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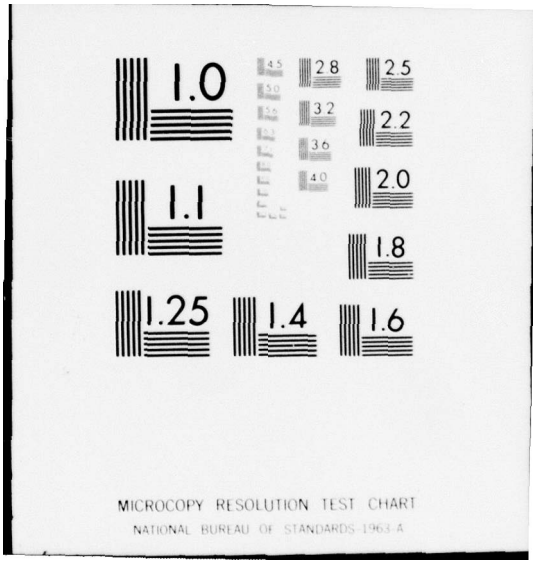
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# A SYSTEMS ANALYSIS OF WATER QUALITY SURVEY DESIGN.

~~FINAL REPORT~~
APPENDIX V.
DOCUMENTATION
AUTOMATED INSTRUMENT USER'S MANUAL.

(11) AUG 1975

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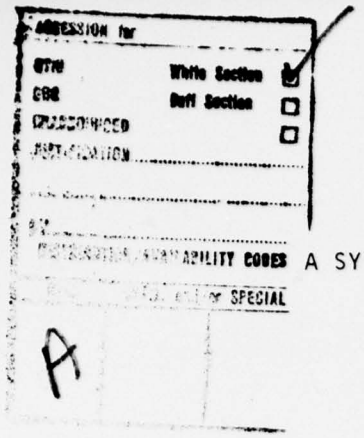


# A SYSTEMS ANALYSIS OF WATER QUALITY SURVEY DESIGN

Automated Instrument User's Manual

Author: Thomas L. Drake

APPENDIX V

August 1975

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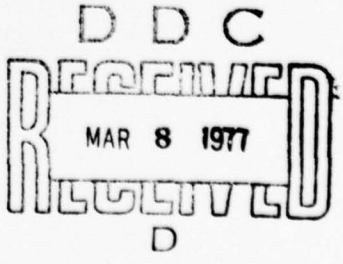

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This is the final report of a three year project titled, "A Systems Analysis of Water Quality Survey Design."

In this project a study was made of water quality surveys conducted by the United States Army Environmental Hygiene Agency (AEHA). Mainly data and reports from studies of Army Ammunition Plants (AAP) were used.

The focus of this project was the development of computer aided procedures which would assure efficient use of manpower and equipment and assure that the measurements taken give a reasonalbe representation of the system. Planning the

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survey, conducting the survey and reporting on the survey were included in the study.

The site modeling program models the manufacturing processes which contribute pollutants to the system, models the sewer system, and models the treatment system including acid or caustic neutralization, settling ponds, and domestic treatment. The inputs to the model are the production levels of the manufacturing processes and the outputs are the predicted pollutant measurement values at each possible measure point in the system.

The resource matching program accepts data defining proposed measurements and matches these against the available time, manpower, and equipment. The output lists the pollutant to be measured at each measure point, the total commitment of time for each analyst and for each piece of equipment. Note is made of any overcommitment of manpower or equipment.

The model refinement or updating program accepts measurements taken during a preliminary survey or during a regular survey and computes suggested new parameters for the process models.

The indicator model program evaluates the performance of sanitary treatment facilities.

The program uses design data, data from the operating log and/or data generated during the survey and computes key operational characteristics. Comparing these with desirable values as cited in design books and manuals will give the survey planner insight into the operation of the system and suggest the need for more survey measurements or the need for changes in operation.

A system was developed for automatic instrumentation of pH, conductivity, and other parameters which use strip charp recordings. Interface hardware was selected and purchased and interface software was developed for direct connection to a digital computer.

A data handling system was developed for use during and after the survey. A PDP8-OS/8 and peripheral equipment was purchased. Software was developed to perform data handling functions and to direct the user in application of the software. The program accepts raw data from the analytical chemist and performs data conversions, transcriptions. and data logging functions. Output is available in several forms as may be needed for various reports during and at the end of the survey.

