Keyboards Range From Simple Components To Intelligent Input Subsystems

by Julie Pingry, Senior Editor

Integrating the keyboard into a system poses choices of technology, intelligence and layout to system designers. Both keyswitch and electronics technology have advanced to allow data entry keyboards to be self-contained systems. European DIN standards for ergonomics that dictate detachability are further impetus for intelligent keyboards. With the microprocessors currently used, basic keyboard control and functions to control many elements of an input system are available.

At the other extreme, many computer-based systems are now low-cost commodity items. These applications require a keyboard that is inexpensive and ready to integrate. Since the lifespan of personal computers and low-end terminals is short, many reliability features like non-contact switching, double-shot molded keycaps and life cycles up to 100 million keystrokes are more than the application demands.

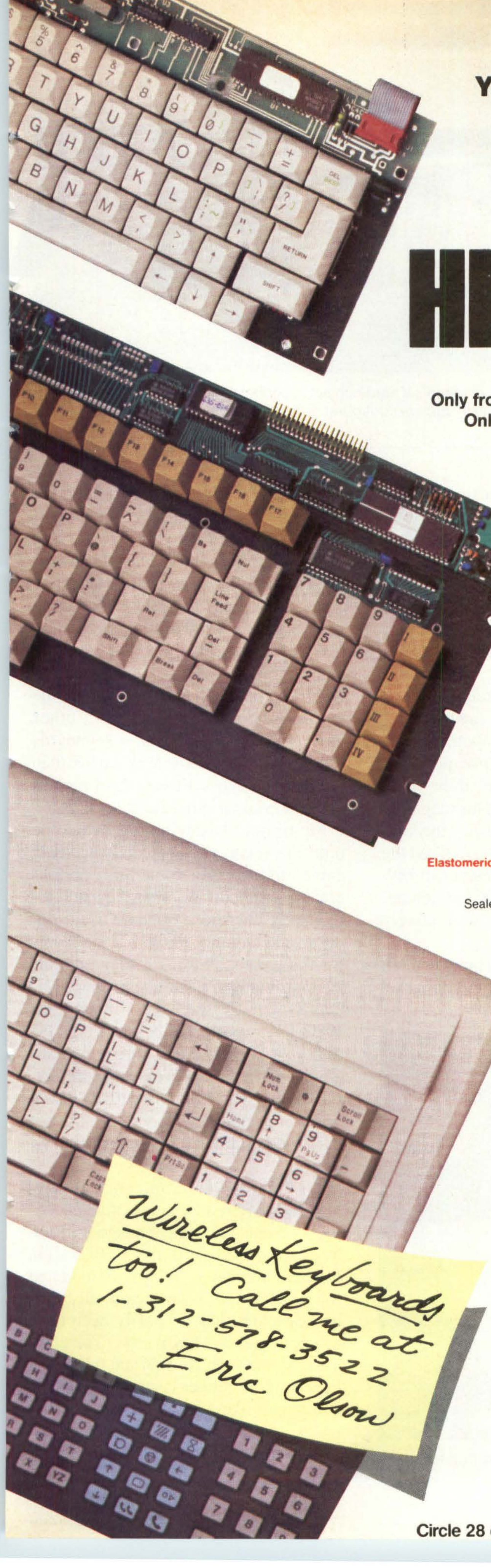
So the data entry full array, full travel keyboard business can be divided into at least two distinct categories. Simple, low-cost devices for integral use and high-end, reliable, intelligent peripheral products both can use any of several technologies for switching. Important differences will be in customizing, delivery, marketing and support. Switch technology will still be a choice, even after the vendor has been chosen.

Ergonomic standards have changed more than where the electronics are placed; the demand for a low profile package has opened the market. Many designs are calling for a new keyboard to meet standards or special requirements, and some firms are now looking beyond their long-standing supplier for comparison.

Technology Trends

Glass reed relay and electromechanical switching were mainstay keyboard technologies for many years. Over the past 10 years, other technologies have gained

Figure 1: A line of full-travel membrane keyboards is available from Oak Switch.



