INTERACTIVE GRAPHICS ON LOW-COST CRT DISPLAYS

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ABSTRACT :

This paper describes an inter-active graphics C.R.T. terminal using raster-scanning techniques. It is not intended to provide a high-precision display but rather as a low-cost "electronic blackboard" having a resolution that is quite sufficient for many applications. The basic unit provides a uniform plotting matrix over the screen of 160 x 48 points. An improved version provides 160 x 96 points with point spacing of approximately 0.050" in both axes on a 12" diagonal screen. The system uses ASC II coding and control software is in Fortran.

EXPOSE :

Ce résumé décrit un terminal à tube cathodique avec graphiques inter-actifs, employant les techniques de la ligne d'image. Quoique ce terminal n'a pas été conçu pour donner un affichage avec grande précision mais plutôt de servir comme un "tableau électronique", il possède une résolution qui est plus que suffisante pour diverses applications. L'Unité de base fournit une matrice uniforme pour traçage de courbes sur une grandeur d'écran de 160 x 48 points. Une version améliorée possède 160 x 96 points avec un espace entre les points d'environ 0.050" sur les deux axes sur un écran de 12" de diagonale. Le système est codé en ASC II et le software de contrôle est en Fortran.

LOW COST GRAPHICS FOR CRT TERMINALS

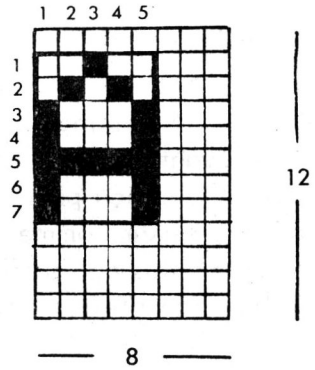
The "weak link" in many a computer-based information system is still the ability of the user to read and comprehend the reams of output data presented to him. The purpose of an information system is to convey information, not merely "data".

CRT Terminals, now becoming popular, provide the vehicle for presenting information to the user in more comprehensible form using inter-active graphical techniques. However, graphic CRT's are very expensive so it was our objective to develop a low-cost graphics "add-on" to a basic alphanumerics CRT. We did not seek high precision but rather a simple, cheap device capable of producing "pictures that would save a thousand words".

Lektrographics * is just that, - it is a simple plug-in module that fits some of the CRT's in Lektromedia's line, thereby providing a graphics display generator. To make the system interactive, some computer software is needed.

Display Characteristics

Lektrographics works on the principle of accessing the full area of the dot field which normally contains a character and the surrounding spaces.



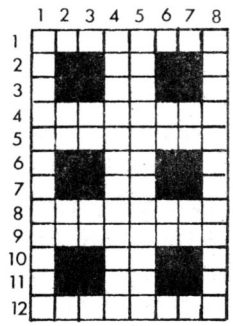
Typical Alphanumeric Upper Case 'A', note : area surrounding 5 x 7 matrix is not normally accessible.

In this way continuous vertical and horizontal lines can be drawn and curves can be approximated from a point pattern of 160 x 48 filling the screen. This concurs with an 80 x 16 alphanumeric format. Any character location can display either an alphanumeric or a graphic character.

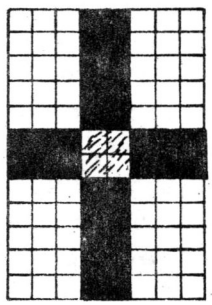
Low Cost Graphics for CRT Terminals.

Display Characteristics (Continued)

The graphics repertoire provides two basic character structures shown below :-



Graphics
Point Pattern



Graphics Bar Pattern
(Center area lights up with
any segment).

The point pattern consists of 6 points arranged uniformly in the full font like a domino. Any number of dots can be lit up in any combination. Likewise the bar pattern is used to form continuous lines by lighting up any number of combination of the 4 sections.

The screen has 1280 character locations arranged in an 80 (horiz) x 16 (vertical) format. At any location, one can display either a "point pattern" or a bar pattern or an alphanumeric or a programmable special symbol. Photo no. 1 shows all four being displayed simultaneously on the screen.

To construct a graph displaying a mathematical function, one would form the axes using the bar pattern and plot the curve using the point pattern. Photo no. 2 shows a computer-generated sine wave.

