The Vertical-Format Handheld User Interface: Where Did We Come From, Where Are We Going and Why Haven't We Gotten There Yet?

Jake Schwartz

The vertical-format handheld calculator has evolved significantly in the past 25 or so years. Due primarily to the advances in electronics' density, speed and cost, these units have been transformed from fixed-function, non-programmable, closed boxes to flexible, customizable and connectable tools for many disciplines. However, still more can (and probably will) be done to maintain and/or increase the ease-of-use as capabilities continue to grow.

Two issues which have been addressed by Hewlett-Packard machines over the past two decades have been (1) accessing more built-in functions than the calculator has keys; and (2) providing an increasing amount of user-defined functionality and customizability in a handheld. Continuous changes to keyboards followed by changes in displays and finally upgrades to both together have been the vehicles through which these features have been incorporated.

Keyboard Evolution Allows More Built-In Functions

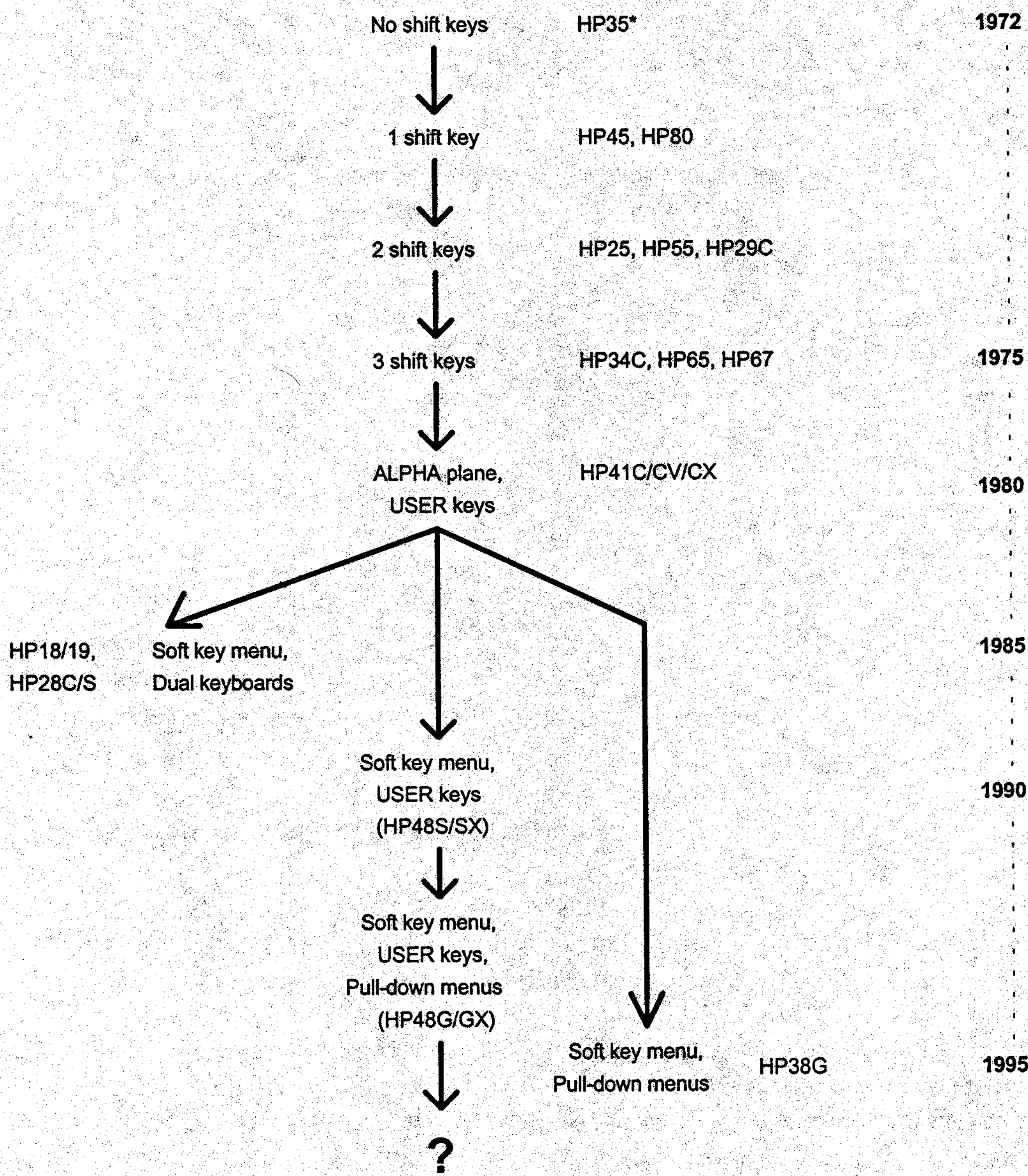
From the days of the HP35 calculator up to the introduction of the HP67, the solution for providing more functionality than keys was to increase keyboard use through shift keys. (Even the HP35's arc key serves as a limited shift for the three trig keys in the same row.) With as many as three shifts in the HP65 and HP67 (and again later in the HP34C), calculator keyboards were becoming extremely "busy". Nevertheless, each and every function in these units could be clearly found printed either on the keys or on the surface around them. As a result, virtually any function could be reached with a maximum of two keystrokes. Figure 1 shows a rough evolution of the HP calculator keyboard.

