Keyboard selection criteria

John C. Overby, President, Advanced Input Devices, Coeur D'Alene, ID

With the explosive growth of industrial electronics currently under way, design engineers are repeatedly facing the challenge of selecting a custom keyboard that best suits their requirements. The problem becomes one of determining which of the several technologies available is best for the product being designed, based on the operating parameters established for the keyboard.

This dilemma has developed over the past decade as new technologies and manufacturing cost reductions have resulted in a rapid growth within the keyboard industry and, in turn, a diversification of products. Today, there are 25 major keyboard suppliers using different design standards that incorporate various switching technologies. Fortunately, the problem has been limited somewhat by the absence of foreign imports, which currently account for only three percent of the market.

In response to the outcries of the design engineering community, the keyboard industry is beginning to standardize their product specifications. A major turn toward standardization came in 1980 when the German Deutsche Industrie Norm (DIN) dictated the maximum keyboard profile be less than 0.75 inch for operator comfort when the keyboard is mounted at 11 deg to the console surface. They also demanded ergonomic (human) factors be considered. Among the ergonomic factors receiving the most attention were operator comfort and tactile feel—the "snap-over" sensation from feeling the keyswitch operating point. By mid-1982, both large and small keyboard suppliers were introducing or already manufacturing new DIN profile keyboards.

Keyboard profile heights

Although the standards set by the DIN are helpful, keyboard selection remains a difficult challenge. To best overcome this challenge, the design engineer must first be versed in the two keyboard profile heights available today and understand the keyswitching technologies associated with each.

Custom keyboards for wide range of applications include encoded and non-encoded boards with various keytop configurations, complete drop-in front-panel assemblies, LEDs, deadfront display and integral legends.

The low-profile keyboard was developed in 1975, with a maximum keyboard height of 1½ inches (bottom of the keyboard to the top of the keys) and usually employing full-travel keyswitch technology. Full-travel, low-profile keyboards incorporate long keystrokes (0.150 to 0.190 inch), which normally create an audible noise for operator feedback when the keys are bottomed. Although the keyboard height of the low-profile products exceeds the DIN standards, low-profile keyboards will continue to be used by customers who require medium to high volumes of keyboards for rapid data entry, such as word processing manufacturers.

The three predominate keyswitch technologies associated with the low-profile, full-travel keyboard are capacitance, hard mechanical and ferrite core.

Capacitance is the most popular full-travel keyswitching technology, utilizing a flexible mylar capacitor plate mounted to the bottom of the switch plunger. The switching takes place when the key and plunger assembly is depressed and the increased plate capacitance is detected by an electronic scanning circuit. This technology's higher basic electronics costs are often offset by its lower keyswitch and circuit board cost. Common applications for full-travel capacitance switching include office equipment and computer terminals.

Hard mechanical keyswitch technology utilizes either gold cross-

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point or bifurcated wiping contacts to perform the switching function. When the key is pushed, the attached plunger forces the SPST contacts to close. Hard mechanical switching lends itself primarily to applications requiring a lower-volume cost alternative to capacitance switching.