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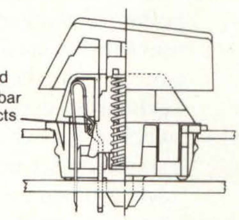

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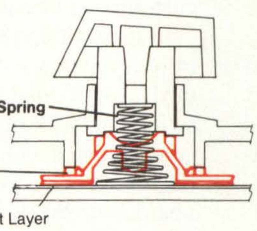

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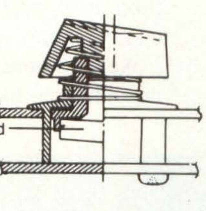

Full Travel Capacitive

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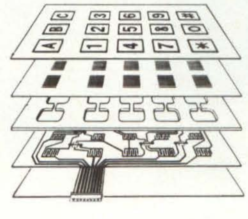

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prominence; nevertheless, reed and mechanical keyboards are still available from several sources. In the mid-1970s, inherently reliable noncontact technologies had a surge in popularity. More recently, membrane and elastomer (or rubber) switches have gained market share. All these types of switches will be used for data entry keyboards throughout this decade. And though functionality, quality and supplier capability may be the major factors in choices, the technologies do differ and each has strong features.

Reed relay switching is still useful for very hostile environments. The sealed contact switches are impervious to oil, gas and humidity, and may be found in point-of-sale, machine tool and process control applications. Though not a volume production offering, Keytronics (Spokane, WA) and Maxi-Switch (Minneapolis, MN) supply reed relay boards. A major drawback to reed switching for data entry keyboards is that the switches are too tall to meet DIN standards for low-profile.

Electromechanical (often called mechanical) switching was not very reliable in its original form, partly because the physical contact points could wear and were not sealed from contaminants. Most mechanical keyboards are now specified for 20 million-50 million keystrokes; Hi-Tek's (Garden Grove, CA) IBM PC-compatible products are specified at 100 million cycles.

One design change that contributes to enhanced mechanical switch reliability is a move away from the single gold contact for closure. One firm focusing on this field, Stackpole (Raleigh, NC), uses twin bifurcated contacts, for four contact points, rather than one. Hi-Tek similarly uses trifurcated contacts. Cherry (Waukegan, IL), another leader in mechanical keyboards, uses gold wire crosspoint switches, for extremely high pressure on a small contact area closing. Mechanical keyboard manufacture is relatively low cost; and since single keys can be made, customizing doesn't cost much.

In 1968, Micro Switch (Freeport, IL) introduced new levels of reliability with the Hall-effect keyboard. This magnetic switching technique eliminates the hard contact, and its introduction marked the beginning of electronic noncontact keyboard availability. Hall-effect switching, though highly reliable, is a relatively costly technology.

Another noncontact switching method, capacitance, has gained a large market share since the mid- to late-1970s. Though electronic in the switch function, capacitive products are not as expensive to manufacture as Hall-effect. The wide use of these two contactless technologies increased the industry standard life cycle specifications to 100 million cycles. Capacitive keyboards are available from many firms, including Keytronics, General Instrument (El Paso, TX) and some whose product line began with other technologies. All noncontact keyboards have generally been more expensive than hard-contact types, though many models are now comparably priced.

Membrane keyswitching has come onto the scene fairly recently for data entry products. For some time, peripheral, instrument and other keypads for relatively low-speed use have used conductive screening on membrane layers for flat panels. A full-travel membrane keyboard (**Figure 1**) was introduced by Oak Switch (Crystal Lake, IL) in August 1980, just two months before IBM's PC with that keyboard technology was announced. The layers of a membrane keyboard may switch either by hard contact or by capacitance, depending on what material is screened onto the switching layers.

A similar layered approach to keyboards is offered by conductive elastomer or conductive rubber materials. Rubber may be used in a dome configuration for hard contact switching or screened for capacitance. Like membrane, rubber switching has primarily been used in minimal travel key panels. The costs are low, and with appropriate full-travel keys over the rubber layers as actuators, companies like Advanced Input Devices (AID) (Coeur D'Ilene, ID) and Maxi-Switch offer products for data entry. There have been some doubts about the

Figure 3: Stackpole's KS-600E mechanical hard-contact keyboard meets DIN low-profile specifications and can easily be made in custom configurations.

Figure 2: The PC-84D from Hi-Tek uses the Dvorak key layout, with often-used keys in convenient positions. Note that vowels are on the left side of the home row.

