STANDARDIZED PLOTTING CONTROL FOR THE 701 OUTPUT WRITER

by

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ABSTRACT: *The plotting control routine PLOT-701 for the Wang 701 Output Writer is capable of (x, y) simultaneous digital plotting of a system of functions:*

$$y_i = f_i(x) \quad [1 \leqslant i \leqslant 9]$$

A simple device allows the combination of optional linear or logarithmic scales for the x-axis and y-axis in the system of coordinates. Because of the four quadrant plotting capability, the origin can be located anywhere in the plotting area.

The x-direction is vertical and corresponds to the columns, the y-direction is horizontal and corresponds to the lines on the 701 Output Writer. Therefore, the maximum number of distinguishable y-coordinates is limited to 136, whereas no restriction exists for the x-coordinates when continuous forms are used. The plotting accuracy is practically unlimited in the sense that the user, by simply changing input data, can expand or reduce the scale.

The i-th function is plotted with digit i [1⩽i⩽9]. For convenient reading of the graph, the program additionally plots lines and columns within a distance of five coordinates.

A subroutine Y-0000 must be prepared which calculates $y_i = f_i(x)$ for given x, and stores the y_i values in a relatively addressed y_i array. This subroutine depends on the type of functions the user wishes to plot.

The entire program package consists of two main parts:

PLOT-701-1: Plotting routine using two subroutines (270 steps).

PLOT-701-2: Input and additional output section (235 steps).

Program Package PLOT-701-1

PLOT-701-1 performs the actual plotting and identifying of each x-coordinate and gives the range of y-coordinates and y-increment.

Program Package PLOT-701-2

PLOT-701-2 consists of three parts:

(1) Detailed identification of y-coordinates. Graphical marking of columns and/or listing of the y-value of each column (138 steps).

(2) Input and log-conversion. Input of begx, endx, stepx, begy, endy, stepy. Log-conversion if log-scale is used (65 steps).

(3) Initialization. Typewriter on & off. Input of log-criteria log-scale x and/or log-scale y. Input i of y_i and basis address y_i-array (32 steps).

PLOT-701-2 performs convenient input of data and allows the user to obtain detailed information about the y-coordinates.

The most convenient use of the plotting program is to simultaneously store PLOT-701 and the subroutine Y-0000 for calculating y_i. Forty data registers are available to store Y-0000 and the y_i-array. If Y-0000 requires more space, the plotting can be handled in different ways.

First, the user can work only with PLOT-701-1. In this case, the input data must be stored by hand into the data registers. All information about x-coordinates and basic information about y-coordinates is provided in the program package. Second, a two-phase handling of PLOT-701 is possible. In one phase, input and detailed y-coordinate identification is performed by PLOT-701. The actual plotting, however, is realized in another phase after loading PLOT-701 and Y-0000 into core. In this way, seventy data registers are available to store Y-0000 and the y_i-array.

There is no nesting of subroutines except PLOT-701-21.

Plotting Procedure

The plotting is performed line by line by a stepwise changing of x within the arbitrarily chosen interval from begx to endx using optional increments Δx. At each line the user-written function subroutine Y-0000 is called once to calculate the y_i-array. PLOT-701-1 supplies Y-0000 with the current x and the basis address for the

Author Dr. Ludwig Nastansky reviews the results of an engineering production application of his 701 plotting package. Note the convenient recessed table compartment for the 700 calculator.

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y_i-array. This indirect addressing feature allows use of arbitrary scratch registers within Y-0000. Say, for example, the y_i-array is computed for a given $\bar{x}$:

$$\bar{y}_i = f_i(\bar{x}) \qquad [1 \leqslant i \leqslant 9]$$

The column pointer is then changed stepwise within the range given by arbitrarily choosing begy and endy in increments of optional Δy. A character, i, is printed if:

$$\dot{y} \leqslant f_i(\bar{x}) < \dot{y} + \Delta\dot{y} \qquad [1 \leqslant i \leqslant 9]$$

In general, Δy depends on y because of the log-scale capability of PLOT-701.

