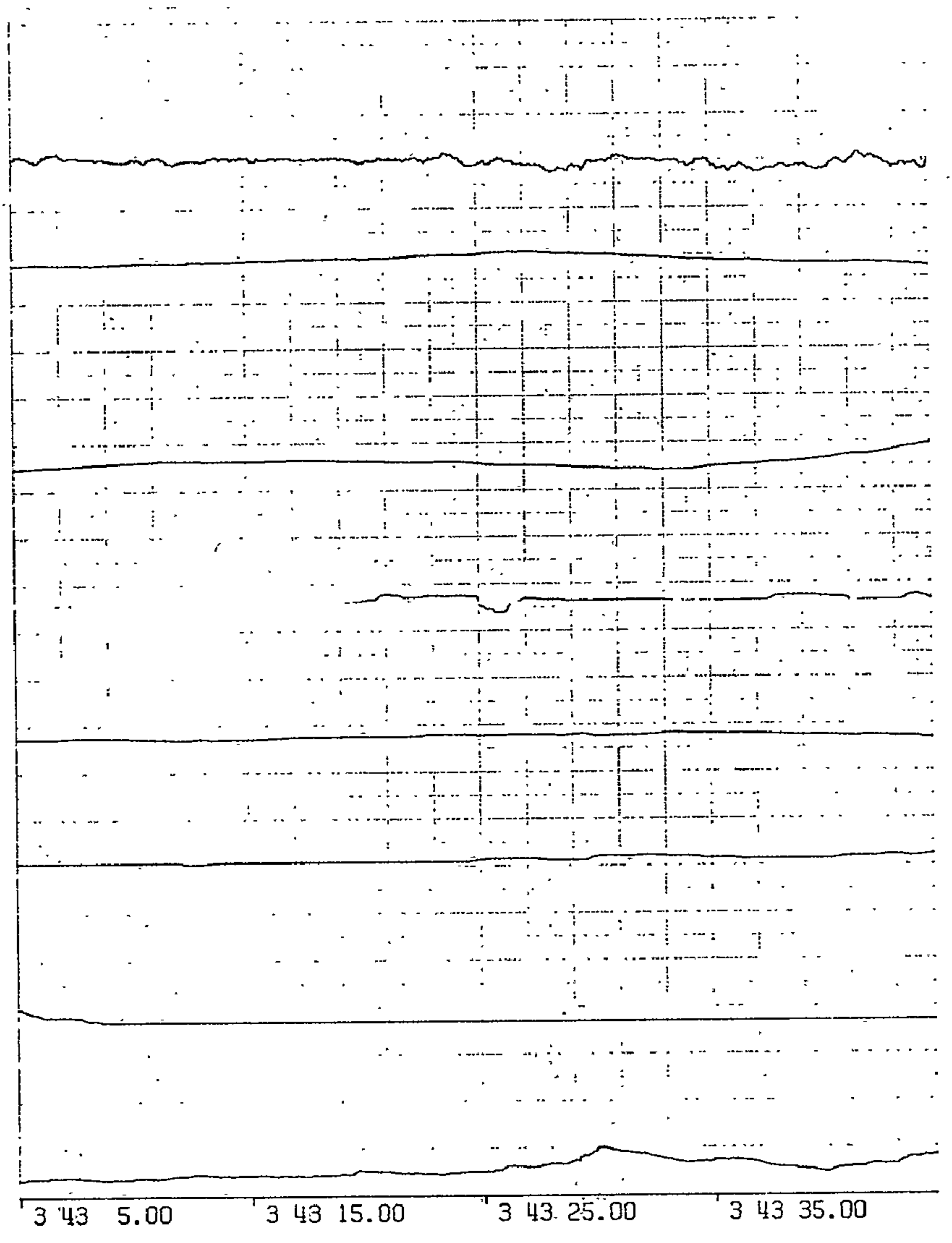

3 45 25.00
3 45 35.00
3 45 45.00
3 45 55.00




R/P BEECH 0099 DIG COND 9 FLT COND

TEST 092-1 RUN NO 106604

ILS APPROACH PLOT FORMAT 10


3 43 5.00
3 43 15.00
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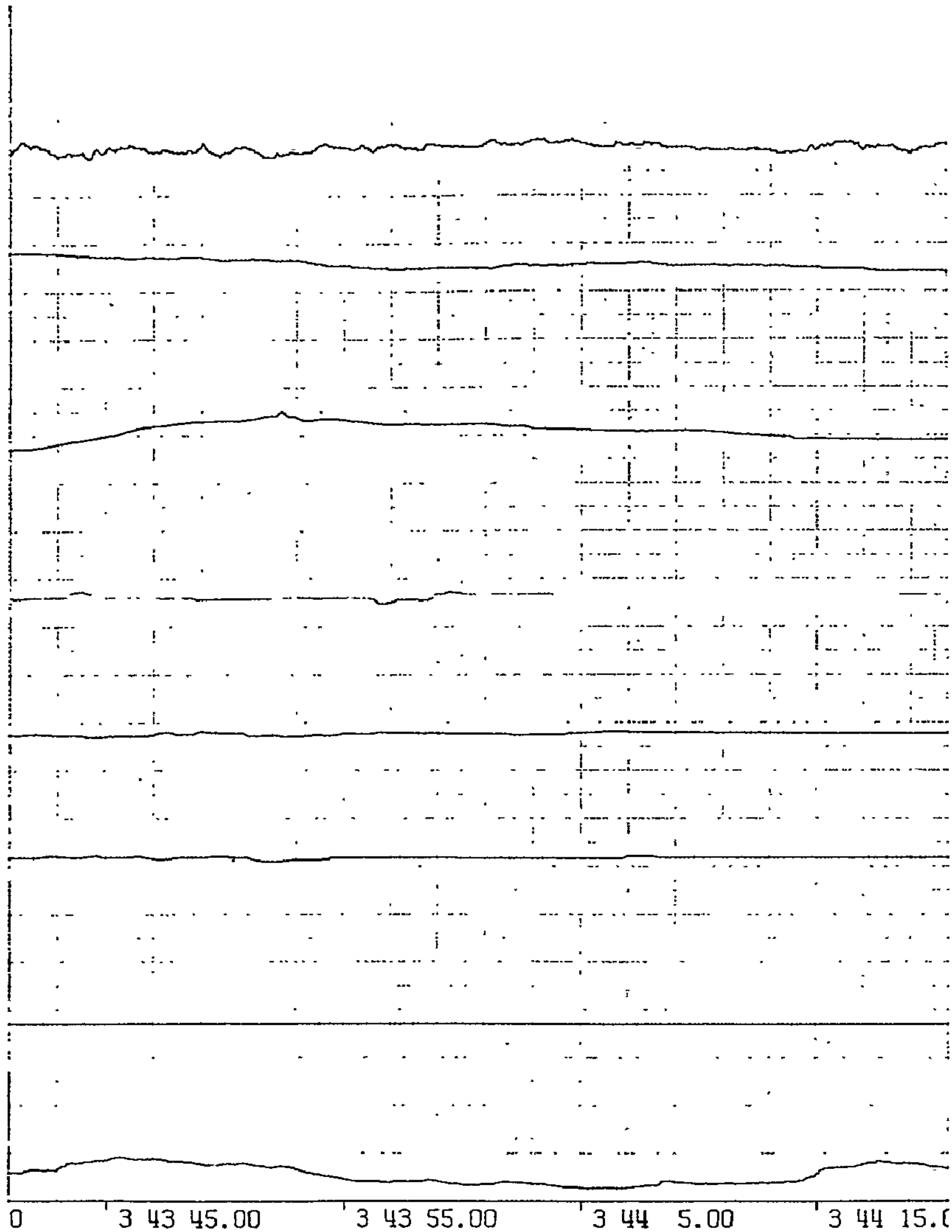
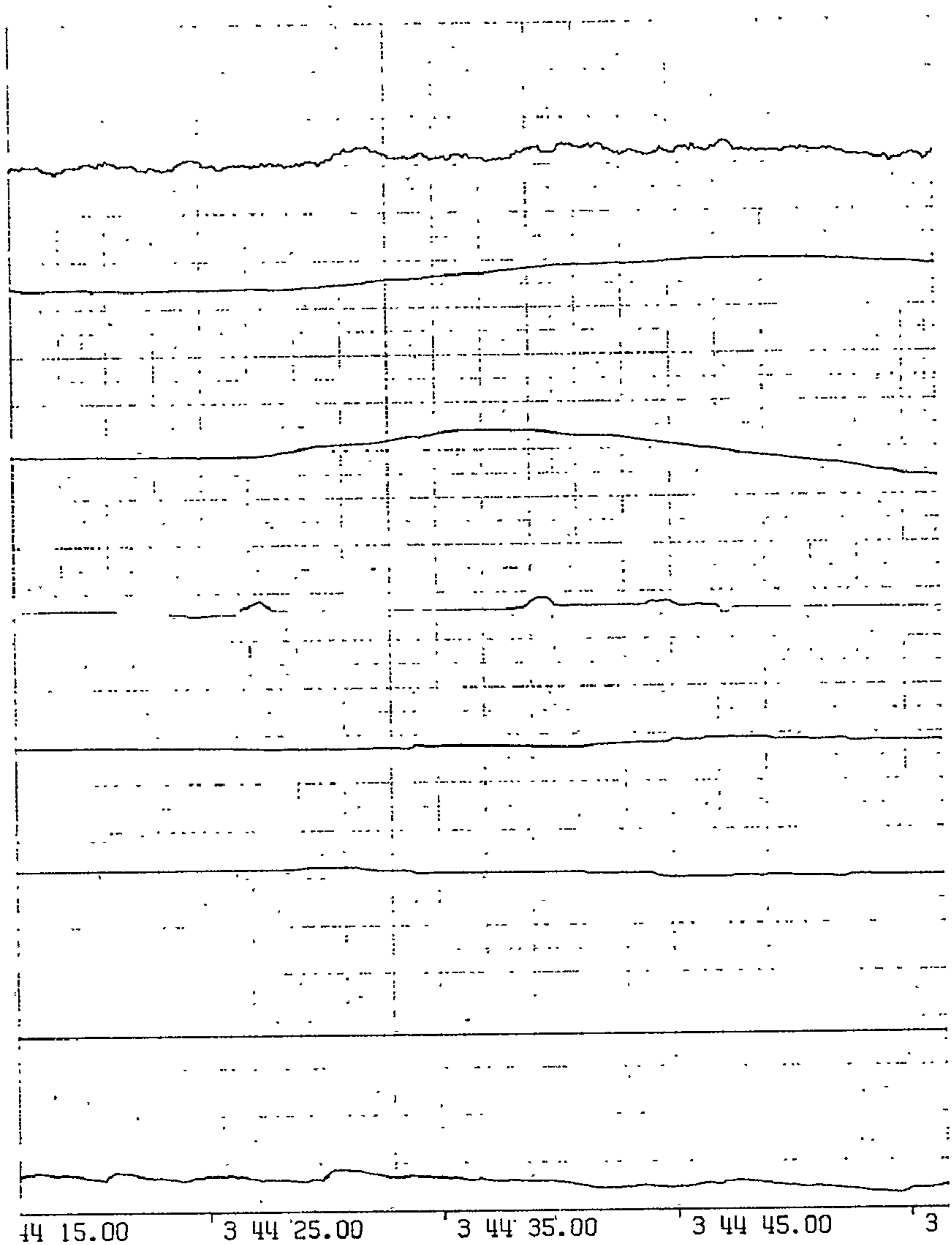
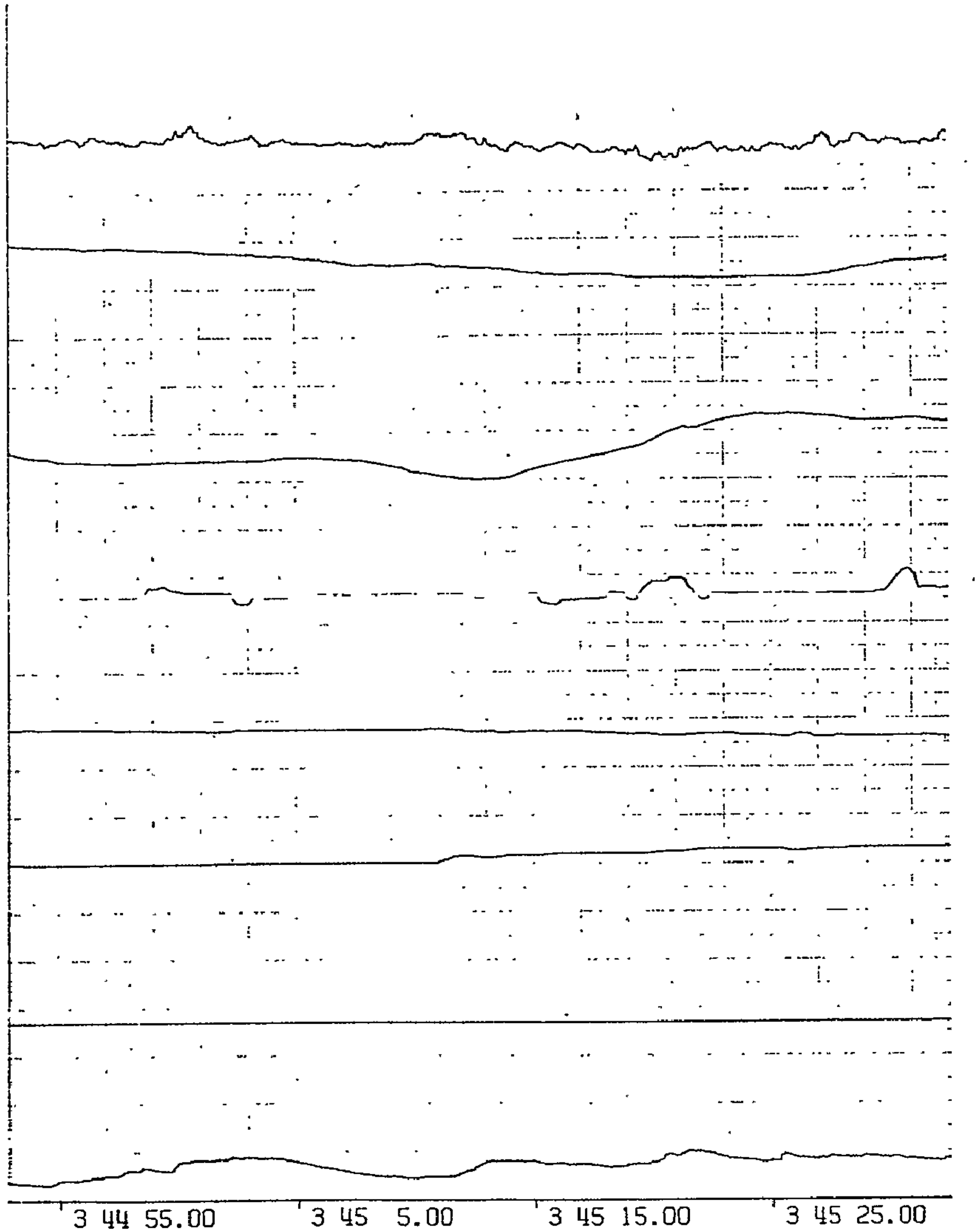
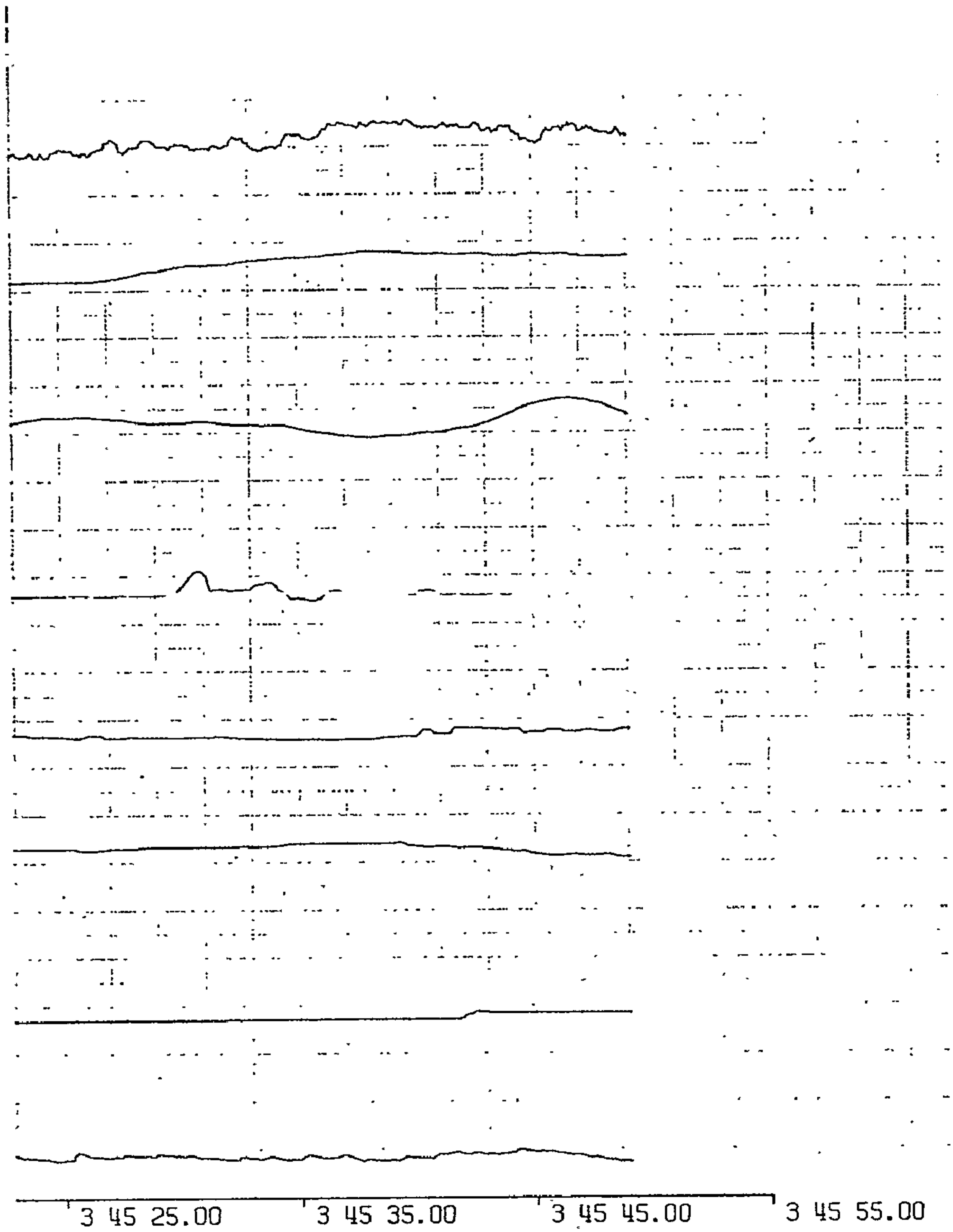
3 43 35.00