Recommendations are: the survey planner should obtain sufficient data in a proliminary survey to model and analyze the site; measurements should be automated to the maximum extent possible; data handling should be delegated to the computer when the operations are well defined and repetitive. The programs, software and hardware included here will assist the survey planner in following these recommendations and design a more effective survey.

TABLE OF CONTENTS

## INTRODUCTION

A Fisher Scientific Accumet Model 52Ø Digital pH/Ion meter, a Yellow Springs Model 33 S-C-T meter, a Talos 514B graphic tablet, and a Digital Equipment Corporation RTØ2-BA data entry terminal are interfaced to the data handling system via a Digital Equipment Corporation PDM-7Ø programmable data mover. Figures 1 and 2 are block diagrams showing the connections between this instrumentation, the PDM-7Ø programmable data mover, and the data handling system. The manuals, supplied with each component accurately describes the operation of each component. Each component can operate in a stand-alone mode independent of the data handling system or under the control of the data handling system.

Data and commands are entered into the data handling system via either the Teletype, optical mark reader, RTØ2 data entry terminal, or automated instrumentation with the program INPUT. Several commands are provided which program the PDM-7Ø. Data reduction is provided by INPUT to convert the raw measurements received to a final measurement value.

The Talos digitizer provides the capability to the Army personnel of automating the data reduction of field strip chart recordings. By placing a strip chart on a 14 inch by 14 inch active area on the digitizer surface, the user through either a four button cursor or a stylus determine the X-Y coordinates of any point of this graph to an accuracy of .Ø1 inches. The X-Y coordinates of this point are displayed on a front panel display and can be transferred to the data handling system via the PDM-7Ø by pressing a cursor button or touching the point with the stylus. The OS/8 BASIC program WTHDL.BA is provided for handling the digitizer data.

The Fisher Scientific pH/Ion meter provides a 5 digit display on the front panel of the meter and is interfaced to the PDM-7Ø. This front panel display can be transferred to the data handling system via the PDM-7Ø by pressing the lighted button on the PDM-7Ø interface.

The Yellow Springs S-C-T meter was slightly modified to permit this meter to provide two analog outputs. One output is proportional to the S-C-T meter reading while the other output is coded to give the front panel switch settings. These analog outputs are interfaced to the PDM-7Ø with the value of the outputs being transferred to the data handling system whenever a lighted button on the S-C-T meter is pressed.

Each measurement must have an ID and a measurement value. The RTØ2 data entry terminal provides the user of the automated instrumentation the capability to enter this ID information via the keyboard for each measurement. This terminal also has a 32 character alphanumeric display to receive messages from the data handling system.

The PDM-7Ø programmable data mover provides a communications link and formatting facilities for concentrating and transferring data between a selected source and destination. This data may be in an analog, parallel BCD or binary, and serial format. The PDM-7Ø can be operated as a stand-alone unit or under the control of a host computer. Integration into the data handling system is easily accomplished through the system's standard asynchronous serial interface.

