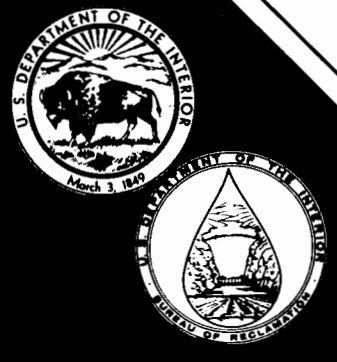
GR-84-16

# HYDRAULIC FLUME LABORATORY EROSION-TEST EQUIPMENT

November 1984
Engineering and Research Center

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16. ABSTRACT

This report documents the results of PRESS Project No. DB-13, phase II, "Identification of Potentially Erosive Soils." A self-contained, portable, recirculating, tilting, hydraulic demonstration flume was acquired and modified for use as soil test equipment. This erosion flume was placed in operation, and preliminary hydraulic calibration was completed.

Preston tubes and a differential pressure transducer were used to determine channel bed boundary shear stresses or tractive forces. Three different size Preston tubes were developed for measuring the wide range of shear stresses generally encountered on typical Bureau of Reclamation project features. Hydraulic calibration data were finalized by digital computer data reduction from analog strip chart data input.

Phase III of the project involves completing the hydraulic calibration, completing soil testing, and developing final instrumentation and data acquisition systems.

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by

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Division of Research and Laboratory Services
Engineering and Research Center
Denver, Colorado

November 1984

UNITED STATES DEPARTMENT OF THE INTERIOR ★ BUREAU OF RECLAMATION

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Eugene Ziegler, Hydraulics Branch, assisted by Lee Elgin, designed and developed the Preston tubes and the related shear stress instrumentation system. Mr. Ziegler dedicated many hours completing the initial hydraulic calibrations. Robert Richmond, Geotechnical Branch, designed the soil-sample test fixture, completed the preliminary hydraulic calibrations, and assumed the responsibility for completing phase III of the project. Laboratory shop personnel helped accomplish the required plumbing and electrical system modifications in a timely and professional manner. Henry Hoff, Geotechnical Branch, developed the computer programs for digitizing the analog strip chart output of the hydraulic calibration data.

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## INTRODUCTION

The overall purpose of this project was to plan for, acquire, and place in operation laboratory test equipment to determine the potential resistance of soils to surface erosion from flowing water. This equipment would be used for testing nondispersive soils in auxiliary and emergency spillways, earth-lined and unlined channels, canals, wasteways, compacted embankments, and other structures. This project is listed as No. DB-13 under the USBR (Bureau of Reclamation) PRESS (Program Related Engineering and Scientific Studies) and is entitled, "Identification of Potentially Erosive Soils."

USBR Report No. GR-82-3 [1][1] discusses phase I of the project, which was completed in FY 1981. The approach for phase I involved a review of the literature on the subject and recommendations for obtaining laboratory equipment suitable for USBR erosion testing. Phase II, performed during FY 1982 and FY 1983, comprised acquisition of the equipment, calibration, and placement in operation. Phase III includes the testing of different soils from field sites to establish criteria for assessing the potential erosion resistance for anticipated field conditions. It should begin in FY 1984.

This report summarizes the results of phase II investigations: (1) equipment acquisition, (2) hydraulic calibration, (3) preliminary operation, and (4) modifications made to improve the operation of the laboratory erosion flume.

## SUMMARY AND CONCLUSIONS

As part of phase II, PRESS DB-13, a portable, self-contained, recirculating, tilting, hydraulic demonstration flume was acquired. The flume was fabricated by Engineering Laboratory Design, Inc., of Lake City, Minnesota, in accordance with Specification No. 2-07-81-S0245, and was delivered in July 1982. The flume has a working channel length of 12 ft (3.7 m), a depth of 18 in (0.46 m), and a width of 12 in (0.30 m). Water is recirculated by a 15-hp, 440-volt/3-phase electric motor-operated centrifugal pump capable of supplying water at 2,250 gal/min (0.142 $m^3/s$) under a 10-ft (3.3-m) pressure head. Flow is regulated by a butterfly valve installed in an 8-in (203-mm) diameter supply line. The reservoir is constructed of fiberglass and has a 760-gal (2.88-$m^3$) capacity. The equipment can be tilted vertically from zero to 8 percent. A soil sample is inserted flush in the channel bottom, approximately 3 ft (1.0 m) upstream from the tailgate. Preliminary

[1] Numbers in brackets refer to entries in the bibliography.

calculations indicate that the channel length is sufficient to develop a uniform boundary layer for all flow conditions.

Three Preston tubes were developed for determining the channel bed boundary shear stress, or tractive force, anticipated for the wide range of water velocities and field service conditions generally encountered on USBR project features. A differential pressure transducer and Hewlett-Packard 7702A strip chart data recorder were used with the Preston tubes for preliminary hydraulic calibration. A Hewlett-Packard 9111A Graphics Tablet was used to create a digital file from the analog output of the HP 7702A strip chart recording. Data files were created and analyzed to determine the mean and median differential pressure measurements. The data were also analyzed for systematic interference from mechanical vibrations. Appendix C contains details of the computer and statistical analyses performed to reduce the differential pressure transducer output data.

Some plumbing and electrical systems were modified to improve the operation and extend the service life of the laboratory erosion flume equipment components. A soil sample test fixture was designed, fabricated, and installed flush with the channel bed.

Preliminary operation of the laboratory erosion flume indicated that a uniform boundary layer was not being developed at high flow velocities. Screens and tube-type flow diffusers were tried but had limited success in improving boundary layer development at the soil sample location. Boundary layer development problems were attributed to insufficient channel length for the extreme high velocity flow conditions.

The inline flowmeter failed after approximately 16 months of operation. This failure was attributed to particles colliding with the sensitive turbine blades of the flowmeter.

Repairs to the regulating flow control valve were necessary because of water-induced rusting of the exposed valve shaft supports. The valve was repaired and zerk grease fittings and watertight cap seals were provided for the exposed shaft supports.

## DISCUSSION

### Equipment Specifications

Appendix 1 contains the specifications developed for the USBR laboratory erosion flume. Preliminary estimates indicated that considerable time and money would be saved by acquiring the flume

by competitive procurement rather than by in-house design and fabrication. The equipment specification was based on the concept of modifying a commercially available hydraulic demonstration channel to provide the water velocities and associated shear stresses commonly encountered on USBR project features.

The major modifications to the commercially available hydraulic demonstration flume included the installation of a low-pressure, high-volume centrifugal pump; a 15-hp electric motor; an oversize reservoir; large supply piping; a steel head tank; heavy duty jack screws; an inline flowmeter; a reservoir thermocouple; and a specially designed square-tube structural support frame.

Jones [1] summarized the results of a search of the pertinent literature and a technical review of investigations into laboratory soil erosion test equipment, conducted by various researchers. His report outlined the criteria to be used as the basis for the USBR laboratory erosion equipment. The specific operating requirements are restated here:

1. Capability of obtaining the uniform tractive force, or other units of shearing resistance (sic), or the velocity over a wide range, on the surface of undisturbed or compacted specimens.

2. Control of water quality. – Because the type and amount of dissolved salts can affect the erosion of soil by interacting with the chemicals in the soil, it is sometimes desirable and mandatory to use water from the project under study or the synthetic equivalent of its major components in a laboratory test. This requires the use of water of the desired quality, in a quantity suitable for laboratory handling. An alternative is to transport the erosion equipment to a field site having an adequate water supply.

3. Temperature control. – A pumped recirculating system in a test apparatus causes a rise in water temperature, influencing soil erosion. A system without temperature control would require the use of calibration factors for water temperature versus erosion, possibly introducing inaccuracies.

4. Minimum disturbance from boundary conditions. – Although it is impossible to eliminate all the effects on soil erosion caused by boundaries between a soil specimen and adjacent parts of its test apparatus, these effects should be reduced as much as possible.

**Additional Technical Considerations**

In addition to the criteria defined above, other technical considerations for the laboratory erosion equipment developed as work progressed on the specifications. Most of these technical considerations arose as "lessons learned" from the Corps of Engineers' WES (Waterways Experiment Station) operating experience with their laboratory erosion flume. Liaison between representatives of USBR and WES resulted in the following additional technical considerations for the laboratory erosion flume specification:

1. A flowmeter, accurate throughout the entire operating range of the centrifugal pump and electric motor system, was incorporated into the supply line at the location most likely to have fully developed pipe flow.

2. Additional structural reinforcing flanges and fiberglass stiffeners were specified for critical flume locations, such as piping connections and high-contact stress areas between the structural frame and the fiberglass reservoir.

3. A venting valve, with an overflow return to the reservoir, was incorporated into the head-tank design to increase the system operating pressure.

4. The gear ratio for the motorized headgate was changed to allow its precise placement.

5. An improved C-clamp design was specified for the Pitot tube rack to prevent rocking and improve its operation along the flume channel.

6. A drain plug was specified for installation at the lowest point in the reservoir to facilitate draining and cleaning.

7. A separate, multipurpose control panel was specified for the following functions: slope, headgate, tailgate, water temperature, flow, and motor starter for the centrifugal pump.

8. Large ball-bearing casters and heavy-duty square tubing were specified for the structural support frame.

9. An oversize reservoir was specified to increase water storage volume, to prevent creation of a suction vortex during high-slope operation, and to minimize temperature gain in the closed-loop system.

**Laboratory Erosion Flume Configuration**

Figures 1 through 8 are record photographs of the USBR laboratory erosion flume as delivered in July 1982. Figure 9 is a 3-sheet drawing of the laboratory erosion flume from Engineering Laboratory Design, Inc.

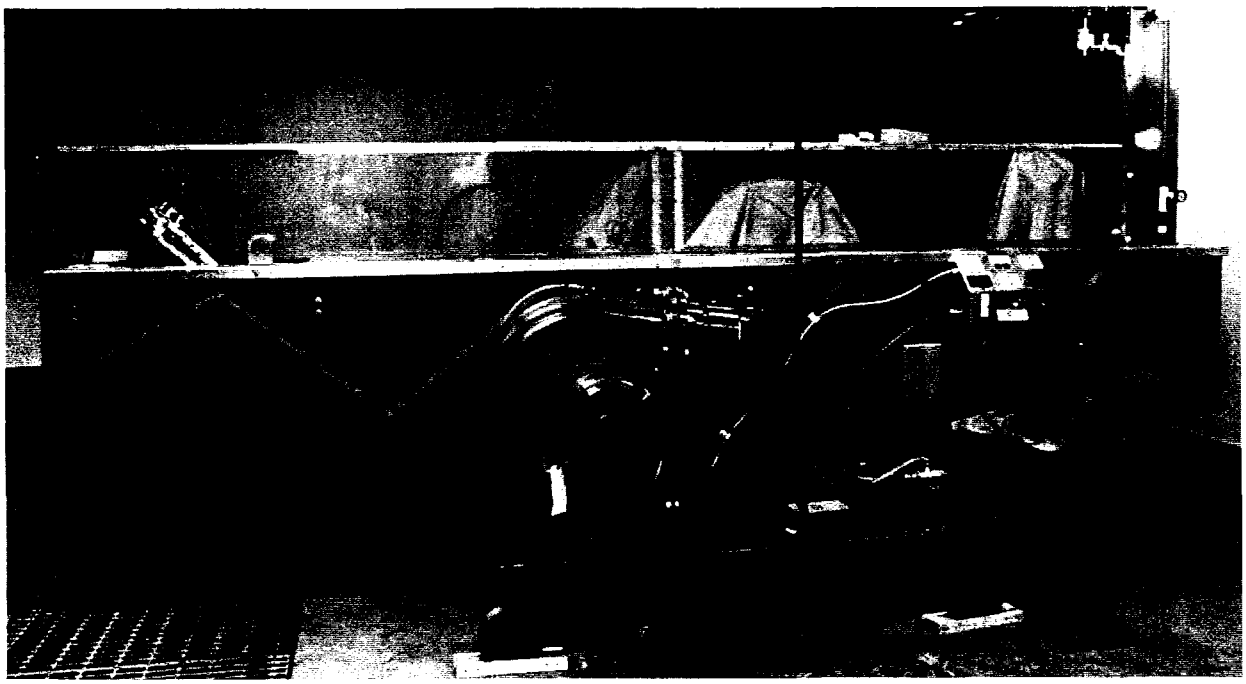


Figure 1. – Laboratory erosion flume as delivered to the Soil Testing Section in July 1982. P801-D-80828

**Preston Tube Design**

Appendix 2 contains calculations for the three Preston tubes designed for use with the laboratory erosion flume. It is not the intent of this report to discuss the theory of boundary layer development or the applicability of Preston's equations for determining channel-bed shear stresses. Preston tube design criteria and the equations governing their operating range are contained in references [2] through [5]. The Preston tubes were selected to allow some overlap in their operating range to verify the technical adequacy of each tube. The range of interest for the channel-bed shear stress measurements was selected to represent the field service conditions generally encountered in USBR project features [6].

Figure 10 shows the design details and the effective operating ranges of the 1/16-, 1/8-, and 1/4-in-diameter Preston tubes.

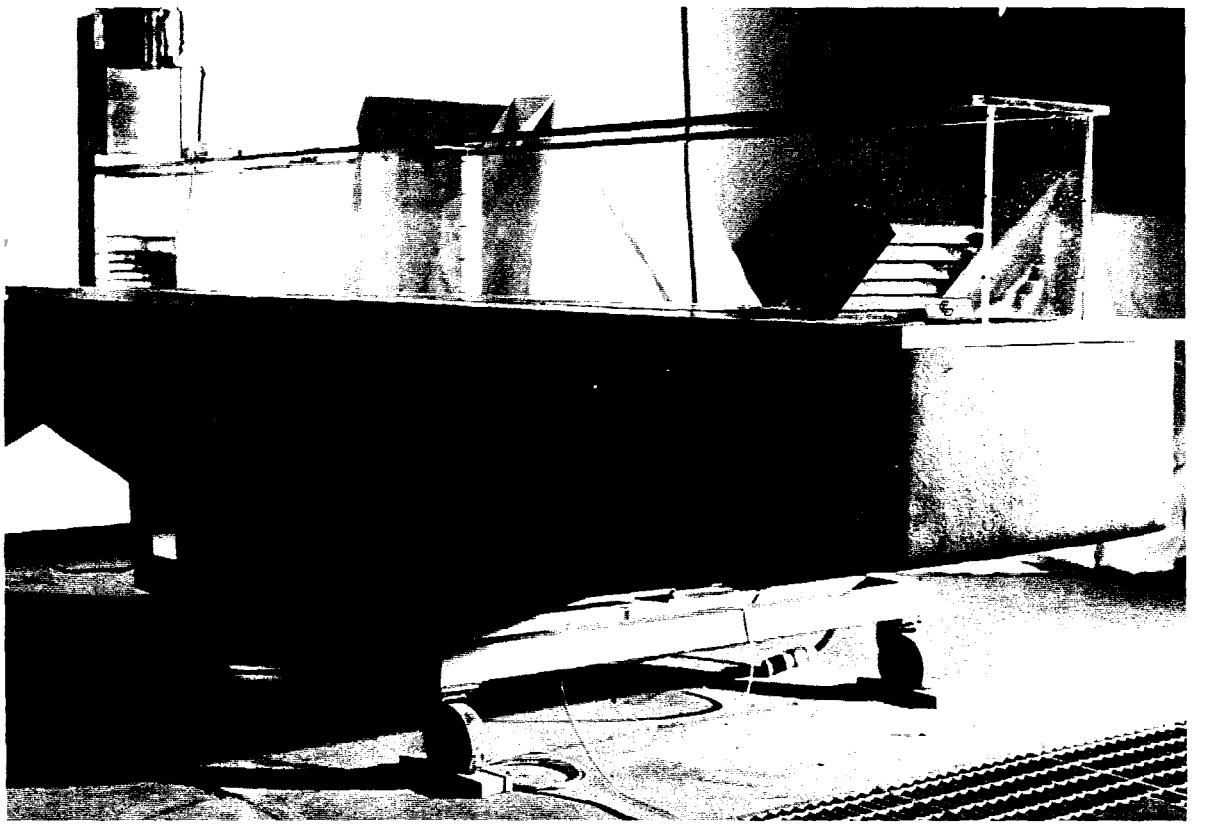


Figure 2. – Laboratory erosion flume. View shows structural chassis frame, oversize reservoir, and clear Plexiglas flume channel. P801-D-80829

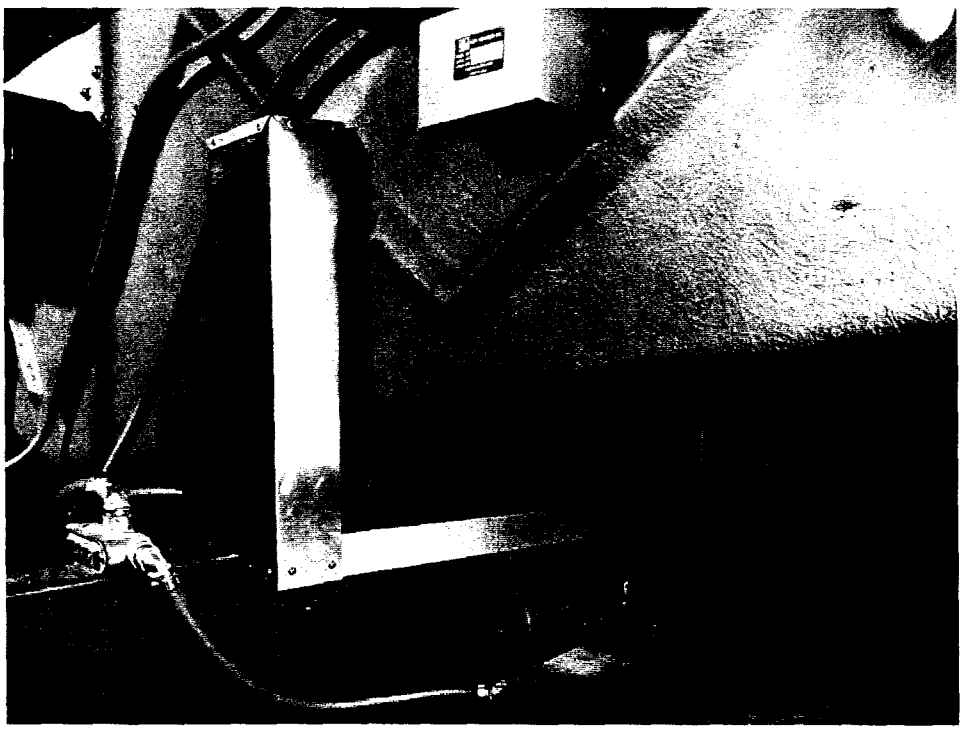


Figure 3. – Jack screws and electric motor assembly used for tilting the flume reservoir. View shows lowered position with flume channel horizontal. P801-D-80830

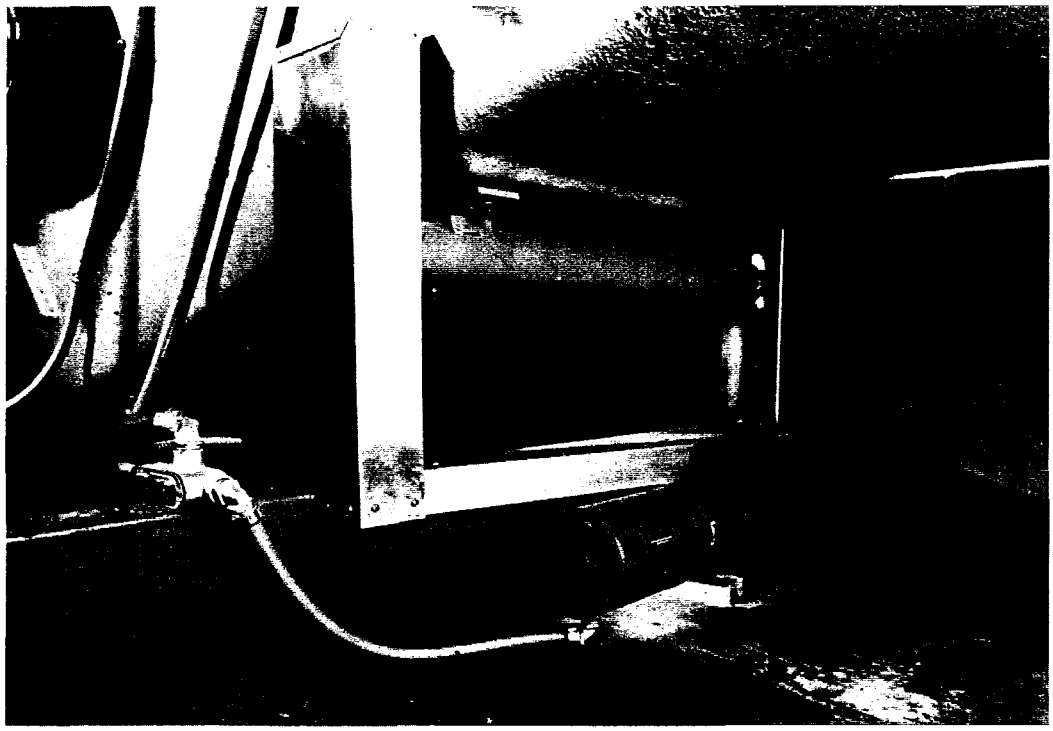


Figure 4. – Jack screws and electric motor assembly used for tilting the flume reservoir. View shows extended position with flume channel at maximum slope. P801-D-80831

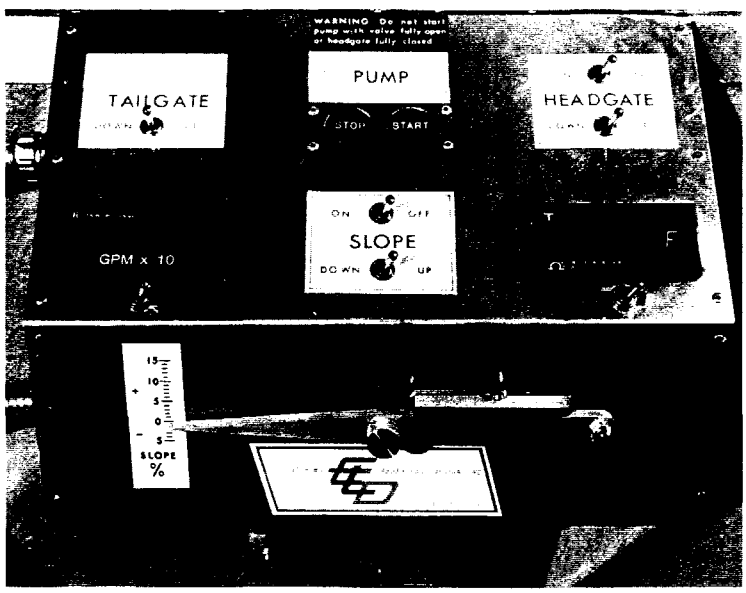



Figure 5. – Control panel for operating tailgate, centrifugal pump, electric motor, headgate, inline flowmeter, jack screws and motor assembly, and reservoir thermocouple. P801-D-80832

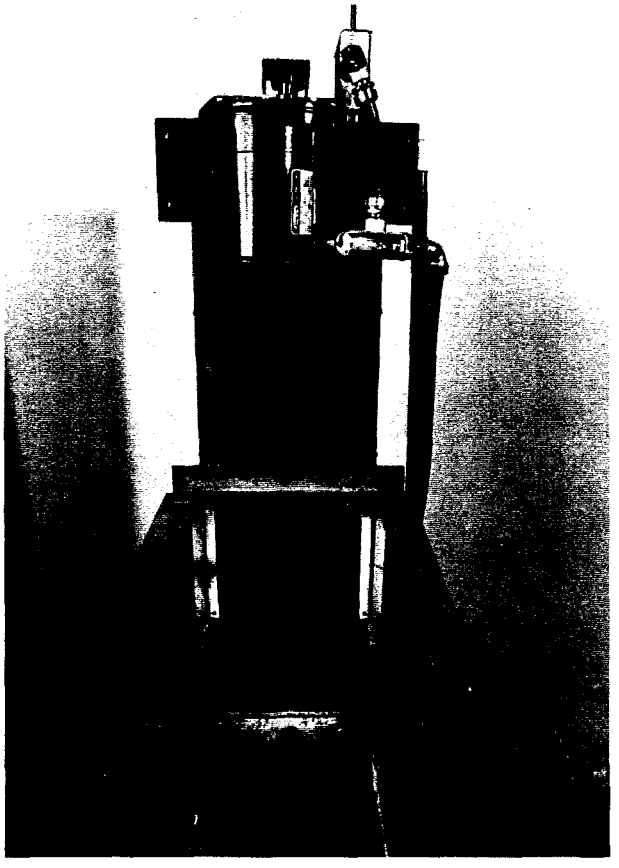


Figure 6. – Upstream view showing vertical sliding headgate and reversible electric motor operator.
P801-D-80833

**Shear Stress Instrumentation System**

Figure 11 shows the schematic diagram of the shear stress instrumentation system used for preliminary hydraulic calibration of the laboratory erosion flume. The major features of this system are a differential pressure transducer with a 0- to 3450-Pa (0.5-lbf/in$^2$) operating range, two calibration water chambers with an integral point gauge, valved connections for the dynamic and static water pressure from the Preston tube, and a Hewlett-Packard 7702A strip chart data recorder. This system enables the operator to calibrate the differential pressure transducer and then to immediately begin boundary shear stress measurements. Excessive vibration prevents calibrating the differential pressure transducer during flume operation.

Figure 12 is a sample output strip chart showing the pressure transducer calibration and the measurement of differential pressure response between the dynamic and static water pressures, i.e., ($p$-$p_o$). Integration of the response curve, to determine the mean value of ($p$-$p_o$), was first accomplished visually by interpreting the strip chart recording. The mean value was determined

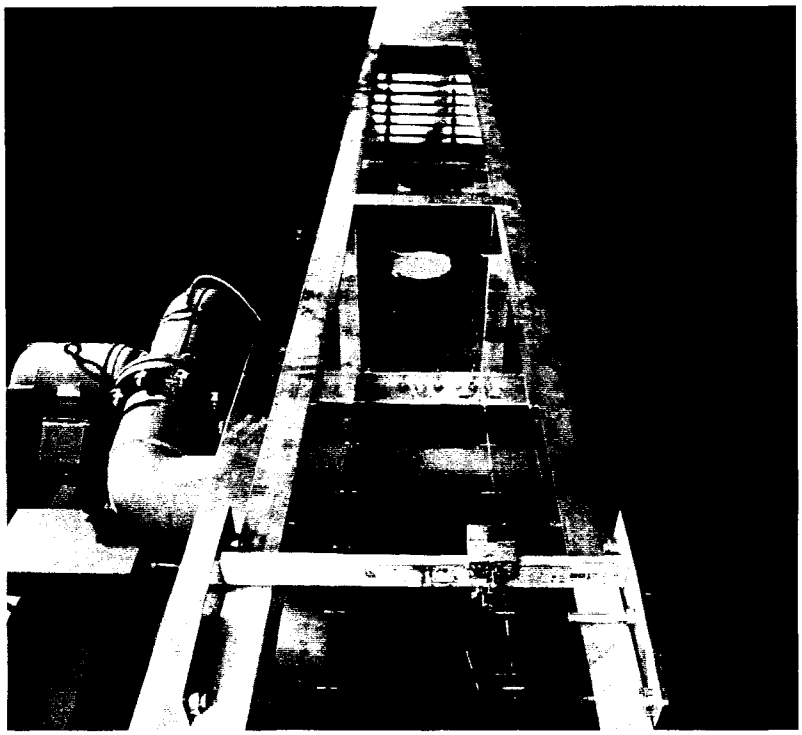


Figure 7. – Downstream view showing soil sample cell, located flush with flume channel bottom and approximately 1 m upstream of tailgate assembly. P801-D-80834

Figure 8. – Laboratory erosion flume operating at low flow rate, high flow depth, and flume channel in horizontal position. P801-D-80835

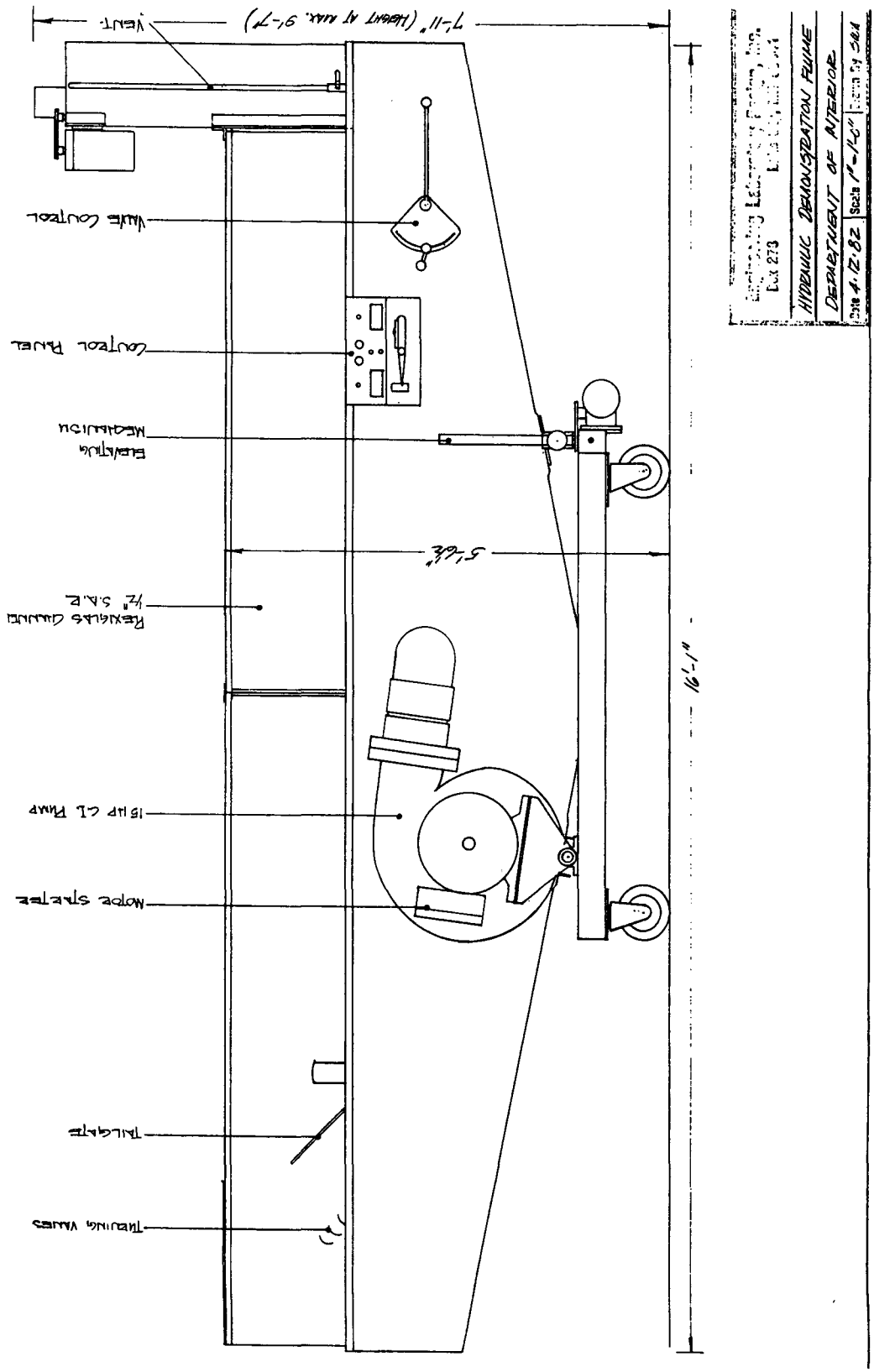



Figure 9. – Hydraulic Demonstration Flume Drawing by Engineering Laboratory Design, Inc. (sheet 1 of 3).

