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MONITORING DEFLECTION AT LOCKPORT AND AT BRANDON ROAD LOCKS, CH--ETC(U)
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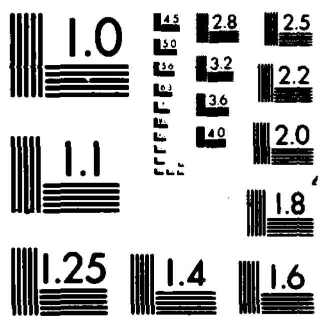

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LEVEL II

MISCELLANEOUS PAPER SL-80-18

MONITORING DEFLECTION AT LOCKPORT AND AT BRANDON ROAD LOCKS CHICAGO DISTRICT

by

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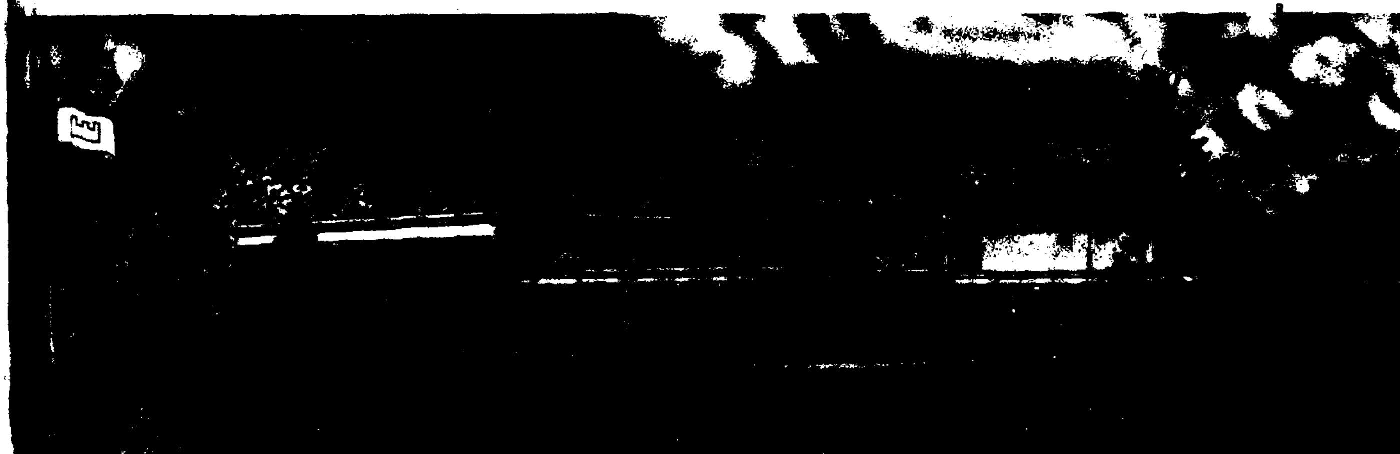
U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Miss. 39180

October 1980

Final Report



Prepared for U. S. Army Engineer District, Chicago
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Deflection
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Lockport Lock and Dam
Locks (Waterways)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A monitoring program was conducted at Lockport Lock and at Brandon Road Lock to record any movement occurring at specific locations.

Movement of Lockport monolith 63 was measured in comparison with monolith 57; tilt measurements were made on both monoliths. Extensometers were placed across existing cracks in a gallery through monolith 50. These measurements, with temperature data, were automatically recorded for a period of seven months.
(Continued)

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20. ABSTRACT (Continued).

The results show monolith 63 to be stable relative to monolith 57 and the cracks in monolith 50 at the gallery to be opening.

At Brandon Road Lock, fixed Whittemore gage points were installed across cracks. The gage points were read periodically by members of the lock staff and the data sent to the U. S. Army Engineer Waterways Experiment Station (WES) for analysis. The data show that existing cracks on Brandon Road Lock opened about 0.06 in. during this period. Readings continue on Brandon Road Lock.

PREFACE

A monitoring study was conducted at Lockport and at Brandon Road Locks for the U. S. Army Engineer District, Chicago. Authorization for the investigation reported here was given in DA Form 2544, dated 9 June 1978 and 12 June 1978.

The work was accomplished during the period November 1978 to July 1979 under the direction of Mr. Bryant Mather, Acting Chief, Structures Laboratory (SL); Mrs. Katharine Mather, Chief, Engineering Sciences Division; Mr. Billy R. Sullivan, Chief, Engineeing Physics Branch; and Mr. Dale Glass, Project Leader. This report was prepared by Mr. Glass and Mr. Sullivan.

The Commanders and Directors of Waterways Experiment Station during this period were COL John L. Cannon, CE, and COL Nelson P. Conover, CE. The Technical Director was Mr. Fred R. Brown.

CONTENTS

CONVERSION FACTORS, INCH-POUND TO METRIC (SI)
UNITS OF MEASUREMENT

Inch-Pound units of measurement used in this report can be converted to metric (SI) as follows:

Multiply	By	To Obtain
inches	25.4	millimetres
feet	0.3048	metres
Fahrenheit degrees	5/9	Celsius degrees*

* To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula: C = (5/9) (F - 32). To obtain Kelvin (K) readings, use K = C + 273.15.

MONITORING DEFLECTION AT LOCKPORT AND AT BRANDON ROAD LOCKS, CHICAGO DISTRICT

PART I: INTRODUCTION

Background

1. Periodic Inspection Report No. 2 on Lockport Lock, dated June 1973, contained recommendations for a monitoring program for monoliths 57 and 63. In Periodic Inspection Report No. 2 for Brandon Road Lock and Dam, dated August 1973, the Chicago District recommended a monitoring program for Brandon Road Lock and Dam.

2. After a field inspection by Waterways Experiment Staion (WES) and Chicago District personnel, a monitoring plan was proposed. The plan was accepted and the work began on 12 November 1978 and continued for a period of seven months at Lockport Lock and is continuing at Brandon Road.

Objective and Scope

3. The objective of the Lockport study was to monitor and record any movement in the lower forebay monolith 63 as referred to the lower right gate monolith 57. Electronic extensometers and inclinometers were used as sensors of the movement. Extensometers were also installed across cracks in the gallery through monolith 50. Thermocouples were installed to monitor the temperature at gage points to permit correcting data for temperature effects on the transducers. All data were recorded automatically and records were mailed to WES by the lockmaster.

4. The objective of the Brandon Road Lock and Dam study was to install and have measured fixed gage points across cracks on both lock walls and in a structure called the ice house adjoining the ice chute. The gage points were measured manually with a Whittemore gage by lock personnel and the results were sent to WES periodically.

PART II: INSTRUMENTATION

5. The following instrumentation* installed at Lockport Lock was:

   a. Three extensometers were installed between monoliths 57 and 63 for the purpose of monitoring the movement of 63 with respect to 57. The movement of monolith 63 was referenced to the downstream vertical face of monolith 57. Figure 1 shows the extensometers to monitor downstream (gage No. 1) and lateral (gage No. 2) movements. Figure 2 shows an extensometer to monitor vertical (gage No. 3) movements. The extensometer rods are connected to built-in linear potentiometer for remote electrical readout.

   b. Two inclinometers (tilt meters) capable of measuring ±14.5-deg tilt were installed on monolith 63. One inclinometer was installed with its sensitive axis parallel to the lock wall (meter No. 1) and the other perpendicular to the lock wall (meter No. 2). These meters are fully self-contained and designed to operate from a standard DC power source. Its output is an analog DC signal directly proportional to the sine of the angle of tilt. These meters are shown in Figure 1.

   c. Two inclinometers (meters No. 3 and 4) were also installed on monolith 57 in the same manner as described in b above and are also shown in Figure 1.

   d. A thermocouple was installed on one of the steel extensometers for measuring the temperature in the steel rods.

   e. An automatic data acquisition system (data logger) was set up in the gate control house on monolith 57. All the transducers described in a, b, c, and d above were connected by instrumentation cable to the data logger and were monitored on eight channels.

   f. Three extensometers were installed across cracks in the gallery in monolith 50. Figure 3 shows the location of these gages (extensometers 4, 5, and 6) in the gallery. These transducers monitored crack movement directly and were recorded remotely.

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* Extensometers were model E-1A made by IRAD, Inc., Lebanon, New Hampshire. Inclinometers (tilt meters) were model LSOC-14.5° made by Schavitz Engineering, Pennsauken, New Jersey.

g. A thermocouple was installed in the gallery in monolith 50 to monitor the temperature.

h. An automatic data acquisition system was set up in the gate control house on monolith 56. Transducers described in f and g above were connected by instrumentation cable to the data logger and was monitored on four channels.

6. The instrumentation installed at Brandon Road Lock was:

a. Two sets of fixed gage points were installed across cracks in the concrete on both monoliths 47 and 49 and their locations are shown in Figure 4.

b. Two sets of fixed points were installed across cracks on both monoliths 48 and 50 and one set installed across the construction joint. These are shown in Figure 5.

c. Three fixed points were installed across cracks on the floor and walls of the ice house.

7. A soil test Multi-Position Strain Gage (Whittemore gage) was left with the Assistant Lockmaster at Brandon Road Lock. A sketch of the fixed point locations and instructions for operation of the strain gage was also provided. Reading were made weekly and transmitted to WES.

PART III: RESULTS AND DISCUSSION

8. All gages were monitored for a minimum period of six months. The data has been reduced to plots as shown in the figures. Figure 1 shows the location of extensometers 1 and 2 which measured the axial upstream-downstream movement (No. 1) and lateral movement (No. 2). Figure 1 also shows the locations of tilt meters 1 through 4. Figure 2 shows the location of extensometer 3 mounted along the stairway and anchored at the base of monolith 63 and near the top of monolith 57 to detect any vertical movement.

9. The results of continuous electronic monitoring are shown on Figures 4 and 5.

10. Axial movement of monolith 63 as shown in Figure 4 was ±0.10 in. with a residual displacement of +0.10 in. corresponding to a separation of joint opening of 0.10 in. Lateral movement as shown on Figure 5 amounts to -0.10 in. toward the river side from the centerline of the lock chamber. Figures 6 shows a similar amount of shortening in the vertical direction. Figure 7 shows the temperature recorded on one of the extensometers which was used to make thermal corrections on the extensometer indications.

11. The results from four tilt meters located as shown on Figure 1 are shown on Plates 8 through 11. No significant movement is indicated on either monolith 57 or 63. A shift occurred on monolith 57 axial tilt meter and on both axial and lateral tilt meters on monolith 63 at 118 days. This amounts to 0.1 degree of tilt. The reason for this is not known and is probably an electronic shift since the extensometer did not confirm such a change at 118 days.

12. Extensometers 4, 5, and 6 were located across existing cracks in a gallery as shown in Figure 3. These extensometers were mounted perpendicular to the direction of flow; two in a horizontal plane, and extensometer 5 in a vertical plane to monitor crack opening caused by a portion of the land-side lock wall moving toward the lock chamber. Results are shown on Figures 12, 13, and 14. Extensometer 4 shows a movement of 0.030 in. corresponding to the existing crack

increasing in width. Extensometer 5 shows up to 0.10 in. and Extensometer 6 shows a movement of 0.30 in. similar to Extensometer 4. Figure 15 shows a plot of the gallery temperature used to correct the gage for temperature effects. Extensometer 5 shows less daily variation due to temperature movement and emptying and filling loads since it was mounted in a vertical plane.

13. The fixed gage points installed at Brandon Road Lock located as shown in Figures 16, 17, and 18, were monitored for a period of eight months. These Whittemore gages were placed in 3/8-in. diameter drilled holes in the concrete. Gage inserts were fitted and driven in place. The results of periodic readings are shown in Figures 19 through 30. Points were lost on gage No. 1 after five weeks and were reset at the 27th week. Gage No. 2 shows a crack opening of 0.040 in. and Gage No. 3 shows as much as 0.060 in. A similar trend is indicated for all gages through gage No. 9 except for gage No. 7 which was installed across a monolith joint between monoliths 48 and 50. Gage Nos. 10, 11 and 12 were located across cracks in the ice house as shown in Figure 18 and showed little movement.

PART IV: CONCLUSIONS

14. The following conclusions can be drawn from this monitoring program at Lockport Lock:

<u>a</u>. At Lockport Lock extensometers 1, 2, and 3 show monolith 63 to be stable relative to monolith 57 to within ±0.10 in. The long extensometers and temperature corrections required indicate that the precision of the measurement is not better than ±00.10 in.

<u>b</u>. The relative stability of monolith 57 and 63 is also confirmed by the results from the tilt meters in which little tilting was indicated.

<u>c</u>. The East or landside lock wall measurements in the gallery showed the existing cracks to be widening by a maximum of 0.040 in. during this monitoring period.

15. The following conclusions can be drawn from this monitoring program at Brandon Road Lock:

<u>a</u>. The fixed point data showed all the cracks to be widening a maximum of 0.060 in. and this occurred as the temperature increased during the later half of the monitoring period.