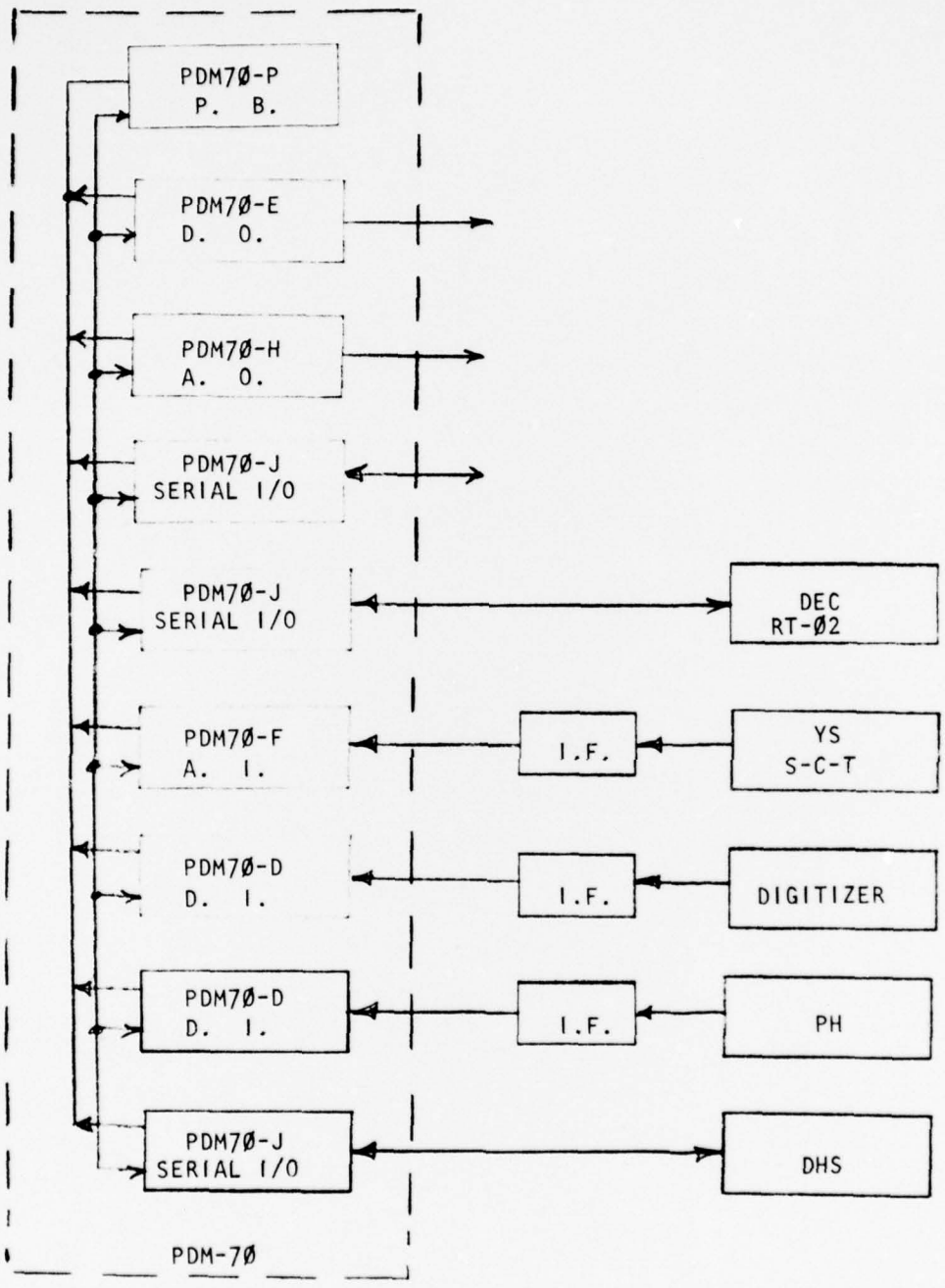


FIGURE 1 BLOCK DIAGRAM OF AUTOMATED INSTRUMENTATION

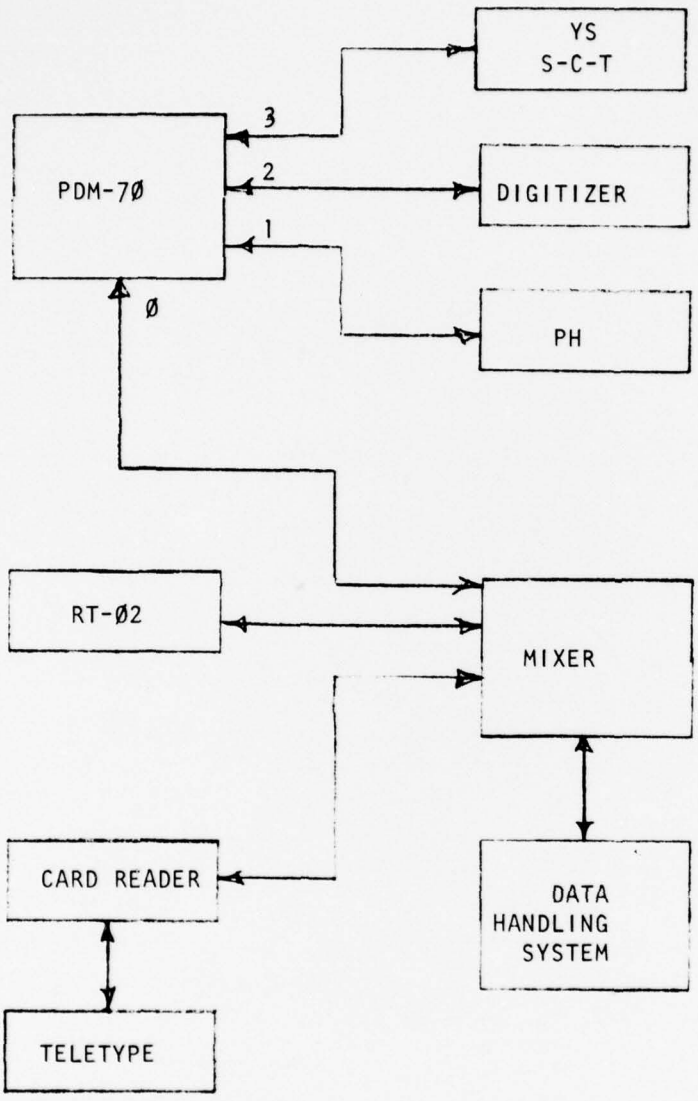


FIGURE 2 DATA HANDLING SYSTEM - AUTOMATED INSTRUMENTATION INTERCONNECTIONS

## FISHER SCIENTIFIC DIGITAL pH/ION METER

A Fisher Scientific accumet model 52Ø Digital pH/Ion meter is interfaced to the PDM7Ø-D 8-digit BCD input module. The user manual, supplied by Fisher Scientific, accurately describes, the operation of this pH/Ion meter. This interface is mounted on the back of the pH meter with a 25 foot cable connecting this interface with the PDM7Ø-D. A lighted push button on this interface box will externally trigger the PDM7Ø-D module, when pressed, and cause the present meter reading to be transferred to the PDM7Ø-D. This interface has no effect on the operation of this pH/Ion meter.

Each meter reading consists of 5 decimal digits with these 5 digits being interfaced to the PDM7Ø-D. Therefore, a front panel meter reading of 7.452 and 12.345 will be respectively interpreted by the PDM-7Ø as Ø7452 and 12345. Note that the decimal point is dropped and 5 digits are always transferred.

Data from this pH/Ion meter may be entered into the system via the program INPUT. This program receives data and commands from either the Teletype, optical mark reader, digitizer, manual data entry station, or interfaced automated instrumentation. Either the Teletype or the RT-Ø2 manual data entry terminal must be used with this pH/Ion meter to enter the ID tags for each measurement. The NTRAN data input option should be used with this program to disable translation of input character strings. In addition, the default ID input option (DEFID) and skip ID input option (SKPID) may be desirable to significantly reduce the amount of typing.