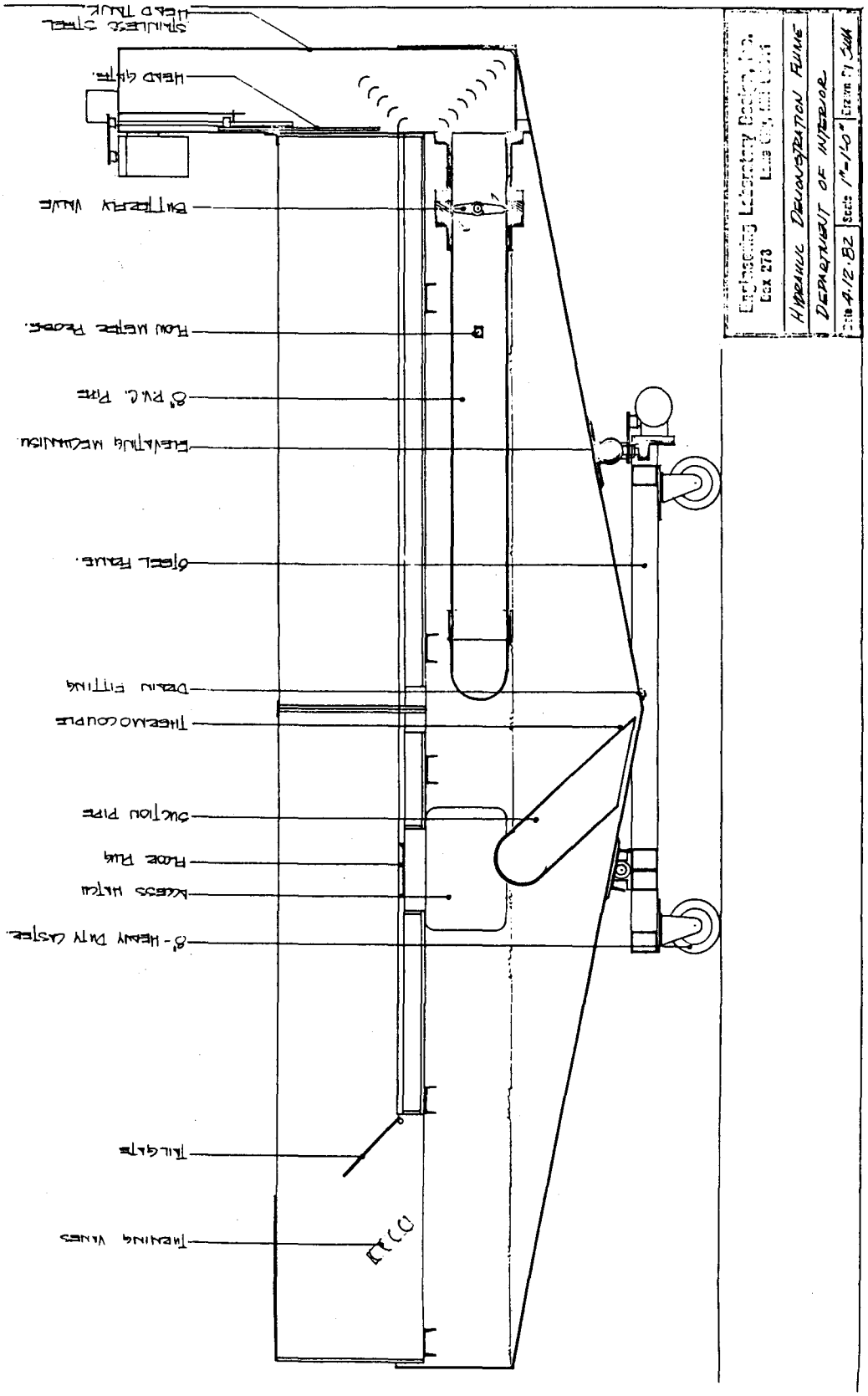



Figure 9. – Hydraulic Demonstration Flume Drawing by Engineering Laboratory Design, Inc. (sheet 2 of 3).

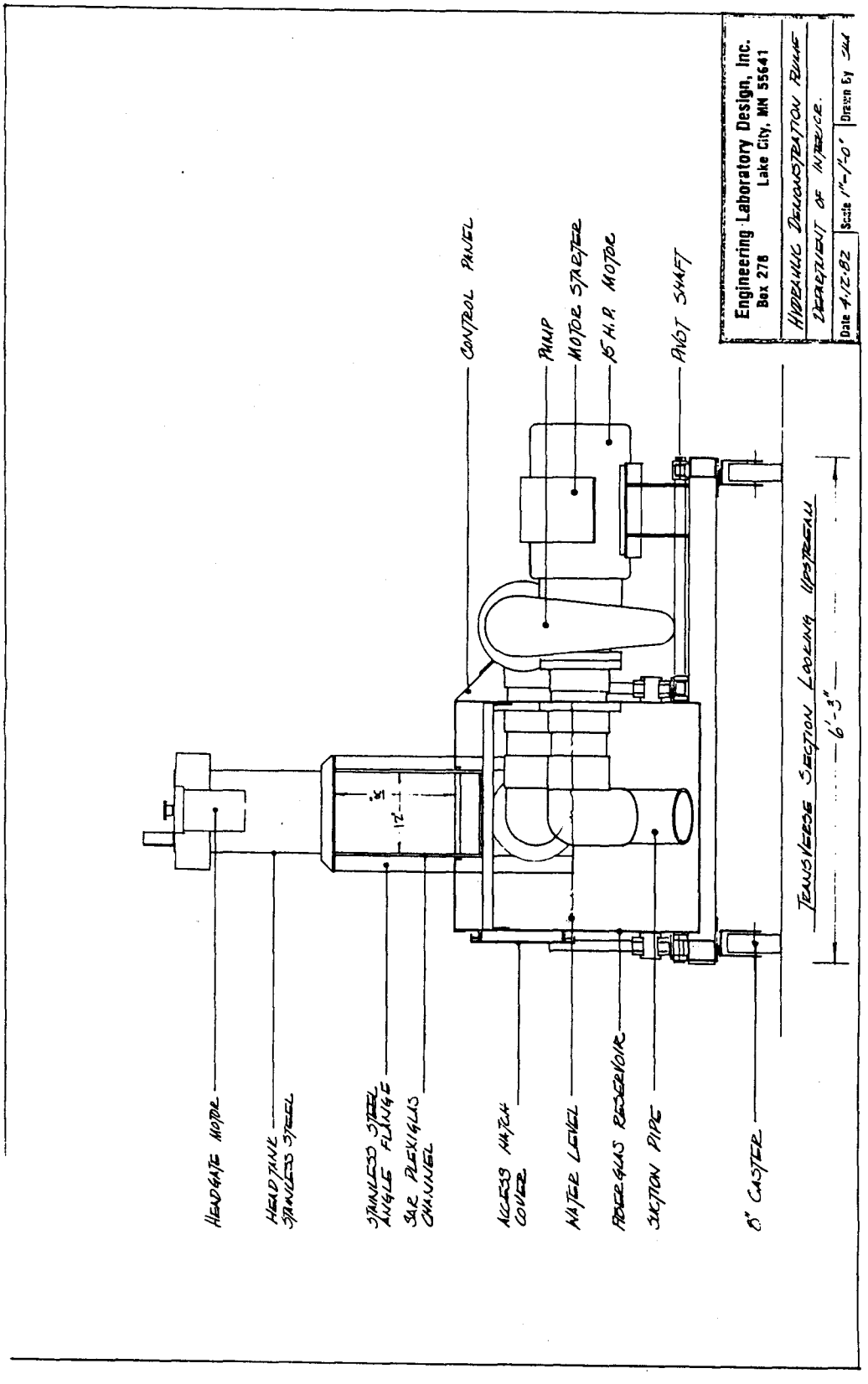
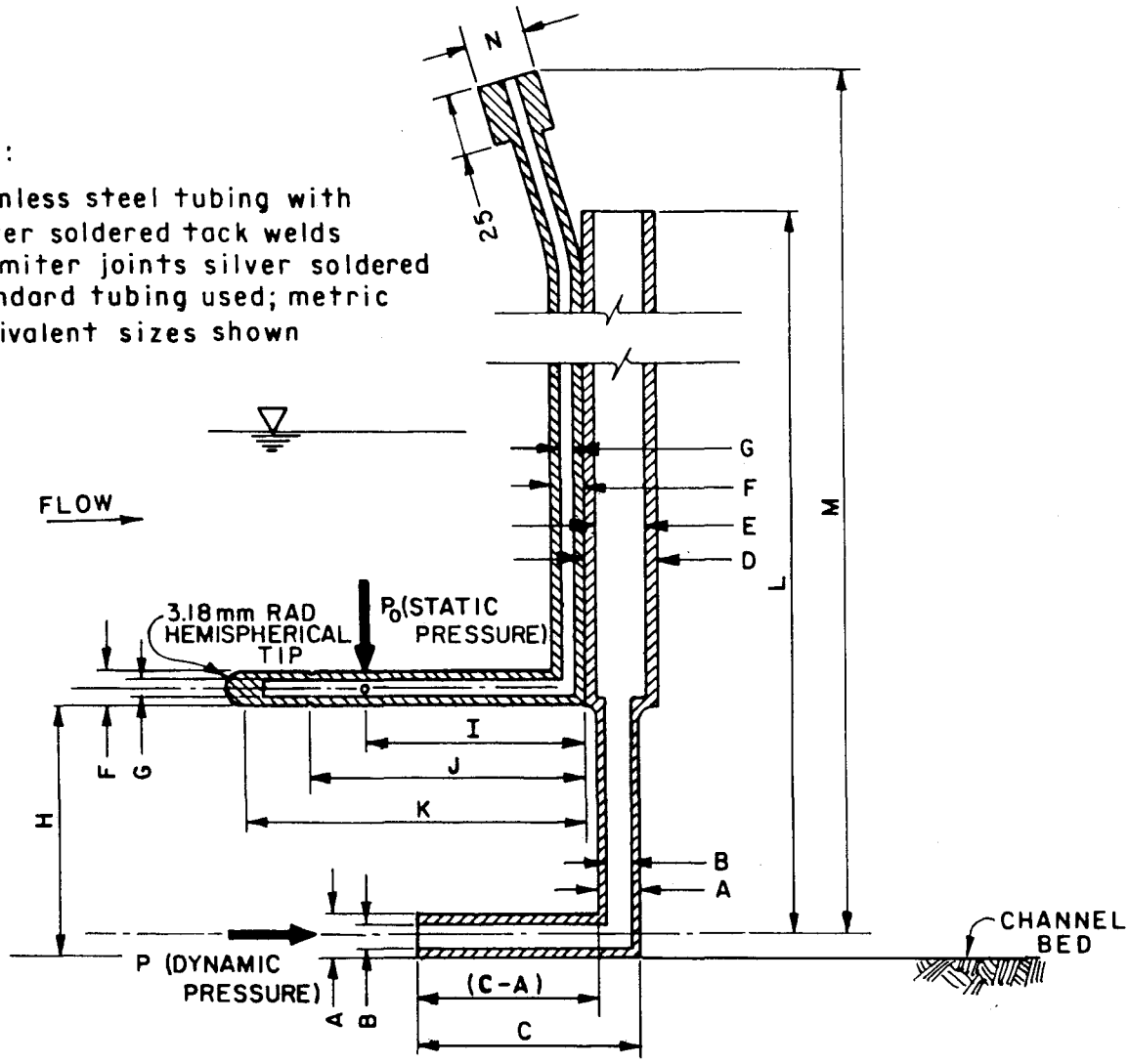



Figure 9. – Hydraulic Demonstration Flume Drawing by Engineering Laboratory Design, Inc. (sheet 3 of 3).

NOTES:

1. Stainless steel tubing with silver soldered tack welds
2. 45° miter joints silver soldered
3. Standard tubing used; metric equivalent sizes shown




| TUBE NUMBER | τ (PASCALS) | | DIMENSIONS (mm) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MIN | MAX | A* | B* | C | D* | E* | F* | G* | H | I | J | K | L | M | N* |
| 1. $\frac{1}{4}$" | 0.0383 | 1.92 | 6.35 | 3.81 | 38.1 | 6.35 | 3.81 | 3.18 | 0.794 | 25.4 | 25.4 | 40.0 | 47.6 | 560 | 585 | 6.35 |
| 2. $\frac{1}{8}$" | 0.158 | 7.66 | 3.18 | 1.90 | 38.1 | 6.35 | 3.81 | 3.18 | 0.794 | 25.4 | 25.4 | 40.0 | 47.6 | 560 | 585 | 6.35 |
| 3. $\frac{1}{16}$"** | 0.623 | 30.7 | 1.59 | 0.952 | 38.1 | 6.35 | 3.81 | 3.18 | 0.794 | 25.4 | 25.4 | 40.0 | 47.6 | 560 | 585 | 6.35 |

* INDICATES DIAMETER.

** DYNAMIC PRESSURE TUBE FABRICATED WITH 13 mm RADIUS BEND INSTEAD OF 45° MITER JOINT.

Figure 10. – Preston tube details and effective operating ranges.

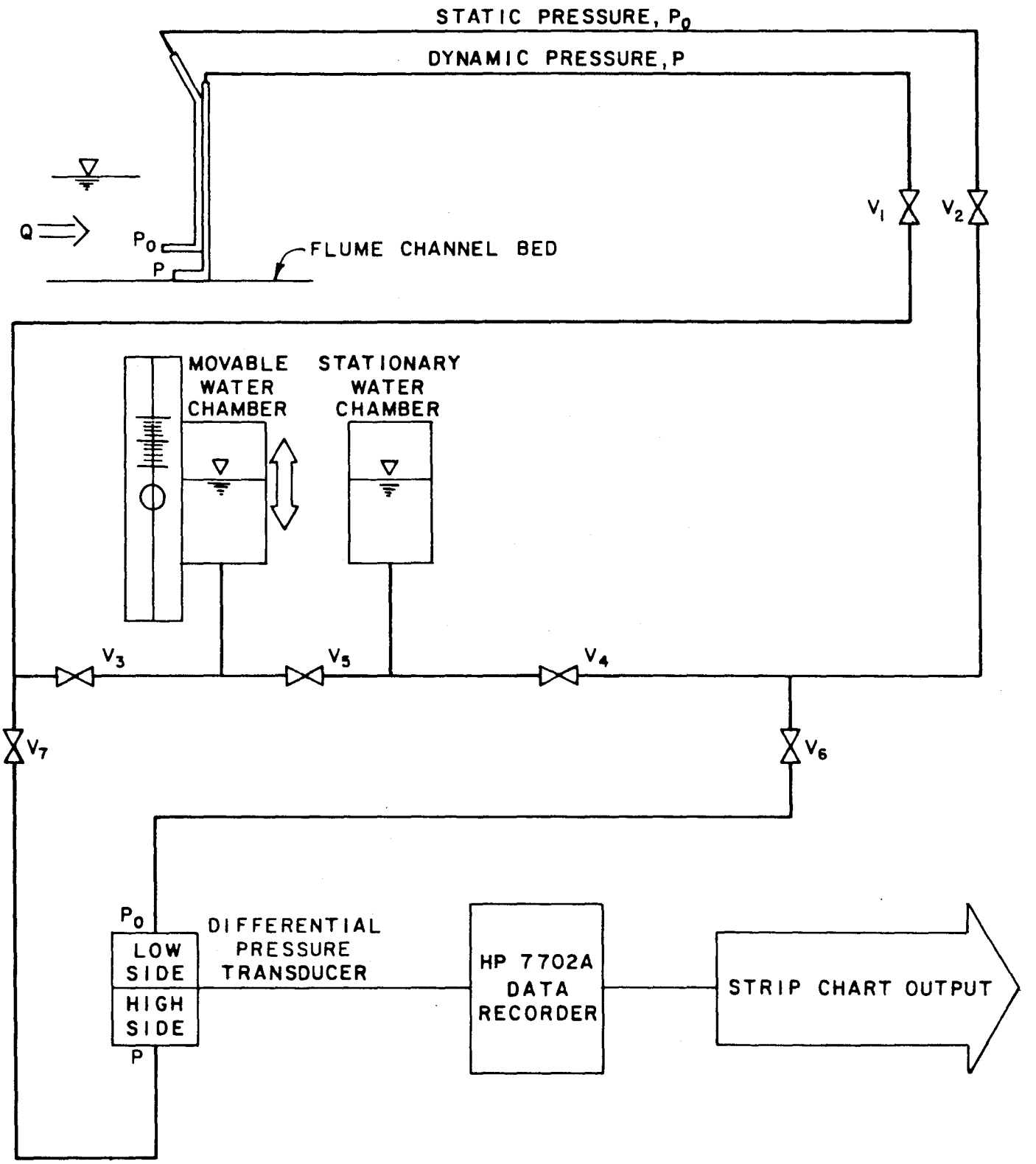



Figure 11. – Shear stress instrumentation system – schematic diagram.

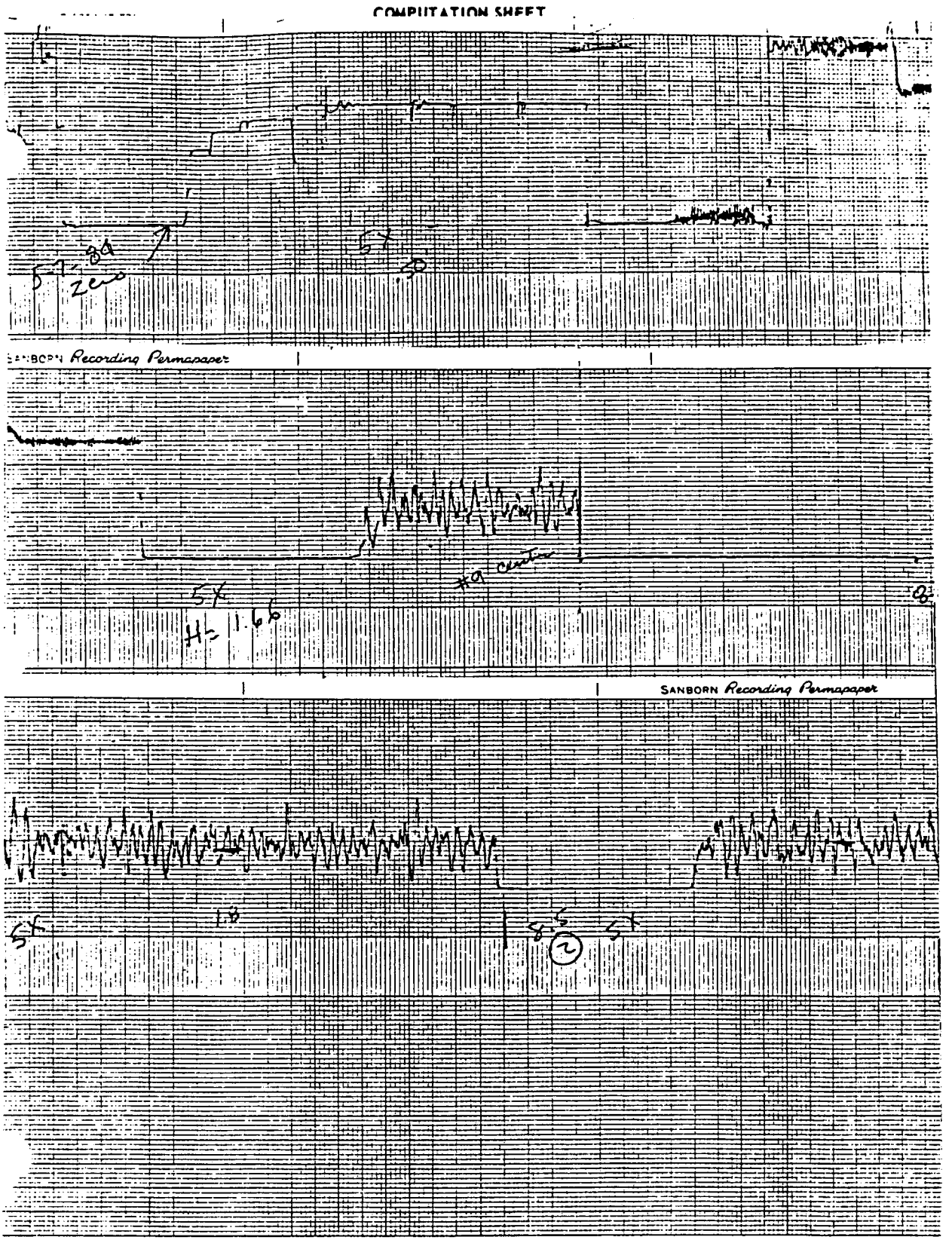



Figure 12. – Example calibration and differential pressure response measurement (strip chart recorder output).

using a clear, rectangular piece of plastic with a line scribed along its major axis. The plastic was positioned on the analog strip chart so that an apparent uniform distribution of data points was observed above and below the line. The visual interpretations of the analog strip chart outputs were checked using the digitizer feature of the HP 9111A graphics tablet. For this process, the analog strip chart was secured to the graphics tablet and the peak data points were digitized. Data files were created for each analog strip chart. Numerical integration of the response curve, using the graphics tablet, was accomplished using the computer program contained in appendix 3. Digital files of the analog strip chart output were statistically analyzed to determine the mean, median, minimum, and maximum values of the differential pressure transducer response. Additional analyses were performed to determine the presence of interference induced by systematic mechanical vibrations from the flume operation. No significant systematic mechanical vibration interferences were detected.

Details of these investigations and computer analyses are contained in appendix 3. Figures 13 (11 sheets) and 14 (11 sheets) show the digital and analog outputs, respectively, of the preliminary differential pressure transducer response measurements.

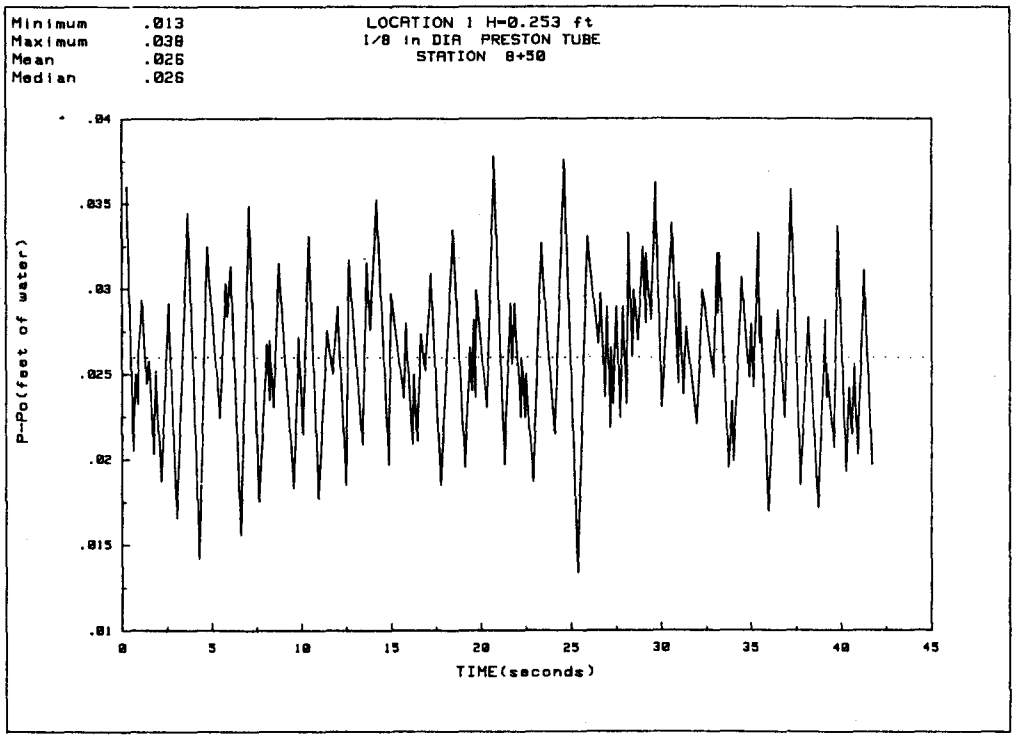
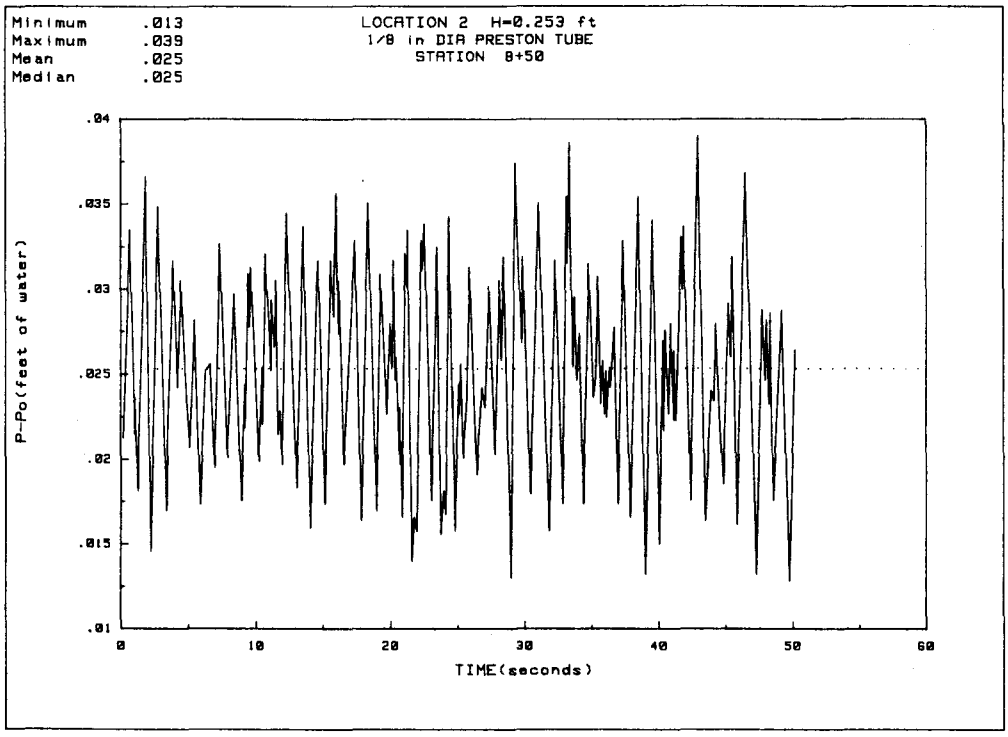



Figure 13. – Computer graphics output of differential pressure transducer response ($p$-$p_o$) (sheet 1 of 6).



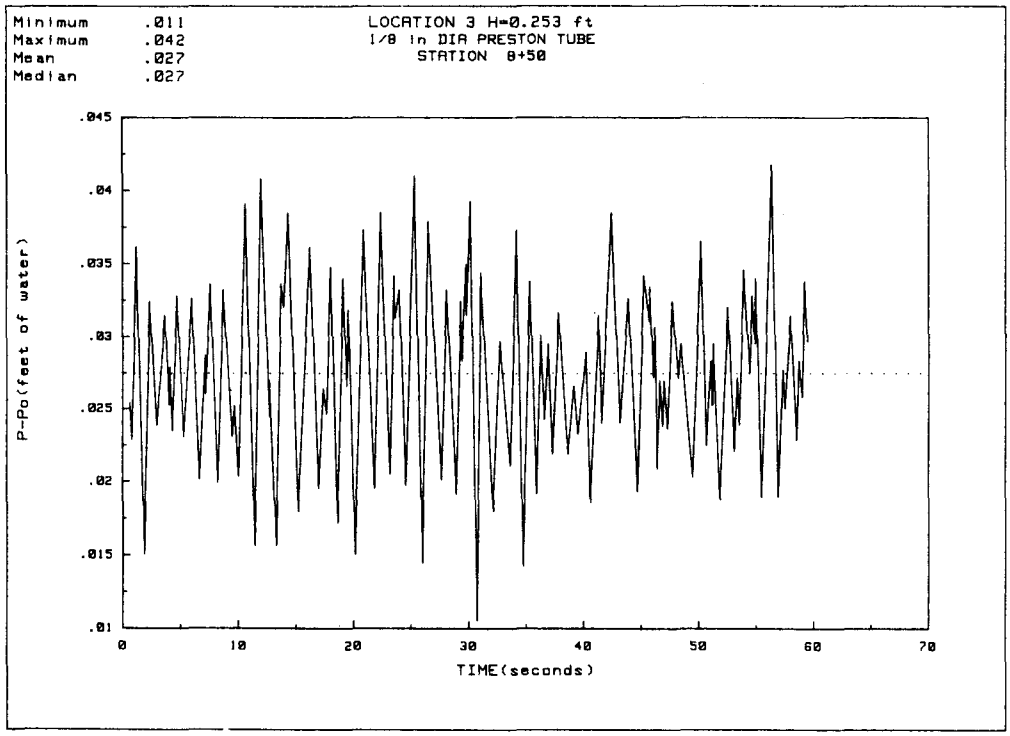
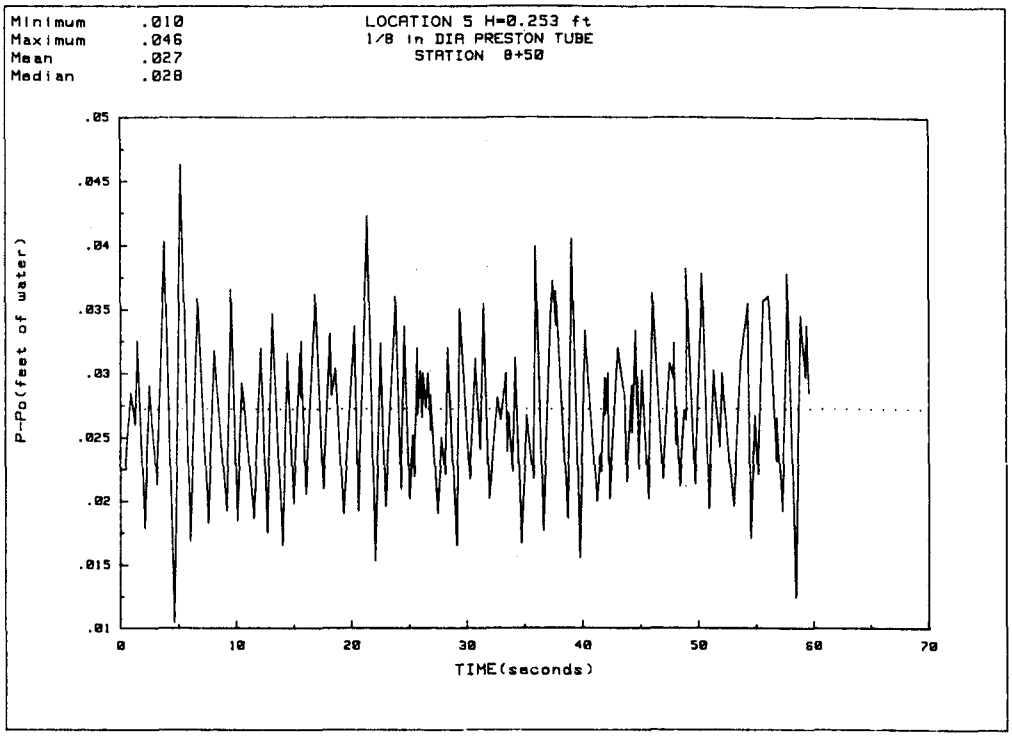




Figure 13. – Computer graphics output of differential pressure transducer response ($p$-$p_o$) (sheet 2 of 6).