0
3 43 45.00
3 43 55.00
3 44 5.00
3 44 15.(


44 15.00
3 44 25.00
3 44 35.00
3 44 45.00
3


3 44 55.00
3 45 5.00
3 45 15.00
3 45 25.00


3 45 25.00
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3 45 45.00
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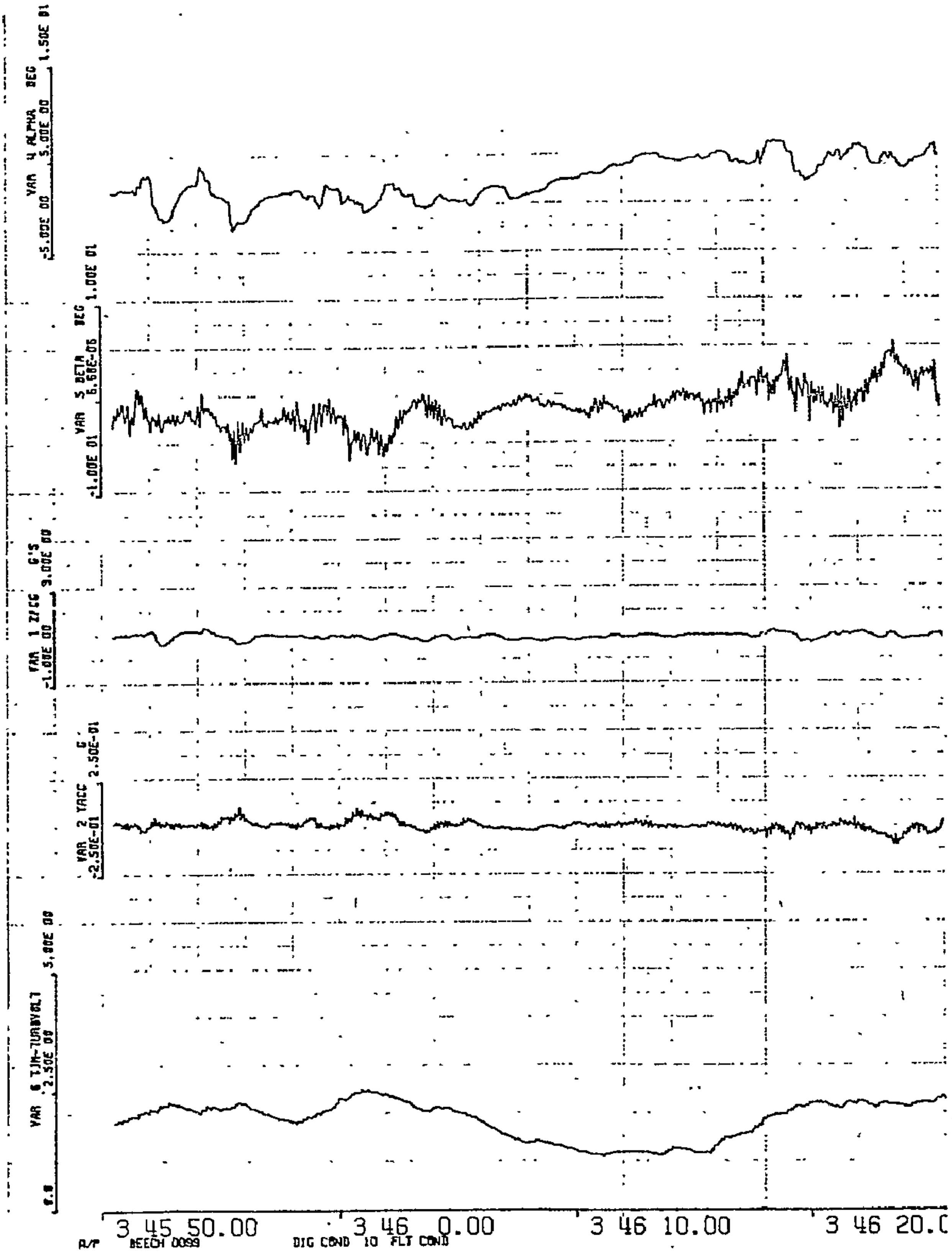
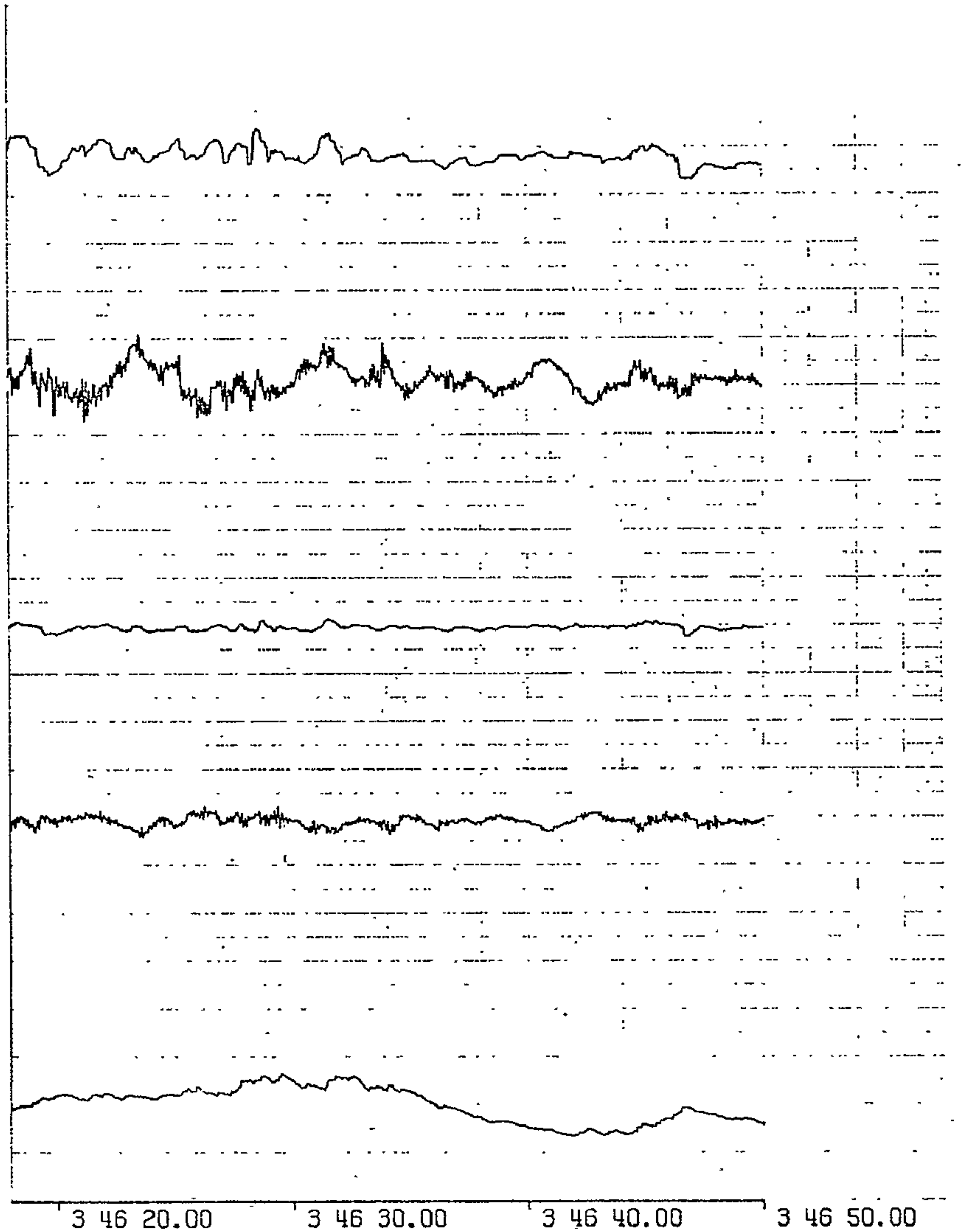
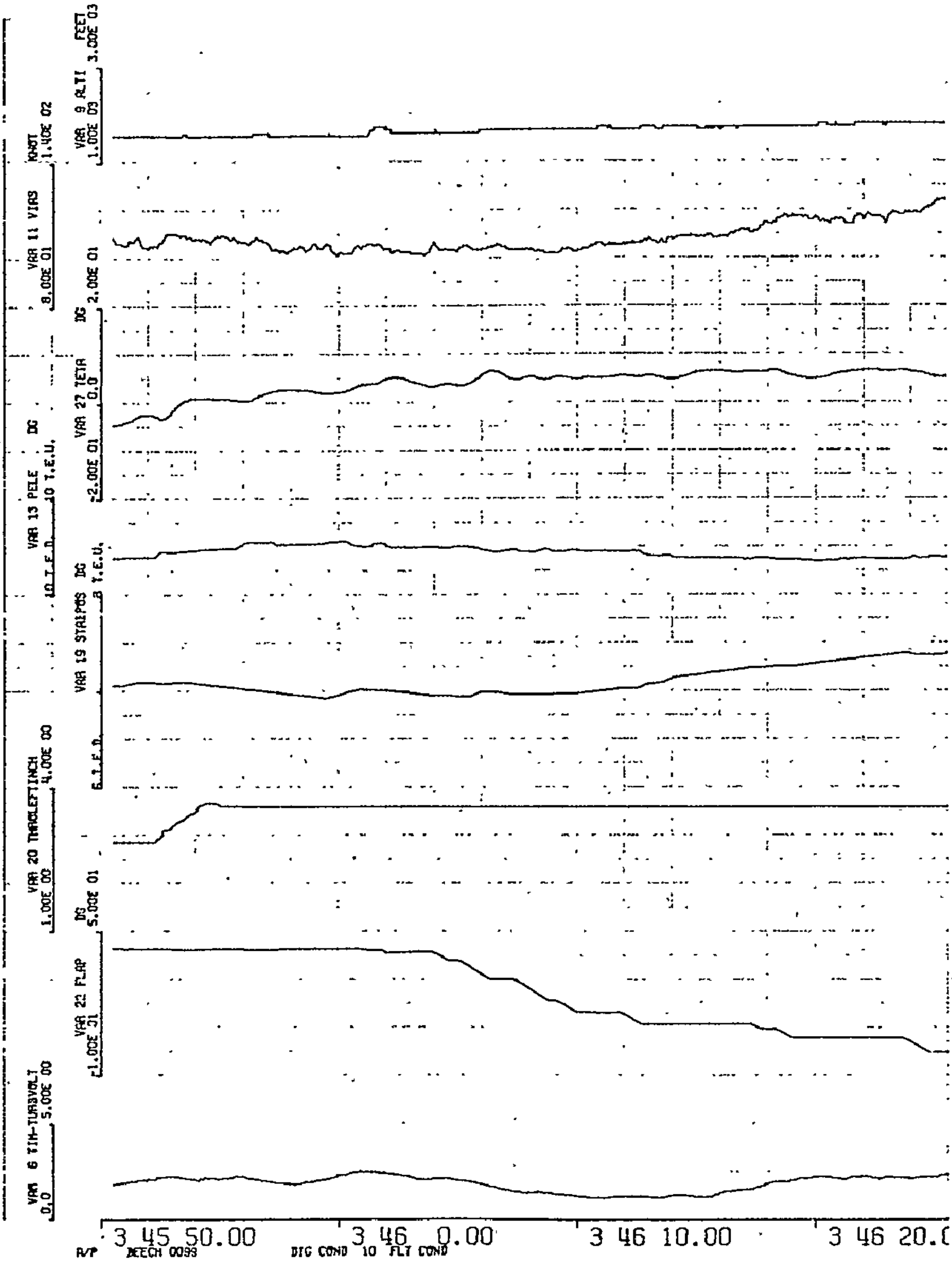



A/P BEECH 0099 DIG COND 10 FLT COND

TEST 092-1 RUN NO 124517

RIDE QUALITIES - GO AROUND PLOT FORMAT 04

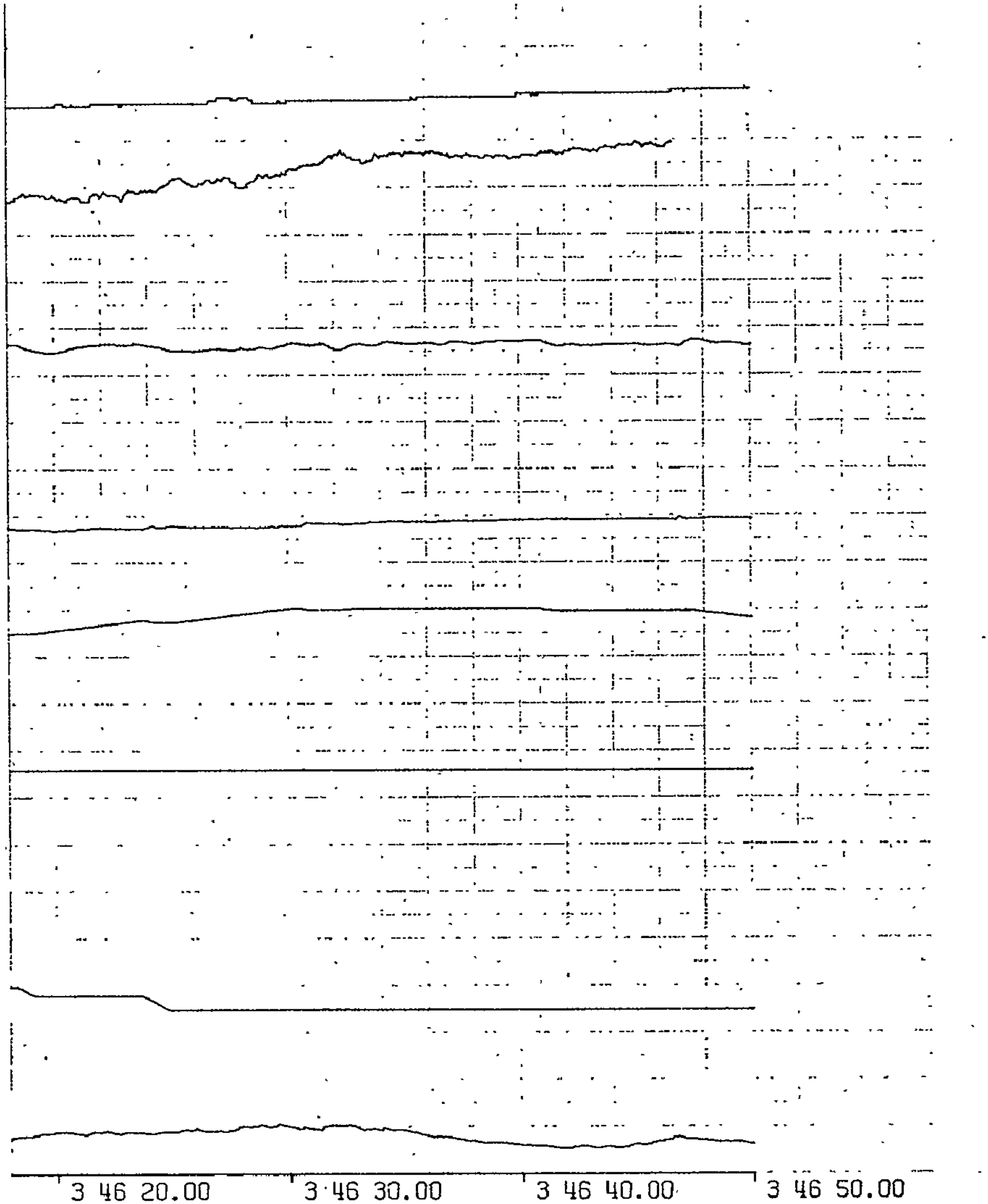

3 46 20.00
3 46 30.00
3 46 40.00
3 46 50.00




A/P BEECH 0099 DIG COND 10 FLT COND

TEST 092-1 RUN NO 106604

GO AROUND PLOT FORMAT 11


3 46 20.00
3 46 30.00
3 46 40.00
3 46 50.00

## APPENDIX D - SECTION 2

## SAMPLE FLIGHT STATISTICAL CALCULATIONS

## QUALITATIVE ANALYSIS

A/P NO. 0099 TEST NO. 0921 RUN NO. 148609 COND I CALIBRATION PROGRAM FLT COND

| BEGINNING TIME | ENDING TIME | SAMPLE SIZE |
|---|---|---|
| 2 58 50.00 | 2 59 50.01 | 2446 |

| VARIABLE | MINIMUM | AT TIME (HMS) | MAXIMUM | AT TIME (HMS) | MEAN | SIGMA | RMS | SAMPLES |
|---|---|---|---|---|---|---|---|---|
| 1 ZACG | 9.4287E-01 | 2 59 43.41 | 1.3133E 00 | 2 58 58.30 | 1.0836E 00 | 7.6631E-02 | 1.0863E 00 | 2446 |
| 2 YACC | -9.8425E-03 | 2 59 17.76 | 2.5591E-02 | 2 58 57.96 | 8.4665E-04 | 5.0301E-03 | 5.1006E-03 | 2446 |
| 3 XACC | 8.3991E-02 | 2 58 56.93 | 1.1561E-01 | 2 59 48.09 | 1.0212E-01 | 6.0508E-03 | 1.0230E-01 | 2446 |
| 4 ALPHA | 3.4247E 00 | 2 58 55.06 | 4.4521E 00 | 2 59 42.39 | 4.0432E 00 | 1.7705E-01 | 4.0471E 00 | 2446 |
| 5 BETA | -1.5354E 00 | 2 58 58.03 | 3.9368E-02 | 2 59 17.66 | -4.7849E-01 | 2.5355E-01 | 5.4152E-01 | 2446 |
| 6 TIM-TURB | -1.0653E-02 | 2 58 50.00 | 2.8419E-02 | 2 58 58.33 | -8.4571E-03 | 6.9108E-03 | 1.0922E-02 | 2446 |
| 7 TIM-A/S | 6.4786E 01 | 2 59 41.46 | 8.1616E 01 | 2 58 57.71 | 7.1166E 01 | 4.8904E 00 | 7.1333E 01 | 2446 |
| 8 TIM | 6.4786E 01 | 2 59 41.86 | 8.1616E 01 | 2 58 57.34 | 7.1412E 01 | 4.9067E 00 | 7.1581E 01 | 2446 |
| 9 ALTI | 6.4034E 03 | 2 58 50.22 | 7.0865E 03 | 2 59 44.04 | 6.7263E 03 | 2.1895E 02 | 6.7298E 03 | 2446 |
| 10 ALTIFINE | 6.4195E 03 | 2 58 55.48 | 7.0973E 03 | 2 59 46.01 | 6.7401E 03 | 2.1595E 02 | 6.7435E 03 | 2446 |
| 11 VIAS | 1.3796E 02 | 2 59 42.65 | 1.5625E 02 | 2 58 58.89 | 1.4458E 02 | 4.9407E 00 | 1.4466E 02 | 2446 |
| 12 VIASFINE | 1.3706E 02 | 2 59 44.93 | 1.5268E 02 | 2 58 57.91 | 1.4344E 02 | 4.7205E 00 | 1.4351E 02 | 2446 |
| 13 PELE | -1.3076E 00 | 2 59 10.13 | 5.1752E-01 | 2 58 50.00 | -5.9974E-01 | 3.3120E-01 | 6.8512E-01 | 2446 |
| 14 PAILRGHT | -6.9232E-01 | 2 59 6.77 | 1.1538E 00 | 2 58 51.77 | 1.7806E-01 | 3.6028E-01 | 4.0188E-01 | 2446 |
| 15 PAILLEFT | -3.8356E-01 | 2 58 51.82 | 1.5160E 00 | 2 59 7.06 | 5.7198E-01 | 3.6058E-01 | 6.7615E-01 | 2446 |
| 16 PRUD | -5.8473E-01 | 2 58 57.74 | 3.3434E-01 | 2 59 16.07 | 1.1034E-01 | 1.9651E-01 | 2.2537E-01 | 2446 |
| 17 AIL-TRIM | 2.9744E 00 | 2 58 50.00 | 3.0769E 00 | 2 58 50.15 | 2.9795E 00 | 2.2037E-02 | 2.9794E 00 | 2446 |
| 18 RUD-TRIM | -5.4340E-01 | 2 58 50.00 | -5.4340E-01 | 2 58 50.00 | -5.4340E-01 | 0.0 | 5.4340E-01 | 2446 |
| 19 STABPOS | 6.2269E-01 | 2 58 50.00 | 1.1491E 00 | 2 59 0.73 | 1.0476E 00 | 9.1476E-02 | 1.0516E 00 | 2446 |
| 20 THRCLEFT | 3.3926E 00 | 2 58 56.51 | 3.5962E 00 | 2 58 50.00 | 3.4643E 00 | 5.2389E-02 | 3.4647E 00 | 2446 |
| 21 THROLGHT | 3.2766E 00 | 2 58 56.54 | 3.3873E 00 | 2 58 50.00 | 3.2965E 00 | 3.0679E-02 | 3.2966E 00 | 2446 |
| 22 FLAP | -2.0558E-01 | 2 58 50.00 | -2.0558E-01 | 2 58 50.00 | -2.0558E-01 | 0.0 | 2.0558E-01 | 2446 |
| 23 DISC 23 | DISCRETE | | | | | | | |
| 24 DISC 24 | DISCRETE | | | | | | | |
| 25 SELE | 4.3396E-01 | 2 59 43.45 | 1.7703E 00 | 2 58 50.00 | 8.6856E-01 | 3.3277E-01 | 9.3012E-01 | 2446 |
| 26 SAILRGHT | 9.4418E-01 | 2 59 43.82 | 1.2585E 00 | 2 58 51.92 | 1.0804E 00 | 6.0006E-02 | 1.0821E 00 | 2446 |
| 27 TETA | 2.0089E 00 | 2 58 50.00 | 8.5374E 00 | 2 59 7.23 | 6.2336E 00 | 1.6156E 00 | 6.4396E 00 | 2446 |
| 28 PHI | 1.6681E 01 | 2 59 37.19 | 2.8589E 01 | 2 58 54.08 | 2.1485E 01 | 3.7240E 00 | 2.1805E 01 | 2446 |
| 29 SAILLEFT | -1.3661E-01 | 2 58 50.00 | -3.8940E-02 | 2 59 5.74 | -1.2317E-01 | 3.6066E-02 | 1.2834E-01 | 2446 |
| 30 SRUD | -5.8347E-01 | 2 58 57.94 | 1.0056E-01 | 2 59 21.96 | -1.0708E-01 | 1.7178E-01 | 2.0242E-01 | 2446 |
| 31 AIL-SIGN | 2.2439E 01 | 2 58 56.54 | 2.2615E 01 | 2 58 50.00 | 2.2615E 01 | 1.3125E-02 | 2.2615E 01 | 2446 |
| 32 RUDDSIGN | 1.2823E 01 | 2 58 56.54 | 2.0096E 01 | 2 58 50.00 | 2.0093E 01 | 1.4746E-01 | 2.0093E 01 | 2446 |
| 33 DC MONT | 1.1424E 01 | 2 58 50.00 | 1.1475E 01 | 2 58 58.01 | 1.1452E 01 | 2.5755E-02 | 1.1452E 01 | 2445 |
| 34 HEAD | 3.4147E-01 | 2 59 18.55 | 3.6046E 01 | 2 59 17.54 | 1.7064E 01 | 1.3812E 01 | 2.1953E 01 | 2414 |
| 35 | NTC | | | | | | | |
| 36 Q | -5.2505E-01 | 2 59 16.68 | 2.6967E 00 | 2 58 58.01 | 6.2809E-01 | 6.4627E-01 | 9.0120E-01 | 2445 |
| 37 AC MONT | SSD | | | | | | | |
| 38 | NTC | | | | | | | |
| 39 | NTC | | | | | | | |
| 40 P | -4.1176E 00 | 2 58 58.08 | -5.4901E-01 | 2 58 52.36 | -1.8790E 00 | 4.8863E-01 | 1.9415E 00 | 2445 |
| 41 QDOT | 5.1476E-85 | 2 58 56.54 | 8.2354E-02 | 2 58 55.36 | 5.9584E-02 | 5.7573E-03 | 5.9861E-02 | 2446 |
| 42 R | -2.0416E 01 | 2 58 56.54 | 3.5213E 00 | 2 58 54.03 | 2.6460E 00 | 6.2171E-01 | 2.7181E 00 | 2446 |
| 43 PDOT | 9.9569E-02 | 2 58 54.53 | 1.7069E-01 | 2 59 2.89 | 1.3265E-01 | 1.2114E-02 | 1.3321E-01 | 2445 |
| 44 RDOT | 8.0825E-02 | 2 58 50.05 | 1.4087E 00 | 2 58 56.54 | 9.1248E-02 | 2.6962E-02 | 9.5147E-02 | 2446 |
| 45 RUAC | 1.3273E-01 | 2 58 57.81 | 7.3396E 00 | 2 58 56.54 | 7.1753E-01 | 1.8034E-01 | 7.3984E-01 | 2446 |
| 46 ELAC | 1.5568E 00 | 2 58 50.05 | 8.1072E 00 | 2 58 56.54 | 2.3370E 00 | 3.4532E-01 | 2.3624E 00 | 2446 |
| 47 RAAC | 5.2371E-02 | 2 58 52.06 | 1.0024E 01 | 2 58 56.54 | 4.3235E-01 | 2.3052E-01 | 4.8997E-01 | 2446 |
| 48 LAAC | 1.8187E-01 | 2 58 51.06 | 9.9655E 00 | 2 58 56.54 | 2.6713E-01 | 1.9939E-01 | 3.3334E-01 | 2446 |
| 49 RDCTGYRO | -2.6815E 00 | 2 58 53.59 | -1.2862E 00 | 2 59 35.04 | -2.0132E 00 | 4.0827E-01 | 2.0541E 00 | 2445 |