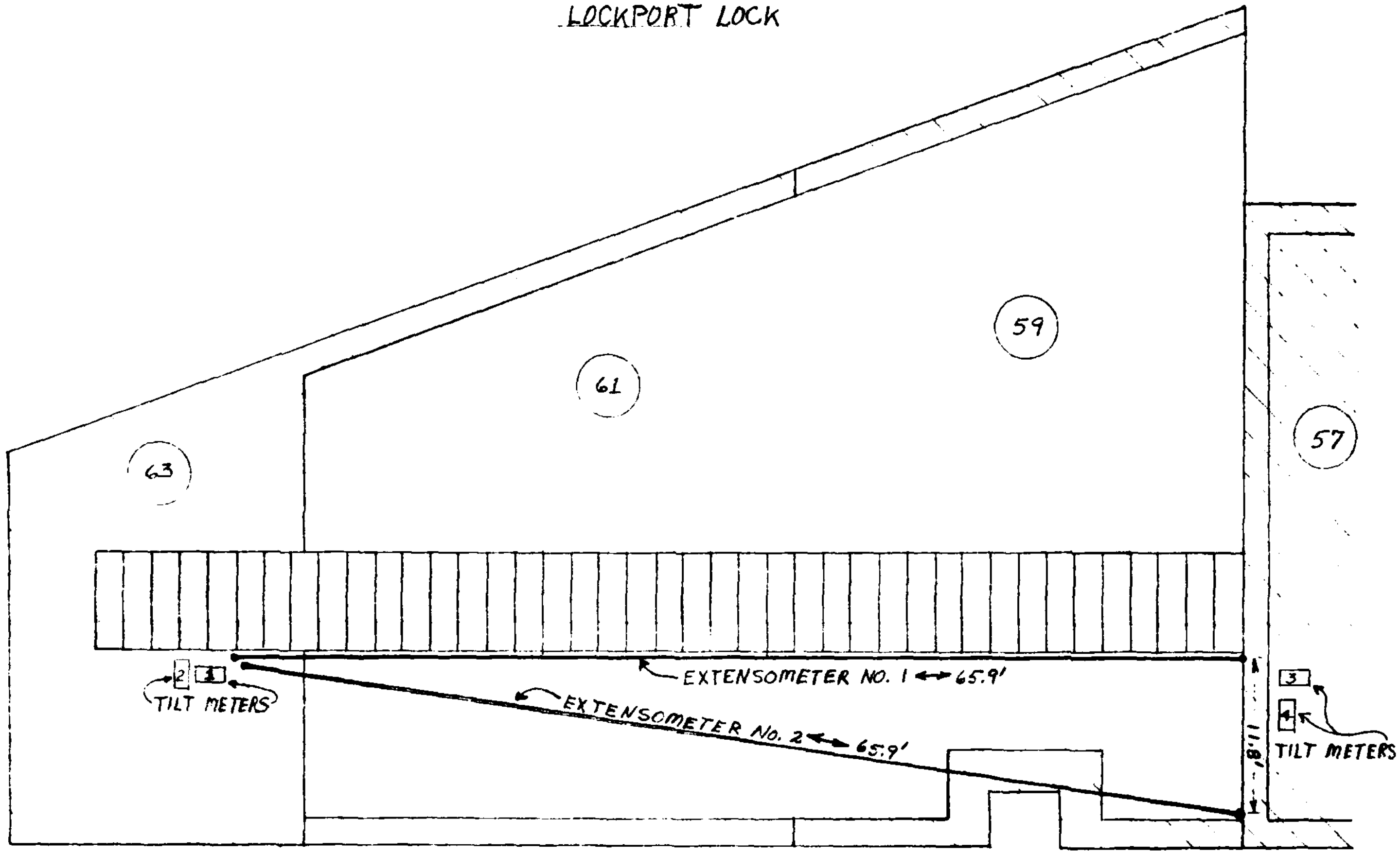
<u>b</u>. Gage points 10, 11, and 12 located across cracks in the ice house at Brandon Road showed very little movement during this monitoring period.

PART V: RECOMMENDATIONS

16. These results show slowly occurring movements which can be monitored satisfactorily using fixed gage points. Unless dynamic or rapidly changing movements are occurring, fixed points are precise, more reliable, and less expensive, and provide the data needed to determine long-term trends. Electronic data loggers should be reserved for rapidly changing conditions and short-term monitoring. Reliable data can be obtained using automatic loggers by periodic checks on calibration, attention to abrupt changes in data with verification and their origin, and careful data analysis.

17. It is recommended that fixed points be installed at Lockport across existing cracks for long-term monitoring and that measurements continue on the Brandon Road gage points by the lock personnel at weekly intervals. A cost proposal and schedule was submitted to the district, 11 February 1980, for review and action.

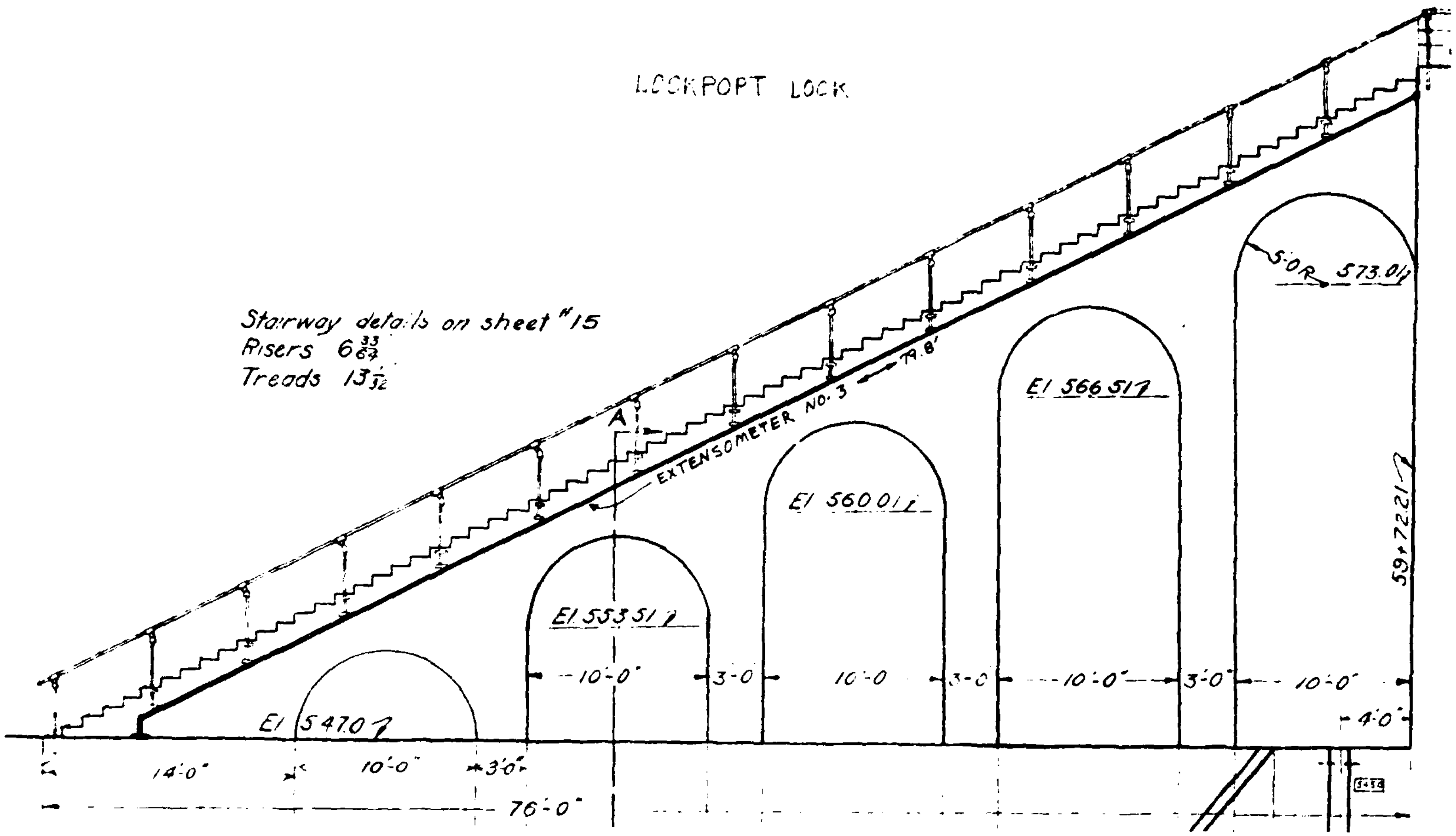
LOCKPORT LOCK



EXTENSOMETER NO.'S 1 & 2 BETWEEN MONOLITHS 57 & 63
FOR MEASURING SEPARATION & LATERAL MOVEMENTS
& INCLINOMETER NO'S 1, 2, 3, & 4 FOR MEASURING TILT