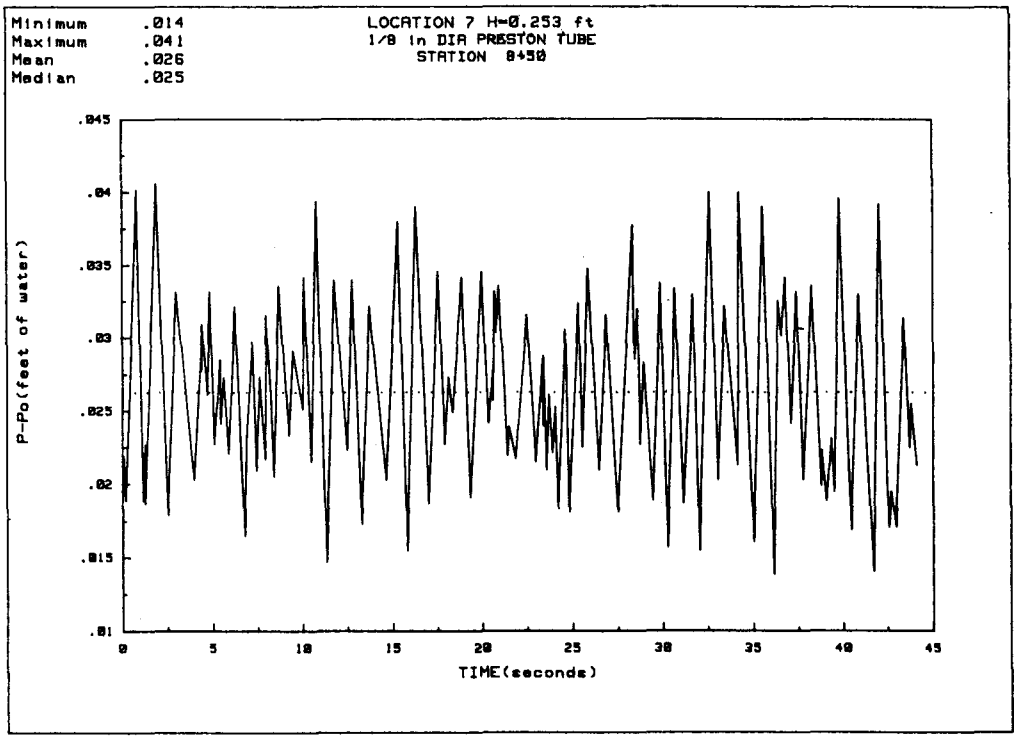
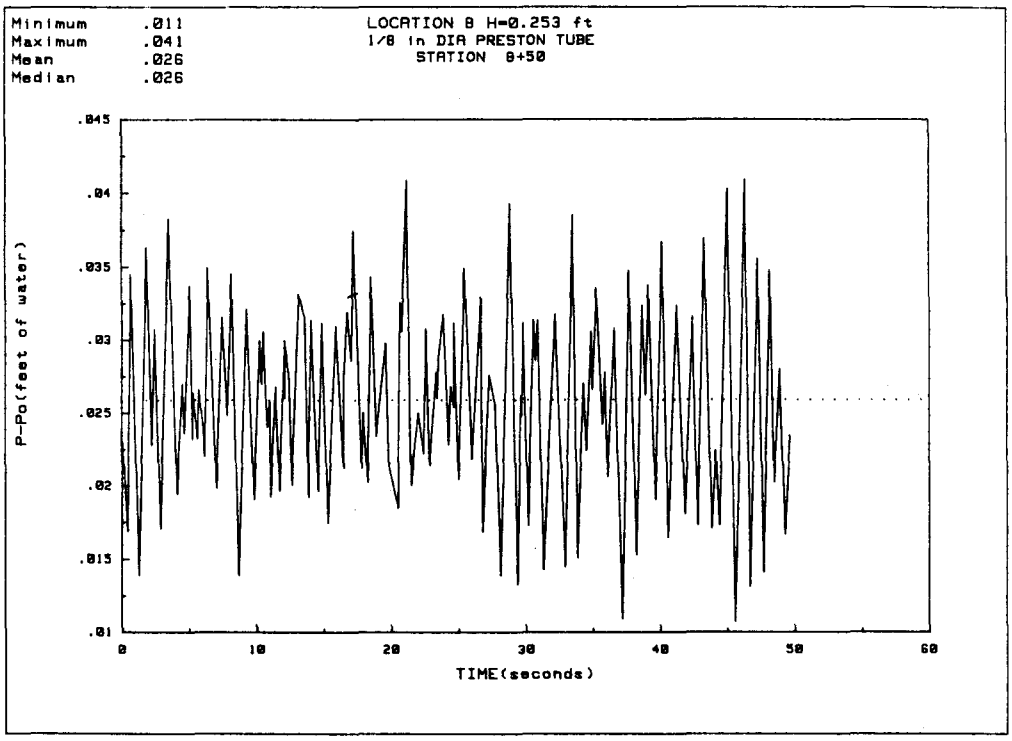




Figure 13. – Computer graphics output of differential pressure transducer response ($p$-$p_o$) (sheet 3 of 6).



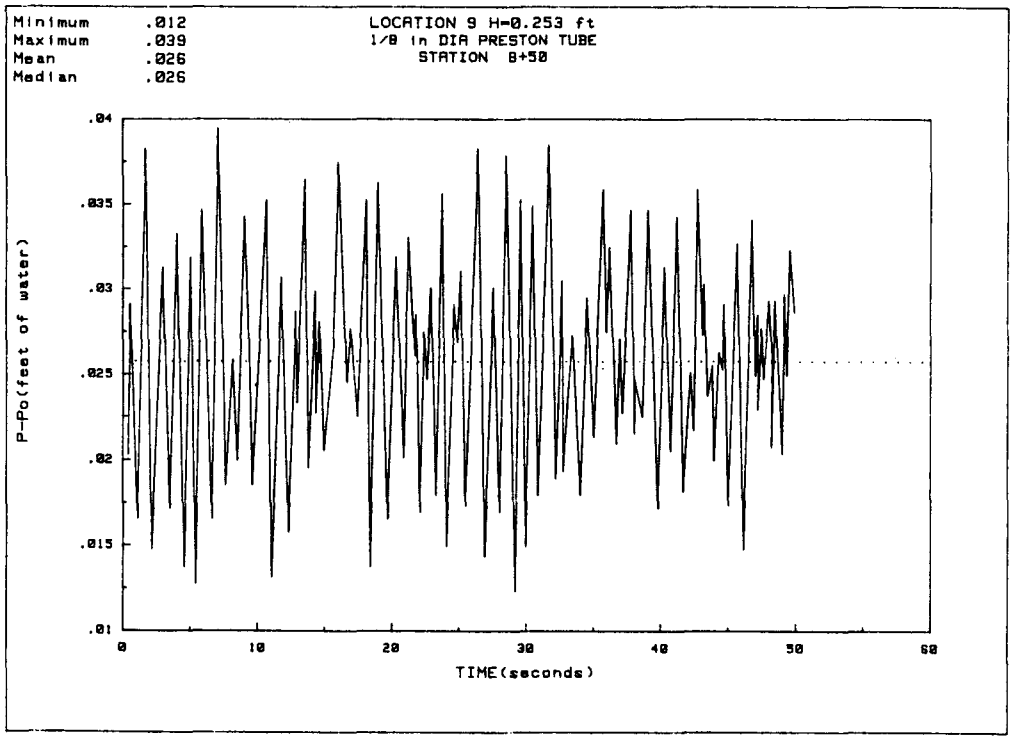
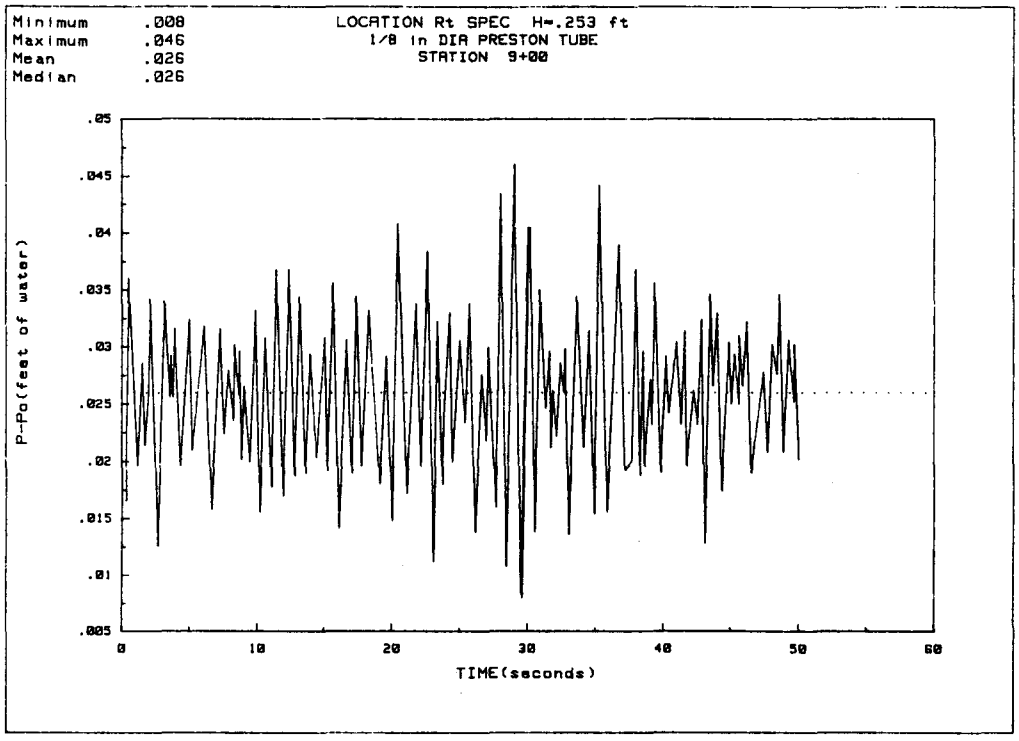




Figure 13. – Computer graphics output of differential pressure transducer response ($p$-$p_o$) (sheet 4 of 6).



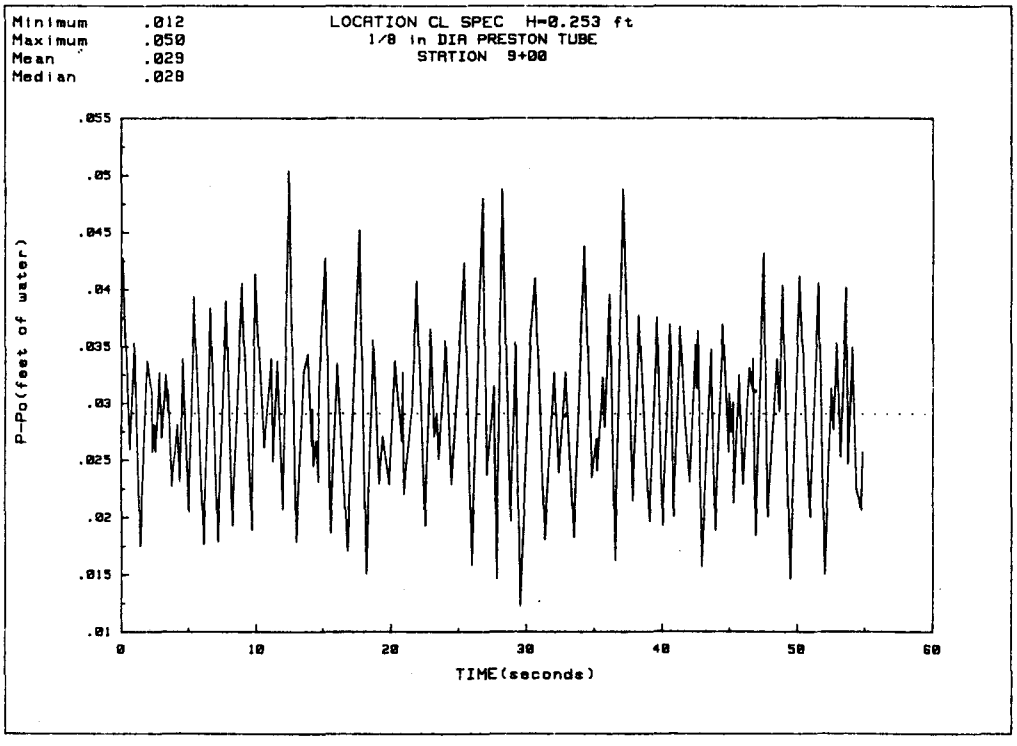
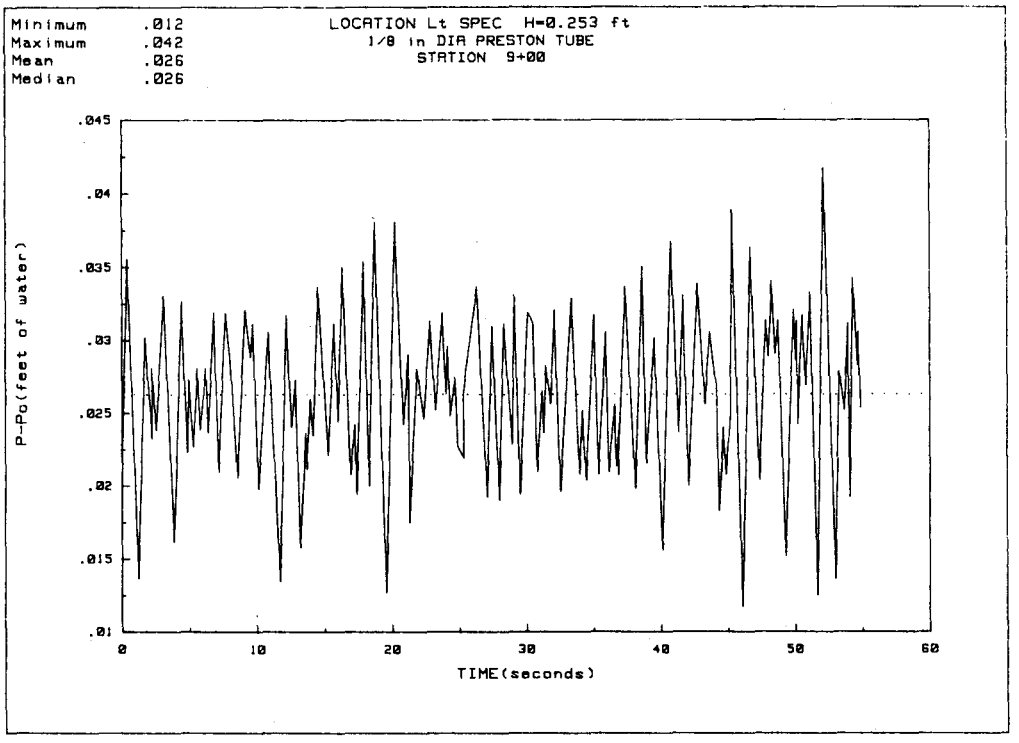




Figure 13. – Computer graphics output of differential pressure transducer response ($p$-$p_o$) (sheet 5 of 6).



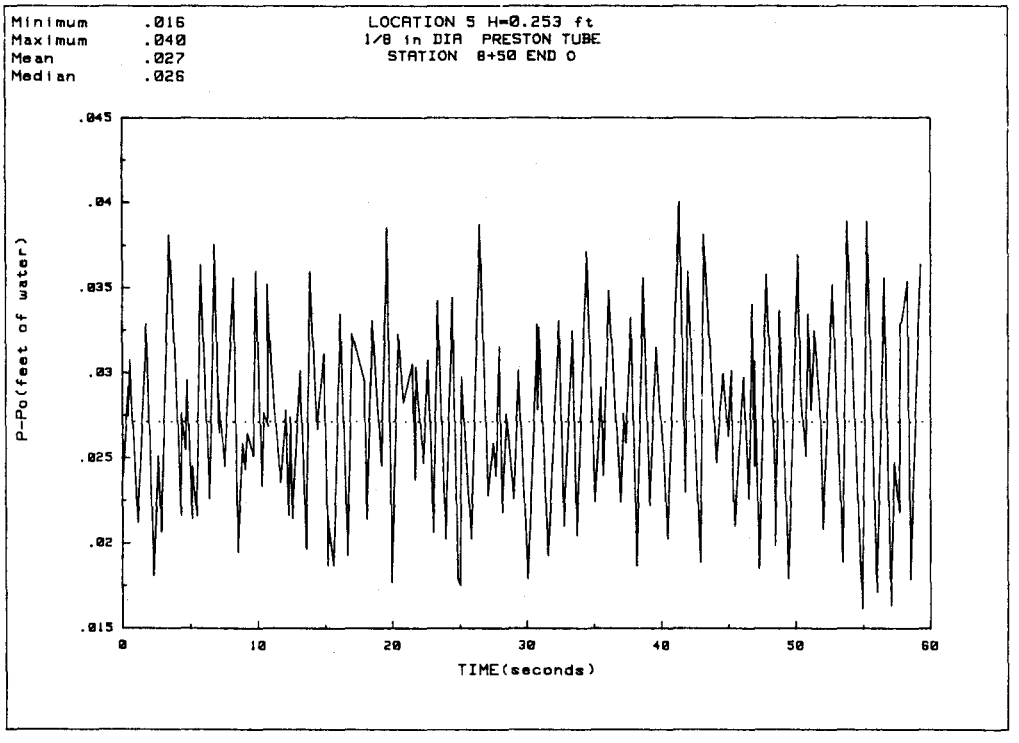




Figure 13. – Computer graphics output of differential pressure transducer response ($p$-$p_o$) (sheet 6 of 6).

EROSION TEST

Sheet 1 of 11

DATE 5-22-84

TEST NO. Practice

STATION 8+50

LOCATION 1

CHART SPEED 2.5 mm/s

OPERATOR RDR

PRESTON TUBE 1/8-in.

TEST CONDITIONS H = 0.253'
Raised Tail Gate

PRESTON TUBE READINGS $(p - p_0)$ - 0.01 ft.

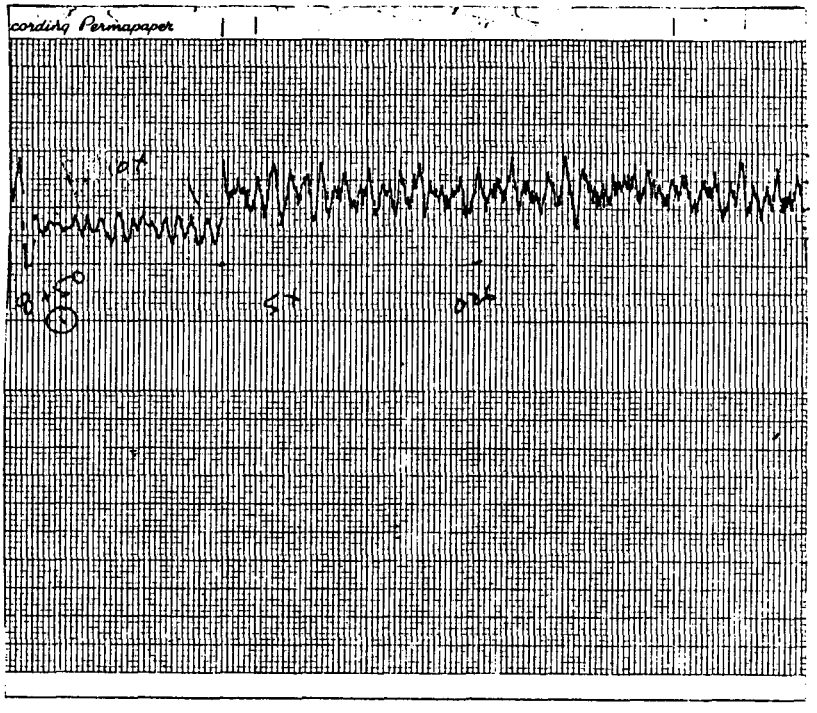



Figure 14. – Strip chart output of differential pressure transducer response ($p$-$p_o$) (sheet 1 of 11).

EROSION TEST

Sheet 2 of 11

DATE _____

TEST NO. _____

STATION 8+50

LOCATION 2

OPERATOR _____

PRESTON TUBE _____

TEST CONDITIONS _____

PRESTON TUBE READINGS $(p - p_0)$ - 0.01 ft.

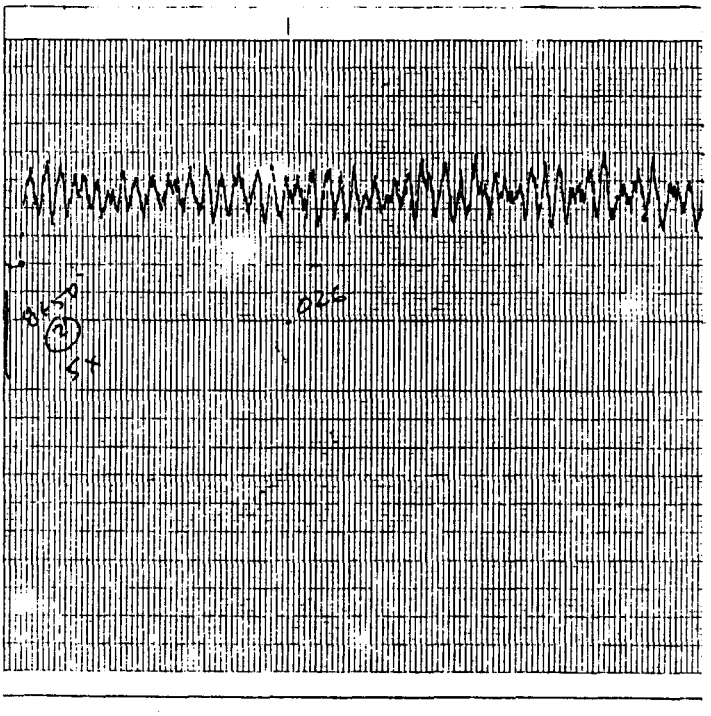


Figure 14. – Strip chart output of differential pressure transducer response ($p$-$p_o$) (sheet 2 of 11).

EROSION TEST

Sheet 3 of 11

DATE _____

TEST NO. _____

STATION 8+50

LOCATION 3

OPERATOR _____

PRESTON TUBE _____

TEST CONDITIONS _____

_____

PRESTON TUBE READINGS ($p - p_0$) - 0.01 ft.

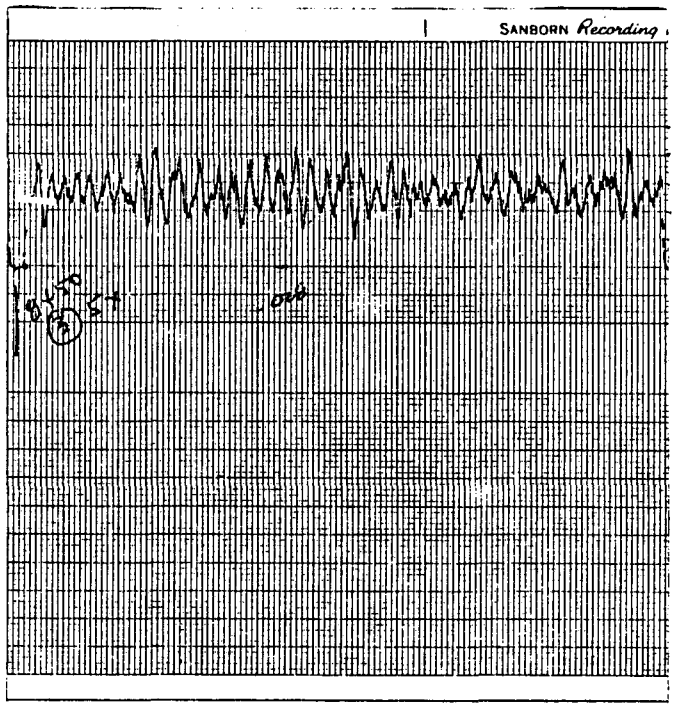



Figure 14. – Strip chart output of differential pressure transducer response ($p$-$p_o$) (sheet 3 of 11).

EROSION TEST

Sheet 4 of 11

DATE _____

TEST NO. _____

STATION 8+50

LOCATION 5

OPERATOR _____

PRESTON TUBE _____

TEST CONDITIONS _____

PRESTON TUBE READINGS ($p - p_o$) - 0.01 ft.

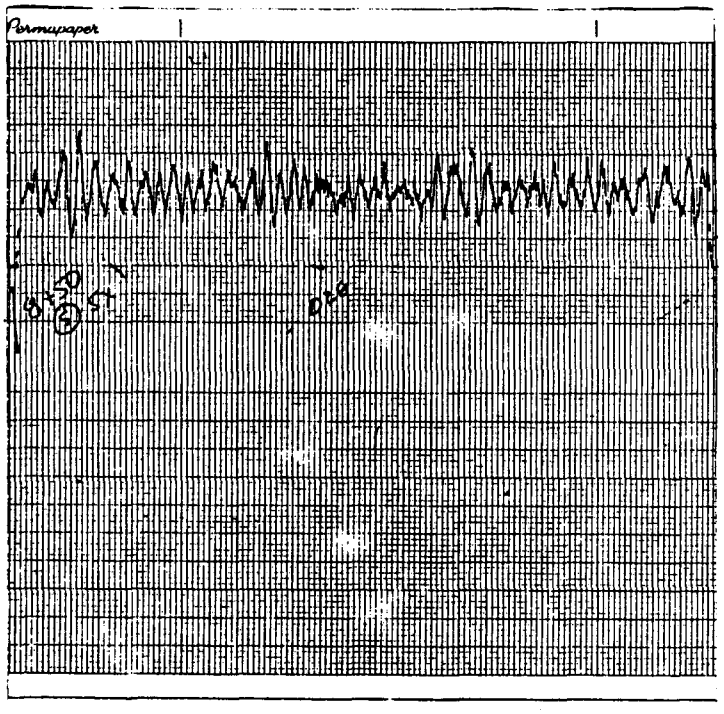



Figure 14. – Strip chart output of differential pressure transducer response ($p$-$p_o$) (sheet 4 of 11).

EROSION TEST

Sheet 5 of 11

DATE _____

TEST NO. _____

STATION 8+50

LOCATION 7

OPERATOR _____

PRESTON TUBE _____

TEST CONDITIONS _____

PRESTON TUBE READINGS $(p - p_o)$ - 0.01 ft.

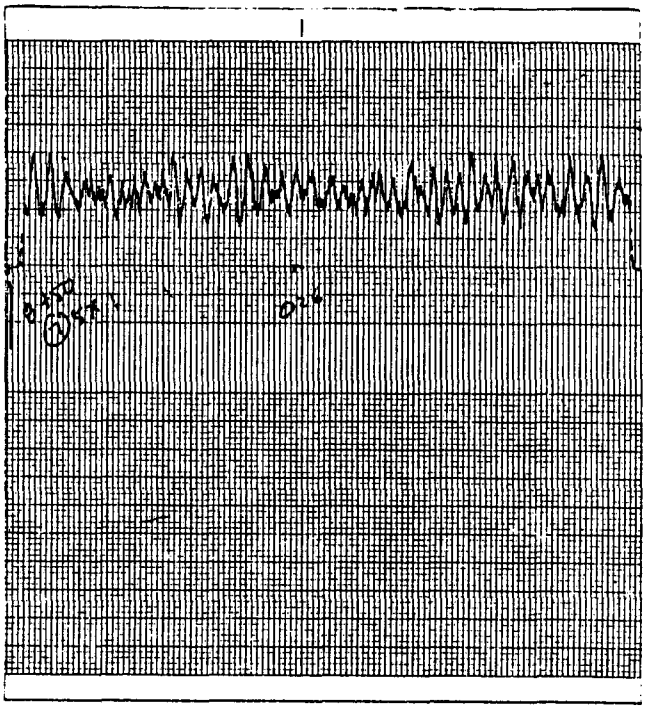


Figure 14. – Strip chart output of differential pressure transducer response $(p-p_o)$ (sheet 5 of 11).

EROSION TEST

Sheet 6 of 11

DATE _____

TEST NO. _____

STATION 8+50

LOCATION 8

OPERATOR _____

PRESTON TUBE _____

TEST CONDITIONS _____

PRESTON TUBE READINGS ($p - p_0$) - 0.01 ft.

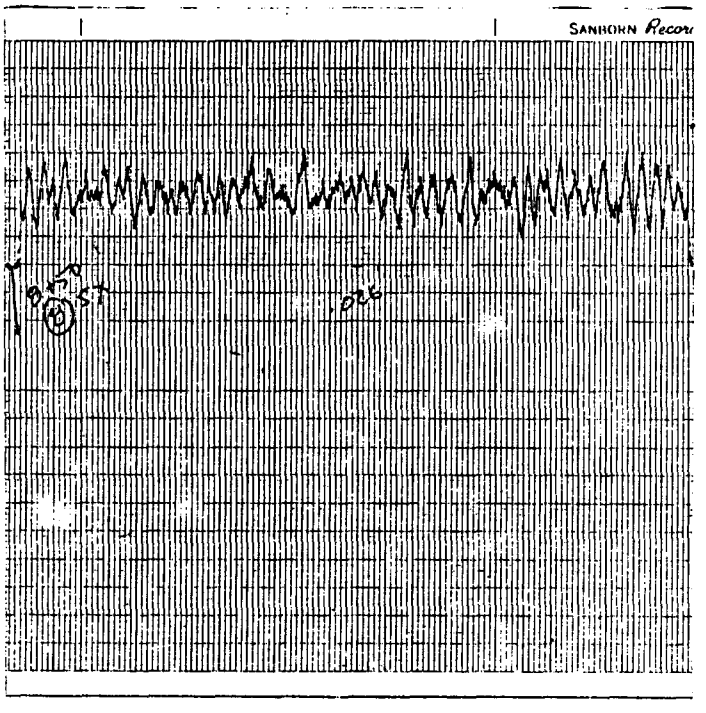



Figure 14. – Strip chart output of differential pressure transducer response ($p$-$p_o$) (sheet 6 of 11).

EROSION TEST

Sheet 7 of 11

DATE _____

TEST NO. _____

STATION 8+50

LOCATION 9

OPERATOR _____

PRESTON TUBE _____

TEST CONDITIONS _____

PRESTON TUBE READINGS $(p - p_o)$ - 0.01 ft.

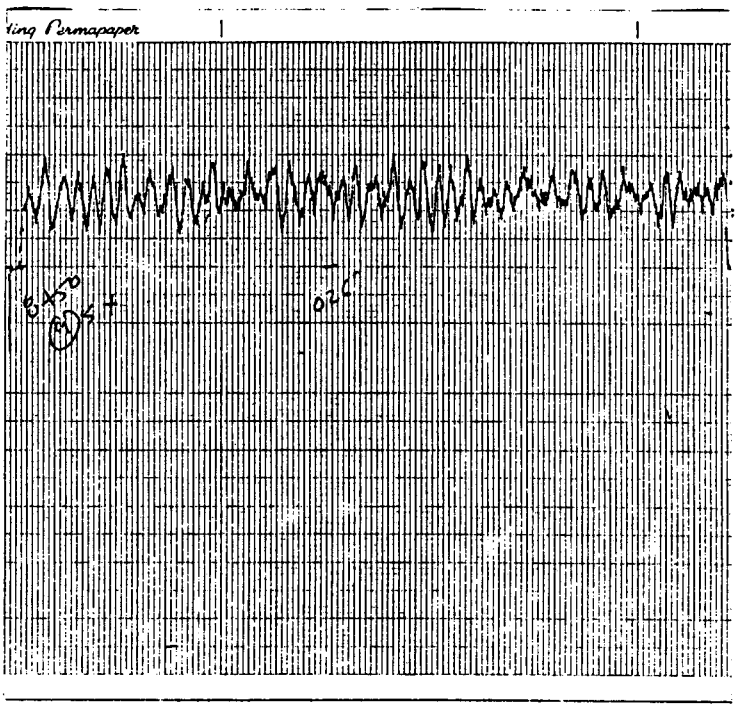



Figure 14. – Strip chart output of differential pressure transducer response ($p$-$p_o$) (sheet 7 of 11).