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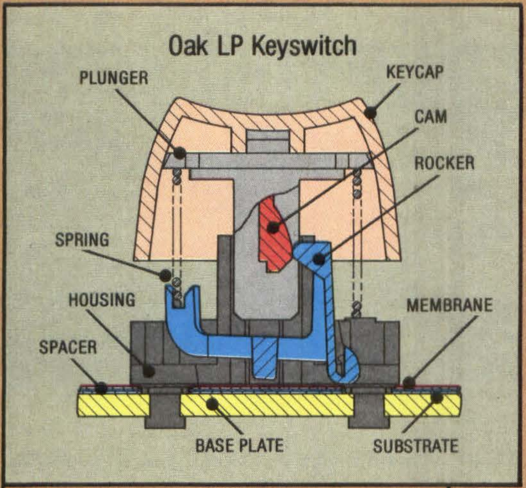

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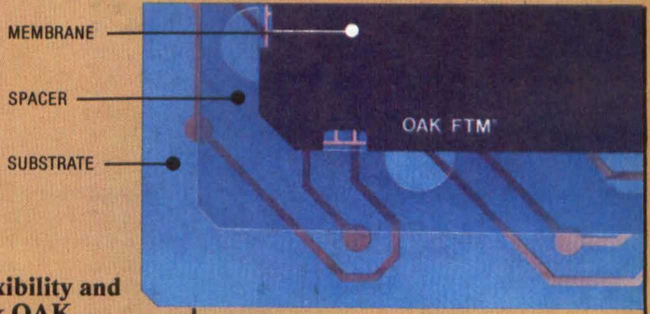

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wear tendencies of elastomer keyboards since switching actually deforms the rubber layer. However, AID specifies a minimum of 60 million keystrokes with their non-silicone rubber dome keyswitches.

Each switching technology has advantages, and the system design will determine which characteristics are most important. The quality of the finished product in feel, life specifications, delivery time and cost are the main factors to consider. These may be largely independent of the technology, but vary between suppliers.

The Low End

Since computers are no longer necessarily large, expensive machines and, more importantly, since technology advances occur very frequently, the useful life of many systems has dropped. The volumes for these micro systems are often very large and profit margins accordingly small. As systems drop in cost and high-volume applications like personal computers and terminals become more competitive, keyboard costs must be kept low.

Membrane and rubber keyboards do not need to be placed directly on a printed circuit board. For a detached DIN-standard keyboard, some of this advantage is lost. But many low-end systems still use integral keyboards. These keyboards can be "wired-only" or unencoded, with electronics for keyboard control included with the computer or terminal boards.

Portable computers may demand an integral keyboard. Another consideration with portable systems is low power consumption. Electromechanical keyboards, whether membrane or mechanical, drain little power when keys are not depressed. Since capacitance switches are scanned for data, they drain more power than desirable for battery-driven computers.

Many simple computer-based products are designed for relatively inexperienced users, or for infrequent use. Even poorly manufactured computers last as long as most companies and individuals want to keep a particular model. The common 100 million keystroke spec of Hall-effect and capacitance products is clearly more than needed for these systems, which might not even reach the 20 million-50 million keystrokes of many low-cost hard contact models.

Simple unencoded keyboards, commonly mechanical, membrane or rubber, are generally inexpensive. But costs to makers of mechanical keyboards using precious metal contacts such as gold can vary greatly with market forces. Rubber keyboards may also use these variable-price metals on the controlling PC board.

A natural extension of the keyboard is control of other input devices in the enclosure or connected to it.

Figure 4: Trackball and keyboard are included in one enclosure in the programmable Wico Smartboard; it can be used either as a Dvorak or standard Qwerty device.

Many companies currently supply unencoded keyboards at low prices. But as in other commodity markets, Japanese and other far-East companies' labor force usually produce for much less than US laborers. Several Japanese companies have offices in the US: Alps is based in San Jose, CA, now; Panasonic's Electronic Components Division in Secaucus, NJ, handles their keyboard line; and Fujitsu America's keyboard operation is based in Lake Bluff, IL.

Though many US keyboard manufacturers are using automation and off-shore manufacturing, these Asian firms are difficult to compete with for simple mechanical products. Some US makers of rubber and membrane products have a lead on the Japanese in these inherently low-cost technologies. Despite the furor over the IBM PCjr chicklet keyboard, supplier AID is shipping large volumes of inexpensive rubber dome keyboards. Many other domestic firms are looking to value-adding and higher-end market segments for their livelihood.

Flexible Keyboards

Detached keyboards with other ergonomic and OEM design features are the mainstay for most US manufacturers. For heavy-use systems, feel, layout, configurability and, above all, reliability, are critical. To compete in this market, firms must be able to customize keyboard appearance and electronics to customer specification and turn out consistent products in a reasonably short time.

Again, many technologies compete. As for reliability, noncontact is inherently good. To compete with Hall-effect and capacitance, keyboards using other types of switches are also specified at 100 million cycles. In membrane, the layers themselves have an almost unlimited life, and, as mentioned earlier, several approaches to mechanical contacts have improved their performance.