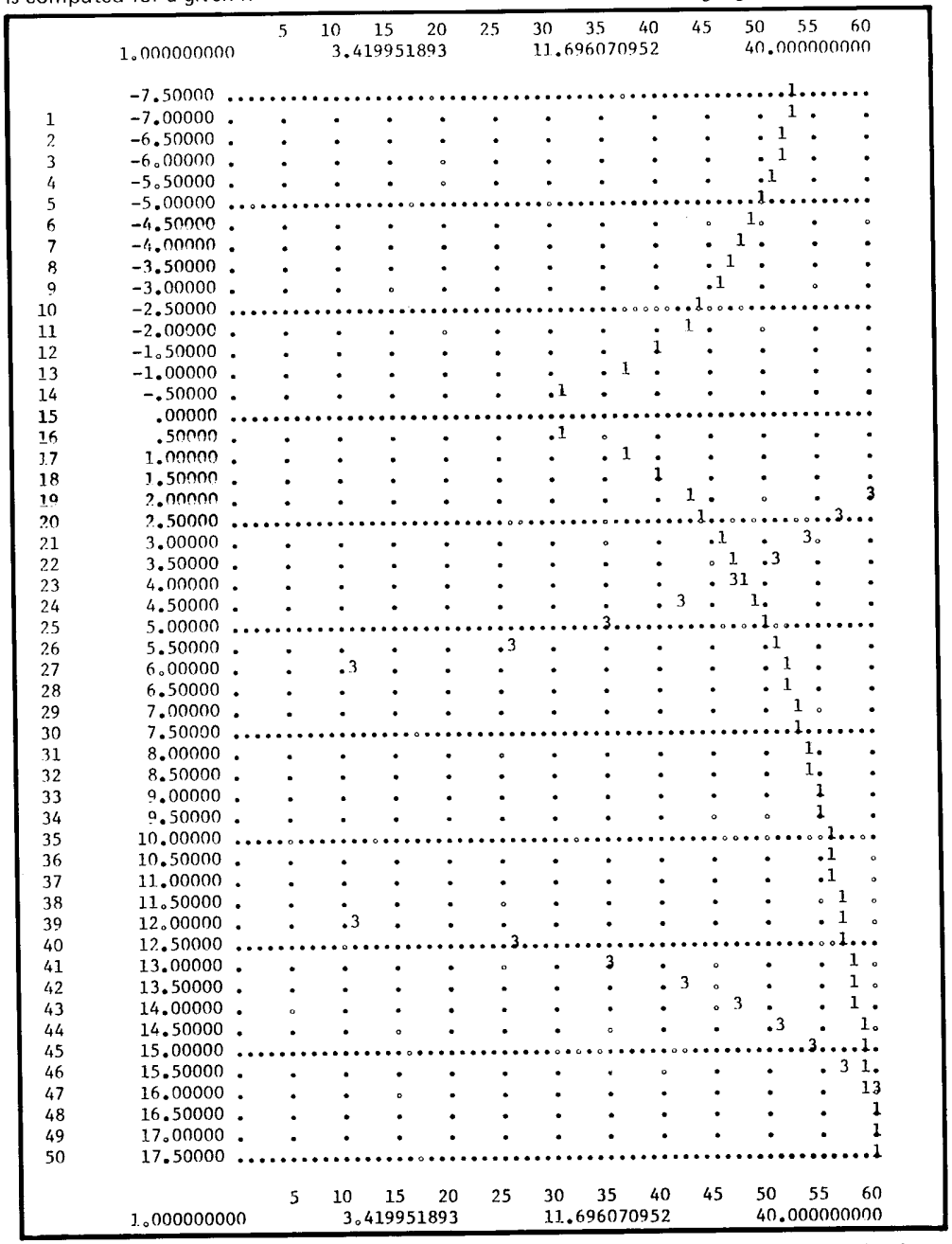

FIGURE 1 LINEAR SCALE x — LINEAR SCALE y with $-7.5 \leqslant x \leqslant 17.5$; $\Delta x = 0.5$; $-20 \leqslant y \leqslant 40$; and $\Delta y = 1$.

Examples (See Figures 1 and 2)