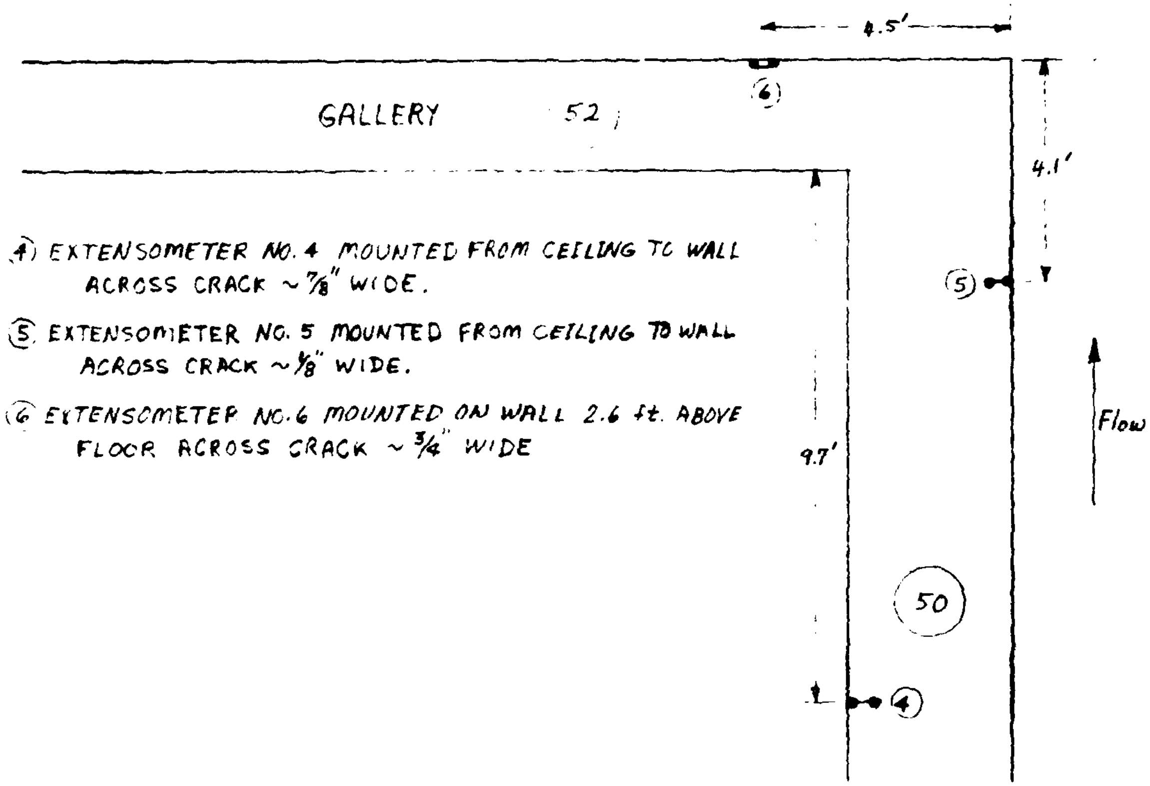
FIGURE 1

LOCKPORT LOCK



EXTENSOMETER NO. 3 BETWEEN MONOLITHS 57 & 63
FOR MEASURING VERTICAL DISPLACEMENTS
FIGURE 2

LOCKPORT LOCK



EXTENSOMETER NO.'S 4, 5, & 6 MOUNTED IN GALLERY IN MONOLITHS 50 & 52 FOR MEASURING CRACK WIDTHS

FIGURE 3

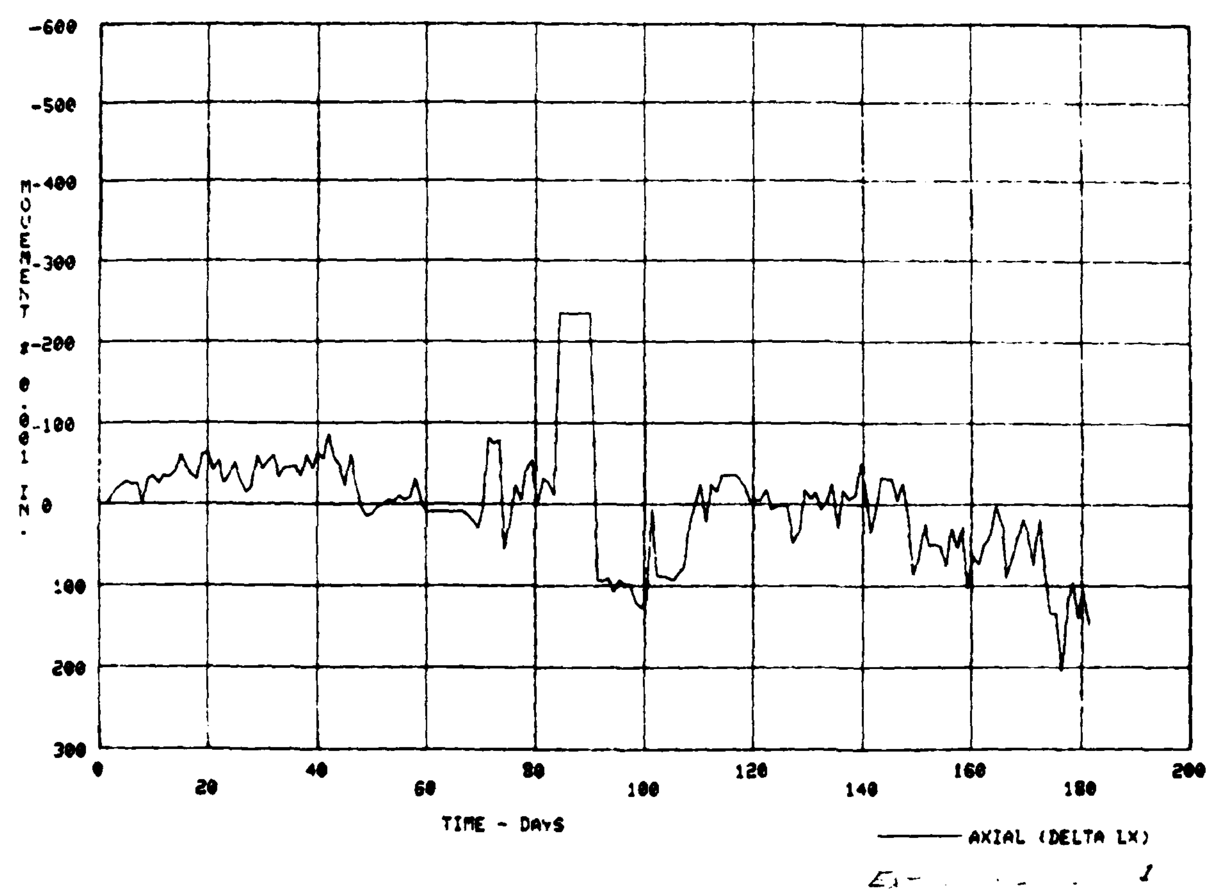
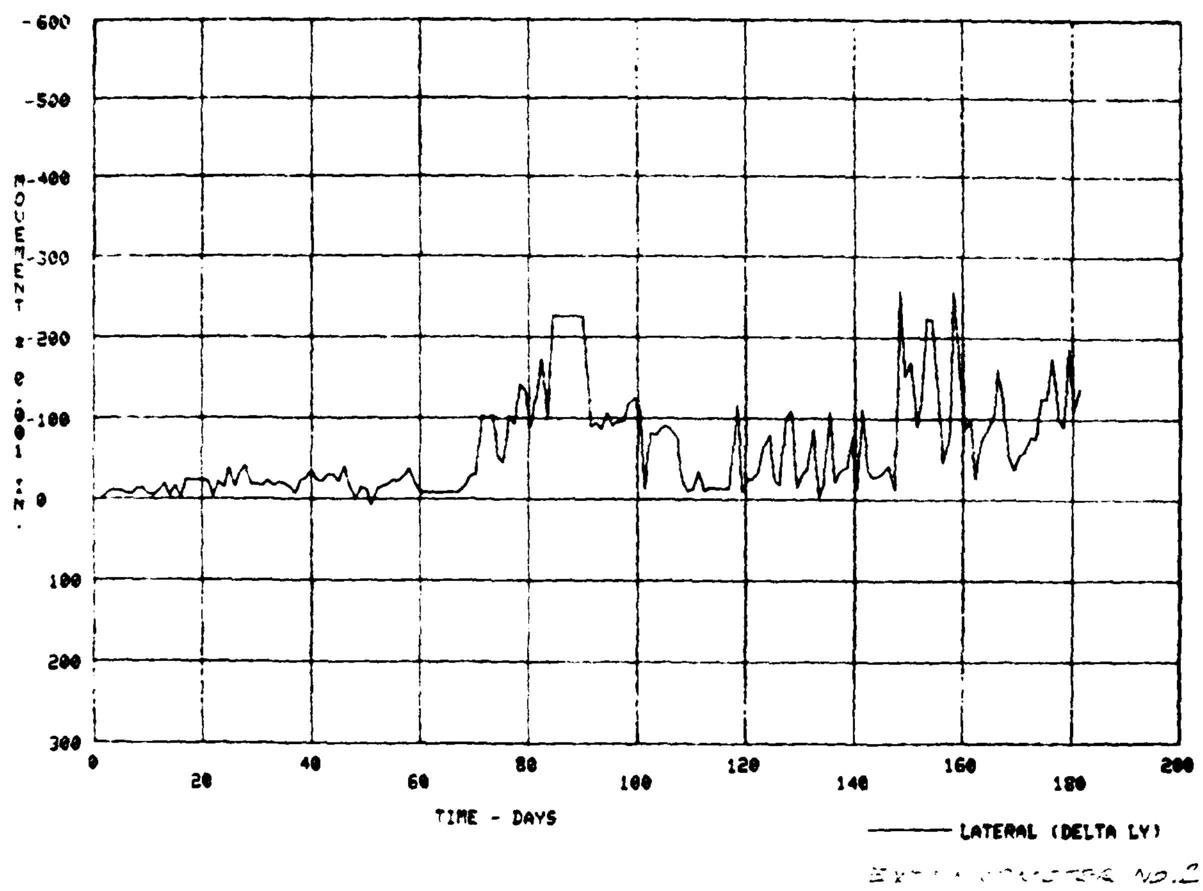
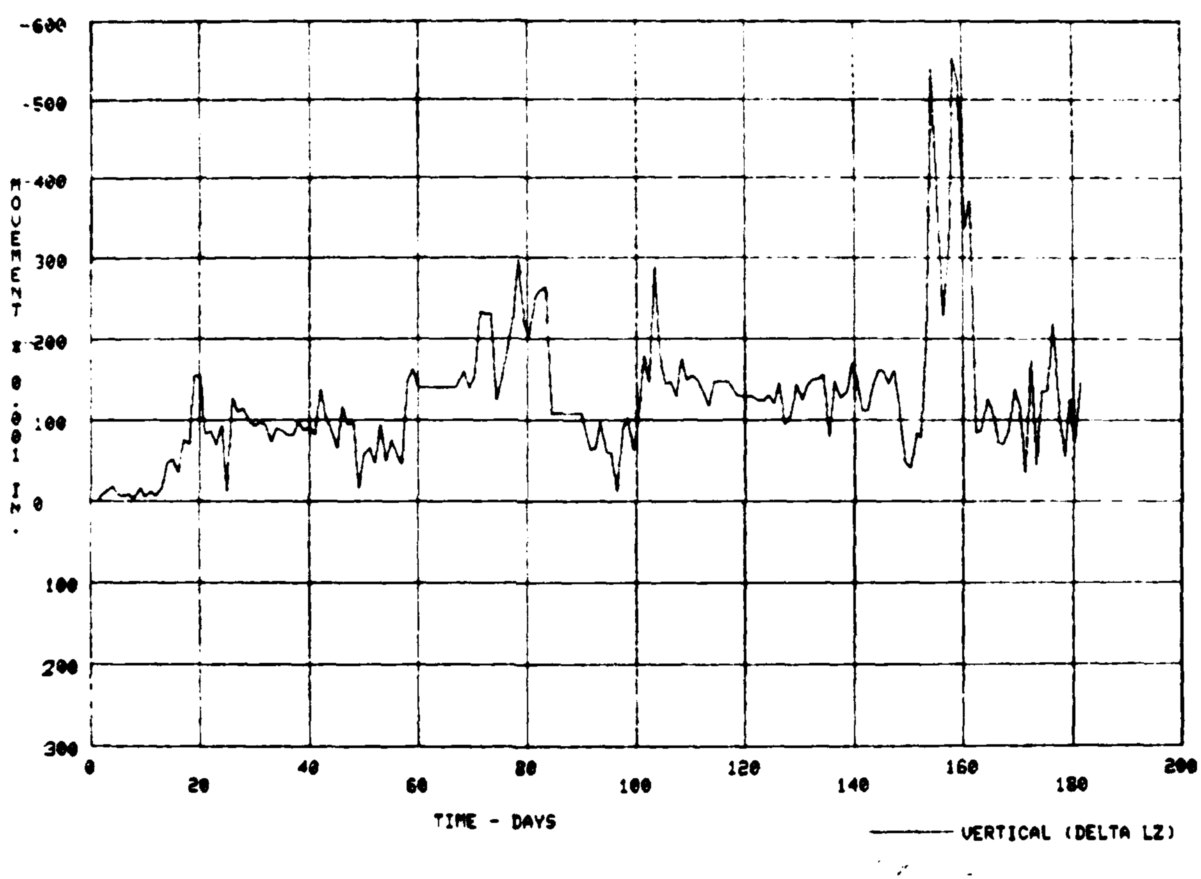


FIGURE 4: LOCKPORT L & D, MONOLITH NO.63



LOCKPORT L & D, MONOLITH NO. 63



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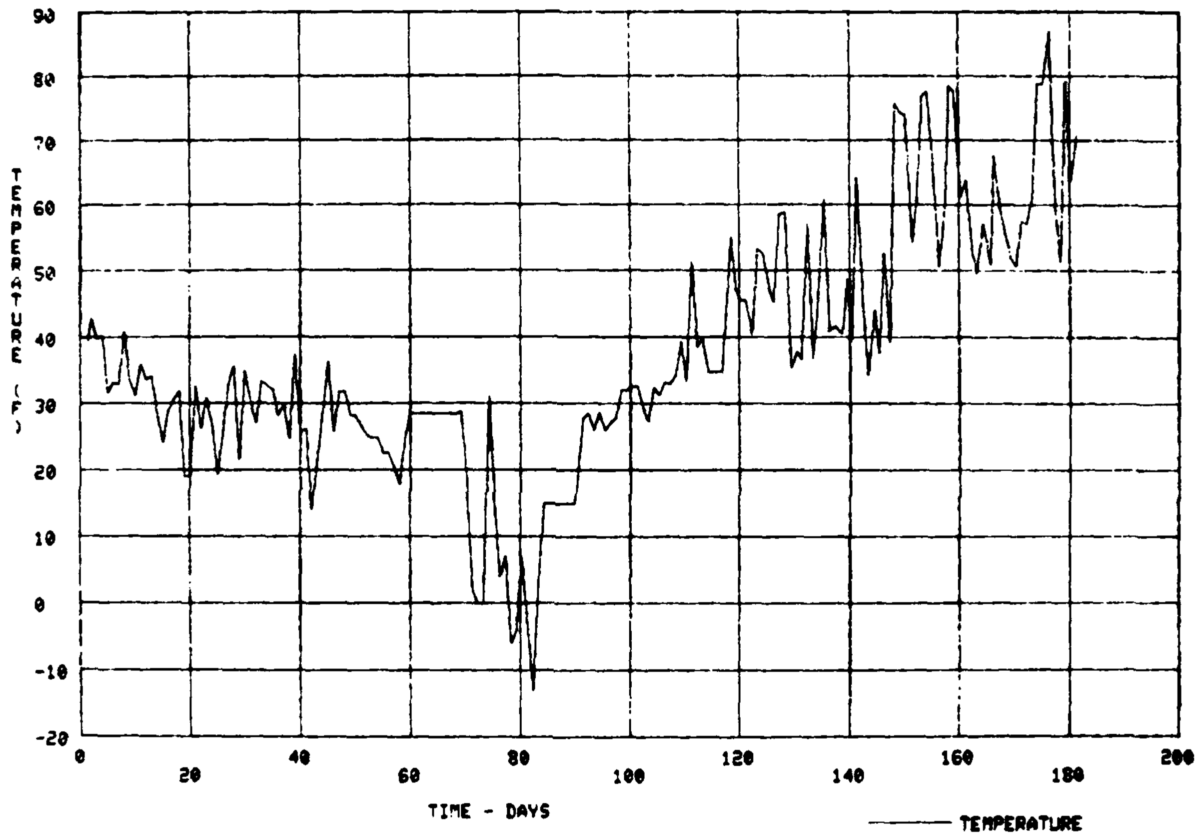

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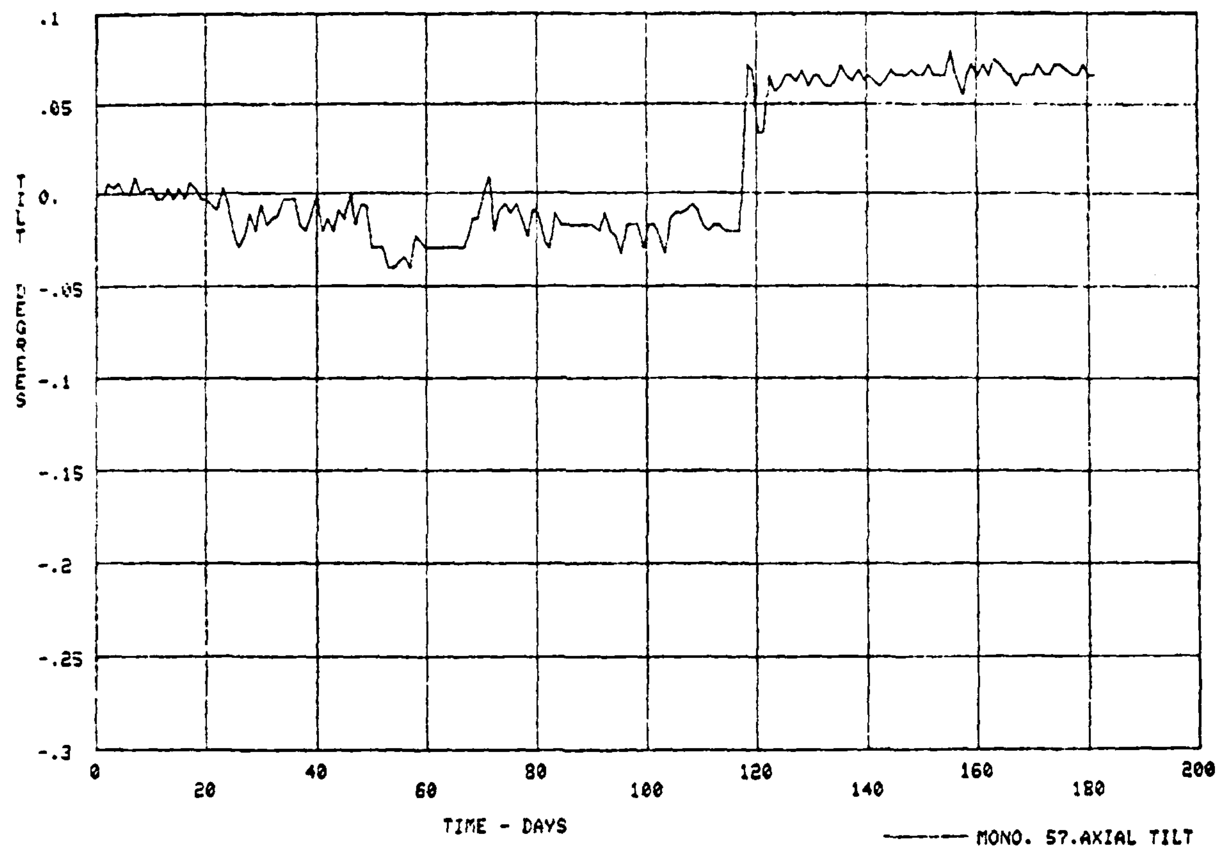

