Keyboards Continue Evolving

despite challenges from other input devices, keyboards will remain on top

Keyboards are undergoing major changes due to cost pressures, modularity trends and ergonomic considerations. Keyboard designs remain custom and unique to every terminal and computer product, but certain functional characteristics have become common to most applications.

by Mark E. Tiddens

The most popular method of entering data into a system is via a full-travel keyboard (full-travel defined as 0.150″ or greater). It might appear that other data entry devices such as micromotion keyboards, (less than 0.150″ travel), flat panel keyboards (no travel), OCR (Optical Character Recognition), voice data entry, and hand print data entry could decrease the use of full-travel keyboards for data entry. However, for most data entry applications where full-travel keyboards are currently being used, these other devices are not as efficient. These newer data entry methods are enhancing existing data entry applications and finding new applications, rather than replacing full-travel keyboards.

If increasing the efficiency of data entry was truly a major objective in exploring the use of other data entry devices, a major effort would be put into using an improved keyboard layout. The conventional Q W E R T Y layout was originally designed to slow data entry so an operator could not exceed the capability of the old keyboard designs. Proponents of the Dvorak simplified keyboard, for example, which merely rearranges the keys, say that an operator could produce the same output for 5% of the effort.

Keyboards will remain the most popular form of data entry since increased efficiency is not obtained in most data entry applications with devices other than keyboards, and also since all of the other devices cost more than keyboards. And although flat panel and micromotion keyboards have become popular in replacing pushbuttons in many applications, the operator feedback of a full-travel keyboard appears to be necessary for the entering of strings of alphanumeric data into a system.

keyboard fundamentals

Full-travel, data entry keyboards are arrays of switches which are placed in rows on 3/4″ centers. Most of these keyboards are arranged according to the Q W E R T Y layout. The horizontal offsets between the rows of keytops is 3/8″, 3/16″ and 3/8″ respectively, from the top row to the bottom row above the spacebar.

Each key position is composed of a keytop and switch. The switch has a plunger that the keytop snaps onto, a housing which is either molded individually or together in a single block with the other switch housings, and some kind of switch mechanism. Switches are located electrically in an X-Y switch matrix so that each switch has a unique X-Y location which can be identified. For example, when the Y lines are scanned by applying a signal to each one successively, any appearance of a signal on the X lines would indicate that a switch closure or coupling has occurred. The position of the key that has been operated is identified by the X line where the signal appeared coincident with the Y line

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where a signal was applied. A typical 80-station keyboard would have eight X lines and ten Y lines.

The entire switch matrix must be scanned and keys validated within 2 to 3 msec to allow high speed operation. It has become common to scan the switch matrix twice to confirm that a key has been depressed. This protects against false key closures caused by any interference. This double-scan verification and related algorithms have been developed and proven by keyboard manufacturers based on many years of usage in many applications.

The keyboard has to be totally impervious to differences in operator touch and speed, combinations of which cause switch teasing, bounce or several keys down at once. The ability of the keyboard to accept a number of keys down at once is called "rollover." The most popular rollovers are two key rollover — the second key that is depressed is validated when the first key is released, and N-key rollover — every key is immediately validated as it is depressed, regardless of how many keys are down elsewhere on the keyboard. When keys are actually depressed simultaneously i.e. within one scan of the switch matrix, this is obviously an error condition because an operator cannot know which key was meant to be hit first. This can be treated in many ways, including processing just one of the keys arbitrarily, both of the keys in whichever order they appeared in the matrix scan (the most popular method), or none of the keys with perhaps some kind of error message to the operator. In any case, the scanning of the keyboard switch matrix appears to be much simpler than it is, so an experienced keyboard manufacturer should be used or consulted.

which switch?

The choice of switch technology involves first, the application planned for the keyboard. If it is an application which has other electronics in the same enclosure as the keyboard, it should be considered if the other electronics can service the keyboard with minimum extra cost and components. If, for example, the microcomputer in the terminal or small computer has enough time to service the keyboard scanning and validation, a wired-only keyboard could be used to minimize cost. In this case, a contact switch technology would be selected for the keyboard to facilitate direct scanning of the keyboard.

In the past, reedswitches, Hall-effect switches, and gold-contact switches were popular for wired-only keyboard applications. However, these technologies are too expensive today because of their magnet and reed capsule, precious metal content, and semiconductor and magnet, respectively. Membrane keyboards are quickly becoming popular replacements for these technologies — not only do they eliminate the costly switch mechanisms, but they eliminate the use of an expensive printed circuit board.

However, membrane keyboards are still in their infancy for full-travel keyboard applications. Several manufacturers have introduced them and, as has always been the case, the reception of a new technology is somewhat cool until it has been thoroughly proven in the lab and in field use.

Oak Industries was one of the first to introduce a full-travel membrane keyboard. Subsequently, Key Tronic and Microswitch have introduced their versions. All three claim their membranes are unique and have been specially designed for full-travel keyboard requirements. Althouth initially it seems that a membrane keyboard is simple, manufacturers claim that very special design and production precautions must be taken to insure reliability to maintain acceptable features, such as a reasonable operating point tolerance. The pretravel, or distance to point of operation, of a switch must be between 50 to 60% of the key travel and not vary more than ±0.035″. Otherwise, adjacent keys will throw an operator off by being too touchy at the top of the keystroke.

detached keyboards

Portable, detached keyboards have become popular. They allow the operator to orient the keyboard to a comfortable position. For detached keyboards, the cost of the cable between the keyboard and terminal is significantly reduced

Keyboard Ergonomics

Keytop appearance (including shape, legend quality, matte finishes), smooth switch feel, and tight operating point (pretravel) tolerances are critical to operator comfort and throughput. Achieving, and maintaining, consistent and acceptable human factors is as important to a keyboard manufacturer's success as reliability, price, and delivery.