Each measurement or command received by the program INPUT must be of

the format

CMD ID1 ID2 ID3 ID4 ID1Ø ID5 ID7 ID8 ID6 V1 ... VN

where

| | | |
|---|---|---|
| CMD | = | Command Code |
| IDi | = | Day ID |
| ID2 | = | Point ID |
| ID3 | = | Period ID |
| ID4 | = | Parameter ID |
| ID1Ø | = | Methods ID |
| ID5 | = | Discrete ID |
| ID7 | = | Quality ID |
| ID8 | = | Accuracy ID |
| ID6 | = | Comment ID |
| V1 | = | First measurement |
| VN | = | Nth measurement |

Each command and each ID is a character string from Ø to 6 characters in length with a single space delimiting each field in the command string.

The operator would usually perform the following steps when using INPUT to receive pH data from the pH/Ion meter.

1. Load INPUT (R INPUT)
2. Disable Translation (NTRAN)
3. Program PDM-7Ø (PROG 1)
4. Name Chemist (NACHEM V1)
5. Specify File Name (FNAM PAR V1 V2)
6. Enable Conversions (ON)

7. Supply Default iD (DEFID ID)

8. Enable Skip ID Option (SKPID ID)

9. Enter Data

10. End (END)

The program INPUT is loaded by typing

R INPUT

and expects to receive input from the card reader. To disable translation, either the command NTRAN must be entered via a mark card or the 4 characters consisting of Line Feed, 9, 6, and Carriage Return must be typed. The (#) will be printed to specify that translation is disabled and input is expected from the Teletype keyboard.