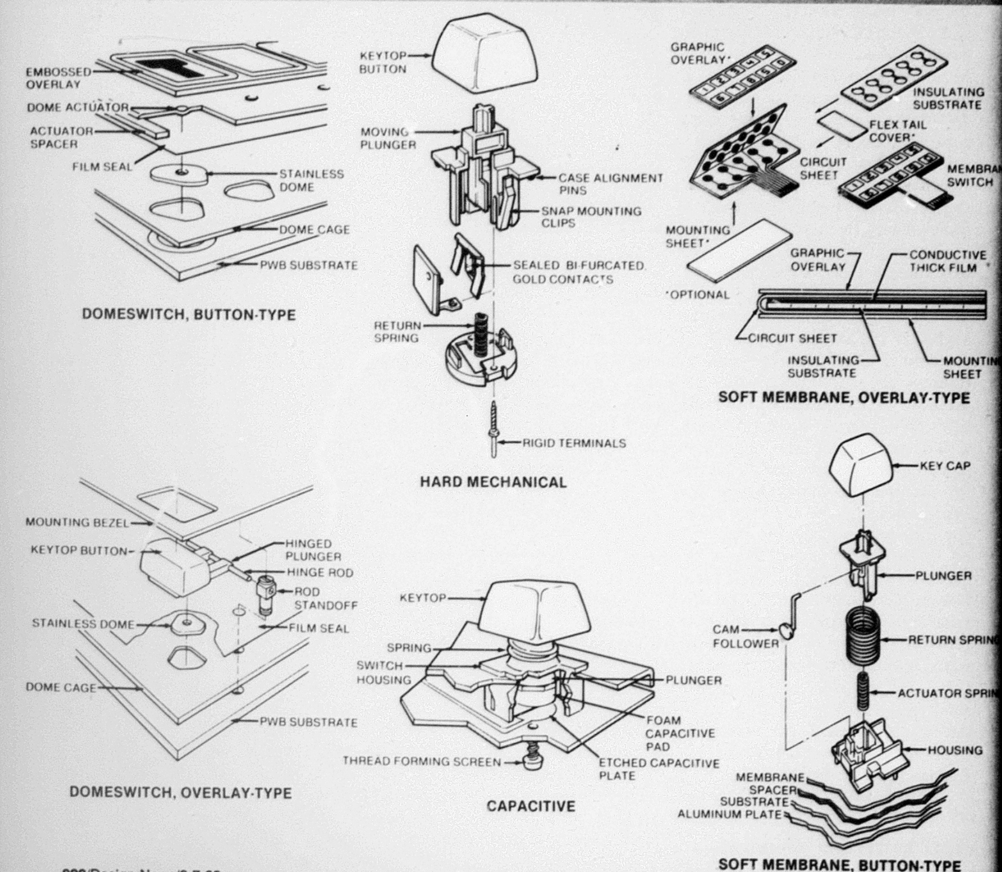
Ferrite core keyswitch technology offers high reliability with only a small price premium over capacitance. The heart of the switch is a linear saturable ferrite core with two preformed leads through it. The drive lead is periodically driven by a current pulse. Through transformer action, the response to the current pulse is revealed on the sense lead.

The magnitude of the sense response is determined by the proximity of a magnet to the ferrite core. If the magnet is close to the core (undepressed key), flux from the magnet saturates the core, restraining the sense response. As the plunger is depressed, the magnet moves away from the core and the response increases until it triggers the sensing electronics. The ferrite core technology, also available in DIN profile, is expected to remain popular in word-processing.

Microprofile keyboards to DIN standards

In response to the DIN specifications, several keyboard suppliers are producing a unit commonly called the microprofile keyboard. Microprofile indicates maximum key height of less than 0.75 inch and a key travel less than 0.120 inch. Operator feedback of successful switch closure is accomplished with true "snap-over" tactile feel and the accompanying "click." ⇒

Typical configurations


EMBOSSED OVERLAY
DOME ACTUATOR
ACTUATOR SPACER
FILM SEAL
STAINLESS DOME
DOME CAGE
PWB SUBSTRATE
DOMESWITCH, BUTTON-TYPE
KEYTOP BUTTON
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HINGED PLUNGER
HINGE ROD
ROD STANDOFF
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FILM SEAL
DOME CAGE
PWB SUBSTRATE
DOMESWITCH, OVERLAY-TYPE
KEYTOP
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Technologies most often associated with microprofile keyboards include domeswitch, membrane and conductive rubber. Since domeswitch and membrane are used in most applications, they will be the focus of attention.

Domeswitch technology consists of a stainless-steel dome-shaped switch sealed to a printed circuit board. When actuated, the dome center collapses, forming a metal jumper from one set of PC board pads (at the perimeter) to a pad located at the center. The dome's inherent memory (flexibility) allows it to snap down, creating a true "snap-over" tactile feel.