QUALITATIVE ANALYSIS

A/P NO. 0099 TEST NO. 0921 RUN NO. 148609 COND 1 CALIBRATION PROGRAM FLT COND

| BEGINNING TIME | ENDING TIME | SAMPLE SIZE |
|---|---|---|
| 2 58 50.00 | 2 59 50.01 | 2446 |

| VARIABLE | | MINIMUM | AT TIME (HMS) | MAXIMUM | AT TIME (HMS) | MEAN | SIGMA | RMS | SAMPLES |
|---|---|---|---|---|---|---|---|---|---|
| 50 | | NTC | | | | | | | |
| 51 | TETACOMM | -8.9664E 00 | 2 58 50.00 | 1.0785E 01 | 2 59 48.71 | -7.9020E 00 | 4.0254E 00 | 8.8682E 00 | 2445 |
| 52 | PHI COMM | -1.1990E 01 | 2 59 47.72 | -1.1814E 01 | 2 58 50.00 | -1.1824E 01 | 3.6865E-02 | 1.1824E 01 | 2446 |
| 53 | PSI COMM | 1.3178E 00 | 2 59 48.26 | 3.0178E 00 | 2 59 36.04 | 2.2068E 00 | 2.5707E-01 | 2.2217E 00 | 2446 |
| 54 | DPSICOMM | -2.6241E-01 | 2 59 48.51 | -6.7149E-02 | 2 59 8.63 | -9.9511E-02 | 3.7829E-02 | 1.0646E-01 | 2446 |
| 55 | FLEKSIGN | 3.0105E 01 | 2 58 50.00 | 3.0105E 01 | 2 58 50.00 | 3.0105E 01 | 0.0 | 3.0105E 01 | 2446 |
| 56 | | NTC | | | | | | | |
| 57 | TETAGYRO | -2.0423E 01 | 2 59 2.40 | -1.7671E-01 | 2 59 48.81 | -1.1201E 01 | 6.1351E 00 | 1.2771E 01 | 2446 |
| 58 | Q GYRO | -3.2388E-01 | 2 58 50.00 | 1.5259E-05 | 2 59 48.00 | -3.0683E-01 | 6.5951E-02 | 3.1384E-01 | 2446 |
| 59 | RUD ACT | -2.2809E 00 | 2 58 57.79 | 2.4038E 00 | 2 59 2.23 | 5.7124E-02 | 3.6328E-01 | 3.6774E-01 | 2446 |
| 60 | ELEVACT | -6.4502E-01 | 2 59 17.84 | 8.0254E 00 | 2 59 10.18 | 3.9517E 00 | 1.6811E 00 | 4.2944E 00 | 2446 |
| 61 | RTALACT | -3.0965E 00 | 2 59 7.04 | -2.8424E-01 | 2 58 52.01 | -1.7490E 00 | 4.9942E-01 | 1.8189E 00 | 2446 |
| 62 | LTALACT | -5.3018E-01 | 2 58 51.74 | 1.6960E 00 | 2 59 6.89 | 6.3105E-01 | 4.1942E-01 | 7.5772E-01 | 2446 |
| 63 | PHI GYRO | -3.4766E 01 | 2 59 18.35 | -2.3996E 01 | 2 58 50.00 | -3.1442E 01 | 2.8081E 00 | 3.1567E 01 | 2446 |
| 64 | P GYRO | -2.2473E-01 | 2 58 52.19 | 6.7415E-01 | 2 58 58.06 | 1.4548E-03 | 4.7633E-02 | 4.7655E-02 | 2446 |
| 65 | | NTC | | | | | | | |
| 66 | | NTC | | | | | | | |
| 67 | ALT-LD | -5.0516E 00 | 2 59 49.61 | -1.9369E 00 | 2 59 33.46 | -3.3368E 00 | 7.0725E-01 | 3.4109E 00 | 2446 |
| 68 | ALT-GD | 6.2916E-02 | 2 58 50.05 | 7.9473E-02 | 2 58 50.00 | 7.7902E-02 | 4.8513E-03 | 7.8053E-02 | 2446 |
| 69 | LOC | SSD | | | | | | | |
| 70 | GLID | -2.3582E-02 | 2 58 50.00 | -2.3582E-02 | 2 58 50.00 | -2.3582E-02 | 0.0 | 2.3582E-02 | 2446 |
| 71 | | NTC | | | | | | | |
| 72 | | NTC | | | | | | | |
| 73 | | NTC | | | | | | | |
| 74 | | NTC | | | | | | | |
| 75 | | NTC | | | | | | | |
| 76 | | NTC | | | | | | | |
| 77 | OAT | 4.5499E 01 | 2 59 43.21 | 4.9121E 01 | 2 58 51.89 | 4.7271E 01 | 1.1613E 00 | 4.7285E 01 | 2446 |

## QUALITATIVE ANALYSIS

A/P NO. 0099 TEST NO. 0921 RUN NO. 124616 COND 2 CALIBRATION PROGRAM FLT COND

| BEGINNING TIME | ENDING TIME | SAMPLE SIZE |
|---|---|---|
| 3 1 30.01 | 3 3 20.01 | 4483 |

| VARIABLE | MINIMUM | AT TIME (HMS) | MAXIMUM | AT TIME (HMS) | MEAN | SIGMA | RMS | SAMPLES |
|---|---|---|---|---|---|---|---|---|
| 50 | NTC | | | | | | | |
| 51 THETACOMM | -8.9864E 00 | 3 1 30.03 | -8.9279E 00 | 3 1 30.00 | -8.9643E 00 | 2.8717E-02 | 8.9643E 00 | 4483 |
| 52 PHI COMM | -1.1873E 01 | 3 2 53.01 | -1.0641E 01 | 3 2 28.16 | -1.1811E 01 | 4.4532E-02 | 1.1811E 01 | 4463 |
| 53 PSI COMM | -2.1409E 00 | 3 2 53.46 | 5.4795E 00 | 3 2 52.21 | 2.2682E 00 | 6.3690E-01 | 2.2983E 00 | 4483 |
| 54 DPSICOMM | -1.0620E-01 | 3 1 30.00 | -1.0620E-01 | 3 1 30.00 | -1.0620E-01 | 0.0 | 1.0620E-01 | 4493 |
| 55 TLERSION | 3.0105E 01 | 3 1 30.00 | 3.0105E 01 | 3 1 30.00 | 3.0105E 01 | 0.0 | 3.0105E 01 | 4483 |
| 56 | NTC | | | | | | | |
| 57 THETACYRO | -9.5212E 00 | 3 1 3[illegible].99 | -1.6142E 00 | 3 3 16.59 | -5.7926E 00 | 2.6476E 00 | 6.2690E 00 | 4483 |
| 58 Q GYRO | -3.2363E-01 | 3 1 30.00 | -2.4290E-01 | 3 2 28.99 | -3.2376E-01 | 3.1984E-03 | 3.2377E-01 | 4483 |
| 59 PUD ACT | -1.5782E 00 | 3 1 37.46 | 1.1155E 00 | 3 2 28.18 | 1.1843E-01 | 6.6781E-01 | 6.1924E-01 | 4483 |
| 60 ELEVACT | 4.0948E-01 | 3 1 36.18 | 7.0861E 00 | 3 1 37.12 | 4.1960E 00 | 1.1066E 00 | 4.3394E 00 | 4483 |
| 61 LTALECT | -3.4401E 00 | 3 1 46.00 | 1.0047E 00 | 3 2 29.66 | -1.2242E 00 | 8.7829E-01 | 1.5066E 00 | 4483 |
| 62 LTALACT | -4.1301E-01 | 3 2 27.99 | 3.2192E 00 | 3 1 46.05 | 1.5126E 00 | 6.3358E-01 | 1.6400E 00 | 4483 |
| 63 PHI GYRO | -1.2269E 01 | 3 1 44.13 | 6.5451E-01 | 3 2 57.34 | -5.2554E 00 | 3.4761E 00 | 6.3010E 00 | 4483 |
| 64 P GYRO | -2.2472E 00 | 3 2 51.65 | 2.0225E 00 | 3 2 50.45 | -3.6808E-02 | 2.5551E-01 | 2.5815E-01 | 4483 |
| 65 | NTC | | | | | | | |
| 66 | NTC | | | | | | | |
| 67 ALT-LO | SSD | | | | | | | |
| 68 ALT-GD | 7.9473E-02 | 3 1 30.25 | 9.6028E-02 | 3 1 30.00 | 9.4869E-02 | 4.2256E-03 | 9.4963E-02 | 4483 |
| 69 LOC | SSD | | | | | | | |
| 70 GLID | -2.3457E-01 | 3 3 12.18 | -2.3582E-02 | 3 1 33.41 | -5.2311E-02 | 4.5486E-02 | 6.9321E-02 | 4483 |
| 71 | NTC | | | | | | | |
| 72 | NTC | | | | | | | |
| 73 | NTC | | | | | | | |
| 74 | NTC | | | | | | | |
| 75 | NTC | | | | | | | |
| 76 | NTC | | | | | | | |
| 77 OAT | 4.5137E 01 | 3 2 49.29 | 5.2380E 01 | 3 2 35.43 | 4.9253E 01 | 2.1688E 00 | 4.9300E 01 | 4483 |

## QUALITATIVE ANALYSIS

A/P NO. 0099 TEST NO. 0921 RUN NO. 124616 COND 2 CALIBRATION PROGRAM FLT COND

| BEGINNING TIME | ENDING TIME | SAMPLE SIZE |
|---|---|---|
| 3 1 30.01 | 3 3 20.01 | 4483 |

| | VARIABLE | MINIMUM | AT TIME (HMS) | MAXIMUM | AT TIME (HMS) | MEAN | SIGMA | RMS | SAMPLES |
|---|---|---|---|---|---|---|---|---|---|
| 1 | ZACC | 8.2588E-01 | 3 2 53.29 | 1.2548E 00 | 3 2 49.52 | 9.8029E-01 | 3.1446E-02 | 9.8379E-01 | 4483 |
| 2 | YACC | -9.1535E-02 | 3 2 51.77 | 6.3976E-02 | 3 2 53.04 | -1.4650E-02 | 1.0481E-02 | 1.8013E-02 | 4483 |
| 3 | XACC | -3.7616E-02 | 3 1 36.80 | 3.2603E-02 | 3 2 51.63 | -3.7596E-04 | 1.0452E-02 | 1.0459E-02 | 4483 |
| 4 | ALPHA | [illegible] | 3 2 [illegible] | [illegible] | 3 2 49.34 | [illegible] | [illegible] | [illegible] | 4483 |
| 5 | BETA | -7.4016E 00 | 3 2 53.09 | 5.1102E 00 | 3 2 51.25 | 2.7675E-01 | 4.2745E-01 | 5.0922E-01 | 4483 |
| 6 | TIM-TURN | -1.0655E-02 | 3 1 49.12 | 1.7080E 00 | 3 2 52.16 | 2.7503E-01 | 3.6140E-01 | 4.5464E-01 | 4483 |
| 7 | TIM-A/S | 7.0396E 01 | 3 2 23.15 | 8.0494E 01 | 3 1 30.00 | 7.4540E 01 | 2.6206E 00 | 7.4586E 01 | 4483 |
| 8 | TIM | 7.0396E 01 | 3 2 53.14 | 8.1616E 01 | 3 1 32.12 | 7.4805E 01 | 2.5818E 00 | [illegible] | 4483 |
| 9 | ALTI | 4.5591E 03 | 3 3 16.43 | 5.6570E 03 | 3 1 30.00 | 5.1760E 03 | 3.7469E 02 | 5.1896E 03 | 4483 |
| 10 | ALTILINE | 4.6224E 03 | 3 3 19.71 | 5.8806E 03 | 3 1 30.00 | 5.2204E 03 | 3.7345E 02 | 5.2337E 03 | 4483 |
| 11 | VIAS | 1.4360E 02 | 3 2 52.19 | 1.5844E 02 | 3 1 37.46 | 1.4952E 02 | 2.9212E 00 | 1.4955E 02 | 4483 |
| 12 | VIASLINE | 1.4165E 02 | 3 2 53.24 | 1.5507E 02 | 3 1 32.23 | 1.4834E 02 | 2.8702E 00 | 1.4837E 02 | 4483 |
| 13 | DELE | -4.6617E-01 | 3 2 53.54 | -2.2395E-01 | 3 1 38.57 | -3.8426E-01 | 6.3714E-02 | 3.8950E-01 | 4483 |
| 14 | FAILRGHT | -1.6154E 00 | 3 2 33.56 | 1.3646E 00 | 3 2 27.56 | -1.3930E-01 | 4.8679E-01 | 5.0633E-01 | 4463 |
| 15 | FAILLEFT | -6.7580E-01 | 3 2 28.16 | 2.2460E 00 | 3 2 33.56 | 8.8570E-01 | 4.6958E-01 | 1.0025E 00 | 4483 |
| 16 | FRUD | 2.7969E-02 | 3 1 31.13 | 3.3434E-01 | 3 2 20.16 | 1.5701E-01 | 6.4825E-02 | 1.5987E-01 | 4483 |
| 17 | AIL-TRIM | 9.2300E-01 | 3 3 3.27 | 3.0769E 00 | 3 1 30.18 | 2.5915E 00 | 7.5613E-01 | 2.6996E 00 | 4483 |
| 18 | RUD-TRIM | -5.4340E-01 | 3 1 30.00 | -5.4340E-01 | 3 1 30.00 | -5.4340E-01 | 0.0 | 5.4340E-01 | 4483 |
| 19 | STAPPOS | 8.5948E-01 | 3 1 31.60 | 9.6230E-01 | 3 2 11.28 | 9.2158E-01 | 4.7467E-02 | 9.2280E-01 | 4483 |
| 20 | THELLEFT | 2.2769E 00 | 3 1 30.00 | 2.4752E 00 | 3 2 10.32 | 2.3757E 00 | 6.8693E-02 | 2.3767E 00 | 4483 |
| 21 | THRRGHT | 2.1099E 00 | 3 1 41.66 | 2.4231E 00 | 3 2 10.25 | 2.2743E 00 | 1.0798E-01 | 2.2769E 00 | 4483 |
| 22 | FLAP | -2.0558E-01 | 3 1 30.00 | -2.0558E-01 | 3 1 30.00 | -2.0558E-01 | 0.0 | 2.0558E-01 | 4483 |
| 23 | DISC 23 | DISCRETE | | | | | | | |
| 24 | DISC 24 | DISCRETE | | | | | | | |
| 25 | SELI | 6.4496E-01 | 3 2 8.82 | 1.1373E 00 | 3 1 30.23 | 7.9396E-01 | 1.0888E-01 | 8.0139E-01 | 4483 |
| 26 | SAILRGHT | 1.3428E-03 | 3 2 34.13 | 1.0490E 00 | 3 1 30.30 | 3.6661E-01 | 3.2228E-01 | 4.8813E-01 | 4483 |
| 27 | THETA | -1.3436E 00 | 3 2 30.08 | 1.4795E 00 | 3 3 9.94 | 1.7361E-01 | 5.4229E-01 | 5.6940E-01 | 4483 |
| 28 | PHI | -5.6229E 00 | 3 2 17.95 | 4.4225E 00 | 3 2 34.11 | -7.3217E-01 | 1.4807E 00 | 1.6518E 00 | 4483 |
| 29 | SAILLEFT | -1.0256E 00 | 3 1 30.00 | -1.3861E-01 | 3 2 49.81 | -5.3395E-01 | 1.9999E-01 | 5.7017E-01 | 4483 |
| 30 | SRUD | -2.4146E-01 | 3 1 30.03 | 1.5060E-02 | 3 2 24.96 | -9.2209E-02 | 4.4772E-02 | 1.0248E-01 | 4483 |
| 31 | AIL-SIGN | 2.2615E 01 | 3 1 30.00 | 2.2615E 01 | 3 1 30.00 | 2.2615E 01 | 0.0 | 2.2615E 01 | 4483 |
| 32 | RUDDSIGN | 2.0096E 01 | 3 1 30.00 | 2.0096E 01 | 3 1 30.00 | 2.0096E 01 | 0.0 | 2.0096E 01 | 4483 |
| 33 | DC MONT | 1.1424E 01 | 3 1 32.23 | 1.1475E 01 | 3 1 30.00 | 1.1472E 01 | 1.2363E-02 | 1.1472E 01 | 4483 |
| 34 | HEAD | 3.3797E 01 | 3 2 24.89 | 3.4922E 01 | 3 2 24.87 | 3.4001E 01 | 9.6946E-02 | 3.4001E 01 | 4483 |
| 35 | | NTC | | | | | | | |
| 36 | Q | -1.9182E 00 | 3 2 51.79 | 2.5861E-01 | 3 2 53.11 | -5.6133E-01 | 1.8671E-01 | 5.9157E-01 | 4483 |
| 37 | AC MONT | SSD | | | | | | | |
| 38 | | NTC | | | | | | | |
| 39 | | NTC | | | | | | | |
| 40 | P | -5.9019E 00 | 3 2 56.55 | 4.0292E 00 | 3 2 51.65 | -1.3033E 00 | 9.9158E-01 | 1.6376E 00 | 4483 |
| 41 | QDOT | 1.1765E-02 | 3 2 49.52 | 1.1765E-01 | 3 2 52.04 | 6.2429E-02 | 6.6082E-03 | 6.2787E-02 | 4483 |
| 42 | R | -3.4123E 00 | 3 2 52.28 | 3.8038E 00 | 3 2 53.04 | 9.8801E-02 | 6.0571E-01 | 6.1371E-01 | 4483 |
| 43 | PDOT | 7.8449E-02 | 3 2 52.33 | 7.7070E-01 | 3 2 49.29 | 1.3503E-01 | 1.7717E-02 | 1.3618E-01 | 4483 |
| 44 | RDOT | 5.7732E-02 | 3 2 49.61 | 1.2701E-01 | 3 2 49.39 | 9.2629E-02 | 6.2611E-03 | 9.3041E-02 | 4483 |
| 45 | FDAC | 4.9390E-01 | 3 2 55.94 | 9.2175E-01 | 3 1 34.77 | 8.0994E-01 | 1.1624E-01 | 8.1824E-01 | 4483 |
| 46 | FLAC | 1.7518E 00 | 3 2 52.28 | 3.0385E 00 | 3 1 43.89 | 2.4409E 00 | 1.8561E-01 | 2.4479E 00 | 4483 |
| 47 | RAAC | 5.2371E-02 | 3 1 42.79 | 8.3449E-01 | 3 1 46.00 | 3.2146E-01 | 1.7130E-01 | 3.6425E-01 | 4485 |
| 48 | LAAC | 1.8187E-01 | 3 2 29.41 | 6.5149E-01 | 3 1 46.30 | 3.4760E-01 | 9.3776E-02 | 3.6002E-01 | 4483 |
| 49 | RUDTGYRO | -2.7636E 00 | 3 2 53.79 | 2.7808E 00 | 3 2 52.36 | -1.0025E-01 | 4.5732E-01 | 4.6818E-01 | 4483 |