The operator would program the PDM-7Ø to transfer data from the pH/Ion meter to the data handling system by pressing the CLEAR button on the front panel of the PDM-7Ø and then typing

PROG 1

The following commands

#DEFID 1 16 2 PH

#SKIP 1 16 2 PH H AR <

specifies to the program INPUT that the Day, Point, Period, and Parameter ID tags are respectively 1, 16, 2, and PH. For measurements, input the discrete ID tag from the keyboard and use the default ID tags for the remaining ID tags. For these input options, the user would enter a measurement using the following steps:

1. Type Space (Measurement line)

2. Type Discrete ID

3. Type Space (Discrete ID terminator)

4. Push Button on Interface to Transfer Meter Reading

5. Type Carriage Return

The program INPUT will divide the measurement value received by 1000 to yield the final measurement value. This division restores the decimal point which was ignored by the PDM-70.

An example of data entry is as follows:

```
.R INPUT
NTRAN
#PROG 1
#FNAME PH 01 05
#NACHEM 01   DRAKE
#ON
#DEFID 1 16 2 PH   CL AR
#SKPID 1 16 2 PH   CL AR <
# 1 07324     *  7.324
# 2 06321     *  6.321
# 3 12126     * 12.126
#DEFID 1 S3 2 PH
# 1 04324     *  4.324
# 2 07324     *  7.324
# 3 0761      * 10.761
```

This example receives the measurements

```
1 16 2 PH  1 CL AR   7.324
1 16 2 PH  2 CL AR   6.321
```

```
1 16 2 PH  3 CL AR  12.126
1 S3 2 PH  1         4.324
1 S3 2 PH  2         7.324
1 S3 2 PH  3        10.761
```

## YELLOW SPRINGS MODEL 33 S-C-T METER

A Yellow Springs Model 33 S-C-T meter is interfaced to the PDM7Ø-F analog input module. Channel Ø of the PDM7Ø-F receives an analog signal proportional to the S-C-T meter reading. Channel 1 of the PDM7Ø-F receives an analog signal which is coded to indicate instrument functions. This S-C-T meter was slightly modified internally to accomplish this interface. A lighted push button was added to this instrument to trigger the PDM7Ø-F.

Data from this S-C-T meter may be entered into the system via the program INPUT. Either the Teletype or the RT-Ø2 manual data entry terminal must be used with this S-C-T meter to enter the ID tags for each measurement. For input from a keyboard, the program INPUT should be used with the NTRAN, DEFID, and SKPID input options.

Each measurement or command received by the program INPUT must be of the format

CMD ID1 ID 2 ID3 ID4 ID1Ø ID5 ID7 ID8 ID6 V1 ... VN

where

CMD = Command Code

ID1 = Day ID

ID2 = Point ID

ID3 = Period ID

ID4 = Parameter ID

ID1Ø = Methods ID

ID5 = Discrete ID

ID7 = Quality ID

ID8 = Accuracy ID

ID6 = Comment ID

V1 = First Measurement

VN = Nth Measurement

Each command and each ID is a character string from Ø to 6 characters in length with a single space delimiting each field in the command string.

The operator would usually perform the following steps when using INPUT to receive conductivity data from the S-C-T meter.

1. Load INPUT (R INPUT)
2. Disable Translation (NTRAN)
3. Program PDM-7Ø (PROG 3)
4. Name Chemist (NACHEM V1)
5. Specify File name (FNAM PAR V1 V2)
6. Enable Conversions (ON)
7. Calibrate (CN PAR V1 V2 V3 V4 V5 V6)
8. Supply Default ID (DEFID ID)
9. Enable Skip ID Option (SKPID ID)
10. Enter Data
11. End (END)

The program INPUT initially expects to receive input from the card reader. To disable translation, either the command NTRAN must be entered via a mark card or the 4 characters consisting or Line Feed, 9, 6, and Carriage Return must be typed. The (#) will be printed to specify that translation is disabled and input is expected from the Teletype keyboard.

The operator would program the PDM-7Ø to transfer data from the S-C-T meter to the data handling system by first pressing the CLEAR button on the

PDM-7Ø front panel and then typing

PROG 3

The data reduction algorithm for conductivity must be calibrated. This is accomplished with the following steps:

1. Type CN followed by a Space
2. Type COND followed by 2 Spaces
3. On X1 range and Ø conductivity reading, type Ø followed by space
4. Push button on meter to enter meter reading.
5. On Red Line, type 37Ø followed by a space
6. Push button on meter to enter meter reading
7. Type a Carriage Return.

