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An Interactive, Computer-Based Management System for Hydrologic Data

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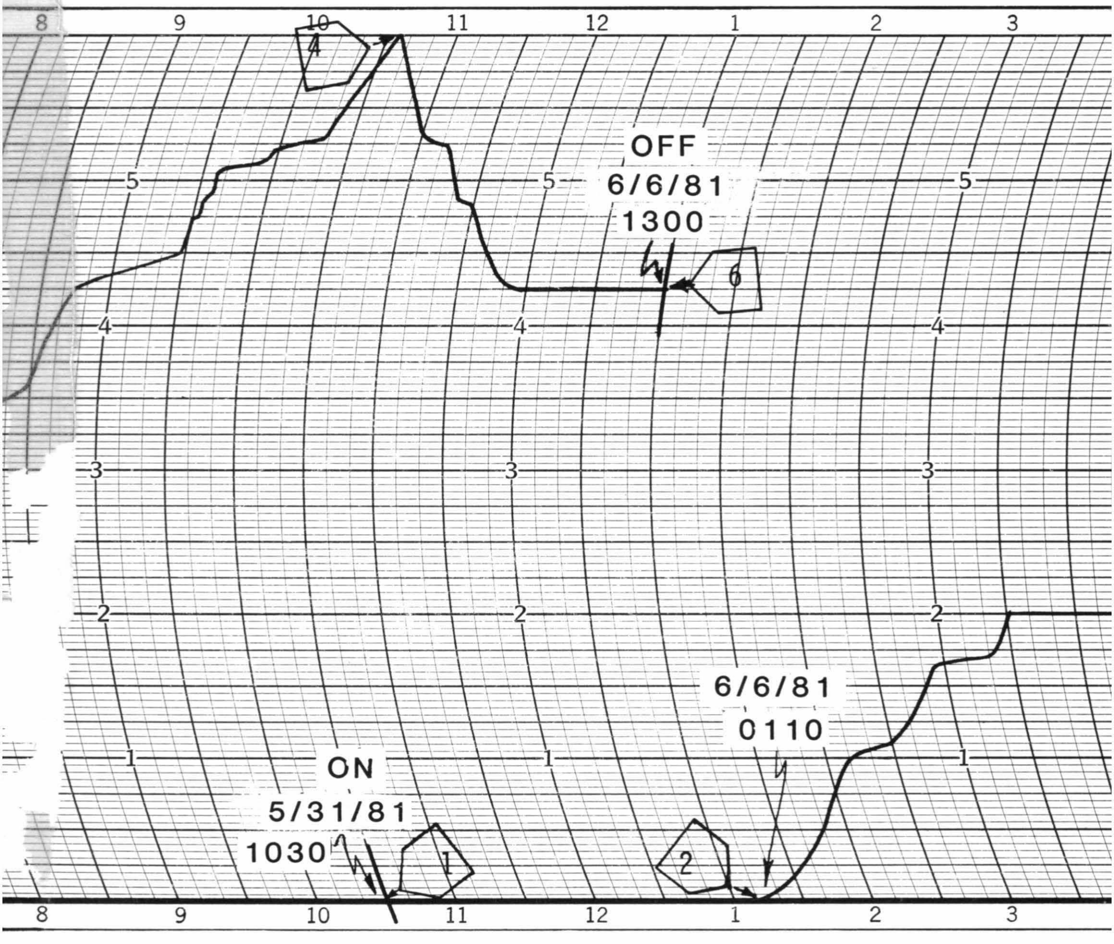

James R. Nichols, Dean and Director
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The Virginia Agricultural and Mechanical College came into being in 1872 upon acceptance by the Commonwealth of the provisions of the Morrill Act of 1862 "to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life." Research and investigations were first authorized at Virginia's land-grant college when the Virginia Agricultural Experiment Station was established by the Virginia General Assembly in 1886.

The Virginia Agricultural Experiment Station received its first allotment upon passage of the Hatch Act by the United States Congress in 1887. Other related Acts followed, and all were consolidated in 1955 under the Amended Hatch Act which states "It shall be the object and duty of the State agricultural experiment stations . . . to conduct original and other researches, investigations and experiments bearing directly on and contributing to the establishment and maintenance of a permanent and effective agricultural industry of the United States, including the researches basic to the problems of agriculture and its broadest aspects and such investigations as have for their purpose the development and improvement of the rural home and rural life and the maximum contributions by agriculture to the welfare of the consumer . . . "

In 1962, Congress passed the McIntire-Stennis Cooperative Forestry Research Act to encourage and assist the states in carrying on a program of forestry research, including reforestation, land management, watershed management, rangeland management, wildlife habitat improvement, outdoor recreation, harvesting and marketing of forest products, and "such other studies as may be necessary to obtain the fullest and most effective use of forest resources."

In 1966, the Virginia General Assembly "established within the Virginia Polytechnic Institute a division to be known as the Research Division . . . which shall encompass the now existing Virginia Agricultural Experiment Station . . . "

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ABSTRACT

An automated system has been developed to digitize the continuous traces generated by strip chart recorders. The system is comprised of an electronic digitizer, computer terminal, mainframe computer, and customdesigned software. The digitizer is connected to a computer terminal with a cassette tape operating in local mode when a chart is being digitized. After digitization is completed, an interactive processing system consisting of a system controller and a series of Fortran programs is accessed to perform various data management, data error diagnostics, data reduction, data summary, and graphics functions.

Acknowledgments

Special thanks are extended the Virginia Agricultural Foundation for an equipment grant that made this study possible. Contributions from Louise Howard, Kara Hurst, J.Nick Jones, Jr., and Phillip McClellan also are gratefully acknowledged.

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INTRODUCTION

In 1967 Shanholtz and Burford (1967) presented a series of programs for the analysis and reduction of hydrologic data. The system includes programs for manipulating precipitation, streamflow, temperature, air movement, soil moisture, and land-use-related data. The programs were successful in reducing the data into the standard forms recommended by Hobbs and Crammatte (1964) and more recently by Brakensiek et al. (1979) in a routine manner. The original programs were developed for use on an IBM 7040-1401 computer, accepted input information from cards or magnetic tape, and had magnetic tape output. All processing of these programs was in the batch mode.

With this system, however, visual data interpretation and data input were too laborious, and alternative methods were developed. The first development was an error diagnostic package which scanned basic data sets for machine detectable errors (Carr et al., 1980). This routine successfully eliminated the need for time consuming manual scanning of data records. The second major development was the use of digitizers to mechanically record the line traces from strip charts. As a consequence, additional software was written to make the digitizer output compatible with required inputs of the existing programs. The resulting program still operated in a batch mode, but used the interactive Conversational Monitoring System (CMS) available on the IBM/370 mainframe for input, previewing, and editing of data sets.

Despite this progress, the task of converting line traces on strip charts to completely processed data (for example, rainfall amount and intensity) still required considerable monitoring by skilled personnel. The seemingly endless codes for site locations, gauge types, gauge numbers, and chart types, and the complexity of the column-oriented format caused numerous operator errors. Consequently, the design of a new set of programs was undertaken to more fully use the power of an interactive programming environment.

In the interactive mode, a program is executed on a terminal where errors are displayed as they occur and corrections may be made before processing continues. As a result, errors can be detected and corrected in a single run. Interactive programs normally use "English" or "user friendly" type commands to allow non-programmers to submit programs and data without learning complex data base codes or detailed computerprogramming techniques.

The system described herein was developed to aid in the processing of strip charts used in the collection of hydrologic data. It was designed to run in conjunction with the IBM CMS time-sharing package (Version 6) available at the VPI&SU Computer Center and with Numonics automated digitizing hardware (Model 1224). The programs were written in FORTRAN IV and the CMS EXEC language.

DIGITAL CONVERSION OF ANALOG DATA

Hardware

An electronic digitizer micro-processor [Numonics 1224 (Figure 1)] interfaced with a computer terminal with dual cassettes [Texas Instruments, TI 733] was used to convert line traces to digital format. Characteristics of this system that affect the digitizing of strip charts include operating mode, data conversion, and transfer options. Characteristics of the system configuration described herein are summarized below. Additional details can be obtained from the Numonics Users Manual (Numonics).

Operation Mode

The digitizer operates in a Cartesian coordinate system and requires a reference X-Y axis. The digitizer contains an option to allow rotation of the X-Y axes to simplify chart placement. For example, if a chart is placed as shown in Figure 2, the X and Y axes would be referenced as indicated, eliminating the need to align charts with pre-determined X-Y axes.

Data Conversion and Transfer Options

Data can be transferred to the TI terminal by the digitizer in either the automatic or the manual mode. In the manual mode, coordinates are sent to the terminal by pressing the enter key [En] on the digitizer keyboard or by depressing a foot pedal.