In harsh environments, reed relay has long been the standard. But the sealed membrane technology used for flat controls in many factories can also prevent contamination in a properly designed full-travel keyboard. In a capacitive membrane product, Micro Switch uses six layers; three are for venting so that external air pressure or temperature changes do not destabilize air pressure in the three switching layers of the sealed unit. Cherry uses membrane technology to provide a seal for silver hard contacts.

One of the main considerations for data entry devices is operator comfort, or ergonomics. European DIN standards sug-

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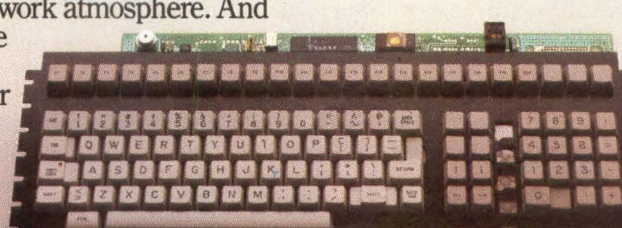

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Figure 5: This Keytronics subsystem with touch pad and keyboard also has ports for other input devices.

gest a home row height of 30mm or less from the desktop, with a profile angle at 15° or less. Except for reed-type switches, all switch technologies can be made to the low-profile size dictated.

In addition to height, ergonomic standards call for some form of feedback for the operator. Though tactile feel keyboards have long been available and gained popularity for a while, most full-time data entry operators find the make-point change in force tiring on the fingers. Most keyboard models are available with either linear or tactile feel. And if linear feel is wanted as well as some sort of feedback, an audible click may be used. The office environment may, however, benefit from an approach like Micro Switch's Silent-Tactile series.

Another feature that can promote accurate data entry at very high speeds is N-key rollover. This feature assures that when several keys (up to a set N or the total keys on the board) are depressed in more rapid succession than they can be processed, all are retained in memory in the sequence they were entered. This feature is standard on some noncontact keyboards, and it is an option on many products. Multikey rollover is sufficient for most uses and, with mechanical technologies, usually less expensive.

Optimum operator throughput requires a new layout of the keys. The standard Qwerty layout was developed when all typing was on mechanical devices. Before this standard, keyboards were laid out serially A-Z. Anyone who has used a mechanical typewriter has experienced key lock-ups if they type rapidly; strike two keys in succession and the first will tend not to be out of the way of the second as it comes up. The Qwerty arrangement helped avoid some key clashes by separating some keys and also slowing down typing speed.

Another arrangement, called Dvorak after its designer, places the most commonly used keys in the easiest positions to reach (**Figure 2**). Studies show vast improvements in entry speed with the Dvorak keyboard, and some schools are teaching touch typing on them. But until the education process is further along, the Dvorak keyboard options from many of the leading manufacturers will be small-run production items.

Though most designs require a custom-manufactured keyboard, the IBM PC keyboard and the DEC VT 220 configuration have become popular semistandards for layout and look. Many systems can use one of these types of keyboard and get very good turnaround time and price from the supplier. Nevertheless, most designs will vary at least the color or placement of some keys.

A vendor's ability to meet specific design requirements is important. Though rubber and membrane keyboards are generally screened all at once with a new pattern needed for each different customer order, the technologies are generally inexpensive on large runs. Mechanical keyboards can be custom-configured easily, as illustrated in Stackpole's KS-600E (**Figure 3**), for which they have keys already made and simply cut a new metal plate for the placement of the keys. The model EKS from AID is a similar single-key approach with rubber domes.

Some keyboards can be configured for various applications with PROMs or EPROMs. Essential to using other input devices connected through the keyboard, PROM can also provide flexibility as to what function keys do, where functions will reside and type of rollover. Fast production turnaround can also be achieved when a standard physical keyboard is customized via PROM programming.

One of the most interesting ergonomic dictates from the DIN group is for detachable keyboards. The standard was set for comfort and flexibility. Detaching the keyboard has several effects: information out of the keyboard must be converted from its parallel form out of the matrix into serial for transmission; and all electronics must be in the enclosure. In the past, many keyboard companies worried little about enclosures, let alone microprocessors. For the future, these detached keyboards may provide the basis for intelligent input subsystems.

Input Subsystems

The trend toward intelligent peripherals is nearly universal, and now that most keyboards are attached to the system via a serial connection, they must also have a microcontroller. Most keyboards use the Intel 8048/49/50/51 family or an equivalent or similar 8-bit part. These devices are not used to their fullest on only keyboard encoding/decoding, scanning and control.