Graphics characters are encoded in 7 bit code and transmission and data handling processes them as any ASC II character. For transmission purposes, graphics characters are enclosed between ASC II "Shift Out" and "Shift In" control characters. Within the terminal, Bit 8 is used to distinguish a graphic from an alphanumeric and the status of Bit 7 determines whether a graphic is a point or a bar pattern. Bits 1 thur 6 determine the status of each point or bar.

It is possible within the CRT to directly position the cursor to any character location using a special instruction (1 CTRL character) followed by 'x' and 'y' positioning characters. This eliminates the annoyance of a "dancing cursor" and greatly reduces storage requirements and transmission time.

Low Cost Graphics for CRT Terminals (Continued)

Interactive Software

Graphics generating software has been written in FORTRAN and BASIC. The program is based on computing the x and y coordinates of the function to be plotted and then approximating the true value of y by using the direct cursor addressing to position an appropriate graphic character.

Take for example, the Sine wave $y = A\sin x$ shown in in Photo no. 2. - First, the program specified the format of the axes and delivered a chain of Bar characters. Next, the user specified the function to be plotted, its peak value and the range of x for which a plot is required. The system is capable of plotting up to 160 increments in 'x' and for each, the program solves the equation, thus developing a table of y versus x.

The program then scans through the table and for each increment of x calculates the character location on the screen containing the value of y. It then delivers the cursor address command (1 CTRL character) followed by column and line count. It then calculates which dot in the field most closely approximates the y value and sends the appropriate graphic character. Each column on the screen contains 2 values of the equation (i.e. two columns of dots in each font). Having plotted the first, this is temporarily memorised while the second is calculated. If the second value lies within the same character location, a new graphic character is calculated which replaces the first, if not, then the new cursor address and character is transmitted.

Programmable Characters

It is also possible to display "full font" special characters, individually programmed. This, for example, would allow you to display scientific symbols such as the integral, square root, franctions, subscripts and superscripts, foreign alphabets and APL operators.

Each special symbol may need special interpretation routines at the computer. For example $\surd$ (which can be assigned a unique code in the shifted out ASC II set) can be programmed to initiate the calculation of a square root.

Similarly, each of the APL characters initiates a particular routine.

Low Cost Graphics for CRT Terminals (Continued)

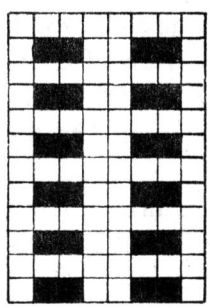
Bilingual Character Set

French accented lower case characters can be displayed on some LEK terminals using the full font as does the graphics. In this case, we are following the protocol proposed by the National Research Council in the expectation that this may eventually become a standard. There are 10 accented characters, on 5 keys, which replace certain infrequently used symbols.

Overstriking

One of the shortcomings of the basic Lektrographics is that the vertical resolution, i.e. dot spacing is inferior to the horizontal.

This limitation has been overcome by means of storing two graphic characters at each location and super-imposing them electronically (over-striking *). This doubles the number of points in the vertical axis, i.e. the point-plotting matrix becomes 160 x 96. The layout in the font is as shown :-



Graphics-Overstricking
Point Pattern.

With this geometry the resolution in the x and y axes is the same, namely about 0.050" on a 12" diagonal screen.

The overstruck version is coded such that all 6 points in one column are stored in one memory and all 6 points in the other are stored in a second memory. This is done largely for convenience in graphic-generating software.

* Patent pending.

Low Cost Graphics for CRT Terminals (Continued)

Overstricking (Continued)

Another feature of the overstricking capability of the terminal is that alphanumerics can be overstruck. This is particularly relevant when CRT's are used in APL systems since overstricking is an inherent feature in the interpretation of APL operators.

The overstricking can also be used for some foreign accents and diacriticals used in transliteration.

Overstruck characters are entered either automatically by recognising particular codes as in the case of diacriticals, or by means of a "printing backspace" in the case of APL or by means of a "supershift" for the high-resolution graphics.

Direct Interaction with the Display

Some of the LEK terminals are equipped with a touch-sensitive screen overlaying the display. This device was invented at NRC and produces "x" "y" coordinates defining the position of a passive stylus, -such as one's finger. Resolution is approximately 0.10" which is comparable with the character-spacing on the screen but inferior to the graphics point resolution.