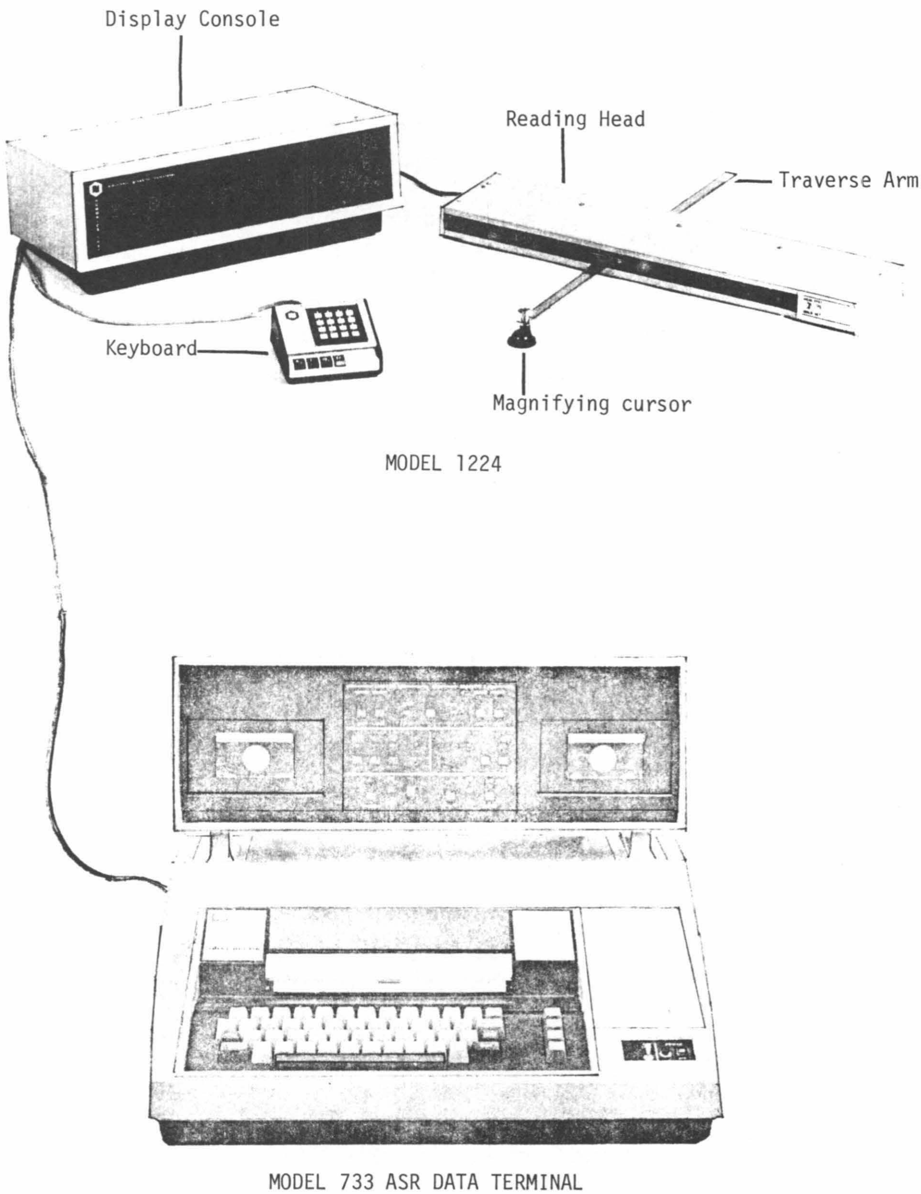

Figure 1. Numonics 1224 electronic digitizer/microprocessor interfaced with TI 733 computer terminal with dual cassettes.

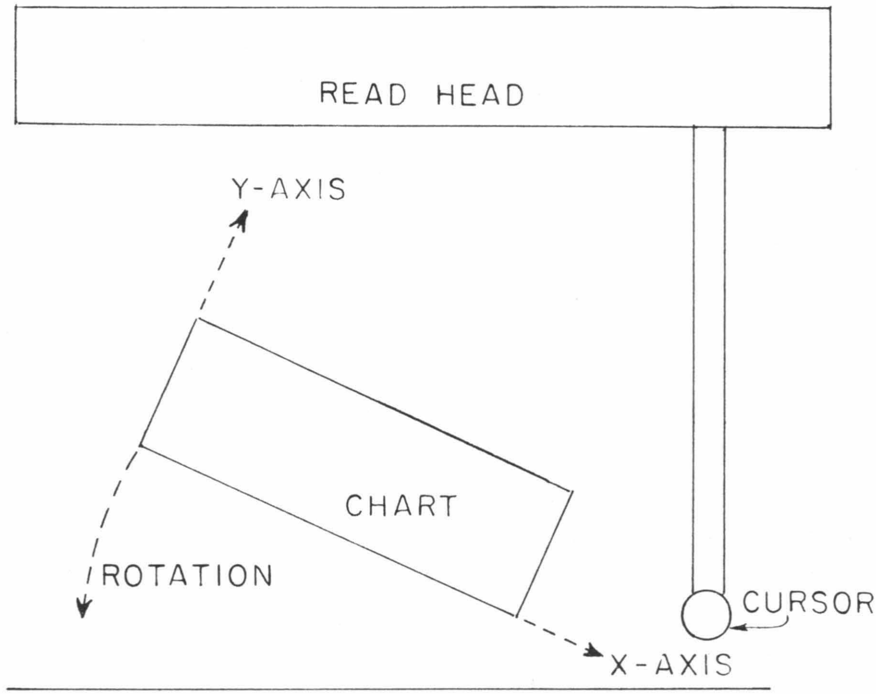

Figure 2. AXIS rotation procedure.

The automatic data transfer mode uses two digitizer options. The first is the OUTPUT IMAGE option, which uses programmable non-volatile memory to control the format of data written to the cassette tape. This option also allows keys [1] through [6] on the digitizer keyboard to be pre-programmed to enter values of 1111.0, 2222.0, 3333.0, 4444.0, 5555.0 and 6666.0, respectively. This multiple key function provides a method for entering data management and error codes during chart digitizing. OUTPUT IMAGE is the default option and is accessed when the digitizer is turned on.

The resolution of data selection is controlled by the MAPPING INCREMENTAL OUTPUT option. The system accuracy is limited to a 0.25 mm (0.01 in) change in the X or Y coordinate, which is the accuracy increment that is typically used. To implement this option, desired resolutions are entered for both the X and Y coordinates, which may be the same or different. As the cursor is moved along the pen trace, the data are sent automatically to the tape cassette at the selected increments. Because the digitizer send rate can exceed the terminal receive rate, the cursor must be moved at a rate less than or equal to the receive rate to avoid data loss.

The above hardware features and chart characteristics are the basis for the procedures which were developed to properly convert and transfer data from strip charts. These procedures are discussed in the following sections.

Software

Transformation Functions

Many strip charts have curvilinear time scales. Because the digitizer operates in a Cartesian system, transformation functions are necessary to relate the linear time coordinate of the digitizer to the corresponding curvilinear time coordinate of the strip chart. For example, Point A in Figure 3 would be recorded by the digitizer as (T_2,y) while the actual coordinate of Point A in strip chart time is (T_3,y). For the example shown in Figure 3, the time coordinate must be corrected by an amount $XC = T_3-T_2$.

A general function to provide this correction was developed from the geometry of Figure 4. The development was simplified because the time axis of hydrologic charts is normally the arc of a circle. Based on experience gained from digitizing charts, the chart time arc was expanded to include the chart width so that the chart edges could be used as a reference to define the y-axis. This was accomplished by expanding the time arc from the top recording line to the edge of the chart paper, and expanding the arc an equivalent distance below the bottom chart line (Figure 5). Referring to Figure 4, the radius for the time arc is given by

$$R = (S_1^2+YCC_1^2)/2S_1 \qquad (1)$$

where:

R = the radius of the circle;

S_1 = the distance from the chord YC_1 to

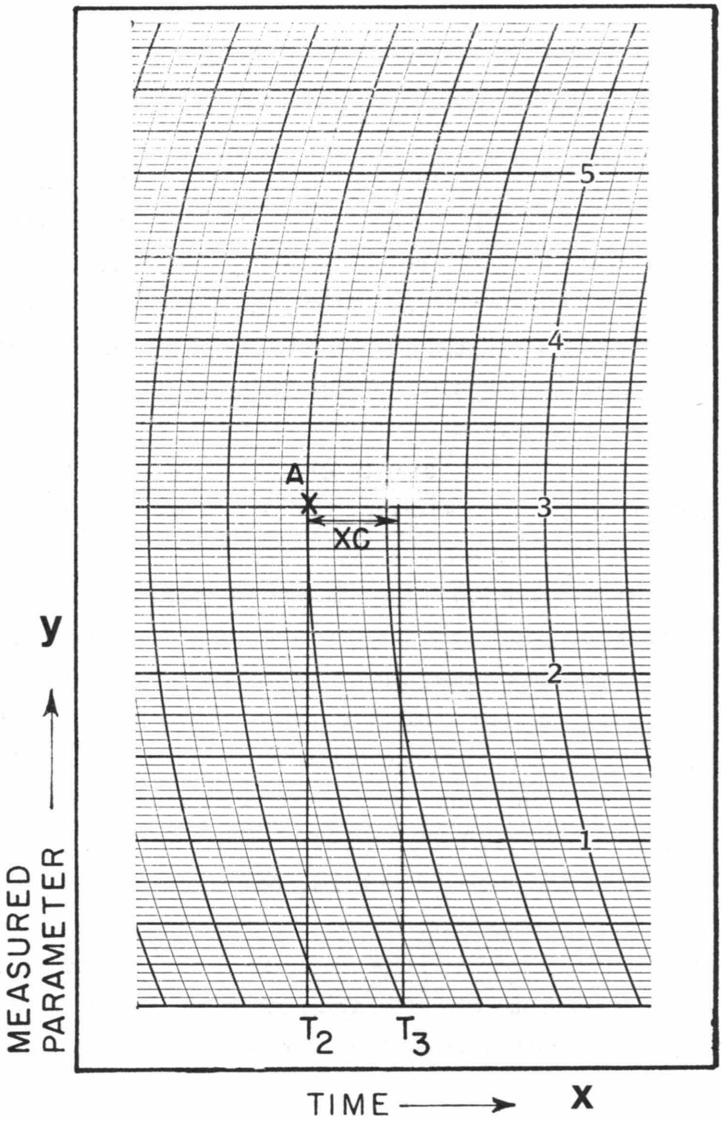

Figure 3. Time adjustment for curvilinear charts.