QUALITATIVE ANALYSIS

A/P NO. 0099 TEST NO. 0921 RUN NO. 124616 COND 3 CALIBRATION PROGRAM FLT COND

| BEGINNING TIME | ENDING TIME | SAMPLE SIZE |
|---|---|---|
| 3 11 25.01 | 3 13 20.02 | 4689 |

| VARIABLE | MINIMUM | AT TIME (HMS) | MAXIMUM | AT TIME (HMS) | MEAN | SIGMA | RMS | SAMPLES |
|---|---|---|---|---|---|---|---|---|
| 1 ZACC | 6.9914E-01 | 3 11 31.21 | 1.7131E 00 | 3 11 45.60 | 1.0626E 00 | 1.5525E-01 | 1.0739E 00 | 4689 |
| 2 YACC | -8.5630E-02 | 3 11 29.23 | 8.8583E-02 | 3 12 15.69 | 5.3157E-03 | 2.6585E-02 | 2.6791E-02 | 4689 |
| 3 XACC | -1.4131E-01 | 3 11 55.21 | 1.1364E-01 | 3 12 14.88 | 2.3832E-02 | 5.4130E-02 | 5.9144E-02 | 4689 |
| 4 ALPHA | -1.6423E 00 | 3 11 56.46 | 6.1452E 00 | 3 11 36.14 | 2.5506E 00 | 1.4023E 00 | 3.2127E 00 | 4689 |
| 5 BETA | -7.1260E 00 | 3 12 16.00 | 4.8425E 00 | 3 12 49.80 | -7.1365E-01 | 2.0594E 00 | 2.1796E 00 | 4689 |
| 6 TIM-TURB | -5.9500E-01 | 3 12 42.14 | 3.2130E 00 | 3 12 6.26 | 1.4239E 00 | 5.2132E-01 | 1.5154E 00 | 4689 |
| 7 TIM-A/S | 3.0605E 01 | 3 12 10.90 | 7.4034E 01 | 3 11 26.02 | 4.2123E 01 | 1.3479E 01 | 4.4227E 01 | 4689 |
| 8 TIM | 3.1126E 01 | 3 12 10.71 | 7.4114E 01 | 3 11 26.62 | 4.2419E 01 | 1.3536E 01 | 4.4527E 01 | 4689 |
| 9 ALTI | 2.7147E 03 | 3 11 55.96 | 2.9679E 03 | 3 11 33.96 | 2.7786E 03 | 6.2562E 01 | 2.7793E 03 | 4689 |
| 10 ALTIFINE | 2.7315E 03 | 3 12 13.13 | 2.9626E 03 | 3 11 33.96 | 2.7981E 03 | 5.3005E 01 | 2.7986E 03 | 4689 |
| 11 VIAS | 8.9677E 01 | 3 12 11.91 | 1.4966E 02 | 3 11 26.06 | 1.0724E 02 | 1.8691E 01 | 1.0886E 02 | 4689 |
| 12 VIASFINE | 6.6229E 01 | 3 12 15.29 | 1.4975E 02 | 3 11 26.09 | 1.0556E 02 | 1.9311E 01 | 1.0731E 02 | 4689 |
| 13 PELE | -5.1601E 00 | 3 12 51.58 | 1.5160E 00 | 3 11 35.93 | -2.7531E 00 | 1.6138E 00 | 3.1912E 00 | 4689 |
| 14 PAILRGHT | -6.7404E 00 | 3 12 44.98 | 1.0712E 01 | 3 11 54.08 | 1.1557E 00 | 2.6174E 00 | 2.8566E 00 | 4689 |
| 15 PAILLEFT | -9.9243E 00 | 3 11 54.88 | 7.6697E 00 | 3 12 44.95 | -2.9276E-01 | 2.5912E 00 | 2.6077E 00 | 4689 |
| 16 PRUD | -4.7716E 00 | 3 11 35.99 | 6.1975E 00 | 3 13 6.97 | 2.3401E 00 | 2.9792E 00 | 3.7933E 00 | 4689 |
| 17 AIL-TRIM | 8.2651E-01 | 3 11 47.73 | 1.0256E 00 | 3 11 25.01 | 8.8521E-01 | 6.0882E-02 | 8.9030E-01 | 4689 |
| 18 RUD-TRIM | -5.4340E-01 | 3 11 25.01 | 4.6491E 00 | 3 12 43.02 | 1.1629E 00 | 2.4245E 00 | 2.6889E 00 | 4689 |
| 19 STABPOS | -1.2956E-01 | 3 11 54.31 | 1.6246E 00 | 3 11 45.25 | 6.6229E-01 | 3.8669E-01 | 7.6692E-01 | 4689 |
| 20 THROLLEFT | 2.2769E 00 | 3 11 32.84 | 3.4587E 00 | 3 12 13.92 | 3.0071E 00 | 4.9136E-01 | 3.0470E 00 | 4689 |
| 21 THROLRGHT | 2.1511E 00 | 3 11 33.74 | 3.4519E 00 | 3 12 13.87 | 2.9151E 00 | 5.0496E-01 | 2.9585E 00 | 4689 |
| 22 FLAP | -2.0558E-01 | 3 11 25.01 | 4.2800E 01 | 3 12 19.98 | 3.3997E 01 | 1.6430E 01 | 3.7759E 01 | 4689 |
| 23 DISC 23 | DISCRETE | | | | | | | |
| 24 DISC 24 | DISCRETE | | | | | | | |
| 25 SELE | -5.0527E 00 | 3 12 52.27 | 1.8407E 00 | 3 11 36.12 | -2.6350E 00 | 1.9601E 00 | 3.2841E 00 | 4689 |
| 26 SAILRGHT | -5.4461E 00 | 3 12 45.28 | 9.3749E 00 | 3 11 55.21 | 1.3199E 00 | 2.3952E 00 | 2.7348E 00 | 4689 |
| 27 TETA | -4.8726E 00 | 3 11 55.34 | 5.1849E 00 | 3 12 10.76 | 1.8575E 00 | 1.5964E 00 | 2.4492E 00 | 4689 |
| 28 PHI | -4.5311E 01 | 3 11 41.20 | 2.9950E 01 | 3 12 1.77 | -4.0062E 00 | 1.9363E 01 | 1.9773E 01 | 4689 |
| 29 SAILLEFT | -6.1184E 00 | 3 11 55.27 | 4.3462E 00 | 3 12 45.30 | -5.3384E-01 | 1.8291E 00 | 1.9054E 00 | 4689 |
| 30 SRUD | -4.4311E 00 | 3 11 34.14 | 7.5394E 00 | 3 13 7.24 | 2.1617E 00 | 2.8918E 00 | 3.6105E 00 | 4689 |
| 31 AIL-SIGN | 5.4348E 00 | 3 11 33.99 | 2.2615E 01 | 3 11 25.01 | 2.1178E 01 | 2.9958E 00 | 2.1389E 01 | 4689 |
| 32 RUDDSIGN | 1.0150E 01 | 3 11 34.04 | 2.0096E 01 | 3 11 25.01 | 1.9968E 01 | 1.2279E 00 | 1.9905E 01 | 4689 |
| 33 DC MONT | 1.1270E 01 | 3 11 55.66 | 1.1610E 01 | 3 11 34.26 | 1.1353E 01 | 8.1585E-02 | 1.1354E 01 | 4689 |
| 34 HEAD | 1.3906E 01 | 3 11 56.52 | 2.7190E 01 | 3 11 28.64 | 1.9843E 01 | 3.1951E 00 | 2.0099E 01 | 4688 |
| 35 | NTC | | | | | | | |
| 36 Q | -4.7046E 00 | 3 12 15.86 | 5.9164E 00 | 3 11 45.23 | 4.4120E-01 | 1.8980E 00 | 1.9486E 00 | 4689 |
| 37 AC MONT | 2.4130E 01 | 3 11 33.96 | 2.4790E 01 | 3 11 34.29 | 2.4156E 01 | 1.1004E-01 | 2.4156E 01 | 45 |
| 38 | NTC | | | | | | | |
| 39 | NTC | | | | | | | |
| 40 P | -1.7882E 01 | 3 11 33.82 | 1.7857E 01 | 3 12 0.32 | -1.3984E 00 | 5.0471E 00 | 5.2373E 00 | 4689 |
| 41 QDOT | 5.1476E-85 | 3 11 52.22 | 1.4178E-01 | 3 11 29.82 | 6.2532E-02 | 1.4429E-02 | 6.4224E-02 | 4689 |
| 42 R | -6.2167E 00 | 3 11 49.18 | 6.5753E 00 | 3 12 3.19 | -2.4458E-01 | 2.8521E 00 | 2.8625E 00 | 4689 |
| 43 PDOT | 5.1476E-85 | 3 11 26.73 | 3.2716E-01 | 3 11 26.16 | 1.3741E-01 | 3.3880E-02 | 1.4153E-01 | 4689 |
| 44 RDOT | 4.6165E-02 | 3 11 33.01 | 1.3856E-01 | 3 11 27.59 | 9.3537E-02 | 1.0993E-02 | 9.4175E-02 | 4689 |
| 45 RUAC | 1.8273E-01 | 3 11 26.04 | 1.5830E 00 | 3 12 19.69 | 6.5889E-01 | 3.0711E-01 | 7.2694E-01 | 4689 |
| 46 LLAC | 5.3207E-01 | 3 12 3.63 | 3.5063E 00 | 3 11 46.73 | 1.9204E 00 | 5.3592E-01 | 1.9936E 00 | 4689 |
| 47 RA/C | 1.3266E-02 | 3 12 0.20 | 1.1865E 00 | 3 11 32.81 | 3.6091E-01 | 1.9908E-01 | 4.1217E-01 | 4689 |
| 48 LAAC | 1.8187E-01 | 3 11 27.41 | 9.6457E-01 | 3 11 55.17 | 4.5826E-01 | 1.4679E-01 | 4.8120E-01 | 4689 |
| 49 FOOTGYRO | -5.3901E 00 | 3 12 3.24 | 5.7966E 00 | 3 11 49.28 | 2.9737E-01 | 2.3697E 00 | 2.3883E 00 | 4689 |

## QUALITATIVE ANALYSIS

A/P NO. 0099 TEST NO. 0921 RUN NO. 124616 COND 3 CALIBRATION PROGRAM FLT COND

| BEGINNING TIME | ENDING TIME | SAMPLE SIZE |
|---|---|---|
| 3 11 25.01 | 3 13 20.02 | 4689 |

| VARIABLE | MINIMUM | AT TIME (HMS) | MAXIMUM | AT TIME (HMS) | MEAN | SIGMA | RMS | SAMPLES |
|---|---|---|---|---|---|---|---|---|
| 50 | NTC | | | | | | | |
| 51 TETACOMM | -9.0449E 00 | 3 12 3.93 | 1.0668E 01 | 3 11 41.70 | -7.7631E 00 | 4.1541E 00 | 8.8047E 00 | 4689 |
| 52 PHI COMM | -1.1931E 01 | 3 12 5.50 | 1.4634E 01 | 3 12 50.43 | 9.5800E-01 | 1.2649E 01 | 1.2686E 01 | 4689 |
| 53 PSI COMM | -2.4346E 00 | 3 12 3.09 | 7.0627E 00 | 3 11 29.79 | 3.2133E 00 | 1.8144E 00 | 3.6464E 00 | 4689 |
| 54 IPSICOMM | -2.6241E-01 | 3 11 41.23 | -6.7149E-02 | 3 11 34.06 | -1.4635E-01 | 4.1394E-02 | 1.5209E-01 | 4689 |
| 55 ELERSIGN | 3.0105E 01 | 3 11 25.01 | 3.0105E 01 | 3 11 25.01 | 3.0105E 01 | 0.0 | 3.0105E 01 | 4689 |
| 56 | NTC | | | | | | | |
| 57 TETAGYRO | -7.0054E 00 | 3 12 16.76 | 1.5595E 00 | 3 11 53.27 | -3.1021E 00 | 1.6360E 00 | 3.5071E 00 | 4689 |
| 58 Q GYRO | -3.2380E-01 | 3 11 30.34 | 8.8698E-02 | 3 11 41.32 | -2.1057E-01 | 6.0257E-02 | 2.2136E-01 | 4689 |
| 59 RUD ACT | -1.0011E 01 | 3 11 32.69 | 4.6291E 00 | 3 12 19.73 | -4.7420E-01 | 1.8146E 00 | 1.8755E 00 | 4689 |
| 60 ELEVACT | -2.0510E 00 | 3 12 3.71 | 8.4941E 00 | 3 11 47.96 | 2.3936E 00 | 1.8679E 00 | 3.4441E 00 | 4689 |
| 61 ETALACT | -2.6119E 00 | 3 12 44.42 | 5.9243E 00 | 3 11 59.00 | -6.4239E-01 | 2.1735E 00 | 2.2696E 00 | 4689 |
| 62 LTALACT | -5.6028E 00 | 3 11 59.09 | 5.7969E 00 | 3 12 44.42 | 7.5095E-02 | 2.4472E 00 | 2.4483E 00 | 4689 |
| 63 PHI GYRO | -3.4287E 01 | 3 12 1.79 | 4.2297E 01 | 3 11 49.47 | 2.3045E 00 | 1.9310E 01 | 1.9447E 01 | 4689 |
| 64 P GYRO | -1.5281E 01 | 3 12 0.27 | 1.5730E 01 | 3 11 33.94 | 8.5488E-02 | 3.3102E 00 | 3.3113E 00 | 4689 |
| 65 | NTC | | | | | | | |
| 66 | NTC | | | | | | | |
| 67 ALT-LO | 3.7379E-01 | 3 13 16.10 | 5.8571E 00 | 3 11 43.59 | 3.6248E 00 | 1.4300E 00 | 3.8967E 00 | 4689 |
| 68 ALT-GO | 6.2916E-02 | 3 11 25.45 | 7.9473E-02 | 3 11 25.01 | 7.6182E-02 | 6.6074E-03 | 7.6468E-02 | 4689 |
| 69 LOC | -1.1091E 00 | 3 11 47.66 | 1.4583E 00 | 3 11 22.52 | 5.5241E-01 | 7.5094E-01 | 9.3223E-01 | 4546 |
| 70 GLID | -8.8773E-01 | 3 12 16.96 | -4.7659E-01 | 3 13 19.90 | -8.0672E-01 | 6.8572E-02 | 8.0963E-01 | 4689 |
| 71 | NTC | | | | | | | |
| 72 | NTC | | | | | | | |
| 73 | NTC | | | | | | | |
| 74 | NTC | | | | | | | |
| 75 | NTC | | | | | | | |
| 76 | NTC | | | | | | | |
| 77 OAT | 5.2380E 01 | 3 12 35.83 | 5.6725E 01 | 3 11 39.19 | 5.3545E 01 | 9.5874E-01 | 5.3553E 01 | 4689 |

QUALITATIVE ANALYSIS

A/P NO. 0099 TEST NO. 0921 RUN NO. 124616 COND 4 CALIBRATION PROGRAM FLT COND

| BEGINNING TIME | ENDING TIME | SAMPLE SIZE |
|---|---|---|
| 3 13 20.27 | 3 15 30.01 | 5277 |

| VARIABLE | MINIMUM | AT TIME (HMS) | MAXIMUM | AT TIME (HMS) | MEAN | SIGMA | RMS | SAMPLES |
|---|---|---|---|---|---|---|---|---|
| 1 ZACC | 7.4783E-01 | 3 13 24.53 | 1.3621E 00 | 3 15 23.53 | 1.0014E 00 | 8.4909E-02 | 1.0050E 00 | 5277 |
| 2 YACC | -7.9724E-02 | 3 14 39.94 | 9.3504E-02 | 3 15 21.96 | -9.9716E-03 | 2.1387E-02 | 2.3568E-02 | 5277 |
| 3 XACC | -5.9803E-02 | 3 14 29.27 | 9.1096E-02 | 3 13 27.75 | -3.4240E-02 | 3.6174E-02 | 4.9809E-02 | 5277 |
| 4 ALPHA | -7.6923E-01 | 3 14 21.10 | 5.9519E 00 | 3 13 22.06 | 1.6923E 00 | 9.3644E-01 | 1.9224E 00 | 5277 |
| 5 BETA | -7.1260E 00 | 3 14 33.24 | 5.3937E 00 | 3 13 25.16 | 2.1738E-01 | 1.5228E 00 | 1.5382E 00 | 5277 |
| 6 TIM-TURB | 7.1222E-01 | 3 14 47.69 | 2.3143E 00 | 3 15 22.76 | 1.5793E 00 | 3.6412E-01 | 1.6207E 00 | 5277 |
| 7 TIM-A/S | 3.0005E 01 | 3 13 25.71 | 4.5469E 01 | 3 14 30.48 | 3.7566E 01 | 2.1895E 00 | 3.7632E 01 | 5277 |
| 8 TIM | 3.0005E 01 | 3 13 25.95 | 4.4500E 01 | 3 14 30.50 | 3.7815E 01 | 2.1850E 00 | 3.7881E 01 | 5277 |
| 9 ALTI | 1.6900E 03 | 3 15 29.71 | 2.9196E 03 | 3 13 34.26 | 2.2571E 03 | 3.6902E 02 | 2.3858E 03 | 5277 |
| 10 ALTIFINE | 1.7103E 03 | 3 15 29.71 | 2.9398E 03 | 3 13 34.26 | 2.3717E 03 | 3.7859E 02 | 2.4017E 03 | 5277 |
| 11 VIAS | 9.2603E 01 | 3 13 24.20 | 1.1309E 02 | 3 14 30.82 | 1.0307E 02 | 3.4896E 00 | 1.0313E 02 | 5277 |
| 12 VIASFINE | 6.6497E 01 | 3 13 20.42 | 1.1278E 02 | 3 13 29.75 | 1.0194E 02 | 5.4276E 00 | 1.0208E 02 | 5277 |
| 13 FELE | -4.7668E 00 | 3 13 36.30 | -4.5210E-01 | 3 15 21.99 | -1.9679E 00 | 9.7112E-01 | 2.1944E 00 | 5277 |
| 14 FAILRGHT | -5.0278E 00 | 3 14 39.87 | 6.1923E 00 | 3 15 22.16 | 1.0464E 00 | 1.9395E 00 | 2.2037E 00 | 5277 |
| 15 FAILLEFT | -5.5706E 00 | 3 15 22.16 | 5.7421E 00 | 3 14 39.96 | -1.9605E-01 | 1.8823E 00 | 1.8925E 00 | 5277 |
| 16 FRUD | 1.4576E 00 | 3 14 53.59 | 6.1975E 00 | 3 13 27.06 | 3.9557E 00 | 1.1029E 00 | 4.1062E 00 | 5277 |
| 17 AIL-TRIM | 8.2057E-01 | 3 13 20.47 | 9.2308E-01 | 3 13 20.27 | 8.5569E-01 | 4.6697E-02 | 8.5708E-01 | 5277 |
| 18 RUD-TRIM | 4.5283E 00 | 3 13 25.93 | 4.6491E 00 | 3 13 20.27 | 4.6451E 00 | 2.1730E-02 | 4.6452E 00 | 5277 |
| 19 STABPOS | -7.4851E-01 | 3 14 49.65 | 5.3778E-01 | 3 13 20.27 | -3.3966E-01 | 4.1114E-01 | 5.6646E-01 | 5277 |
| 20 THRLEFT | 2.4256E 00 | 3 13 55.98 | 3.4008E 00 | 3 13 20.27 | 2.7750E 00 | 2.3114E-01 | 2.7846E 00 | 5277 |
| 21 THRD.GHT | 2.4231E 00 | 3 13 59.96 | 3.3226E 00 | 3 13 24.60 | 2.7262E 00 | 2.0580E-01 | 2.7339E 00 | 5277 |
| 22 FLAP | 4.2624E 01 | 3 14 54.55 | 4.2800E 01 | 3 13 20.27 | 4.2790E 01 | 3.4727E-02 | 4.2790E 01 | 5277 |
| 23 DISC 23 | DISCRETE | | | | | | | |
| 24 DISC 24 | DISCRETE | | | | | | | |
| 25 SELE | -4.6302E 00 | 3 13 23.15 | -4.1007E-01 | 3 15 22.36 | -1.8751E 00 | 1.0587E 00 | 2.1516E 00 | 5277 |
| 26 SAILRGHT | -2.9795E 00 | 3 14 40.41 | 5.2893E 00 | 3 15 22.58 | 8.4602E-01 | 1.5609E 00 | 1.7754E 00 | 5277 |
| 27 THIA | -6.4606E 00 | 3 14 20.12 | 6.5965E 00 | 3 13 21.63 | -2.3386E 00 | 2.1884E 00 | 3.2028E 00 | 5277 |
| 28 PHI | -1.9744E 01 | 3 13 26.52 | 1.0016E 01 | 3 14 37.56 | -2.1244E 00 | 5.0769E 00 | 5.5034E 00 | 5277 |
| 29 SAILLEFT | -2.6295E 00 | 3 15 22.58 | 3.0566E 00 | 3 14 40.21 | -9.7364E-02 | 1.1301E 00 | 1.1343E 00 | 5277 |
| 30 SRUD | 1.2121E 00 | 3 14 54.23 | 7.5394E 00 | 3 13 27.78 | 3.8069E 00 | 1.0714E 00 | 3.9548E 00 | 5277 |
| 31 AIL-SIGN | 1.1995E 01 | 3 13 25.53 | 2.2015E 01 | 3 13 20.27 | 2.1499E 01 | 2.0116E 00 | 2.1593E 01 | 5277 |
| 32 RUDDSIGN | 2.0096E 01 | 3 13 20.27 | 2.0096E 01 | 3 13 20.27 | 2.0096E 01 | 0.0 | 2.0096E 01 | 5277 |
| 33 DC MONT | 1.1270E 01 | 3 13 20.27 | 1.1424E 01 | 3 15 25.73 | 1.1328E 01 | 3.8822E-02 | 1.1328E 01 | 5277 |
| 34 HEAD | 1.8549E 01 | 3 14 17.47 | 2.1497E 01 | 3 13 20.42 | 1.9417E 01 | 5.2169E-01 | 1.9424E 01 | 5277 |
| 35 | NIC | | | | | | | |
| 36 Q | -3.1373E 00 | 3 15 29.89 | 2.6096E 00 | 3 13 27.28 | -5.9394E-01 | 8.5037E-01 | 1.0373E 00 | 5277 |
| 37 AC MONT | SSO | | | | | | | |
| 38 | NIC | | | | | | | |
| 39 | NTC | | | | | | | |
| 40 P | -1.3864E 01 | 3 13 46.62 | 8.8824E 00 | 3 14 53.00 | -1.4463E 00 | 3.5297E 00 | 3.8146E 00 | 5277 |
| 41 CDOT | 1.1761E-02 | 3 13 49.04 | 1.1765E-01 | 3 13 34.63 | 6.2513E-02 | 1.2607E-02 | 6.3772E-02 | 5277 |
| 42 R | -5.1457E 00 | 3 13 26.47 | 4.8419E 00 | 3 15 22.51 | -1.6208E-01 | 1.3574E 00 | 1.3631E 00 | 5277 |
| 43 PDOT | -4.2671E-02 | 3 14 53.27 | 3.4130E-01 | 3 14 30.67 | 1.3738E-01 | 3.5552E-02 | 1.4191E-01 | 5277 |
| 44 RDOT | 4.6125E-02 | 3 14 39.89 | 1.3856E-01 | 3 14 38.61 | 9.3824E-02 | 1.1047E-02 | 9.4213E-02 | 5277 |
| 45 FUAC | 1.2725E-01 | 3 13 22.60 | 1.5830E 00 | 3 13 50.84 | 7.4984E-01 | 2.7851E-01 | 7.9614E-01 | 5277 |
| 46 LLAC | 9.3299E-01 | 3 13 26.86 | 2.8045E 00 | 3 13 56.18 | 1.7443E 00 | 3.4712E-01 | 1.7790E 00 | 5277 |
| 47 FAAC | 1.3266E-02 | 3 13 56.12 | 1.1012E 00 | 3 13 52.41 | 3.3736E-01 | 1.8995E-01 | 3.8716E-01 | 5277 |
| 48 LAAC | 2.2101E-01 | 3 13 22.46 | 7.2976E-01 | 3 14 1.53 | 4.1902E-01 | 1.2834E-01 | 4.4124E-01 | 5277 |
| 49 RUDTGYRO | -3.9946E 00 | 3 15 22.58 | 4.7335E 00 | 3 13 26.52 | 1.4810E-01 | 1.0447E 00 | 1.0551E 00 | 5277 |