With the HP41 (in 1979), the road took a new twist in addressing the ever-increasing number of functions. With the advent of the ALPHA key plane (in conjunction with the first alphanumeric LCD), one could spell out any function needed and thus reduce the required number of shift keys on the keyboard. The USER-mode key assignments also allowed functions to be rearranged over the entire keyboard.

Then in 1986, the Saturn-processor-based machines began to roll out and the HP18C business calculator took us in two new directions with respect to the user-interface. The first change was the switch to dual keyboards; one designated for the ALPHA keys and the other for the remaining functions. The second, and perhaps more significant advance was the use of the bottom row of the LCD to spell out the definitions of soft keys located in the top row of the keyboard just below. This displayed soft-key "menu" concept took firm hold and has appeared in just about every subsequent HP machine (plus many high-end units from TI, Sharp and Casio as well).

Finally, in 1990 the HP48S/SX combined the soft-key menus of the HP18C and HP28C/S with the USER keys of the HP41 to attain the current *keyboard* state of the art. It doesn't appear that either the HP48G/GX or the HP38G has made any significant strides in the area of *keyboard-based* improvement to the user interface.

Figure 1. HP Calculator Keyboard Evolution

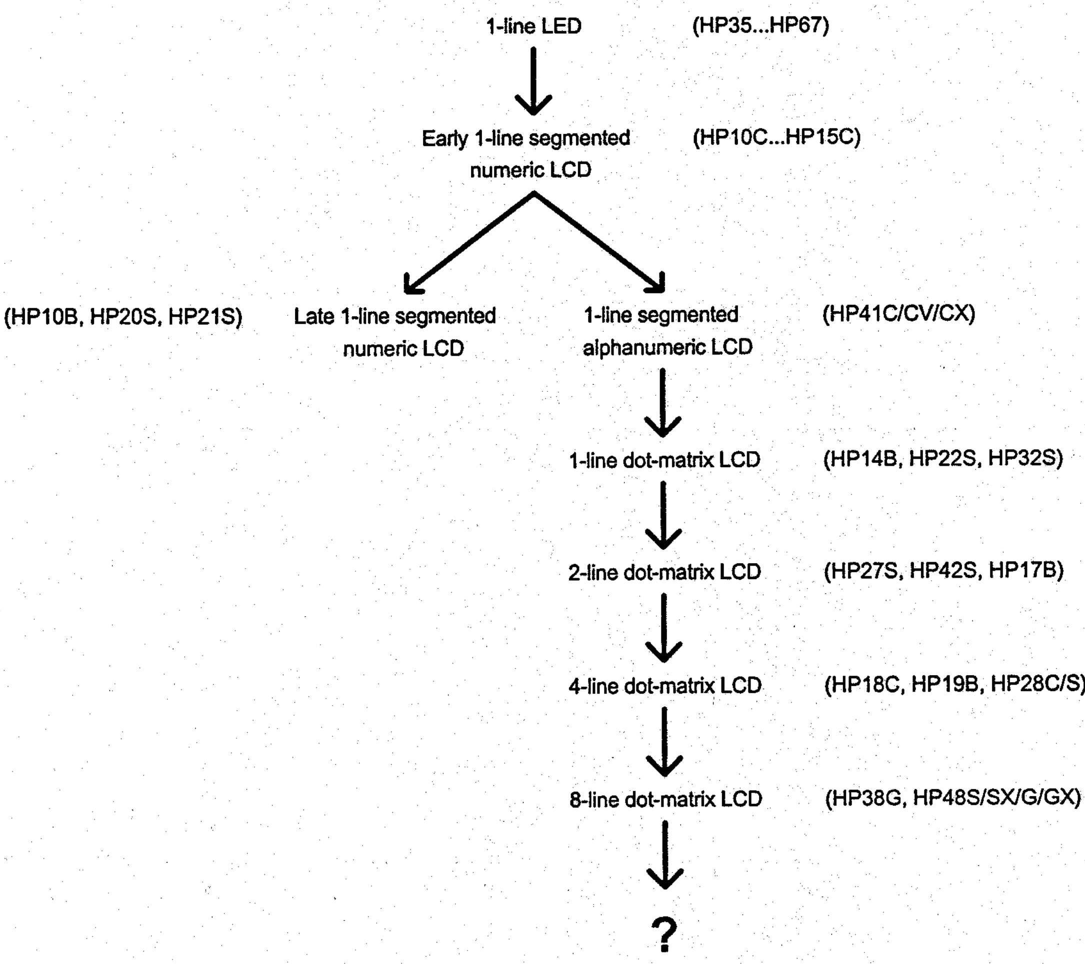


* The HP35 arc key acts as a shift for only the three trig keys, so it isn't counted.

Display Upgrades Keep the Pace