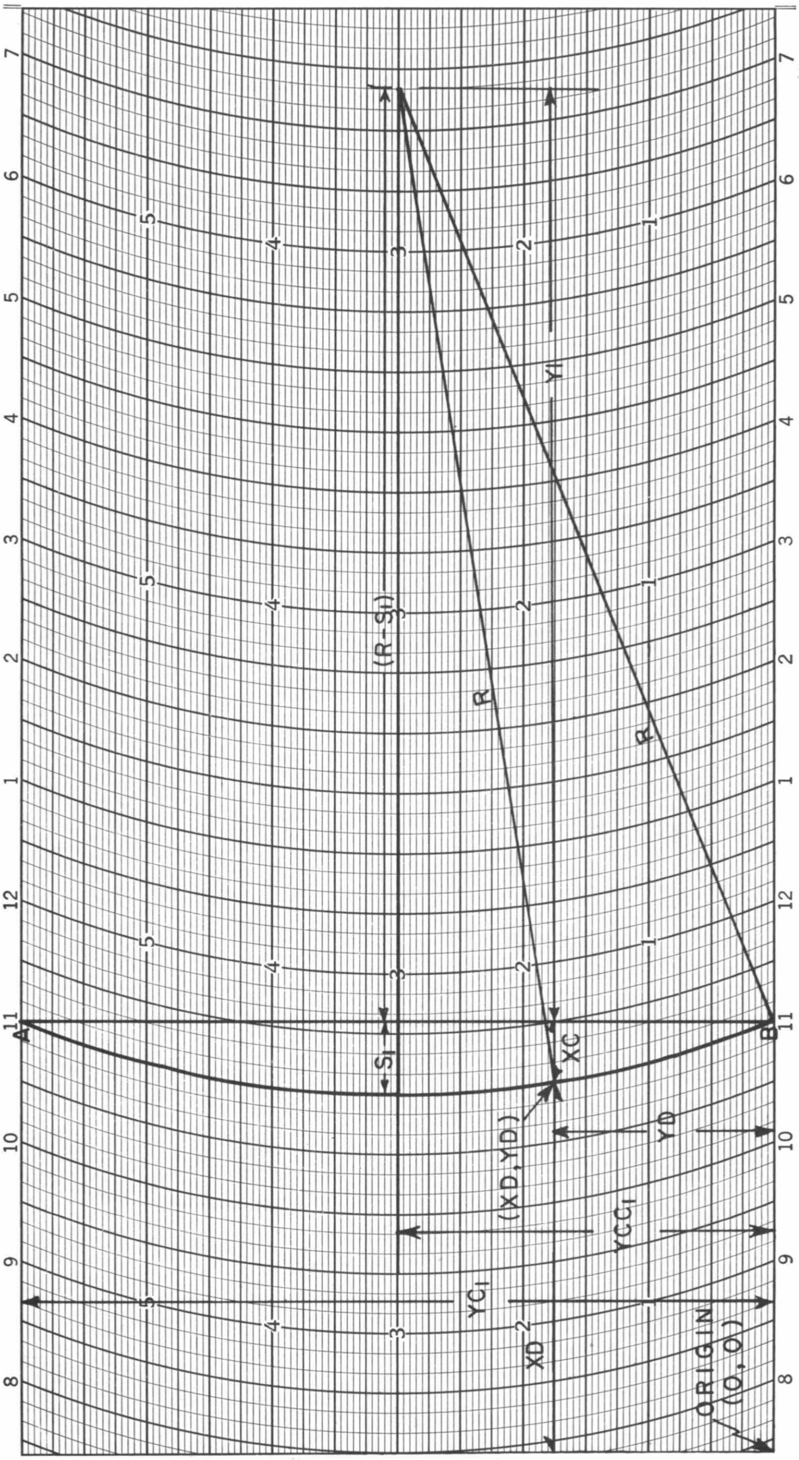

Figure 4. Schematic used to determine radius (R) of arc.

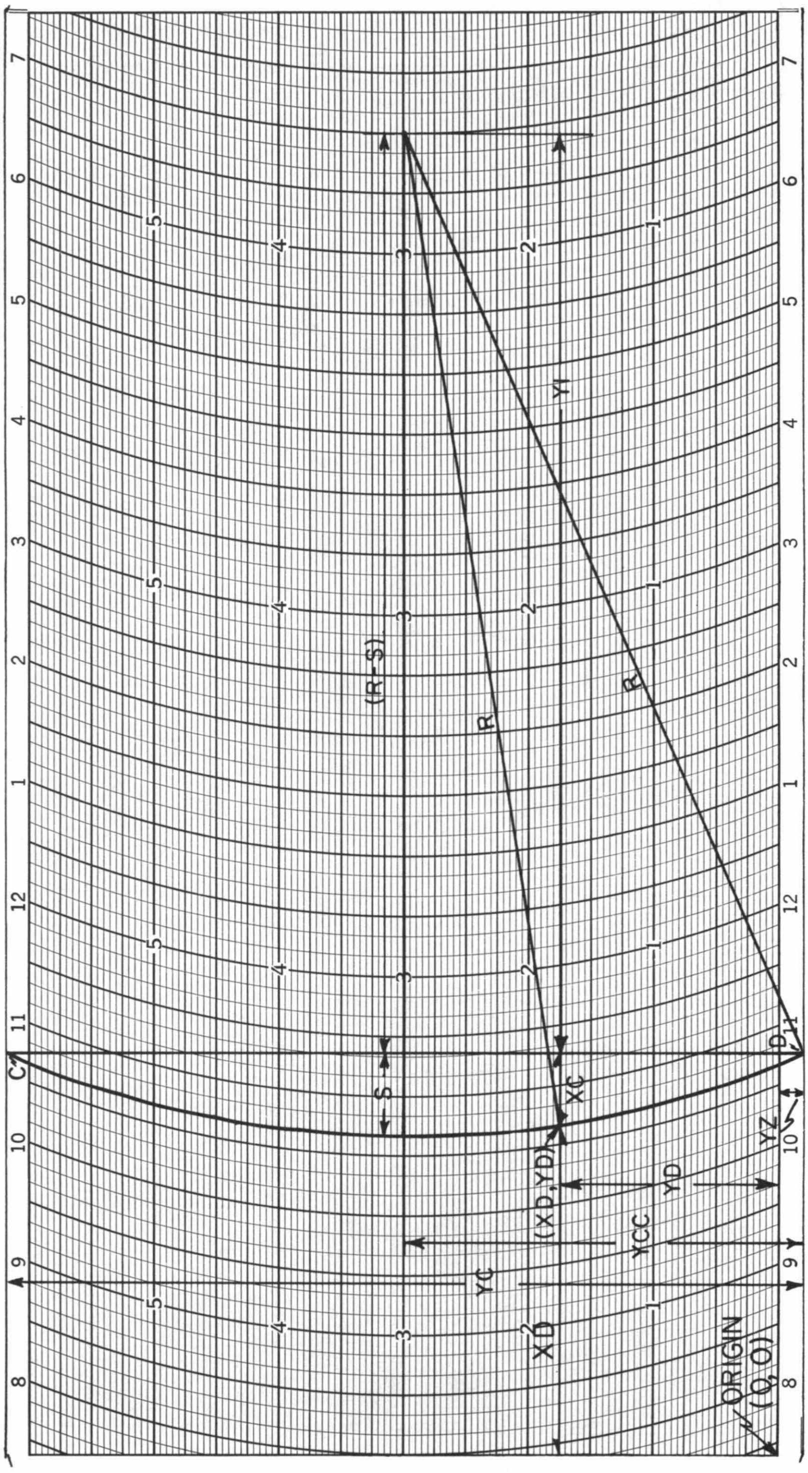

Figure 5. Schematic used to develop transformation function for curvilinear strip charts.

the arc at the midpoint of the chord; and

YCC_1 = 1/2 the chord length YC_1.

The values of S_1 and YCC_1 were obtained from each chart (e.g., see Figure 4).

A second equation, which used the geometry of Figure 5, was developed to calculate the correction for each Y-coordinate obtained by the digitizer, using the radius R obtained from Equation (1), the characteristic chord length of the chart, and the coordinate obtained by the digitizer. The magnitude of the correction, XC, depends on the vertical distance from the edge of the strip chart and is given by the relationship:

$$XC = -Y_1+[R^2-(YCC-YD)^2]^{0.5} \qquad (2)$$

where:

XC = the amount of correction;

Y_1 = R-S (S is the measured distance from the mid-chord arc);

YCC = one half the chord length (YC); and

YD = the Y coordinate obtained by the digitizer.

The X-coordinate (time) obtained by the digitizer, XD, is corrected with the expression:

$$X_{actual} = XD+XC \qquad (3)$$

Management and Error Identification Codes

Management and error identification codes were developed to aid digitizing and to provide flags for pre-processing the digital output. The OUTPUT IMAGE multiple keys, discussed previously, are used to enter codes.

Management Codes -- The first management code is 1111.0 and is assigned to key [1]. This entry flags the beginning of a chart. The second management code, 2222.0 (key [2]), is used to specify the beginning of an event. The third management code, 3333.0 (key [3]), is used to flag the end of a time span. This code is entered when the right edge of a chart is reached. The fourth management code, 4444.0 (key [4]), is used to indicate recording-pen reversals. This code is entered at the point where the pen trace reverses direction at the top or bottom of the chart, and is explained more fully in the section on vertical chart registration. The last management code, 6666.0 (key [6]), is used to flag the end of a line trace, which may wrap around a chart more than once. Use of the codes is illustrated in Figure 6.