QUALITATIVE ANALYSIS

A/P NO. 0099 TEST NO. 0921 RUN NO. 124616 COND 4 CALIBRATION PROGRAM FLT COND

| BEGINNING TIME | ENDING TIME | SAMPLE SIZE |
|---|---|---|
| 3 13 20.27 | 3 15 30.01 | 5277 |

| VARIABLE | MINIMUM | AT TIME (HMS) | MAXIMUM | AT TIME (HMS) | MEAN | SIGMA | RMS | SAMPLES |
|---|---|---|---|---|---|---|---|---|
| 50 | NTC | | | | | | | |
| 51 THTACOMM | -8.9664E 00 | 3 13 48.64 | -8.8694E 00 | 3 13 21.72 | -8.9409E 00 | 3.5958E-02 | 8.9410E 00 | 5277 |
| 52 PHI COMM | -1.1673E 01 | 3 13 20.27 | 1.4624E 01 | 3 13 26.50 | 1.5661E 00 | 1.2162E 01 | 1.2267E 01 | 5277 |
| 53 PSI COMM | -1.5546E 00 | 3 15 22.55 | 8.1179E 00 | 3 13 26.52 | 4.1037E 00 | 1.2322E 00 | 4.2656E 00 | 5277 |
| 54 EPSICOMM | -1.9430E-01 | 3 13 22.04 | -1.0620E-01 | 3 13 25.58 | -1.3106E-01 | 2.6043E-02 | 1.3362E-01 | 5277 |
| 55 ELERSION | 3.0105E 01 | 3 13 20.27 | 3.0105E 01 | 3 13 20.27 | 3.0105E 01 | 0.0 | 3.0105E 01 | 5277 |
| 56 | NTC | | | | | | | |
| 57 THETAGYRO | -6.7658E 00 | 3 13 21.38 | 4.8916E 00 | 3 14 20.22 | 2.6959E 00 | 2.2872E 00 | 3.5354E 00 | 5277 |
| 58 Q GYRO | -2.4290E-01 | 3 13 20.27 | -1.6193E-01 | 3 13 21.32 | -2.3905E-01 | 1.7236E-02 | 2.3967E-01 | 5277 |
| 59 RUD ACT | -5.7944E 00 | 3 14 39.20 | 4.3949E 00 | 3 13 26.64 | -7.5255E-02 | 1.3625E 00 | 1.3645E 00 | 5277 |
| 60 ELEVACT | -8.7935E-01 | 3 13 26.77 | 6.2679E 00 | 3 15 25.59 | 2.3029E 00 | 1.1613E 00 | 2.5792E 00 | 5277 |
| 61 LTALACT | -5.2066E 00 | 3 14 2.09 | 5.3404E 00 | 3 15 21.94 | -1.3459E-01 | 2.1618E 00 | 2.1660E 00 | 5277 |
| 62 LTALACT | -5.3341E 00 | 3 15 21.96 | 5.2110E 00 | 3 15 3.64 | -3.8638E-01 | 2.2112E 00 | 2.2448E 00 | 5277 |
| 63 PHI GYRO | -1.2987E 01 | 3 15 3.72 | 1.9683E 01 | 3 13 26.54 | -1.7531E-01 | 5.3413E 00 | 5.3442E 00 | 5277 |
| 64 P GYRO | -5.8427E 00 | 3 14 57.97 | 9.6629E 00 | 3 13 48.62 | 2.2875E-01 | 1.7348E 00 | 1.7498E 00 | 5277 |
| 65 | NTC | | | | | | | |
| 66 | NTC | | | | | | | |
| 67 ALT-LO | -5.9082E 00 | 3 14 36.18 | 6.4952E-01 | 3 13 20.50 | -2.6872E 00 | 1.8911E 00 | 3.2860E 00 | 3092 |
| 68 ALT-GD | 7.7472E-02 | 3 13 20.27 | 9.6028E-02 | 3 14 28.38 | 8.4618E-02 | 7.6629E-03 | 8.4964E-02 | 5277 |
| 69 LOC | -2.1000E-01 | 3 14 7.21 | 8.6170E-01 | 3 13 20.27 | 3.9251E-01 | 2.5291E-01 | 4.7199E-01 | 5277 |
| 70 GLID | -4.6418E-01 | 3 13 20.27 | 5.7931E-01 | 3 13 54.70 | 1.2998E-01 | 2.5214E-01 | 2.8367E-01 | 5277 |
| 71 | NTC | | | | | | | |
| 72 | NTC | | | | | | | |
| 73 | NTC | | | | | | | |
| 74 | NTC | | | | | | | |
| 75 | NTC | | | | | | | |
| 76 | NTC | | | | | | | |
| 77 OAT | 5.2017E 01 | 3 13 38.96 | 5.9984E 01 | 3 15 29.12 | 5.5523E 01 | 2.1216E 00 | 5.5564E 01 | 5277 |

## QUALITATIVE ANALYSIS

A/P NO. 0099 TEST NO. 0921 RUN NO. 124616 COND 5 CALIBRATION PROGRAM FLT COND

| BEGINNING TIME | ENDING TIME | SAMPLE SIZE |
|---|---|---|
| 3 15 35.01 | 3 16 50.00 | 3054 |

| VARIABLE | MINIMUM | AT TIME (HMS) | MAXIMUM | AT TIME (HMS) | MEAN | SIGMA | RMS | SAMPLES |
|---|---|---|---|---|---|---|---|---|
| 1 ZACC | 6.6959E-01 | 3 16 12.04 | 1.5376E 00 | 3 15 37.90 | 1.0184E 00 | 1.1616E-01 | 1.0250E 00 | 3054 |
| 2 YACC | -1.3601E-01 | 3 16 26.05 | 9.9410E-02 | 3 16 27.63 | -1.8626E-02 | 2.9719E-02 | 3.5073E-02 | 3054 |
| 3 XACC | -3.0635E-02 | 3 15 55.08 | 2.7964E-01 | 3 15 52.56 | 1.5348E-01 | 5.0990E-02 | 1.6173E-01 | 3054 |
| 4 ALPHA | -2.8046E-01 | 3 15 30.33 | 9.6986E 00 | 3 15 5?.46 | 4.2321E 00 | 1.2617E 00 | 4.4526E 00 | 3054 |
| 5 BETA | -5.3750E 00 | 3 15 44.14 | 6.6536E 00 | 3 15 46.73 | 9.9085E-01 | 1.5401E 00 | 1.8313E 00 | 3054 |
| 6 TIP-TURB | 7.5130E-01 | 3 16 41.20 | 2.5004E 00 | 3 16 37.58 | 1.6420E 00 | 4.5607E-01 | 1.7042E 00 | 3054 |
| 7 TIM-A/S | 3.5615E 01 | 3 15 46.75 | 7.9377E 01 | 3 16 40.95 | 5.8058E 01 | 1.2462E 01 | 5.9381E 01 | 3054 |
| 8 TIM | 3.5615E 01 | 3 15 46.75 | 8.0494E 01 | 3 16 40.00 | 5.3310E 01 | 1.2453E 01 | 5.9634E 01 | 3054 |
| 9 ALTI | 1.6900E 03 | 3 15 35.73 | 2.5761E 03 | 3 16 31.15 | 2.1003E 03 | 3.0790E 02 | 2.1227E 03 | 3054 |
| 10 ALTIFINE | 1.6796E 03 | 3 15 37.38 | 2.5932E 03 | 3 16 49.63 | 2.1002E 03 | 3.1199E 02 | 2.1233E 03 | 3054 |
| 11 VIAS | 9.8455E 01 | 3 15 42.88 | 1.5551E 02 | 3 16 49.31 | 1.2978E 02 | 1.6693E 01 | 1.3085E 02 | 3054 |
| 12 VIASFINE | 9.6672E 01 | 3 16 [illegible] | 1.5296E 02 | 3 16 49.61 | 1.2856E 02 | 1.6165E 01 | 1.2957E 02 | 3054 |
| 13 DELE | -2.3913E 00 | 3 15 38.29 | 2.3427E 00 | 3 15 50.57 | -8.4576E-01 | 7.5451E-01 | 1.1334E 00 | 3054 |
| 14 DAILRGHT | -5.0276E 00 | 3 15 58.75 | 4.5565E 00 | 3 15 39.60 | -1.9305E-01 | 1.7934E 00 | 1.8038E 00 | 3054 |
| 15 DAILLEFT | -3.8172E 00 | 3 15 29.65 | 5.7431E 00 | 3 15 50.75 | 1.0081E 00 | 1.6814E 00 | 1.9605E 00 | 3054 |
| 16 PEDL | -3.8051E-01 | 3 16 2?.50 | 5.1536E 00 | 3 15 4?.02 | 1.8624E 00 | 1.3179E 00 | 2.2932E 00 | 3054 |
| 17 AIL-TRIM | -5.1262E-01 | 3 16 21.71 | 9.2308E-01 | 3 15 37.14 | 3.4628E-01 | 6.9018E-01 | 7.7218E-01 | 3054 |
| 18 RUD-TRIM | -2.1138E 00 | 3 16 22.90 | 4.6491E 00 | 3 15 35.01 | 1.8619E 00 | 2.4156E 00 | 3.0499E 00 | 3054 |
| 19 STABPOS | -6.2490E-01 | 3 15 35.01 | 1.4717E 00 | 3 15 56.24 | 7.3408E-01 | 6.5115E-01 | 9.8126E-01 | 3054 |
| 20 THRSLEFT | 2.8160E 00 | 3 15 35.01 | 3.7173E 00 | 3 15 36.71 | 3.6229E 00 | 1.6013E-01 | 3.6365E 00 | 3054 |
| 21 THRSRGHT | 2.7652E 00 | 3 15 35.03 | 3.6115E 00 | 3 15 36.76 | 3.5022E 00 | 9.9813E-02 | 3.5036E 00 | 3054 |
| 22 FLAP | -2.0598E-01 | 3 15 48.49 | 4.2800E 01 | 3 15 35.38 | 5.3503E 00 | 1.3404E 01 | 1.4432E 01 | 3054 |
| 23 DISC 23 | DISCRETE | | | | | | | |
| 24 DISC 24 | DISCRETE | | | | | | | |
| 25 SELE | -2.0981E 00 | 3 15 36.44 | 2.6847E 00 | 3 15 50.50 | -3.4002E-02 | 8.3937E-01 | 8.4006E-01 | 3054 |
| 26 SAILRGHT | -1.4143E 01 | 3 16 45.04 | 3.3536E 00 | 3 15 40.48 | -6.6329E-02 | 1.4132E 00 | 1.4147E 00 | 3054 |
| 27 TETA | -4.8726E 00 | 3 16 45.04 | 9.2432E 00 | 3 16 31.63 | 5.7660E 00 | 2.0500E 00 | 6.1203E 00 | 3054 |
| 28 PHI | -3.2702E 01 | 3 16 35.24 | 2.9990E 01 | 3 16 45.04 | -8.2256E 00 | 1.0952E 01 | 1.3697E 01 | 3054 |
| 29 SAILLEFT | -1.6346E 00 | 3 15 40.38 | 7.1368E 00 | 3 16 45.04 | 8.5482E-01 | 9.3269E-01 | 1.2652E 00 | 3054 |
| 30 SRUD | -1.6005E 00 | 3 16 45.04 | 4.8888E 00 | 3 15 40.95 | 1.6826E 00 | 1.3173E 00 | 2.1369E 00 | 3054 |
| 31 AIL-SIGN | 1.1602E 01 | 3 16 30.23 | 2.2615E 01 | 3 15 35.23 | 2.0936E 01 | 2.6300E 00 | 2.1126E 01 | 3053 |
| 32 RUDSIGN | 1.[illegible]E 01 | 3 15 45.[illegible] | 2.2096E 01 | 3 15 3?.01 | 2.0?54E 01 | 1.2196E-01 | 2.0094E 01 | 3054 |
| 33 TC MONT | 1.0245E 01 | 3 16 45.04 | 1.1526E 01 | 3 16 33.11 | 1.1382E 01 | 4.7220E-02 | 1.1382E 01 | 3054 |
| 34 HEAD | 1.0252E 01 | 3 16 45.04 | 1.9037E 01 | 3 16 28.46 | 1.7715E 01 | 1.8325E 00 | 1.7810E 01 | 3054 |
| 35 | NTC | | | | | | | |
| 36 Q | -3.4656E 00 | 3 15 48.56 | 2.6967E 00 | 3 15 37.80 | -1.7556E-01 | 9.8178E-01 | 9.9735E-01 | 3054 |
| 37 AC MONT | LSD | | | | | | | |
| 38 | NTC | | | | | | | |
| 39 | NTC | | | | | | | |
| 40 P | -9.7255E 00 | 3 15 44.14 | 6.0883E 00 | 3 16 12.58 | -1.5454E 00 | 2.8418E 00 | 3.2348E 00 | 3054 |
| 41 QDOT | -2.3529E-02 | 3 16 10.69 | 2.9765E 00 | 3 16 45.04 | 6.4236E-02 | 5.5142E-02 | 8.4558E-02 | 3054 |
| 42 R | -1.9508E 01 | 3 16 45.04 | 3.9240E 00 | 3 16 24.85 | -7.5297E-01 | 1.9310E 00 | 2.0726E 00 | 3054 |
| 43 PDOT | -2.8449E-02 | 3 16 10.61 | 2.8448E-01 | 3 15 44.73 | 1.3800E-01 | 3.8720E-02 | 1.4333E-01 | 3053 |
| 44 RDOT | -3.4639E-02 | 3 16 26.00 | 2.9218E 00 | 3 16 45.04 | 9.3574E-02 | 5.3239E-02 | 1.0033E-01 | 3054 |
| 45 RDAC | 1.0274E-01 | 3 15 42.54 | 6.3621E 00 | 3 16 45.04 | 7.1473E-01 | 3.1843E-01 | 7.8245E-01 | 3054 |
| 46 ELAC | 5.4308E-01 | 3 15 50.60 | 8.6141E 00 | 3 16 45.04 | 2.1265E 00 | 5.4003E-01 | 2.1940E 00 | 3054 |
| 47 RAAC | 1.2760E-02 | 3 15 41.14 | 9.9853E 00 | 3 16 45.04 | 3.7416E-01 | 2.8767E-01 | 4.7193E-01 | 3054 |
| 48 LAAC | 2.2101E-01 | 3 15 41.24 | 4.2481E 00 | 3 16 45.04 | 3.6976E-01 | 2.1793E-01 | 4.2791E-01 | 3054 |
| 49 ROOTGYRO | -1.0807E 01 | 3 16 45.04 | 4.9110E 00 | 3 16 29.66 | 5.7337E-01 | 1.5339E 00 | 1.6375E 00 | 3054 |

CUALITATIVE ANALYSIS

A/P NO. 6099 TEST NO. 0921 RUN NO. 124616 COND 5 CALIBRATION PROGRAM FLT COND

| BEGINNING TIME | ENDING TIME | SAMPLE SIZE |
|---|---|---|
| 3 15 35.01 | 3 16 50.00 | 3054 |

| VARIABLE | MINIMUM | AT TIME (HMS) | MAXIMUM | AT TIME (HMS) | MEAN | SIGMA | RMS | SAMPLES |
|---|---|---|---|---|---|---|---|---|
| 50 | NTC | | | | | | | |
| 51 TETACOMM | -9.0449E 00 | 3 15 48.70 | -8.9279E 00 | 3 15 35.06 | -8.9845E 00 | 2.1189E-02 | 8.9846E 00 | 3053 |
| 52 PHI COMM | -1.1173E 01 | 3 15 42.39 | 1.4634E 01 | 3 15 35.60 | -2.3069E 00 | 1.2211E 01 | 1.2427E 01 | 3054 |
| 53 PSI COMM | -2.[illegible]366E 00 | 3 16 28.65 | 8.7041E 00 | 3 16 24.35 | 3.0623E 00 | 1.6638E 00 | 3.4860E 00 | 3054 |
| 54 DPSICOMM | -1.8430E-01 | 3 15 42.27 | -1.0620E-01 | 3 15 35.01 | -1.3181E-01 | 1.9447E-02 | 1.3324E-01 | 3054 |
| 55 ELERSION | 3.0105E 01 | 3 15 35.01 | 3.0105E 01 | 3 15 35.01 | 3.0105E 01 | 0.0 | 3.0105E 01 | 3054 |
| 56 | NTC | | | | | | | |
| 57 TETAGYRO | -8.6326E 00 | 3 16 37.68 | 1.3867E 00 | 3 15 35.01 | -5.6245E 00 | 1.7277E 00 | 5.8964E 00 | 3054 |
| 58 [illegible] GYRO | -4.6582E-01 | 3 16 21.21 | -2.4290E-01 | 3 15 35.01 | -3.6386E-01 | 9.4996E-02 | 3.7606E-01 | 3054 |
| 59 RUD ACT | -7.3169E 00 | 3 15 43.45 | 2.6921E 00 | 3 16 23.89 | -1.7072E-01 | 1.4567E 00 | 1.4667E 00 | 3054 |
| 60 ELEVACT | -4.1601E 00 | 3 15 56.13 | 8.6113E 00 | 3 16 10.48 | 3.4951E 00 | 1.9474E 00 | 3.9986E 00 | 3054 |
| 61 RTALACT | -4.5714E 00 | 3 15 [illegible] | 4.1686E 00 | 3 16 9.95 | -8.7028E-01 | 1.8914E 00 | 2.0820E 00 | 3054 |
| 62 LTALACT | -4.7654E 00 | 3 16 9.97 | 4.7424E 00 | 3 15 43.50 | -3.3125E-02 | 1.8288E 00 | 1.8291E 00 | 3054 |
| 63 PHI GYRO | -3.4399E 00 | 3 15 42.98 | 2.8895E 01 | 3 16 35.91 | 4.9965E 00 | 1.0608E 01 | 1.1726E 01 | 3054 |
| 64 P GYRO | -3.8702E 00 | 3 16 12.55 | 6.0674E 00 | 3 16 30.23 | 2.9572E-01 | 1.3095E 00 | 1.3425E 00 | 3054 |
| 65 | NTC | | | | | | | |
| 66 | NTC | | | | | | | |
| 67 ALT-LO | SSU | | | | | | | |
| 68 ALT-GD | 9.6028E-02 | 3 15 35.01 | 9.6028E-02 | 3 15 35.01 | 9.6028E-02 | 0.0 | 9.6028E-02 | 3054 |
| 69 CLC | 9.8116E-01 | 3 15 35.01 | 1.4583E 00 | 3 15 44.33 | 1.1971E 00 | 1.4103E-01 | 1.1955E 00 | 384 |
| 70 CLID | -8.9091E-01 | 3 16 0.25 | 9.3214E-01 | 3 15 44.65 | -5.6022E-02 | 4.9091E-01 | 4.9409E-01 | 2715 |
| 71 | NTC | | | | | | | |
| 72 | NTC | | | | | | | |
| 73 | NTC | | | | | | | |
| 74 | NTC | | | | | | | |
| 75 | NTC | | | | | | | |
| 76 | NTC | | | | | | | |
| 77 OAT | 5.6363E 01 | 3 16 36.58 | 6.0346E 01 | 3 15 27.83 | 5.8350E 01 | 1.0895E 00 | 5.8360E 01 | 3054 |

## QUALITATIVE ANALYSIS

A/P NO. 0099 TEST NO. 0921 RUN NO. 148609 COND 6 CALIBRATION PROGRAM FLT COND

| BEGINNING TIME | ENDING TIME | SAMPLE SIZE |
|---|---|---|
| 3 29 10.00 | 3 30 30.00 | 3259 |

| VARIABLE | MINIMUM | AT TIME (HMS) | MAXIMUM | AT TIME (HMS) | MEAN | SIGMA | RMS | SAMPLES |
|---|---|---|---|---|---|---|---|---|
| 1 ZACG | 7.8688E-01 | 3 29 12.43 | 1.5376E 00 | 3 30 11.90 | 1.1391E 00 | 7.3500E-02 | 1.1414E 00 | 3259 |
| 2 YACC | -2.7559E-02 | 3 29 19.15 | -2.9528E-03 | 3 29 33.63 | -1.2084E-02 | 3.0086E-03 | 1.2453E-02 | 3259 |
| 3 XACC | 7.4109E-02 | 3 30 16.06 | 1.2747E-01 | 3 29 58.38 | 1.0446E-01 | 1.6067E-02 | 1.0569E-01 | 3259 |
| 4 ALPHA | 2.3288E 00 | 3 29 12.63 | 5.0685E 00 | 3 30 12.03 | 3.6059E 00 | 2.7361E-01 | 3.6142E 00 | 3259 |
| 5 BETA | -5.1181E-01 | 3 30 12.50 | 8.2677E-01 | 3 29 18.97 | -2.5911E-02 | 1.6314E-01 | 1.6519E-01 | 3259 |
| 6 TIM-TURB | 2.8419E-02 | 3 29 53.04 | 2.8240E-01 | 3 29 18.95 | 1.2556E-01 | 7.1333E-02 | 1.4441E-01 | 3259 |
| 7 TIM-A/S | 7.1518E 01 | 3 29 31.69 | 8.1616E 01 | 3 30 20.83 | 7.5815E 01 | 2.7925E 00 | 7.5866E 01 | 3259 |
| 8 TIM | 7.1518E 01 | 3 29 31.74 | 8.1616E 01 | 3 30 20.68 | 7.6076E 01 | 2.8487E 00 | 7.6130E 01 | 3259 |
| 9 ALTI | 5.9936E 03 | 3 29 10.00 | 6.7450E 03 | 3 30 21.69 | 6.4583E 03 | 2.2243E 02 | 6.4621E 03 | 3259 |
| 10 ALTIFINE | 3.1463E 03 | 3 29 22.61 | 6.7866E 03 | 3 30 28.72 | 5.8898E 03 | 1.3052E 03 | 6.0323E 03 | 3259 |
| 11 VIAS | 1.4674E 02 | 3 29 35.00 | 1.5625E 02 | 3 30 22.06 | 1.5085E 02 | 2.8544E 00 | 1.5088E 02 | 3259 |
| 12 VIASFINE | 1.4502E 02 | 3 29 34.97 | 1.5346E 02 | 3 30 29.75 | 1.4870E 02 | 2.7826E 00 | 1.4873E 02 | 3259 |
| 13 PELE | -1.2506E 00 | 3 29 18.48 | 1.7530E-01 | 3 30 22.43 | -6.0621E-01 | 3.3764E-01 | 6.9389E-01 | 3259 |
| 14 PAILRGHT | 4.6154E 00 | 3 30 21.05 | 5.0769E 00 | 3 29 30.97 | 4.9017E 00 | 1.1585E-01 | 4.9030E 00 | 3259 |
| 15 PAILLEFT | -5.2055E 00 | 3 29 39.66 | -4.4018E 00 | 3 30 22.06 | -4.7053E 00 | 1.0843E-01 | 4.7066E 00 | 3259 |
| 16 PRUD | 2.7969E-02 | 3 29 11.05 | 1.3008E-01 | 3 29 10.00 | 1.1482E-01 | 3.6404E-02 | 1.2046E-01 | 3259 |
| 17 AIL-TRIM | 1.5806E 01 | 3 29 10.00 | 1.5806E 01 | 3 29 10.00 | 1.5806E 01 | 0.0 | 1.5806E 01 | 3259 |
| 18 RUD-TRIM | -4.2264E-01 | 3 29 10.00 | -4.2264E-01 | 3 29 10.00 | -4.2264E-01 | 0.0 | 4.2264E-01 | 3259 |
| 19 STABPOS | 3.1703E-01 | 3 29 14.53 | 1.3019E 00 | 3 30 11.75 | 7.6943E-01 | 2.3096E-01 | 8.0335E-01 | 3259 |
| 20 THRULEFT | 3.4669E 00 | 3 30 1.43 | 3.7885E 00 | 3 29 10.00 | 3.6582E 00 | 1.4518E-01 | 3.6611E 00 | 3259 |
| 21 THRORGHT | 3.3320E 00 | 3 30 1.26 | 3.6178E 00 | 3 29 10.00 | 3.4980E 00 | 1.2367E-01 | 3.5002E 00 | 3259 |
| 22 FLAP | -2.0558E-01 | 3 29 10.00 | -2.0558E-01 | 3 29 10.00 | -2.0558E-01 | 0.0 | 2.0558E-01 | 3259 |
| 23 DISC 23 | DISCRETE | | | | | | | |
| 24 DISC 24 | DISCRETE | | | | | | | |
| 25 SELE | -4.7005E 00 | 3 30 12.35 | 9.4932E 00 | 3 29 12.65 | 2.5704E 00 | 3.7432E 00 | 4.5408E 00 | 3259 |
| 26 SAILRGHT | -7.0175E 00 | 3 29 11.24 | -2.3033E 00 | 3 30 23.12 | -4.8491E 00 | 6.7418E-01 | 4.8957E 00 | 3259 |
| 27 TETA | 3.2440E 00 | 3 29 19.44 | 6.7729E 00 | 3 29 11.56 | 4.4135E 00 | 6.2445E-01 | 4.4574E 00 | 3259 |
| 28 PHI | 1.5280E 01 | 3 30 22.33 | 2.9639E 01 | 3 30 11.71 | 2.5986E 01 | 2.2943E 00 | 2.6088E 01 | 3259 |
| 29 SAILLEFT | 3.5489E 00 | 3 30 21.12 | 6.2398E 00 | 3 29 11.22 | 5.0646E 00 | 4.1430E-01 | 5.0815E 00 | 3259 |
| 30 SRUD | 1.2976E 00 | 3 30 24.74 | 3.0932E 00 | 3 29 10.76 | 2.2181E 00 | 2.7292E-01 | 2.2348E 00 | 3259 |
| 31 AIL-SIGN | 1.2307E 01 | 3 30 21.19 | 2.2615E 01 | 3 29 37.80 | 1.9103E 01 | 1.7355E 00 | 1.9182E 01 | 3259 |
| 32 RUDDSIGN | 2.0096E 01 | 3 29 10.00 | 2.0096E 01 | 3 29 10.00 | 2.0096E 01 | 0.0 | 2.0096E 01 | 3259 |
| 33 DC MONT | 1.1424E 01 | 3 29 41.06 | 1.1731E 01 | 3 30 21.19 | 1.1467E 01 | 4.0128E-02 | 1.1467E 01 | 3259 |
| 34 HEAD | 6.3046E 00 | 3 29 10.00 | 3.3797E 01 | 3 30 29.83 | 1.9490E 01 | 8.2420E 00 | 2.1161E 01 | 3259 |
| 35 | NTC | | | | | | | |
| 36 Q | -3.2243E 00 | 3 29 12.23 | 5.5701E 00 | 3 30 11.61 | 1.1194E 00 | 8.1929E-01 | 1.3872E 00 | 3259 |
| 37 AC MONT | 2.4130E 01 | 3 29 39.66 | 2.4130E 01 | 3 29 39.66 | 2.4130E 01 | 0.0 | 2.4130E 01 | 7 |
| 38 | NTC | | | | | | | |
| 39 | NTC | | | | | | | |
| 40 P | -3.6078E 00 | 3 30 12.62 | 4.7060E-01 | 3 29 19.86 | -1.4851E 00 | 5.1841E-01 | 1.5730E 00 | 3259 |
| 41 CDOT | -1.1765E-02 | 3 30 11.90 | 1.4118E-01 | 3 29 12.43 | 6.3195E-02 | 1.3976E-02 | 6.4722E-02 | 3259 |
| 42 R | 2.3657E 00 | 3 29 19.27 | 3.6038E 00 | 3 29 59.52 | 3.0908E 00 | 2.6249E-01 | 3.1019E 00 | 3259 |
| 43 PDOT | 9.9569E-02 | 3 29 18.11 | 1.8491E-01 | 3 29 10.12 | 1.4576E-01 | 1.3494E-02 | 1.4638E-01 | 3259 |
| 44 RDOT | 8.0625E-02 | 3 30 12.17 | 1.3856E-01 | 3 30 12.25 | 1.0652E-01 | 5.1288E-03 | 1.0664E-01 | 3259 |
| 45 RUAC | 1.8273E-01 | 3 29 34.19 | 1.8164E 00 | 3 29 21.53 | 7.8974E-01 | 2.4997E-01 | 8.2836E-01 | 3259 |
| 46 ELAC | 5.8207E-01 | 3 29 58.00 | 5.0660E 00 | 3 30 12.20 | 2.1289E 00 | 8.3969E-01 | 2.2885E 00 | 3259 |
| 47 RAAC | -6.4946E-02 | 3 30 21.10 | 1.6557E 00 | 3 29 23.05 | 4.0398E-01 | 2.8931E-01 | 4.9689E-01 | 3259 |
| 48 LAAC | 2.2101E-01 | 3 29 10.36 | 1.2776E 00 | 3 29 15.91 | 3.5383E-01 | 1.2399E-01 | 3.7492E-01 | 3259 |
| 49 RDOTGYRO | -3.0098E 00 | 3 29 59.49 | -1.9428E 00 | 3 29 12.33 | -2.5502E 00 | 2.6530E-01 | 2.5640E 00 | 3259 |