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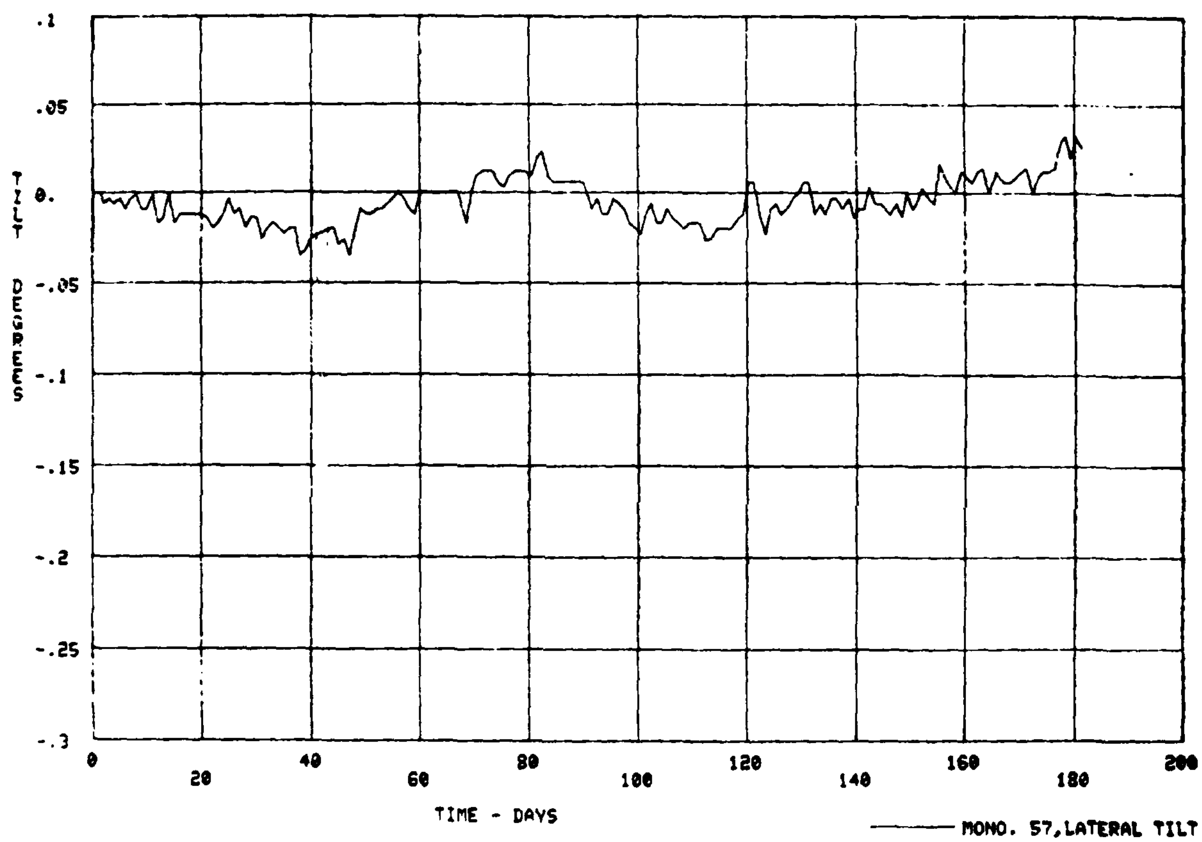
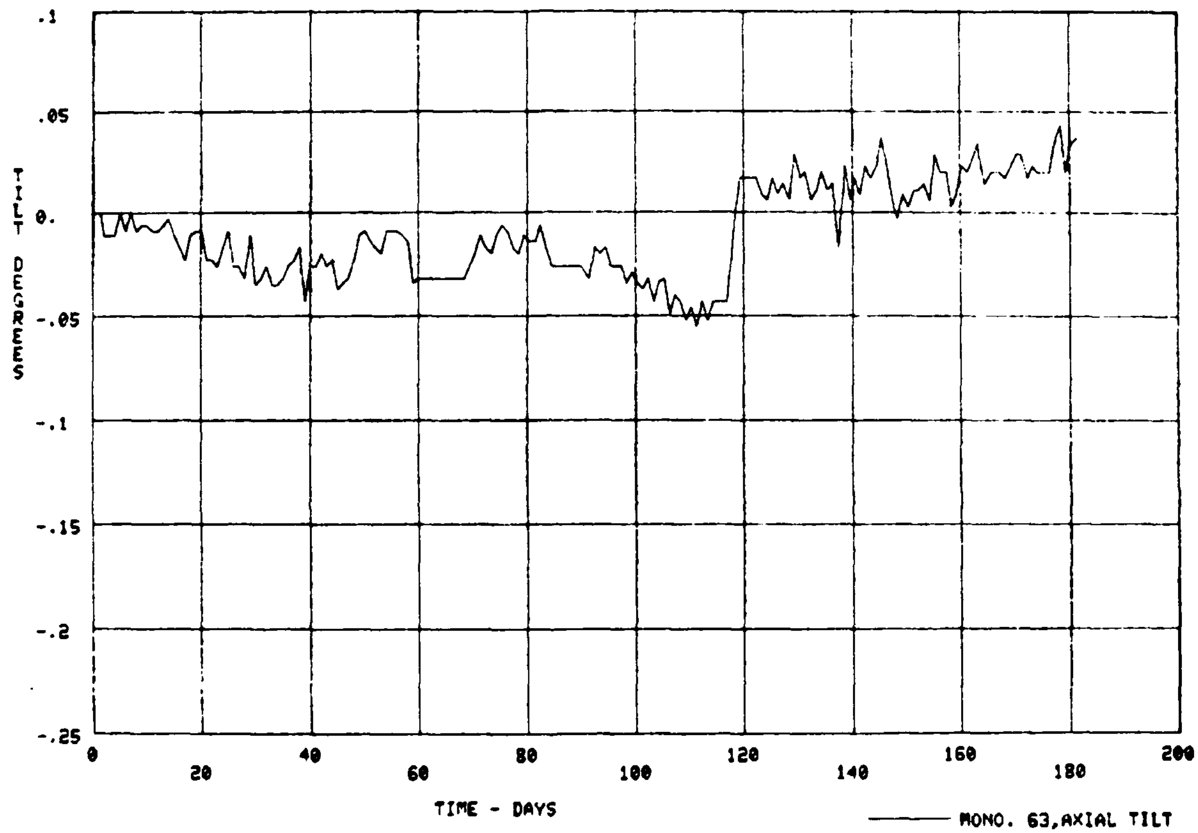
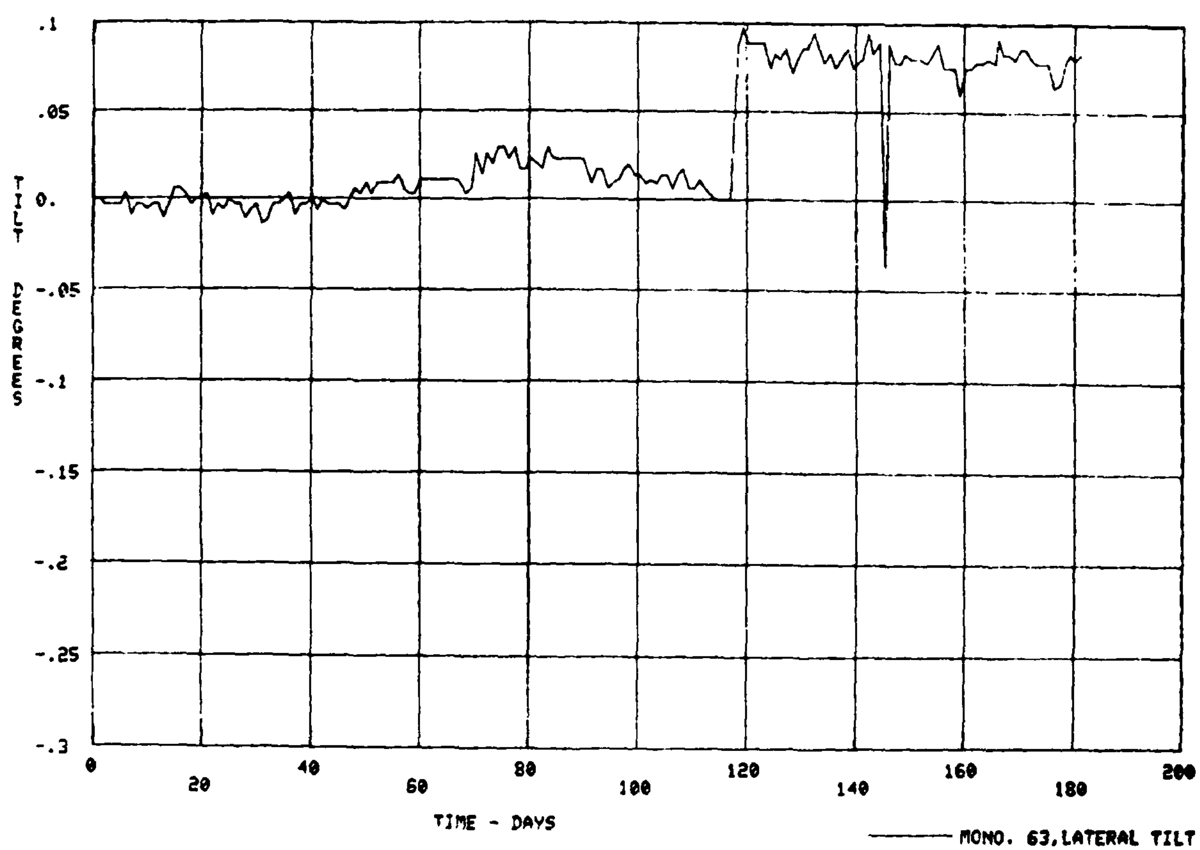


LOCKPORT L & D, MONOLITH NO. 57



LOCKPORT L & D, MONOLITH NO. 63



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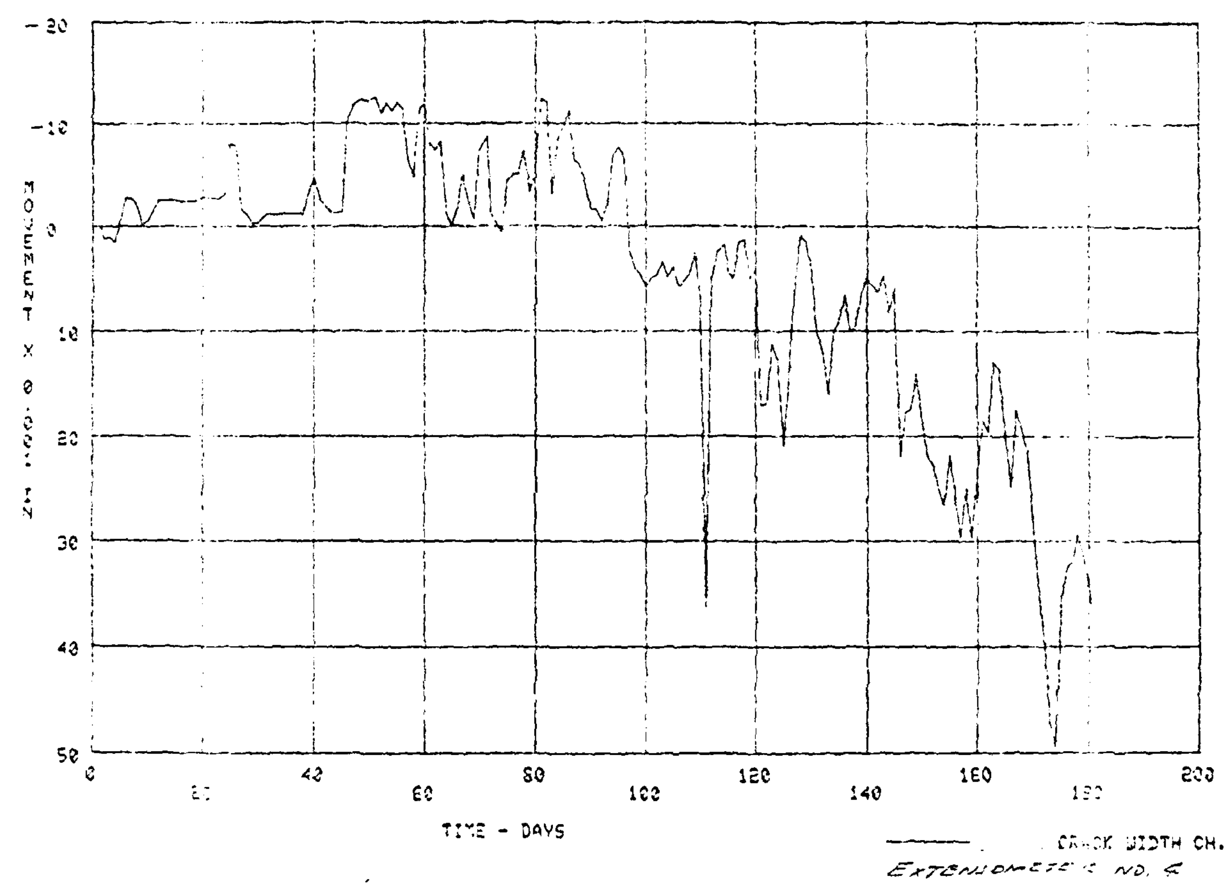
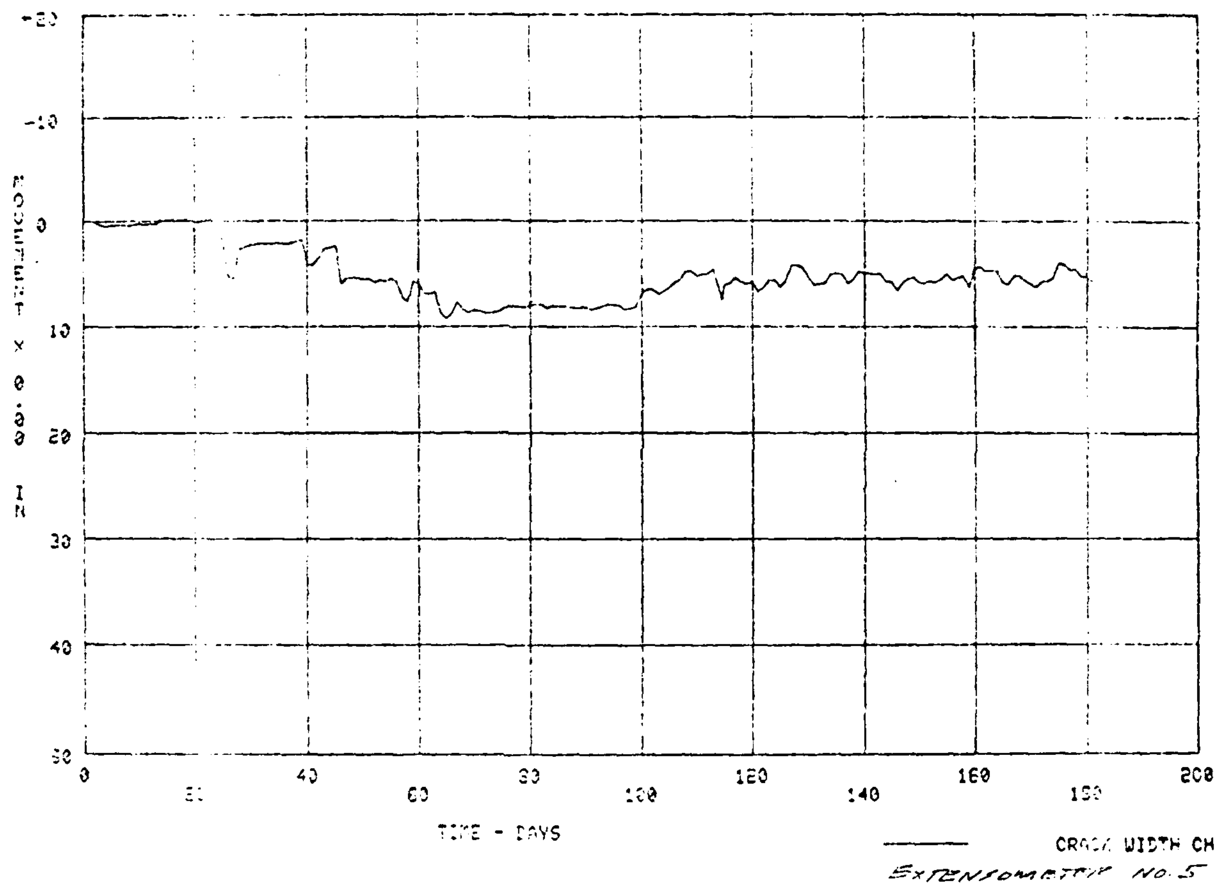