Error Codes -- The error code is 5555.0 (key [5]) and is used to flag data digitized incorrectly. The code is entered when an error is made during digitizing. A management code must immediately follow the error code to specify the section of data in error. The data are then corrected by restarting digitization at the point specified by the management code. For example, if an error is made while digitizing the chart shown in Figure 6 after the beginning of the 0110, 6/6/81 storm event, then to correct the error the codes 5555.0 and 2222.0 are entered, which would indicate that

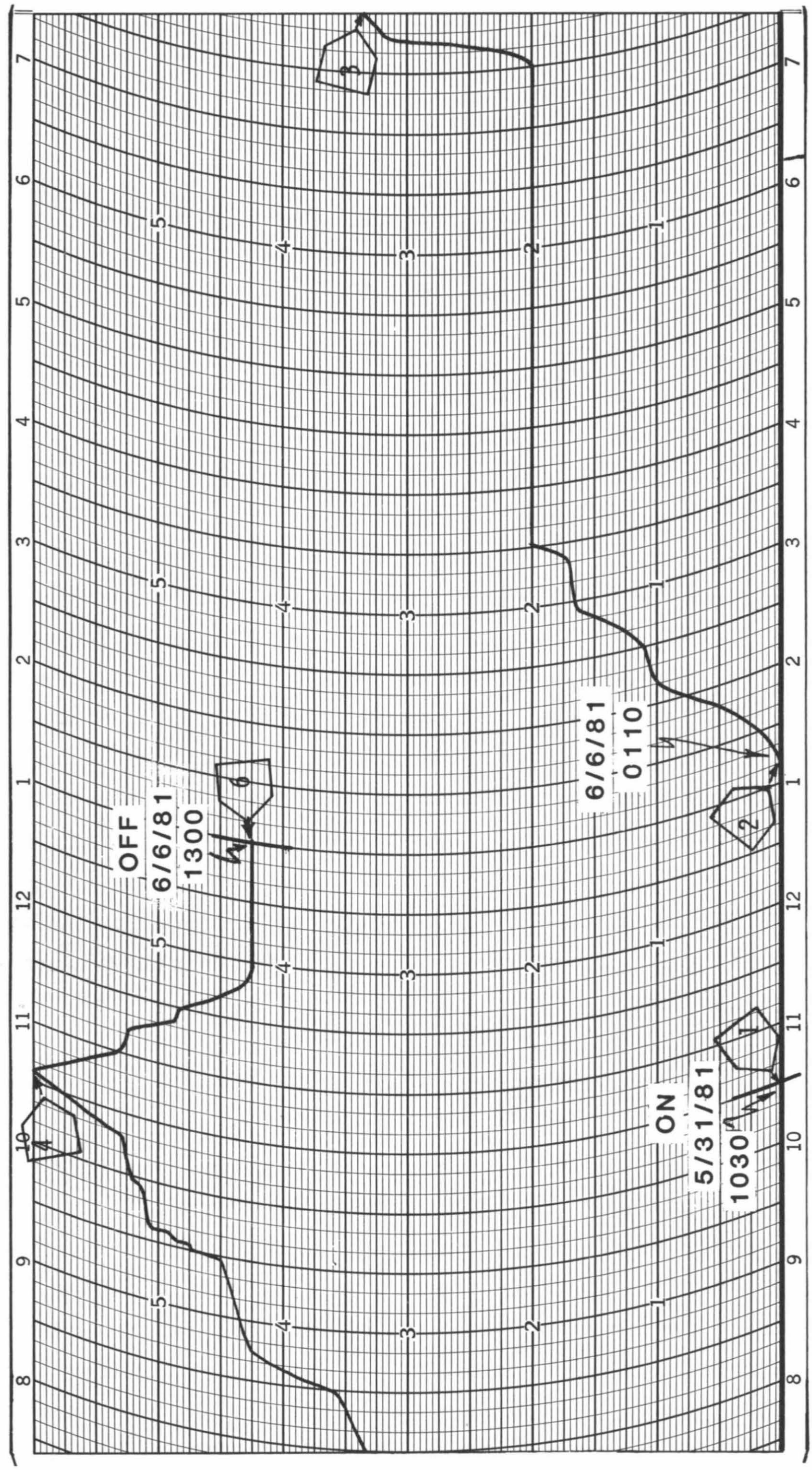

Figure 6. Management codes used while digitizing.

digitizing is to be restarted at the beginning of the storm event 0110, 6/6/81. The management code, 2222.0, is not re-entered during a restart.

Horizontal Chart Registration

Recording data on charts attached to rotating drums often results in multiple pen traces. When the chart is removed, a long continuous pen trace may appear as multiple segments where a segment is actually one continuous time span (see line A-C, Figure 7). The multiple pen traces must be converted to an equivalent continuous pen trace. To achieve horizontal registration, a procedure was developed to accumulate the X-coordinate by adding the sum of previous time spans to the X-coordinate in the time span being digitized. The OUTPUT IMAGE multiple key [3] (data management code 3333.0) is used to flag the end of a time span which will continue from the left side of the chart (Point B, Figure 7).

Vertical Chart Registration

Some strip chart data recorders are designed so that the pen reverses its direction of travel at chord end points (see A-B, Figure 4) to increase recording range. Because coordinates obtained after a reversal may be increasing or decreasing, a flag was necessary to insure proper vertical registration of data. The management code 4444.0 was assigned to flag reversals. The code is entered with a OUTPUT IMAGE multiple key [4] when reversals are encountered (see Figure 6).

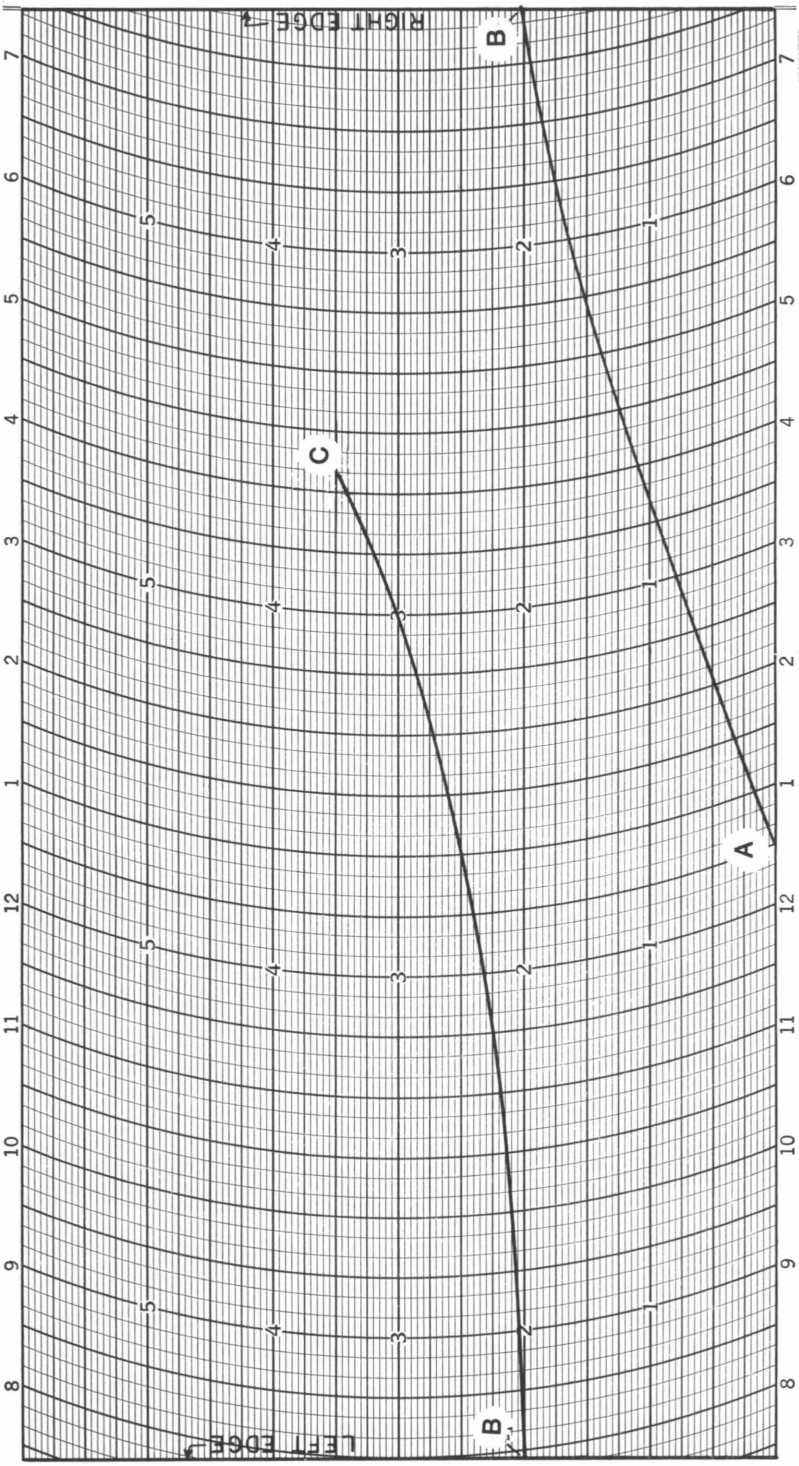

Figure 7. Schematic to illustrate horizontal chart registration.

INTERACTIVE PROCESSING SYSTEM

The interactive processing system consists of a system controller and a series of Fortran programs designed to perform various data management, error diagnostic, reduction, summary, and graphics functions. The controller and programs are described briefly in the following sections.

System Controller

Operation of the interactive system is maintained by the Hydrologic Analysis System (HAS) controller , which was written in CMS EXEC language. The function of HAS is to generate input/output FILE DEFINITIONS and program control files, to access available Fortran programs, to scan error return codes and take appropriate corrective action, to schedule and submit selected data files to the printer and/or plotter, and to archive data. The HAS program can be accessed by entering:

```
HAS [arg1] [arg2]
```

Arguments arg1 and arg2 are used to specify the beginning and ending programs that will be executed during a given session. The CMS operating system will prompt the user for the Filename (FN), Filetype (FT) and Filemode (FM) of program input data files that are needed by a specific program.