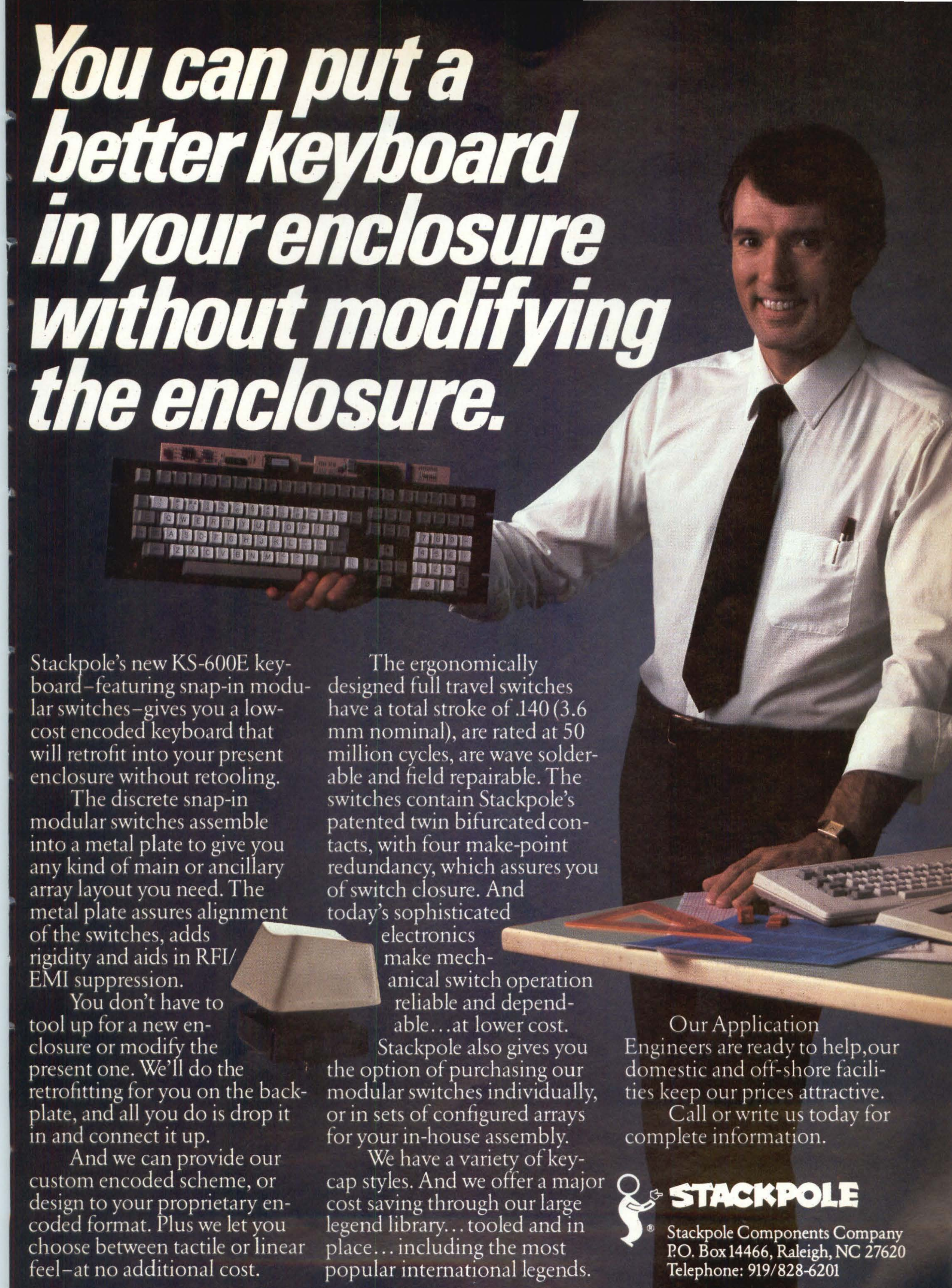
A natural use for the processing power is to incorporate other input devices into the enclosure, or at least connect them through a port on the keyboard. The keyboard processor can then control several input devices, as well as minimizing the tangle of cords out the back of the system.

Though this is a new idea, several firms already have products with other devices included in the keyboard enclosure. Wico (Niles, IL), traditionally a manufacturer of controls for video games, has entered the keyboard market with their Smartboard keyboard with an integral trackball (**Figure 4**). The trackball quadrature output is translated into keystrokes through a Motorola 6802 processor.