Touch panel coordinates are multiplexed with keyboard data for transmission to the computer. The NRC protocol for header word formats is being used.

Audio-visual capabilities

Some of the LEK terminals are also equipped with random-access audio and slides. Again, these devices are controlled under the NRC header-word protocol. The rear-projected slide image is adjacent to the CRT display with the touch panel overlaying both images.

Low Cost Graphics for CRT Terminals (Continued)

Many New Uses

Imaginative users will quickly see that whole new dimensions of inter-action between man and machine are made possible by the terminals I have described.

They are being developed primarily for Computer Aided Learning in coordination with NRC's CAL project. We modestly suggest that they are the most advanced CAL terminals available in the world today.

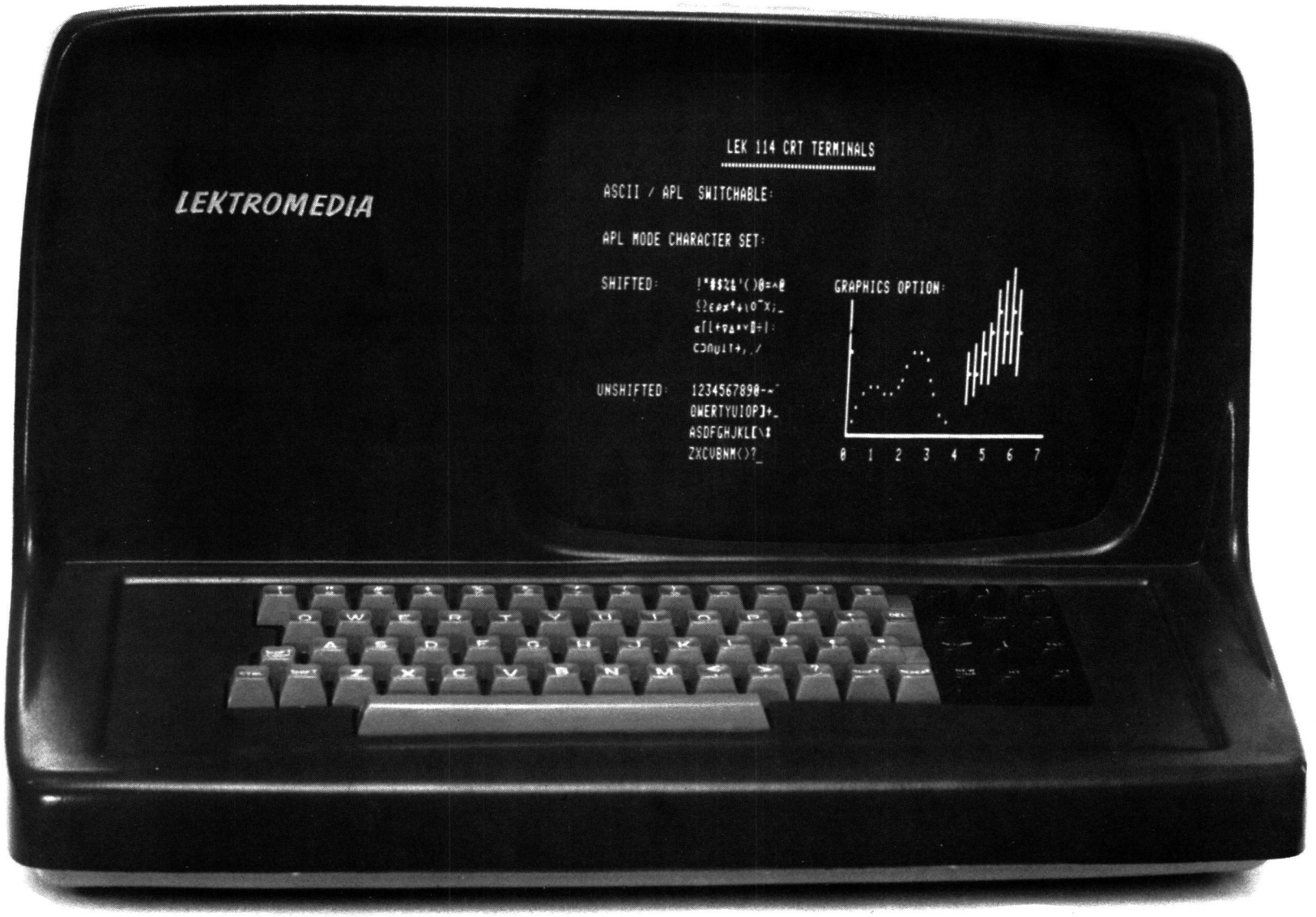


PHOTO 1 -- Showing programmable characters, graphics and alphanumerics on the screen.