## QUALITATIVE ANALYSIS

A/P NO. 0099  TEST NO. 0921  RUN NO. 148609  COND 6  CALIBRATION PROGRAM  FLT COND

| BEGINNING TIME | ENDING TIME | SAMPLE SIZE |
|---|---|---|
| 3 29 10.00 | 3 30 30.00 | 3259 |

| VARIABLE | MINIMUM | AT TIME (HMS) | MAXIMUM | AT TIME (HMS) | MEAN | SIGMA | RMS | SAMPLES |
|---|---|---|---|---|---|---|---|---|
| 50 | NTC | | | | | | | |
| 51 TETACOMM | -8.2259E 00 | 3 30 12.10 | 7.0998E 00 | 3 29 12.53 | -7.7950E-02 | 2.6380E 00 | 2.6391E 00 | 3259 |
| 52 PHI COMM | -4.1904E 00 | 3 29 42.24 | 6.1839E-01 | 3 30 22.77 | -1.9088E 00 | 6.3097E-01 | 2.0104E 00 | 3259 |
| 53 PSI COMM | 1.7282E 00 | 3 29 21.46 | 2.6661E 00 | 3 29 16.71 | 2.1052E 00 | 1.4826E-01 | 2.1105E 00 | 3259 |
| 54 DPSICOMM | -2.2336E-01 | 3 29 41.09 | -1.0620E-01 | 3 29 11.61 | -1.7075E-01 | 3.0886E-02 | 1.7352E-01 | 3259 |
| 55 ELEKSIGN | 3.0105E 01 | 3 29 10.00 | 3.0105E 01 | 3 29 10.00 | 3.0105E 01 | 0.0 | 3.0105E 01 | 3259 |
| 56 | NTC | | | | | | | |
| 57 TETAGYRO | -9.0420E 00 | 3 29 11.44 | -1.0153E 00 | 3 29 40.10 | -4.3566E 00 | 2.2205E 00 | 4.8898E 00 | 3259 |
| 58 Q GYRO | -4.0485E-01 | 3 29 10.00 | -8.0963E-02 | 3 30 12.20 | -3.2060E-01 | 5.4319E-02 | 3.2517E-01 | 3259 |
| 59 RUD ACT | -8.0197E 00 | 3 30 21.12 | 6.5030E 00 | 3 29 21.53 | 3.9023E-01 | 1.5089E 00 | 1.5586E 00 | 3259 |
| 60 ELEVACT | -1.1190E 01 | 3 29 12.40 | 1.4118E 01 | 3 30 11.78 | 3.5354E 00 | 3.7519E 00 | 5.1552E 00 | 3259 |
| 61 RTALACT | -8.1352E 00 | 3 29 25.82 | 6.0434E 00 | 3 30 22.72 | -1.1806E 00 | 1.9911E 00 | 2.3148E 00 | 3259 |
| 62 LTALACT | -6.3886E 00 | 3 30 22.72 | 6.3827E 00 | 3 29 15.91 | -2.5705E-02 | 1.8221E 00 | 1.8222E 00 | 3259 |
| 63 PHI GYRO | -3.1176E 01 | 3 29 10.98 | -2.7586E 01 | 3 30 20.36 | -2.9695E 01 | 8.0749E-01 | 2.9706E 01 | 3259 |
| 64 P GYRO | 2.2472E-01 | 3 29 10.46 | 6.7415E-01 | 3 29 11.39 | 4.2978E-01 | 8.1823E-02 | 4.3750E-01 | 3259 |
| 65 | NTC | | | | | | | |
| 66 | NTC | | | | | | | |
| 67 ALT-LO | SSD | | | | | | | |
| 68 ALT-CO | 9.6028E-02 | 3 29 10.00 | 9.6028E-02 | 3 29 10.00 | 9.6028E-02 | 0.0 | 9.6028E-02 | 3259 |
| 69 LOC | SSD | | | | | | | |
| 70 GLID | -2.3582E-02 | 3 29 10.00 | -1.7376E-02 | 3 30 13.55 | -2.3580E-02 | 1.0902E-04 | 2.3580E-02 | 3259 |
| 71 | NTC | | | | | | | |
| 72 | NTC | | | | | | | |
| 73 | NTC | | | | | | | |
| 74 | NTC | | | | | | | |
| 75 | NTC | | | | | | | |
| 76 | NTC | | | | | | | |
| 77 OAT | 4.8396E 01 | 3 29 45.33 | 4.9845E 01 | 3 29 10.00 | 4.8779E 01 | 3.4672E-01 | 4.8780E 01 | 3259 |

QUALITATIVE ANALYSIS

A/P NO. 0099 TEST NO. 0921 RUN NO. 124616 COND 7 CALIBRATION PROGRAM FLT COND

| BEGINNING TIME | ENDING TIME | SAMPLE SIZE |
|---|---|---|
| 3 37 20.01 | 3 38 30.01 | 2852 |

| VARIABLE | MINIMUM | AT TIME (HMS) | MAXIMUM | AT TIME (HMS) | MEAN | SIGMA | RMS | SAMPLES |
|---|---|---|---|---|---|---|---|---|
| 1 ZACC | 6.4064E-01 | 3 38 25.13 | 1.3133E 00 | 3 38 5.69 | 1.0005E 00 | 9.5740E-02 | 1.0055E 00 | 2848 |
| 2 YACC | -[illegible].1693E-02 | 3 38 22.77 | 7.1850E-02 | 3 38 15.05 | -1.6683E-02 | 2.4295E-02 | 2.9472E-02 | 2848 |
| 3 XACC | 1.[illegible]E-02 | 3 37 59.03 | 7.8062E-02 | 3 38 17.27 | 3.9210E-02 | 9.1126E-03 | 4.0255E-02 | 2848 |
| 4 ALPHA | 1.3014E 00 | 3 [illegible] 26.23 | [illegible]E 00 | 3 38 [illegible].66 | 3.[illegible] 00 | 5.1391E-01 | 3.[illegible]E 00 | 2848 |
| 5 BETA | -3.1890E 00 | 3 38 15.00 | 3.1102E 00 | 3 37 24.14 | 3.1557E-01 | 9.2170E-01 | 9.7422E-01 | 2848 |
| 6 TIM-TURB | 9.5574E-01 | 3 37 53.02 | 3.0176E 00 | 3 38 24.41 | 1.9794E 00 | 4.4136E-01 | 2.0280E 00 | 2848 |
| 7 TIM-A/S | 7.1510E 01 | 3 37 32.70 | 8.2728E 01 | 3 37 20.61 | 7.7319E 01 | 2.7159E 00 | 7.7350E 01 | 2848 |
| 8 TIM | 7.1510E 01 | 3 37 32.70 | 8.2728E 01 | 3 37 40.79 | 7.7519E 01 | 2.1959E 00 | 7.7550E 01 | 2848 |
| 9 ALTI | 2.8513E 03 | 3 37 25.39 | 3.3978E 03 | 3 37 59.69 | 2.9635E 03 | 3.6041E 01 | 2.9637E 03 | 2848 |
| 10 ALTIFINE | 2.8765E 03 | 3 37 53.16 | 3.0013E 03 | 3 37 26.89 | 2.9243E 03 | 2.4537E 01 | 2.9245E 03 | 2848 |
| 11 VIAS | 1.4577E 02 | 3 37 15.07 | 1.5844E 02 | 3 37 26.89 | 1.5317E 02 | 2.3649E 00 | 1.5319E 02 | 2848 |
| 12 VIASFINE | 1.4357E 02 | 3 38 1[illegible].07 | 1.5725E 02 | 3 37 56.10 | 1.5127E 02 | 2.[illegible]E 00 | 1.5129E 02 | 2848 |
| 13 PED | -1.0725E 00 | 3 37 31.04 | 1.1827E-01 | 3 37 55.93 | -5.2990E-01 | 2.8623E-01 | 6.0226E-01 | 2848 |
| 14 PAILRGHT | 5.3845E-01 | 3 37 41.06 | 1.3646E 00 | 3 37 36.79 | 9.4025E-01 | 1.4217E-01 | 9.5094E-01 | 2848 |
| 15 PAILLEFT | -6.0272E-01 | 3 37 40.75 | 2.6093E-01 | 3 37 40.99 | -1.5558E-01 | 1.3509E-01 | 2.0604E-01 | 2848 |
| 16 PRUD | -7.4143E-02 | 3 37 20.03 | 5.3556E-01 | 3 37 36.62 | 1.9725E-01 | 1.3284E-01 | 2.3781E-01 | 2848 |
| 17 AIL-TRIM | 3.1795E 00 | 3 37 20.00 | 3.5399E 00 | 3 38 4.82 | 3.1841E 00 | 2.2425E-02 | 3.1842E 00 | 2848 |
| 18 RUD-TRIM | -4.2264E-01 | 3 37 20.00 | -1.8112E-01 | 3 38 4.82 | -4.2255E-01 | 4.5262E-03 | 4.2258E-01 | 2848 |
| 19 STABPOS | 5.2770E-01 | 3 37 38.09 | 7.0759E-01 | 3 37 20.00 | 6.4051E-01 | 5.5523E-02 | 6.4292E-01 | 2848 |
| 20 THROLEFT | 2.8884E 00 | 3 37 20.00 | 2.8814E 00 | 3 37 20.00 | 2.8884E 00 | 0.0 | 2.8884E 00 | 2848 |
| 21 THRORGHT | 2.7610E 00 | 3 37 20.94 | 2.7775E 00 | 3 37 22.14 | 2.7683E 00 | 3.4678E-03 | 2.7683E 00 | 2848 |
| 22 FLAP | -2.0558E-01 | 3 37 20.00 | -2.0558E-01 | 3 37 20.00 | -2.0558E-01 | 0.0 | 2.0558E-01 | 2848 |
| 23 DISC 23 | DISCRETE | | | | | | | |
| 24 DISC 24 | DISCRETE | | | | | | | |
| 25 SPLI | -2.7661E 00 | 3 37 56.40 | 8.0038E 00 | 3 37 38.46 | 1.7736E 00 | 2.3840E 00 | 2.9714E 00 | 2848 |
| 26 SAILRGHT | -7.4365E 00 | 3 37 33.18 | 7.2297E 00 | 3 38 10.20 | -3.1936E-01 | 2.3670E 00 | 2.3835E 00 | 2848 |
| 27 TETA | 6.7932E-02 | 3 37 38.21 | 3.5965E 00 | 3 37 50.16 | 1.9493E 00 | 7.4601E-01 | 2.0874E 00 | 2848 |
| 28 PHI | -3.9831E 00 | 3 38 10.78 | 1.2746E 00 | 3 37 44.02 | -1.3516E 00 | 1.1925E 00 | 1.8024E 00 | 2848 |
| 29 SAILLEFT | -4.8721E 00 | 3 38 17.05 | 6.9379E 00 | 3 37 33.23 | 9.6370E-01 | 1.8865E 00 | 2.1207E 00 | 2848 |
| 30 SROM | -8.0206E 00 | 3 38 19.79 | 6.4278E 00 | 3 37 20.00 | 7.0085E-01 | 2.9941E 00 | 3.0075E 00 | 2848 |
| 31 AIL-SIGN | 5.3467E 00 | 3 38 9.60 | 2.2615E 01 | 3 37 20.00 | 2.2215E 01 | 1.4338E 00 | 2.2261E 01 | 2848 |
| 32 RUDDSIGN | -9.4214E-01 | 3 38 15.72 | 2.1096E 01 | 3 37 20.00 | 1.8451E 01 | 4.0802E 00 | 1.8897E 01 | 2831 |
| 33 DC MONT | 1.1373E 01 | 3 37 20.79 | 1.1731E 01 | 3 37 36.72 | 1.1444E 01 | 5.7624E-02 | 1.1444E 01 | 2848 |
| 34 HEAD | 2.7050E 01 | 3 38 18.54 | 2.7612E 01 | 3 37 30.32 | 2.7350E 01 | 1.3924E-01 | 2.7350E 01 | 2848 |
| 35 | NTC | | | | | | | |
| 36 Q | -4.0[illegible]E 00 | 3 37 [illegible].02 | 2.6967E 00 | 3 37 50.05 | -5.4114E-01 | 9.7236E-01 | 1.1126E 00 | 2848 |
| 37 AC MONT | 7.4136E 01 | 3 37 32.25 | 2.4310E 01 | 3 37 36.67 | 2.4199E 01 | 1.1299E-01 | 2.4199E 01 | 62 |
| 38 | NTC | | | | | | | |
| 39 | NTC | | | | | | | |
| 40 P | -7.1760E 00 | 3 37 41.23 | 7.0901E 00 | 3 38 17.32 | -1.2234E 00 | 1.9942E 00 | 2.3449E 00 | 2848 |
| 41 QDOT | -2.3525E-02 | 3 38 24.12 | 1.5294E-01 | 3 37 32.99 | 6.6168E-02 | 2.5294E-02 | 7.0838E-02 | 2848 |
| 42 R | -2.[illegible]E 00 | 3 37 20.02 | 2.6958E 00 | 3 37 29.50 | 2.9515E-02 | 8.9414E-01 | 8.9437E-01 | 2848 |
| 43 PDOT | -4.2671E-02 | 3 38 20.07 | 3.5560E-01 | 3 37 36.55 | 1.4612E-01 | 4.7974E-02 | 1.5380E-01 | 2848 |
| 44 RDOT | 4.6185E-02 | 3 38 7.11 | 1.7320E-01 | 3 38 29.62 | 1.0942E-01 | 1.3557E-02 | 1.1246E-01 | 2848 |
| 45 RUAC | 1.7384E-01 | 3 38 19.49 | 5.0016E 00 | 3 38 4.68 | 8.1787E-01 | 5.0164E-01 | 9.5941E-01 | 2848 |
| 46 FLAC | 5.8207E-01 | 3 37 35.44 | 4.7920E 00 | 3 38 0.62 | 2.3232E 00 | 7.6915E-01 | 2.4472E 00 | 2848 |
| 47 RAAC | 1.3266E-02 | 3 37 27.11 | 4.1585E 00 | 3 37 32.32 | 5.6990E-01 | 4.6235E-01 | 7.3417E-01 | 2848 |
| 48 LAAC | 2.2101E-01 | 3 37 20.20 | 3.5083E 00 | 3 37 32.32 | 5.2878E-01 | 3.2532E-01 | 6.2084E-01 | 2848 |
| 49 RDOTGYRO | -2.0249E 00 | 3 37 29.53 | 1.8045E 00 | 3 37 20.03 | 7.3432E-03 | 6.5769E-01 | 6.5774E-01 | 2848 |

QUALITATIVE ANALYSIS

A/P NO. C099 TEST NO. C921 RUN NO. 124616 COND 7 CALIBRATION PROGRAM FLT COND

| BEGINNING TIME | ENDING TIME | SAMPLE SIZE |
|---|---|---|
| 3 37 20.01 | 3 38 30.01 | 2852 |

| VARIABLE | MINIMUM | AT TIME (HMS) | MAXIMUM | AT TIME (HMS) | MEAN | SIGMA | RMS | SAMPLES |
|---|---|---|---|---|---|---|---|---|
| 50 | NTC | | | | | | | |
| 51 THETACOMM | -6.3541E 00 | 3 37 32.40 | 5.5790E 00 | 3 37 33.41 | -5.8934E-01 | 1.9399E 00 | 2.0274E 00 | 2848 |
| 52 PHI COMM | -1.6055E 01 | 3 38 4.97 | 1.1467E 01 | 3 37 32.27 | 9.8937E-02 | 2.2094E 00 | 2.2106E 00 | 2848 |
| 53 PSI COMM | -4.3698E 00 | 3 38 15.77 | 7.4751E 00 | 3 38 4.77 | 1.1511E 00 | 1.7099E 00 | 2.0607E 00 | 2848 |
| 54 UPSILCOMM | -1.9076E 00 | 3 38 4.75 | 1.2606E 00 | 3 38 15.98 | 5.9976E-02 | 4.0346E-01 | 4.0789E-01 | 2848 |
| 55 ELERSIGN | 3.0105E 01 | 3 37 20.00 | 3.0105E 01 | 3 37 20.00 | 3.0105E 01 | 0.0 | 3.0105E 01 | 2848 |
| 56 | NTC | | | | | | | |
| 57 THETAGYRO | -3.2916E 00 | 3 37 56.18 | 1.3269E-01 | 3 37 38.24 | -1.6779E 00 | 7.7479E-01 | 1.7579E 00 | 2848 |
| 58 Q GYRO | -4.0485E-01 | 3 38 24.46 | 1.7778E-01 | 3 37 57.61 | -1.9957E-01 | 4.9621E-02 | 2.0468E-01 | 2848 |
| 59 RUD ACT | -2.4533E 01 | 3 38 4.40 | 1.0917E 01 | 3 38 4.75 | -4.1476E-01 | 4.3150E 00 | 4.3421E 00 | 2848 |
| 60 ELEVACT | -1.1190E 01 | 3 37 49.66 | 1.5993E 01 | 3 38 24.41 | 4.4284E 00 | 4.0725E 00 | 6.0163E 00 | 2848 |
| 61 ETALACT | -1.7510E 01 | 3 37 32.43 | 1.9265E 01 | 3 37 35.27 | -9.9646E-01 | 5.3885E 00 | 5.4788E 00 | 2848 |
| 62 LTALACT | -1.6582E 01 | 3 37 35.27 | 1.5208E 01 | 3 38 4.90 | 2.2832E-01 | 4.6886E 00 | 4.6942E 00 | 2848 |
| 63 PHI GYRO | -2.9354E 00 | 3 38 17.76 | 3.0478E 00 | 3 37 56.35 | -6.7588E-02 | 1.1920E 00 | 1.1939E 00 | 2848 |
| 64 P GYRO | -4.7191E 00 | 3 38 17.32 | 3.3202E 00 | 3 37 41.21 | 4.2158E-01 | 7.5370E-01 | 8.6359E-01 | 2848 |
| 65 | NTC | | | | | | | |
| 66 | NTC | | | | | | | |
| 67 ALT-LO | OSD | | | | | | | |
| 68 ALT-GD | 6.2916E-02 | 3 37 20.00 | 7.9473E-02 | 3 37 20.50 | 6.3102E-02 | 1.7451E-03 | 6.3126E-02 | 2848 |
| 69 LEC | SSD | | | | | | | |
| 70 GLID | -4.7659E-01 | 3 38 29.05 | -1.1667E-01 | 3 37 25.52 | -3.2767E-01 | 1.0492E-01 | 3.4406E-01 | 2848 |
| 71 | NTC | | | | | | | |
| 72 | NTC | | | | | | | |
| 73 | NTC | | | | | | | |
| 74 | NTC | | | | | | | |
| 75 | NTC | | | | | | | |
| 76 | NTC | | | | | | | |
| 77 OAT | 5.6001E 01 | 3 37 34.34 | 5.7449E 01 | 3 37 54.98 | 5.6777E 01 | 2.6708E-01 | 5.6777E 01 | 2848 |