EROSION TEST

Sheet 8 of 11

DATE _____

TEST NO. _____

STATION 9+00

LOCATION Rt.

OPERATOR _____

PRESTON TUBE _____

TEST CONDITIONS _____

PRESTON TUBE READINGS $(p - p_0)$ - 0.01 ft.

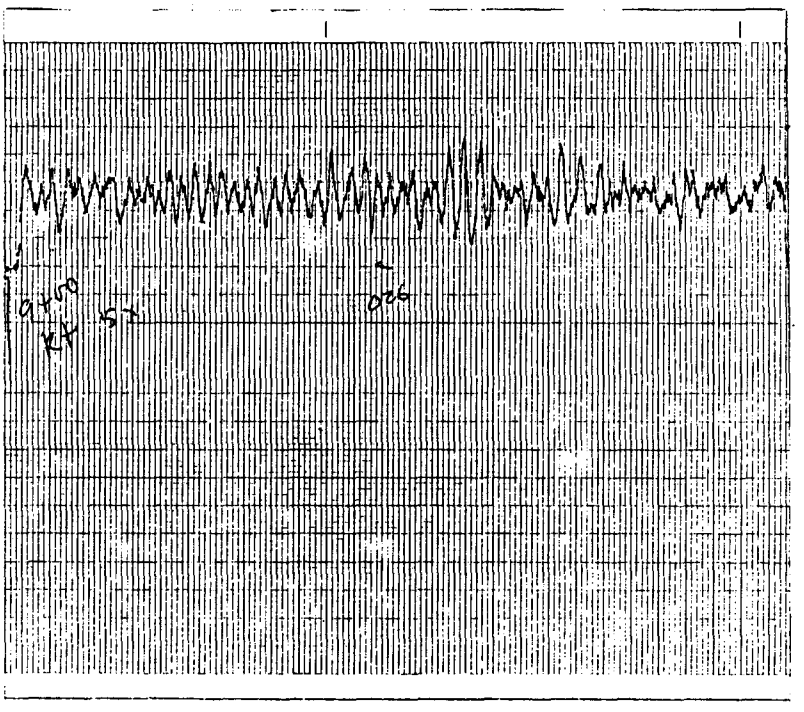



Figure 14. – Strip chart output of differential pressure transducer response ($p$-$p_o$) (sheet 8 of 11).

EROSION TEST

Sheet 9 of 11

DATE _____

TEST NO. _____

STATION 9+00

LOCATION ℄

OPERATOR _____

PRESTON TUBE _____

TEST CONDITIONS _____

PRESTON TUBE READINGS ($p - p_o$) - 0.01 ft.

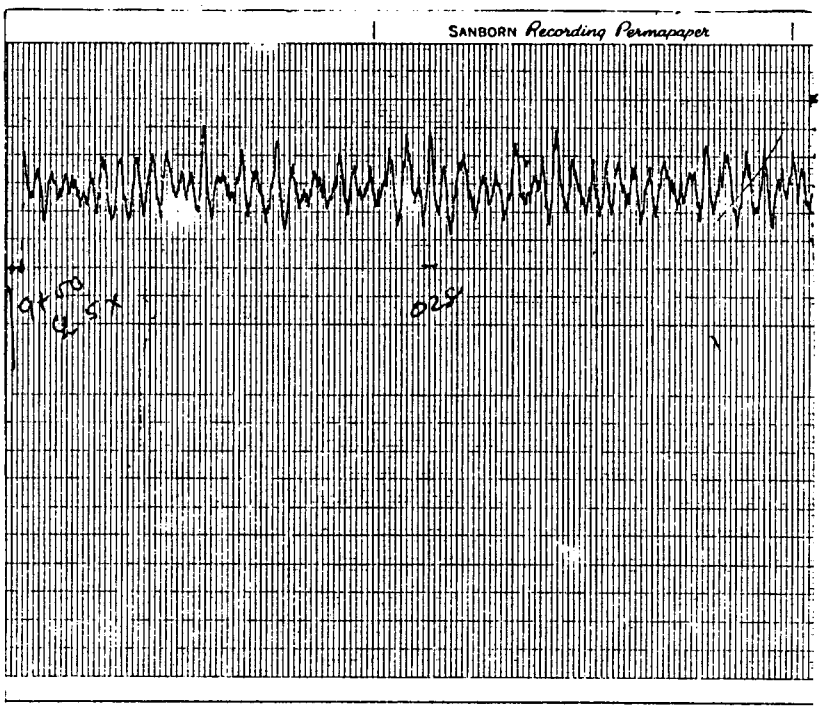



Figure 14. – Strip chart output of differential pressure transducer response ($p$-$p_o$) (sheet 9 of 11).

EROSION TEST

Sheet 10 of 11

DATE _____

TEST NO. _____

STATION 9+00

LOCATION Lt.

OPERATOR _____

PRESTON TUBE _____

TEST CONDITIONS _____

PRESTON TUBE READINGS $(p - p_0)$ - 0.01 ft.

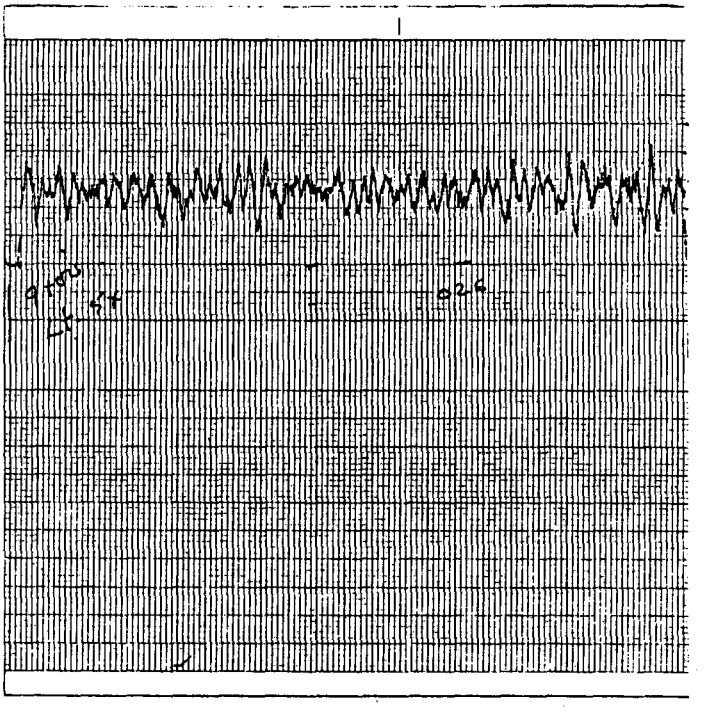


Figure 14. – Strip chart output of differential pressure transducer response ($p$-$p_o$) (sheet 10 of 11).

EROSION TEST

Sheet 11 of 11

DATE _____

TEST NO. _____

STATION 8150

LOCATION 5 End of Test

OPERATOR RDR

PRESTON TUBE _____

TEST CONDITIONS _____

PRESTON TUBE READINGS $(p - p_o)$ - 0.01 ft.

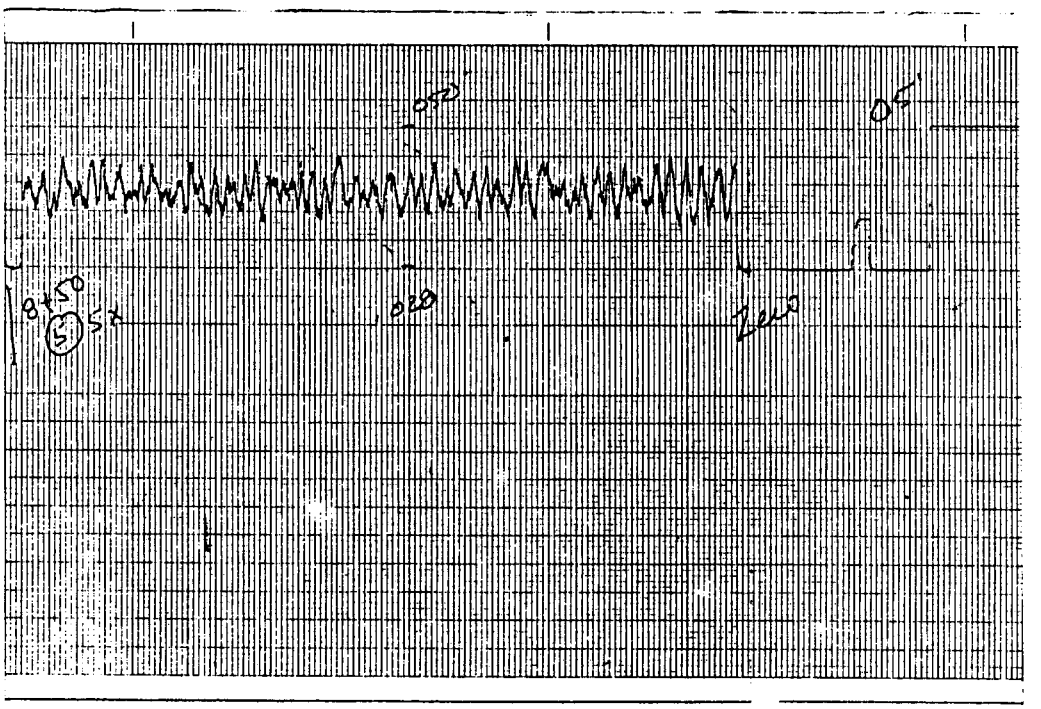



Figure 14. – Strip chart output of differential pressure transducer response ($p$-$p_o$) (sheet 11 of 11).

### Channel Bed Shear Stress Measurements

Figure 15 shows the locations that were used for preliminary shear stress measurements along the flume channel bed. The locations were selected to investigate the effects of the channel walls and of the length of the channel bed on the development of a uniform boundary layer near the soil sample fixture. Table 1 shows preliminary results of the channel bed shear stress measurements using the 1/8-in (3.18-mm) diameter Preston tube and the shear stress instrumentation system.

Figure 16 shows the velocity profiles and system flow characteristics of the WES laboratory erosion flume (provided courtesy of WES); it is offered for comparative information purposes. Preliminary operation of the erosion flume showed reasonable agreement with the WES data.

### Miscellaneous Flume Modifications

Figure 17 shows a schematic diagram of the plumbing modifications, which were made to accommodate filling and draining the flume, to provide lubricating, fresh water to the centrifugal pump bearing, and to allow temperature control of the recirculating water by adjusting the supply and drain system. The 15-hp electric motor and the motor controller were modified for 440-V service to reduce operating current draw and extend service life.

A point gage was fabricated for convenience in measuring the average elevation of the water surface in the flume channel. Improvements were made to the Preston tube rack to ensure a tube placement flush with and perpendicular to the surface of the channel bottom.

## BIBLIOGRAPHY


[1] Jones, C. W., *Laboratory Tests for Soil Surface Resistance to Flowing Water*, Bureau of Reclamation Report No. GR-82-3, Denver, Colo., January 1982.

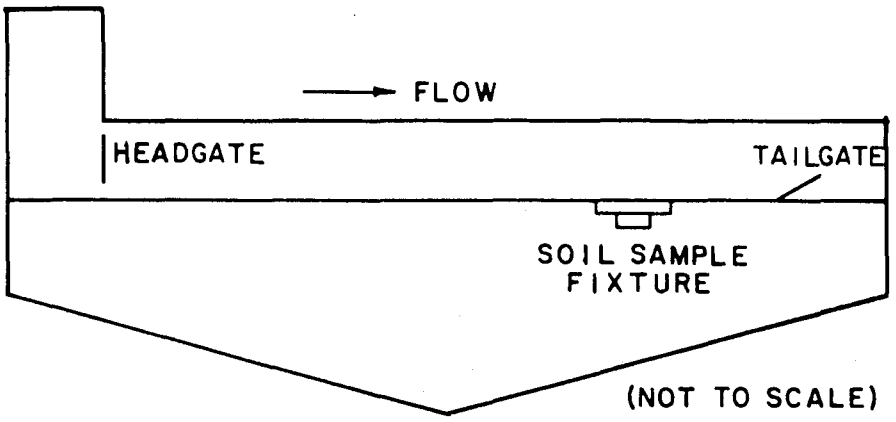
[2] Preston, J. H., "The Determination of Turbulent Skin Friction by Means of Pitot Tubes," *Journal of the Royal Aeronautical Society*, vol. 58, Cambridge University, pp. 109-121, February 1954.

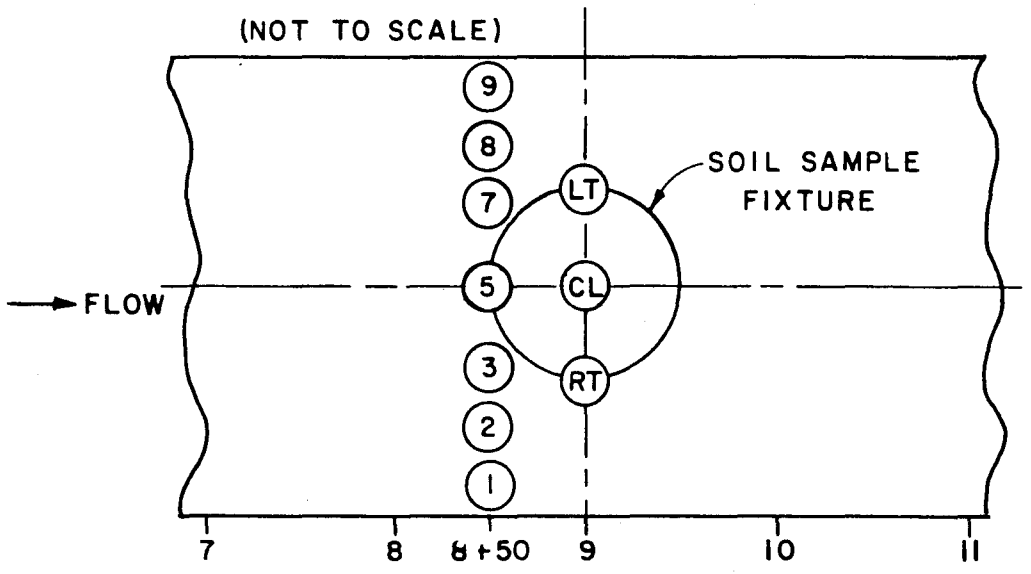
[3] Patel, V. C., "Calibration of the Preston Tube and Limitations on its Use in Pressure Gradients," *Journal of Fluid Mechanics*, vol. 23, part I, Great Britain, pp. 185-208, 1965.

[4] McAllister, J. E., et al., "Preston Tube Calibrations and Direct Force Floating Element Measurements in a Two-Dimensional Turbulent Boundary Layer," *Journal of Fluids Engineering Division*, ASME, vol. 104, pp. 156-161, June 1982.

[5] Ippen, A. T., et al., "The Distribution of Boundary Shear Stresses in Curved Trapezoidal Channels," Massachusetts Institute of Technology Hydrodynamics Laboratory Technical Report No. 43, Cambridge, Mass., October 1960.

[6] Gibbs, H. J., *A Study of Erosion and Tractive Force Characteristics in Relation to Soil Mechanics Properties*, Bureau of Reclamation Soils Engineering Report No. EM-643, Denver, Colo., February 1962.




| POSITION | LOCATION |
|---|---|
| 9 | 6 in U.S., 5 in Left |
| 8 | 6 in U.S., 4 in Left |
| 7 | 6 in U.S., 3 in Left |
| 5 | 6 in U.S., |
| 3 | 6 in U.S., 3 in Right |
| 2 | 6 in U.S., 4 in Right |
| 1 | 6 in U.S., 5 in Right |
| RT | Right specimen/channel bed |
| CL | Center of specimen |
| LT | Left specimen/channel bed |

Figure 15. – Flume channel bed shear stress measurement locations.

Table 1. – Channel bed shear stress measurements (1/8-in (3.81-mm) diameter Preston tube).

| Location | Differential pressure transducer response ($p$-$p_o$), in feet of water | | | | | $\tau_o$, shear stress* lbf/ft² |
|---|---|---|---|---|---|---|
| | Visual data | Digitized data | | | | |
| | Mean | Min | Max | Mean | Median | Mean |
| 1 | 0.026 | 0.013 | 0.038 | 0.026 | 0.026 | 0.014 |
| 2 | 0.026 | 0.013 | 0.039 | 0.025 | 0.025 | 0.014 |
| 3 | 0.028 | 0.011 | 0.042 | 0.027 | 0.027 | 0.015 |
| 5 | 0.028 | 0.010 | 0.046 | 0.027 | 0.028 | 0.015 |
| 7 | 0.026 | 0.014 | 0.041 | 0.026 | 0.025 | 0.014 |
| 8 | 0.026 | 0.011 | 0.041 | 0.026 | 0.026 | 0.014 |
| Rt. Specimen | 0.026 | 0.008 | 0.046 | 0.026 | 0.026 | 0.014 |
| Cl. Specimen | 0.028 | 0.012 | 0.050 | 0.029 | 0.028 | 0.015 |
| Lt. Specimen | 0.026 | 0.012 | 0.042 | 0.026 | 0.026 | 0.014 |
| 5 (retest) | 0.026 | 0.016 | 0.040 | 0.027 | 0.026 | 0.015 |

* To calculate shear stresses, temperature corrections must be used:

$$\tau_o = A(p\text{-}p_o)^{7/8}$$

where: $A$ = 0.0096, for temperatures 60-69 °F
$A$ = 0.0092, for temperatures 70-79 °F
$A$ = 0.0090, for temperatures 80-89 °F

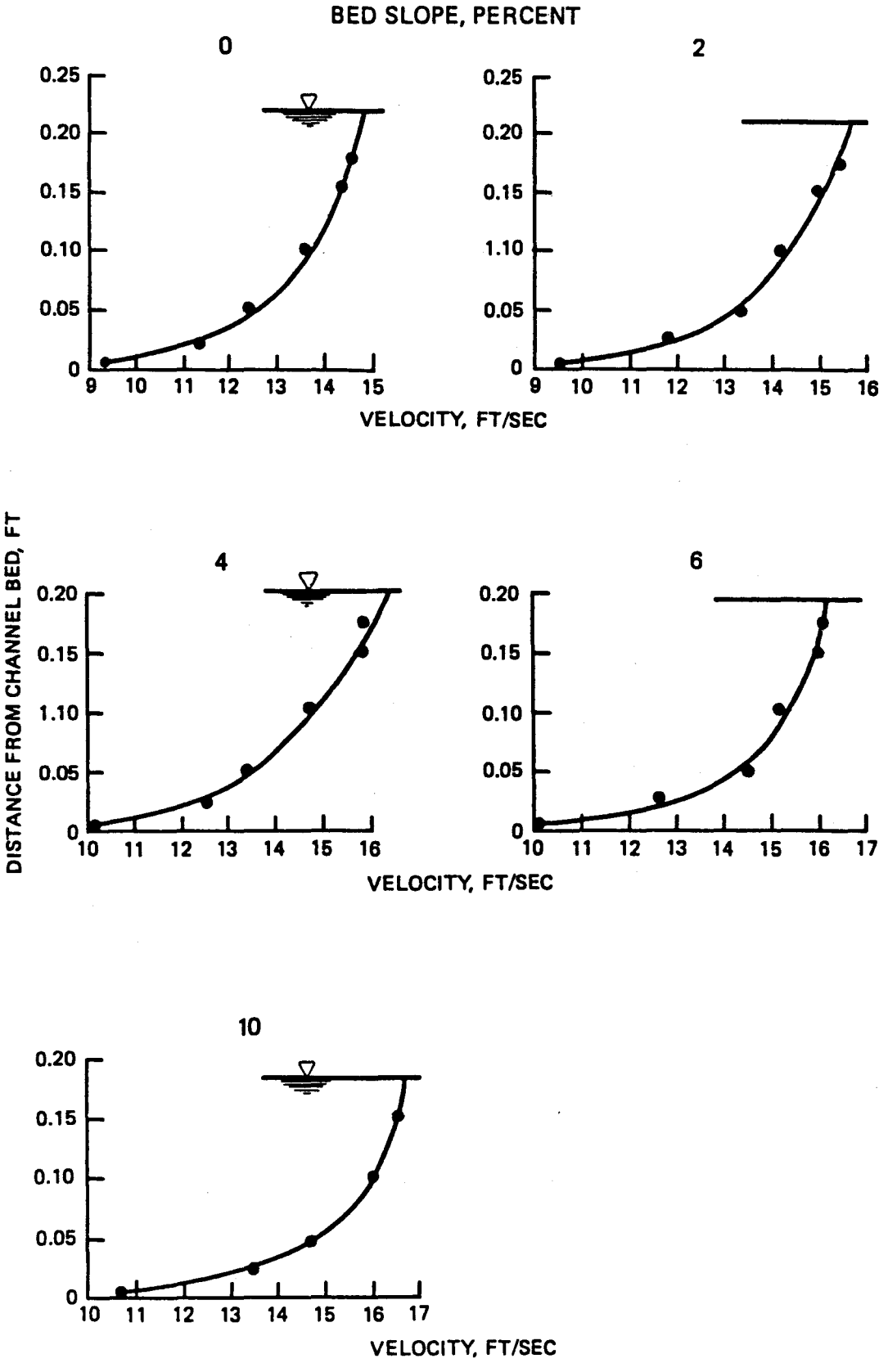



Figure 16. – Velocity profiles and system operating characteristics (sheet 1 of 4).

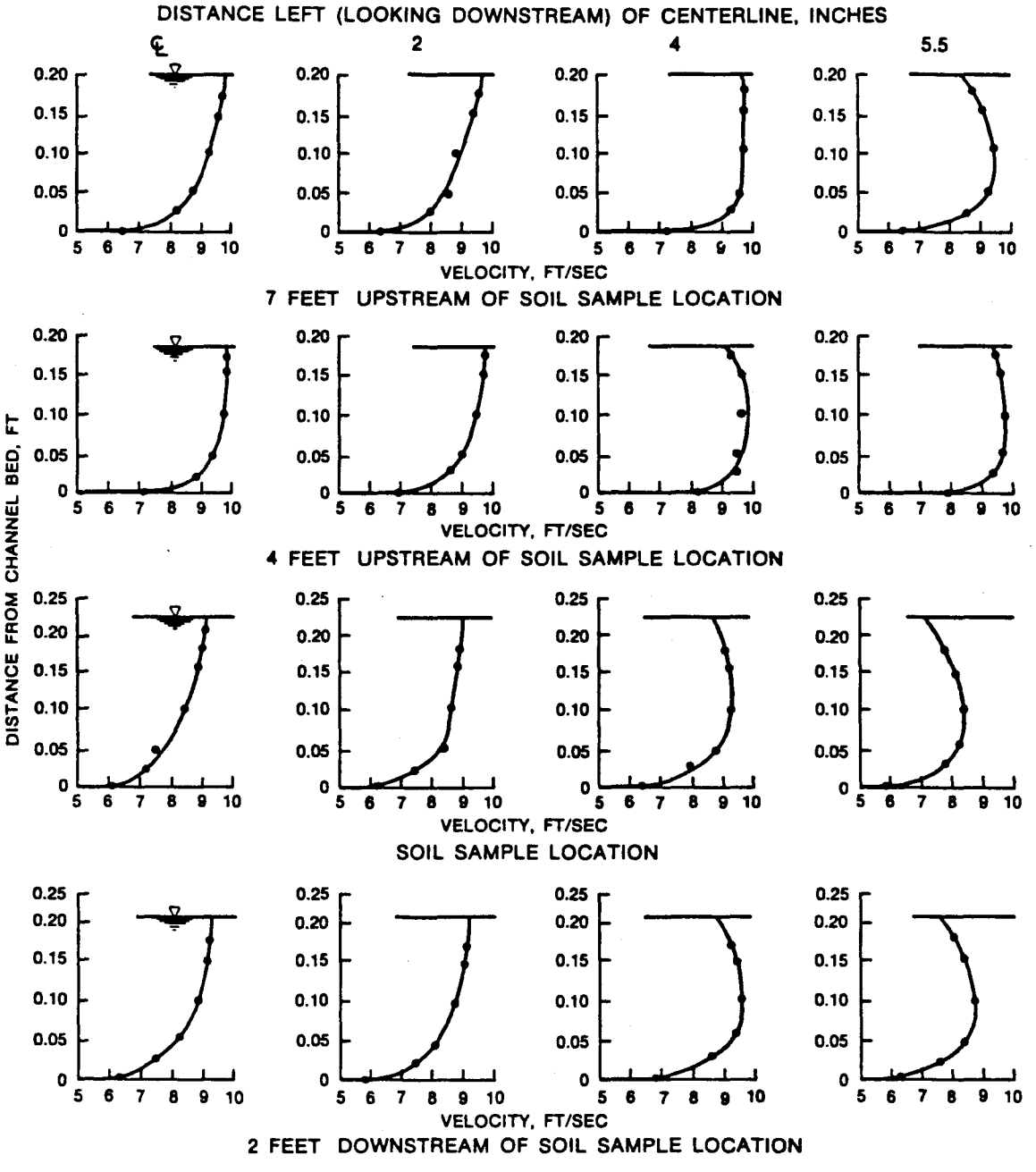



Figure 16. – Velocity profiles and system operating characteristics (sheet 2 of 4).

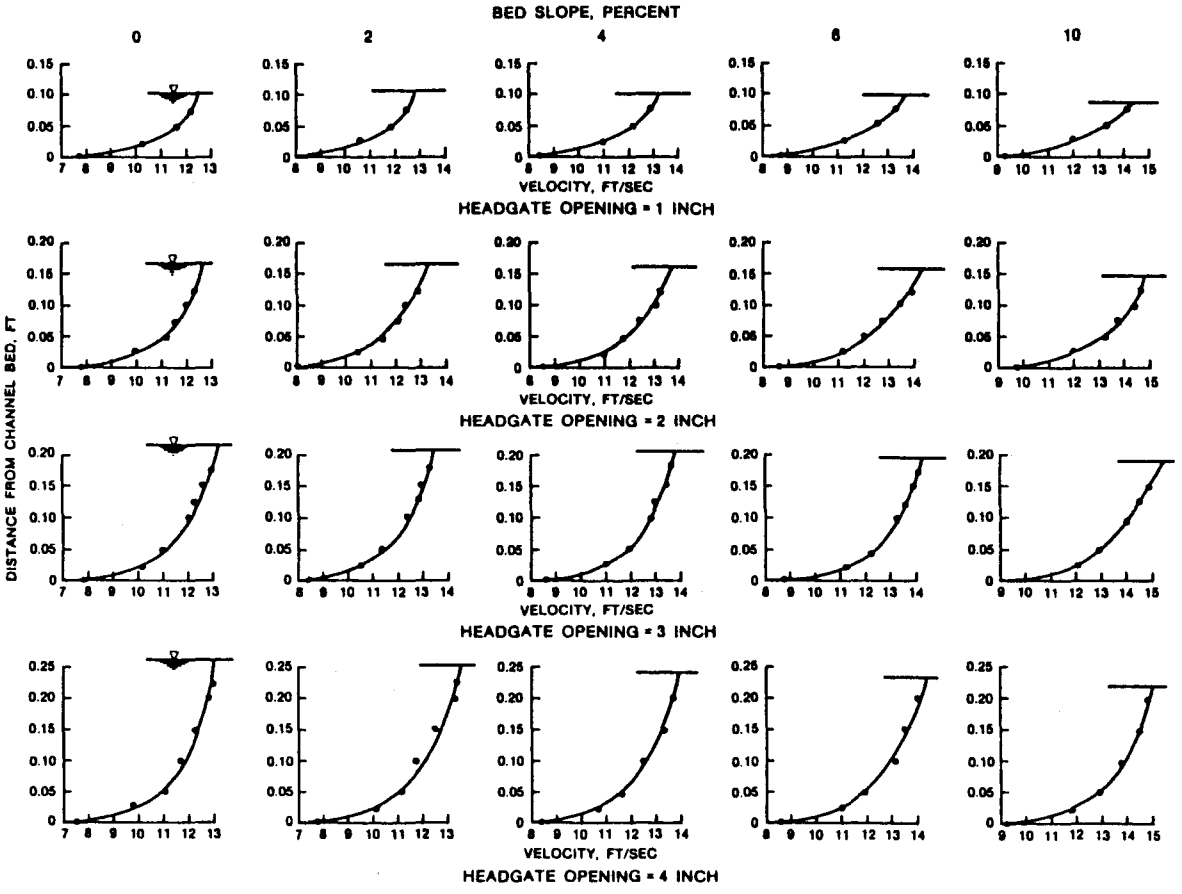



Figure 16. – Velocity profiles and system operating characteristics (sheet 3 of 4).

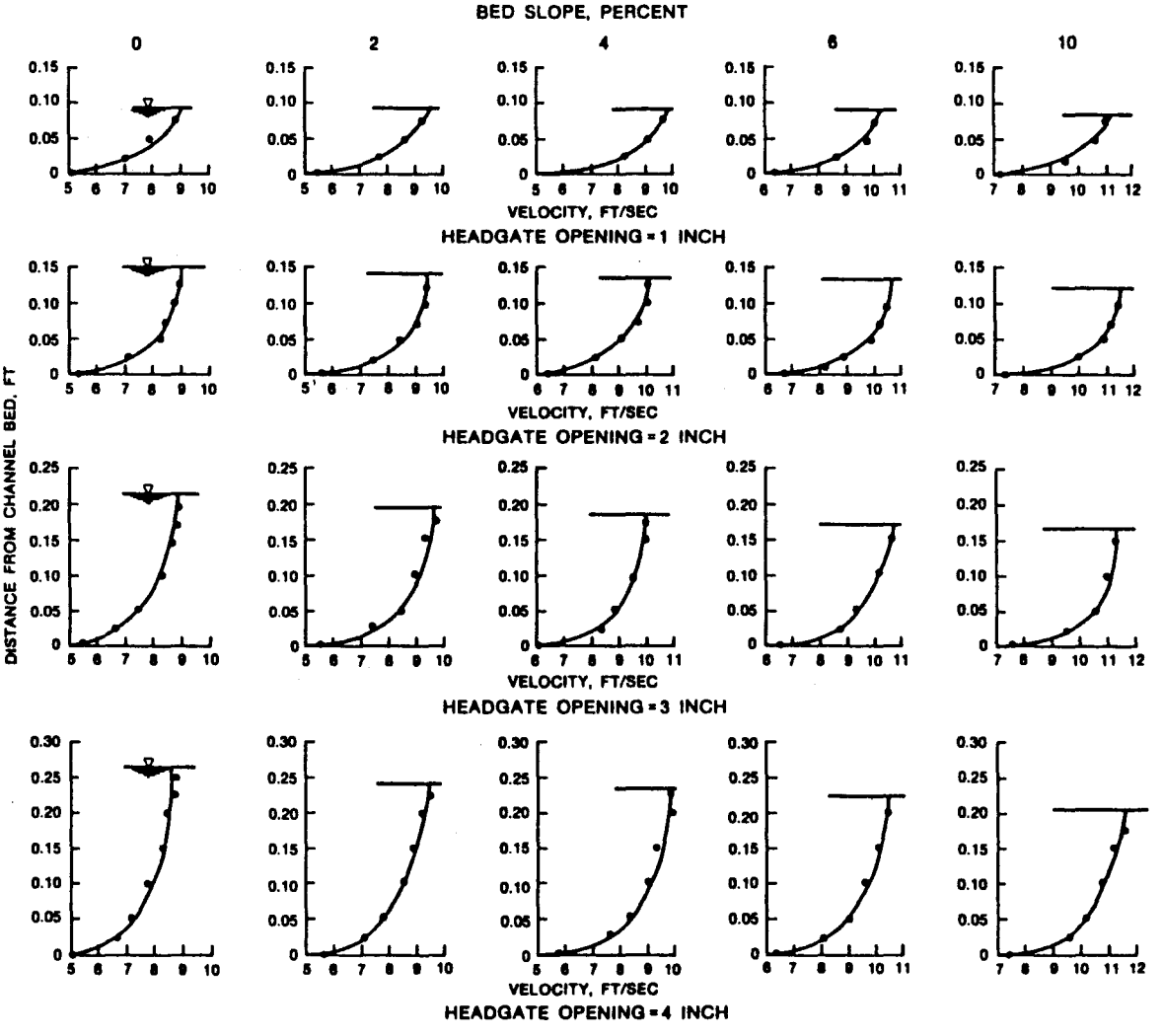



Figure 16. – Velocity profiles and system operating characteristics (sheet 4 of 4).