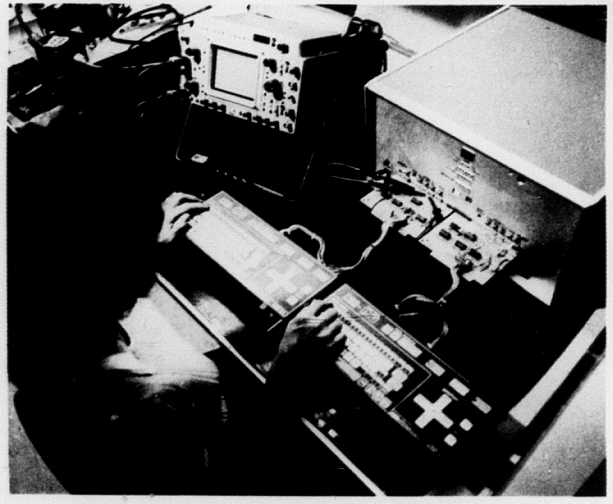
Membrane keyboards normally use conductive silver contacts and interconnections screened on two sections of thin, flexible polyester sheet. A spacer layer with contact openings or gaps is sandwiched between the two circuits. When the graphic overlay is pressed, the upper membrane flexes downward until it touches the lower silver conductor, thereby closing the SPST circuit. Actuation force normally varies from two to eight ounces and the laminate assembly usually requires a rigid backing plate to prevent flexing.

Since their introduction, microprofile keyboards and keypanels have found wide acceptance, particularly in handheld applications. Executive desktop terminals, instrumentation, PABX equipment and telephones normally have opted for the domeswitch technology, while overlay membranes are proving popular for home consumer products, where low prices are paramount.

Higher-priced instrumentation (medical, process control, machine tool) go to domeswitch and hard-mechanical systems where reliability and tactile feedback are important considerations. Lowest-priced instruments and automotive applications favor flat-membrane. ⇒

Applications for various types of keyboards

APPLICATION	MOST LIKELY TECHNOLOGY				
	Capacitance	Domeswitch	Hard Mechanical	Soft Membrane	Ferrite Core
Appliances		X		X	
Automotive		X		X	
Avionic Controls		X	X	X	
Bank Teller Terminals	X	X	X		
Bench Instruments		X	X	X	
Compact Desktop Terminals		X	X		
Factory Data Systems	X	X		X	X
Fast Food Entry Systems		X		X	
Games & Toys		X		X	
Graphic Terminals	X	X	X	X	
Ground Support Equipment		X			
Hand-Held Instruments		X	X	X	
Home Computers	X	X	X	X	
Keypunch Data Entry	X				X
Low-Cost Terminals	X	X	X	X	
Machine Tool Controls		X		X	
Medical Instrumentation		X			
Military Terminals		X		X	X
Navigation Instruments		X			
Office Machines	X	X	X	X	X
Photo Composition	X				
Point-Of-Sale		X			
Portable Terminals		X		X	
Process Controllers		X		X	
Robotic Equipment		X		X	
Security & Alarm Devices		X	X	X	
Sign Programmers		X	X		
Small Business Systems	X				X
Telephones & PBXs		X	X		
Terminal Controls		X	X	X	
Weighing Systems		X	X		
Word Processing	X				X



Keyboard electronics are checked at AID plant in Coeur D'Alene, ID.