## QUALITATIVE ANALYSIS

A/P NO. 0099 TEST NO. 0921 RUN NO. 124617 COND 8 CALIBRATION PROGRAM FLT COND

| BEGINNING TIME | ENDING TIME | SAMPLE SIZE |
|---|---|---|
| 3 40 50.01 | 3 41 40.00 | 2038 |

| VARIABLE | MINIMUM | AT TIME (HMS) | MAXIMUM | AT TIME (HMS) | MEAN | SIGMA | RMS | SAMPLES |
|---|---|---|---|---|---|---|---|---|
| 1 ZACG | 7.5750E-01 | 3 41 36.47 | 1.4498E 00 | 3 41 4.09 | 1.0950E 00 | 1.3124E-01 | 1.1028E 00 | 2038 |
| 2 YACC | -6.2008E-02 | 3 40 55.06 | 7.8740E-02 | 3 41 19.14 | 1.0615E-02 | 2.8380E-02 | 3.0300E-02 | 2038 |
| 3 XACC | -8.3993E-02 | 3 41 5.42 | 6.8181E-02 | 3 41 39.44 | -1.6390E-02 | 4.6084E-02 | 4.8346E-02 | 2038 |
| 4 ALPHA | 6.8492E-02 | 3 41 17.17 | 4.5890E 00 | 3 40 56.05 | 2.4235E 00 | 9.4088E-01 | 2.5998E 00 | 2038 |
| 5 BETA | -5.0787E 00 | 3 41 10.64 | 3.3465E 00 | 3 41 29.76 | -1.1354E 00 | 1.7635E 00 | 2.0974E 00 | 2038 |
| 6 TIM-TURB | 7.9037E-01 | 3 41 25.81 | 1.8454E 00 | 3 41 12.34 | 1.1777E 00 | 2.2582E-01 | 1.1992E 00 | 2038 |
| 7 TIM-A/S | 3.3371E 01 | 3 41 29.03 | 7.1518E 01 | 3 40 56.07 | 4.8697E 01 | 1.2604E 01 | 5.0302E 01 | 2038 |
| 8 TIM | 3.3371E 01 | 3 41 30.15 | 7.1518E 01 | 3 40 56.07 | 4.9028E 01 | 1.2523E 01 | 5.0602E 01 | 2038 |
| 9 ALTI | 2.7630E 03 | 3 40 53.32 | 3.1929E 03 | 3 41 14.62 | 2.8105E 03 | 3.6527E 01 | 2.8107E 03 | 2038 |
| 10 ALTIFINE | 2.7937E 03 | 3 41 31.46 | 2.8706E 03 | 3 41 14.45 | 2.8302E 03 | 2.2389E 01 | 2.8303E 03 | 2038 |
| 11 VIAS | 9.3334E 01 | 3 41 32.24 | 1.4600E 02 | 3 40 56.12 | 1.1638E 02 | 1.7253E 01 | 1.1765E 02 | 2038 |
| 12 VIASFINE | 6.6229E 01 | 3 41 30.70 | 1.4376E 02 | 3 40 56.12 | 1.1508E 02 | 1.7867E 01 | 1.1646E 02 | 2039 |
| 13 FELE | -1.8780E 00 | 3 41 38.94 | 2.8937E-01 | 3 41 17.71 | -7.6783E-01 | 4.7479E-01 | 9.0277E-01 | 2038 |
| 14 FAILRGHT | -5.0961E 00 | 3 40 53.71 | 6.2885E 00 | 3 41 15.51 | 1.1015E-01 | 3.4512E 00 | 3.4529E 00 | 2038 |
| 15 FAILLEFT | -5.7169E 00 | 3 41 15.53 | 5.6514E 00 | 3 40 53.69 | 6.0943E-01 | 3.3773E 00 | 3.4318E 00 | 2038 |
| 16 FRUD | -2.8313E 00 | 3 40 54.20 | 3.7042E 00 | 3 41 37.59 | -1.3673E-01 | 1.5955E 00 | 1.6013E 00 | 2038 |
| 17 AIL-TRIM | 3.0769E 00 | 3 41 2.45 | 3.3846E 00 | 3 41 37.59 | 3.1573E 00 | 4.7667E-02 | 3.1576E 00 | 2038 |
| 18 RUD-TRIM | -4.2264E-01 | 3 40 50.01 | -3.0188E-01 | 3 41 24.44 | -4.2258E-01 | 2.6828E-03 | 4.2259E-01 | 2038 |
| 19 STABPOS | -9.6044E-01 | 3 41 21.71 | 8.0948E-01 | 3 40 50.01 | -1.9547E-01 | 6.7480E-01 | 7.0261E-01 | 2038 |
| 20 THROLLFT | 2.6901E 00 | 3 40 57.79 | 3.4587E 00 | 3 41 33.14 | 2.8335E 00 | 2.5397E-01 | 2.8449E 00 | 2038 |
| 21 THRORGHT | 2.5385E 00 | 3 40 57.73 | 3.4057E 00 | 3 41 33.25 | 2.6871E 00 | 2.6620E-01 | 2.7003E 00 | 2038 |
| 22 FLAP | -2.0558E-01 | 3 40 50.01 | 4.2800E 01 | 3 41 27.41 | 2.8813E 01 | 1.4945E 01 | 3.2458E 01 | 2038 |
| 23 DISC 23 | DISCRETE | | | | | | | |
| 24 DISC 24 | DISCRETE | | | | | | | |
| 25 SELE | -7.8656E 00 | 3 41 16.71 | 1.2355E 01 | 3 41 29.49 | -5.1735E-01 | 4.7462E 00 | 4.7743E 00 | 2038 |
| 26 SAILRGHT | -1.3513E 01 | 3 41 28.80 | 1.5087E 01 | 3 41 12.14 | 4.4374E 00 | 8.6476E 00 | 9.7169E 00 | 2039 |
| 27 TETA | -2.2259E 00 | 3 41 11.71 | 3.2440E 00 | 3 40 55.02 | 7.9467E-01 | 1.3512E 00 | 1.5676E 00 | 2038 |
| 28 PHI | -4.2859E 01 | 3 41 0.56 | 2.6487E 01 | 3 41 23.61 | -1.0125E 01 | 2.2214E 01 | 2.4411E 01 | 2038 |
| 29 SAILLEFT | -1.2098E 01 | 3 41 16.12 | 1.3117E 01 | 3 41 27.21 | -2.6470E 00 | 7.3692E 00 | 7.9001E 00 | 2038 |
| 30 SRUD | -9.0483E 00 | 3 41 18.42 | 8.3009E 00 | 3 41 31.09 | 1.1019E 00 | 2.7041E 00 | 2.9200E 00 | 2038 |
| 31 AIL-SIGN | -2.0396E-01 | 3 40 54.55 | 2.2615E 01 | 3 40 50.01 | 2.1062E 01 | 3.8910E 00 | 2.1418E 01 | 2035 |
| 32 RUDDSIGN | -7.8572E-01 | 3 41 18.38 | 2.0096E 01 | 3 40 50.01 | 1.9509E 01 | 2.5783E 00 | 1.9679E 01 | 2027 |
| 33 DC MONT | 1.1270E 01 | 3 41 15.22 | 1.1731E 01 | 3 41 18.47 | 1.1369E 01 | 8.5133E-02 | 1.1369E 01 | 2038 |
| 34 HEAD | 1.4890E 01 | 3 41 17.10 | 2.7120E 01 | 3 40 50.01 | 1.9865E 01 | 3.7675E 00 | 2.0219E 01 | 2038 |
| 35 | NTC | | | | | | | |
| 36 Q | -3.3985E 00 | 3 41 38.03 | 5.8313E 00 | 3 41 12.14 | 1.0151E 00 | 1.7253E 00 | 2.0018E 00 | 2038 |
| 37 AC MONT | 2.4130E 01 | 3 40 54.55 | 2.4790E 01 | 3 41 24.29 | 2.4291E 01 | 2.5130E-01 | 2.4293E 01 | 62 |
| 38 | NTC | | | | | | | |
| 39 | NTC | | | | | | | |
| 40 P | -1.9667E 01 | 3 40 54.30 | 1.3980E 01 | 3 41 16.66 | -1.1925E 00 | 5.6969E 00 | 5.8203E 00 | 2038 |
| 41 YDOT | -5.1470E-05 | 3 41 24.37 | 1.4118E-01 | 3 41 11.93 | 6.7575E-02 | 1.9665E-02 | 7.0378E-02 | 2038 |
| 42 R | -6.3013E 00 | 3 41 3.46 | 5.6674E 00 | 3 41 23.34 | -1.1877E 00 | 3.2972E 00 | 3.5046E 00 | 2038 |
| 43 PDOT | -4.2671E-02 | 3 40 59.73 | 2.9871E-01 | 3 40 54.67 | 1.4484E-01 | 4.7926E-02 | 1.5256E-01 | 2038 |
| 44 RDOT | 6.9279E-02 | 3 41 12.29 | 1.3856E-01 | 3 40 59.93 | 1.0826E-01 | 1.0447E-02 | 1.0877E-01 | 2038 |
| 45 RUAC | 1.4384E-01 | 3 41 4.29 | 5.3170E 00 | 3 41 14.42 | 6.8906E-01 | 5.0901E-01 | 8.5663E-01 | 2038 |
| 46 FLAC | 3.4813E-01 | 3 41 27.23 | 4.4031E 00 | 3 40 59.63 | 1.8574E 00 | 8.1782E-01 | 2.0294E 00 | 2038 |
| 47 RAAC | 1.3266E-02 | 3 40 54.57 | 4.2367E 00 | 3 41 37.54 | 5.9322E-01 | 4.0265E-01 | 7.1696E-01 | 2038 |
| 48 LAAC | 2.2101E-01 | 3 40 50.62 | 3.4301E 00 | 3 41 37.54 | 6.8926E-01 | 3.0236E-01 | 7.5266E-01 | 2038 |
| 49 RDDTGYRO | -4.8155E 00 | 3 41 23.44 | 5.7098E 00 | 3 41 2.84 | 1.0651E 00 | 2.7188E 00 | 2.9200E 00 | 2033 |

QUALITATIVE ANALYSIS

A/P NO. 0099  TEST NO. 0921  RUN NO. 124617  COND 8  CALIBRATION PROGRAM  FLT COND

| BEGINNING TIME | ENDING TIME | SAMPLE SIZE |
|---|---|---|
| 3 40 50.01 | 3 41 40.00 | 2038 |

| VARIABLE | MINIMUM | AT TIME (HMS) | MAXIMUM | AT TIME (HMS) | MEAN | SIGMA | RMS | SAMPLES |
|---|---|---|---|---|---|---|---|---|
| 50 | NTC | | | | | | | |
| 51 TETACOMM | -8.9279E 00 | 3 41 18.55 | 1.0493E 01 | 3 41 29.32 | -1.7675E 00 | 3.9352E 00 | 4.3139E 00 | 2038 |
| 52 PHI COMM | -1.1990E 01 | 3 41 23.61 | 1.4458E 01 | 3 41 12.12 | 3.0643E 00 | 7.9979E 00 | 8.5648E 00 | 2038 |
| 53 PSI COMM | -4.7207E 00 | 3 41 18.40 | 8.3524E 00 | 3 41 14.60 | 1.5546E 00 | 1.5673E 00 | 2.2075E 00 | 2038 |
| 54 DPSICOMM | -3.4645E 00 | 3 41 14.57 | 1.8073E 00 | 3 41 24.44 | -1.1979E-01 | 3.2810E-01 | 3.4929E-01 | 2038 |
| 55 FLERSION | 3.0105E 01 | 3 40 50.01 | 3.0105E 01 | 3 40 50.01 | 3.0105E 01 | 0.0 | 3.0105E 01 | 2038 |
| 56 | NTC | | | | | | | |
| 57 TETAGYRO | -4.0104E 00 | 3 41 14.55 | -2.9651E-01 | 3 41 11.73 | -1.8231E 00 | 9.5777E-01 | 2.0594E 00 | 2038 |
| 58 Q GYRO | -1.6193E-01 | 3 40 50.08 | 5.5534E-01 | 3 41 20.46 | -9.3564E-02 | 4.3800E-02 | 1.0331E-01 | 2038 |
| 59 RUD ACT | -2.4533E 01 | 3 41 34.89 | 1.9737E 01 | 3 41 24.51 | -9.6652E-01 | 4.1512E 00 | 4.2478E 00 | 2038 |
| 60 ELEVACT | -1.3885E 01 | 3 41 38.32 | 1.2829E 01 | 3 41 29.64 | 2.7228E 00 | 4.4818E 00 | 5.2441E 00 | 2038 |
| 61 RTALACT | -1.7744E 01 | 3 41 20.34 | 2.0105E 01 | 3 40 54.55 | -2.5784E-01 | 6.0008E 00 | 6.0063E 00 | 2038 |
| 62 LTALACT | -1.6817E 01 | 3 40 54.55 | 1.5405E 01 | 3 41 20.37 | -8.4248E-01 | 5.7438E 00 | 5.8052E 00 | 2038 |
| 63 PHI GYRO | -3.3090E 01 | 3 41 23.68 | 3.8229E 01 | 3 41 0.46 | 6.4636E 00 | 2.2365E 01 | 2.3780E 01 | 2036 |
| 64 P GYRO | -1.1910E 01 | 3 41 16.86 | 1.6854E 01 | 3 40 54.32 | 4.5362E-01 | 4.0184E 00 | 4.0439E 00 | 2038 |
| 65 | NTC | | | | | | | |
| 66 | NTC | | | | | | | |
| 67 ALT-LO | USD | | | | | | | |
| 68 ALT-GD | 4.6359E-02 | 3 41 24.29 | 6.2916E-02 | 3 40 50.01 | 6.2826E-02 | 1.2156E-03 | 6.2838E-02 | 2038 |
| 69 LOC | -9.8611E-01 | 3 41 10.57 | 1.4508E 00 | 3 40 50.01 | -5.3758E-03 | 6.9542E-01 | 6.9544E-01 | 2038 |
| 70 GLID | -9.0682E-01 | 3 41 1.27 | -8.3364E-01 | 3 40 51.88 | -8.8227E-01 | 1.6125E-02 | 8.8242E-01 | 2038 |
| 71 | NTC | | | | | | | |
| 72 | NTC | | | | | | | |
| 73 | NTC | | | | | | | |
| 74 | NTC | | | | | | | |
| 75 | NTC | | | | | | | |
| 76 | NTC | | | | | | | |
| 77 OAT | 5.3828E 01 | 3 41 19.83 | 5.7087E 01 | 3 40 59.26 | 5.4881E 01 | 9.8431E-01 | 5.4890E 01 | 2038 |

QUALITATIVE ANALYSIS

A/P NO. 0099 TEST NO. 0921 RUN NO. 124617 COND 9 CALIBRATION PROGRAM FLT COND

| BEGINNING TIME | ENDING TIME | SAMPLE SIZE |
|---|---|---|
| 3 42 35.01 | 3 45 49.01 | 7907 |

| VARIABLE | MINIMUM | AT TIME (HMS) | MAXIMUM | AT TIME (HMS) | MEAN | SIGMA | RMS | SAMPLES |
|---|---|---|---|---|---|---|---|---|
| 1 ZACG | 6.2114E-01 | 3 43 52.26 | 1.4693E 00 | 3 45 11.85 | 9.8586E-01 | 9.1673E-02 | 9.9012E-01 | 7907 |
| 2 YACG | -6.4961E-02 | 3 45 43.73 | 9.6457E-02 | 3 43 39.85 | 2.1360E-02 | 2.7794E-02 | 3.0509E-02 | 7907 |
| 3 XACG | -8.9972E-02 | 3 45 39.14 | 7.2133E-02 | 3 42 49.93 | -2.5921E-02 | 2.3030E-02 | 3.0178E-02 | 7907 |
| 4 ALPHA | -1.5335E 00 | 3 45 45.86 | 5.4795E 00 | 3 45 11.72 | 1.7514E 00 | 9.5292E-01 | 1.9928E 00 | 7907 |
| 5 BETA | -6.3071E 00 | 3 43 45.50 | 3.5039E 00 | 3 44 25.73 | -2.2095E 00 | 1.4788E 00 | 2.6587E 00 | 7907 |
| 6 TIM-TURB | 6.7315E-01 | 3 44 5.29 | 2.6073E 00 | 3 45 21.46 | 1.5789E 00 | 4.7120E-01 | 1.6478E 00 | 7907 |
| 7 TIM-A/S | 3.2249E 01 | 3 42 48.88 | 4.4590E 01 | 3 45 39.71 | 3.7844E 01 | 2.0222E 00 | 3.7898E 01 | 7907 |
| 8 TIM | 3.2249E 01 | 3 42 48.90 | 4.4590E 01 | 3 45 0.60 | 3.8100E 01 | 2.0291E 00 | 3.8154E 01 | 7907 |
| 9 ZLTI | 1.8723E 02 | 3 44 22.66 | 3.0562E 03 | 3 42 40.11 | 2.4132E 03 | 4.4703E 02 | 2.4542E 03 | 7907 |
| 10 ALTIFINE | 5.1476E-85 | 3 44 22.66 | 3.0495E 03 | 3 42 56.20 | 2.4307E 03 | 4.6081E 02 | 2.4740E 03 | 7907 |
| 11 VIAS | 9.2605E 01 | 3 45 19.97 | 1.1162E 02 | 3 45 38.31 | 1.0149E 02 | 3.2523E 00 | 1.0155E 02 | 7907 |
| 12 VIASFINE | 6.6296E 01 | 3 43 28.87 | 1.1222E 02 | 3 42 48.29 | 1.0073E 02 | 6.1615E 00 | 1.0092E 02 | 7907 |
| 13 PELE | -4.2165E 00 | 3 45 36.49 | -6.2320E-01 | 3 44 47.35 | -2.3332E 00 | 5.9511E-01 | 2.4079E 00 | 7907 |
| 14 PAILRGHT | -1.0769E 00 | 3 43 25.68 | 6.2885E 00 | 3 45 30.74 | 1.5012E 00 | 6.8240E-01 | 1.6490E 00 | 7907 |
| 15 PAILLEFT | -5.7169E 00 | 3 45 30.71 | 1.8082E 00 | 3 45 25.65 | -6.3604E-01 | 6.9439E-01 | 9.4165E-01 | 7907 |
| 16 PRUD | -8.4492E-01 | 3 43 42.43 | 2.6831E 00 | 3 42 37.98 | 1.1021E 00 | 2.8027E-01 | 1.1372E 00 | 7907 |
| 17 ZIL-TRIM | 3.0769E 00 | 3 42 27.93 | 3.2821E 00 | 3 45 54.42 | 3.1610E 00 | 3.9455E-02 | 3.1612E 00 | 7907 |
| 18 RUD-TRIM | -4.2264E-01 | 3 42 35.01 | 1.8114E-01 | 3 42 40.34 | -1.8576E-01 | 4.4553E-02 | 1.9103E-01 | 7907 |
| 19 STABPOS | -1.0665E 00 | 3 44 51.89 | -1.4726E-01 | 3 45 39.12 | -6.7419E-01 | 1.8649E-01 | 6.9951E-01 | 7907 |
| 20 THROLEFT | 2.7149E 00 | 3 43 8.58 | 3.4091E 00 | 3 42 40.21 | 2.8268E 00 | 2.4343E-01 | 2.8373E 00 | 7907 |
| 21 THRORGHT | 2.6703E 00 | 3 43 8.55 | 3.2859E 00 | 3 42 40.06 | 2.7693E 00 | 2.0379E-01 | 2.7772E 00 | 7907 |
| 22 FLAP | 4.1747E 01 | 3 43 40.55 | 4.2800E 01 | 3 42 35.01 | 4.2610E 01 | 2.1217E-01 | 4.2611E 01 | 7907 |
| 23 DISC 23 | DISCRETE | | | | | | | |
| 24 DISC 24 | DISCRETE | | | | | | | |
| 25 SELE | -7.7952E 00 | 3 45 45.18 | 1.2543E 01 | 3 45 26.59 | 2.5031E 00 | 4.3132E 00 | 4.9869E 00 | 7907 |
| 26 SAILRGHT | -1.5408E 01 | 3 43 26.22 | 1.5191E 01 | 3 45 21.58 | 4.6720E 00 | 6.2270E 00 | 7.7348E 00 | 7907 |
| 27 TETA | -5.5784E 00 | 3 44 45.00 | 1.6560E 00 | 3 42 55.29 | -1.9726E 00 | 1.3643E 00 | 2.3984E 00 | 7907 |
| 28 PHI | -1.0287E 01 | 3 45 16.77 | 1.1777E 01 | 3 43 23.58 | 8.2804E-01 | 3.3832E 00 | 3.4831E 00 | 7907 |
| 29 SAILLEFT | -1.2497E 01 | 3 45 21.19 | 1.3117E 01 | 3 45 35.63 | -3.3218E 00 | 5.1053E 00 | 6.0933E 00 | 7907 |
| 30 SRUD | -9.6178E 00 | 3 43 40.41 | 7.6249E 00 | 3 43 27.50 | 1.0698E 00 | 2.9214E 00 | 3.1110E 00 | 7907 |
| 31 AIL-SIGN | -9.9692E-01 | 3 45 3.18 | 2.2615E 01 | 3 42 35.01 | 2.1893E 01 | 2.6803E 00 | 2.2056E 01 | 7903 |
| 32 RUDDSIGN | -4.7289E-01 | 3 43 40.19 | 2.0096E 01 | 3 42 35.01 | 1.9430E 01 | 2.4877E 00 | 1.9589E 01 | 7899 |
| 33 DC MONT | 1.1219E 01 | 3 45 30.46 | 1.1834E 01 | 3 43 40.58 | 1.1329E 01 | 7.1391E-02 | 1.1329E 01 | 7907 |
| 34 HEAD | 1.8194E 01 | 3 44 27.67 | 1.9529E 01 | 3 43 48.68 | 1.8886E 01 | 3.1304E-01 | 1.8889E 01 | 7907 |
| 35 | NTC | | | | | | | |
| 36 Q | -4.6175E 00 | 3 45 45.40 | 3.5674E 00 | 3 45 42.11 | -6.3130E-01 | 1.3078E 00 | 1.4522E 00 | 7907 |
| 37 AC MONT | 2.4130E 01 | 3 42 40.11 | 2.5620E 01 | 3 43 40.58 | 2.4252E 01 | 2.6785E-01 | 2.4254E 01 | 77 |
| 38 | NTC | | | | | | | |
| 39 | NTC | | | | | | | |
| 40 P | -1.5843E 01 | 3 43 56.97 | 9.5922E 00 | 3 44 39.89 | -1.4867E 00 | 3.4475E 00 | 3.7499E 00 | 7907 |
| 41 QDOT | -2.3529E-02 | 3 45 46.55 | 1.6471E-01 | 3 44 45.00 | 6.7561E-02 | 2.2126E-02 | 7.1280E-02 | 7907 |
| 42 R | -3.0250E 00 | 3 44 26.49 | 4.6769E 00 | 3 43 24.77 | 6.5182E-02 | 1.2033E 00 | 1.2051E 00 | 7907 |
| 43 PDOT | -8.5344E-02 | 3 45 19.13 | 3.2716E-01 | 3 43 57.38 | 1.4399E-01 | 4.6732E-02 | 1.5139E-01 | 7907 |
| 44 RDOT | 6.9279E-02 | 3 43 40.41 | 1.5010E-01 | 3 42 43.20 | 1.0627E-01 | 1.1502E-02 | 1.0689E-01 | 7907 |
| 45 RUAC | 1.4384E-01 | 3 42 51.89 | 5.0058E 00 | 3 43 11.48 | 7.4261E-01 | 4.6459E-01 | 8.7597E-01 | 7907 |
| 46 FLAC | 3.0914E-01 | 3 43 1.54 | 3.5453E 00 | 3 45 39.95 | 1.3639E 00 | 6.5016E-01 | 1.5109E 00 | 7907 |
| 47 RAAC | 1.3266E-02 | 3 42 36.31 | 2.9071E 00 | 3 42 55.44 | 5.1231E-01 | 3.0632E-01 | 5.9691E-01 | 7907 |
| 48 LAAC | 1.8187E-01 | 3 42 59.97 | 2.4126E 00 | 3 42 55.44 | 6.1004E-01 | 2.4136E-01 | 6.5605E-01 | 7907 |
| 49 RDOTGYRO | -3.5344E 00 | 3 43 24.82 | 3.1358E 00 | 3 44 26.56 | -5.0583E-03 | 8.8561E-01 | 8.8563E-01 | 7907 |