In order to compliment improvements to the user interface based on keyboard changes, calculator displays followed suit. Throughout the "Classic" (HP35 ... HP67), "Woodstock" (HP21 ... HP29C), and "Spice" (HP31E ... HP34C) series machines, the one-line light-emitting-diode display reigned as king. See figure 2 for a chart of display evolution.

Figure 2. HP Calculator Display Evolution



That changed for the better when one-line liquid crystal displays were employed in two flavors; with the early segmented numeric type in the horizontal-format "Voyager" (HP10C ... HP15C) series (in the early 1980's) and the segmented alphanumeric LCD in the HP41 series units (1979-1983). The segmented numeric one-liner was continued in the vertical-format HP10B, HP20S and HP21S machines in the mid-to-late 1980's, while the alphanumeric LCD migrated to the various dot-matrix varieties to follow from the mid 1980's to the present.

Picking up with the alphanumeric dot-matrix machines, HP produced four types of screens; with 1-, 2-, 4- and 8-line LCDs. All these provided some form of soft-key menus, assigning varying functionality to the top-row keys.

Customizing the User Interface: Keyboards and Displays In Concert

With the advent of programmable pocket calculators in 1974, the concept of user customizability was incorporated into handhelds and has been steadily enhanced. In the HP65 and HP67, we saw the first example of user-definable keys, with a single row of five keys labeled "A" through "E", providing access to programs at five corresponding local labels. (Texas Instruments did not remain on the sidelines in this area, contributing the SR-52 and TI-58/59 with that same five-key row.)