Keytronics' 5153T (**Figure 5**) has an integral touch pad; the keyboard also has ports for connecting barcode scanners and voice input systems through it. Such a configuration, with one other type of input control included in the keyboard enclosure and ports for others, may become common.

In their PC AT, IBM has provided the bidirectional interface needed to connect more than one device through the keyboard. The new interface allows the computer to respond to the keyboard, for acknowledgement of a mode change, often signaled by an LED indicator on the keyboard. This is needed to switch from keyboard operation to another form of input, if both are controlled by one set of electronics.

Initially, the inclusion of multiple devices in the keyboard means only some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changes in the interface electronics. For the inclusion of many input controls in a single subsystem, a more powerful processor may be needed. And for voice I/O, extensive electronics are needed. A variety of relatively low-cost processors can handle keyboard control as well as translation of other types of signals into keystrokes. This scheme allows the host of common application packages written for keyboard entry to use mice, touch pads, light pens and other devices with no drivers.

As many keyboard manufacturers point out, they cope with most of the elements that a computer manufacturer does now: processors, interface electronics, PC board assembly, enclosures and plastics. Some hint that they may pursue systems since keyboards are one of the elements that cannot be significantly reduced in size for portable systems. Still, that would mean competing with current customers.

For the present, count on the power of low-cost processors within the keyboard to control several input devices. Simplification of peripheral hardware and interfaces as well as software interfaces for input options may be eased by keyboard subsystems.

Human Interface

A variety of keyboards and suppliers compete in nearly every segment of the market. Technology, customization, feel, delivery speed and prices are relevant in the choice. In many cases, trust in the supplier, an affinity for a particular feel or layout or a desire to have extremely good lifecycle specification may outweigh other criteria.

Specific operating conditions of the system must be considered in choosing a keyboard. Harsh environments benefit from sealed keyswitches, reed or membrane. For inexperienced users, tactile feel may be desirable (although in general, desired key feel is highly individual). Mechanical contact products tend to be less expensive. If integral to the system, separate electronics, as with a membrane keyboard, may be easier to service.

Turn-around time is critical in having designs completed within short market acceptance periods. Supplier ability to aid in design, to configure products and to vary the production run for a system are always important. The custom nature of the keyboard business has changed very little, even with the popularity of PC and VT 220 configurations.

To meet DIN standards, purchasing a keyboard will generally include the enclosure and electronics. Such peripheral products offer potential for a single-box input subsystem. And with graphics and other menu-driven software, mouse, touch pad or trackball input can increase efficiency. Should the market for data entry become sufficiently interested in productivity to push for education, even the Dvorak keyboard layout may take off. DD

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CIRCUIT/LOGIC DESIGN

(continued from p. 62)

The Low Cost Alternative

Valid, Mentor and Daisy each offer low-cost workstations that provide an excellent solution. Using the smaller workstation for schematic capture and then performing the design verification on the gate array vendor's CAD/CAE system is the most appropriate solution for the majority of gate array designs.

Prices for these machines are roughly $20,000. In comparing the offerings from the three firms, Valid's Scaldsystem IV was the favored choice, with Daisy's Personal Logician (AT) running a close second. Both workstations offer the basic capabilities, other than computational horsepower, found in the Scaldsystem I and Logician, respectively. Futurenet (Canoga Park, CA) is another vendor offering a low cost system compatible with LSI Logic's cell library (**Figure 5**). In contrast, Mentor's Capture Station is only a schematic capture system. Although verification software can be added to the system, it is not part of the standard $20,000 configuration.

Until the price of the larger systems comes down, or the performance increases, low-cost workstations are a better buy. Simply stated, the additional computational horsepower found in the higher priced systems is not worth the extra cost.

Where We Stand

Like most design projects, we ran into a few snags. The most significant difficulty was the incompatibility between Valid's simulator and LSI Logic's Design Verifier. The software permits the use of statistical delay data (for wiring and fanout) to be incorporated into the design verification process. However, in order to utilize this data, Valid's simulator must be invoked. The Design Verifier requires a "delay" command be placed inside the simulator command file, but the simulator was unable to understand the command.

To rectify the problem, Valid recently tailored their simulator to meet the Design Verifier's requirements. This new version of the simulator (7.5) is just reaching beta-site testing. Unfortunately, this stumbling block consumed a large chunk of time. Since we are still in the process of designing our chip, update reports will be published periodically. DD

Acknowledgements

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