The HAS controller allows the user to specify multiple or single program execution. This option is controlled by arg2. When arg2 is given a legitimate program name, execution proceeds from arg1 to arg2, inclusively. To execute only the program given by arg1 leave arg2 blank. All programs in a stack, beginning with arg1, will be executed if arg2 is set equal to ALL. When arg1 is omitted, the user is prompted for begin and end programs, or all available programs may be displayed, and the user is prompted for the program name.

Available routines include CASsette, DIGit, ERRor, REDuce, TABles, GRAph, ARChive, VERify, RECall, RELoad, ATLas and MERge (See Table 1 for hierachical order). The CMS command

```
HAS CASsette REDuce
```

would access HAS and execute programs CASsette, DIGit, ERRor and REDuce (Table 1).
The CMS command

```
HAS DIGit ALL
```

would access HAS and start executing programs with DIGit and all subsequent routines in the program stack, while the CMS command

```
HAS DIGit
```

would access HAS and execute only program DIGit.

Table 1. Hierarchical order of programs maintained by HAS.

Program Stacks							
CASsette	ATLas	ARChive	VERify	RECall	MERge	GRAph	RELoad
DIGit							
ERRor							
REDuce							
TABles							

The CMS command HAS is used to address each program stack or a program within the stack.

Program Constants

Two special data files are required for most programs to be executed by the HAS system. These files contain constants for strip charts and the station, or location, where the data were collected. Although program constants for a given station could be included in one file, the data were separated into two files for ease of file management, maintenance, and display.

Chart Constants

Typical information in the chart data file is stored in the CMS datafile CHARTPAR ATLAS (Table 2). Each chart type must be included in this data file.

The data for line 2 of Table 2 were obtained graphically from Chart No. 5-4002-B as illustrated in Figure 8. Column one, Table 2, represents the type of data being recorded (See bottom of Table 1 for codes). The chart type follows in columns 3-10. The time in hours required for the chart to make one revolution is given in columns 11-17. This number usually is stamped on the chart-drum gear. The remaining data are obtained

Table 2. Chart constants and record format for data file CHARTPAR ATLAS.

Data[1] type [1]	Chart[2] type [3-10]	Time per revolution [11-17] (hrs)	Chart length [18-27] (ins)	Vertical scale [28-36] (units/in)	Cord length [37-44] (ins)	Mid-chord to arc [45-53] (ins)	Edge of chart to chart zero [54-62][3] (ins)
P	5-4046-B	192.0	11.50	1.0000	6.36	0.66	0.18
P	5-4002-B	12.0	11.50	1.0000	6.36	0.66	0.18
P	5-4042-B	12.0	11.50	1.0000	6.36	0.66	0.18
P	5-4047-B	24.0	11.50	1.0000	6.36	0.66	0.18
P	1015-SSB	12.0	11.50	0.6667	5.97	0.88	1.11
Q	5-1940-A	24.0	14.40	0.2000	5.36	0.55	0.18
Q	5-1940-A	12.0	14.40	0.2000	5.36	0.55	0.18
Q	5-1940-X	6.0	14.40	0.1000	5.36	0.55	0.18
Q	5-1940-A	6.0	14.40	0.2000	5.36	0.55	0.18
Q	5-1941-A	192.0	14.40	0.2000	5.36	0.55	0.18
R	5-1941-A	192.0	14.40	0.2000	5.36	0.55	0.18
Q	5-1941-A	96.0	14.40	0.2000	5.36	0.55	0.18
T	5-207-WB	176.0	11.50	31.8741	3.80	0.35	0.39
T	5-209-WB	176.0	11.50	31.8741	3.80	0.35	0.39
T	3102-W#2	195.0	11.28	66.0377	2.64	0.15	0.26
T	3102-W#3	195.0	11.28	66.0377	2.64	0.15	0.26
T	3102-W#1	195.0	11.28	33.0189	2.64	0.15	0.26
H	5-207-WB	176.0	11.50	63.2911	2.30	0.10	0.41
H	5-209-WB	176.0	11.50	63.2911	2.30	0.10	0.41
S	5-1050-A	192.0	14.40	1.0000	4.09	0.29	0.57
B	5-1068-B	192.0	11.54	1.0033	3.90	0.29	0.45
E	5-1941-A	192.0	14.40	1.2000	5.36	0.55	0.18
T	#C314W	168.0	11.48	33.8462	4.02	0.38	0.44
H	#C314W	168.0	11.48	31.7460	3.89	0.35	0.41

[1] Data type codes are as follows:
- P - Precipitation
- Q - Streamflow
- R - Retention structure (Pond)
- T - Temperature
- H - Humidity
- S - Solar radiation
- B - Barometric pressure
- E - Evaporation

[2] See Figure 5.
[3] Field location of data storage.

from Figure 8 as follows: the chart length is given by line F-G; the vertical chart scale is given by the vertical chart length (YS_1, inches) divided by the corresponding recording range [15.76 centimeters (6 inches) for this example]; the chart chord length is YC; the perpendicular distance from the center of chord YC to its arc is S; the distance from the bottom edge of the recording surface to the edge of the chart is YZ. For this example, the chart constants are P, 5-4002-B, 12.00, 11.50, 1.00, 6.36, 0.66 and 0.18, respectively. Note that a data record is formatted as shown in Table

2. Data entry into the CHARTPAR ATLAS can be accomplished interactively by entering the CMS command

HAS ATLas

which provides appropriate prompts.

Graphical procedures for obtaining data for other chart types are given in appendix A.

Station Constants

Typical information in the station constants data file is stored in the CMS data file STATION ATLAS, and is displayed in Table 3. This data file includes site code, watershed code, location identification, type of strip chart and number of hours per revolution (for cross-referencing with the data stored in CHARTPAR ATLAS), the gauge datum elevation, pondage and rate conversion data (only for runoff), and CMS data filenames and filetypes for the rating and pondage tables. The station constants corresponding to the example given in the previous section on chart constants are found in Table 3, line 3. Note that a data record is formatted as shown in Table 3. Data entry can be accomplished interactively by entering the CMS command

HAS ATLas

which provides appropriate prompts.

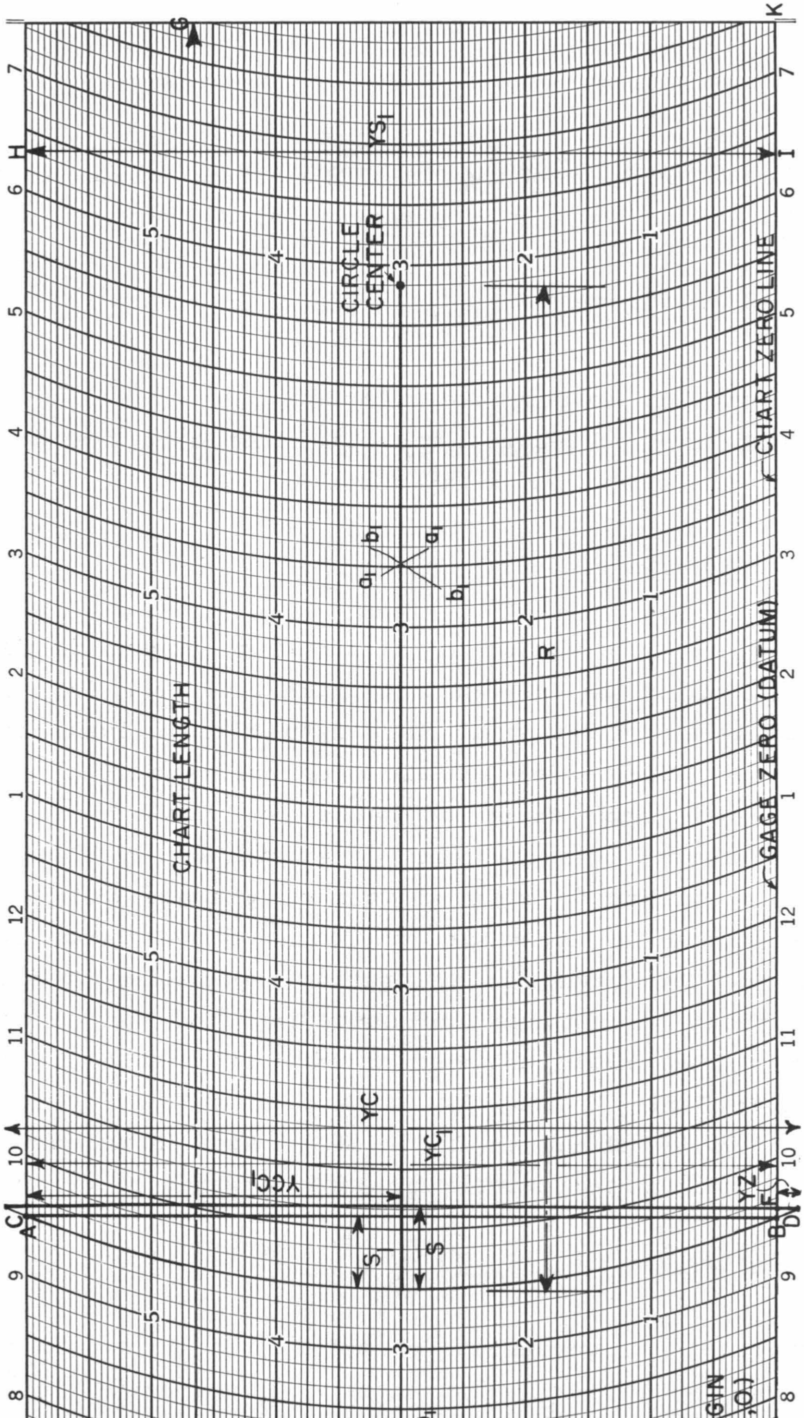

Figure 8. Chart No. 5-4002-B. Variables for data file CHARTPAR ATLAS.