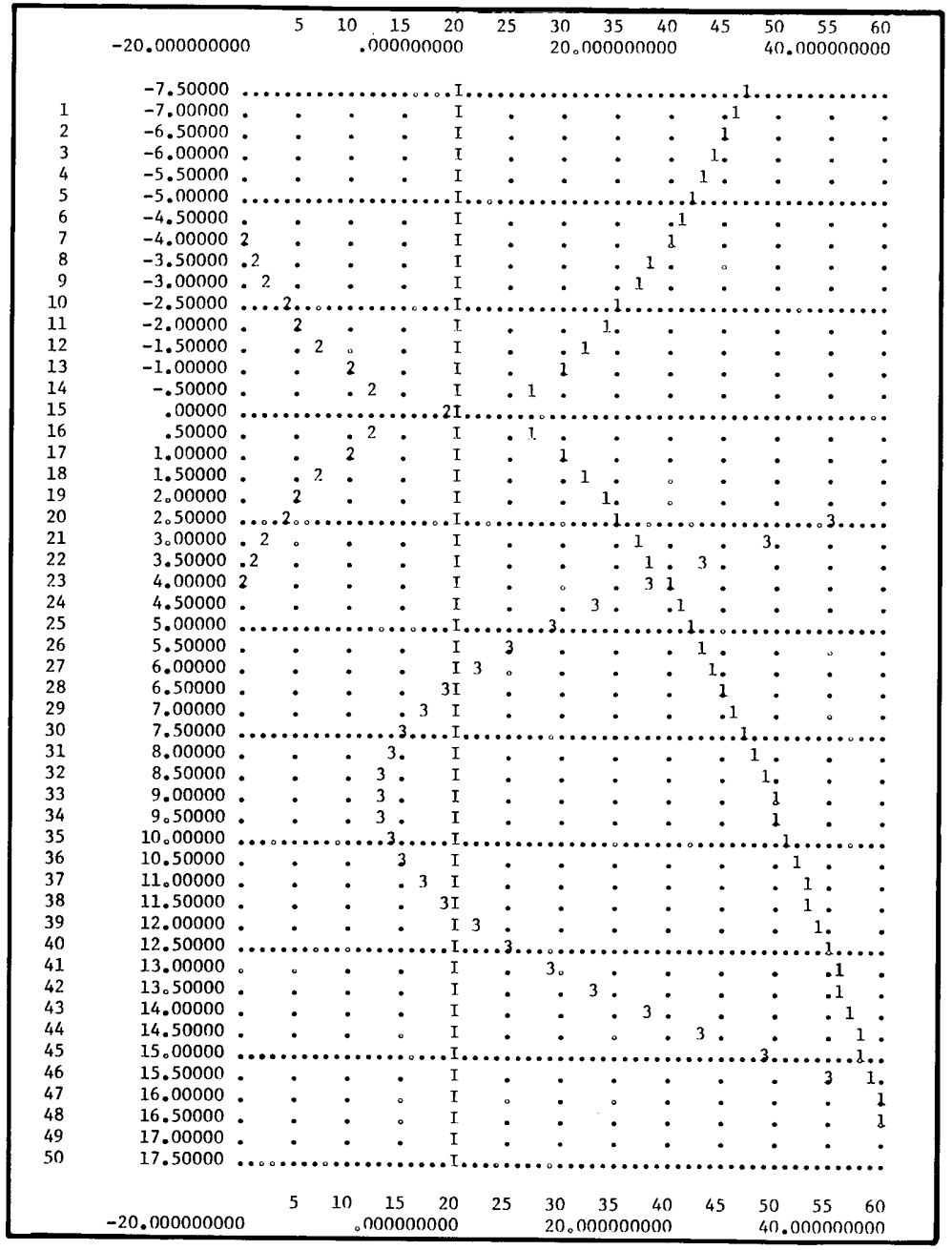

FIGURE 2 LINEAR SCALE x — LOG SCALE y with $-7.5 \leqslant x \leqslant 17.5$; $\Delta x = 0.5$; $1 \leqslant y \leqslant 40$; and 60 y-coordinate.

Some examples of the use of PLOT-701 at the Department of Operations Research arise in the plotting of engineering production functions, functions in lot-size problems, and equal-output factor combination curve systems.

To illustrate the graphical output of PLOT-701, some examples of plotting the functions

$$y_{1,2} = \pm\sqrt{|100x|}, \text{ and } y_3 = (x-9)^2 - 7$$

are given. If the functions are multivalued in the sense that for a given x there is more than one y-value, the functions can be divided into different single-valued parts and then can be plotted with different digits. Figure 1 demonstrates this technique where $+\sqrt{|100x|}$, is plotted with digit "1" and $-\sqrt{|100x|}$, is plotted with digit "2".

Figures 1 and 2 illustrate the general use of PLOT-701; similar sample plots illustrating log scale x — linear scale y, log scale y and various ranges of x and y coordinates are included with program 6.3.1. The graphs differ in the combination of linear (lin)-scale and log-scale and the range of y-coordinates.

Figure 3 shows an expanded section of Figure 1. To obtain this graph, it is only necessary to change six input data compared with the graph of Figure 1. The detailed listing of y-coordinates with PLOT-701-21 is given in Figure 4. The values correspond to the y-coordinates of Figure 2. The listing