This was enhanced in 1979 with the HP41C, when the number of local labels was increased to ten, allowing the top *two* rows of keys to correspond to user-program labels "A" through "J". Also, with the USER key assignments in the HP41 series, remapping the full keyboard to any desired arrangement of ROM- or RAM-based functions would be identified through the use of keyboard overlays. Although the HP41's ALPHA capability allowed the keyboard to become less physically cluttered, keystroke counts soared as functions such as 'PROMPT' required as many as nine button presses (**XEQ ALPHA P R O M P T ALPHA**).

This requirement to spell out functions which did not already reside on keys was circumvented by the soft-key LCD menu over the top row of keys in the HP18C (released in the Summer of '86) and continued on later machines. (Note that the capability to spell out any function in the command line still remains as a convenience on the HP48 series.) Not only did the soft-key menus enhance the ability to access the built-in functionality, but the VAR menu and subdirectory structure also simplified accessing user-created programs and other RAM-based storage values. Finally, the addition of custom/temporary menus in the HP48 series achieved the pinnacle of customizability, allowing the user to mix and match RAM and ROM functions in any desired order.

In the HP48G-series and finally with the HP38G, user-input display forms, choose boxes and vertical browser-type scrolling display windows (used in conjunction with cursor keys) were incorporated to attain the highest flexibility in HP calculators to date.

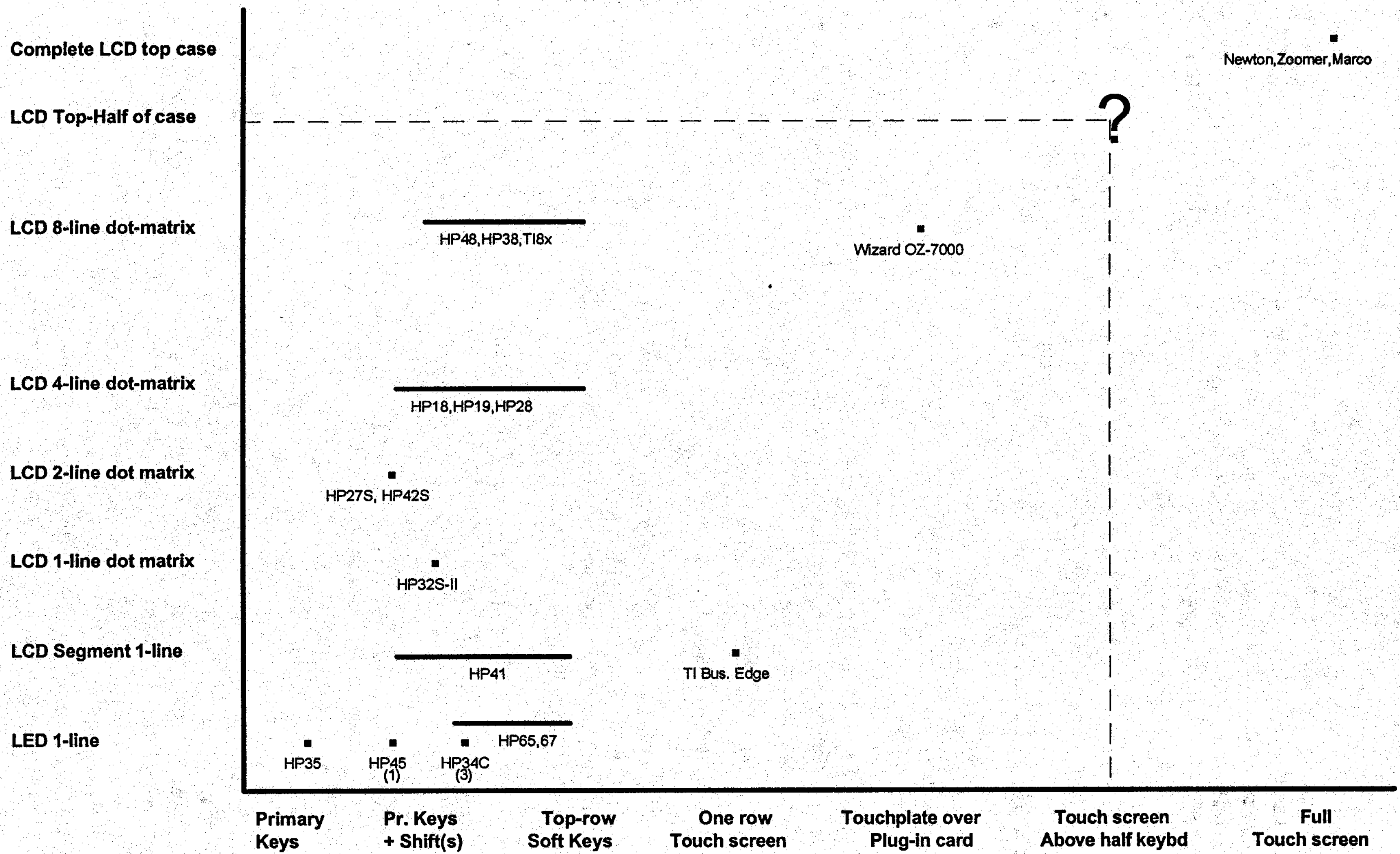
Where Have the Other Manufacturers Gone?