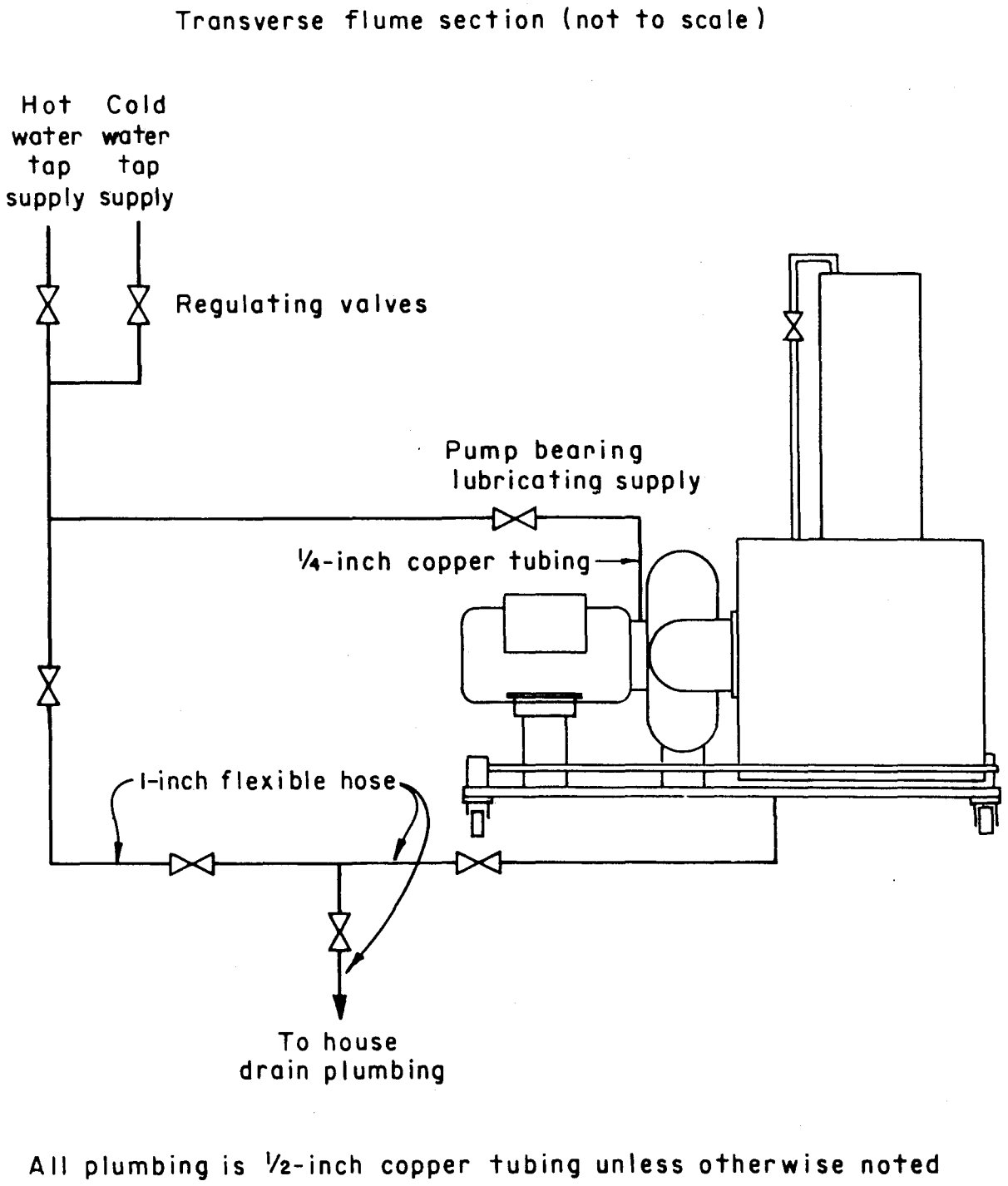



Figure 17. – Plumbing modifications – schematic diagram.

# APPENDIX

# APPENDIX A

## SPECIFICATIONS NO. 2-07-81-S0245

## SPECIFICATIONS

I. *Scope.* – This specification covers the requirements for a self-contained, recirculating, tilting, hydraulic demonstration flume with integral pump, flow channel, and reservoir.

II. *General Equipment Description.* –

A. The basic flume shall consist of a unit of standard manufacture with modifications to suit the specified pump capacity, tilt, access for an experimental plug in the base of the channel and necessary structural reinforcement to prevent excessive deflection and leakage during shipment, installation, and operation. The flume shall be capable of producing uniform flow over the bottom of the working channel section. The flume shall operate by pumping the reservoir fluid through a head tank/head gate assembly, through the working channel and back to the fluid reservoir. Working section materials shall be corrosion resistant. All components shall be sealed to prevent leakage throughout the full range of operation. The entire flume assembly (i.e., channel, reservoir, pump, and motor) shall be supported by a structural framework of welded or bolted steel of sufficient stiffness to prevent distortion or excess vibration during operation.

B. The flume shall contain the following features and equipment:

1. Dimensions. – Maximum overall dimensions shall not exceed 6-ft (2-m) width, 9-ft (3-m) height (at maximum tilt) by 16-ft (5.3-m) length. Interior channel dimensions shall be not less than 10-in (0.25-m) width, 18-in (0.46-m) height by 11-ft (3.3-m) length.

2. Reservoir. – The capacity of the reservoir shall be sufficient to completely fill the channel. The reservoir shall be constructed of a rigid, corrosion-resistant material such as reinforced fiberglass or stainless steel. The reservoir shall be internally or externally structurally reinforced at high contact stress areas such as bearing support surfaces, pivot points or pipe flange connections. A leakproof access port, with gasketed cover, shall be provided in the reservoir so that the experimental plug (see specification paragraph 15) is manually accessible from below the channel bottom. A drain plug shall be provided at the lowest point in the reservoir to facilitate drainage and internal cleaning operations.

3. Channel. – The channel shall be constructed of clear 1/2-in abrasion-resistant Plexiglas or toughened plate glass. The channel walls shall have sufficient stiffening to prevent deflection and leakage at all sealing surfaces with the reservoir and head tank at full operating capacity. Plexiglas shall be sealed with solvent welded joints and plate glass shall be sealed with flexible sealing compound to prevent leakage at full operating capacity.

4. Head tank. – A head tank containing the head gate and motor operator shall be provided and be constructed of either 1/2-in abrasion-resistant Plexiglas or toughened plate glass. The head tank shall be designed to resist an internal water pressure of 15 $lb/in^2$. An overflow valve system with capability to vent the head tank and return water to the reservoir shall also be provided.

5. Turning vanes. – Turning vanes constructed of a corrosion-resistant material shall be provided to direct high velocity waterflow to and from the reservoir.

6. Headgate. – A headgate constructed of a corrosion-resistant material operated by an electric motor shall be provided. The gearing of the motor and screw pitch of the gate operator shall provide for gate translation at a rate not to exceed 0.2 cm/s.

7. Tailgate. – A tailgate constructed of a corrosion-resistant material operated by an electric motor shall be provided.

8. Tilt. – The flume shall be capable of powered tilt from 0 percent to 16 percent from the horizontal. Tilt shall be accomplished by two electrically operated synchronized jack screws. The jack screws shall be spaced on opposite sides of the reservoir and shaft connected to the drive motor with flexible couplings. The jack screws shall have not less than 2-ton capacity and shall be keyed, worm-gear activated with not less than 14 in travel with a gear ratio of approximately 32 rotations/in.

9. Pump and piping system. – An electric motor operated centrifugal pump with a mechanical seal shall be provided. A 15-hp 220/230-V, 3-phase electric motor with magnetic motor starter shall be either close coupled or belt coupled to a pump that shall deliver 0 to 2,200 gal/min at a head of 10 ft. A manually operated flow control valve shall be provided in the supply line from the pump to the reservoir. The supply line shall be a minimum of 8-in nominal diameter. All flanged connections and pipe joints shall be sealed to prevent leakage at full pressure and flow conditions.

10. Limit switches. – Limit switches shall be provided for the headgate, tailgate, and tilting motors.

11. Support frame. – A structural steel frame of either welded or bolted construction shall be provided. The frame shall have 4 ball-bearing caster wheels of approximately 8-in diameter. The frame shall be stiffened with gusset plates and other reinforcement as necessary to prevent excessive deflection or vibration during operation. Stiffening and reinforcement shall be provided adjacent to all areas where the frame contacts external items such as equipment foundations and support plates.

12. Flowmeter. – A flowmeter with either gauge or LED output, with capacity to accurately measure flow rates throughout the operating range of the pump system, shall be provided. The flowmeter shall be located either in the supply line, downstream from the pump, or in the reservoir immediately upstream of the turning vanes used to direct water into the channel. The flowmeter shall be installed such that reliable flow rate measurements can be obtained with minimum interference to incoming flow.

13. Temperature gage. – A temperature gauge shall be installed with the sensor located in the reservoir such that the sensor remains submerged during the entire operating range of the pump system.

14. Pitot tube. – A Pitot tube, adjustable support rack, and manometer board shall be furnished. The adjustable support rack shall be movable along the major axis of the channel and connected to the channel by C-clamp-type fixtures or the equivalent.

15. Experimental plug. – A removable, Plexiglas plug, 1/2-in thick and 10 in in diameter shall be centered in the bottom of the channel one-third the distance upstream from the tailgate. The top surface of the plug shall rest flush with the channel bottom surface. A leakproof seal shall be provided around the plug.

16. Control panel. – A separate enclosed control panel with the following functions shall be provided:

a. Pump motor switch
b. Headgate motor switch
c. Tailgate motor switch

d. Slope control motor switch
e. Flowmeter output
f. Temperature gage output

17. General construction. – The flume shall be constructed with care taken to avoid safety hazards in the design and layout of the overall equipment. Care shall be taken to avoid large appurtenant structures, sharp exposed edges or surfaces, and cut, unfiled metal surfaces and edges.

## APPENDIX B

## PRESTON TUBE DESIGN CALCUATIONS

This appendix contains the Preston tube design calculations and documents the three final tube configurations selected. References [2] through [5] are the technical literature used to determine the configuration and effective operating ranges of the three Preston tubes. This appendix is not intended to provide a detailed discussion of the theoretical considerations of boundary shear stresses or the measurement techniques that have been developed by various researchers.

Using figure 3 of reference [2], an apparent linear relationship between boundary shear stress and difference in dynamic and static pressure is observed for a limited range. The function $\log_{10}(\tau_o d^2/4\rho v^2)$ appears valid between the nondimensional boundary values of 2.6 and 4.3. Therefore,

$$2.6 \leq \log_{10} (\tau_o d^2/4\rho v^2) \geq 4.3 \qquad (1)$$

where:

$\tau_o$ = boundary shear stress, in lbf/ft$^2$
$d$ = preston tube diameter, in ft
$\rho$ = mass density of fluid, in slugs/ft$^3$
$v$ = kinematic viscosity of fluid, in ft$^2$/s

Rewriting equation (1): $10^{2.6} \leq \tau_o d^2/4\rho v^2 \leq 10^{4.3}$

Evaluating exponents: $400 \leq \tau_o d^2/4\rho v^2 \leq 20{,}000$

Substituting constants for water at 70 °F:

$$\rho = 19.4 \text{ slugs/ft}^3$$
$$v = 1.05 \times 10^{-5} \text{ ft}^2/\text{s}$$

Then:

$$4\rho v^2 = 8.56 \times 10^{-10} \text{ slugs (ft)/s}^2$$

Evaluating upper and lower boundary values and selecting tube diameters of 1/4, 1/8, and 1/16 inches yields:

| | |
|---|---|
| $d$ = 1/4 | 0.0008 lbf/ft$^2$ $\leq \tau \leq$ 0.0390 lbf/ft$^2$ |
| $d$ = 1/8 | 0.0032 lbf/ft$^2$ $\leq \tau \leq$ 0.160 lbf/ft$^2$ |
| $d$ = 1/16 | 0.0126 lbf/ft$^2$ $\leq \tau \leq$ 0.630 lbf/ft$^2$ |

These preliminary operating ranges for the selected Preston tubes are considered suitable for measuring the boundary shear stresses of interest, as discussed in reference [6].

Equations (9) and (14) of reference [5] determine the range of equation (1) that must be selected in order to corroborate the terms:

$$\log_{10}(\tau_o d^2/4\rho v^2) \text{ and } \log_{10}(p\text{-}p_o)d^2/4\rho v^2$$

For 1/4-in diameter round Pitot tubes in one fluid, equation (14) of reference [5] yields:

$$\tau_o = 0.0403\ (4\rho v^2/d^2)^{1/8}\ (p\text{-}p_o)^{7/8} \qquad (2)$$

Equation (2) defines the boundary shear stress as a function of the fluid mass density, kinematic viscosity, differential pressure, and tube diameter. Because the mass density and kinematic viscosity of water vary with temperature, the effect on the shear stress is determined:

| Temp °F | ρ slugs/ft$^3$ | v ft$^2$/s | $(\rho v^2)^{1/8}$ |
|---|---|---|---|
| 40 | 1.94 | 1.67 x 10$^{-5}$ | 0.0694 |
| 50 | 1.94 | 1.41 x 10$^{-5}$ | 0.0666 |
| 60 | 1.94 | 1.21 x 10$^{-5}$ | 0.0641 |
| 70 | 1.94 | 1.05 x 10$^{-5}$ | 0.0618 |
| 80 | 1.93 | 0.930 x 10$^{-5}$ | 0.0600 |
| 90 | 1.93 | 0.823 x 10$^{-5}$ | 0.0581 |

Substituting the tabular values above into equation (2) yields:

For $d$ = 1/4 inch,

| Temp, °F | Shear stress, $\tau_o$, lbf/ft$^2$ |
|---|---|
| 40 | 0.0087 $(p\text{-}p_o)^{7/8}$ |
| 50 | 0.0084 $(p\text{-}p_o)^{7/8}$ |
| 60 | 0.0081 $(p\text{-}p_o)^{7/8}$ |
| 70 | 0.0078 $(p\text{-}p_o)^{7/8}$ |
| 80 | 0.0075 $(p\text{-}p_o)^{7/8}$ |
| 90 | 0.0073 $(p\text{-}p_o)^{7/8}$ |

For $d$ = 1/8 inch,

| Temp, °F | Shear stress, $\tau_o$, lbf/ft$^2$ |
|---|---|
| 40 | 0.0104 $(p\text{-}p_o)^{7/8}$ |
| 50 | 0.0100 $(p\text{-}p_o)^{7/8}$ |
| 60 | 0.0096 $(p\text{-}p_o)^{7/8}$ |
| 70 | 0.0092 $(p\text{-}p_o)^{7/8}$ |
| 80 | 0.0090 $(p\text{-}p_o)^{7/8}$ |
| 90 | 0.0087 $(p\text{-}p_o)^{7/8}$ |

For $d$ = 1/16 inch,

| Temp, °F | Shear stress, $\tau_o$, lbf/ft$^2$ |
|---|---|
| 40 | 0.0124 $(p\text{-}p_o)^{7/8}$ |
| 50 | 0.0119 $(p\text{-}p_o)^{7/8}$ |
| 60 | 0.0114 $(p\text{-}p_o)^{7/8}$ |
| 70 | 0.0110 $(p\text{-}p_o)^{7/8}$ |
| 80 | 0.0107 $(p\text{-}p_o)^{7/8}$ |
| 90 | 0.0103 $(p\text{-}p_o)^{7/8}$ |

For convenience, initial hydraulic calibrations were performed using a manometer to determine the differential pressure in feet of water. The differential pressure and feet of water are related by:

$$(p\text{-}p_o) = \gamma(h\text{-}h_o) \tag{3}$$

where:

$\gamma$ = unit weight of water, in lbf/ft$^3$
$h$ = total dynamic water pressure head, in ft
$h_o$ = static water pressure head, in ft

