ABSTRACT

PLOTS - General Purpose Incremental Plotting
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Purpose/Description: To plot continuous line curves, discrete point curves, and histograms from magnetic tape or card input using the "CALCOMP" recorder as the 1401 output medium. Input data may be signed integer, exponential, or floating point numbers. After scaling by 1401, data points represent rectangular coordinate deflections expressed in hundredths of an inch from origin.

Method: N/A

Restrictions/Range: Dependent upon maximum width of plotter paper roll.

Storage Requirements: 4K core.

Equipment Specifications: 1401 with 4K core, Advanced Programming, High-Low-Equal Compare, and Multiply-Divide; 1402, 1403 (optional); 1407; 729 (optional); CALCOMP Incremental Recorder (RPQ #W01372).

JEB:ep
5/17/62

PROGRAM WRITE-UP

1. Identification

   a. Title - PLOTS - General Purpose Incremental Plotting

   b. Author - Jack Bresenham, May 17, 1962

   c. Installation - Scientific Computation Laboratory, IBM, San Jose

   d. 1401 to on-line CALCOMP Recorder

   e. Autocoder

2. Purpose

   To plot continuous line curves, discrete point curves, and histograms from magnetic tape or card input using the "CALCOMP" recorder as the 1401 output medium. Input data format may be integer, exponential, or floating point. After scaling, data points represent rectangular coordinate deflections expressed in hundredths of an inch from origin.

3. Restrictions

   a. IBM 1401 (4K core) with Advanced Programming Features, High-Low-Equal Compare Feature, Multiply-Divide Feature; IBM 1402; IBM 1407; CALCOMP Incremental Recorder (RPQ #W01372); IBM 1403 (optional); IBM 729 (optional).

   b. "TRAVEL" subroutine for straight line movement.

   c. Data: Intefer, Exponential or Floating Point representation per FORTRAN. Binary-Coded decimal digits with sign to left of number. See Appendix A Control Card Specifications.

   d. One control card is required for each curve file. See Appendix A Control Card Specifications.

4. Method

   a. See Appendix A Control Card Specifications and Item 6-a for range.

   b. As plotter's digital increment is 0.01-inch in direction 0°, 45°, 90°, 135°, 180°, 225°, 270°, or 315°, a least mean square error straight line is approximated between successive points. See "TRAVEL" subroutine for computational algorithm.

5. Usage

a. Core positions 1 through 80 and 200 through 3809 and Index registers 1, 2, & 3.

b. See Appendix A Control Card Specifications - for input data format.

c. See Appendix B Operating Instructions - for operation notes.

6. Coding Information

a. The following constants control allowable x, y ranges shown in Appendix A Control Card Specifications:

Source Card	Name	Low Order Location	Function
5-41	ULIMX	2753	Max Positive X
5-42	LLIMX	2759	Max Negative X
5-43	LIMXL	2765	Space between both +, - plots
1-46	+1000	3773	Max absolute y deflection
1-49	+1000	3773	Max absolute y deflection
2-54	-300	3786	Space between + only plots

If tape #2 is not available, change the operation code of card 7-05 from RWD to NOP and core location 3647 from U to N.

b. Input data is held in 200-332 for easy listing.

c. Plotting is at 200 increments/second between points with CALCOMP Model 560R. With tape input, plotting is effectively about 1 to 1.5 inches/second if multiple file tape searching is required and the backspace file RPQ is not available.

7. Checkout

a. Status - Complete

b. Method - Satisfactory plotting of test figures and a months production plotting to date.

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APPENDIX A: CONTROL CARD SPECIFICATIONS
GENERAL PURPOSE INCREMENTAL PLOTTING

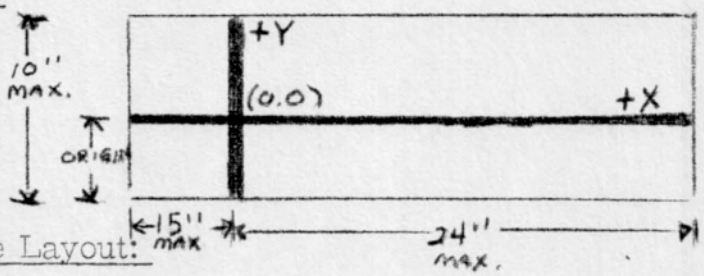
Purpose:

The program is intended to plot continuous line curves, discrete point curves, and histograms from magnetic tape or card input using the CALCOMP Recorder as the output medium.