Europe, especially Germany, has led a recent trend towards increased ergonomic concern. The height is the most significant area affecting keyboards. It has been demonstrated that the keyboard should sit lower on the desk for increased operator comfort. Although there still remains some debate regarding the proposed DIN specifications, the height reduction agrees with an ongoing trend towards lower profile (e.g. the 1/2″ reduction in 1975 to achieve more portability and a sleeker appearance).

Two technologies available are tactile-feel capacitance and linear-feel screened contact. A capacitance keyboard is the most cost effective package for all encoded applications (those with electronics immediately associated with the keyboard), especially in detached keyboard enclosures where an inexpensive μP can provide a three or four wire serial output. Detached keyboards are becoming increasingly important for operator comfort in high use applications and are recommended by the German specifications. Tactile feel has become preferred in high duty applications because it provides the necessary operator feedback without an objectionable noise or forcing the fingers to impact the bottom of the keystroke.

The screened-contact technology is cost effective for wired-only keyboard applications. These applications are typically lower-duty terminals and small computers in which the keyboard is not in a detached enclosure. The keyboard does not require dedicated electronics because the X-Y lines of the switch matrix are scanned and keys processed by the main electronics in the unitized enclosure. The cost savings of the screened contact keyboard is due to elimination of the printed circuit board (and electronics). Adding back either an integral PCB or a separate daughter board (plus connector and mounting) defeats this advantage over a low-cost capacitive keyboard design.

A sculptured keytop shape is clearly preferred by the major terminal and computer manufacturers, and can be seen on IBM's new typewriters, IBM's new personal computer and Apple's new personal computers. The single-axis dish is the "fresh, new look" on the low profile ergonomic keyboards. The dish is MT1055 matte finish and the sides are SPI/SPE #5 matte finish to meet the reflectivity requirements i.e. reduce glare. It appears that the truncated Selectric III shape will allow one line of legend on the front skirt, although IBM has disposed of front legends and put more legends on the top (the Selectric III dish is .460″ by .560″). The home row shape will be used for stepped keyboard requirements. At the present time, it appears that all sloped (flat) keyboards will become stepped or sculptured, and that the new dish will be used for all applications. D

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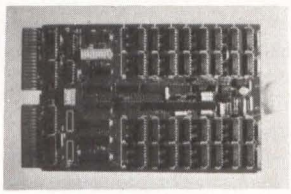

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by using a serial data interface. This allows the use of an inexpensive, four conductor cable which carries data in (optional for a handshake interface or driving lighted or audio feedback on the keyboard), data out, power, and ground. Most popular of these cables are the inexpensive standard phone cord and modular connectors.

The necessity of serial output to reduce cable costs requires electronics immediately associated with the keyboard. The most cost effective method is to use an inexpensive switch technology with a small microcomputer, such as the Intel 8021/8048 family, which provides key scanning, validation and serial data output at TTL-compatible levels through the cable. Since a printed circuit board must be used in the keyboard enclosure to mount the serial interface electronics, capacitive keyboard technologies, which also use the printed circuit board as part of the switch mechanism, are the most cost effective for this application.

Membrane keyboards, in addition to not yet being fully proven, require a separate daughter board for the serial interface electronics, which defeats the savings gained by using the membrane. In short, the number of parts for a membrane keyboard with daughter printed circuit board is greater and more costly than that of a capacitance keyboard.

a new profile

There has been an increasing demand for a lower profile, full-travel keyboard in which the keys sit lower on the desktop. Germany actually specifies a lower profile in proposed industry standard specifications which call out a maximum 30mm height from the top of the second or home row keytop to the desktop. Even though these German DIN specs state that a higher keyboard can be used if a wide palm rest is provided, computer and terminal manufacturers are looking for a new keyboard appearance. Keyboard manufacturers are scrambling to introduce low profile keyboards to meet this demand. Most have used it as an opportunity to introduce new switch technologies — either the old switch technologies were not cost effective or would not fit into the new profile.

a new keytop shape

The sculptured keytop appearance, where the top and bottom rows are higher than the center rows, has become popular in all full-travel keyboard applications. In addition, a semi or rough-matte finish for the keytops reduces glare, and a new keytop dish, which has a single radius curvature, is quickly replacing the complex radii dish keytop. The new dish, even though it does not offer a significant increase in square area available for legends, allows more flexibility in placement of legends — the simple curvature allows legends to be placed closer to the sides and corners of the dish.

Computer and terminal manufacturers are taking the opportunity to update their equipment with the new keytop features along with the change to the lower profile.

final result

New computers and terminals are being introduced with detached keyboard enclosures using inexpensive phone cable connections to the CRT. The keyboard is lower profile and has sculptured, matte finish keytops with a simple curvature dish. Thus, portability is offered, the keyboard is more comfortable, glare is reduced and the keytop legends are relocated as desired. The result is a fresh, new look on a product that is much more acceptable functionally to the dramatically increasing number of users. The 1980s will see increased trends in these directions. D