QUALITATIVE ANALYSIS

A/P NO. 0099 TEST NO. 0921 RUN NO. 124617 COND 9 CALIBRATION PROGRAM FLT COND

| BEGINNING TIME | ENDING TIME | SAMPLE SIZE |
|---|---|---|
| 3 42 35.01 | 3 45 49.01 | 7907 |

| VARIABLE | MINIMUM | AT TIME (HMS) | MAXIMUM | AT TIME (HMS) | MEAN | SIGMA | RMS | SAMPLES |
|---|---|---|---|---|---|---|---|---|
| 50 | NTC | | | | | | | |
| 51 TETACOMM | -8.9279E 00 | 3 45 40.99 | 1.0551E 01 | 3 43 12.80 | 3.9461E-01 | 3.6542E 00 | 3.6754E 00 | 7907 |
| 52 PHI COMM | -1.1990E 01 | 3 44 47.20 | 1.4517E 01 | 3 43 27.08 | 3.1090E 00 | 6.0142E 00 | 6.7703E 00 | 7907 |
| 53 PSI COMM | -6.0665E 00 | 3 43 40.28 | 8.7628E 00 | 3 45 26.82 | 1.4882E 00 | 1.6667E 00 | 2.2344E 00 | 7907 |
| 54 DPSICOMM | -2.0975E 00 | 3 42 40.11 | 1.4163E 00 | 3 43 40.53 | 6.0376E-02 | 3.7181E-01 | 3.7668E-01 | 7907 |
| 55 ELERSIGN | 3.0105E 01 | 3 42 35.01 | 3.0105E 01 | 3 42 35.01 | 3.0105E 01 | 0.0 | 3.0105E 01 | 7907 |
| 56 | NTC | | | | | | | |
| 57 TETAGYRO | -1.7341E 00 | 3 42 35.01 | 6.8916E 00 | 3 45 45.82 | 2.9164E 00 | 1.7383E 00 | 3.3951E 00 | 7907 |
| 58 Q GYRO | -2.4290E-01 | 3 45 40.76 | 8.8698E-02 | 3 43 47.23 | -7.7517E-02 | 3.8594E-02 | 8.6593E-02 | 7907 |
| 59 RUD ACT | -2.4650E 01 | 3 43 58.17 | 1.9503E 01 | 3 43 40.60 | -6.9465E-01 | 4.5760E 00 | 4.6284E 00 | 7907 |
| 60 ELEVACT | -1.9040E 01 | 3 45 41.50 | 1.5641E 01 | 3 45 44.37 | 9.8776E-01 | 5.0499E 00 | 5.1456E 00 | 7907 |
| 61 RTALACT | -1.7744E 01 | 3 44 27.87 | 1.9988E 01 | 3 42 40.14 | -1.9348E-02 | 6.0180E 00 | 6.0181E 00 | 7907 |
| 62 LTALACT | -1.6817E 01 | 3 42 40.11 | 1.5522E 01 | 3 45 21.75 | -6.9077E-01 | 5.6497E 00 | 5.6918E 00 | 7907 |
| 63 PHI GYRO | -1.3466E 01 | 3 45 32.11 | 9.2702E 00 | 3 45 16.82 | -2.4924E 00 | 3.4540E 00 | 4.2594E 00 | 7907 |
| 64 P GYRO | -6.2921E 00 | 3 44 39.92 | 1.2360E 01 | 3 43 56.97 | 7.1593E-01 | 1.7926E 00 | 1.9302E 00 | 7907 |
| 65 | NTC | | | | | | | |
| 66 | NTC | | | | | | | |
| 67 ALT-LO | OSD | | | | | | | |
| 68 ALT-GD | 4.6359E-02 | 3 43 40.60 | 7.9473E-02 | 3 45 0.31 | 6.5006E-02 | 5.5047E-03 | 6.5238E-02 | 7907 |
| 69 LOC | -3.0814E-01 | 3 45 21.78 | 6.0904E-01 | 3 43 26.10 | 1.8114E-01 | 2.3176E-01 | 2.9415E-01 | 7907 |
| 70 GLID | -7.6602E-01 | 3 42 35.01 | 3.6207E-01 | 3 45 46.23 | -1.2155E-01 | 2.4723E-01 | 2.7549E-01 | 7907 |
| 71 | NTC | | | | | | | |
| 72 | NTC | | | | | | | |
| 73 | NTC | | | | | | | |
| 74 | NTC | | | | | | | |
| 75 | NTC | | | | | | | |
| 76 | NTC | | | | | | | |
| 77 OAT | 5.2380E 01 | 3 42 48.58 | 6.1432E 01 | 3 45 12.41 | 5.6224E 01 | 2.6413E 00 | 5.6286E 01 | 7907 |

QUALITATIVE ANALYSIS

A/P NO. 0099 TEST NO. 0921 RUN NO. 124617 COND 10 CALIBRATION PROGRAM FLT COND

| BEGINNING TIME | ENDING TIME | SAMPLE SIZE |
|---|---|---|
| 3 45 50.50 | 3 46 50.01 | 2426 |

| VARIABLE | | MINIMUM | AT TIME (HMS) | MAXIMUM | AT TIME (HMS) | MEAN | SIGMA | RMS | SAMPLES |
|---|---|---|---|---|---|---|---|---|---|
| 1 | ZACC | 6.0164E-01 | 3 46 46.72 | 1.4206E 00 | 3 45 54.30 | 1.0025E 00 | 1.1385E-01 | 1.0089E 00 | 2426 |
| 2 | YACC | -1.0039E-01 | 3 46 23.65 | 1.1122E-01 | 3 45 55.77 | -1.1092E-03 | 2.9401E-02 | 2.9422E-02 | 2426 |
| 3 | XACC | -7.2155E-02 | 3 45 57.73 | 2.3419E-01 | 3 46 28.71 | 1.3704E-01 | 7.1932E-02 | 1.5037E-01 | 2426 |
| 4 | ALPHA | -2.4038E 00 | 3 45 55.58 | 7.3973E 00 | 3 46 28.61 | 3.4036E 00 | 1.8381E 00 | 3.8682E 00 | 2426 |
| 5 | BETA | -6.7323E 00 | 3 45 55.68 | 5.7674E 00 | 3 46 25.55 | -2.6822E-01 | 1.8902E 00 | 1.9092E 00 | 2426 |
| 6 | TIM-TURB | 1.1030E 00 | 3 46 11.09 | 2.6855E 00 | 3 46 29.49 | 1.9004E 00 | 4.1108E-01 | 1.9445E 00 | 2426 |
| 7 | TIM-A/S | 3.6737E 01 | 3 46 3.48 | 6.9274E 01 | 3 46 46.62 | 4.9689E 01 | 9.6296E 00 | 5.0613E 01 | 2426 |
| 8 | TIM | 3.7858E 01 | 3 45 59.75 | 6.9274E 01 | 3 46 46.62 | 4.9944E 01 | 9.5694E 00 | 5.0853E 01 | 2426 |
| 9 | ALTI | 1.5534E 03 | 3 45 50.50 | 3.1246E 03 | 3 46 47.95 | 1.7972E 03 | 1.7224E 02 | 1.8054E 03 | 2426 |
| 10 | ALTIFINE | 1.5259E 03 | 3 45 52.95 | 2.1715E 03 | 3 46 49.81 | 1.7944E 03 | 1.7703E 02 | 1.8031E 03 | 2426 |
| 11 | VIAS | 1.0138E 02 | 3 45 59.82 | 1.4454E 02 | 3 46 47.48 | 1.1901E 02 | 1.3585E 01 | 1.1978E 02 | 2426 |
| 12 | VIASLINE | 1.0176E 02 | 3 45 59.87 | 1.4516E 02 | 3 46 30.94 | 1.1792E 02 | 1.3108E 01 | 1.1865E 02 | 2426 |
| 13 | PELE | -3.0187E 00 | 3 46 19.87 | 1.3731E 00 | 3 46 0.02 | -1.1006E 00 | 1.0259E 00 | 1.5046E 00 | 2426 |
| 14 | PAILRGHT | 3.0769E-01 | 3 46 47.65 | 2.8461E 00 | 3 46 2.23 | 1.1902E 00 | 3.5126E-01 | 1.2410E 00 | 2426 |
| 15 | PAILLEFT | -1.9178E 00 | 3 46 2.21 | 4.9316E-01 | 3 46 47.63 | -2.9134E-01 | 3.3605E-01 | 4.4474E-01 | 2426 |
| 16 | PRUD | -7.4143E-02 | 3 45 56.66 | 2.1725E 00 | 3 46 11.53 | 1.3245E 00 | 4.2902E-01 | 1.3922E 00 | 2426 |
| 17 | ELE-TRIM | 3.0769E 00 | 3 45 50.50 | 3.2821E 00 | 3 46 28.73 | 3.1539E 00 | 4.5086E-02 | 3.1542E 00 | 2426 |
| 18 | RUD-TRIM | -1.0112E-01 | 3 45 50.50 | -6.0364E-02 | 3 46 1.56 | -1.8087E-01 | 5.4777E-03 | 1.8096E-01 | 2426 |
| 19 | STABPOS | -1.2963E 00 | 3 45 59.33 | 1.1151E 00 | 3 46 30.06 | 5.4107E-02 | 8.9289E-01 | 8.9453E-01 | 2426 |
| 20 | THROLEFT | 2.8471E 00 | 3 45 50.50 | 3.6731E 00 | 3 45 54.38 | 3.5631E 00 | 1.4325E-01 | 3.5659E 00 | 2426 |
| 21 | THRORGHT | 2.7857E 00 | 3 45 50.67 | 3.6363E 00 | 3 45 54.30 | 3.4604E 00 | 1.3369E-01 | 3.4630E 00 | 2426 |
| 22 | FLAP | -2.0558E-01 | 3 46 24.66 | 4.2800E 01 | 3 45 50.50 | 1.4812E 01 | 1.7451E 01 | 2.2889E 01 | 2426 |
| 23 | DISC 23 | DISCRETE | | | | | | | |
| 24 | DISC 24 | DISCRETE | | | | | | | |
| 25 | SELE | -9.0766E 00 | 3 45 58.30 | 1.7872E 01 | 3 46 14.30 | 1.8285E 00 | 6.3930E 00 | 6.6494E 00 | 2426 |
| 26 | SAILRGHT | -1.0894E 01 | 3 46 1.44 | 1.5087E 01 | 3 46 3.02 | 8.0808E-01 | 5.4922E 00 | 5.5513E 00 | 2426 |
| 27 | THETA | -4.5197E 00 | 3 45 50.50 | 7.8316E 00 | 3 46 47.43 | 5.1476E 00 | 2.4337E 00 | 5.6939E 00 | 2426 |
| 28 | PHI | -5.3040E 00 | 3 46 2.13 | 3.0216E 00 | 3 46 4.95 | -5.3620E-01 | 1.7132E 00 | 1.7951E 00 | 2426 |
| 29 | SAILLEFT | -1.2297E 01 | 3 46 3.11 | 1.0625E 01 | 3 46 22.11 | -3.2705E-02 | 4.5625E 00 | 4.5626E 00 | 2426 |
| 30 | SRUD | -9.0483E 00 | 3 46 1.99 | 8.4799E 00 | 3 46 23.92 | 1.1368E 00 | 3.1976E 00 | 3.3937E 00 | 2426 |
| 31 | AIL-STCN | 3.2466E-01 | 3 46 3.92 | 2.2615E 01 | 3 45 50.50 | 2.1452E 01 | 3.1338E 00 | 2.1680E 01 | 2425 |
| 32 | RUDDSION | -3.1647E-01 | 3 46 1.71 | 2.0096E 01 | 3 45 50.50 | 1.8950E 01 | 3.5042E 00 | 1.9271E 01 | 2426 |
| 33 | DC MONT | 1.1270E 01 | 3 45 51.68 | 1.1731E 01 | 3 46 1.44 | 1.1365E 01 | 7.9399E-02 | 1.1365E 01 | 2426 |
| 34 | HEAD | 1.8194E 01 | 3 46 0.63 | 1.9310E 01 | 3 46 30.62 | 1.8794E 01 | 2.0413E-01 | 1.8796E 01 | 2426 |
| 35 | | NTC | | | | | | | |
| 36 | Q | -3.8338E 00 | 3 46 6.92 | 5.3089E 00 | 3 45 52.98 | -3.8296E-01 | 1.2853E 00 | 1.3412E 00 | 2426 |
| 37 | AC MONT | 2.4132E 01 | 3 46 1.27 | 2.4790E 01 | 3 46 1.49 | 2.4235E 01 | 2.0872E-01 | 2.4236E 01 | 59 |
| 38 | | NTC | | | | | | | |
| 39 | | NTC | | | | | | | |
| 40 | P | -1.1519E 01 | 3 46 1.69 | 7.6079E 00 | 3 46 3.31 | -1.4690E 00 | 2.7349E 00 | 3.1140E 00 | 2426 |
| 41 | QDOT | -2.3529E-02 | 3 46 21.56 | 1.6471E-01 | 3 45 52.51 | 6.5720E-02 | 2.2598E-02 | 6.9496E-02 | 2426 |
| 42 | R | -3.3298E 00 | 3 46 24.17 | 3.0260E 00 | 3 46 26.85 | 1.2603E-01 | 1.0813E 00 | 1.0886E 00 | 2426 |
| 43 | PDOT | -9.9563E-02 | 3 46 29.07 | 3.2716E-01 | 3 46 28.73 | 1.4439E-01 | 5.2468E-02 | 1.5363E-01 | 2426 |
| 44 | RDOT | 6.9274E-02 | 3 46 20.04 | 1.5010E-01 | 3 45 55.77 | 1.0710E-01 | 1.3082E-02 | 1.0789E-01 | 2426 |
| 45 | RUAC | 1.4384E-01 | 3 45 50.72 | 5.2003E 00 | 3 45 59.43 | 8.1276E-01 | 5.2959E-01 | 9.7008E-01 | 2426 |
| 46 | ELAC | 3.4813E-01 | 3 45 51.16 | 5.1049E 00 | 3 46 47.60 | 1.8837E 00 | 8.6500E-01 | 2.0729E 00 | 2426 |
| 47 | RAAC | 1.3266E-02 | 3 45 52.24 | 3.6892E 00 | 3 46 47.75 | 5.8385E-01 | 4.3512E-01 | 7.2815E-01 | 2426 |
| 48 | LAAC | 2.2101E-01 | 3 45 53.03 | 2.9213E 00 | 3 46 47.70 | 5.9266E-01 | 2.8302E-01 | 6.5677E-01 | 2426 |
| 49 | RDOTGYRO | -2.2711E 00 | 3 46 26.89 | 2.6920E 00 | 3 46 24.09 | -7.8099E-02 | 7.9204E-01 | 7.9588E-01 | 2426 |

QUALITATIVE ANALYSIS

A/P NO. 0099 TEST NO. (921 RUN NO. 124617 COND 10 CALIBRATION PROGRAM FLT COND

| BEGINNING TIME | ENDING TIME | SAMPLE SIZE |
|---|---|---|
| 3 45 50.50 | 3 46 50.01 | 2426 |

| VARIABLE | MINIMUM | AT TIME (HMS) | MAXIMUM | AT TIME (HMS) | MEAN | SIGMA | RMS | SAMPLES |
|---|---|---|---|---|---|---|---|---|
| 50 | NTC | | | | | | | |
| 51 TETACOMM | -9.1034E 00 | 3 45 59.50 | 1.0551E 01 | 3 45 52.54 | -3.8752E-01 | 5.2481E 00 | 5.2624E 00 | 2426 |
| 52 PHI COMM | -1.1940E 01 | 3 46 1.27 | 1.4517E 01 | 3 45 57.54 | 8.7516E-01 | 5.2096E 00 | 5.2126E 00 | 2426 |
| 53 PSI COMM | -4.6030E 00 | 3 46 1.99 | 1.0463E 01 | 3 46 47.72 | 1.5496E 00 | 1.8729E 00 | 2.4306E 00 | 2426 |
| 54 CPSICOMM | -2.9179E 00 | 3 46 47.70 | 1.3778E 00 | 3 46 1.99 | 7.1993E-02 | 4.2075E-01 | 4.2686E-01 | 2426 |
| 55 FLERSIGN | 3.0105E 01 | 3 45 50.50 | 3.0105E 01 | 3 45 50.50 | 3.0105E 01 | 0.0 | 3.0105E 01 | 2426 |
| 56 | NTC | | | | | | | |
| 57 TETAGYRO | -4.6490E 00 | 3 46 6.30 | 6.4124E 00 | 3 45 50.50 | -2.7938E 00 | 2.1353E 00 | 3.5164E 00 | 2426 |
| 58 P GYRO | -1.6193E-01 | 3 45 51.56 | 5.3334E-01 | 3 45 57.14 | -8.2544E-02 | 4.5656E-02 | 9.4320E-02 | 2426 |
| 59 RUD ACT | -2.4066E 01 | 3 46 0.98 | 1.9152E 01 | 3 45 59.77 | -7.1166E-01 | 4.9036E 00 | 4.9550E 00 | 2426 |
| 60 ELEVACT | -1.6814E 01 | 3 45 52.36 | 1.4001E 01 | 3 46 47.09 | 1.9494E 00 | 5.5298E 00 | 5.8633E 00 | 2426 |
| 61 RTALACT | -1.7744E 01 | 3 46 4.78 | 1.9871E 01 | 3 46 3.95 | -5.8221E-01 | 6.3021E 00 | 6.3259E 00 | 2426 |
| 62 LTALACT | -1.6877E 01 | 3 46 3.95 | 1.5288E 01 | 3 46 0.38 | -9.7495E-02 | 5.8090E 00 | 5.8099E 00 | 2426 |
| 63 PHI GYRO | -5.7680E 00 | 3 46 4.95 | 3.2871E 00 | 3 46 23.48 | -1.2622E 00 | 1.8177E 00 | 2.2130E 00 | 2426 |
| 64 P GYRO | -4.7191E 00 | 3 46 3.31 | 8.9888E 00 | 3 46 1.71 | 7.1833E-01 | 1.3178E 00 | 1.5008E 00 | 2426 |
| 65 | NTC | | | | | | | |
| 66 | NTC | | | | | | | |
| 67 ALT-LO | -4.0306E 00 | 3 46 49.99 | 5.9571E 00 | 3 45 50.77 | 2.1899E 00 | 2.8114E 00 | 3.5637E 00 | 2415 |
| 68 ALT-GO | 6.2916E-02 | 3 45 56.54 | 9.6028E-02 | 3 46 47.31 | 7.9241E-02 | 3.2517E-03 | 7.9307E-02 | 2426 |
| 69 LOC | 2.6330E-01 | 3 45 50.50 | 1.4583E 00 | 3 46 16.26 | 7.2941E-01 | 3.8236E-01 | 8.2355E-01 | 1056 |
| 70 CLID | -9.2591E-01 | 3 46 30.03 | 9.3214E-01 | 3 46 1.61 | 2.0256E-02 | 4.8127E-01 | 4.8169E-01 | 2295 |
| 71 | NTC | | | | | | | |
| 72 | NTC | | | | | | | |
| 73 | NTC | | | | | | | |
| 74 | NTC | | | | | | | |
| 75 | NTC | | | | | | | |
| 76 | NTC | | | | | | | |
| 77 UAT | 5.9622E 01 | 3 46 8.12 | 6.5053E 01 | 3 45 59.50 | 6.0699E 01 | 7.6729E-01 | 6.0704E 01 | 2426 |