Figure 12: LOCKPORT L & D, MONO 50 GALLERY



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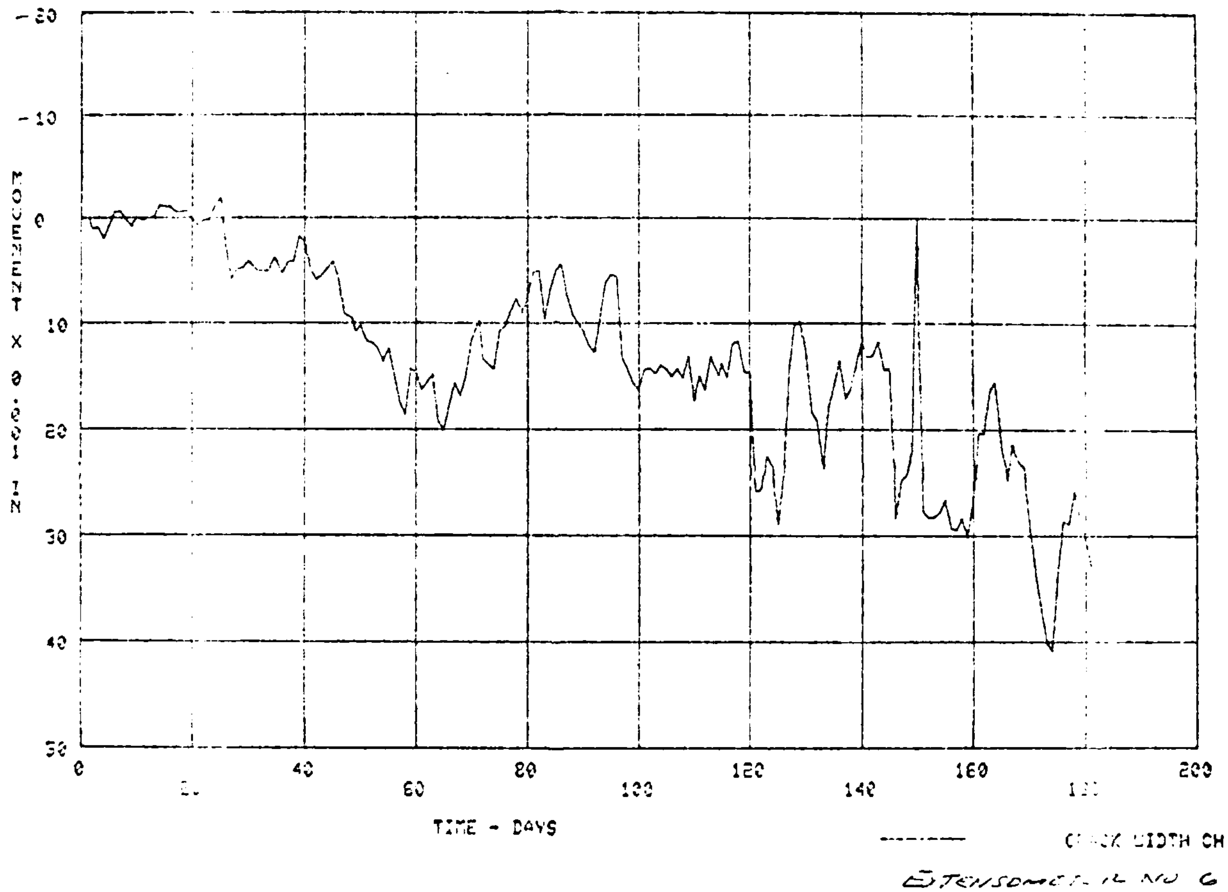
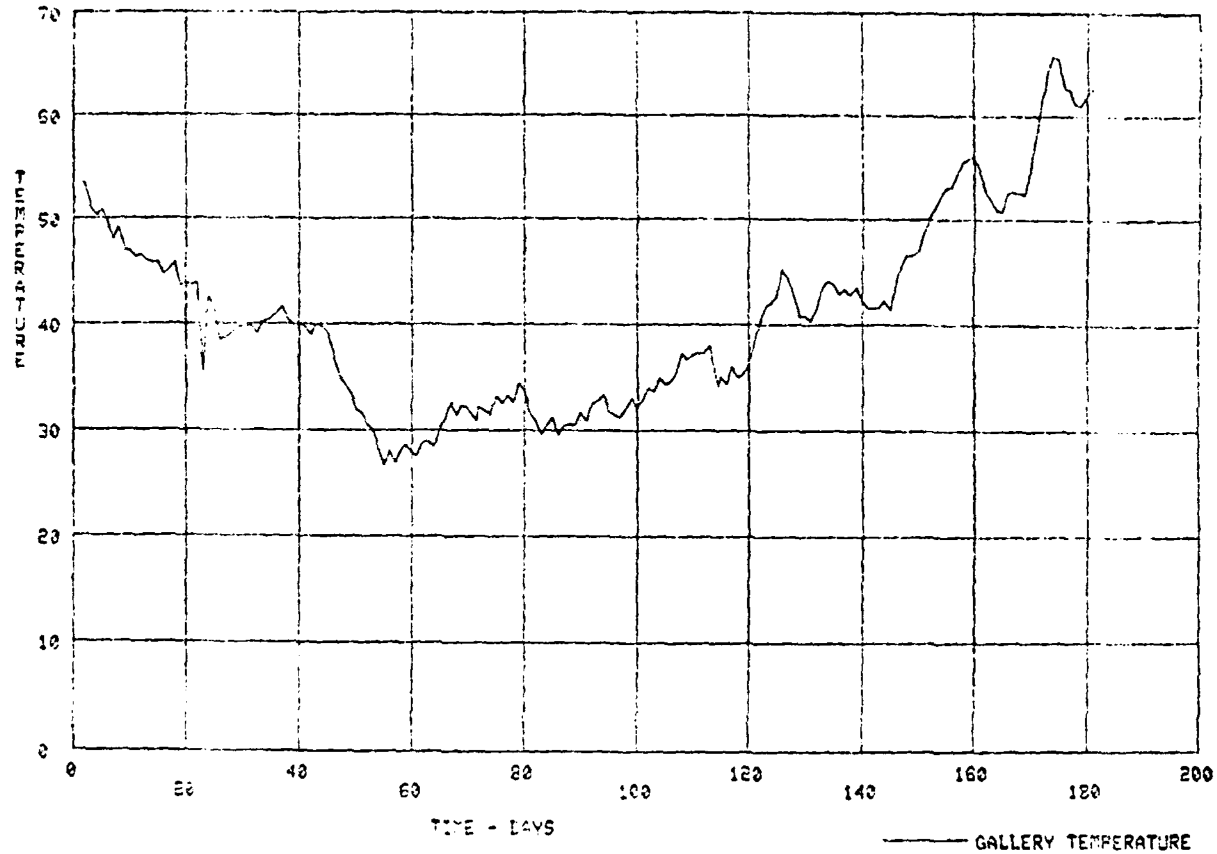
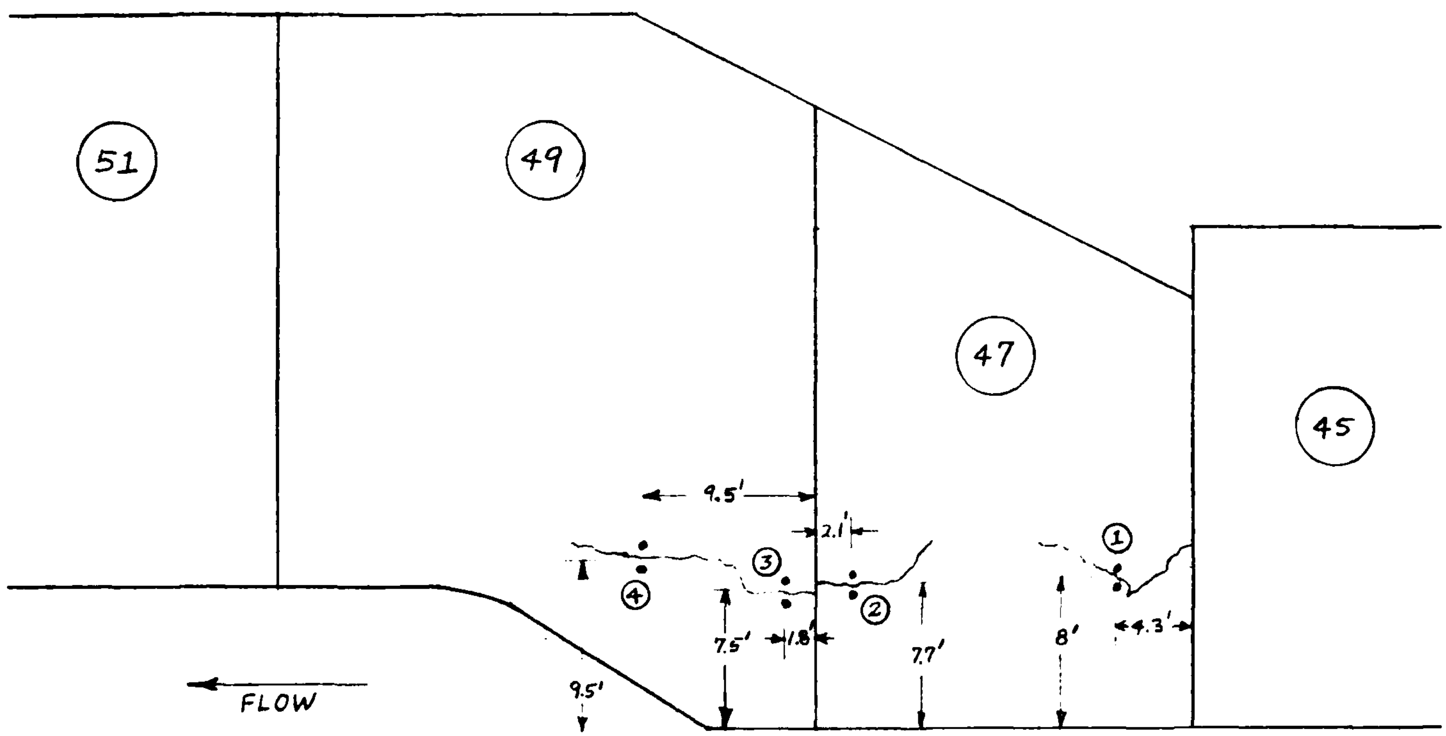