# APPENDIX C

## HP 9111A GRAPHICS TABLET COMPUTER PROGRAM FOR DETERMINING MEAN AND OTHER STATISTICAL PARAMETERS OF $(p\text{-}p_o)$

```
5       ! TRACE
10      DISP "PRINTER ON ?"
15      CALL Known
20      RESTORE
25      CONTROL 2,1;0 !P ALL OFF
30      CONTROL 1,4;0  !FUNCT OFF
35      !PRINTALL IS 701
40      !
45      ! PROGRAM GENERAL PLOT(RAY)- H HOFF - AUG 7, 1984 - VERSION 3
50      !
55      DISP "PROGRAM IS INITIALIZING - WAIT"
60      ON TIMEOUT 7,15 RECOVER Error
65     !ENABLE INTR 5;1
70    !ON ERROR RECOVER  Error
75      GOTO Cont_er
80 Error:    !
85     !PRINTER IS 701
90      IF ERRN=163 THEN PRINT " ARE DEVICES TURNED ON ????,HP-IB CONNECTED ????"
95      PRINT "FAILURE :";ERRN
100     !(INTERFACE NOT PRESENT=163)
105     IF ERRN=168 OR ERRN=72 THEN !I/O TIMEOUT
110       IF ERRN=168 THEN OUTPUT 1;"ERRN 168 I/O TIMEOUT"
115       IF ERRN=72 THEN OUTPUT 1;"ERRN 72  EXTERNAL DISC DOWN"
120       WAIT 15
125       RESTORE
130       GOTO 5
135     END IF
140     STOP
145 Acdown:  !
150     STATUS 5,1;Powerbackon
155     Acpower=BIT(Powerbackon,1)
160     OUTPUT 1;"ACPOWER";Acpower
165     ENABLE INTR 5;2
170     WAIT 1
175     IF Acpower=0 THEN 175
180     OUTPUT 1;"AC POWER RETURN"
185     DISP
190     PRINT "WAIT FOR READY"
195     WAIT 15
200     GOTO 5
205 Cont_er:  !
210     ! SUSPEND INTERACTIVE
215     MASS STORAGE IS ":INTERNAL"
220     !  MASS STORAGE IS ":HP9134,700"
225     P_no=1
230     PRINTER IS P_no                  !1=DISPLAY;;706=LINE PRINTER;701=9876A PRI
NTER
235     !
240     ! 1=CRT,704=LP,705=PLOTTER,RD=INTERNAL,LD=INTERNAL,4,1
245     ! 709=SCANNER,722=3456DMM,724=3437VM,704=9875A(EXT TAPE)
250     ! HP9895,800=9895A FLEXIBLE DISC, 3325S/F=717,9134A=HP9895,800,0 TO 3
255     !
260     Pr=701
265     Idisc4$=":INTERNAL,4,1"
270     OPTION BASE 1
275     COM REAL Cal_m_b(10,10,2)          !SLOPE,Y-INTERCEPT
280     COM Gage(10,2,2,2)
285     COM Nametest$(4)[80]
290     COM Title$(10)[80]                 !short title
295     COM Fp_$(10,49)[10]                    !ITEM STOR OF FRONT PAGE -STRING DAT
A
300     COM Ts2$(10,100)[14]               !SYS,LINE
305     COM Nam9$(4,3)[100]               !(TYPE,L1/L2/D)
310     COM Nam9d$(4,7)[7]
315     COM Idisc4$[20]
```

```
320   COM Pr
325   COM REAL Ts1(1,1)
330   COM REAL Ts2(10,100,7)                !SYS,LINE,ITEM
335   COM INTEGER No_of_reads(10)          !NUMBER OF DATA SAMPLES TAKEN(ON SYS BA
SIS
340   COM INTEGER System_type(10)          !TYPE1=TRI,TYPE2=DI
345   COM INTEGER Touch(10)                !TOUCH POINT
350   COM INTEGER Channal(10,10)
355   COM INTEGER P_no                     !PRINTER NO
360   COM Func$[4]                         !DMM FUNCTION
365   COM INTEGER Chan_no,I66,R_d
370   COM INTEGER Time_flag(10)            !IS DATA TAKING CONTROLLED BY TIME(1 OR
 0)
375   COM INTEGER Delta_flag(10)           !IS DATA TAKING CONTROLLED BY DELTA(1 O
R 0
380   COM INTEGER Control_flag(10)         !SYSTEM IS BEING CONTROLLED(1 OR 0)RELA
YS
385   COM INTEGER Delta_chan__(10)        !channal read to find delta change
390   COM INTEGER Num_per_system(10)       !NUM OF POINTS PER SYSTEM
395   COM INTEGER Print_flag(10)           !NOT USED
400   COM INTEGER Power
405   COM REAL Last_datum_del(10)         !USED TO COMPARE PWITH PRESENT READING
410   COM REAL Last_time(10)               !used to compare previous time for read
415   COM REAL Delta_(10)                   !DIFFERENCE INITIATING A SYSTEM SCAN
420   COM REAL Time_delta(10)              !TIME DIFF INITIATING A SCAN
425   COM REAL Y_volts_(9)                   !TEM STORAGE OF VOLTAGE READINGS
430   COM REAL T_d_(9)                     !TEM STORAGE OF CONVERTED READINGS
435   COM REAL Cal_nl(10,20,2)             !NON-LINEAR CAL FACTORS,1=VOLTS,2=VAL
440   COM REAL Cal_nl_n(10)                !NUMBER OF NL CAL FACTORS PER SENSOR
445   COM /Scan/ Record,System_no,Halt_flag,Flag,F2_flag,I17,M_rec !NON ARRAY SC
AN FLAGS
450   COM /Title/ List_flag,Ed_flag,Vflag,S_code$[1],Title_flag
455   COM /Gage/ Gage_no(20,2)
460   COM /Ctime/ C_time(15),R_chan_no(10,2)
465   COM /Wf/ Water_cf(10)              !water level correction factor
470   COM /Ts2_lines/ Ts2_lines(5)
475   COM /Udc/ Old_chars$[20],Size(20),Chars(20,30,3)
480   DIM Tem$[10]                         !temp storage of time
485   !    INTEGER R_chan_no(10,2)         !2 R/SYS,(1)=F,(2)=R
490   REAL Last_datum_r(10)                !used to find position to sw relays
495   REAL R_last_postion(10)             !1=FORWARD 0=REV
500   REAL R_control_value(10)             !VALUE USED TO CONTROL RELAYS
505   DIM Fp$(49)[10]
510   DIM X_(20),Y_(20)
515        ! DATA PAIRS
520        !Fp_$( , )/Fp$( )
525        !Ts2( , , )/Ts( , )
530        !Ts2$( , )/Ts$( )
535   DIM Month$(12)[3]
540   DATA "STRAIN/TIME"
545   READ Nametest$(1)
550   Ts2_lines(1)=200
555   Ts2_lines(2)=100
560   Ts2_lines(3)=100
565   Ts2_lines(4)=100
570   !
575   ! INITILIZE SECTION
580   !
585   System_no=1                        !SYSTEM NO(1 TO 30)
590   Record=1
595   M_rec=0
600   Title_flag=0                       !IS TITLE DISPLAYED
605   Vflag=0                            !set when voltage heading wanted
610   V_or_eu_flag=1                     !volts=0,eu=1(volts/convert flag)
615   List_flag=0                        !SET LIST CODE
```

```
620   Halt_flag=0                          !set when Ts1 or Ts2 full to  halt reads
625   F2_flag=0                            !set to keep from reseting dmm to AC
630   List_fp_flag=0                       !SET TO LIST FP ONLY(NOT ENTER FP DATA)
635   Ed_flag=0
640 ! CALL E_log_p
645 ! STOP
650   IF Power=1 THEN GOTO Power_on    !1=POWER ON,0=POWER has been off
655   ! ---------------------------------------------------------------------
660   ! Initiatiliztion from DISK
665   DISP "RECOVERING FROM POWER DOWN"
670   GOTO 1005
675   ASSIGN @File10 TO "READS"
680   ASSIGN @File8 TO "CALFAC"
685   ASSIGN @File7 TO "FLAGS"
690   ASSIGN @File6 TO "DELTA"
695   ASSIGN @File5 TO "TITLE"
700   ASSIGN @File4 TO "LAST"
705   ASSIGN @File3 TO "GAGE"
710   ASSIGN @File2 TO "WATCF"
715   !
720   ON END @File10 GOTO 730
725   ENTER @File10;No_of_reads(*)
730   OFF END @File10
735   ASSIGN @File10 TO *
740   !
745   ON END @File8 GOTO 775
750   FOR I=1 TO 30
755     FOR J=1 TO 10
760       ENTER @File8,(I-1)*10+J;Cal_m_b(I,J,1),Cal_m_b(I,J,2)
765     NEXT J
770   NEXT I
775   OFF END @File8
780   ASSIGN @File8 TO *
785   !
790   ON END @File7 GOTO 800
795   ENTER @File7;Delta_flag(*),Time_flag(*),Control_flag(*),R_last_postion(*)
800   OFF END @File7
805   ASSIGN @File7 TO *
810   !
815   ON END @File6 GOTO 825
820   ENTER @File6;Delta_chan__(*),Delta_(*),Time_delta(*),R_chan_no(*),R_contro
l_value(*)
825   OFF END @File6
830   ASSIGN @File6 TO *
835   !
840   ON END @File4 GOTO 850
845   ENTER @File4;Last_datum_del(*),Last_datum_r(*),Last_time(*)
850   OFF END @File4
855   ASSIGN @File4 TO *
860   !
865   ON END @File2 GOTO 875
870   ENTER @File2;Water_cf(*)
875   OFF END @File2
880   ASSIGN @File2 TO *
885   !
890   ON END @File5 GOTO 910
895   FOR I=1 TO 30
900     ENTER @File5,I;Title$(I)
905   NEXT I
910   OFF END @File5
915   ASSIGN @File5 TO *
920   !
925   ON END @File3 GOTO 935
930   ENTER @File3;Gage(*)
935   OFF END @File3
940   ASSIGN @File3 TO *
```

```
945  !
950   ASSIGN @File3 TO "CALNL"
955   ON END @File3 GOTO 995
960   FOR I=1 TO 30
965     ENTER @File3,I;Cal_nl_n(I),X_(*),Y_(*)
970     FOR J=1 TO 20!MAX
975       Cal_nl(I,J,1)=X_(J)
980       Cal_nl(I,J,2)=Y_(J)
985     NEXT J
990   NEXT I
995   OFF END @File3
1000  ASSIGN @File3 TO *
1005!
1010  ASSIGN @File1 TO "FP"
1015  FOR I=1 TO 10
1020    ENTER @File1,I;Fp$(*)
1025    FOR J=1 TO 49
1030      Fp_$(I,J)=Fp$(J)
1035    NEXT J
1040  NEXT I! ----
1045  ASSIGN @File1 TO *
1050 !
1055  GOTO 1115
1060  FOR I=1 TO 30
1065    ASSIGN @File1 TO "SYS"&VAL$(I)
1070    DISP "SYS"&VAL$(I)
1075    ON END @File1 GOTO 1100
1080    FOR J=1 TO No_of_reads(I)
1085      ENTER @File1,J;Ts2(I,J,1),Ts2(I,J,2),Ts2(I,J,3),Ts2(I,J,4),Ts2(I,J,5),
Ts2(I,J,6),Ts2(I,J,7),Ts2$(I,J)
1090    NEXT J
1095    ASSIGN @File TO *
1100  NEXT I
1105  OFF END @File1
1110 !
1115  DISP "PROGRAM IS INITIALIZING - WAIT"
1120 Power_on:!
1125  Power=1
1130  E4$=CHR$(132)!UL
1135  E2$=CHR$(129)!B
1140  E9$=CHR$(131)!B,IV
1145  E8$=CHR$(130)!B
1150  E3$=CHR$(128)!CLEAR
1155 !     1,2,3,4,5,6,7,8,9,0,1,2,3,4,5,6,7,8,9,0,1,2,3,4,5,6,7,8,9,0
1160  DATA 1,1,1,1,1,1,1,1,1,1
1165  READ System_type(*)
1170  DATA 2,2,2,2,2,2,2,2,2,2
1175  READ Num_per_system(*)
1180  DATA 1,1,1,1,1,1,1,1,1,1
1185  READ Delta_chan__(*)
1190 !HEADINGS-8 CHAR
1195  Nam9$(1,1)="| TIME    | P-Po    |SYS/LINE| DATE  TIME    |"
1200  Nam9$(1,2)="| secs    | ins     |        |               |"
1205  Nam9$(1,3)="""|"",3D.4D,""|"",2D.5D,""|"",2D,6D,""|"",14A,""|"""
1210 !
1215  Nam9$(2,1)="|  TIME   | PRESS   |SYS/LINE| DATE  TIME    |"
1220  Nam9$(2,2)="|  days   | lb/in2  |        |               |"
1225  Nam9$(2,3)="""|"",5D.2D,""|"",5D.2D,""|"",2D,6D,""|"",14A,""|"""
1230 !
1235 !
1240  DATA  3D.4D,2D.5D
1245  READ Nam9d$(1,1),Nam9d$(1,2)
1250  DATA  6D.D,6D.D
1255  READ Nam9d$(2,1),Nam9d$(2,2)
1260 !
```

```
1265  DISP "PROGRAM READY"
1270  OUTPUT CRT;DATE$(TIMEDATE),TIME$(TIMEDATE)
1275  ON KEY 0 LABEL "SYS NO         ",2 GOSUB System_no
1280  ON KEY 1 LABEL "INITIALIZE     ",2 GOSUB Initialization
1285  ON KEY 2 LABEL "PLOT           ",2 CALL Plot
1290  ON KEY 3 LABEL "XFILE          ",2 CALL Copy
1295  ON KEY 4 LABEL "FRONT PAGE     ",2 GOSUB Front_page
1300  ON KEY 5 LABEL "DIGITIZER      ",2 CALL Digitizer
1305  ON KEY 6 LABEL "STATUS         ",2 CALL Status
1310  ON KEY 7 LABEL "LIST           ",2 GOSUB List
1315  ON KEY 8 LABEL "EDIT           ",2 CALL Edit
1320  ON KEY 9 LABEL "OTHER KEYS     ",2 GOTO 1330
1325  GOTO 1380
1330  ON KEY 5 LABEL "               ",2 GOTO 1330
1335  ON KEY 6 LABEL "               ",2 GOTO 1330
1340  ON KEY 7 LABEL "               ",2 GOTO 1330
1345  ON KEY 8 LABEL "               ",2 GOTO 1330
1350  ON KEY 1 LABEL "               ",2 GOTO 1330
1355  ON KEY 2 LABEL "               ",2 GOTO 1330
1360  ON KEY 3 LABEL "               ",2 GOTO 1330
1365  ON KEY 4 LABEL "TIMESET        ",2 CALL Time_set
1370  ON KEY 9 LABEL "OTHER KEYS",2 GOTO 1275
1375  ! ************************************************************************
1380 Loop:GOTO Loop
1385  ! ************************************************************************
1390 System_no: !
1395  INPUT "SYSTEM NO.",Syst_no
1400  IF (INT(Syst_no)<1) OR (INT(Syst_no)>30) THEN GOTO Cancel
1405  System_no=Syst_no
1410  Title_flag=0
1415  OUTPUT 2 USING "#,B";255,75
1420  RETURN
1425 Cancel: !
1430  BEEP
1435  DISP "SELECTION CANCELLED"
1440  RETURN
1445  ! ************************************************************************
1450 List:! LISTS DATA
1455  INPUT "SYSTEM NO. FOR LISTING OF DATA",I1
1460  IF (INT(I1)<1) OR (INT(I1)>30) THEN GOTO Cancel
1465  System_no=I1
1470  List_flag=1
1475  INPUT "START AT LINE NO.(LIST ALL = 1)",Start
1480  INPUT "MEDIA(D,P)",S_code$
1485  SELECT S_code$
1490  CASE "D"
1495    PRINTER IS 1
1500    OUTPUT 2 USING "#,B";255,75
1505  CASE "P"
1510    PRINTER IS Pr
1515    INPUT "TITLE OR FRONT PAGE(T OR F)",Q3$
1520    IF UPC$(Q3$)="T" THEN
1525      PRINT Title$(I1)
1530    ELSE
1535      List_fp_flag=1
1540      CALL Front_page(I1,List_fp_flag)
1545      List_fp_flag=0
1550    END IF
1555  END SELECT
1560  Record=I1
1565  CALL Title
1570 !
1575  ALLOCATE T(Num_per_system(I1))
1580  FOR J=Start TO No_of_reads(I1)
1585    FOR I=1 TO Num_per_system(I1)
1590      T(I)=Ts2(I1,J,I)
```

```
1595     NEXT I
1600     PRINT USING Nam9$(System_type(I1),3);T(*),I1,J,Ts2$(I1,J)
1605   NEXT J
1610   DEALLOCATE T(*)
1615 !
1620   Title_flag=0
1625   PRINTER IS P_no
1630   RETURN
1635 ! ************************************************************************
1640 Initialization:! Zero reads,touch,title
1645   INPUT "SYSTEM NO. FOR INITIALIZATION",I4
1650   IF (INT(I4)<1) OR (INT(I4)>30) THEN GOTO Cancel
1655   INPUT "INITILIZE DISK TO ZERO(YES OR NO)",Q5$
1660   IF UPC$(Q5$)<>"YES" THEN RETURN
1665   No_of_reads(I4)=0
1670 !ASSIGN @File10 TO "READS"
1675 !OUTPUT @File10;No_of_reads(*)
1680 !ASSIGN @File10 TO *
1685!Touch(I4)=9999
1690!ASSIGN @File9 TO "TOUCH"
1695!OUTPUT @File9;Touch(*)
1700!ASSIGN @File9 TO *
1705   LINPUT "ENTER TITLE(60 CHAR MAX)",Title$(I4)
1710 !ASSIGN @File3 TO "TITLE"
1715 !OUTPUT @File3,I4;Title$(I4)
1720 !ASSIGN @File3 TO *
1725   DISP "SYSTEM ";I4;" INITIALIALIZED"
1730   RETURN
1735 ! ************************************************************************
1740 Front_page:!
1745   I7=System_no
1750   List_fp_flag=0
1755   CALL Front_page(I7,List_fp_flag)
1760   RETURN
1765   END
1770 ! ************************************************************************
1775   SUB Front_page(I7,List_fp_flag)
1780     OPTION BASE 1
1785 !
1790 ! PAGE OF MANUALLY ENTERED DATA
1795 !
1800     COM REAL Cal_m_b(*),Gage(*),Nametest$(*)
1805     COM Title$(*),Fp_$(*),Ts2$(*),Nam9$(*),Nam9d$(*),Idisc4$,Pr
1810     COM Ts1(*),Ts2(*)
1815     COM INTEGER No_of_reads(*),System_type(*),Touch(*)
1820     COM INTEGER Channal(*),P_no,Func$[4]
1825     COM INTEGER Chan_no,I66,R_d,Time_flag(*),Delta_flag(*),Control_flag(*),D
elta_chan__(*),Num_per_system(*),Print_flag(*),Power
1830     COM REAL Last_datum_del(*),Last_time(*),Delta(*),Time_delta(*),Y_volts_(
*),T_d(*),Cal_n1(*),Cal_n1_n(*)
1835     DIM Fp$(49)[10],Line$(4,7)[80],N$[40]
1840 !
1845     CALL Known
1850     IF List_fp_flag=0 THEN
1855       INPUT "SYSTEM NO. FOR FRONT PAGE",I7
1860       IF (INT(I7)<1) OR (INT(I7)>30) THEN GOTO Cancel
1865       INPUT "XFILE(Y OR N)",Q$
1870     ELSE
1875       Q$="N"
1880     END IF
1885 !
1890     SELECT Q$
1895     CASE "Y"
1900       Xedit$="X"
1905       INPUT "ENTER XFILE NAME",Fx$
```

```
1910      ASSIGN @I4 TO "Y"&Fx$[2,10]&Idisc4$
1915      ENTER @I4;Fp$(*),Xtouch,Xread
1920      ASSIGN @I4 TO *
1925    CASE "N"
1930      Xedit$="S"
1935      FOR J=1 TO 49
1940        Fp$(J)=Fp_$(I7,J)
1945      NEXT J
1950    END SELECT
1955   !FOR I=1 TO 8
1960   !PRINT USING "#,Z";0,1,2,3,4,5,6,7,8,9    !USED FOR FORMAT SETUP
1965   !NEXT I
1970    IF List_fp_flag=0 THEN
1975      OUTPUT 2 USING "#,B";255,75
1980      N$="     SYSTEM "&VAL$(I7)
1985      IF Xedit$="X" THEN N$="     XFILE(Y): "&Fx$
1990      PRINT "  MAMUAL ENTRY FORM - "&Nametest$(System_type(I7))&N$
1995    ELSE
2000      PRINTER IS Pr
2005      OUTPUT Pr USING "#,@"
2010    END IF
2015    PRINT USING "#,K";CHR$(132)               !UL
2020    PRINT USING "78X"
2025 ! ------------------------------------------------------------------------
2030 ! TYPE 1 DATA (4 LINES)
2035 ! ------------------------------------------------------------------------
2040    PRINT USING "#,K";CHR$(128)               !CL
2045    DATA  "|TITLE     |CONT      |CONT      |SUB TITLE |CONT      |CONT
 |CONT      |"
2050    DATA  "|DATE PLACE|LOAD NO.  |          |          |          |
|          |"
2055    DATA  "|SAMPLE NUM|SPEC NO.  |DRILL HOLE|DEPTH     |CLASS SYM |SPEC GRAV
 |SPEC TYPE |"
2060    DATA  "|          |          |          |          |          |
|          |"
2065 !
2070 ! ------------------------------------------------------------------------
2075 ! TYPE 2 DATA (3 LINES)
2080    DATA  "|TITLE     |CONT      |CONT      |SUB TITLE |CONT      |CONT
 |CONT      |"
2085    DATA  "|DATE PLACE|LOAD NO.  |          |          |          |
|          |"
2090    DATA  "|SAMPLE NUM|SPEC NO.  |DRILL HOLE|DEPTH     |CLASS SYM |SPEC GRAV
 |SPEC TYPE |"
2095    DATA  "|          |          |          |          |          |
|          |"
2100 ! ------------------------------------------------------------------------
2105 !
2110    SELECT System_type(I7)
2115    CASE 1
2120      No_lines=4
2125    CASE 2
2130      No_lines=4
2135    END SELECT
2140    READ Line$(1,1),Line$(1,2),Line$(1,3),Line$(1,4)
2145    READ Line$(2,1),Line$(2,2),Line$(2,3),Line$(2,4)
2150 !
2155    K=0
2160    FOR Line=1 TO No_lines
2165      PRINT Line$(System_type(I7),Line)
2170      PRINT USING "#,K";CHR$(132)!UL
2175      IMAGE "|",7(10A,"|")
2180      PRINT USING 2175;Fp$(1+K),Fp$(2+K),Fp$(3+K),Fp$(4+K),Fp$(5+K),Fp$(6+K)
,Fp$(7+K)
2185      PRINT USING "#,K";CHR$(128)!CL
```

```
2190      K=K+7
2195    NEXT Line
2200    PRINT USING "#,K";CHR$(128)!CL
2205    IF List_fp_flag=1 THEN
2210      PRINTER IS 1
2215      SUBEXIT
2220    END IF
2225 !
2230    CALL Cursor(Fp$(*),No_lines)
2235 ! ------------------------------------------------------------------------
2240 ! STORE DATA
2245    SELECT Xedit$
2250    CASE "X"
2255      ASSIGN @I4 TO "Y"&Fx$[2,10]&Idisc4$
2260      OUTPUT @I4;Fp$(*),Xtouch,Xread
2265      ASSIGN @I4 TO *
2270      DISP "FRONT PAGE DATA STORED - XFILE(Y): ";Fx$
2275    CASE "S"
2280      FOR J=1 TO 49
2285        Fp_$(I7,J)=Fp$(J)
2290      NEXT J
2295      ASSIGN @File3 TO "FP"
2300      OUTPUT @File3,I7;Fp$(*)
2305      ASSIGN @File3 TO *
2310      DISP "FRONT PAGE DATA STORED - SYSTEM NO.";I7
2315    END SELECT
2320    CALL Known
2325    SUBEXIT
2330 Cancel:BEEP
2335    DISP "SELECTION CANCELLED"
2340  SUBEND
2345 ! ************************************************************************
2350  SUB File_check(F$,Check$,No,L$)!No=0,PRESNT WANTED;No=1,ABSENT WANTED
2355    Check$="OK"
2360    SUBEXIT
2365  ! CHECKS FOR  VALID FILE INPUT
2370    OPTION BASE 1
2375    DIM Cat$(10)[41]
2380    Check$="NO"
2385    L=LEN(F$)
2390    IF F$[1,1]<>L$ THEN Error1
2395    IF L>6 THEN Error2
2400    S$=""
2405    FOR I=1 TO 6-L
2410      S$=S$&" "
2415    NEXT I
2420    F$=F$&S$
2425 Loop: !
2430 !*** WARNING ***  'CAT TO' STATEMENT NOT TRANSLATED.
2435 !CAT TO Cat$(*),B,B;L$
2440  ! CHECK FOR PRESENT
2445    IF No=1 THEN Dup
2450    FOR I=1 TO 10
2455      IF Cat$(I)="" THEN GOTO Error3
2460      IF F$=Cat$(I)[1,6] THEN GOTO Ok
2465    NEXT I
2470    GOTO Test
2475 Dup: ! CHECK FOR ABSENT
2480    FOR I=1 TO 10
2485      IF Cat$(I)="" THEN GOTO Ok
2490      IF F$=Cat$(I)[1,6] THEN GOTO Error4
2495    NEXT I
2500 Test:IF B<>0 THEN GOTO Loop
2505 Ok: !
2510    Check$="OK"
2515    SUBEXIT
```

```
2520 Error1:DISP "ERROR - FILE ";F$;":FILE NAME MUST START WITH ";L$
2525    SUBEXIT
2530 Error2:DISP "ERROR - FILE ";F$;":MAX OF 6 CHAR`S"
2535    SUBEXIT
2540 Error3:DISP "ERROR - FILE ";F$;":NOT FOUND"
2545    SUBEXIT
2550 Error4:DISP "ERROR - FILE ";F$;":ALREADY PRESENT"
2555    SUBEXIT
2560  SUBEND
2565  ! ********************************************************************
2570  SUB Auscl(Min,Max,Offset,Tick)     ! CALCULATES PLOT END POINTS
2575    INTEGER Power,N,Dir
2580    Range=ABS(Max-Min)
2585    Power=INT(LGT(Range))
2590    Norm=Range/10^Power
2595    N=10*(Norm>=5)+5*((Norm<5) AND (Norm>=2))+2*((Norm<2) AND (Norm>1))+(Nor
m<=1)
2600    Inter=DROUND(N*10^(Power-1),1)
2605    Dir=SGN(Min-Max)
2610    X=(Min-Offset)/10^Power
2615    GOSUB Rout
2620    Minm=Rout*10^Power+Offset
2625    Dir=SGN(Max-Min)
2630    X=(Max-Offset)/10^Power
2635    GOSUB Rout
2640    Maxm=Rout*10^Power+Offset
2645    Tick=PROUND(ABS(Maxm-Minm)/Inter+1,0)
2650    GOTO Exit
2655 Rout:Test=FRACT(ABS(X))    ! ROUND OUT X TO MULTIPLE OF N IN DIRECTION Dir.
2660    Digit=INT(10*Test)
2665 !*** CAUTION ***  DEFINITION OF 'MOD' WITH NEGATIVE ARGUMENT HAS CHANGED.
2670    Delta=Digit*(N=10)+Digit MOD N*(N<>10)
2675    Round=((SGN(X)*Dir>0)*N-SGN(X)*Dir*Delta)/10*((Test-Digit/10 OR Delta)<>
0)
2680    IF ABS(SGN(X)*Digit/10+Dir*Round)>1 THEN Round=1-Digit/10
2685    Rout=SGN(X)*(INT(ABS(X))+Digit/10)+Dir*Round
2690    RETURN
2695 Exit: !
2700    Tick=Tick-1
2705    Min=Minm
2710    Max=Maxm
2715  SUBEND
2720  ! ********************************************************************
2725  DEF FNSpa$(INTEGER X) ! SPA function of PRINT
2730    INTEGER I
2735    ALLOCATE R$[X+(NOT X)]
2740    R$=""
2745    FOR I=1 TO X
2750      R$=R$&CHR$(32)
2755    NEXT I
2760    RETURN R$
2765  FNEND
2770  !********************************************************************
2775  SUB Title
2780  !
2785    OPTION BASE 1
2790    COM REAL Cal_m_b(*),Gage(*),Nametest$(*)
2795    COM Title$(*),Fp_$(*),Ts2$(*),Nam9$(*),Nam9d$(*),Idisc4$,Pr
2800    COM Ts1(*),Ts2(*)
2805    COM INTEGER No_of_reads(*),System_type(*),Touch(*)
2810    COM INTEGER Channal(*),P_no,Func$[4]
2815    COM INTEGER Chan_no,I66,R_d,Time_flag(*),Delta_flag(*),Control_flag(*),D
elta_chan__(*),Num_per_system(*),Print_flag(*),Power
2820    COM REAL Last_datum_del(*),Last_time(*),Delta_(*),Time_delta(*),Y_volts_
(*),T_d_(*),Cal_n1(*),Cal_n1_n(*)
```

```
2825    COM /Scan/ Record,System_no,Halt_flag,Flag,F2_flag,I17,M_rec
2830    COM /Title/ List_flag,Ed_flag,Vflag,S_code$,Title_flag
2835  !
2840    E3$=CHR$(128)
2845    E4$=CHR$(132)!UL
2850    PRINTER IS 1
2855    IF (List_flag=1) AND (S_code$="P") THEN PRINTER IS Pr
2860    IF (List_flag=1) OR Ed_flag=1 THEN GOTO Skip5
2865    PRINT USING "#,@"
2870 Skip5:  !
2875    List_flag=0
2880    IF Vflag=1 THEN PRINT "                                        VOLTAGE READINGS"
2885    Vflag=0
2890  !
2895    PRINT USING "#,K";E4$                  !UL
2900    Im$=VAL$(1+(Num_per_system(Record)+1)*9+15)&"X"
2905    PRINT USING Im$
2910    PRINT USING "#,K";E3$                      !CL UL
2915    PRINT Nam9$(System_type(Record),1)
2920    PRINT USING "#,K";E4$                  !UL
2925    PRINT Nam9$(System_type(Record),2)
2930    PRINT USING "#,K";E3$                  !CL
2935    Title_flag=1
2940  SUBEND
2945  !END
2950  !************************************************************
2955  SUB Fplabels(Fp$(*))
2960  !
2965    IF VAL(Fp$(7))=1 THEN Type$="UNDISTURBED"
2970    IF VAL(Fp$(7))=2 THEN Type$="REMOLDED"
2975    LORG 1
2980    CSIZE 2.2
2985    MOVE 15,4
2990    LABEL "SAMPLE NO. ";Fp$(1);" SPEC No. ";Fp$(2);" SPEC SIZE ";TRIM$(Fp$(1
2))&"X"&TRIM$(Fp$(11));"    ";Type$
2995    MOVE 15,1
3000    LABEL "CLASS SYMBOL :";Fp$(5);" HOLE No. :";Fp$(3);" DEPTH :";Fp$(4);"
ft."
3005  SUBEND
3010  !************************************************************
3015  SUB Least_squares(X_(*),Y_(*),J1,M,B)
3020  ! Best_fit:!
3025    IF J1>1 THEN
3030      Sum_x=0
3035      Sum_y=0
3040      Sum_xx=0
3045      Sum_xy=0
3050      FOR Ia=1 TO J1
3055        Sum_x=Sum_x+X_(Ia)
3060        Sum_y=Sum_y+Y_(Ia)
3065        Sum_xx=Sum_xx+X_(Ia)*X_(Ia)
3070        Sum_xy=Sum_xy+X_(Ia)*Y_(Ia)
3075      NEXT Ia
3080      X_ave=Sum_x/J1
3085      Y_ave=Sum_y/J1
3090      M=(Sum_xy-J1*X_ave*Y_ave)/(Sum_xx-J1*X_ave*X_ave)!SLOPE
3095      B=Y_ave-M*X_ave                              !Y INTERCEPT
3100    ELSE
3105      PRINT "ERROR LEAST SQ INVALID"
3110    END IF
3115  SUBEND
3120  !************************************************************
3125  SUB Init_plot(Fp$(*),Q$(*),No_lines,M$)
3130    OPTION BASE 1
3135  !
```

```
3140 ! MANUALLY ENTERED DATA FOR PLOT SETUP
3145 !Q$=Question$
3150 !Fp$=I_plot$
3155    DIM Line$(7)[80]
3160    OUTPUT 2 USING "#,B";255,75
3165    PRINTER IS 1
3170    PRINT M$
3175    PRINT USING "#,K";CHR$(132)                !UL
3180    PRINT USING "78X"
3185 ! ---------------
3190    PRINT USING "#,K";CHR$(128)                !CL
3195 !
3200    FOR I=1 TO No_lines
3205      Line$(I)=""
3210      FOR J=1 TO 7
3215        Space$=RPT$(" ",10-LEN(Q$(I,J)))
3220        Line$(I)=Line$(I)&"|"&Q$(I,J)&Space$
3225      NEXT J
3230      Line$(I)=Line$(I)&"|"
3235    NEXT I
3240 !
3245    K=0
3250    FOR Line=1 TO No_lines
3255      PRINT Line$(Line)
3260      PRINT USING "#,K";CHR$(132)!UL
3265      IMAGE "|",7(10A,"|")
3270      PRINT USING 3265;Fp$(1+K),Fp$(2+K),Fp$(3+K),Fp$(4+K),Fp$(5+K),Fp$(6+K)
,Fp$(7+K)
3275      PRINT USING "#,K";CHR$(132)!CLEAR
3280      K=K+7
3285    NEXT Line
3290    PRINT USING "#,K";CHR$(128)
3295 !
3300    CALL Cursor(Fp$(*),No_lines)
3305    SUBEXIT
3310 Cancel:BEEP
3315    DISP "SELECTION CANCELLED"
3320  SUBEND
3325 ! ************************************************************************
3330  SUB Label(X,Y,Lorg,Csize,Dir,L$)
3335    DEG
3340    CSIZE Csize
3345    LORG Lorg
3350    LDIR Dir
3355    MOVE X,Y
3360    LABEL L$
3365  SUBEND
3370  !*****************************************************************
3375  SUB Time_set
3380!
3385    OUTPUT 2 USING "#,B";255,75
3390    DIM Day$(0:6)[9]
3395    DATA Monday,Tuesday,Wednesday,Thursday,Friday,Saturday,Sunday
3400    READ Day$(*)
3405!
3410    Dmy$=DATE$(TIMEDATE)
3415    Hms$=TIME$(TIMEDATE)
3420    PRINT "DATE: ";Dmy$
3425    PRINT "TIME: ";Hms$
3430    INPUT "SET TIME AND DATE(Y OR N)",Q$
3435    IF Q$<>"Y" THEN SUBEXIT
3440    INPUT "ENTER DATE(DD JAN YYYY)",Dmy$         ! WAIT for INPUT
3445    INPUT "ENTER TIME(HH:MM:SS)",Hms$
3450 !
3455    SET TIMEDATE DATE(Dmy$)+TIME(Hms$)
```

```
3460!
3465    W=(TIMEDATE DIV 86400) MOD 7! Day of week
