Users' choice is name of keyboard game

Variety of electromechanical and solid state devices with multiplicity of logic circuits offer buyer different performance, reliability claims

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Spurred by the growth in time-sharing terminals, the keyboard industry's expansion presents engineers with an increasingly wide choice of units for computer terminals. But although companies are claiming high reliability, they use different yardsticks to measure lifetime and vary strongly in their approaches to achieving it.

Reliability primarily depends on the type of device used to obtain key closure and on the encoding circuit. Most companies are pushing electromechanical reed switches, although some strongly maintain that contactless types, such as capacitive-coupled or Hall-effect units, offer the highest reliability. But few agree on the optimum encoding circuitry; some favor diode logic while others criticize this approach for its excessive use of components and complicated wiring interconnections.

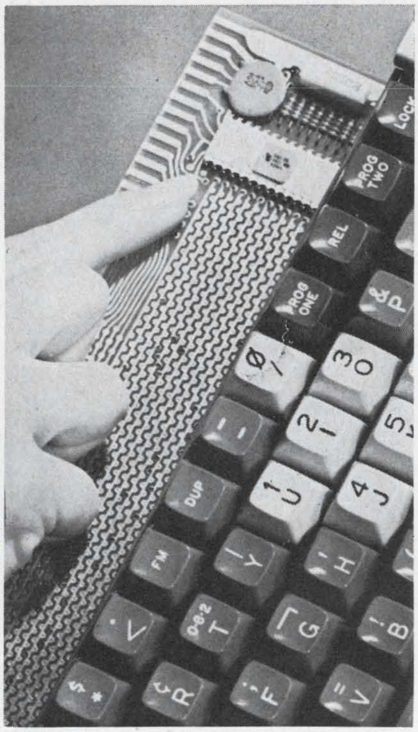
However, the engineer at least can specify any code to the keyboard manufacturer and get the unit he wants—provided he's willing to pay the price. All keyboards now handle the American Standard Code for Information Interchange (ASCII) and many can handle the extended binary coded decimal interchange code (EBCDIC).

But even if special codes aren't designated, keyboard price remains high because of the custom nature of the business—most manufacturers don't have product lines but fill each special order as it's received.

Prices could drop in the near future it the industry booms as expected. Estimates of the present keyboard market range from $5 million to $10 million. William Polley, marketing manager of Ikor, Inc., sees sales reaching $75 million by 1975, and George L. Rice, vice president of Synergistics Inc., anticipates a growth rate of 50% a year with no end in sight.

Old standby. Most keyboards today use electromechanical reed switches whose contacts are in the open state. One of the big drawbacks is that reed tips may bounce away from each other as they are brought together, rebounding several times before they make contact. Wetting contacts with mercury eliminates bounce, but also boosts price, increases susceptibility to damage from shock and vibration, confines the switch to a fixed position, and slows operating speed.

Other approaches to reducing bounce include use of buffer circuitry or of strobes indicating that encoded outputs are ready to be read. KDI-Navcor Inc. installs an optional r-c network to completely



All in one. MOS encoding circuit replaces multitude of discrete components.

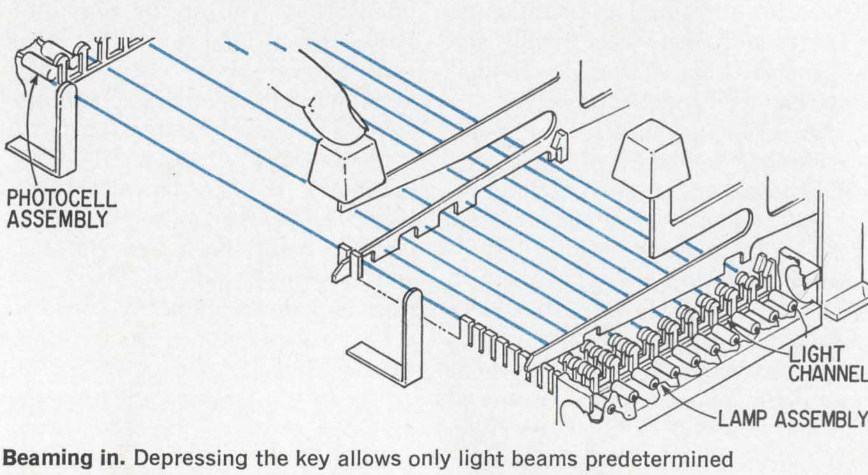
eliminate bounce. All three techniques are costly.