This calibration sequence should produce a typical command line such as the following:

#CN COND Ø 3ØL+ØØØ7 31L+1965 37Ø 3ØL+Ø376 31L+Ø941

CN = Calibration Command

Ø = Current Conductivity Meter Reading

3ØL+ØØØ7 = Measurement by PDM-7Ø of Ø Meter Reading

31L+1965 = Function Information from PDM-7Ø

37Ø = Current Conductivity Meter Reading

3ØL+Ø376 = PDM-7Ø Channel Ø Reading

31L+ØØ41 = PDM-7Ø Channel 1 Reading

This calibration sequence can be entered at any time.

This calibration can be checked with the command CHCAL at any time as follows:

1. Type CHCAL
2. Type Space
3. Type COND

4. Type 2 Spaces

5. Enter a conductivity measurement by pressing button

6. Type Carriage Return

A typical print out is as follows:

#CHCAL COND 3ØL+Ø418 31L+16Ø5 * 412Ø

Note that each time the push button is pressed, the PDM-7Ø sends 18 characters to the program INPUT. Each measurement is identified by a PDM-7Ø module number (3), channel number (Ø or 1), gain (L), and a signed 4 digit reading followed by a space.

## TALOS DIGITIZER SYSTEM

The Talos Cybergraphic Data Tablet and Digitizer system consists of the following items:

Tablet

Stylus

Cursor

Electronic Conversion Unit

BCD Display

Power Cord

Manual

Interface to PDM70-D 8-Digit Input

This system converts the position information of either a stylus or a cursor on the 14" by 14" active digitizer tablet surface into a digital tablet surface into a digital output that can be displayed and processed by the computer. The lower left hand corner of the active tablet surface has the X,Y coordinates of (1400, 1400). A complete description is found in the operator's manual supplied with the Talos digitizer.

Figure 3 shows a simplified block diagram of the connections between the components which comprise this system. The digitizer will operate in a stand alone mode with or without the PDM70-D interface connected.

The system would normally be operated in the Point Mode. A single conversion in this mode is performed whenever either a Pen Down condition or a Cusor Switch activation. The Pen Down condition is accomplished by pressing the stylus against the active tablet surface. The tip of the stylus has a microswitch to detect this Pen Down condition. The Cursor Switch activation is accomplished by pressing any one of the four buttons

located on the cursor.

The Margin Indicator turns on whenever the Pen or Cursor is moved outside of the specified active area of the tablet. The Pen Proximity turns on whenever the Pen or Cursor is brought close to the Tablet surface. The Power Switch is present on the electronic conversion unit.

The System is capable of detecting the Pen position through various media that have a low dielectric constant, such as paper, wood, most plastics, rubber, and glass.

The tablet cannot be used to digitize in the proximity with conductive materials such as metal or partially conductive materials such as pencil lead or certain felt tip inks.

The OS/8 BASIC program WTHDL.BA is provided for handling the Talos digitizer data. This program receives X-Y coordinate information from the digitizer on-line, converts these coordinates from the digitizer units to the units of the strip chart recording, and places these converted coordinates in a file. The program provides the user with the capability to edit the data received from the digitizer and the data within the data files created by this program. These data files are OS/8 ASCII format files and can be accessed by any OS/8 BASIC program.

The PDM-70/digitizer interface permits the following information to be transferred as an 8 BCD digit character string:

X coordinate

Y coordinate

Cursor Button

Margin Indicator

A margin indication indicates that the information received is invalid.