LOCKPORT L & D, MONO 58 GALLERY



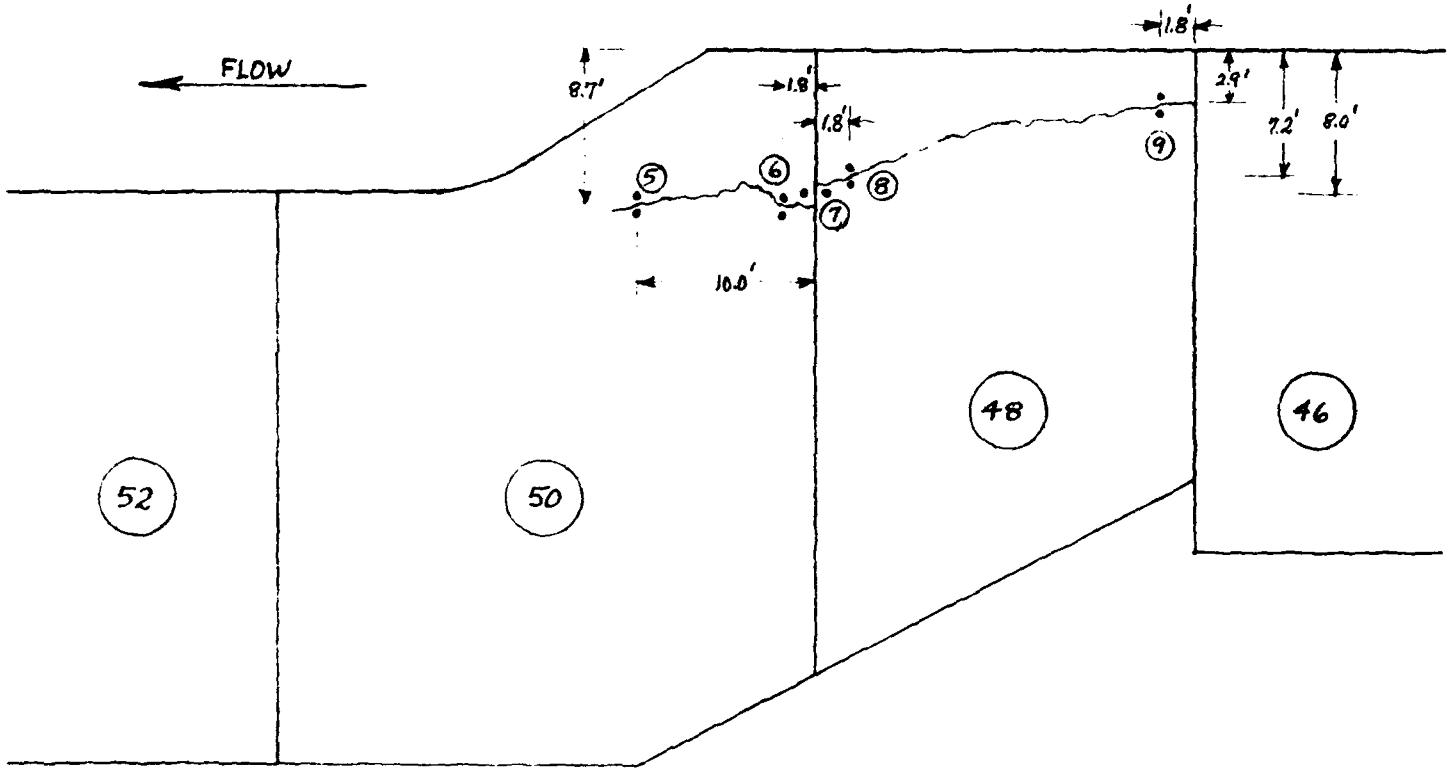
[illegible] 1 & 2, MONO 50 [illegible] GALLERY

BRANDON ROAD LOCK



LOCATION OF WHITTEMORE GAGE POINTS 1,2,3,&4
FOR MEASURING CRACK WIDTHS
FIGURE 16

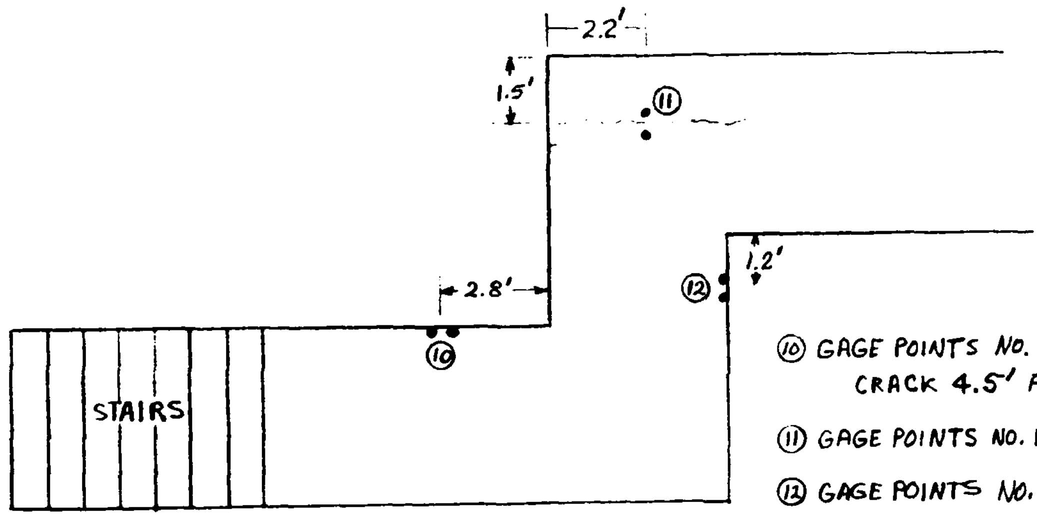
BRANDON ROAD LOCK



LOCATION OF WHITTEMORE GAGE POINTS 5,6,7,8, & 9
FOR MEASURING CRACK WIDTHS
FIGURE 17

BRANDON ROAD LOCK

ICE HOUSE



(10) GAGE POINTS NO. 10 MOUNTED ON WALL ACROSS CRACK 4.5' ABOVE FLOOR.

(11) GAGE POINTS NO. 11 MOUNTED ACROSS CRACK ON FLOOR.

(12) GAGE POINTS NO. 12 MOUNTED ON WALL ACROSS JOINT AT 30 DEGREE ANGLE FROM HORIZONTAL 4.8' ABOVE FLOOR.

LOCATION OF WHITTEMORE GAGE POINTS 10, 11, & 12
FOR MEASURING CRACK WIDTHS

FIGURE 18

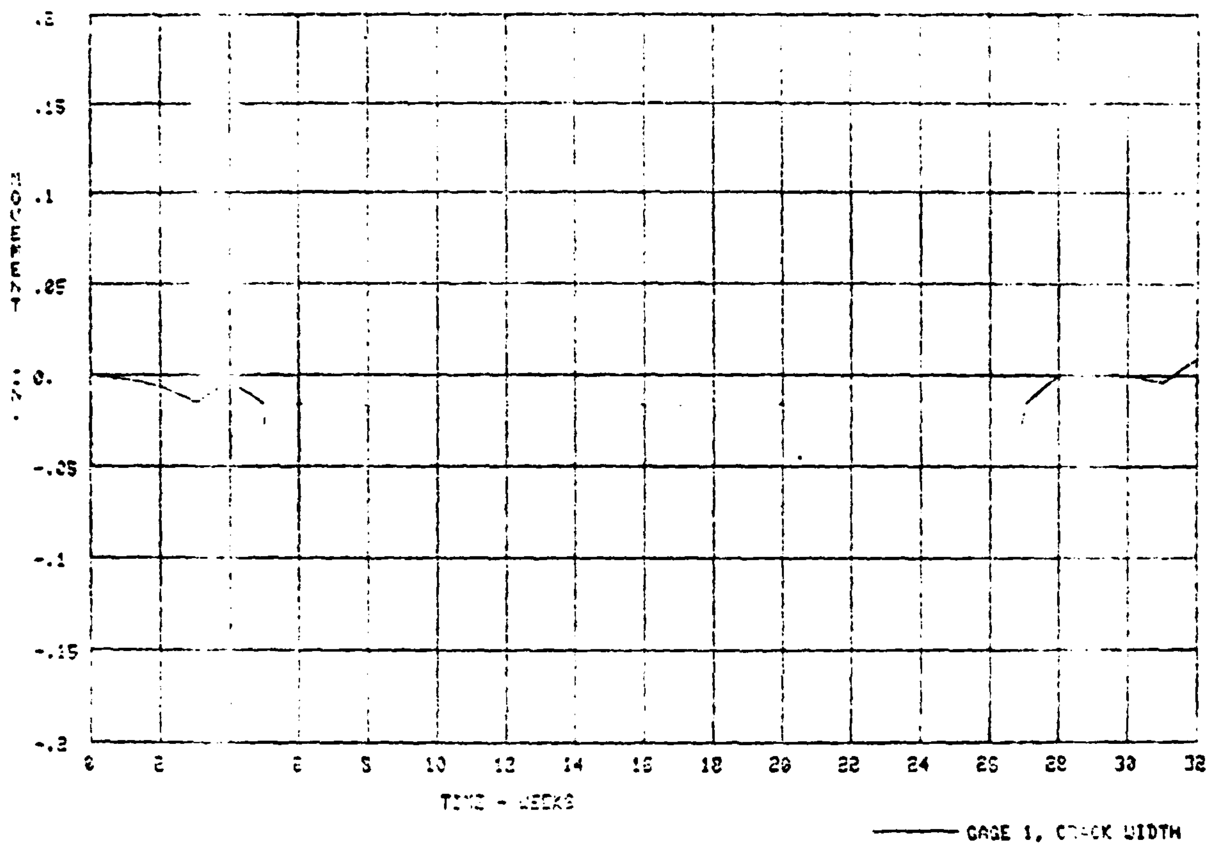
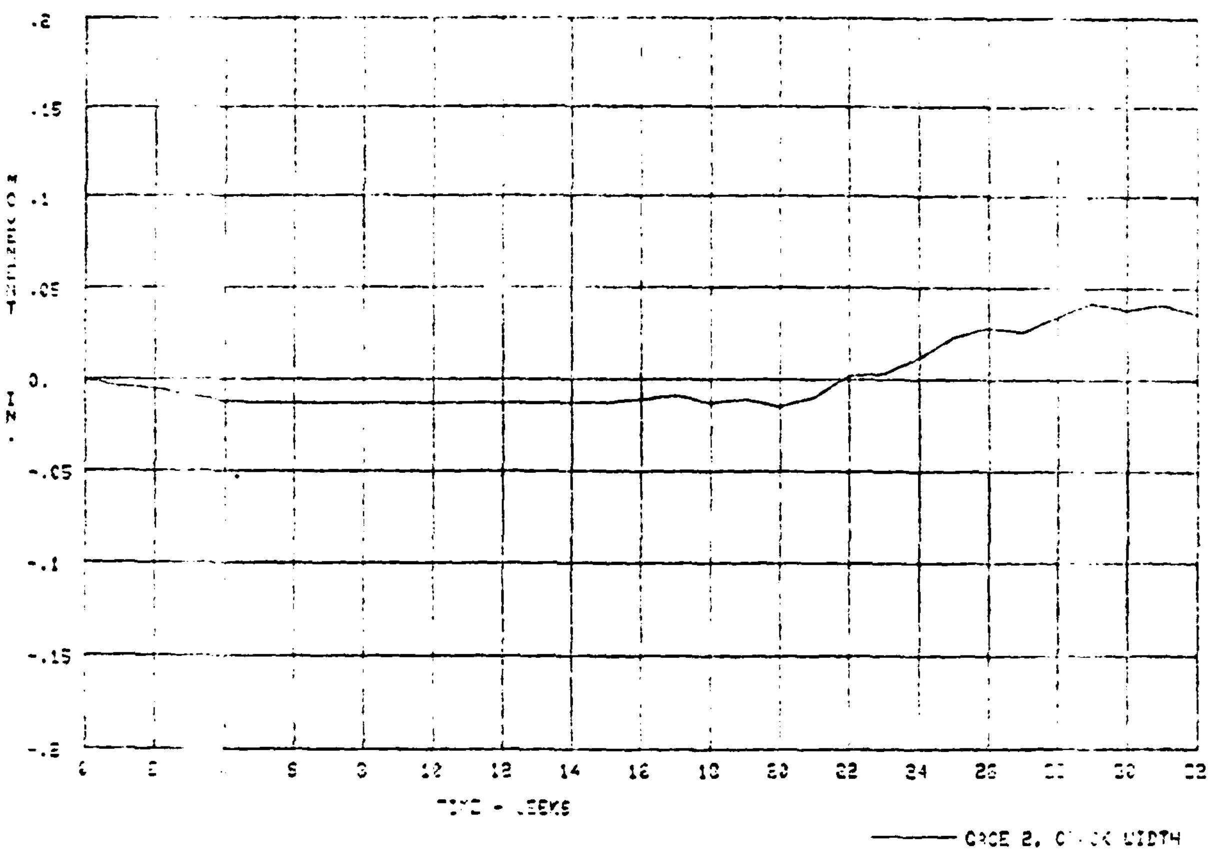
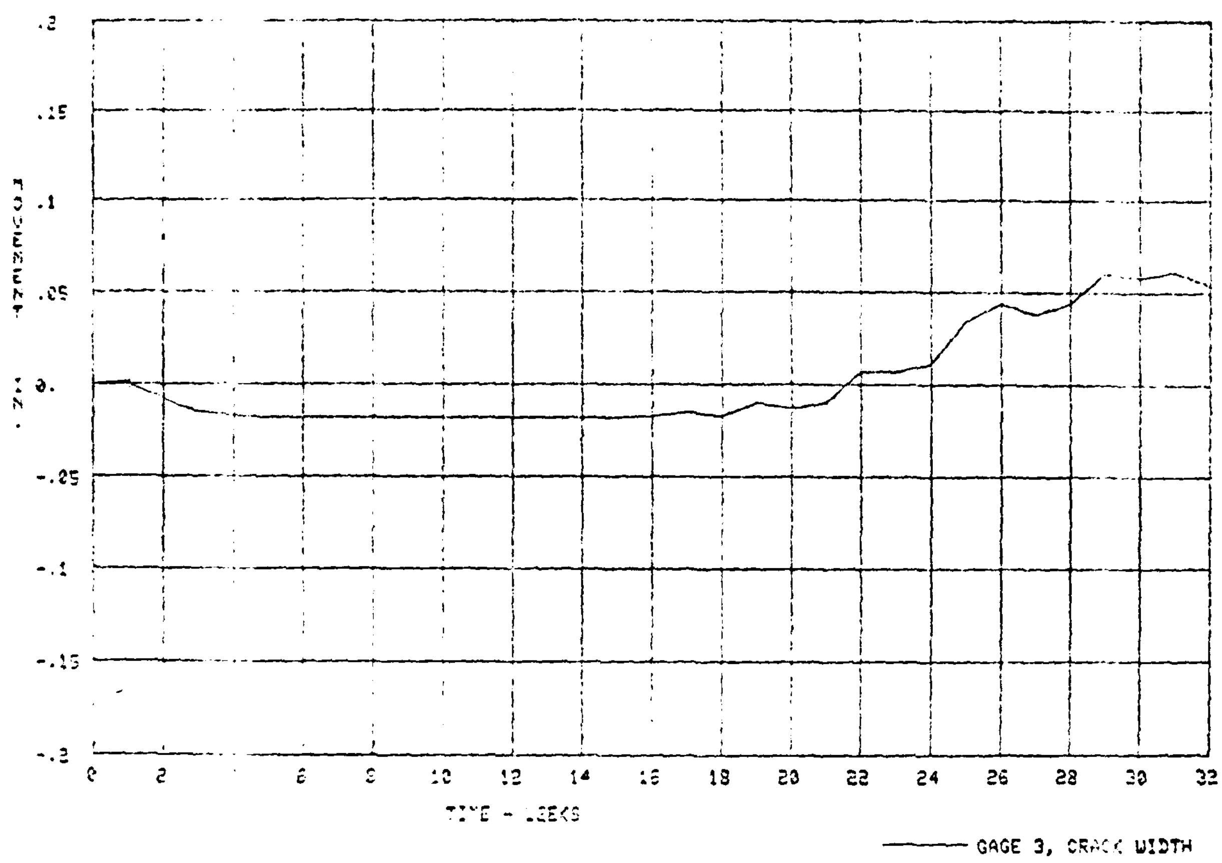