But in spite of the bounce problem manufacturers like George Risk Industries of Columbus, Neb., KDI-Navcor Inc. of Norristown, Pa., and Killian Engineering of Braintree, Mass., stick with reed switches. The newer, more exotic keyboards just don't make it, asserts Killian's marketing manager, William Bixby. "Keyboards incorporating oscillators such as proximity pickups, transducers, capacitive-coupled and magnetoresistive boards, are subject to frequency drift, while the more esoteric types such as the Hall-effect keyboard, require expensive tooling and IC manufacture leading to the development of new technologies at the user's expense," he says.

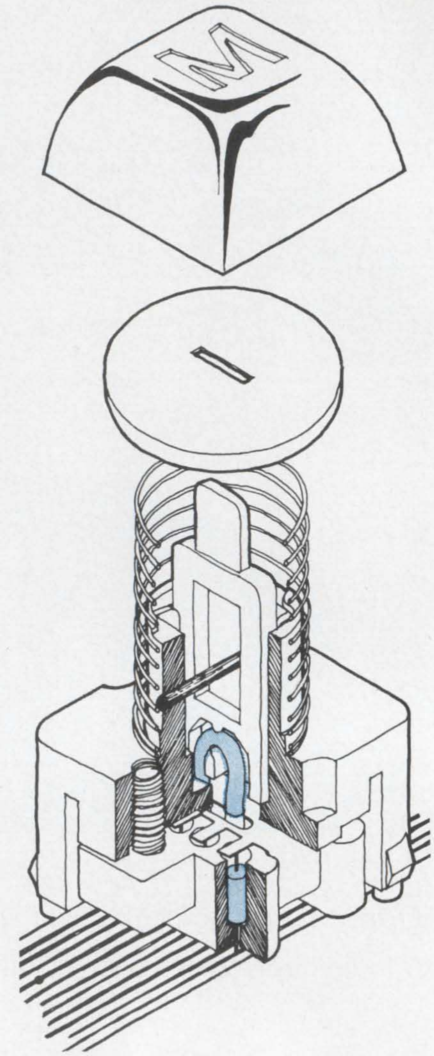
Another approach to the electromechanical switch is taken by Synergistics Inc. of East Natick, Mass. The basic element of its modular keyboard is a three-part keyswitch consisting of a key, key strip, and terminal strip. The key assembly, the guts of the Synergistics keyboard, is capable of producing a 9-bit code using preset pins and a mechanical switch. A code mask is provided in the form of a plastic material to allow contact with only selected pins. The code contact comprises a stamped spring metal plate with 10 contact arms to join with the unmasked pins when the key is depressed. The key strip is a flat plastic wire with 10 conductors into which the key assembly pins are embedded to contact with the wire conductors. The pins form the contact point for the code contacts of the key assembly. The plastic terminal strip contains 10 conducting wires; the wires contact each key strip to form a given keyboard configuration.

The Synergistics keyboard is the least expensive unit on the market. The company says it keeps the price down because no printed-circuit boards are needed; there are no switch placement changes, only pin layout alterations, and there's no tooling necessary for any number of rows. Yet the reliability claimed—over 10 million keystrokes—compares with similar claims made by other manufacturers.

Another keying approach—taken by Mechanical Enterprises of Alexandria, Va., in its Mercutronic Coding Keyboard makes use of a



Beaming in. Depressing the key allows only light beams predetermined by the "shuttered" keylever to pass, thereby forming the correct code.



Squeeze play. When pinch is removed, mercury flows in tube (inverted u) and circuit is formed with diode (cylinder).

mercury movement in a sealed, flexible tube that is pinched in a normally closed position. When the key is depressed, the pinching action on the tube is relieved and an electrical circuit is formed. The key module itself is snapped into an aluminum extrusion containing a flat 11-wire cable. Diode encoding circuits are located in the key module and make permanent contact with the wires; the number of diodes in the key module determine the code for that particular key.