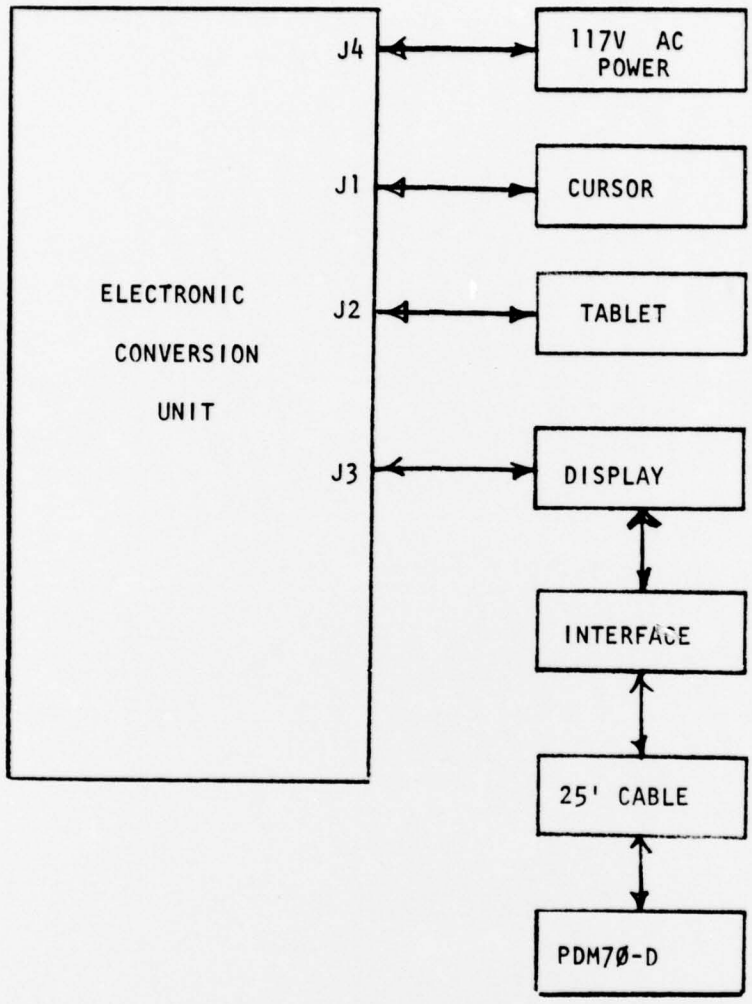


FIGURE 3 BLOCK DIAGRAM OF DIGITIZER

## WTHDL.BA

The OS/8 BASIC program WTHDL.BA is provided for handling the Talos digitizer data. While in the input mode, this program receives x-y coordinate information from the digitizer on-line, converts these coordinates from digitizer units to the units of the strip chart recording, and places these converted coordinates in a file. While in the edit mode, this program provides the user with the capability to edit the data received from the digitizer and the data within the data files created by this program. These data files are OS/8 ASCII files and can be accessed by any OS/8 BASIC program.

This program has a coordinate buffer array to store those x-y coordinates which have been received from either the Talos digitizer, keyboard, or data file. The number of coordinates which can be handled by this program is 500. This program assumes that the Talos digitizer is interfaced to the data handling system via the PDM-70.

On input, each coordinate $(X_d,Y_d)$ received from the digitizer is converted to $(X_g,Y_g)$ by the linear conversion equations

$$X_g = S_1 X_d + B_1$$

$$Y_g = S_2 Y_d + B_2$$

where the calibration coefficients $(S_1, B_1, S_2, B_2)$ are determined via a calibration step. A calibration step is entered when the input mode is entered for the first time.

At the beginning, the message

FUNCTION?

is printed for the user to select a program mode of operation. The user must respond with

I Input Mode

E Edit Mode

P Program PDM-70

S Save Option

to specify this mode. The user must program the PDM-70 before data can be received from the Talos digitizer.

Input Mode

When "I" is typed for the function, the program prints

FILE EXTENSION?

to receive a two character file extension from the operator for the file to be created. This file is on device DSK with the file name of WTDATA. If the operator typed the characters "ØI", the input data from the digitizer would be placed within the file DSK:WTDATA.ØI.

The program prints

ENTER 4 POINTS

to receive 4 calibration X-Y coordinates from the digitizer and 4 corresponding coordinate values from the keyboard. The first 2 coordinates calibrate the X-axis while the last 2 coordinates calibrate the Y-axis. After receiving each coordinate from the digitizer, the program will print the actual values received and then request from the operator via the keyboard the corresponding graph X or Y coordinate. A typical print out might be

```
ENTER 4 POINTS
X = 47  Y = 71Ø
X = ? Ø
X = 1203 Y = 692
X = ? 1Ø
X = 577  Y = 11Ø
Y = ? -1Ø
```

X = 633  Y = 131Ø

Y = ? + Ø

all coordinate values from the digitizer are positive integers and are less than 14ØØ.

The program now prints

ENTER PLOT

to announce that it is now ready to accept X-Y coordinates from the digitizer. After each coordinate is received, the program prints the converted X-Y coordinate values. A typical printout might be

1.34  7.65

1.57  5.34

3.42  -4.27

When a margin error is detected, the program prints

MARGIN ERROR

and ignores this point.