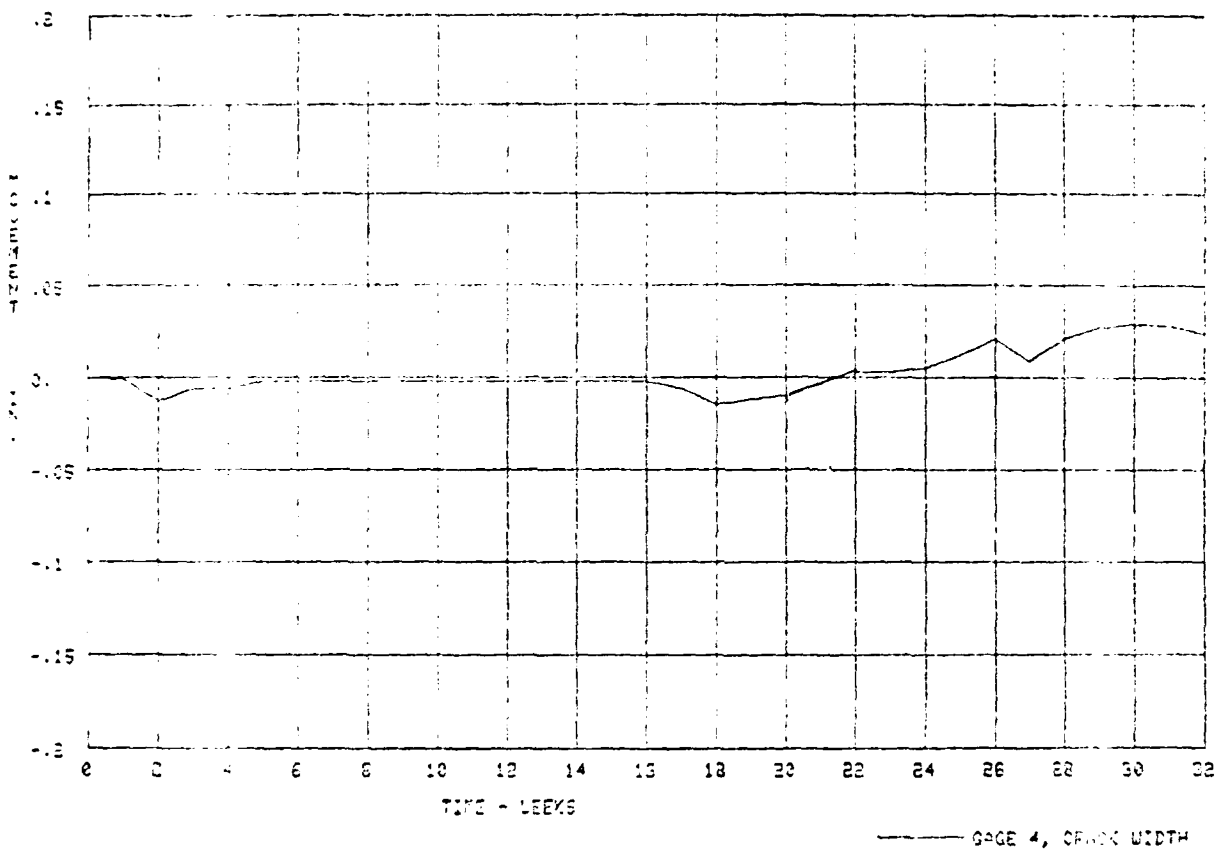
Figure D- E ... ROAD L ? D, GAGE READINGS



ROAD L & E, GAGE READINGS



GAGE READINGS



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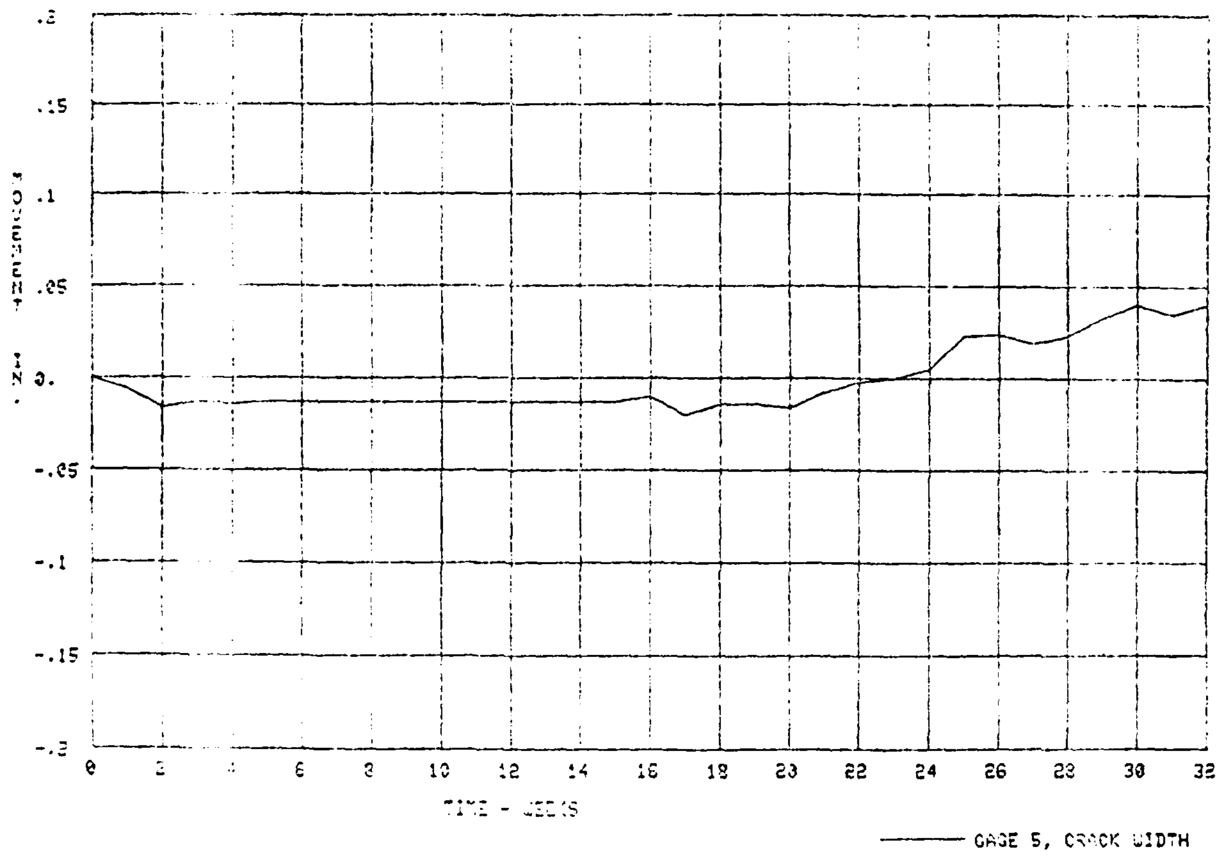

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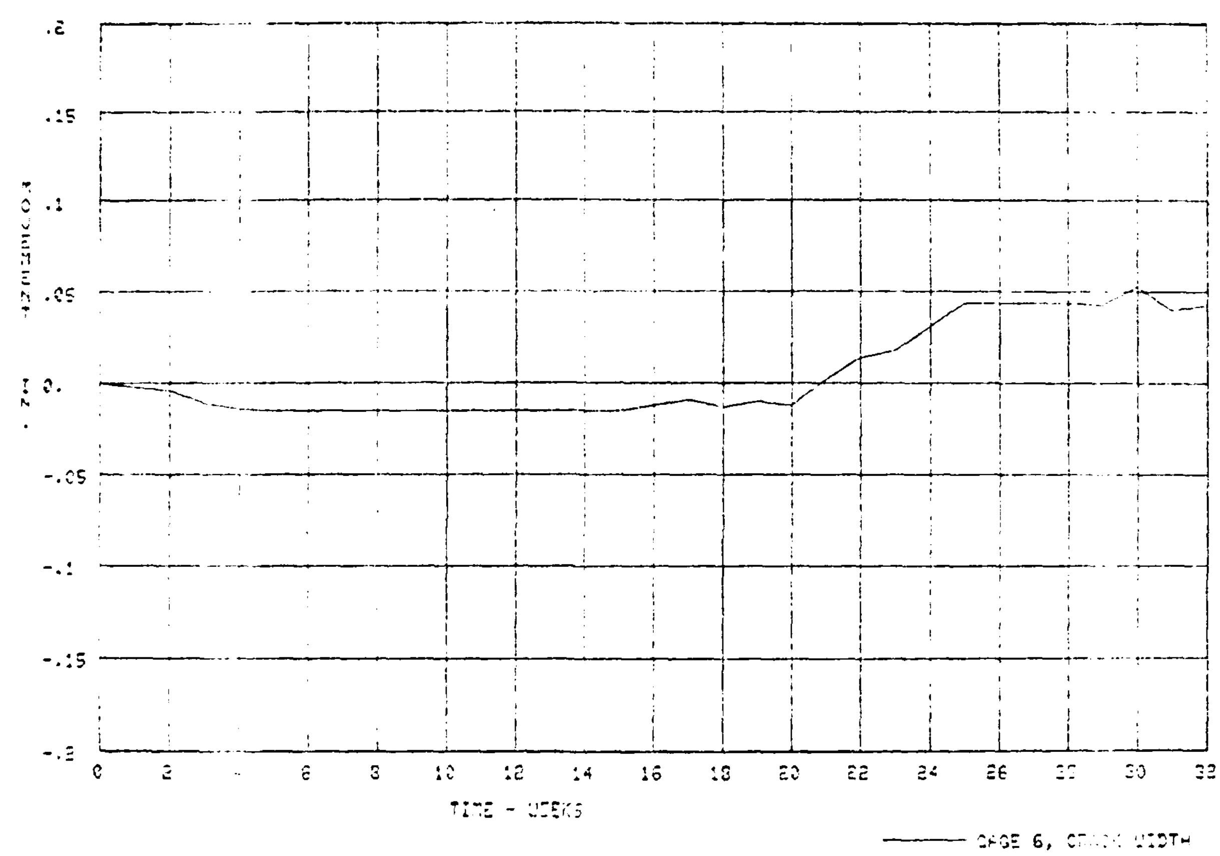