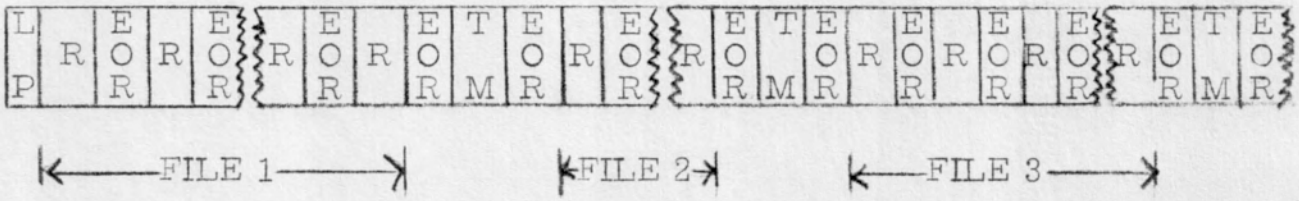
Machine Requirements:

IBM 1401 Central Process Unit (4K core)
Advanced Programming Features
High-Low-Equal Compare Feature
Multiply-Divide Feature
IBM 1402 Card Read-Punch
IBM 1407 Inquiry Station
CALCOMP Incremental Recorder
IBM 729 Magnetic Tape Unit (optional)
IBM 1403 Printer (132 positions) (optional)

Graph Layout:



Magnetic Tape Layout:



LP	Load Point
R	Record of up to 132 BCD characters
EOR	End of Record gap
TM	Tape mark (FORTRAN "end file")

Format:

Tape: Maximum record length of 132 BCD characters. End of File as last record of each curve (see FORTRAN statement "END FILE i" or 1401 instruction "WRITE TAPE MARK")

Card: End of File card (7-8 punch in column 1) as last card of each curve. Control card as first card of each curve.

Data: Integer, Exponential, or Floating Point representation per FORTRAN. Binary-coded decimal characters with sign to left of number. One data point plotted per record for each curve; with multiple value records, the particular pair of x and y values for plotting is selected per the control card. Multiple curves relative to the same x axis as specified in the control card.

Scale: After scaling, data points represent rectangular coordinate deflections expressed in hundredths of an inch from origin.

Control Card:

One control card is required for each curve.

Column 1	TYPE OF PLOT: point P, line L, histogram H
Column 2	AXIS CONTROL: same x axis as previous curve *.
Column 3	X FORMAT: integer I, floating point F, exponential E.
Column 4	NEGATIVE X: no negative values of x in curve (blank), negative values of x present N.
Column 5	Y FORMAT: integer I, floating point F, exponential E.
Column 7	AXIS FLAG: draw no axes (blank), draw x axis X, draw y axis Y, draw both x and y axis Z.
Columns 9-12	ORIGIN: a four digit number (0 to 1000) designating the location (expressed in hundredths of an inch) from the negative y margin to the y = o point.
Columns 14-16	X LOCATION: a three-digit number (2 to 132 for magnetic tape, 2 to 80 for card) designating the rightmost character position (including decimal point and exponent) of x value within a record.
Columns 18-22	X SCALE: a five-character scaling factor, expressed as a digit times a power of ten, for x values. Form AE±BB (e.g. 5E-01 for 5×10^{-1}). After scaling, x must be within $(-1500) \leq x \leq (+2400)$.
Columns 24-26	Y LOCATION: a three-digit number (2 to 132 for magnetic tape, 2 to 80 for card) designating the rightmost character position (including decimal point and exponent) of y value within a record.

Columns 28-32 — Y SCALE: a five character scaling factor, expressed as a digit times a power of ten, for y values. Form $AE^{\pm}BB$ (e.g. 3E+21 for 3×10^{21}). After scaling, y must be within (-origin)$\leq y \leq$ (+1000-origin).

Column 34 — HEADINGS: number (0-9) of heading records to be skipped per data block.

Columns 36-38 — DATA: a three-digit number (0-999) designating the number of data records per data block. If the number of headings is blank or zero, the number of data records per data block is unlimited.

Column 40 — MARKER: A single character designating the type of symbol to be drawn for each point.

Punches	Symbol	Punches	Symbol
blank	none	12-3-8 °	star
12 +	dot	11-3-8 $	circle
11 −	diamond	12-4-8)	square
3-8 =	double diamond	11-4-8 *	asterisk

Column 42 — INPUT: magnetic tape T, card C

Columns 43-44 — FILE: a two-digit number (1-99) specifying the number of the file, within a tape reel, from which records are to be extracted for plotting. Used only with magnetic tape input.

Column 46 — LIST: no listing of input records (blank), single space 1, double space 2, triple space 3, first character control 4. Both heading and data records will be printed.

Column 48 — SKIP: if a + as the second character of any input data record is to designate that the plotter pen is to be raised from the paper prior to moving to the coordinate point contained in that record, punch an * (11-4-8) in column 48 of the control card.

