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SOME OBSERVATIONS ABOUT THE HEWLETT-PACKARD 2640A DISPLAY TERMINAL

by J. H. Saltzer

For the last three years, the Computer Systems Research Division of Project MAC has been exploring the market for terminals, looking for ways to modernize its selection of interactive time-sharing terminals. Two specific goals have been to obtain higher output writing rates than 134.5 bps and to obtain cathode ray tube display for flexibility and quiet operation. The division's use of terminals is perhaps 75% for preparation and editing of text, for programs, memos, or mail. Program debugging and execution occupy most of the remaining 25% of its use.

Most of the new interactive terminals that have been examined have been disappointing for a variety of reasons, usually summarized best as "inadequate human engineering". The Hewlett-Packard HP-2640A terminal seems somewhat higher in quality (as well as price) than most of the others we have encountered. This note lists those aspects of the HP-2640A that in my opinion make it more desireable, and at the same time discusses several examples of inadequate human engineering that it exhibits. These points are collected from observations of my own as well as many other members of our group.

First, the good news. The following points seem to make this terminal design of higher quality than others I have seen:

1. It is relatively compact and pleasing in overall appearance, and ruggedly constructed.
2. The keyboard is separate from the display, allowing personal choice of viewing distance and angle.
3. The terminal is genuinely quiet. There is no 60-cycle hum, no noisy fan, and no high pitched horizontal flyback oscillator whine.
4. The character font design is pleasingly similar to a good quality office typewriter.

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5. The characters are all easily distinguished from one another, without resort to slashed zeros or misshapen ones. There are no "strange" interpretations of the ASCII graphics.

6. Focus and character size remain uniform at all points on the screen.

7. The screen is set at a comfortable viewing angle.

8. The screen is sufficiently glare-free that reflections from non-illuminated objects are not a problem.

9. Underlining is available, and is legible.

10. The terminal has a character display memory larger than the current screen size, and within limits allows scrolling backward to review earlier output without bothering the main time-sharing system. Further, the terminal does not waste memory on short lines. This feature appears to be an important way of taking a load off the time-sharing system, and is therefore worth quite a bit economically.

11. Text can be displayed in "inverse video" mode, with dark characters on a light background. Further, the inverse video is complete, without intervening black lines. This mode seems to me more natural and produces less eyestrain than the more common light characters on a dark background.

12. There is a "half-brightness" mode that used in combination with inverse video produces the most readable display I have yet encountered.

13. The display rate of 2400 bps is a qualitative improvement over 150 bps and 300 bps terminals, not just a quantitative one. It leads to a different mode of thinking about what output to request.

14. The pressing of all function keys and buttons accessible to the user (including cursor position) can be detected by the time-sharing system, and it can invoke any function of the terminal. This feature allows the time-sharing system to keep track of what is going on.

15. In a few months of service, both reliability and maintainability have proven to be excellent.

16. Program-settable tab positions are very handy since we use the terminal with two different systems with different standard tab settings.

17. The memory lock feature is handy for holding onto output that should not be overwritten.

18. Many features of the terminal are implemented by a programmable microprocessor. This fact is of interest primarily because some of the human engineering deficiencies, described in the next section of this note, may be repairable simply by rewriting the microprocessor program. Also, the terminal can be used as a base for experimenting with alternate human engineering strategies.

With the above list of good features helping explain why the HP-2640A terminal has proven more interesting than others, I now switch to those places in which the human engineering of that terminal is inadequate:

1. It is hard to believe that the company that manufactures the HP-35, HP-45, etc. line of hand-held calculators with their exquisitely designed keyboard touch could at the same time sell a terminal with such a poor keyboard touch as the HP-2640A. On a scale of one (excellent) to five (awful), I consider the HP-2640A keyboard to be fourth-rate. Specifically, the following characteristics that I associate with a first-rate keyboard are missing:
   a) break-through: the tactile feedback mechanism that tells the touch typist that this key stroke has been recognized.
   b) keyboard curvature: the key tops should not be in a plane, but rather the rows should be placed in a slight concave curve, so as to track the curved path followed by the tip of an unfolding finger reaching for higher rows.
   c) mechanical interlock: there should be a mechanism that prevents several keys from being depressed simultaneously, yet allows rollover.

   The key spring system, combined with these three lacks, produces a very poor keyboard "feel", which leads a touch typist to many frequent mistakes, usually in the form of gratuitous home-row characters. Almost any standard office electric typewriter provides an example of a keyboard that has a better touch than the HP-2640A. In my opinion, the poorly-engineered keyboard all by itself changes the HP-2640A terminal from "obvious first choice--let's standardize on this" to "questionable--let's wait to see if someone does better".