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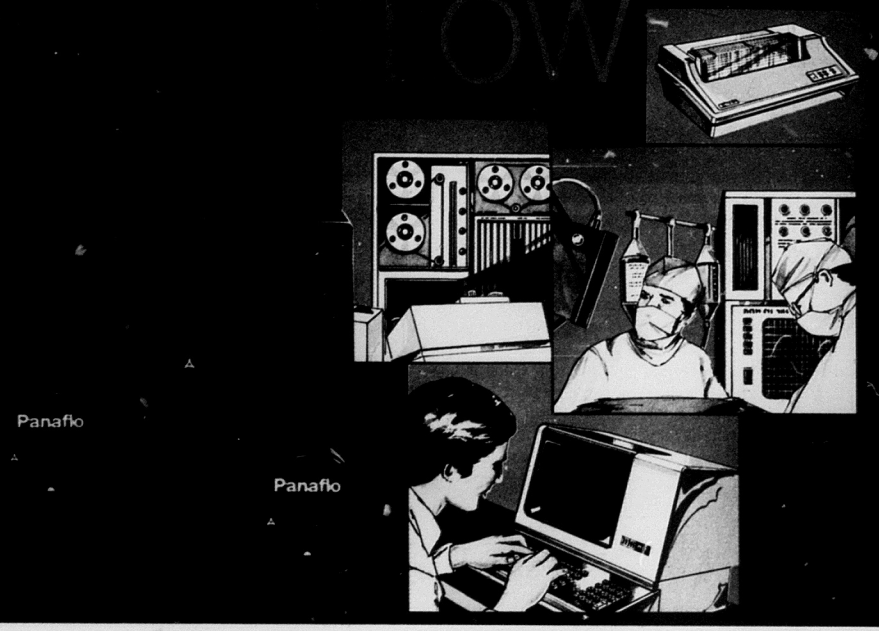

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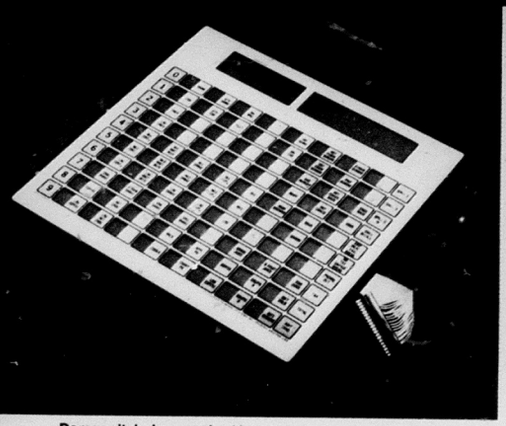
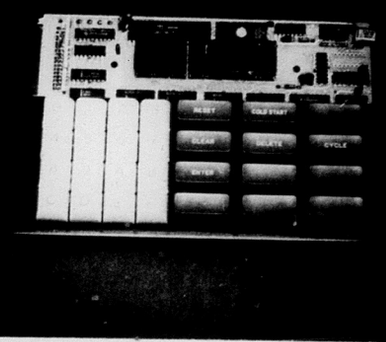


Domeswitch keypanel with cutouts is customized for fast food terminal.



Low-profile, full-travel keyboard uses hard mechanical switching with encoding and LEDs.

Mechanical specifications also required

In addition to the keyboard profile and the switching technology, other considerations such as mechanical, electrical and environmental criteria must be weighed as the design engineer makes his selection.

Mechanical considerations include the operating force that must be acceptable to the end user, and is normally specified by the keyboard supplier. The acceptable key travel distance must also be determined, as well as the minimum key spacing, prior to selecting the proper technology and supplier.

Electrical specifications include the maximum allowable contact resistance, as well as the oeprating contact resistance. For most domestic technologies, typical operating contact resistance ranges from less than one ohm to 200 ohms for hard - mechanical - type contact switches and from 20 to more than 1000 ohms for soft (membrane) contact switches.

Electrical service life of the keyboard must also be defined, based on the intended application. This often will be determined by the operating environment and whether the board is sealed against harsh conditions.