Table 3. Station data constants and record format for data file STATION ATLAS.

Site Code [1-4]	Watershed Code [6-9]	Location Identification [11-40]	Chart Type [44-51]	Time per Revolution [54-60]	Gauge Datum Elevation [64-68]	Conversion factors for Pondage [71-82]	Conversion factors for Rating [85-96]	Pondage table Filename [98-113]	Pondage table Type	Rating Table Filename	Rating Table Type [116-131]
Q07	1307	CRAB CREEK, VA. Q07	5-1940-A	24.0	-0.2	0.0000701000	0.0012617500	Q07PRWW	DATA	Q07PRWW	DATA
PP7	1320	PENNVA NORTON, VA. PP7	5-4002-B	12.0							
P08	1308	CRAB CREEK,VA. P08	5-4002-B	12.0							
P01	6601	MOOREFIELD,WVA. P01	5-4002-B	12.0							
P20	1308	BRUSH CREEK,VA. P20	5-4002-B	12.0							
P22	1309	POWELLS CREEK,VA P22	5-4002-B	12.0							
P24	1310	LITTLES WINN CREEK,VA. P24	5-4002-B	12.0							
P25	1310	LITTLES WINN CREEK,VA. P25	5-4002-B	12.0							
P27	1311	ROCKY RUN BRANCH,VA. P27	5-4002-B	12.0							
P29	1312	PONY MOUNTAIN BRANCH, VA. P29	5-4002-B	12.0							
P31	1313	CHUB RUN,VA. P31	5-4002-B	12.0							
P32	1313	CHUB RUN,VA. P32	5-4002-B	12.0							
P34	1314	FOSTERS CREEK,VA. P34	5-4002-B	12.0							
P36	1315	CHESTNUT BRANCH,VA. P36	5-4002-B	12.0							
P37	1315	CHESTNUT BRANCH,VA. P37	5-4002-B	12.0							
Q4F	1303	PRICES FORK-BLACKSBURG,VA. Q4F	5-1940-A	24.0	-0.2						
Q5F	1304	PRICES FORK-BLACKSBURG,VA. Q5F	5-1940-A	24.0	-0.2						
Q6F	1305	PRICES FORK-BLACKSBURG,VA. Q6F	5-1940-A	24.0	-0.2						
PP1	1320	PENNVA NORTON, VA. PP1	5-4046-B	192.0							
PM1	T101	OXFORD, MISS. TH 10.1	5-4047-B	24.0							
QA1	140	ATHENS, GA. QA1	5-1940-A	24.0	-0.2		0.148645282	HFLU25FT	DATA		
QS1	6606	SULLIVAN SITE- BECKLEY,WVA. AS1	5-1940-A	6.0	-0.2		27.3819967	HFLUM6IN	DATA		
QS6	6606	SULLIVAN SITE- BECKLEY,WVA. QS6	5-1941-A	192.0	-0.2		27.8037872				
QS1E	6606	SULLIVAN SITE- BECKLEY,WVA. QS1	5-1940-A	192.0	-0.2		0.0570751987	HFLUM3FT	DATA		
TGF	1300	PRICES FORK-BLACKSBURG,VA. TGF	3102-W#2	195.0	-10.0						
TAF	1300	PRICES FORK-BLACKSBURG,VA. TAF	5-207-WB	176.0	10.0						
TAFW	1300	PRICES FORK-BLACKSBURG,VA. TAFW	5-207-WB	176.0	-20.0						
HRF	1300	PRICES FORK-BLACKSBURG,VA. HRF	5-207-WB	176.0	0.0						
EAF	1300	PRICES FORK-BLACKSBURG,VA. EAF	5-1941-A	192.0	0.0						
BPO	1300	PRICES FORK-BLACKSBURG,VA. BPO	5-1068	192.0	28.77						
SXX	1321	AXTON,VA. SXX	5-1050-A	192.0	-0.26		851.61				
TMA	VICA	MOUNT HOLLY, VA. TMH	5-207-WB	176.0							
QC1	1319	PRINCE EDWARD CO. CUNG-01	5-1940-A	24.0	-0.2	0.00002912	0.00327634	QC1PRFLU	DATA	QC1PRFLU	DATA
Q01	6601	MOOREFIELD,WVA. Q01	5-1940-A	24.0	-0.2		0.115660012	HFLU45FT	DATA		
Q02	6602	MOOREFIELD,WVA. Q02	5-1940-A	24.0	-0.2		0.101890028	HFLU45FT	DATA		
Q04	6604	MOOREFIELD,WVA. Q04	5-1940-A	24.0	-0.2		0.156920910	HFLU45FT	DATA		
Q05	6605	MOOREFIELD,WVA. Q05	5-1940-A	24.0	-0.2		0.103847146	HFLU45FT	DATA		
Q13	1313	CHUB RUN,VA. Q13	5-1940-A	24.0	-0.2	0.00002724	0.00049023	Q13PRWW	DATA	Q13PRWW	DATA
Q12	1312	PONY MOUNTAIN BRANCH,VA. Q12	5-1940-A	24.0	-0.2	0.0006456601	0.0051710494	Q12PRWW	DATA	Q12PRWW	DATA
Q14	1314	FOSTERS CREEK,VA. Q14	5-1940-A	24.0	-0.2	0.00056627	0.0025482499	Q14PRWW	DATA	Q14PRWW	DATA
Q15	1315	CHESTNUT BRANCH,VA Q15	5-1940-A	24.0	-0.2	0.0000521	0.0009377201	Q15PRWW	DATA	Q15PRWW	DATA
Q08	1308	BRUSH CREEK,VA. Q08	5-1940-A	24.0	-0.2	0.00024679	0.00111057	Q08PRWW	DATA	Q08PRWW	DATA
Q09	1309	POWELLS CREEK,VA. Q09	5-1940-A	24.0	-0.2	0.0003027299	0.00544912	Q09PRWW	DATA	Q09PRWW	DATA
Q10	1310	LITTLE WINNS CREEK,VA. Q10	5-1940-A	24.0	-0.2	0.00023409	0.00067419	Q10PRWW	DATA	Q10PRWW	DATA
Q11	1311	ROCKY RUN BRANCH,VA. Q11	5-1940-A	24.0	-0.2	0.00009927	0.0017863	Q11PRWW	DATA	Q11PRWW	DATA
Q06	1306	THORNE CREEK,VA. Q06	5-1940-A	24.0	-0.2	0.00001804	0.0003247301	Q06PRWW	DATA	Q06PRWW	DATA

Software Packages

CASsette

The function of this routine is to up-load data from a tape cassette to on-line disk, scan data sets for errors in data management codes, and delete data encoded with code 5555.0.

DIGit

The function of this routine is to translate the output from CASsette into proper units. For example, the coordinate points from a rainfall chart would be translated from a length measure to time (X-coordinate), and accumulated rainfall (Y-coordinate). Because the translation of the data can be the source of many common errors, DIGit was designed as an interactive procedure. In the design of the interface between user and computer, operator efficiency was given a higher priority over computer efficiency. Consequently, the inputs are given in "English Style" commands with non-formatted alphanumeric inputs. A diary of the current session also is created by DIGit. This diary aids tracing problems in the data base (i.e. missing date, number of storms for a given chart, etc.).

The interactive section of DIGit consists of two basic prompts. The first prompt relates to chart information while the second relates to storm information.

Chart Information -- The first prompt by DIGit is for chart information. This information pertains to the whole chart and is answered before storm events can be processed. All responses must be typed on a single line and separated by at least one blank. The responses are discussed below in the order that they must be given.

Station Information -- The station code of the chart is the first entry. The code must be a unique set of one to four characters. The first character is used to identify the data type (see Table 2). For example, if the letter Q signifies runoff and the numerial 07 signifies the Crab Creek watershed, then the station code for a runoff station on Crab Creek Watershed would be entered as

```
Q07
```

The site code (Q07) is used to locate the appropriate chart and station constants in Tables 2 and 3, respectively.

The second entry is a sequential number which is used to identify the number of charts that have been placed consecutively and removed on the same day. This value is usually a 1 and appears as

```
Q07 1
```

The third thru sixth entries are placement date, placement time, removal date, and removal time for the chart, respectively. The date and time are entered as integer values. A placement date and time of May 5, 1981 at 2:00 pm would be entered as:

```
050581 1400
```

A removal date and time of May 12, 1981 10:00 am would be entered as:

    051281 1000

The combined station code, chart placement and removal code, and the placement and removal dates and times would appear as:

    Q07 1 050581 1400 051281 1000

The seventh entry is the time zone. Legitimate entries are Daylight (daylight savings time) or Standard (standard time). Minimum truncation is D or S. The previous example now appears as:

    Q07 1 050581 1400 051281 1000 D

The eighth entry is the X-coordinate corresponding to the chart placement time (starting X-coordinate). The starting X-coordinate is recorded manually on the chart during the digital conversion step and entered during the DIGit step. This value is used to determine if chart information corresponds to the chart being processed. Assuming a starting X-coordinate of 3.2, the example now appears as:

    Q07 1 050581 1400 051281 1000 D 3.2

The ninth entry contains optional chart parameters or is left blank for no options. The following options may be entered:

+/- (Flow direction : + for rising hydrograph and - for recession hydrograph)

+/-xxx (Time adjustment factor in minutes)

Q10 (Station Code Modification -- A suffix is added to the station to signify an incomplete chart record, a winter temperature chart and a summer temperature chart, or missing, and a nearby station (Q10A) will be used for missing record.)