It is possible to enter information into the program from the keyboard instead of the digitizer as both of these devices are connected in parallel. A response, such as typing RETURN, from the keyboard will generally cause an input error. When an input error is detected for any reason other than a margin error, the program enters the edit mode.

When receiving input from the digitizer, OS/8 BASIC uses a special Teletype handler. This input handler doesn't echo characters received. This handler has also terminates input wheneber characters are not received within a specified time.

The input mode can also be entered from the edit mode. For this case, the calibration step and file name step are usually omitted. When the input mode is entered from the edit mode, data already has been entered from either the digitizer, a file, or both.

Edit Mode

The edit mode can be entered by typing "E" in response to a function request at the start of the program. The program prints

FILE?

to receive a user specified file. This specification must contain the device, file name, and extension. An invalid name will result in a BASIC runtime error. The data in this file is loaded into a data array. When the edit mode is entered from the input mode, the data is already present in this data array.

To receive edit commands, the program prompts the user with a (#) character and expects one of the following commands:

| | |
|---|---|
| O | Order Coordinates |
| L | List Coordinates |
| C | Change a Coordinate |
| D | Delete a Coordinate |
| I | Enter Input Mode |
| A | Add a Coordinate |
| END | End |

The List (L) command prints for each coordinate a point number, X value, and Y value. The point number is a positive integer starting at zero.

The Order (O) command orders the X-Y coordinates in the buffer according to the value of X from the smallest to the largest.

The Change (C) command permits any X-Y coordinate in the buffer to be modified. This command prints

PT. #?

to request the point number of the coordinate to be changed. If this number is valid, the program prints the old X value and requests a new X from the operator. The program then prints the old Y value and requires the

operator to type a new Y value. A typical print out might be as follows:

```
#?C
PT. #? 11
OLD X = 4.7
NEW X = ? 5
OLD Y = 11.3
NEW Y = ? 7
```

The Delete (D) command permits any X-Y coordinate in the buffer to be deleted. This command prints

```
PT. #?
```

to request the point number of the coordinate to be deleted.

The Input (I) command places the program in the input mode. All coordinates received while in the input mode are added to the current buffer.

The Append (A) command receives a X-Y coordinate from the keyboard and adds this coordinate to the end of the buffer. To receive this data, the program prompts the operator with the following messages:

```
X = ?
Y = ?
```

The End (END) command causes a file to be created with the file name specified at the beginning of either the edit or input mode.

Program Mode

When "P" is typed for the function, the program prints

```
PRESS  PDM-7Ø  CLEAR?
```

to instruct user to press CLEAR button on the front panel of the PDM-7Ø. After this has been pressed, the user should type a RETURN on the keyboard. A program is sent to the PDM-7Ø which selects the Talos digitizer as a source of data and the PDP-8/E as the destination of data. This mode must be entered one time prior to entering the input mode.

File Format

The 2N points which define the N coordinate values are placed in the output file using BASIC program similar to the following:

```
100         FILE  #1: F$
110         FOR  I=0  TO N-1
120         PRINT  #1: W(I)
130         NEXT I
140         CLOSE #1
```

Note that this is an OS/8 ASCII file with one numeric value per line. The first numeric value (I even) is the X-coordinate while the second numeric value (I odd) is the Y-coordinate.

Save Option

When "S" is typed, the program prints the message

SAVE OPTION (YES,NO)?

for which the operator must respond with a YES or NO response. When the save option is enabled, the current coordinate buffer is saved within the file specified at the start of either the input or edit mode on a mode change from either input to edit or from edit to input mode. When save option is disabled, the coordinate buffer is placed in the designated file only when an END command is typed while in edit mode. The program initially has this option disabled.

## RT-Ø2 DATA ENTRY TERMINAL

The RT-Ø2 data entry terminal provides a full alphanumeric keyboard and a 32-character plasma display. This terminal sends and receives the same character codes as the Teletype. However, the Teletype sends upper case alphabetic characters while this terminal sends both upper and lower case characters.

Several data input/output options are build into this terminal. Generally, the EIA RS-232C levels with an 11Ø/11Ø baud transmit/receive rates are normally used. In addition, the data handling system expects this terminal to be operated in a full duplex mode.