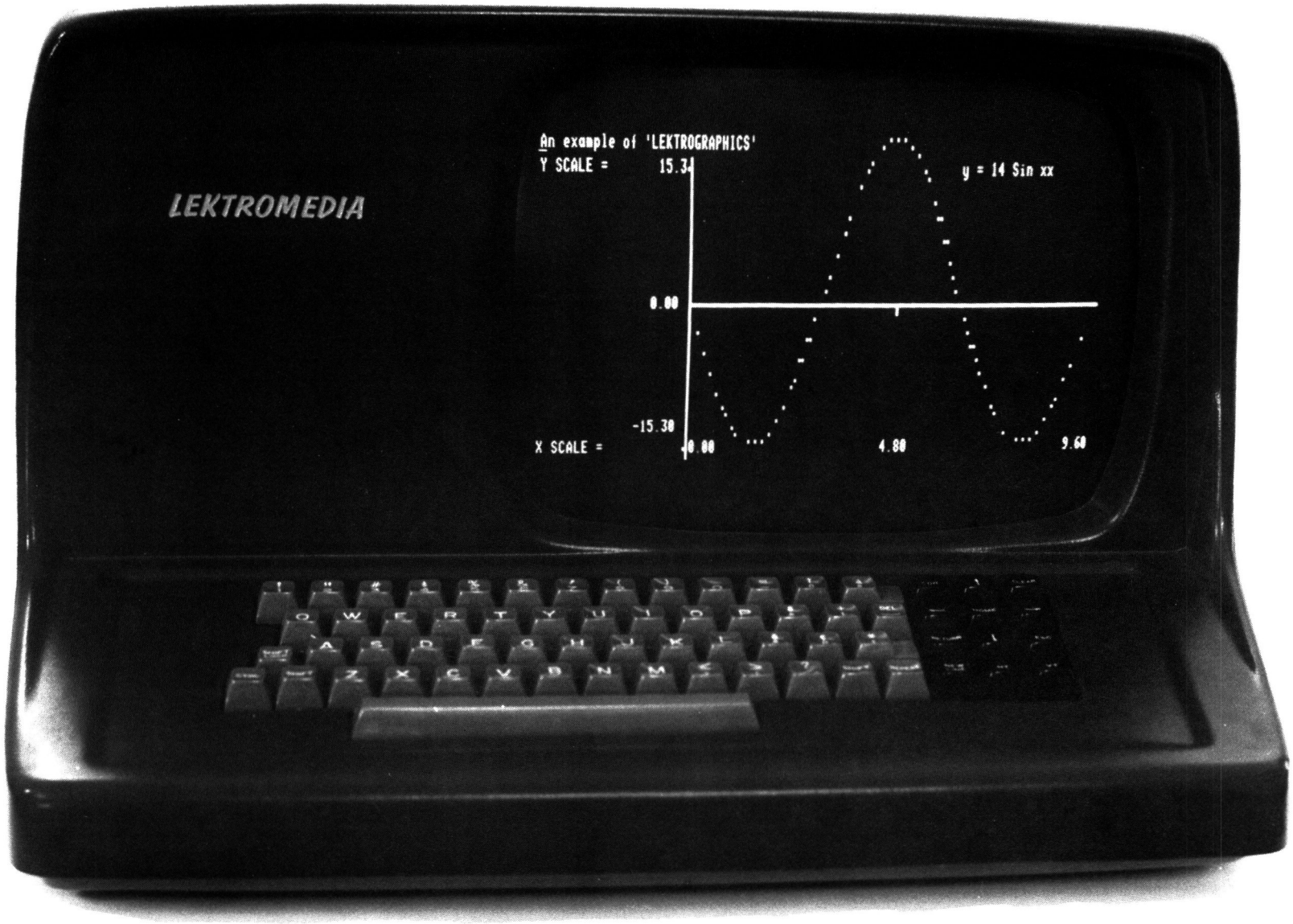


PHOTO 2 -- Showing a computer generated mathematical function on the screen.