2. The maximum output writing speed of the terminal should be higher--at least 9600 bps, possibly 19.2K bps. The higher speed would allow full advantage to be taken of the qualitive difference in methods of use referred to earlier. At 19.2K bps, a typical "screenful" of information can be displayed in a fraction of a second. On the other hand, it is not apparent that still higher speeds provide any significantly different effects for text display. Thus it seems appropriate to have a terminal that solidly takes advantage of this "plateau" effect. It would also be handy if the option of synchronous transmission were available.
3. The HP-2640A design, while allowing for inverse video, makes an assumption that it will be used for highlighting of text, rather than as the normal mode of display. Thus it applies the feature on a character-by-character basis when invoked, and it resets the inverse video mode on every new line. To make inverse video the <u>normal</u> mode of display requires a complex driving program. It also uses up memory in the HP-2640A, since to fill the screen with light, explicit "blank" characters must be stored to fill out every line. The terminal should provide a hand switch that simply inverts the meaning of inverse video*. We have installed such a switch on our HP-2640A, and have found that almost all use of the terminal is in inverse video mode. One minor problem with this simple fix is that it leaves a dark border around the screen, and a word displayed at the screen edge appears to "run" into the border.
4. The "tab" function should be a separately labelled key on the keyboard, reachable without moving the hands from the home key position, just as on any office electric typewriter. The HP-2640A terminal makes this a "function key" on a panel above the keyboard, where it is almost useless as a device to speed up input typing.
5. The "return" key should be both larger and closer to the home row position so that a touch typist does not need to break the rhythm of typing to go to a new line. The present design makes the return

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* This switch should simultaneously invert the meaning of "half bright", or else a second switch to invert that function should be provided also.

key double size. On a good office electric typewriter, the return key is often 4 times normal size and always closer to home row position.

6. The "cursor", representing the next position to be written, should be associated with a position in the memory of the HP-2640A rather than with a position on the screen. The present design insists that the cursor should always be visible on the screen. For example, if one asks the time-sharing system to display a three page memo, the first page is written from the top of the screen to the bottom. Once the bottom of the screen is reached, the terminal continues accepting lines, but it insists on displaying them as fast as they are received, scrolling the display upward at 2400 bps, making it unreadable. A better design would accept additional lines and place them in the memory, but leave the screen displaying the first page of output until the human reader pushed the "next page" button. Again, this effect could be simulated by a program inside the time-sharing system, but such a simulation would take no advantage of the HP-2640A memory capacity and the potential of the HP-2640A terminal to reduce the computing load of the time-sharing system. The whole area of how to utilize to best advantage a terminal with memory and moderate computational capacity needs much more engineering development. For example, it might be appropriate to divide the display into two independently managed windows onto the internal memory, one of which scrolls as at present and the second of which is managed only by the "next page" and "previous page" buttons. In any case, the present design is not well human engineered.

7. The "previous page" and "next page" functions are not symmetric in the case when the last page is partly filled. Thus when flipping back and forth across several pages, the position of material on a page depends on whether one has approached it from above or from below. A better design would keep the position constant.

8. The terminal lacks an overstriking capability. It allows underlining as a special mode, but does not automatically recognize the sequence letter-backspace-underscore. At the least it should handle that sequence in the right way.*

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* Even better, it should recognize all such sequences and be prepared to <u>or</u> together any pair of characters to form an overstrike. Any more general overstrike capability than that is probably not necessary.

9. There is user visible evidence that the processor is "underpowered" for the application. An unusual, non-standard ready-acknowledge protocol is used to keep from overloading the processor on output, and if the time-sharing system does not follow this protocol, two noticeable failures occur during output writing at 2400 bps:
   a) Output blocks are occasionally lost.
   b) Keyboard polling is skipped during output.

   It would seem within the state of the art to have a powerful enough microprocessor to not only run at a higher speed but also not require a special protocol to avoid overloading.
10. The power on-off switch should be located on the keyboard or front panel in an obvious place, rather than hidden on the rear panel of the terminal.
11. The option of having the space character overwrite the current display position should be switchable from the front panel, to allow use with different time-sharing systems. It is currently switchable only by opening the case and throwing a switch mounted on a printed-circuit board.
12. There is no intensity control accessible to the user, so there is no way to adjust screen brightness for varying room lighting conditions.
13. The keyboard cable is attached to the rear of the terminal via a printed circuit board edge connector. This is a fragile method of attachment; the (presumably expensive) PC board is likely to break if someone attempts to "walk off with" the keyboard accidentally. This fragile attachment is all the more surprising when one considers that the terminal is otherwise ruggedly engineered.

If the thirteen defects and troubles described above were all satisfactorily repaired, this terminal would be practically irresistable.