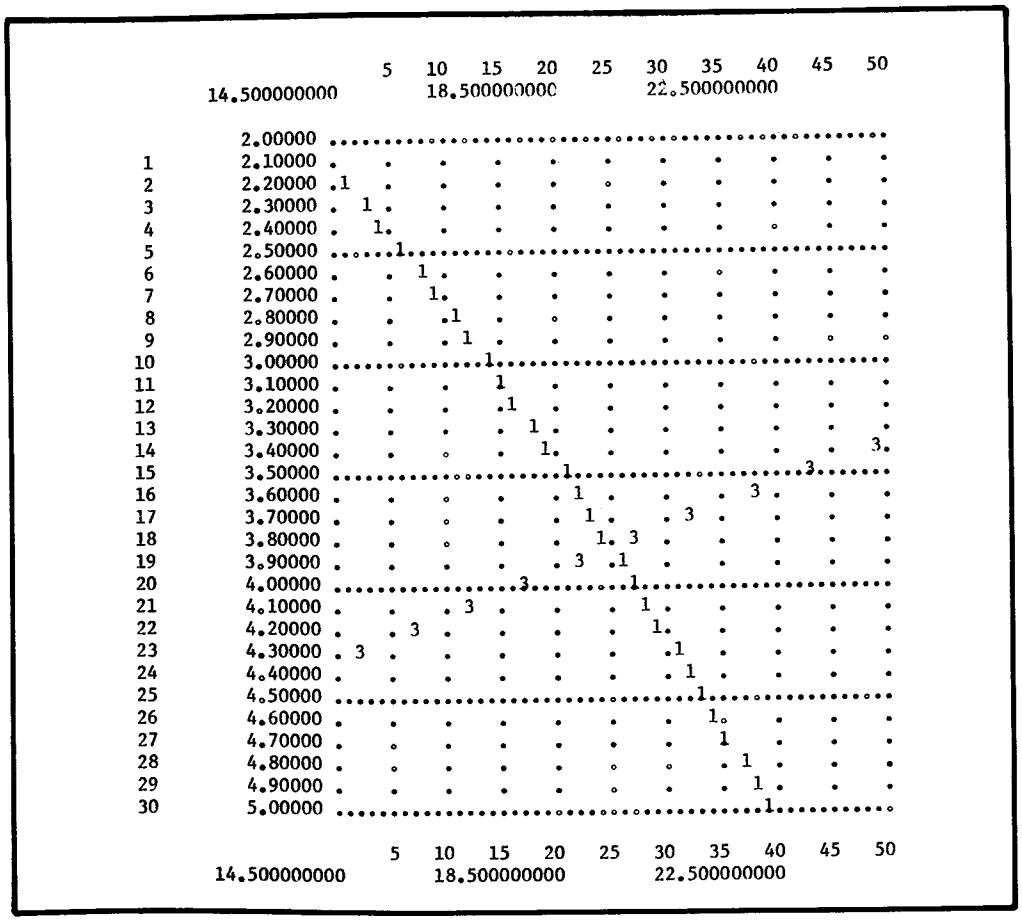

FIGURE 3 Expanded section of Figure 1 where $2 \leqslant x \leqslant 5$; $\Delta x = 0.1$; $14.5 \leqslant y \leqslant 24.5$; and $\Delta y = 0.2$.

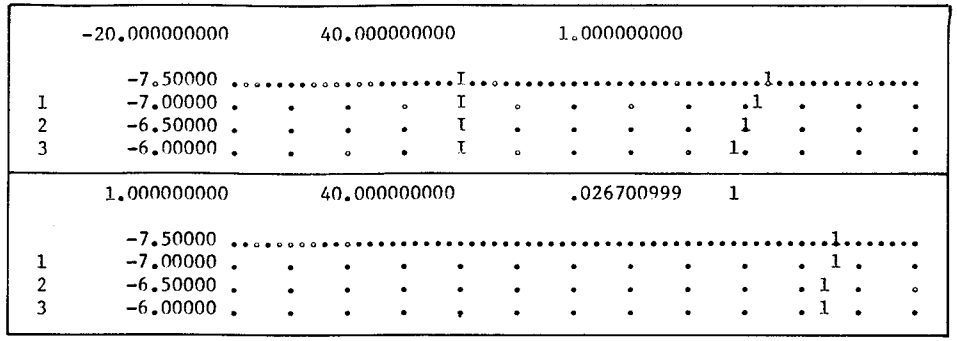

FIGURE 5 Plotting with the smallest program package.

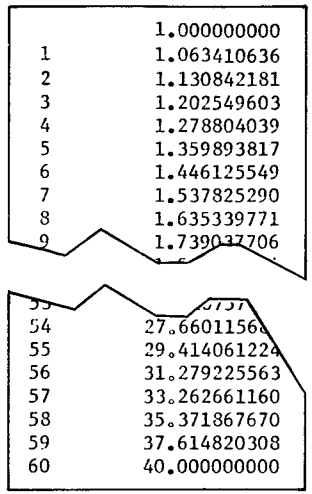

FIGURE 4 Listing of y coordinates.

will be useful if the y-axis has a log-scale. Figure 5 illustrates the above-mentioned use of PLOT-701 in the core-saving version, PLOT-701-1; the plotting area is unchanged. However, compared with Figures 1 through 3, the graphical y-coordinate identification is lacking. Instead, a headline is printed with the range of y, the increment y and a criterion stating whether lin-scale (upper part of Figure 5) or log-scale is used.

Plotting Time:

To obtain an idea of the plotting speed; each of the graphs, Figures 1 and 2, requires about twelve minutes output time including computation. I hope these programs will prove useful to other users. See Forum Exchange Program No. 6.3.1. ■

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