+/-xxx.x (Depth correction)

The options can be entered in any order. The delimiter is a space. The example (in brackets)

Q07 1 050581 1400 051281 1000 D 3.2 [- -10 Q20 2.57]

specifies that stage readings are decreasing (-), a time adjustment is required (-10), the chart being processed is different from the chart specified in the chart information record (Q20), and the stage or depth readings must be corrected (2.57).

After the above options are entered, the user is prompted for chart notes or a null line to continue. A maximum of 10 lines with up to 79 characters may be entered. These records are listed in the diary.

<u>Storm Information</u> -- The second prompt by DIGit is for storm information. This prompt will be asked for each storm (2222.0 data management code) encountered on a chart. All responses required by this question must be typed on a single line. The delimiter for responses is a blank.

The first response is the beginning date and time for the storm. The purpose of this response is to locate the time span occupied by the storm event. A single time span is defined as the chart length. This option is necessary when charts have multiple line traces (cover several time spans) to avoid transferring zero response periods. The start date and time are entered following the same procedure outlined for the chart information response. Any time within the time span is allowable since date and time are used only to index the event location. A storm start date of May 7, 1981 at 9:00 am would be typed as:

050781 0900

The second entry contains optional storm parameters, or is left blank for no options. Legitimate options are:

xxx.xxx (Starting gauge height)
EStimated or ERror (Minimum truncation is ES or ER)
SNow or Hail or SLeet or MR&S or MRS&S or MR&H
(Minimum truncations are SN,H,SL, MR&S,MRS&S,MR&H)

The options (in brackets)

050781 0900 [3.4 ER SNow]

would specify a starting gauge height of 3.4, data have errors, and snow occurred.

After the storm information has been entered, the user is prompted for storm notes or a null line to continue. A maximum of 10 lines with up to 79 characters each may be entered. After the storm notes request is satisfied, all coordinate points are transformed using Equation (1) and corrected as specified in chart options. Redundant coordinate points also are removed. The process is repeated for all storms on the chart.

The completed data base for the previous example would be identified as

Q07BAS81 J125132 A1

and filed on disk. The CMS naming convention for data sets (FN, FT, FM) is used. To facilitate user identification, the FN includes the station code (Q07), basic data (BAS) and the year (81). The FT includes J (Julian date), placement Julian date (125) and ending Julian date (132). The FM is A, which signifies that data storage is on the A disk.

Program control is returned to HAS.

ERRor

The purpose of the ERRor program is to scan data files generated by DIGit for identifiable errors. Because many errors are common to all data types and basic formats are identical, this routine is used for all data types (Carr and Shanholtz, 1978). Types of error diagnostics are summarized by Carr et al. (1980). When error diagnostics have been completed, control is returned to HAS and the status of the ERRor step is displayed at the terminal. If no errors are detected, HAS will pass control to REDuce. When unrecoverable errors are detected, execution is terminated.

REDuce

The function of this program is to process the data files generated by DIGit into formats similar to those suggested by Shanholtz and Burford (1967). Using a previous example from DIGit, the completed data file is identified as

Q07RED81 J125132 A1

and stored on disk. To facilitate user identification the FN includes the station code (Q07), reduced data (RED), and the year (81). The filetype and filemode are as previously defined in DIGit.

TABles

The purpose of this program is to generate tabular listings and a daily summary file from the data generated by REDuce. Two listing types are generated. The first type is a daily summary of the information recorded on the chart (e.g. daily rainfall or runoff). The second type is a year-to-date daily summary that includes accumulated monthly and yearly daily events; maximum and minimum daily, monthly and yearly events; and long-term averages for the station or a near-by station. The daily summary file was designed for ease of graphing daily events and/or statistical comparisons between stations. This file is placed in permanent storage by ARChive.

GRAph

The function of this routine is to generate graphical displays. For example runoff hydrographs, hyetographs, mass diagrams, double mass plots, etc, can be routinely obtained.

ARChive

The purpose of this program is to archive output data files generated by DIGit, REDuce and TABles. The filenames assigned to each CMS data file are concatenated into a CMS file for use by VERify. The archiving step is executed in batch mode. A file of the filenames stored on tape or disk also is returned to CMS for use by VERify.

VERify

The function of this routine is to compare the filenames sent by ARChive with the filenames returned by ARChive to determine files successfully stored. The CMS file is erased when archiving is verified.

RECall

The purpose of this program is to retrieve data files from magnetic tape or disk and return as a CMS reader file. The user is prompted for the station code and the inclusive dates.

RELoad

The function of this routine is to dump CMS reader files to CMS disk.

MERge

The function of this routine is to merge the output files generated by DIGit and REDuce into continuous station record files. The maximum time span covered by a data file is one year.

ATLas

The purpose of this routine is to interactively build and/or modify data files of chart and station constants.

SUMMARY

A procedure was developed to automate the process of extracting data from strip charts. Data are captured from strip charts with a digitizer and stored on a cassette tape. During the next step, which can be during the current session or at a later time, the data are up-loaded to a CMS data file, processed and archived on magnetic tape. Output includes, for each event, a listing of analysis by break-point for each strip chart, a daily summary by strip chart, accumulated monthly and annual summary with statistics, and selected graphical displays.

The interactive computer system reduces the time required to manually tabulate and batch process and archive data by approximately 75 percent. With this system, outdated strip chart recorders are a viable alternative method for data collection.

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Appendix A

Selected charts illustrating the determination of chart constants for data file CHARTPAR ATLAS.

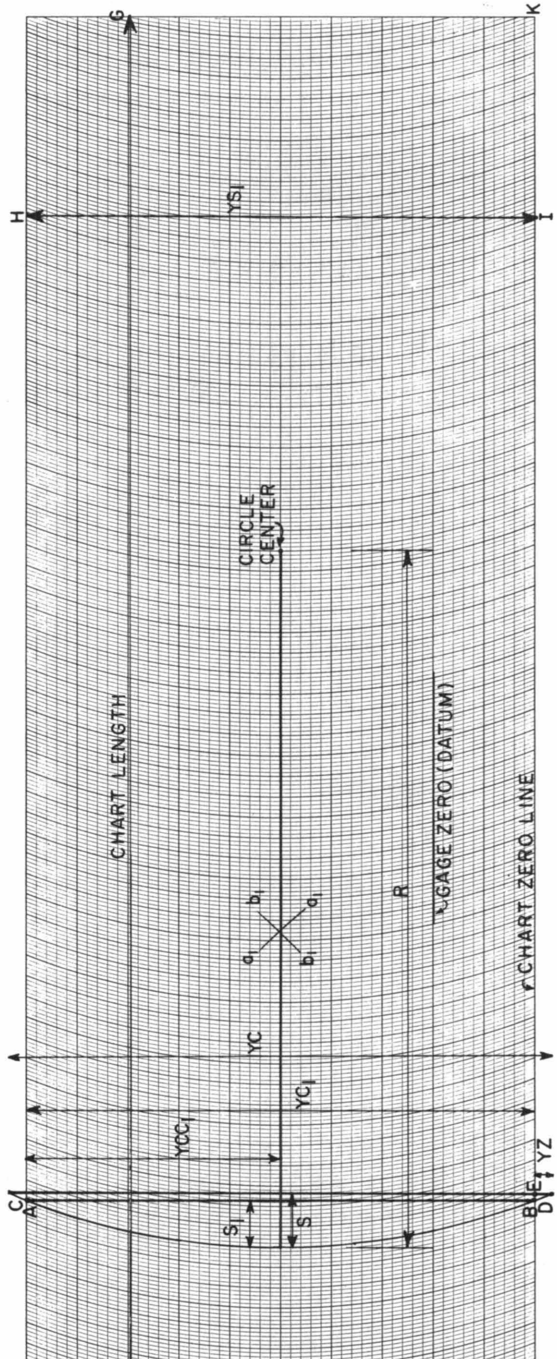

Figure A1. Chart No. 5-1940-AB. Variables for data file CHARTPAR ATLAS.