Figure 3 plots the combination of display and keyboard enhancements and shows a representative number of HP calculators along with some significant vertical-format handhelds from other manufacturers. In this writer's view, there remains significant room for improvement in keyboards and screens in order to enhance the user interface of a vertical-format handheld calculating device.

The use of overlays to designate changing keyboard functionality was extended slightly in Texas Instruments' TI Collegiate scientific calculator, introduced in 1988. This clamshell machine's right-hand keyboard sported slots over every key through which shifted-key functionality labels were viewed. However, with a change of modes between scientific and statistical functions, those same shifted positions became completely redefined. This mode change was activated by an up/down slide switch on the side of the case, which not only performed electrical switching, but also slid an internal plastic sheet up and down to change the shifted keyboard labels on all the keys. Unfortunately however, this concept was not maintained on any subsequent TI models (nor was it adopted by any other manufacturer).

Another progressive keyboard feature is the touch-sensitive surface. Both Texas Instruments and Sharp have experimented in this area. TI's Business Edge calculator (from 1988) sported a single row of touch-sensitive keys which could be made to operate a series of financial computations. Different sets of LCD annunciators would "light" under these keys depending upon which calculation mode was selected. Perhaps the most popular venture into touch-sensitive surfaces was on the original Sharp OZ-7000 Wizard organizer. This clamshell unit sported not only two "regular" keyboards, but a roughly 2-inch-square clear touch-surface over top of the plug-in card port. When a card was inserted, painted function markings on the card which were visible through the clear surface would define the "touch keys". This allowed varying-

Figure 3: Vertical-Format Keyboards vs. Displays



(1) one gold shift key on the HP45

(3) three (gold, blue, black) shift keys on the HP34C

sized touch keys, depending on the number of functions crammed into the currently attached card. A simple card might have four rows of four fairly large functions laid out on its surface, while a complex one might have eight rows of eight much smaller touch areas. This evolved into the fully touch-sensitive LCD in the top half of the case on the horizontal-format Wizard OZ-9500/9600 and Taurus models.

Finally, the "PDA" class of handheld products currently available in the marketplace (such as Zoomer, Newton and Marco) take the user interface to its possible extreme, using a virtual no-key keyboard: the full-screen touch-screen liquid-crystal display. Ruling out irrelevant problems associated with these products such as CPU speed, short battery life and such, there remains a handful of troubling questions about full-sized touch screens. Two issues heard repeatedly are that (1) the repeated use of fingers coats the surface with dirt and oil, requiring frequent cleaning; and (2) there is no tactile feedback when a touch-screen key is pressed. The first issue is addressed by the manufacturers (namely Casio, Apple and Motorola) each providing a storable/detachable stylus for touching the screen's surface. The second issue has an "end-around" approach, with an optional audible click combined with a visual "flash" of the touch-key's surface whenever a key is pressed or tapped.