3470    PRINT TABXY(1,1);"The clock has been set to:"
3475    PRINT TABXY(1,3);Day$(W);" ";Dmy$;"  ";TIME$(TIMEDATE)
3480 !
3485  SUBEND
3490  !*************************************************************
3495  SUB Start_plot(R2$)
3500    GINIT
3505    SELECT R2$
3510    CASE "P"
3515      INPUT "READY TO PLOT(Y OR N)",Q$
3520      PLOTTER IS 705,"HPGL"
3525      PEN 1
3530    CASE "C"
3535      GRAPHICS ON
3540      PLOTTER IS 3,"INTERNAL"
3545      ALPHA ON
3550      DISP "PRESS CONT TO CLEAR CRT WHEN DONE"
3555      WAIT 1
3560      ALPHA OFF
3565    CASE "D"
3570      ALPHA OFF
3575      GRAPHICS ON
3580      PLOTTER IS 3,"INTERNAL"
3585    CASE ELSE
3590      PRINT "ERROR R2$",R2$
3595    END SELECT
3600  SUBEND
3605  !*********************************************************************
3610  SUB End_plot(R2$,Page1)
3615    SELECT R2$
3620    CASE "C"
3625      ON KBD,8 GOTO Exit
3630 Spin:GOTO Spin
3635    CASE "D"
3640      PRINTER IS 701
3645      IF Page1=1 THEN PRINT USING "#,@"
3650      DUMP GRAPHICS
3655    CASE "P"
3660      PEN 0
3665    CASE ELSE
3670      GOTO Exit
3675    END SELECT
3680 Exit: !
3685    OFF KBD
3690    OUTPUT 2 USING "#,B";255,75
3695    PRINTER IS 1
3700    GRAPHICS OFF
3705    ALPHA ON
3710  SUBEND
3715  !*********************************************************************
3720  SUB X_axis(Xmin,Xmax,Ymin,Ymax,Xtica,Top)!TOP=0 TOP MAX OR NORMAL
3725  !TOP=1 WINDOW Xmin,Xmax,Ymax,Ymin
3730    D_x=ABS(Xmax-Xmin)
3735    D_y=ABS(Ymax-Ymin)
3740    DEG
3745    LDIR 0
3750    LORG 6
3755    CSIZE 2.3
3760    CLIP ON
3765    FOR X=Xmin TO Xmax+ABS(D_x/Xtica)/2 STEP ABS(D_x/Xtica)
3770      MOVE X,Ymin
3775      DRAW X,Ymax
3780    NEXT X
```

```
3785    CLIP OFF
3790  !
3795    FOR X=Xmin TO Xmax+ABS(D_x/Xtica)/2 STEP ABS(D_x/Xtica)
3800      IF Top=0 THEN MOVE X,Ymin-.02*D_y
3805      IF Top=1 THEN MOVE X,Ymax+.02*D_y
3810      IF X<.000001 AND X>-.000001 THEN X=0
3815      LABEL X
3820    NEXT X
3825  SUBEND
3830  !************************************************************
3835  SUB Y_axis(Xmin,Xmax,Ymin,Ymax,Ytica)
3840    DEG
3845    D_y=ABS(Ymax-Ymin)
3850    CSIZE 2.3
3855    LORG 8
3860    LDIR 0
3865    CLIP ON
3870    FOR Y=Ymin TO Ymax STEP ABS(D_y/Ytica)
3875      MOVE Xmin,Y
3880      DRAW Xmax,Y
3885    NEXT Y
3890  !
3895    CLIP OFF
3900    FOR Y=Ymin TO Ymax+ABS(D_y/Ytica)/2 STEP ABS(D_y/Ytica)
3905      MOVE Xmin,Y
3910      IF Y<.000001 AND Y>-.000001 THEN Y=0
3915      LABEL Y
3920    NEXT Y
3925  SUBEND
3930  !************************************************************
3935  SUB Log_axis(Xmin2,Xmax2,Ymin2,Ymax2,Dir_y$)
3940  !X INPUT VALUES MUST BE LGT
3945  !
3950  !!! IF INT(Xmax)<>Xmax THEN Xmax=INT(Xmax)+1
3955  !!! Xmin=INT(Xmin)
3960  !!IF (D_x<1) AND (INT(Xmin)=INT(Xmax)) THEN Xmin=INT(Xmin)
3965  !
3970    Xmin=Xmin2
3975    Xmax=Xmax2
3980    Ymin=Ymin2
3985    Ymax=Ymax2
3990    D_x=ABS(Xmax-Xmin)
3995    D_y=ABS(Ymax-Ymin)
4000    Off1=-.01
4005    Off4=-.04
4010    IF Dir_y$="HIGH" THEN !REV SCALE
4015      Off1=.01
4020      Off4=.04
4025      Dum=Ymax
4030      Ymax=Ymin
4035      Ymin=Dum
4040    END IF
4045  ! Log_x: ! -----------
4050    DEG
4055    CLIP ON
4060    LORG 9
4065    FOR D=INT(Xmin) TO Xmax
4070      FOR I=1 TO 9
4075        IF (D=INT(Xmin)) AND (I=1) THEN 4090
4080        MOVE D+LGT(I),Ymin
4085        DRAW D+LGT(I),Ymax
4090      NEXT I
4095      LINE TYPE 1
4100      MOVE D,Ymin
4105      DRAW D,Ymax
```

```
4110    NEXT D
4115 ! Log_labels: ! ----------
4120    CLIP OFF
4125    FOR D=INT(Xmin) TO Xmax
4130      CSIZE 2
4135      LDIR 0
4140      LORG 6
4145      IF D_x>2 THEN 4175
4150      FOR I=2 TO 9
4155        MOVE D+LGT(I),Ymin+Off1*D_y
4160        IF (D+LGT(I)>Xmax) OR (D+LGT(I)<Xmin) THEN 4170
4165        LABEL USING "D";I
4170      NEXT I
4175      LDIR 0
4180      LORG 8
4185      CSIZE 2.3
4190      Dec=D
4195      IF (D<Xmin) THEN 4235
4200      MOVE Dec-.01*D_x,Ymin+Off4*D_y
4205      LABEL "10"
4210      MOVE Dec,Ymin+Off1*D_y
4215      CSIZE 2
4220      LORG 6
4225      LABEL Dec
4230      CSIZE 2.8
4235    NEXT D
4240  SUBEND
4245  !*************************************************************
4250  SUB Enter_data(Q11$,I33,Fp$(*),Ts(*),Ts$(*),Col,Xtouch,Xread,Time1$,Fx$)
4255  !TIME1$="T" READ TIME
4260    OPTION BASE 1
4265    COM REAL Cal_m_b(*),Gage(*),Nametest$(*)
4270    COM Title$(*),Fp_$(*),Ts2$(*),Nam9$(*),Nam9d$(*),Idisc4$,Pr
4275    COM Ts1(*),Ts2(*)
4280    COM INTEGER No_of_reads(*),System_type(*),Touch(*)
4285    COM INTEGER Channal(*),P_no,Func$[4]
4290    COM INTEGER Chan_no,I66,R_d,Time_flag(*),Delta_flag(*),Control_flag(*),D
elta_chan__(*),Num_per_system(*),Print_flag(*),Power
4295    COM REAL Last_datum_del(*),Last_time(*),Delta_(*),Time_delta(*),Y_volts_
(*),T_d_(*),Cal_n1(*),Cal_n1_n(*)
4300  !
4305    SELECT Q11$
4310    CASE "Y" !XFILE
4315      DISP "DISK ACCESS FOR PLOT-WAIT"
4320      ASSIGN @I4 TO "Y"&Fx$[2,10]&Idisc4$
4325      ENTER @I4;Fp$(*),Xtouch,Xread
4330      ASSIGN @I4 TO *
4335      PRINT USING "#,@"
4340      ASSIGN @I4 TO Fx$&Idisc4$
4345      SELECT Time1$
4350      CASE "N"
4355        ENTER @I4;Ts(*)
4360      CASE "T"
4365        ENTER @I4;Ts(*),Ts$(*)
4370      END SELECT
4375      ASSIGN @I4 TO *
4380      DISP
4385  !
4390    CASE "N" !SYS FILE
4395      Xread=No_of_reads(I33)
4400      N=Num_per_system(I33)
4405      IF Col>0 THEN N=Col
4410      FOR I=1 TO Xread
4415        FOR J=1 TO N
4420          Ts(I,J)=Ts2(I33,I,J)
```

```
4425        NEXT J
4430        Ts$(I)=Ts2$(I33,I)
4435      NEXT I
4440      FOR J=1 TO 49
4445        Fp$(J)=Fp_$(I33,J)
4450      NEXT J
4455    CASE ELSE
4460      DISP "DATA ENTRY FAILTURE"
4465    END SELECT
4470  SUBEND
4475  !*********************************************************************
4480  SUB Copy
4485  ! XFILES
4490    OPTION BASE 1
4495    COM REAL Cal_m_b(*),Gage(*),Nametest$(*)
4500    COM Title$(*),Fp_$(*),Ts2$(*),Nam9$(*),Nam9d$(*),Idisc4$,Pr
4505    COM Ts1(*),Ts2(*)
4510    COM INTEGER No_of_reads(*),System_type(*),Touch(*)
4515    COM INTEGER Channal(*),P_no,Func$[4]
4520    COM INTEGER Chan_no,I66,R_d,Time_flag(*),Delta_flag(*),Control_flag(*),D
elta_chan__(*),Num_per_system(*),Print_flag(*),Power
4525    COM REAL Last_datum_del(*),Last_time(*),Delta(*),Time_delta(*),Y_volts_(
*),T_d_(*),Cal_n1(*),Cal_n1_n(*)
4530    COM /Ts2_lines/ Ts2_lines(*)
4535    CALL Known
4540    DIM Fp$(49)[10]!,Ts$(150)[14]
4545    ON KEY 5 LABEL "               ",3 GOTO 4545
4550    ON KEY 6 LABEL "STORE SYSTEM  ",3 GOSUB Store_xfile
4555    ON KEY 7 LABEL "PURGE XFILE   ",3 GOSUB Purge_xfile
4560    ON KEY 8 LABEL "XFILE TO SYS  ",3 GOSUB Xfile_to_system
4565    ON KEY 9 LABEL "OTHER KEYS    ",3 GOTO Out
4570    ON KEY 0 LABEL "CAT TO DISP   ",3 GOSUB Cat_to_disp
4575    ON KEY 1 LABEL "CAT TO PTR    ",3 GOSUB Cat_to_ptr
4580    ON KEY 2 LABEL "RENAME XFILE  ",3 GOSUB Rename_xfile
4585    ON KEY 3 LABEL "LIST XFILE -D ",3 GOSUB Print_xfile_dis
4590    ON KEY 4 LABEL "LIST XFILE -P ",3 GOSUB Print_xfile_prt
4595 Loop3:GOTO Loop3
4600  !
4605 Rename_xfile: !-------------
4610    INPUT "ENTER (NEW NAME,OLD NAME)",Fx_old$,Fx_new$
4615    Fx_old$=TRIM$(Fx_old$)
4620    Fx_new$=TRIM$(Fx_new$)
4625    IF Fx_old$="" OR Fx_new$="" THEN RETURN
4630    IF Fx_old$[1,1]="X" AND Fx_new$[1,1]="X" THEN
4635      RENAME "Y"&Fx_old$[2,10]&Idisc4$ TO "Y"&Fx_new$[2,10]&Idisc4$
4640      RENAME Fx_old$&Idisc4$ TO Fx_new$&Idisc4$
4645      DISP "RENAMED ";Fx_old$;" TO ";Fx_new$
4650    END IF
4655    RETURN
4660     !
4665 Cat_to_disp: !----------------"
4670     !INPUT "ENTER 1ST LETTERS(X OR X1,ETC OF FILE NAME )",X2$
4675    OUTPUT 2 USING "#,B";255,75
4680    X2$="X"
4685    CAT Idisc4$ TO #1;SELECT X2$,NO HEADER
4690    RETURN
4695    !
4700 Cat_to_ptr: !----------------"
4705    X2$="X"
4710    CAT Idisc4$ TO #701;SELECT X2$,NO HEADER
4715    RETURN
4720  !
4725 Purge_xfile: !-------------
4730    LINPUT "ENTER XFILE TO PURGE",Purge$
4735 !CALL File_check(Purge$,Check$,0,"X")
```

```
4740 !IF Check$<>"OK" THEN Out
4745    PURGE Purge$&Idisc4$
4750    PURGE "Y"&Purge$[2,10]&Idisc4$
4755    DISP Purge$;" PURGED"
4760   !OUTPUT 2 USING "#,B";255,75
4765   !CAT Idisc4$ TO #1
4770   !LINPUT "ANOTHER XFILE TO PURGE(Y OR N)",Q3$
4775   !IF Q3$="Y" THEN Purge1
4780    RETURN
4785    !
4790 Store_xfile: !-----------------
4795    INPUT "INPUT SYSTEM NO. TO STORE ON DISC",I33
4800    IF (INT(I33)<1) OR (INT(I33)>30) THEN GOTO Cancel
4805    ALLOCATE Ts(Ts2_lines(System_type(I33)),Num_per_system(I33)),Ts$(Ts2_lin
es(System_type(I33)))[14]
4810    LINPUT "DISK FILE DESIRED(first letter must be a X)",Xfile$
4815 !CALL File_check(Xfile$,Check$,1,"X")
4820 !IF Check$<>"OK" THEN Out
4825    DISP "SYSTEM DATA BEING WRITTEN TO DISK-WAIT"
4830    DIM X$[30]
4835    File$="SYS"&VAL$(I33)
4840    X$="Y"&Xfile$[2,10]&Idisc4$
4845    CREATE BDAT X$,1,768
4850    ASSIGN @I4 TO X$
4855    Xread=No_of_reads(I33)
4860  !
4865    Fp_$(I33,49)="T"
4870    FOR J=1 TO 49
4875      Fp$(J)=Fp_$(I33,J)
4880    NEXT J
4885  !
4890    OUTPUT @I4;Fp$(*),Tou,Xread
4895    ASSIGN @I4 TO *
4900    X$=Xfile$&Idisc4$
4905    CREATE BDAT X$,Ts2_lines(System_type(I33)),(Num_per_system(I33)*8)!+14
4910    ASSIGN @I4 TO X$
4915    FOR I=1 TO No_of_reads(I33)
4920      FOR J=1 TO Num_per_system(I33)
4925        Ts(I,J)=Ts2(I33,I,J)
4930        Ts$(I)=Ts2$(I33,I)
4935      NEXT J
4940      Ts$(I)=Ts2$(I33,I)
4945    NEXT I
4950    OUTPUT @I4;Ts(*)!,Ts$(*)
4955    ASSIGN @I4 TO *
4960    DISP "SYSTEM DATA ";I33;" STORED ON DISK ON FILE ";Xfile$
4965    OUTPUT 2 USING "#,B";255,75
4970   !CAT Idisc4$ TO #1
4975    DEALLOCATE Ts(*),Ts$(*)
4980    RETURN
4985    !
4990 Print_xfile_prt: !-----------
4995    Prt1=1
5000 Print_xfile_dis: !-----------
5005    PRINTER IS CRT
5010    IF Prt1=1 THEN PRINTER IS PRT
5015    Prt1=0
5020    INPUT "INPUT SYSTEM NO.",I33
5025    IF (INT(I33)<1) OR (INT(I33)>30) THEN GOTO Cancel
5030    INPUT "ENTER XFILE",Fx$
5035    ALLOCATE Ts(Ts2_lines(System_type(I33)),Num_per_system(I33)),Ts$(Ts2_lin
es(System_type(I33)))[14]
5040    CALL Enter_data("Y",I33,Fp$(*),Ts(*),Ts$(*),0,Xtouch,Xread,"N",Fx$)
5045 !
5050    PRINT "YFILE: ";"Y"&Fx$[2,10]
```

```
5055    PRINT
5060    PRINT USING "7(10A),10X";Fp$(*)
5065    PRINT
5070    PRINT "XFILE: ";Fx$
5075    PRINT
5080    ALLOCATE T(Num_per_system(I33))
5085    FOR J=1 TO Xread
5090      FOR I=1 TO Num_per_system(I33)
5095        T(I)=Ts(J,I)
5100      NEXT I
5105      PRINT USING Nam9$(System_type(I33),3);T(*),I33,J,Ts$(J)
5110    NEXT J
5115    DEALLOCATE Ts(*),Ts$(*),T(*)
5120    RETURN
5125 !
5130 Xfile_to_system: !--------------
5135   !CAT Idisc4$ TO #1
5140    INPUT "INPUT SYSTEM NO. TO COPY OVER",I33
5145    IF (INT(I33)<1) OR (INT(I33)>30) THEN GOTO Cancel
5150    LINPUT "XFILE TO COPY ON TO SYSTEM",Fx$
5155    ALLOCATE Ts(Ts2_lines(System_type(I33)),Num_per_system(I33)),Ts$(Ts2_lin
es(System_type(I33)))[14]
5160    CALL Enter_data("Y",I33,Fp$(*),Ts(*),Ts$(*),0,Xtouch,Xread,"N",Fx$)
5165    !
5170 !CALL File_check(Xfile$,Check$,1,"X")
5175 !IF Check$<>"OK" THEN Out
5180    FOR I=1 TO 49
5185      Fp_$(I33,I)=Fp$(I)
5190    NEXT I
5195    FOR V=1 TO Xread
5200      FOR J=1 TO Num_per_system(I33)
5205        Ts2(I33,V,J)=Ts(V,J)
5210      NEXT J
5215      Ts2$(I33,V)=Ts$(V)
5220    NEXT V
5225    No_of_reads(I33)=Xread
5230    DEALLOCATE Ts(*),Ts$(*)
5235    RETURN
5240    !
5245 Out:  !
5250    CALL Known
5255    SUBEXIT
5260 Cancel:BEEP
5265    DISP "SELECTION CANCELLED"
5270    PRINTER IS 1
5275  SUBEND
5280  ! ************************************************************************
5285  SUB Status
5290  !
5295    OPTION BASE 1
5300    COM REAL Cal_m_b(*),Gage(*),Nametest$(*)
5305    COM Title$(*),Fp_$(*),Ts2$(*),Nam9$(*),Nam9d$(*),Idisc4$,Pr
5310    COM Ts1(*),Ts2(*)
5315    COM INTEGER No_of_reads(*),System_type(*),Touch(*)
5320    COM INTEGER Channal(*),P_no,Func$[4]
5325    COM INTEGER Chan_no,I66,R_d,Time_flag(*),Delta_flag(*),Control_flag(*),D
elta_chan__(*),Num_per_system(*),Print_flag(*),Power
5330    COM REAL Last_datum_del(*),Last_time(*),Delta_(*),Time_delta(*),Y_volts_
(*),T_d_(*),Cal_nl(*),Cal_nl_n(*)
5335    COM /Scan/ Record,System_no,Halt_flag,Flag,F2_flag,I17,M_rec
5340    COM /Title/ List_flag,Ed_flag,Vflag,S_code$,Title_flag
5345    !
5350    E2$=CHR$(129)!B
5355    E3$=CHR$(128)!CLEAR
5360    E4$=CHR$(132)!UL
```

```
5365    N_ss=10/2 !N_ss=20/2 , N_ss=30/2
5370    PRINTER IS 1
5375    Title_flag=0
5380    OUTPUT 2 USING "#,B";255,75
5385    PRINT
5390    PRINT USING "#,K";E4$
5395    PRINT USING "80X"
5400    PRINT "|System# | Reads    | Delta    | Control ||System#  | Reads    | Del
ta    | Control|"
5405    !
5410    FOR I=1 TO N_ss
5415      PRINT USING "#,K";E4$
5420      IMAGE "|",3X,DD,6X,DDD,24X,"||",3X,DD,7X,DDD,23X,"|"  !;
5425      PRINT USING 5420;I,No_of_reads(I),I+N_ss,No_of_reads(I+N_ss)
5430      FOR J=1 TO 2
5435        Move=21
5440        N=0
5445        IF J=2 THEN
5450          Move=61
5455          N=N_ss
5460        END IF
5465        IF Time_flag(I+N)=1 THEN
5470          CONTROL 1;Move,I+3
5475          PRINT USING "K,DDDD,K";E2$,Time_delta(I+N),"MINS"&E3$&E4$
5480        END IF
5485        IF Delta_flag(I+N)=1 THEN
5490          CONTROL 1;Move,I+3
5495          PRINT USING "K,D.DDDD,K";E2$,Delta_(I+N),"INS"&E3$&E4$
5500        END IF
5505        IF Control_flag(I+N)=1 THEN
5510          CONTROL 1;Move+10,I+3
5515          PRINT USING "K,DD.DD,K";E2$,R_control_value(I+N),"INS"&E3$&E4$
5520        END IF
5525      NEXT J
5530    NEXT I
5535    OUTPUT 1 USING "#,K";E3$
5540  SUBEND
5545  !*****************************************************************
5550  SUB Edit      !JUN 20,1984 -VERSION 3
5555  !
5560    OPTION BASE 1
5565    COM REAL Cal_m_b(*),Gage(*),Nametest$(*)
5570    COM Title$(*),Fp_$(*),Ts2$(*),Nam9$(*),Nam9d$(*),Idisc4$,Pr
5575    COM Ts1(*),Ts2(*)
5580    COM INTEGER No_of_reads(*),System_type(*),Touch(*)
5585    COM INTEGER Channal(*),P_no,Func$[4]
5590    COM INTEGER Chan_no,I66,R_d,Time_flag(*),Delta_flag(*),Control_flag(*),D
elta_chan__(*),Num_per_system(*),Print_flag(*),Power
5595    COM REAL Last_datum_del(*),Last_time(*),Delta_(*),Time_delta(*),Y_volts_
(*),T_d_(*),Cal_nl(*),Cal_nl_n(*)
5600    COM /Scan/ Record,System_no,Halt_flag,Flag,F2_flag,I17,M_rec
5605    COM /Title/ List_flag,Ed_flag,Vflag,S_code$,Title_flag
5610    COM /Ts2_lines/ Ts2_lines(*)
5615  !
5620    Type_t$="N"   !N,T=Ts$()
5625    P_up=0        !1=STORE SYS DATA FOR POWER UP
5630    Max_sys=10    !MAX OF 30
5635    Len_sp=9      !
5640    !
5645    DIM Fp$(49)[10],A$[1],K$[160]
5650    INTEGER Line_d1(100),Line_from_to(100,2)          !DELETES from=1,to=2
5655    CALL Known
5660    I12=2
5665    INPUT "SYSTEM NO. FOR DATA EDIT",I12
5670    IF (INT(I12)<1) OR (INT(I12)>Max_sys) THEN GOTO Cancel
```

```
5675    ALLOCATE Ts(Ts2_lines(System_type(I12)),Num_per_system(I12)),Ts$(Ts2_lin
es(System_type(I12)))[14]
5680    Q11$="N"
5685    LINPUT "XFILE(Y OR N)",Q11$
5690    IF Q11$="Y" THEN INPUT "ENTER XFILE",Fx$
5695    CALL Enter_data(Q11$,I12,Fp$(*),Ts(*),Ts$(*),0,Xtouch,Xread,Type_t$,Fx$)
5700    Total_i=Num_per_system(I12)
5705    !
5710    ON KEY 5 LABEL "               ",3 GOSUB Dum
5715    ON KEY 6 LABEL "               ",3 GOSUB Dum
5720    ON KEY 7 LABEL "HELP           ",3 GOSUB Help
5725    ON KEY 8 LABEL "CURSOR EDIT    ",3 GOTO Cursor_edit
5730    ON KEY 9 LABEL "OTHER KEYS     ",3 GOSUB Store_edit
5735    ON KEY 0 LABEL "COLUMN FILL    ",3 GOSUB Column_fill
5740    ON KEY 1 LABEL "DELETE LINES   ",3 GOSUB Delete_lines
5745    ON KEY 2 LABEL "CHANGE SIGN    ",3 GOSUB Sign_change
5750    ON KEY 3 LABEL "DISP EDIT      ",3 GOSUB Disp_edit
5755    ON KEY 4 LABEL "PRINT EDIT     ",3 GOSUB Print_edit
5760 Loop3:GOTO Loop3
5765    !
5770 Dum:   !
5775    RETURN
5780 P_mess:   !-------------------------------------------------------------
5785    DISP "ENTER (LINE = 0) WHEN DONE WITH SECTION"
5790    WAIT 2
5795    RETURN
5800 Cursor_edit:   !-------------------------------------------------------------
5805    !
5810    ON KEY 5 LABEL "ADVANCE PAGE   ",7 GOSUB Advance_page
5815    ON KEY 6 LABEL "ENTER LINE#    ",7 GOSUB Enter_line_no
5820    ON KEY 7 LABEL "               ",3 GOTO Loop
5825    ON KEY 8 LABEL "               ",3 GOTO Loop
5830    ON KEY 9 LABEL "               ",3 GOTO Loop
5835    ON KEY 0 LABEL "               ",3 GOTO Loop
5840    ON KEY 1 LABEL "               ",3 GOTO Loop
5845    ON KEY 2 LABEL "               ",3 GOTO Loop
5850    ON KEY 3 LABEL "               ",3 GOTO Loop
5855    ON KEY 4 LABEL "               ",3 GOTO Loop
5860  !
5865    PRINTER IS 1
5870    Cursor_mode=1
5875    ALLOCATE Line_no(Ts2_lines(System_type(I12))),Dp$(Ts2_lines(System_type(
I12)))[80]
5880    !TRANSLATE TO ALPHA---------------
5885    Xread_0_flag=0
5890    IF Xread=0 THEN
5895      INPUT "NO. OF LINES TO ADD",Xread
5900      Xread=MIN(Xread,Ts2_lines(System_type(I12)))
5905      Xread_0_flag=1
5910    END IF
5915    DISP "WAIT"
5920    FOR I=1 TO Xread
5925      Line_no(I)=I
5930      Dp$(I)=""
5935      FOR J=1 TO Total_i
5940        OUTPUT Tem7$ USING "#,"&Nam9d$(System_type(I12),J);Ts(I,J)
5945        Blank$=RPT$(" ",Len_sp-LEN(Tem7$))
5950        Dp$(I)=Dp$(I)&Blank$&Tem7$
5955      NEXT J
5960      IF Type_t$="T" THEN
5965        IF Xread_0_flag=1 OR LEN(Ts$(I))<10 THEN
5970          Dp$(I)=Dp$(I)&RPT$(" ",15)
5975        ELSE
5980          Dp$(I)=Dp$(I)&" "&Ts$(I)
5985        END IF
5990      END IF
```

```
5995     NEXT I
6000     DISP
6005     !
6010     L1=MIN(LEN(Dp$(1)),71)
6015     Im$=VAL$(L1)&"A,X,8A"
6020     IF Total_i<6 THEN Im$=VAL$(L1)&"A,5X,8A"
6025     Top_line=-16 !C
6030     PRINT USING "#,K";CHR$(128)
6035     CONTROL 1;1,1
6040     GOSUB Advance_page
6045     Last_l=18
6050     Last_l_1=17
6055     Xtab=1
6060     Ytab=1
6065     ON KNOB .1,5 GOSUB Cursor_wheel
6070     ON KBD,5 GOSUB Read_key
6075 Loop: !GOTO Loop
6080     IF Cursor_mode=0 THEN 5710
6085     GOTO Loop
6090 Cursor_wheel: !---------------------------------------
6095     PRINT TABXY(Xtab,Ytab);CHR$(128);A$
6100     Xtab=Xtab+KNOBX
6105     IF Xtab<1 THEN
6110       Xtab=L1
6115       IF Ytab>1 THEN Ytab=Ytab-1
6120      !IF Ytab<1 THEN Ytab=1
6125     END IF
6130     IF Xtab>L1 THEN
6135       Xtab=1
6140       IF Ytab<Last_l AND Ytab<Bot_line-Top_line+2 THEN Ytab=Ytab+1
6145     END IF
6150     CONTROL 1;Xtab,Ytab
6155     ENTER 1;A$
6160     IF A$="" THEN A$=" "
6165     PRINT TABXY(Xtab,Ytab);CHR$(129);A$
6170     RETURN
6175 Read_key:    !-----------------------------
6180     K$=KBD$
6185     IF NUM(K$[1,1])=255 THEN
6190       SELECT NUM(K$[2,2])
6195       CASE 67
6200         GOTO Enter_data    !CONTINUE
6205       CASE 42
6210         GOSUB Add_line     !INS LN
6215       CASE 47
6220         GOSUB Delete_line !DEL LN
6225       CASE 94,86,60,62
6230         GOSUB Arrow        !ARROWS
6235       CASE ELSE
6240         CONTROL 1,8;1
6245         DISP "INVALID KEY - PRESS CONTINUE TO EXIT CURSOR MODE"
6250         WAIT 1
6255         DISP
6260         RETURN
6265       END SELECT
6270     ELSE
6275       IF Ytab=Last_l OR Top_line+Ytab-1>Xread THEN RETURN
6280       A$=K$[1,1]
6285       PRINT TABXY(Xtab,Ytab);CHR$(128);A$;
6290       Ytab_save=Ytab
6295       Xtab=Xtab+1
6300       IF Xtab>L1 THEN
6305         Xtab=1
6310         IF Ytab<Last_l_1 AND Ytab<Bot_line-Top_line+1 THEN Ytab=Ytab+1 !C
6315       END IF
```

```
6320      ENTER 1;A$
6325      PRINT TABXY(Xtab,Ytab);CHR$(129);A$;
6330      CONTROL 1;1,Ytab_save
6335      ENTER 1;Dp$(Top_line+Ytab_save-1)[1,L1]
6340      CONTROL 1;Xtab,Ytab
6345    END IF
6350    RETURN
6355    !
6360 Enter_line_no:   !----------------------
6365    IF Cursor_mode=0 THEN RETURN
6370    !INPUT "ENTER LINE NO.",T_line
6375    IF Ins_is_at_bot=0 THEN INPUT "ENTER LINE NO.",T_line
6380    Ins_is_at_bot=0
6385    Top_line=MAX(1,MIN(INT(T_line),Xread))-Last_l_1 !C
6390    E_l_flag=1
6395    GOSUB Advance_page
6400    E_l_flag=0
6405    RETURN
6410    !
6415 Advance_page:   !-------------------------
6420    IF Cursor_mode=0 THEN RETURN
6425    OUTPUT 2 USING "#,B";255,75
6430    IF E_l_flag=0 AND Bot_line=Xread THEN Top_line=2-Last_l !C
6435    Top_line=Top_line+17 !C
6440    Bot_line=MIN(Top_line+16,Xread) !C
6445    PRINT TABXY(Xtab,Ytab);CHR$(128);A$;
6450    CONTROL 1;1,1
6455    FOR I=Top_line TO Bot_line
6460      PRINT USING Im$;Dp$(I),VAL$(Line_no(I))
6465    NEXT I
6470    CONTROL 1;1,1
6475    ENTER 1;A$
6480    IF A$="" THEN A$=" "
6485    Xtab=1
6490    Ytab=1
6495    PRINT TABXY(Xtab,Ytab);CHR$(129);A$;
6500    RETURN
6505    !
6510 Add_line:   !----------------------------
6515    IF Xread>=Ts2_lines(System_type(I12)) THEN
6520      Xread=Ts2_lines(System_type(I12))
6525      CONTROL 1,8;1
6530      DISP "MAX LINES EXCEEDED  ";Ts2_lines(System_type(I12))
6535      RETURN
6540    END IF
6545    IF Ytab=Last_l THEN !C
6550      T_line=Bot_line
6555      Ins_is_at_bot=1
6560      GOSUB Enter_line_no
6565      Ins_is_at_bot=0
6570      Ytab=2
6575      PRINT TABXY(1,1);CHR$(128);" ";
6580    END IF
6585    Xread=Xread+1
6590    Start1=Top_line+Ytab-1
6595    FOR I=(Xread-1) TO Start1 STEP -1
6600      Dp$(I+1)=Dp$(I)
6605      Line_no(I+1)=Line_no(I)
6610    NEXT I
6615    Last_i=Start1
6620    Dp$(Last_i)=RPT$(" ",LEN(Dp$(Last_i)))
6625    IF Last_i-1=0 THEN
6630      Line_no(Last_i)=.1
6635    ELSE
6640      Line_no(Last_i)=Line_no(Last_i-1)+.1
```

```
6645      IF Last_i=Xread THEN Line_no(Last_i)=Line_no(Last_i-1)+1
6650    END IF
6655    PRINT TABXY(1,Ytab);CHR$(128);" ";
6660    CONTROL 1;1,Ytab
6665    Bot_line=MIN(Start1+Last_l_1-Ytab,Xread) !C
6670    FOR I=Start1 TO Bot_line
6675      PRINT USING Im$;Dp$(I),VAL$(Line_no(I))
6680    NEXT I
6685    Xtab=1
6690    A$=" "
6695    PRINT TABXY(Xtab,Ytab);CHR$(129);A$;
6700    RETURN
6705    !
6710 Delete_line:   !-------------------------
6715    Start1=Top_line+Ytab-1
6720    IF Start1>Xread OR Ytab=Last_l THEN RETURN
6725    Xread=Xread-1
6730    FOR I=Start1 TO Xread
6735      Dp$(I)=Dp$(I+1)
6740      Line_no(I)=Line_no(I+1)
6745    NEXT I
6750    Dp$(I)=RPT$(" ",LEN(Dp$(I)))
6755    Line_no(I)=0
6760    PRINT TABXY(1,Ytab);CHR$(128);" ";
6765    CONTROL 1;1,Ytab
6770    Bot_line=MIN(Start1+Last_l_1-Ytab,Xread) !C
6775    Bot_lin=Bot_line
6780    IF Bot_line=Xread THEN Bot_lin=Bot_lin+1
6785    FOR I=Start1 TO Bot_lin
6790      PRINT USING Im$;Dp$(I),VAL$(Line_no(I))
6795    NEXT I
6800    Xtab=1
6805    A$=" "
6810    PRINT TABXY(Xtab,Ytab);CHR$(129);A$;
6815    RETURN
6820    !
6825 Arrow:   !------------------------
6830    PRINT TABXY(Xtab,Ytab);CHR$(128);A$;
6835    SELECT NUM(K$[2,2])
6840    CASE 94       !UP
6845      IF Ytab>1 THEN Ytab=Ytab-1
6850    CASE 86       !DOWN
6855      IF Ytab<Last_l AND Ytab<Bot_line-Top_line+2 THEN Ytab=Ytab+1
6860    CASE 60       !LEFT
6865      IF Xtab>1 THEN Xtab=Xtab-1
6870    CASE 62       !RIGHT
6875      Xtab=Xtab+1
6880      IF Xtab>L1 THEN
6885        Xtab=1
6890        IF Ytab<Last_l AND Ytab<Bot_line-Top_line+2 THEN Ytab=Ytab+1
6895      END IF
6900    END SELECT
6905    CONTROL 1;Xtab,Ytab
6910    ENTER 1;A$
6915    IF A$="" THEN A$=" "
6920    PRINT TABXY(Xtab,Ytab);CHR$(129);A$;
6925    RETURN
6930    !
6935 Enter_data: !------------------------
6940    PRINTER IS 1
6945    PRINT USING "#,K";CHR$(128)
6950    CONTROL 1;1,1
6955    OFF KNOB
6960    OFF KBD
6965    OUTPUT 2 USING "#,B";255,75
```

```
6970    !PRINT "DP$(I)"
6975    !FOR I=1 TO Xread
6980    !  PRINT Dp$(I)
6985    !NEXT I
6990     !TRANSLATE TO NUMERIC-----------
6995     DISP "WAIT"
7000     I1=0
7005     FOR I=1 TO Xread
7010       Dp$(I)=TRIM$(Dp$(I))
7015       IF Dp$(I)="" THEN
7020         GOTO 7115
7025       END IF
7030       I1=I1+1
7035       Dp$(I)=" "&Dp$(I)
7040       L1=LEN(Dp$(I))
7045       J=1
7050       FOR K=1 TO L1-1
7055         IF K>=L1 THEN Cont_i
7060         IF Dp$(I)[K,K]=" " AND Dp$(I)[K+1,K+1]<>" " THEN
7065           IF J>Total_i THEN Cont_i
7070           Ts(I1,J)=VAL(Dp$(I)[K,L1])
7075           J=J+1
7080         END IF
7085       NEXT K
7090 Cont_i:      !
7095       IF Type_t$="T" THEN
7100         Ts$(I1)=TRIM$(Dp$(I)[K,L1])
7105         IF LEN(Ts$(I1))<14 THEN Ts$(I1)=" "&Ts$(I1)
7110       END IF
7115     NEXT I
7120     Xread=I1
7125     DISP
7130    !PRINT "NUMERIC DATA"
7135    !FOR Y=1 TO Xread
7140    !  PRINT Ts(Y,1),Ts(Y,2),Ts$(Y)
7145    !NEXT Y
7150     DEALLOCATE Line_no(*),Dp$(*)
7155     Cursor_mode=0
7160     RETURN ! Return to Loop
7165  !
7170 Help: !-------------------------------------------------------------
7175     OUTPUT 2 USING "#,B";255,75
7180     F1$="SYS "&VAL$(I12)
7185     IF Q11$="Y" THEN F1$="File: "&Fx$
7190     PRINT "  EDIT DATA - ";Nametest$(System_type(I12));"  ";F1$