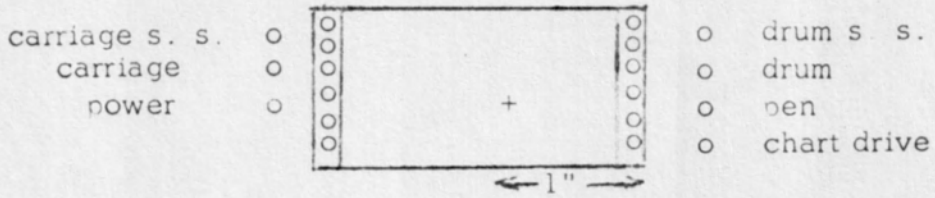
Column 61-80 — IDENTIFICATION: Information from columns 61-80 will be typed on 1407 as plotting is initiated.

APPENDIX B - OPERATING INSTRUCTIONS

1. Set Up

a. Mount tape to be plotted on TAPE #2. If only card input data is to be plotted, mount a scratch tape on TAPE #2.

b. Ready 1402, 1403, 1407, and "CALCOMP" recorder. Use cross-hair insert to initially position pen one inch from right-hand paper edge.



NOTE: When turning "CALCOMP" recorder power ON or OFF, the 1401 mode switch should be in ALTER.

2 Operation

a. Place program deck followed by control cards and data cards, in reader.

NOTE: The last card of each card input data file must be an "END OF FILE" card (7-8 punch in column 1). One control card is required for each curve file.

b. Set mode switch to RUN, tape select switch to N; I/O check stop UP; sense switch A UP.

c. Press CHECK RESET on 1402, CHECK and START RESET on 1401 console.

d. HALT (Str Addr = 380) will occur after 1407 ID message typed.

e. Press START to initiate plotting.

f. HALT (Str Addr = 3685) at end of curve will occur after last card processed or if sense switch E UP, or if a "Stop Plot" card (STOP PLOT in columns 1-9) is read in place of a control card.

g. To continue, press START.

3. Sense Switches

Last Card	SW A	UP-Always
Axis	SW B	UP-Force curve to be plotted on same X axis as that of previous curve. Should not normally be used.
		DOWN- Axis control per control card.
List	SW C	UP- Force 1403 listing of input.
		DOWN- Listing per control card.
Tape Error	SW D	UP- Reread tape error record after HALT (Str Addr=1769).
		DOWN- Bypass tape error record after HALT (Str Addr = 1769).
Interrupt	SW E	UP- Force HALT (Str Addr = 3685) after plotting curve.
		DOWN - Continuous plotting. HALT (Str Addr = 3685) only after "Stop Plot" or last card processed.

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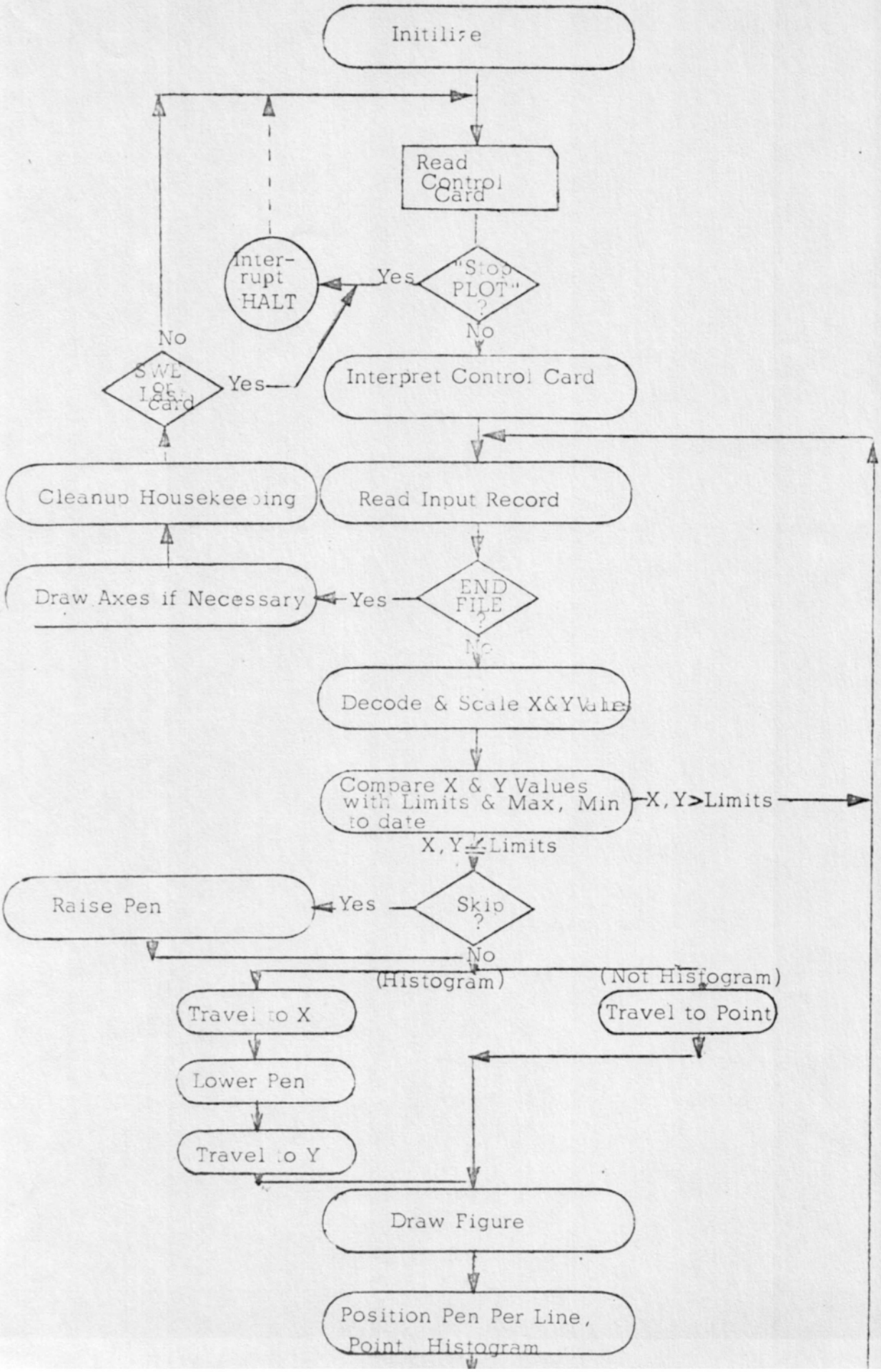
GENERAL PURPOSE INCREMENTAL PLOTTING
MACRO-FLOW DIAGRAM