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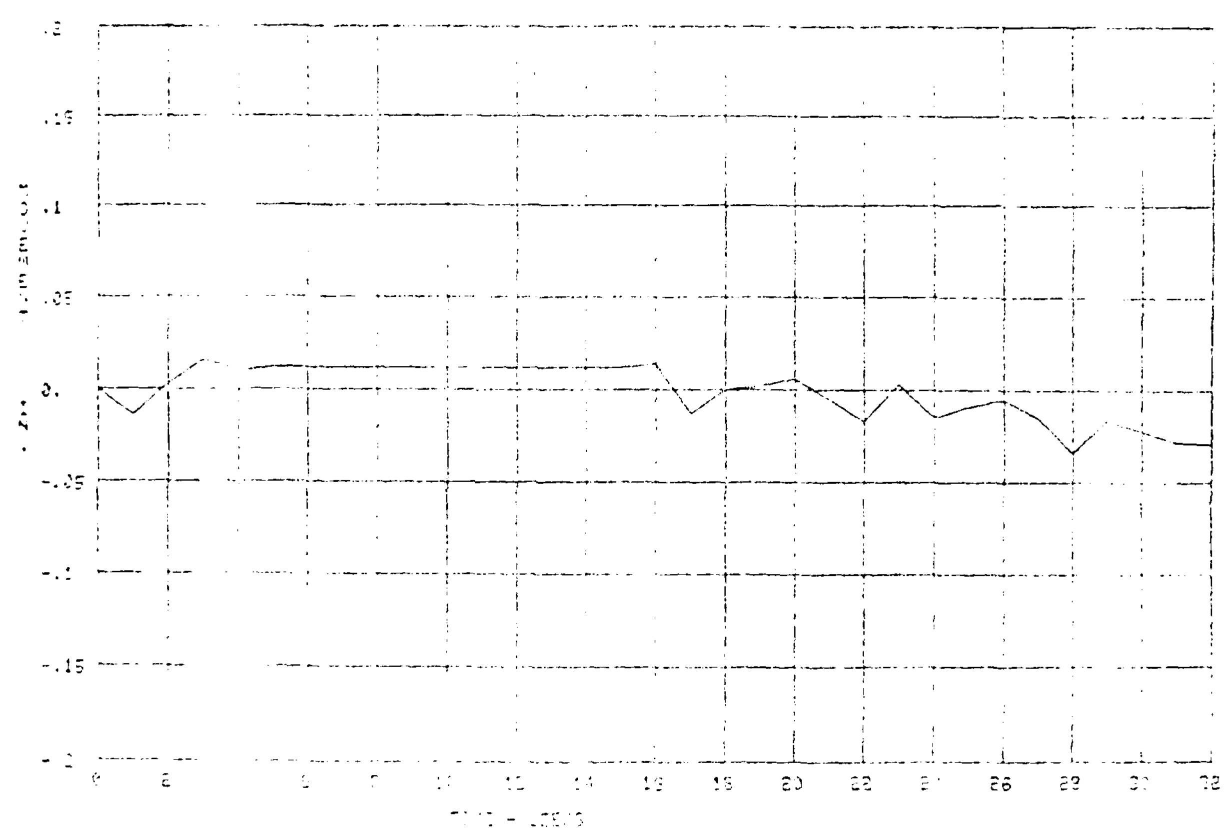
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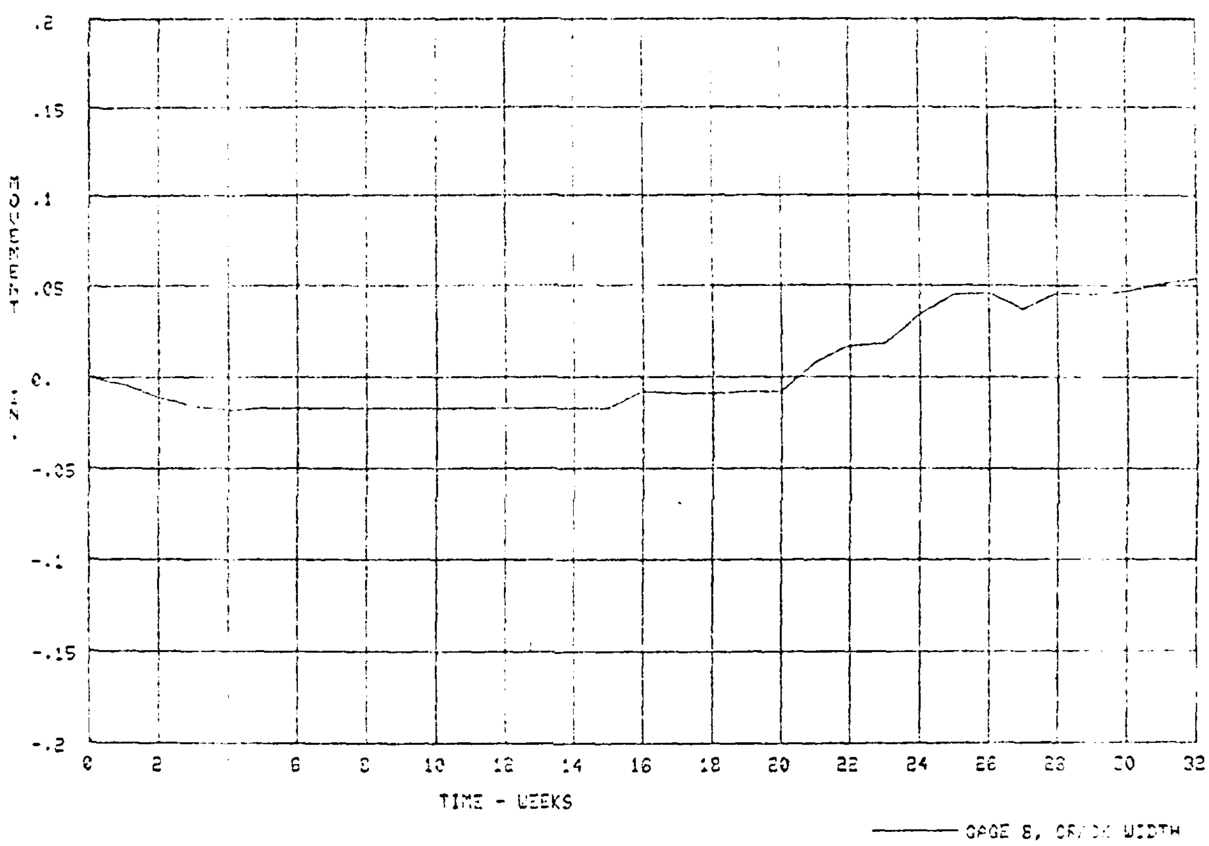
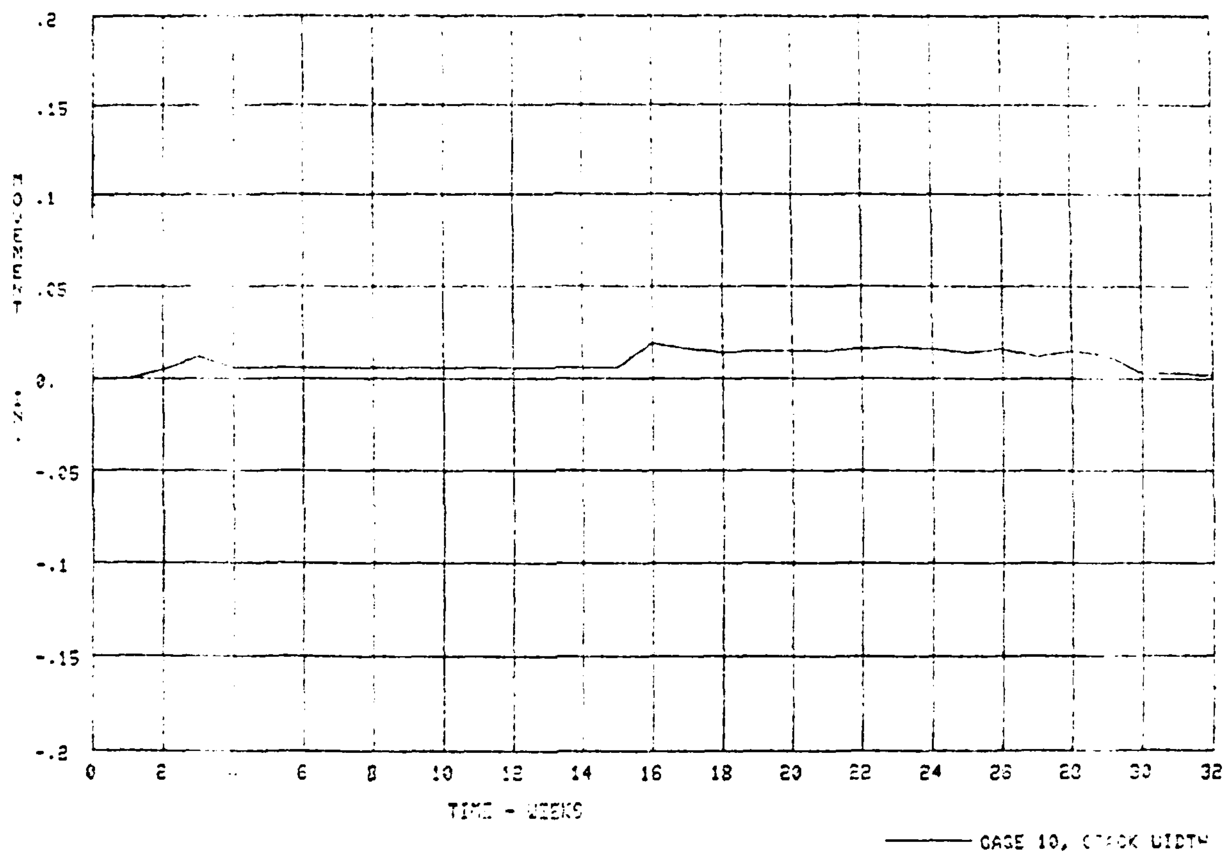


Figure [illegible]: BR[illegible]DON ROAD L & D, GAGE READINGS



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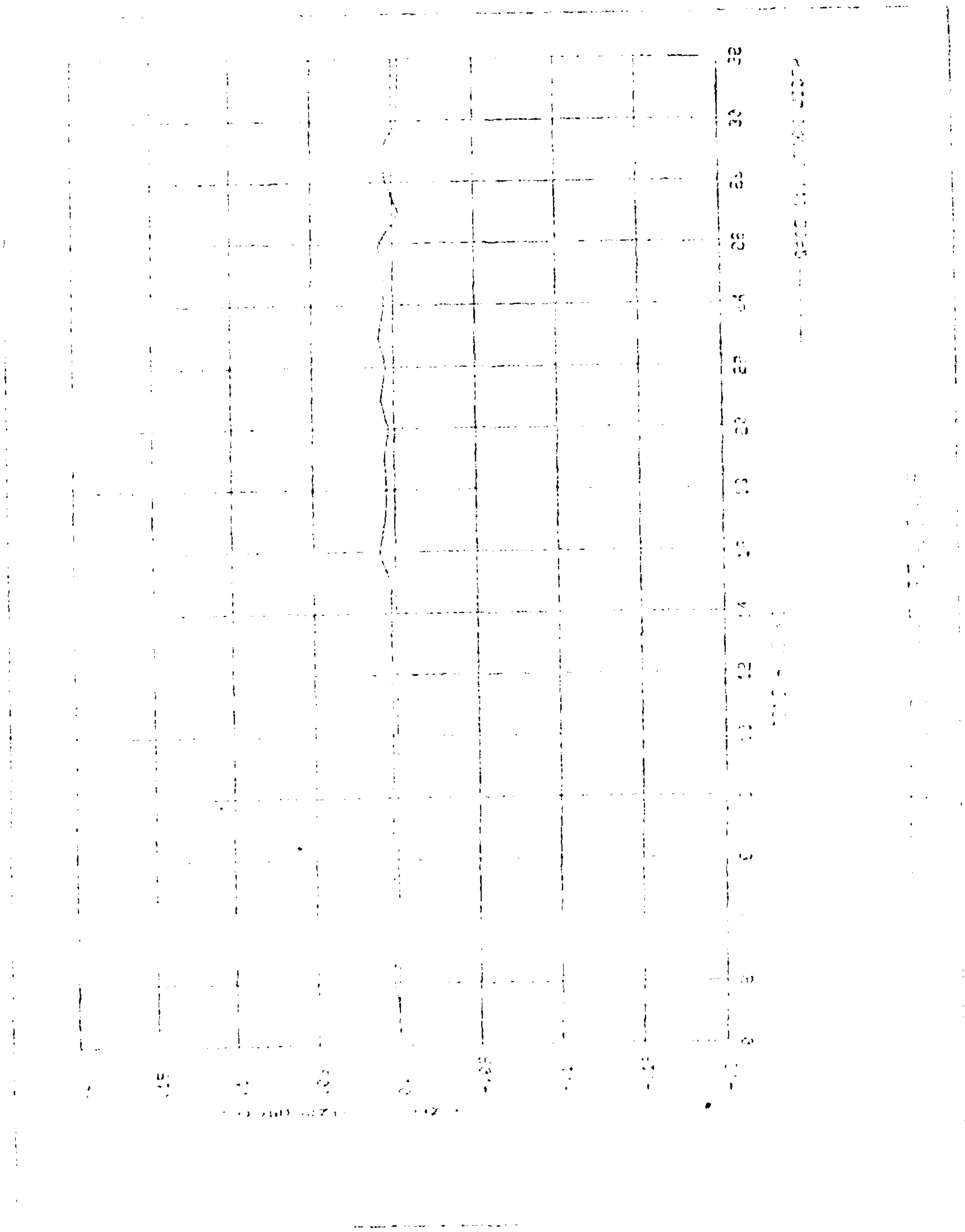

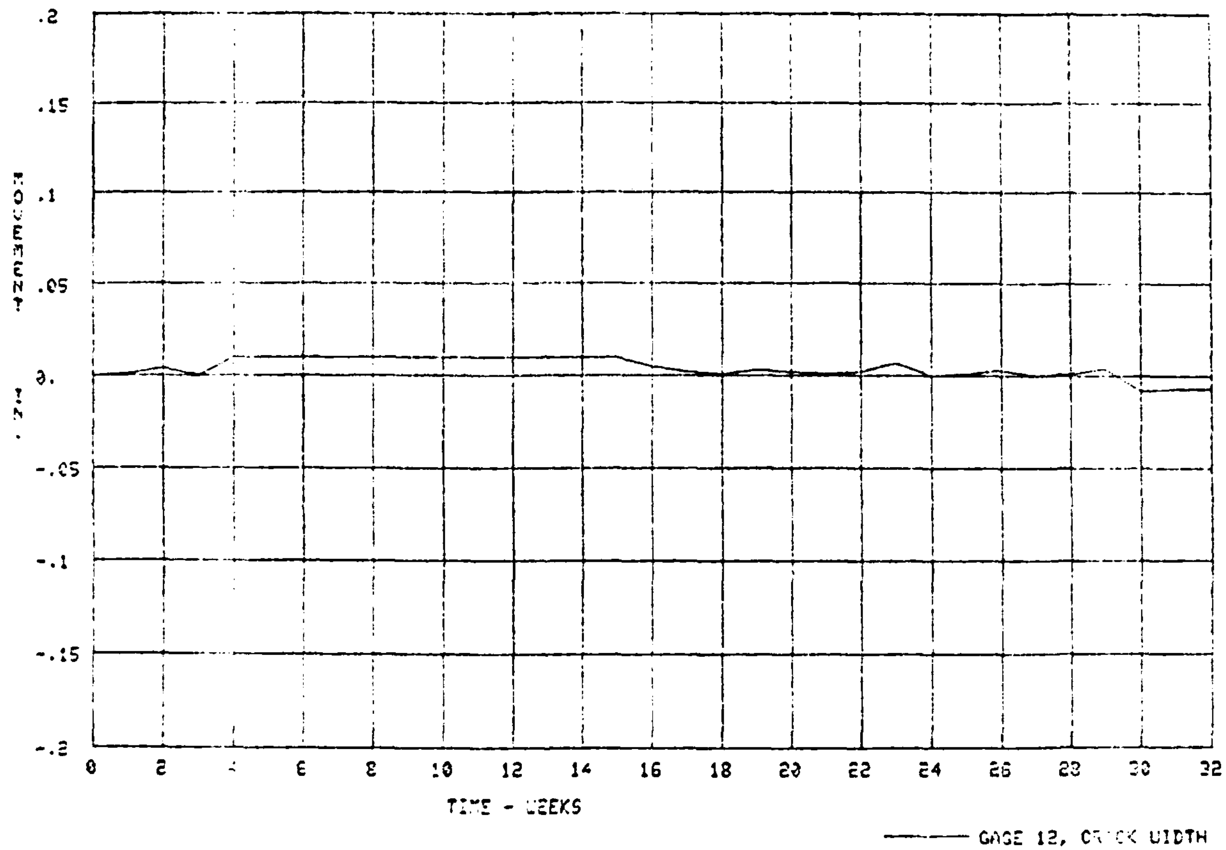

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