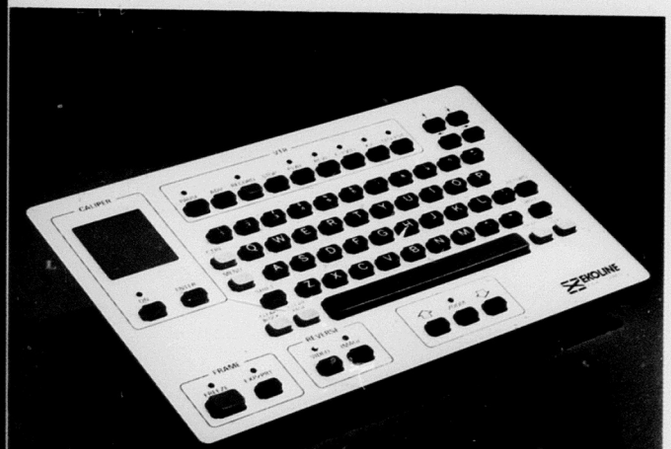
The designer must specify if the board is to be encoded. Presently, more and more keyboards are being designed without vendor electronics, allowing the buyer to match circuit and software to different application requirements. The availability of standard microprocessor-encoding and peripheral chips is facilitating this change. However, nearly all new encoded keyboards employ 8-bit or 4-bit microprocessors. These same micros can control LEDs and perform "handshake" routines with the controller.

Finally, the design engineer must specify the minimum and maximum environmental operating parameters. These parameters include operating temperatures, storage temperatures and humidity. Environmentally sealed keyboards normally will operate at temperatures from −40C to +55C, and can be stored at +70C.

One additional environmental design parameter which must be assessed is the requirement for RFI/EMI and static-shielding. Many keyboard suppliers can design shielding directly into the board when RFI/EMI emissions and/or static discharge are problems.

Graphics unlimited

The design engineer must pay close attention to the graphic requirements of the keyboard as



Microprofile keyboard uses domeswitch technology, LEDs, cutouts and both engraved and panel legends.

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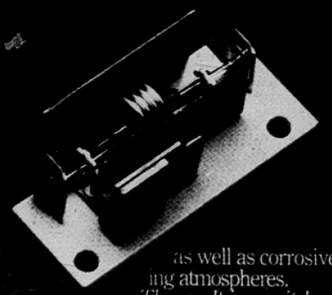

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well. The product must be aesthetically pleasing to the user; time spent on graphic design can make a positive impact toward ensuring customer acceptance. The days of black keys on a black bezel are gone. Today, the designer can select from a spectrum of colors, including standard color matches for special applications.

Legends can be applied to the keys and/or board by several different techniques including engraving, double-shot molding, printing, sublimation and silkscreening overlays. When using a flat keypanel, the designer can also elect to emboss certain areas of the panel to improve key definition or add depth to the panel.

Other options available include the selection of colors for keytops and keytop legends. Recent developments within the plastics industry now make the choice of colors nearly unlimited. The designer also has the choice of various keytop shapes and sizes.

A recent development in legends is the interchangeable overlay, which permits the user to change the keyboard legend quickly and easily. These one-piece templates slip over the keytops, masking the imprinted bezel; they have found wide acceptance in educational and training applications.

Lead times

The final criteria the design engineer must establish are the lead times he will face from his keyboard supplier for prototype and production orders. Some keyboard suppliers can at times deliver working prototypes in as little as three weeks. Full production lead times generally consume a minimum of six weeks. It is not uncommon to encounter prototype lead times in the range of 8 to 12 weeks with an additional 10 to 14 weeks required for production.