"This mechanical approach to the solution of an electronic problem has yielded a reliability of better than 3 million keystrokes", says Ted Watts, marketing manager of ME, adding that "There have been no life measurements on the ability of the natural rubber tube to withstand the corrosive properties of the mercury. A new silicate compound

Who's offering what and at how much

Company	Keying Mech.	Logic	Max. Bits Per Key	Quantity Price	In Lots Of	Unit Price	Keys Per Board
George Risk	reed switch	diode matrix	9	$190	1000	$500	73
KDI-Navcor	reed switch	diode matrix	14	$125	1000	$350	67
Killian	reed switch	diode matrix	8	$150	1000	$500*	50
Synergistics	mechanical spring loaded	diodes in key	9	$ 50	1000	$125	50
Mechanical Enterprises	sealed mercury movement	diodes in key	10	$ 75	1000	$235	50
Datanetics	diaphram switch	diode matrix	8	$150	500	$350	60
Micro Switch-Honeywell	Hall effect device	DTL	8	$100	2500	$250	50
Ikor	capacitive coupling	TTL	12	$140	1000	$375	67
Transducer Systems	proximity transducer	TTL	8	$150	5000	$500*	67
Digitronics	photo cell	photocell & op amp	14	$325	1000	$650	64

*Plus non-recurring charge

is being tested for use as the mercury holding element," he says.

Multilayers. A keyboard making use of multilayer diaphragm mechanical switches as the keying element is produced by Datanetics of Redondo Beach, Calif. The switch is placed above three layers of plastic: the top layer has conductors in the X-direction and the bottom layer in the Y-direction, while the middle layer has holes over the conductor intersections. When the key is depressed the conductors touch, making the circuit. The epoxy-sealed p-c board switching module has two gold contacts per key to insure circuit continuity.

"The Datanetics keyboards have been tested to 14 million keystrokes without a failure" says marketing manager Jerry Satuloff, "and can stand temperatures from —40°F to 140°F in high relative humidities.

Hall-effect. When keyboard manufacturers talk about the competition, the name that usually pops up first is the Micro Switch division of Honeywell Inc. of Freeport, Ill. In place of its old switch, the company employs a Hall generator on an IC chip located in the key [*Electronics,* Sept. 16, 1968, p. 169].

When the key is depressed, a magnetic field surrounds a metallic epitaxial layer on a chip of p-type silicon, whose current is perpendicular to the field. The Hall voltage, developed perpendicular to both the current and field, is in the order of microvolts. An amplifier increases this voltage to a usable level and then flips the trigger which switches the amplifier's output to the proper lines to represent the binary codes for the depressed key. E.C. Leibig, product manager at Micro Switch, says, "Since the output voltage of the Hall generator as a function of magnetic flux is linear, it is not a switch," and engineers at Micro Switch claim there's really no yardstick for life in number of keystrokes; however they have been cycled more than 100 million times without failures.

Jury-rigging. Micro Switch has been receiving some bad publicity recently as a result of keyboard failures [*Electronics,* Oct. 13, p. 35] due to temperature instability of the Hall-effect device and poor workmanship. But Leibig blames improper supply voltage and jury-rigged circuit boards by one customer. However, the consensus

throughout the industry is that the Hall-effect keyboards do not live up to all the hoopla that preceded them. In fact, several large computer console manufacturers, including Honeywell's computer division, are sticking with the older Micro Switch reed keyboard.

Ikor Inc. of Burlington, Mass., is pinning its hopes on a solid state keyboard using capacitive coupling to perform the keying operation. "We aren't going to exotic techniques, but are using proven ones that offer simplicity and reliability; after all, the capacitor has been known since Ben Franklin flew his kite," says Polley. Each key is made of two metal plates, each with a specific hole pattern of from one to seven holes, producing a key with a 12-bit code capability. When the key is depressed, the plates lower into a space between a transmit bar (tied to a 50-kilohertz oscillator) and a receive bar (feeding into an operational amplifier), allowing the 50-khz signal to be capacitively coupled. The amplified a-c signal is sent to logic circuitry when the signal strength is at maximum.

"Since the keyboards don't use switches, reliability is measured as mean-time-between-failures (MTBF) and is in excess of 30,000 hours," Polley says. Manufacturers differ on standards for reliability in quoting either key cycles or MTBF, but both methods have flaws. The key cycle standard overlooks the fact that the keyboard is only as good as the most frequently used key; on the other hand, MTBF includes terminal-on time but not in-use time. The user is largely on his own determining which method is best.