INCREMENTAL PLOT (GENERAL PURPOSE)
OPERATING INSTRUCTIONS (with Monitor)

1. Purpose

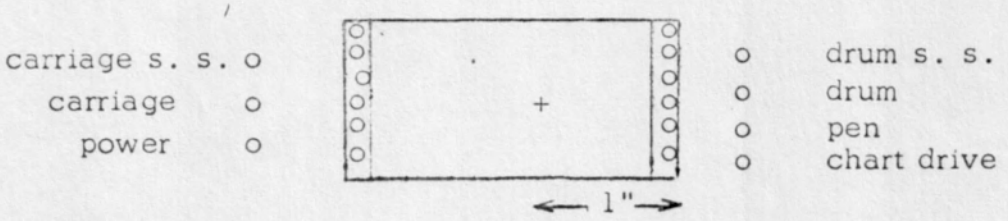
Provide tape and/or card-to-plotter operation with optional listing of original data. One control card is required for each curve file plotted.

2. Set-Up Instructions

a. Mount Monitor Tape on tape unit #1.

b. Mount tape to be plotted on tape unit #2. If only card input data is to be plotted, mount a scratch tape on tape unit #2 to allow the tape to rewind prior to program HALT (str Addr = 3685).

c. Set-up reader, printer, and "CALCOMP" recorder. Use cross-hair insert to initially position pen one inch from right-hand paper edge.



d. Place control cards and data cards, if any, in reader. The last data card of each card input data job must be an "End of File" card (7-8 punch in column 1).

3. Operating Instructions

a. Set mode switch to RUN; tape select switch to N, I/O check stop UP.

b. Press CHECK RESET on 1402; CHECK RESET and START RESET on 1401 console.

c. Set Sense Switches A and E UP; press TAPE LOAD.

d. HALT (Str Addr = 380) will occur after 1407 ID message.

e. Set Sense Switch A UP; press START to initiate plotting.

f. HALT (Str Addr = 3685) at end of curve will occur after last card processed, or after reading a "STOP PLOT" card in place of a control card, or if Sense Switch E UP.

g. To continue, press START.

4. Operating Notes

a. A "Stop Plot" card has STOP PLOT punched in columns 1-9.

b. When turning "CALCOMP" recorder power ON or OFF, the 1401 mode switch should be in ALTER. Turning plotter power ON or OFF can cause a 1401 error condition.

c. Sense Switch over-riding of control card parameters is privided.

Last Card	SW A	UP-Always
Axis	SW B	UP- Force curve to be plotted on same X axis as that of previous curve. Should not normally be used.
		DOWN- Axis control per control card.
List	SW C	UP- Force 1403 listing of output
		DOWN- Listing per control card.
Tape Error	SW D	UP- Reread tape error record after HALT (Str Addr = 1769).
		DOWN- Bypass tape error record after HALT (Str Addr = 1769).
Interrupt	SW E	UP- Force HALT (Str Addr = 3685) after plotting curve.
		DOWN- Continuous plotting. HALT (Str Addr = 3685) only after "stop plot" card or last card.

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