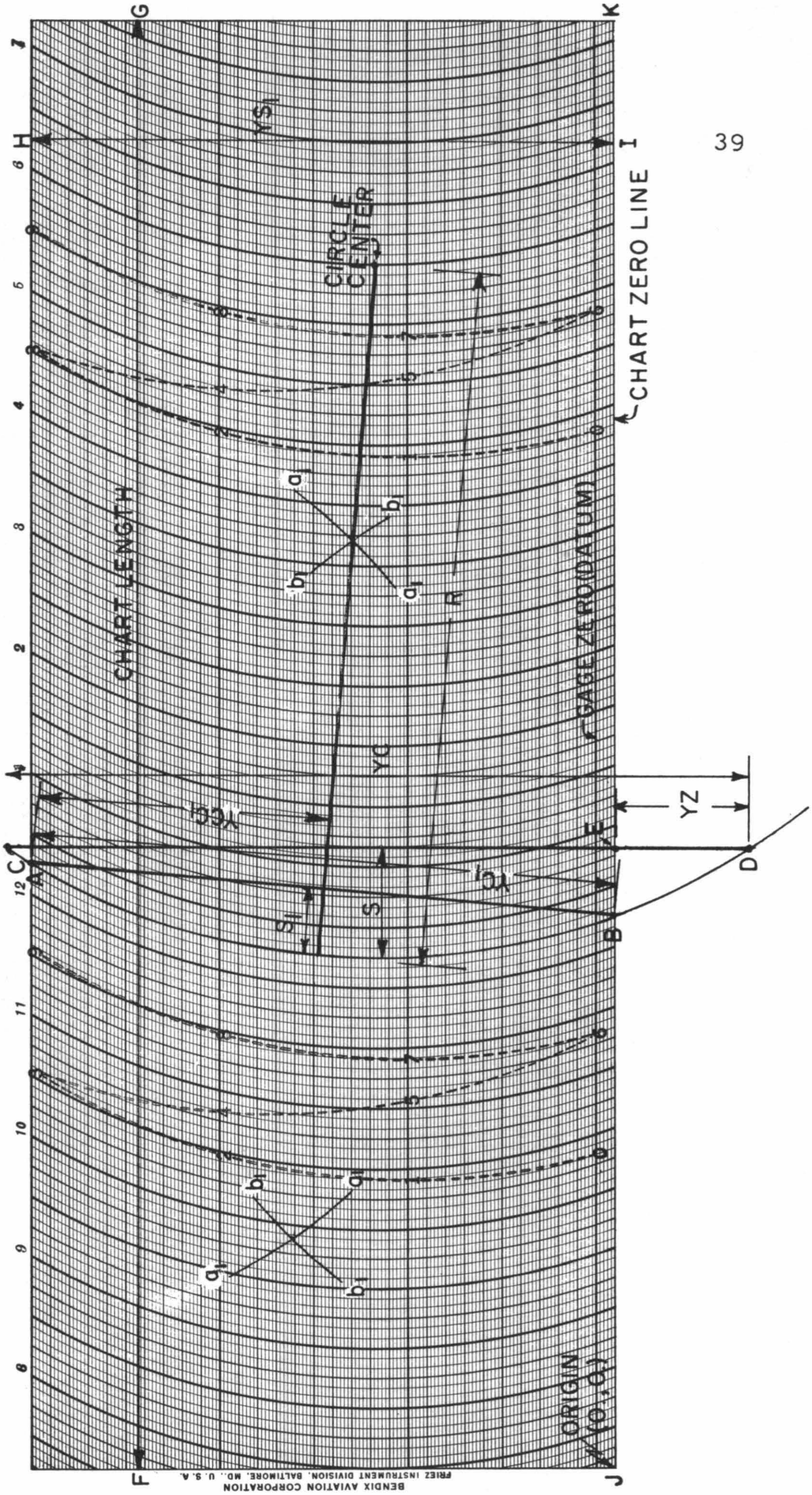

Figure A2. Chart No. 1015-SSB. Variables for data file CHARTPAR ATLAS.

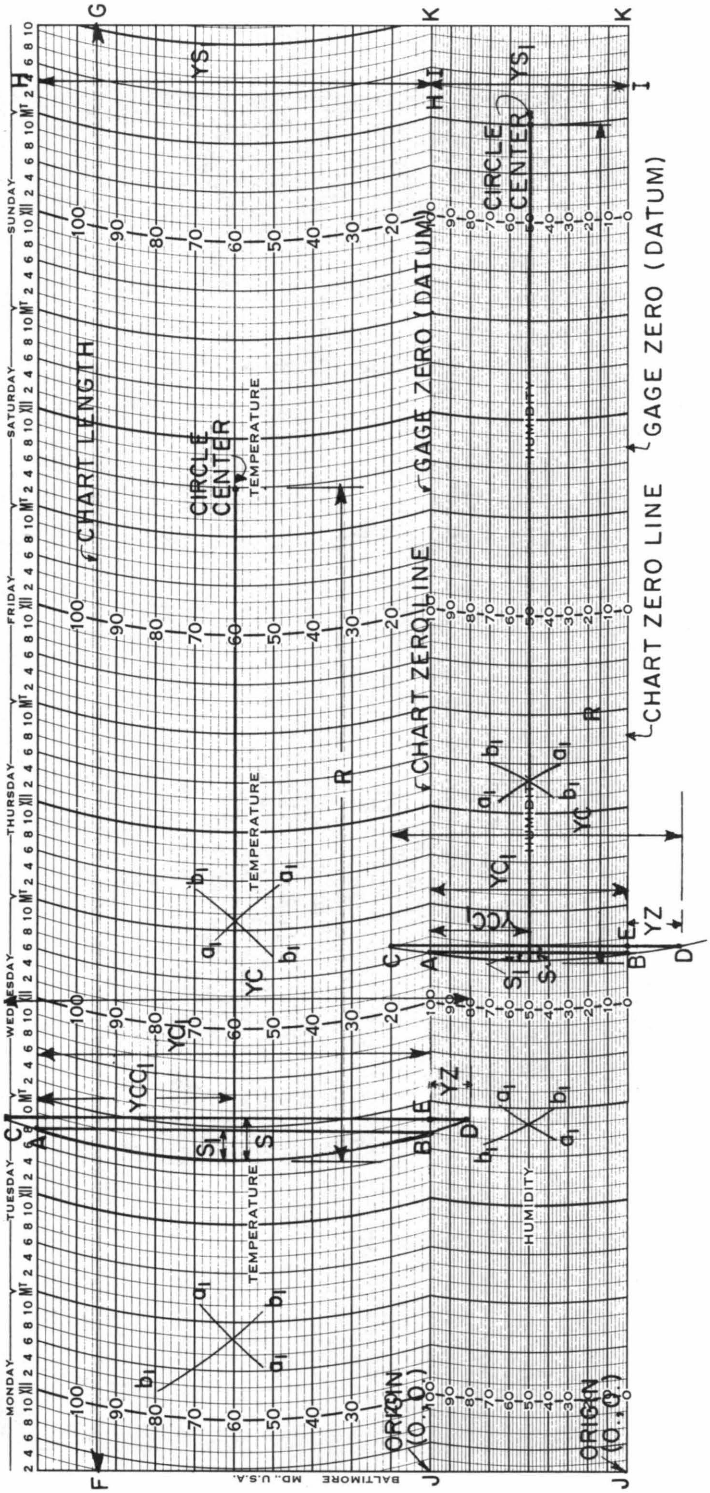

Figure A3. Chart No. 5-207-WB. Variables for data file CHARTPAR ATLAS.

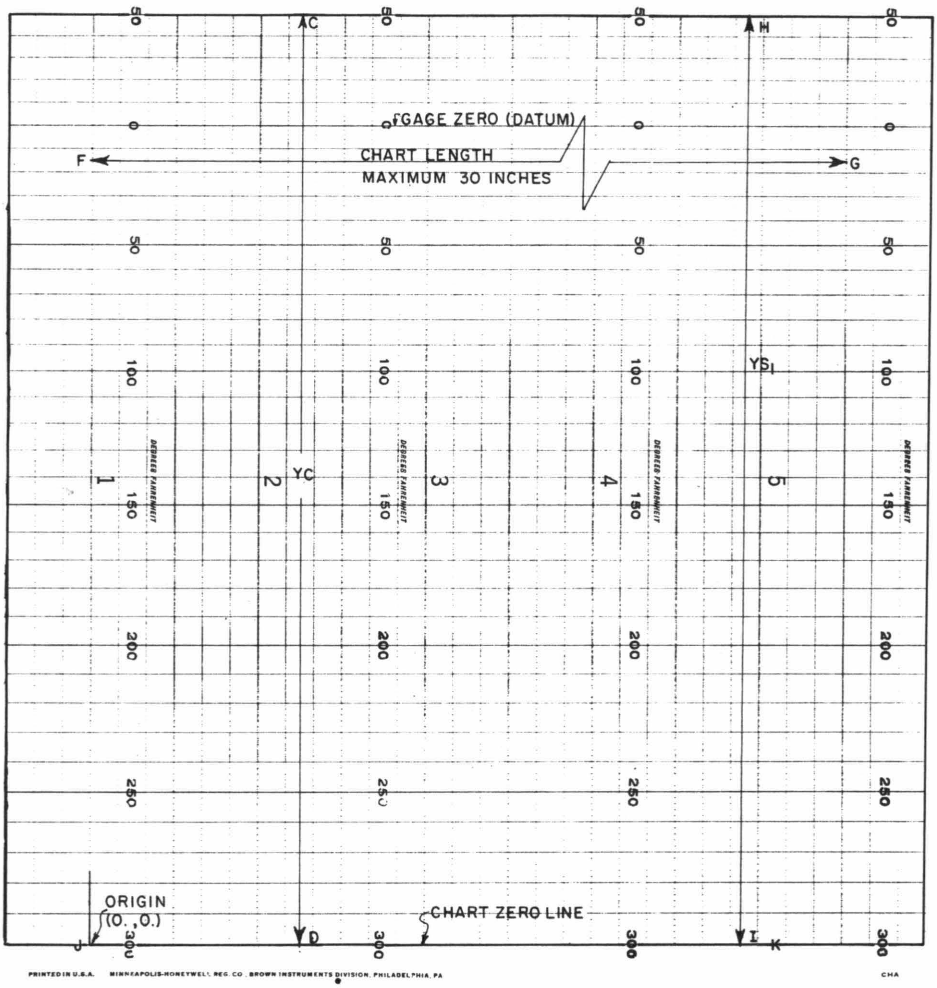

Figure A4. Chart No. 5145. Variables for data file CHARTPAR ATLAS.

Virginia's Agricultural Experiment Stations

1 —— Blacksburg
Virginia Tech
Main Station

2 —— Steeles Tavern
Shenandoah Valley Research Station
Beef, Sheep, Fruit, Forages, Insects

3 —— Orange
Piedmont Research Station
Small Grains, Corn, Alfalfa, Crops

4 —— Winchester
Winchester Fruit Research Laboratory
Fruit, Insect Control

5 —— Middleburg
Virginia Forage Research Station
Forages, Beef

6 —— Warsaw
Eastern Virginia Research Station
Field Crops

7 —— Suffolk
Tidewater Research and Continuing Education Center
Peanuts, Swine, Soybeans, Corn, Small Grains

8 —— Blackstone
Southern Piedmont Research and Continuing Education Center
Tobacco, Horticulture Crops, Turfgrass, Small Grains, Forages

9 —— Critz
Reynolds Homestead Research Center
Forestry, Wildlife

10 —— Glade Spring
Southwest Virginia Research Station
Burley Tobacco, Beef, Sheep

11 —— Hampton
Seafood Processing Research
and Extension Unit
Seafood