A-c excitable. An a-c excited electromagnetic proximity transducer is the keying mechanism nucleus in a new electronic keyboard manufactured by Transducer Systems Inc. of Willow Grove, Pa. The proximity transducer, excited with a specific voltage at a particular carrier frequency, produces an output signal which is a function only of the item or material being detected and is independent of the movement speed of that item. The output response of the transducer can be improved by decreasing the air gap between transducer and detecting element. Since the keying transducers are a-c excited, a 5-khz oscillator is an integral part of the

keyboard. Even though it employs a contactless switch, TSI chooses to quote reliability in terms of key depressions—more than 200 million without a failure, it claims.

'Shuttered.' The interruption of a collimated beam of light is the keying mechanism method used by Digitronics of Albertson, N.Y., in its photocell keyboards. The board, available in either a 10- or 14-bit version, consists of a row of miniature light bulbs on one side of the keyboard and a corresponding row of photocells on the other. Each keylever is notched, or "shuttered," on the underside in a pattern to determine the number of light beams to be passed by that key. Depression of a particular key will interrupt specific light beams, thereby yielding its binary code. Electrical characteristics of the photocells change from 3,000 ohms in the "light" condition to 200,000 ohms in the "dark" state; the photocell output goes directly to an operational amplifier to produce a logic output at the required voltage level.

The lamps used to produce the light beams are connected in series, so a failure of one lamp will produce an easily sensed condition—all lights out. "The MTBF for the lamps is greater than 20,000 hours," says Kenneth Whitehouse, special projects manager at Digitronics. "However we are investigating the use of single, operator-removable light sources in conjunction with fiber optics. This will allow the operator to replace a light failure without waiting for the service man," adds Whitehouse.

On the other side of the coin the Digitronics keyboard requires more power than others—2.2 volts d-c at 350 milliamps for each lamp and 60 volts d-c with power dissipation up to 50 milliwatts at 25°C, derating to zero at 75°C for the photocells. The 14-bit keyboard with data strobe and mechanical interlock requires 30.8 volts d-c at 350 ma to power the logic circuitry.

Keyboard logic ranges from diode matrices to the new metal oxide semiconductor encoding packages. Included in present keyboard logic packs are diode-transistor logic (DTL), transistor-transistor logic (TTL), photocells, and diodes mounted directly in the key module.

Several reed switch keyboard manufacturers consider diode

matrices the best approach to low cost and high reliability. Micro Switch does not share this point of view: its older reed switch keyboard and its Hall-effect unit utilize DTL encoding to provide the required speed at reasonable cost. However, to provide higher reliability at lower cost, they are introducing a new keyboard featuring an MOS encoding circuit enabling the operator to generate up to four levels of code from the same key. The keying mechanism still will make use of the Hall-effect device used previously. MOS will reduce the number of discrete components in the DTL pack significantly—the actual number of components replaced by MOS package exceeds 100. And fewer components means fewer solder joints, and increased logic reliability. Micro Switch is counting on Texas Instruments, producers of the MOS circuit, for the dual in-line encoding pack to be used in their new keyboards.

The new MOS encoded keyboard will go into production in 1970 and is expected to be available in volume quantities by 1971. The new keyboard, in a 50-key array, will be demonstrated for the first time this month at the Fall Joint Computer Conference in Las Vegas.

Faster logic. The TTL pack offers speed at an increase in cost. But the cost/volume ratio decreases as the size of the order increases, offering the big-volume user a faster logic circuit at a decreasing premium. Ikor and TSI use TTL packs to perform the encoding function in their solid state keyboards.

Finally, the photocell encoding is done without the use of diodes or special encoding packs such as DTL and TTL. Photocell output is raised to the desired level by an operational amplifier, with the binary code formed by selection of the desired photocell outputs. The photocell offers simplicity at a sacrifice in speed.

Although the keyboard manufacturers note that savings increase with large orders, the newness of most of the manufacturing companies limits high-volume production capabilities, which vary from 200 to 1,000 units per month. However, most firms, seeing which way the wind is blowing, are beginning to tool up for the anticipated large orders of the early 1970's.