7195     PRINT
7200     PRINT "CURSOR EDIT KEYS"
7205     PRINT
7210     PRINT "(CONTINUE    ) - EXIT CURSOR MODE"
7215     PRINT "(INS LN      ) - INSERT LINE ABOVE"
7220     PRINT "(DEL LN      ) - DELETE LINE"
7225     PRINT "(UP ARROW    ) - VERTICAL MOVEMENT"
7230     PRINT "(DOWN ARROW  ) - VERTICAL MOVEMENT"
7235     PRINT "(LEFT ARROW  ) - HORIZ MOVEMENT"
7240     PRINT "(RIGHT ARROW ) - HORIZ MOVEMENT"
7245     PRINT "(CURSOR WHEEL) - FAST HORIZ & VERT MOVEMENT"
7250     PRINT
7255     PRINT "(ADVANCE PAGE) - LIST 17 LINES OF DATA"
7260     PRINT "(ENTER LINE# ) - LINE NO. TO START PAGE"
7265     PRINT
7270     PRINT "NOTE: Each data item must be separated by at least one SPACE"
7275     RETURN
7280        !
7285 Column_fill: !-----------------------------------------------------
7290     GOSUB P_mess
```

```
7295     INPUT "FROM LINE NO.-COL FILL-",Stuff_from
7300     IF Stuff_from<=0 THEN RETURN
7305     Stuff_from=MAX(1,MIN(Stuff_from,Xread))
7310     INPUT "TO LINE NO.-COL FILL-",Stuff_to
7315     IF Stuff_to<=0 THEN RETURN
7320     Stuff_to=MAX(1,MIN(Stuff_to,Xread))
7325     Stuff_from=MIN(Stuff_from,Stuff_to)
7330     INPUT "ITEM NO.-COL FILL-",Stuff_item
7335     Stuff_item=MAX(1,MIN(Stuff_item,Total_i))
7340     INPUT "-COL FILL-VALUE=?",Col_value
7345     FOR I21=Stuff_from TO Stuff_to
7350       Ts(I21,Stuff_item)=Col_value
7355     NEXT I21
7360     RETURN
7365     !
7370 Sign_change:    !-------------------------------------------------
7375     GOSUB P_mess
7380     INPUT "FROM LINE NO.-SIGN CHANGE-",Stuff_from
7385     IF Stuff_from<=0 THEN RETURN
7390     Stuff_from=MAX(1,MIN(Stuff_from,Xread))
7395     INPUT "TO LINE NO.-SIGN CHANGE-",Stuff_to
7400     IF Stuff_to<=0 THEN RETURN
7405     Stuff_to=MAX(1,MIN(Stuff_to,Xread))
7410     Stuff_from=MIN(Stuff_from,Stuff_to)
7415     INPUT "ITEM NO.-SIGN CHANGE-",Stuff_item
7420     Stuff_item=MAX(1,MIN(Stuff_item,Total_i))
7425     FOR I21=Stuff_from TO Stuff_to
7430       Ts(I21,Stuff_item)=(-1)*Ts(I21,Stuff_item)
7435     NEXT I21
7440     RETURN
7445     !
7450 Delete_lines:    !-------------------------------------------------
7455     GOSUB P_mess
7460     D10=1
7465 Ran_del:    !
7470     INPUT "LINE NO. TO DELETE",Line_d1(D10)
7475     IF Line_d1(D10)<=0 THEN Inclusive_del
7480     Line_d1(D10)=MAX(1,MIN(Line_d1(D10),Xread))
7485     D10=D10+1
7490     GOTO Ran_del
7495              !
7500 Inclusive_del:
7505     D11=1
7510 Seq_del: !
7515     INPUT "DELETE FROM LINE (INCLUSIVE)?",Line_from_to(D11,1)
7520     IF Line_from_to(D11,1)<=0 THEN Close_lines
7525     Line_from_to(D11,1)=MAX(1,MIN(Line_from_to(D11,1),Xread))
7530     INPUT "TO LINE ",Line_from_to(D11,2)
7535     Line_from_to(D11,2)=MAX(1,MIN(Line_from_to(D11,2),Xread))
7540     Line_from_to(D11,1)=MIN(Line_from_to(D11,1),Line_from_to(D11,2))
7545     D11=D11+1
7550     GOTO Seq_del
7555 Close_lines: ! ----------------------
7560     DISP "EDIT DELEATE WORKING - WAIT"
7565   !SORT--
7570     IF D10<2 THEN GOTO 7625
7575     FOR I=1 TO D10-1
7580       FOR J=1 TO D10-1
7585         IF Line_d1(J)>Line_d1(I) THEN
7590           Tem=Line_d1(I)
7595           Line_d1(I)=Line_d1(J)
7600           Line_d1(J)=Tem
7605         END IF
7610       NEXT J
7615     NEXT I
```

```
7620  !
7625    IF D11<2 THEN GOTO 7695
7630    FOR I=1 TO D11-1
7635      FOR J=1 TO D11-1
7640        IF Line_from_to(J,1)>Line_from_to(I,1) THEN
7645          Tem=Line_from_to(I,1)
7650          T1=Line_from_to(I,2)
7655          Line_from_to(I,1)=Line_from_to(J,1)
7660          Line_from_to(I,2)=Line_from_to(J,2)
7665          Line_from_to(J,1)=Tem
7670          Line_from_to(J,2)=T1
7675        END IF
7680      NEXT J
7685    NEXT I
7690  !
7695    I14=1
7700    I19=1
7705    D20=1
7710    FOR I=1 TO Xread
7715      IF (I=Line_d1(I19)) OR (I>=Line_from_to(D20,1)) AND (I<=Line_from_to(D
20,2)) THEN GOTO Delete_lin
7720      FOR J=1 TO Total_i
7725        Ts(I14,J)=Ts(I,J)
7730      NEXT J
7735      Ts$(I14)=Ts$(I)
7740      I14=I14+1
7745      GOTO 7765
7750 Delete_lin: ! ------------------
7755      IF I=Line_d1(I19) THEN I19=I19+1
7760      IF I=Line_from_to(D20,2) THEN D20=D20+1
7765    NEXT I
7770    Xread=I14-1
7775    DISP
7780    RETURN
7785    !
7790 Print_edit:   !-------------------------------------------------------
7795    Dis_flag=1
7800 Disp_edit:   !-------------------------------------------------------
7805    PRINTER IS 1
7810    PRINT USING "#,K";CHR$(128)
7815    IF Dis_flag=1 THEN PRINTER IS PRT
7820    OUTPUT 2 USING "#,B";255,75
7825    ALLOCATE T(Num_per_system(I12))
7830    FOR J=1 TO Xread
7835      FOR I=1 TO Num_per_system(I12)
7840        T(I)=Ts(J,I)
7845      NEXT I
7850      PRINT USING Nam9$(System_type(I12),3);T(*),I12,J,Ts$(J)
7855    NEXT J
7860    DEALLOCATE T(*)
7865    PRINTER IS 1
7870    Dis_flag=0
7875    RETURN
7880    !
7885 Store_edit: ! ------------------------------------------------------
7890    INPUT "STORE EDITED DATA(Y OR N)",Q58$
7895    IF Q58$="N" THEN SUBEXIT
7900    SELECT Q11$
7905    CASE "N"!SYSTEM
7910      IF P_up=1 THEN ASSIGN @File1 TO "SYS"&VAL$(I12)
7915      ALLOCATE T(7)
7920      FOR I=1 TO Xread
7925        FOR J=1 TO Num_per_system(I12)
7930          Ts2(I12,I,J)=Ts(I,J)
7935          T(J)=Ts(I,J)
```

```
7940          NEXT J
7945          Ts2$(I12,I)=Ts$(I)
7950          IF P_up=1 THEN OUTPUT @File1,I;T(*),Ts$(I)
7955        NEXT I
7960        DEALLOCATE T(*)
7965        IF P_up=1 THEN ASSIGN @File1 TO *
7970        No_of_reads(I12)=Xread
7975        IF P_up=1 THEN
7980          ASSIGN @File2 TO "READS"
7985          OUTPUT @File2;No_of_reads(*)
7990          ASSIGN @File2 TO *
7995        END IF
8000        DISP "EDITED DATA STORED - SYSTEM NO.";I12
8005      !
8010      CASE "Y"!XFILE
8015        ASSIGN @I4 TO Fx$&Idisc4$
8020        IF Type_t$="T" THEN
8025          OUTPUT @I4;Ts(*),Ts$(*)
8030        ELSE
8035          OUTPUT @I4;Ts(*)
8040        END IF
8045        ASSIGN @I4 TO "Y"&Fx$[2,10]&Idisc4$
8050        OUTPUT @I4;Fp$(*),Xtouch,Xread
8055        ASSIGN @I4 TO *
8060        DISP "EDITED DATA STORED ON FILE ";Fx$
8065      END SELECT
8070      PRINTER IS 1
8075      SUBEXIT
8080  Cancel:BEEP
8085      OUTPUT 1;"SELECTION CANCELLED"
8090      PRINTER IS 1
8095    SUBEND
8100    !*************************************************************
8105    SUB Cursor(Fp$(*),No_lines)
8110      OPTION BASE 1
8115      DIM A$[1],K$[2]
8120      PRINT CHR$(128);!CL
8125      Last_l=(No_lines+1)*2
8130      Xtab=2
8135      Ytab=4
8140      CONTROL 1;Xtab,Ytab
8145      ENTER 1;A$
8150      PRINT TABXY(Xtab,Ytab);CHR$(133);A$!UL,IV
8155      ON KNOB .1,5 GOSUB Cursor_wheel
8160      ON KBD,5 GOSUB Read_key
8165  Loop:GOTO Loop
8170        !
8175  Cursor_wheel: !
8180      PRINT TABXY(Xtab,Ytab);CHR$(128);CHR$(132);A$!UL
8185      Xtab=Xtab+KNOBX
8190      IF Xtab<2 THEN
8195        Xtab=80
8200        IF Ytab>4 THEN Ytab=Ytab-2
8205      END IF
8210      IF Xtab>80 THEN
8215        Xtab=2
8220        IF Ytab<Last_l THEN Ytab=Ytab+2
8225      END IF
8230      CONTROL 1;Xtab,Ytab
8235      ENTER 1;A$
8240      PRINT TABXY(Xtab,Ytab);CHR$(133);A$!UL,IV
8245      RETURN
8250      !
8255  Read_key: !
8260      K$=KBD$
```

```
8265    IF NUM(K$[1,1])=255 THEN
8270      SELECT NUM(K$[2,2])
8275      CASE 67
8280        GOTO Enter_data
8285      CASE 94,86,60,62
8290        GOSUB Arrow
8295      CASE ELSE
8300        CONTROL 1,8;1
8305        DISP "INVALID KEY - PRESS CONTINUE TO EXIT "
8310        WAIT 1
8315        DISP
8320        RETURN
8325      END SELECT
8330    ELSE
8335      A$=K$[1,1]
8340      IF (Xtab MOD 11)=1 THEN A$="|"
8345      PRINT TABXY(Xtab,Ytab);CHR$(128);CHR$(132);A$;!UL
8350      Xtab=Xtab+1
8355      IF Xtab>77 THEN
8360        Xtab=1
8365        IF Ytab<Last_1 THEN Ytab=Ytab+2
8370      END IF
8375      ENTER 1;A$
8380      PRINT TABXY(Xtab,Ytab);CHR$(128);CHR$(133);A$;!UL,IV
8385    END IF
8390    RETURN
8395    !
8400 Arrow: !
8405    PRINT TABXY(Xtab,Ytab);CHR$(128);CHR$(132);A$;!UL
8410    SELECT NUM(K$[2,2])
8415    CASE 94       !UP
8420      IF Ytab>4 THEN Ytab=Ytab-2
8425    CASE 86       !DOWN
8430      IF Ytab<Last_1 THEN Ytab=Ytab+2
8435    CASE 60       !LEFT
8440      IF Xtab>2 THEN Xtab=Xtab-1
8445    CASE 62       !RIGHT
8450      Xtab=Xtab+1
8455      IF Xtab>77 THEN
8460        Xtab=1
8465        IF Ytab<Last_1 THEN Ytab=Ytab+2
8470      END IF
8475    END SELECT
8480    CONTROL 1;Xtab,Ytab
8485    ENTER 1;A$
8490    IF A$="" THEN A$=" "
8495    PRINT TABXY(Xtab,Ytab);CHR$(133);A$;!UL,IV
8500    RETURN
8505    !
8510 Enter_data: !
8515    PRINTER IS 1
8520    OFF KNOB
8525    OFF KBD
8530    PRINT USING "#,K";CHR$(128)
8535      !ENTER DATA FROM SCREEN
8540    I=0
8545    FOR Y=4 TO Last_1 STEP 2
8550      FOR X=2 TO 77 STEP 11
8555        I=I+1
8560        CONTROL 1;X,Y
8565        ENTER 1;Fp$(I)
8570      NEXT X
8575    NEXT Y
8580    OUTPUT 2 USING "#,B";255,75
8585  SUBEND
```

```
8590  !************************************************************************
8595  SUB Grid(Xmin,Xmax,Ymin,Ymax,Xtica,Ytica,Top,G$)
8600  !TOP=1 WINDOW Xmin,Xmax,Ymax,Ymin
8605    DEG
8610    D_x=ABS(Xmax-Xmin)
8615    D_y=ABS(Ymax-Ymin)
8620    CLIP ON
8625    IF G$="A" THEN
8630      AXES (D_x/Xtica)/2,(D_y/Ytica)/2,Xmin,Ymin,2,2
8635    ELSE
8640      GRID D_x/Xtica,D_y/Ytica,Xmin,Ymin,1,1
8645    END IF
8650    CLIP OFF
8655  ! Label_y--
8660    LORG 8
8665    LDIR 0
8670    CSIZE 2.0
8675    FOR Y=Ymin TO Ymax+ABS(D_y/Ytica)/2 STEP ABS(D_y/Ytica)
8680      MOVE Xmin,Y
8685      IF Y<.000001 AND Y>-.000001 THEN Y=0
8690      LABEL Y
8695    NEXT Y
8700  ! Label_X--
8705    LORG 6
8710    LDIR 0
8715    CSIZE 2.0
8720    FOR X=Xmin TO Xmax+ABS(D_x/Xtica)/2 STEP ABS(D_x/Xtica)
8725      IF Top=0 THEN MOVE X,Ymin-.02*D_y
8730      IF Top=1 THEN MOVE X,Ymax+.02*D_y
8735      IF X<.000001 AND X>-.000001 THEN X=0
8740      LABEL X
8745    NEXT X
8750  SUBEND
8755  !************************************************************
8760  SUB Known
8765  ! Resets to known state
8770    CONTROL 2;1                         !CAPS LOCK ON
8775    OUTPUT 1 USING "#,K";CHR$(128)      !CLEAR CRT MODES
8780    OUTPUT 701 USING "#,K";CHR$(128)
8785    OUTPUT 2 USING "#,B";255,75         !CLEAR CRT
8790    OFF KNOB
8795    OFF KBD
8800    PRINTER IS 1
8805    DISP
8810    ALPHA ON
8815    GRAPHICS OFF
8820  SUBEND
8825  !************************************************************************
8830  SUB Log_axis_y(Xmin2,Xmax2,Ymin2,Ymax2,Dir_y$)
8835  !FOR REVERSE X AND Y
8840  !
8845  !X INPUT VALUES MUST BE LGT
8850  !
8855  !!! IF INT(Xmax)<>Xmax THEN Xmax=INT(Xmax)+1
8860  !!! Xmin=INT(Xmin)
8865  !!IF (D_x<1) AND (INT(Xmin)=INT(Xmax)) THEN Xmin=INT(Xmin)
8870  !
8875    Xmin=Xmin2
8880    Xmax=Xmax2
8885    Ymin=Ymin2
8890    Ymax=Ymax2
8895    D_x=ABS(Xmax-Xmin)
8900    D_y=ABS(Ymax-Ymin)
8905    Off1=-.01
8910    Off4=-.04
8915    IF Dir_y$="HIGH" THEN !REV SCALE
```

```
8920      Off1=.01
8925      Off4=.04
8930      Dum=Ymax
8935      Ymax=Ymin
8940      Ymin=Dum
8945    END IF
8950 ! Log_x: ! -----------
8955    DEG
8960    CLIP ON
8965    LORG 9
8970    FOR D=INT(Ymin) TO Ymax
8975      FOR I=1 TO 9
8980        IF (D=INT(Ymin)) AND (I=1) THEN 8995
8985        MOVE Xmin,D+LGT(I)
8990        DRAW Xmax,D+LGT(I)
8995      NEXT I
9000      LINE TYPE 1
9005      MOVE Xmin,D
9010      DRAW Xmin,D
9015    NEXT D
9020 ! Log_labels: ! ----------
9025    CLIP OFF
9030    FOR D=INT(Ymin) TO Ymax
9035      CSIZE 2
9040      LDIR 0
9045      LORG 8
9050      IF D_y>2 THEN 9080
9055      FOR I=2 TO 9
9060        MOVE Xmin+Off1*D_x,D+LGT(I)
9065        IF (D+LGT(I)>Ymax) OR (D+LGT(I)<Ymin) THEN 9075
9070        LABEL USING "D";I
9075      NEXT I
9080      LDIR 0
9085      LORG 9
9090      CSIZE 2.3
9095      Dec=D
9100      IF (D<Ymin) THEN 9140
9105      MOVE Xmin+Off4*D_x,Dec-.01*D_y
9110      LABEL "10"
9115      MOVE Xmin+Off1*D_x,Dec
9120      CSIZE 2
9125      LORG 8
9130      LABEL Dec
9135      CSIZE 2.8
9140    NEXT D
9145  SUBEND
9150  !*************************************************************
9155  SUB Digitizer
9160  !
9165    OPTION BASE 1
9170    COM REAL Cal_m_b(*),Gage(*),Nametest$(*)
9175    COM Title$(*),Fp_$(*),Ts2$(*),Nam9$(*),Nam9d$(*),Idisc4$,Pr
9180    COM Ts1(*),Ts2(*)
9185    COM INTEGER No_of_reads(*),System_type(*),Touch(*)
9190    COM INTEGER Channal(*),P_no,Func$[4]
9195    COM INTEGER Chan_no,I66,R_d,Time_flag(*),Delta_flag(*),Control_flag(*),D
elta_chan__(*),Num_per_system(*),Print_flag(*),Power
9200    COM REAL Last_datum_del(*),Last_time(*),Delta_(*),Time_delta(*),Y_volts_
(*),T_d_(*),Cal_nl(*),Cal_nl_n(*)
9205    COM /Scan/ Record,System_no,Halt_flag,Flag,F2_flag,I17,M_rec
9210    COM /Title/ List_flag,Ed_flag,Vflag,S_code$,Title_flag
9215    COM /Ts2_lines/ Ts2_lines(*)
9220    !
9225  !CONTINOUS DIGITIZER
9230  !TABLET BLOCK
```

```
9235     DIM X(18000),Y(18000)
9240     GRAPHICS OFF
9245     ALPHA ON
9250     OUTPUT 2 USING "B,#";255,75
9255     PRINT "BLOCK 1  - START"
9260     PRINT "BLOCK 16 - STOP/STORE DATA"
9265     PRINT
9270     INPUT "ENTER SYSTEM NO.",I33
9275     Xmin=0
9280     Xmax=11.45
9285     Ymin=0
9290     Ymax=8.21
9295     INPUT "ENTER XMIN,XMAX,YMIN,YMAX",Xmin,Xmax,Ymin,Ymax
9300 !OUTPUT 706;"IN"
9305 !OUTPUT 706;"OP"
9310 !ENTER 706;P1x,P1y,P2x,P2y
9315 !OUTPUT 701;P1x,P1y,P2x,P2y
9320 !P1x=290.8
9325 !P1y=208.5
9330 !P2x=11632
9335 !P2y=8340
9340!!PRINT P1x,P1y,P2x,P2y
9345 !
9350     OUTPUT 706;"SG"!SINGLE POINT
9355     PRINT "DIGITIZE LOWER LEFT CORNER OF SCALE"
9360     OUTPUT 706;"OD"
9365     ENTER 706;P1x,P1y
9370     PRINT "DIGITIZE UPPER RIGHT CORNER OF SCALE"
9375     OUTPUT 706;"OD"
9380     ENTER 706;P2x,P2y
9385! ! OUTPUT 706;"DC;IP";X_1,Y_1,X_2,Y_2
9390! !OUTPUT 706;"OP"
9395! !ENTER 706;P1x,P1y,P2x,P2y
9400 !OUTPUT 701;P1x,P1y,P2x,P2y
9405     PRINT
9410     PRINT "PRESSING STYLUS ENTERS POINT"
9415     PRINT
9420     PRINT "POINT IS ENTERED WHEN GREEN LIGHT FLASHES"
9425     PRINT
9430     OUTPUT 706;"IN"
9435 Loop: !
9440     PRINT "PRESS BLOCK 1 WITH PEN"
9445  ! OUTPUT 706;"CN"!CONTINOUS
9450!! OUTPUT 706;"SF" !CONTINOUS !PRESSED
9455  ! OUTPUT 706;"SK"!CONTINOUS !1/4" ABOVE
9460 !!OUTPUT 706;"CR";10  !RATE
9465     OUTPUT 706;"SG"!SINGLE POINT
9470 !
9475     LOOP
9480 Check_start:S=SPOLL(706)
9485       IF BIT(S,7)=1 THEN
9490         OUTPUT 706;"BP24,100,4"
9495         OUTPUT 706;"RS1"
9500         ENTER 706;Key
9505       END IF
9510     EXIT IF Key=1
9515     END LOOP
9520  !
9525 Begin: !
9530     GRAPHICS ON
9535     ALPHA OFF
9540     GINIT
9545     D_x=Xmax-Xmin
9550     D_y=Ymax-Ymin
9555     FRAME
```

```
9560     WINDOW Xmin,Xmax,Ymin,Ymax
9565     A=D_x/(P2x-P1x)
9570     C=D_y/(P2y-P1y)
9575     B=Xmin-P1x*A
9580     D=Ymin-P1y*C
9585   !
9590     N=No_of_reads(I33)
9595     PENUP
9600     LOOP
9605 Check_status:S=SPOLL(706)
9610       IF BIT(S,7)=1 THEN
9615         OUTPUT 706;"BP24,100,4"
9620         OUTPUT 706;"RS1"
9625         ENTER 706;Key
9630         IF Key=16 THEN Stop
9635       END IF
9640       IF BIT(S,2)=0 THEN Check_status
9645       OUTPUT 706;"OD"
9650       ENTER 706;X1,Y1!Up
9655!    PRINT X1,Y1
9660!  OUTPUT 706;"BP24,100,1 "
9665       N=N+1
9670     EXIT IF N>3600
9675       X(N)=A*X1+B
9680       Y(N)=C*Y1+D
9685   !PRINT N,X(N),Y(N)
9690       PLOT X(N),Y(N)
9695      !IF Up=0 THEN PENUP
9700     END LOOP
9705   !
9710 Stop: !
9715!    OUTPUT 706;"BP31,30,5;BP28,60;BP24,100"
9720     No_of_reads(I33)=N
9725     FOR I=1 TO N
9730       Ts2(I33,I,1)=X(I)
9735       Ts2(I33,I,2)=Y(I)
9740       !OUTPUT 701;I,X(I),Y(I),Area
9745     NEXT I
9750     OUTPUT 2 USING "B,#";255,75
9755     DISP "DATA STORED ON SYS";I33
9760        !
9765     GRAPHICS OFF
9770     ALPHA ON
9775     PRINTER IS CRT
9780    !GOTO Loop
9785   SUBEND
9790        !*********************************************************************
9795   SUB Plot
9800     OPTION BASE 1
9805     DEG
9810     COM REAL Cal_m_b(*),Gage(*),Nametest$(*)
9815     COM Title$(*),Fp_$(*),Ts2$(*),Nam9$(*),Nam9d$(*),Idisc4$,Pr
9820     COM Ts1(*),Ts2(*)
9825     COM INTEGER No_of_reads(*),System_type(*),Touch(*)
9830     COM INTEGER Channal(*),P_no,Func$[4]
9835     COM INTEGER Chan_no,I66,R_d,Time_flag(*),Delta_flag(*),Control_flag(*),D
elta_chan__(*),Num_per_system(*),Print_flag(*),Power
9840     COM REAL Last_datum_del(*),Last_time(*),Delta_(*),Time_delta(*),Y_volts_
(*),T_d_(*),Cal_nl(*),Cal_nl_n(*)
9845     COM /Ts2_lines/ Ts2_lines(*)
9850   !
9855   ! DATA REDUCTION
9860   !
9865     PRINTER IS 1
9870     DIM Fp$(49)[10],P10(30,2),Answer$(14)[10],Question$(2,7)[10],Mess$[70],L
```

```
$[80]
9875  !
9880    PRINTER IS 1
9885    OUTPUT 2 USING "#,B";255,75
9890    Mess$="PLOT(1 TO 10)"
9895    OUTPUT 2 USING "#,B";255,75
9900    Question$(1,1)="  SYS NO. "
9905    Question$(1,2)="XFILE(Y/N)"
9910    Question$(1,3)="Crt/D/P   "
9915    Question$(1,4)="C SCALEY/N"
9920    Question$(1,5)="Plot/Table"
9925    Answer$(1)="   1"
9930    Answer$(2)="   N"
9935    Answer$(3)="   C"
9940    Answer$(4)="   N"
9945    Answer$(5)="   P"
9950    CALL Init_plot(Answer$(*),Question$(*),1,Mess$)
9955    I33=VAL(Answer$(1))
9960    Q11$=TRIM$(Answer$(2))
9965    R2$=TRIM$(Answer$(3))
9970    C_scale$=TRIM$(Answer$(4))
9975    P_or_table$=TRIM$(Answer$(5))
9980    IF P_or_table$="T" THEN
9985      PRINT "ENTER DONE WHEN FINISHED"
9990    END IF
9995  !
10000   IF I33<1 OR I33>10 THEN Exit
10005   ALLOCATE Ts(Ts2_lines(System_type(I33)),Num_per_system(I33)),Ts$(Ts2_lin
es(System_type(I33)))[14]
10010 Table_loop:  !
10015   IF P_or_table$="T" THEN
10020     SELECT Q11$
10025     CASE "Y"
10030       INPUT "ENTER XFILE",Fx$
10035       IF TRIM$(Fx$)="DONE" OR TRIM$(Fx$)="" THEN Out
10040     CASE "N"
10045       INPUT "ENTER SYS",Sy$
10050       IF TRIM$(Sy$)="DONE" OR TRIM$(Sy$)="" THEN Out
10055       I33=VAL(Sy$)
10060     END SELECT
10065   END IF
10070   IF Q11$="Y" AND P_or_table$="P" THEN INPUT "ENTER XFILE",Fx$
10075   CALL Enter_data(Q11$,I33,Fp$(*),Ts(*),Ts$(*),0,Xtouch,Xread,"N",Fx$)
10080   !P10(15,2)-1=1ST LINE,2=LAST LINE
10085  !1=X
10090  !2=Y
10095   K10=0
10100   P10(1,1)=1
10105   FOR I=2 TO Xread
10110     IF Ts(I,1)<0 THEN
10115       K10=K10+1
10120       P10(K10,2)=I
10125       IF I<Xread THEN P10(K10+1,1)=I+1
10130     END IF
10135   NEXT I
10140   K10=K10+1
10145   P10(K10,2)=Xread
10150  !
10155   !
10160   Ymin=9.E+99
10165   Ymax=-9.E+99
10170   Xmax=-9.E+99
10175   Y_sum=0
10180   FOR I=1 TO Xread
10185     Ts(I,1)=ABS(Ts(I,1))
```

```
10190      IF Ts(I,1)<Xmin THEN Xmin=Ts(I,1)
10195      IF Ts(I,2)<Ymin THEN Ymin=Ts(I,2)
10200      IF Ts(I,1)>Xmax THEN Xmax=Ts(I,1)
10205      IF Ts(I,2)>Ymax THEN Ymax=Ts(I,2)
10210      Y_sum=Y_sum+Ts(I,2)
10215    NEXT I
10220    S_ymin=Ymin
10225    S_ymax=Ymax
10230    Mean=Y_sum/Xread
10235    !
10240    IF P_or_table$="T" THEN Sort
10245    Ymax=Ymax+.01*Ymax
10250    Xmax=Xmax+.01*Xmax
10255   !IF Ymin>=0 THEN Ymin=0
10260   !IF Xmin>=0 THEN Xmin=0
10265    CALL Auscl(Xmin,Xmax,0,Xtica)
10270    CALL Auscl(Ymin,Ymax,0,Ytica)
10275    IF C_scale$="Y" THEN INPUT " ENTER XDIV,XMIN,XMAX,YDIV,YMIN,YMAX",Xtica,
Xmin,Xmax,Ytica,Ymin,Ymax
10280   !------------
10285    CALL Start_plot(R2$)
10290    D_x=ABS(Xmax-Xmin)
10295    D_y=ABS(Ymax-Ymin)
10300    FRAME
10305    Vpx=14.0187*8
10310 ! Vpx=14.0187*5.5
10315    Vpy=14.104*5
10320 ! VIEWPORT 26,Vpx+26,14,Vpy+14
10325    VIEWPORT 16,Vpx+16,14,Vpy+14
10330    WINDOW Xmin,Xmax,Ymin,Ymax
10335    FRAME
10340    Ax=100*RATIO
10345    CLIP OFF
10350 ! CALL Y_axis(Xmin,Xmax,Ymin,Ymax,Ytica)
10355 !     CALL Log_axis(Xmin,Xmax,Ymin,Ymax,"LOW")
10360 ! CALL X_axis(Xmin,Xmax,Ymin,Ymax,Xtica,0)
10365    CALL Grid(Xmin,Xmax,Ymin,Ymax,Xtica,Ytica,0,"A")
10370! ----------------------
10375! PLOT
10380    CSIZE 1.3
10385    LORG 5
10390    CSIZE 1.8
10395    J1=0
10400    FOR J=1 TO K10
10405   !   FOR I=P10(J,1) TO P10(J,2)
10410   !     MOVE Ts(I,1),Ts(I,2)
10415   !     LABEL VAL$(J)
10420   !   NEXT I
10425      PENUP
10430   !   J1=J1+1
10435   !   J1=J1 MOD 10
10440   !   IF J1=2 THEN J1=J1+1
10445   !   LINE TYPE J1
10450      FOR I=P10(J,1) TO P10(J,2)
10455        PLOT Ts(I,1),Ts(I,2)
10460      NEXT I
10465      LINE TYPE 1
10470    NEXT J
10475    PENUP
10480    LINE TYPE 3,1
10485    MOVE Xmin,Mean
10490    DRAW Xmax,Mean
10495    LINE TYPE 1
10500    PENUP
10505 !
```

```
10510   VIEWPORT 0,Ax,0,100
10515   WINDOW 0,Ax,0,100
10520 !
10525 Sort: !
10530   DISP "WAIT"
10535   FOR I=1 TO Xread
10540     FOR J=1 TO Xread
10545       IF Ts(J,2)>Ts(I,2) THEN
10550         Tem1=Ts(I,1)
10555         Tem2=Ts(I,2)
10560         Ts(I,1)=Ts(J,1)
10565         Ts(I,2)=Ts(J,2)
10570         Ts(J,1)=Tem1
10575         Ts(J,2)=Tem2
10580       END IF
10585     NEXT J
10590   NEXT I
10595   IF FRACT(Xread/2)=0 THEN   !EVEN
10600     Median=(Ts(Xread/2,2)+Ts((Xread/2)+1,2))/2
10605   ELSE                       !ODD
10610     Median=Ts(INT(Xread/2)+1,2)
10615   END IF
10620   DISP
10625   IF P_or_table$="T" THEN Table
10630   !
10635   CALL Label(1,54,6,2.5,90,"P-Po(feet of water)")
10640 !
10645   CALL Label(72,7,4,2.5,0,"TIME(seconds)")
10650   CALL Label(1,99,1,2.5,0,"")
10655   D2$="8A,4D.3D"
10660   LABEL USING D2$;"Minimum ";S_ymin
10665   LABEL USING D2$;"Maximum ";S_ymax
10670   LABEL USING D2$;"Mean    ";Mean
10675   LABEL USING D2$;"Median  ";Median
10680  !L$="FIRST TEST"
10685  !CALL Label(66,4,4,2.5,0,L$)
10690 !
10695   L$=TRIM$(Fp$(1)&Fp$(2)&Fp$(3))
10700   CALL Label(66,99,6,2.5,0,L$)
10705   CSIZE 2.3
10710   L$=TRIM$(Fp$(4)&Fp$(5)&Fp$(6))
10715   LABEL L$
10720 ! CALL Label(66,93,6,2.5,0,L$)
10725 ! CALL Label(66,93,6,2.5,0,L$)
10730   LABEL "STATION  ";TRIM$(Fp$(8))
10735   GOTO 10835
10740 !LEGEND--
10745   LORG 3
10750   CSIZE 2.3
10755   X=Vpx+16+2
10760   MOVE X,90
10765   LABEL "LEGEND"
10770   Y2=90
10775   J1=0
10780   FOR J=1 TO K10
10785     MOVE X,Y2-2*J
10790     LINE TYPE 1
10795     LABEL VAL$(J)
10800     J1=J1+1
10805     J1=J1 MOD 10
10810     IF J1=2 THEN J1=J1+1
10815     LINE TYPE J1
10820     MOVE X+4,(Y2-2*J)-1
10825     DRAW X+20,(Y2-2*J)-1
10830   NEXT J
10835   LINE TYPE 1
```

```
10840  !
10845    CALL End_plot(R2$,1)!---------
10850  !
10855!GOTO 9655
10860!INPUT "PRINT TABLE(Y OR N)",Q$
10865 Table:!
10870    IF P_or_table$="T" THEN
10875      IF Table_flag=1 THEN Table1
10880      Table_flag=0
10885      PRINTER IS Pr
10890      OUTPUT Pr USING "#,@"
10895      PRINT Fp$(1)&Fp$(2)
10900      PRINT Fp$(3)
10905 !           12345678901234567890123456789012345678901234567890123456789012345678901234
4567890123456789"
10910      PRINT "   STATION   MINIMUM   MAXIMUM      MEAN    MEDIAN"
10915      PRINT "               inches    inches    inches    inches"
10920      PRINT
10925 Table1:     !
10930      Fp$(8)=TRIM$(Fp$(8))
10935      Table_flag=1
10940      Fp8$=RPT$(" ",10-LEN(Fp$(8)))&Fp$(8)
10945      PRINT USING "10A,4(6D.3D)";Fp8$,S_ymin,S_ymax,Mean,Median
10950!FOR I=1 TO Xread
10955!   PRINT USING "7D.2D,9D.2D";ABS(Ts2(I33,I,1)),Ts2(I33,I,2)
10960!   FOR J=1 TO K10
10965!     IF P10(J,2)=I THEN PRINT
10970!   NEXT J
10975!NEXT I
10980    END IF
10985    IF P_or_table$="T" THEN GOTO Table_loop
10990 Out:  !
10995    PRINTER IS CRT
11000    SUBEXIT
11005 Exit: !
11010    BEEP
11015    DISP "SELECTION CANCELED"
11020 SUBEND
11025 !*****************************************************************
```



GPO 845-404

**Mission of the Bureau of Reclamation**

*The Bureau of Reclamation of the U.S. Department of the Interior is responsible for the development and conservation of the Nation's water resources in the Western United States.*

*The Bureau's original purpose "to provide for the reclamation of arid and semiarid lands in the West" today covers a wide range of interrelated functions. These include providing municipal and industrial water supplies; hydroelectric power generation; irrigation water for agriculture; water quality improvement; flood control; river navigation; river regulation and control; fish and wildlife enhancement; outdoor recreation; and research on water-related design, construction, materials, atmospheric management, and wind and solar power.*

*Bureau programs most frequently are the result of close cooperation with the U.S. Congress, other Federal agencies, States, local governments, academic institutions, water-user organizations, and other concerned groups.*

A free pamphlet is available from the Bureau entitled "Publications for Sale." It describes some of the technical publications currently available, their cost, and how to order them. The pamphlet can be obtained upon request from the Bureau of Reclamation, Attn D-922, P O Box 25007, Denver Federal Center, Denver CO 80225-0007.