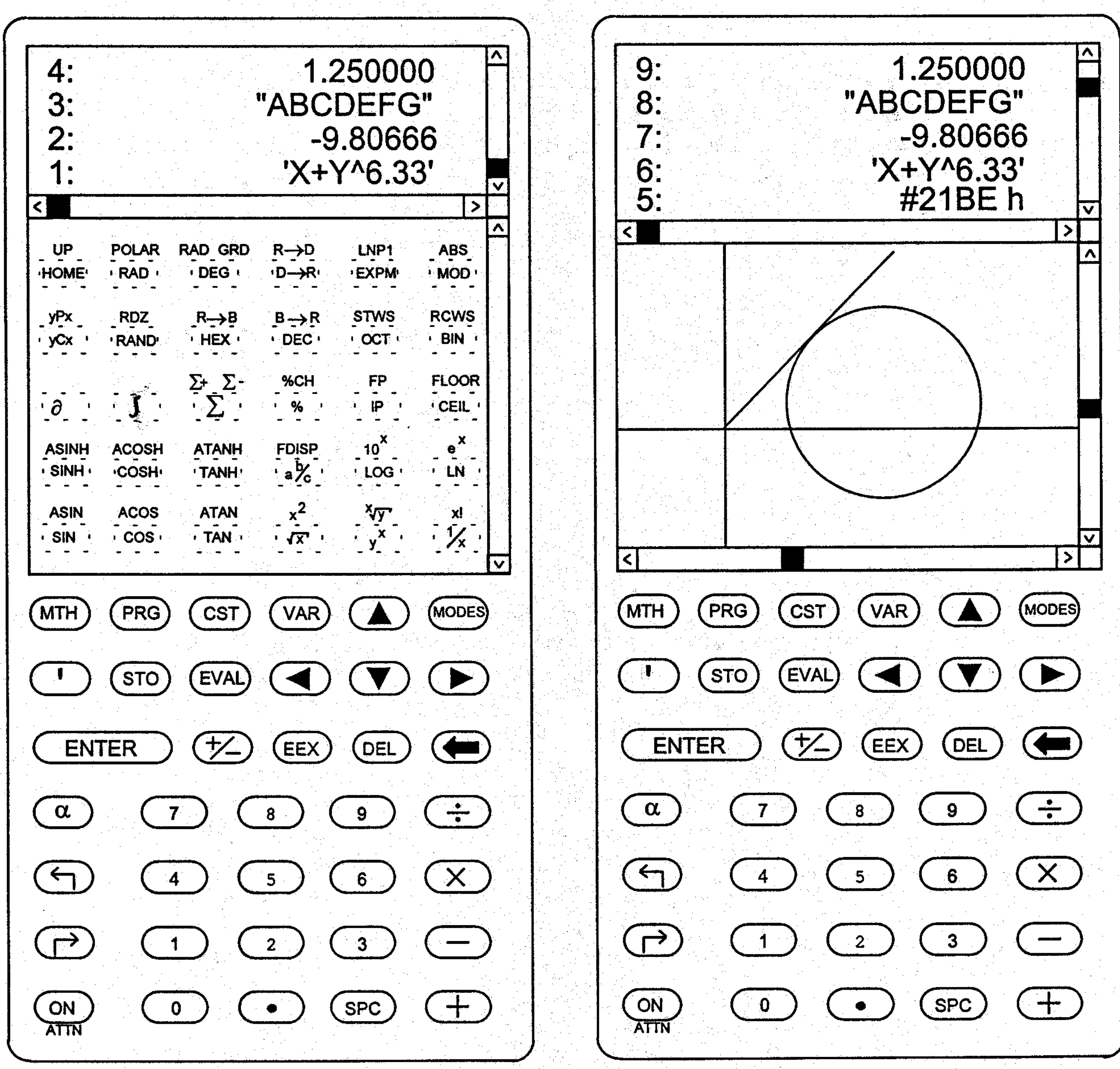
Where Can We Go From Here?