In conclusion, today's design engineer faces a series of decisions that must be answered before he can select his keyboard supplier. The two questions that must be answered first are the selection of the appropriate profile and, concurrently, the correct keyswitch technology. Briefly, the choices are:

- *Capacitance keyswitching* has become the dominant full-travel technology because of its low price at higher volumes for large encoded arrays. Since this technology requires support electronics for sensing, the keyboard can be encoded with little effort, making it ideal for terminal applications requiring a detachable keyboard with serial output. Typical applications for capacitance keyswitching include bank teller terminals, video display terminals, home computers, office machines and word processors.
- *Hard mechanical* technologies have seen a resurgence since the advent of the microprocessor. These low-cost microprocessors, which replaced the more costly logic gate array encoders, can be programmed to eliminate limitations that had earlier spelled the death of mature contact technologies. Now that low-cost sealed designs are available, hard mechanical keyboards will in certain applications improve field reliability. Typical applications for this technology are similar to capacitance boards, except in severe environmental conditions.
- *Ferrite core* keyswitches achieved industry-wide acceptance about 12 years ago. The success in office-environment, full-travel applications is attributed to excellent performance

Attributes and trade-offs

DESIGN ATTRIBUTE	TECHNOLOGY					
		Domeswitch			Membrane	
	Capacitance	Button	Overlay	Hard Mechanical	Button (FTM)	Overlay
Profile-micro (DIN)	X	X	X	X	X	X
-low	X			X	X	
Key Feel-tactile (Break away)		X				
-linear	X			X	X	
-sponge	X					
Contact-solid-state						
-material		Stainless		Gld/Slv	Slv	Slv
-resistance		200	200	2	200	200
-hysteresis		X	X			
-sealed		X	X		X	X
Legends-button	X	X		X	X	
-panel		X	X			X
Switch-centers (in. min.)		½ ¾	½	½	⅝	¾
-travel (in)	0.160	0.060	0.015	0.150	0.160	0.005
-force (oz)	3	3	8	3	3	8
-life (mcbf)	100M	10M	10M	10M	10M	10M
-dustproof		X	X		X	X
-spillproof		X	X			X
Minimum interface	byte	matrix	matrix	matrix	matrix	matrix
Price range	med.	low	low	low	low	low
Electrostatic option		X	X		X	X
Front-mounting option		X	X			X
Number of sources	many	many	many	many	many	many

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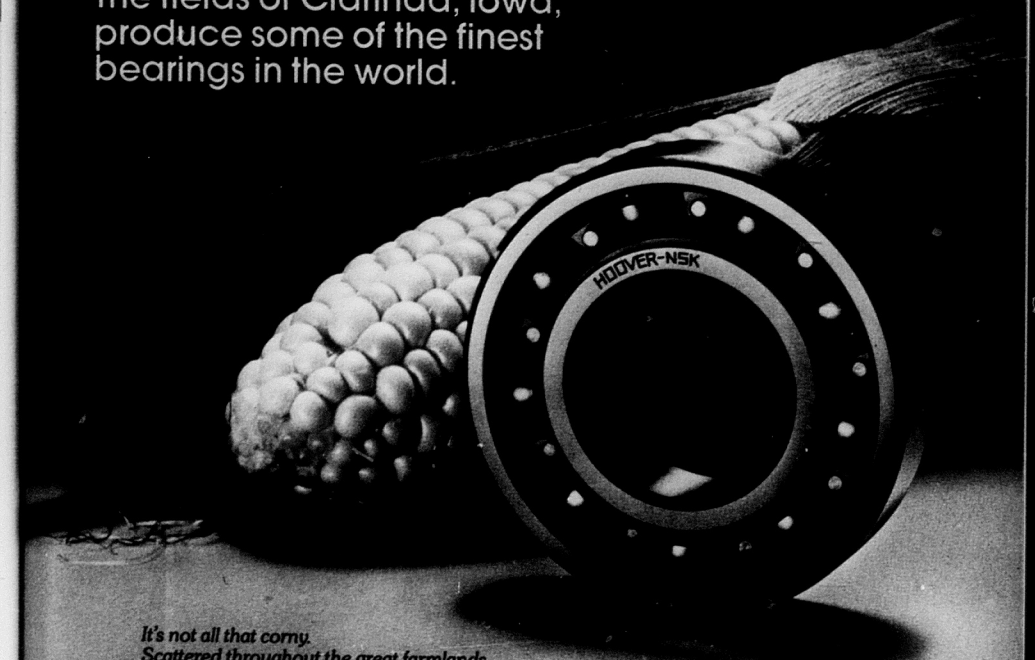