This leads to the question of where we should proceed from here with vertical-format handhelds which primarily serve as portable mathematical problem-solving assistants. Due to the need for a numeric keypad which should remain in real physical keys for data entry, our full-screen PDA-style approach probably fails. In addition, the enormous expense of placing LCD displays over each row of keys on a calculator keyboard in order to provide an "automatic electronic keyboard overlay" would likely be deemed as impractical. The pull-down menu approach which is beginning to appear in HP (HP38G), TI (TI82/92) and Sharp (EL9200/9300) machines does give users access to an unlimited number of functions, but requires using cursor keys repeatedly until the desired function name is reached.

One solution proposed here permits a minimum number of keystrokes required to access the maximum number of functions, while allowing a numeric keypad to remain. Consider a slightly-taller-than-an-HP48-sized unit which contains seven rows of keys at the bottom. Above the keys lies a touch-screen LCD extending over the remaining surface of the top of the case. This LCD could then be used for a multitude of purposes. In it's "default" state, perhaps it would show a four-level stack at the top with several rows of soft keys below. These soft keys might access further soft-key menus ouitward along the branches of the menu tree. The primary difference between this approach and the existing one is that there would be no need for multiple "pages" of single-line menus, since all menu functionality would be visible at a glance. Utilizing an LCD with the high resolution of that in the HP200LX could achieve extremely fine detail as to allow multiple shifted soft-key positions labeled on the screen along with the primary function inside the key area. Figure 4 shows two examples of such an approach.

With the LCD divided into multiple windows with the stack window above and the soft-key window below, the views of each could be adjusted by adjusting the horizontal partition between them. In order to see a larger portion of the stack, one would simply drag the partition downward. In order to see the upper stack levels, the icons on the side of the window would be used to slide the view upwards. In the lower soft-key window, the built-in functions would be exposed one full menu at a time. Customizing this key window could provide for dozens of RAM and ROM-based functions to be accessible simultaneously. For graphics applications, plots would go to the DISP window, which could be revealed alone over the entire LCD surface or in addition to either the stack or menu-key windows or both. This window could be scrolled in any direction to scan its full size.

Figure 4: A Proposed Key/Touch-LCD Machine



An optional "keyclick" sound could be provided for use in conjunction with touching the soft keys. The various modes and other forms could cause pop-up windows to appear which could be filled out and then dismissed. Essentialy, the screen would become disassociated from the hard keyboard and become a more flexible tool for both input and output.

Why Haven't We Gotten There Yet?

Here we are, sitting in the middle of the HP48 era and at the beginning of the HP High-School calculator era, waiting for something to come next. There are probably several reasons why we haven't experienced a vertical-format unit similar to the one proposed above. Some that come to mind are: (1) the persistence of generally negative feelings about touchscreens; (2) the lack of an adequately high-powered CPU to be chosen as the successor to HP's Saturn architecture; and (3) the lack of an adequate high-capacity battery source for handhelds to assure 100+-hour usage between replacements. Since an outboard pointing device is surely impractical for a handheld, the touchscreen poses a useful alternative for manipulating a windowing display. With many low-power-drain chips coming onto the market for handheld applications, such as the Power PC 603, the StrongARM and the like, we can be assured that something will become a likely candidate for HP's next design. And lastly, with newer, more powerful battery choices reaching market such as lithium-ion, lithium-polymer and zinc-air chemistries, the portable power problem should soon be a thing of the past.

We wait impatiently for something to emerge which offers not only unprecedented functionality in a scientific handheld, but also reaches new heights in user-friendliness, convenience and customizability.