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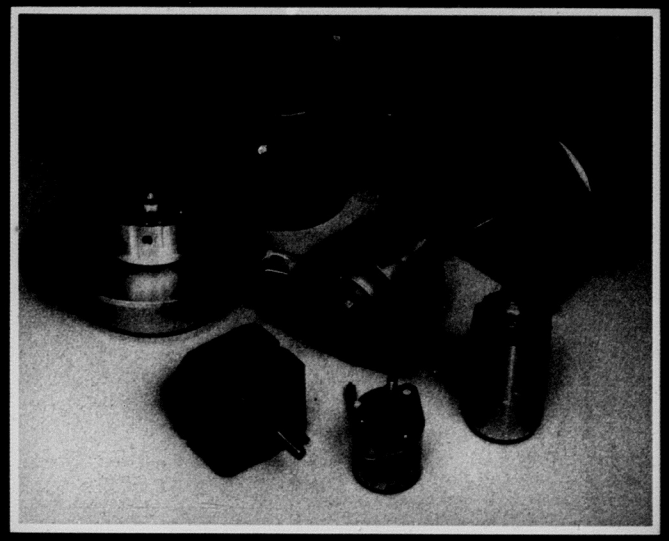

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and significantly lower selling prices than other technologies. Ferrite core keyswitching offers good switch-to-switch consistency and is not readily subject to failure through dust, spills, moisture and other office hazards. Applications include keypunch data entry, higher-cost terminals, office machines, small business systems, factory data systems and others.

- The most visible design change in the keyboard industry is the trend toward *microprofile* construction. Many of these new designs incorporate fewer components and less expensive materials than their full-travel predecessors. Several technologies are now becoming available in the microprofile format.
- *Integrated switch panel* construction is also becoming popular. Domeswitch and membrane panels include the switching, overlay backing plate, cutouts for LEDs and segmented displays, as well as mounting studs. The finished overlay is attached to the keyboard panel with adhesives. This integrated panel construction eliminates the need for most discreet switches. Sealed keyboard construction is permitting the use of keyboards in hazardous environments, which had previously excluded the use of unsealed products.

Applications requiring key centers less than the ¾-inch minimum provided by conventional full-travel technologies are now employing domeswitch and membrane panels that can supply key centers down to 0.400 inch. LED targets and dense legend requirements can also be incorporated. Embossing of the overlay adds a raised picture frame to the overlay, simulating the feel of a conventional molded button and helping to form a barrier between the closely spaced keys.

Utilizing these criteria and making the determinations outlined above, the design engineer can more accurately select the correct keyboard profile and keyswitching technology for his particular application. Most domestic keyboard suppliers also maintain application engineering departments to assist the designer in making the final selections to help ensure the success of his project. □

Major suppliers

COMPANY	TECHNOLOGY				
	Capacitance	Domeswitch	Hard Mechanical	Soft Membrane	Ferrite Core
Advanced Input Devices		X	X	X	
AMP(Chomerics)				X	
Brady/Xymox Division				X	
Centralab				X	
Cherry Electrical	X		X	X	
Cortron Division/ITW	X				X
Digitran	X	X			
General Instrument	X				
Grayhill		X	X		
Hi-Tek			X		
Keytek Div. Elco Corp		X	X	X	X
Key Tronic	X		X		
MaxiSwitch	X		X		
Micro Switch Div-Honeywell	X			X	
Oak Switch Systems				X	
Rogers				X	
Sheldahl			X		
Stackpole			X		
TEC		X	X		X
Texas Instruments		X			

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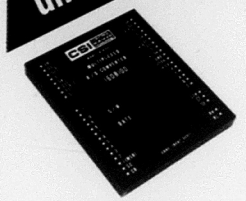

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