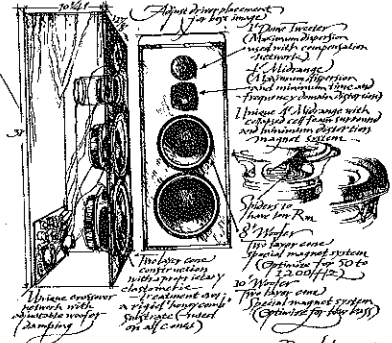


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Computer Bits



By Hal Chamberlin

KEYBOARDS

WHAT IS the most important part of a microcomputer system? Is it the microprocessor chip, memory boards, mass storage system, or display interface? If it is the part that is most used by the owner, then the answer is probably the keyboard. As necessary as these other parts are to the functioning of the system, most users spend far more time with the keyboard than any other peripheral.

Human Factors. When speaking of keyboards in conjunction with microcomputers, we mean so-called alphanumeric keyboards; that is, those that have 10 digits, 26 English letters, and an adequate complement of punctuation marks. Today, the feature that most distinguishes a microcomputer from the multitude of less expensive programmable calculators is the ability to handle textual information as easily as numerical information.

Assuming an alphanumeric keyboard is needed, how many and what kind of characters should it have? Since all personal computers use the ASCII character code which in its smallest form defines 10 digits, 26 letters, and 27 symbols, it follows that a minimum keyboard should have all of these. A more comprehensive keyboard would have an additional 26 lower-case letters and 5 symbols and thus could be called a full ASCII keyboard.

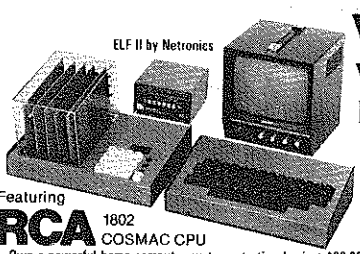
Mechanics. Just having an acceptable arrangement of keys doesn't necessarily make an acceptable keyboard; mechanics are important too. Probably the most important mechanical factor is the size and spacing of the keys. In this respect, the standards are quite clear: the keys are to be placed on 3/4-inch centers both horizontally and vertically and are to be staggered by 3/16 inch for the top two and bottom two rows and 3/16 inch for the middle two rows.

keys packed together with as little as 1/2-inch spacing. The results have been tens of thousands of lost sales and, for at least one vendor, a new line of machines with standard-size keyboards.

Another area of considerable variation among available systems is keyboard travel. On standard typewriters, this varies from nearly an inch on manual to about 1/8-inch on electric machines. The electronic keyboard industry, however, is in general agreement the optimum travel should be about 0.15 inch for the feel of good positive action.

One final human-factor feature that is nice to have on a keyboard is automatic repeat. It is often necessary to enter the same character continuously—as when moving the cursor for editing. Pounding the same key repeatedly not only shortens its life, but is annoying and slow.

Interfaces. Several general methods of keyboard interfacing are in common use, even on packaged systems in which the keyboard is integral to the system. Modular computers, such as S-100 machines, often use the key-



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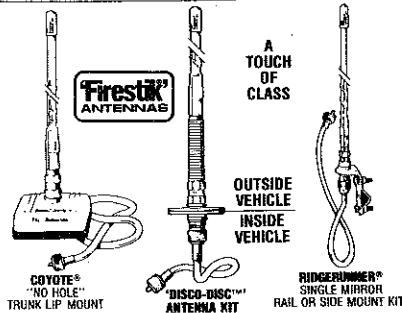
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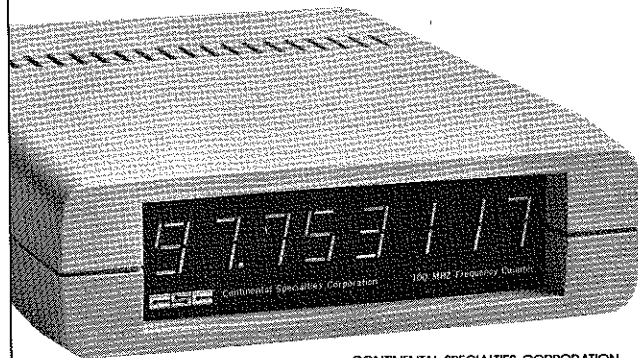
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board of an external display terminal. From the computer's point of view, characters come in at random times on a serial interface encoded and ready to go. A large number of modular machines use a video display interface plugged directly into the bus and a separate keyboard interfaced to a parallel port. This approach saves the expense of a separate terminal and gives added flexibility.

In either case, the computer program must be "looking" at the keyboard when the keys are struck, otherwise the input characters may be lost. A system with this difficulty can be greatly helped by having audible feedback to tell the operator instantly when a keystroke is or is not accepted. A better way to solve the problem is to use interrupts with the keyboard. With interrupts, every keystroke interrupts the running program and informs it that a key has been struck. If the program is not yet ready for an input, the character is read and placed in a memory buffer. When the program is ready, the buffer is examined first and characters are taken from it until the buffer is empty. Then the program waits for a keyboard input. This is a very valuable feature for interactive programs written in BASIC, in which it is easy for the operator to get ahead of the program.

While the keyboard logic does most of the work associated with scanning the keys and forming the character code on modular systems, many packaged systems use the microprocessor itself to do this task at much lower cost. In these systems, the individual keyswitches are wired into a matrix, usually with 8 rows and 8 columns and a switch at each crosspoint. The 8 column wires are then connected to an internal 8-bit output port and the 8 row wires to an 8-bit input port. Whenever a key is depressed, an output is connected to an input with the combination different for each key. With proper construction, it is possible for the program to identify which keyswitch is closed and then look up its code in a memory table for use by the rest of the software.

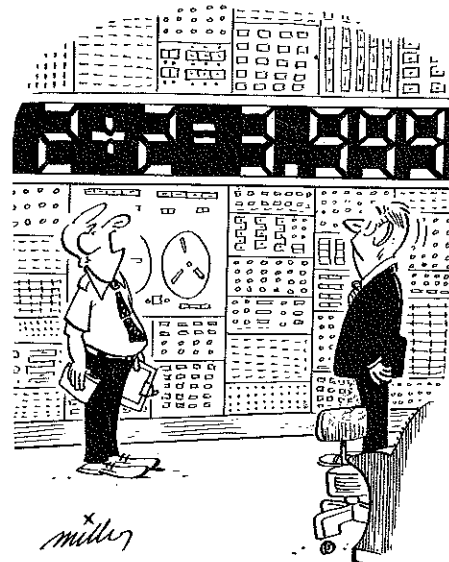
Typically the keyboard-read program, which is usually part of ROM software, scans the keyboard, which means it "looks" at each key in sequence and registers a character when it locates a depressed key. Additional software tests are required to prevent the same character from being generated each time the software scans and to negate the effects of keyswitch contact bounce.

There are two common ways of solving the former problem, each giving a different typing characteristic to the keyboard. One of these is to stop scanning the keyboard when a depressed key is found, output the code, and then wait until the key is released. At that point, scanning is resumed. This system is called "two-key rollover" because it produces the proper sequence of characters (that is, the same sequence that was typed) for a maximum of two keys being pressed simultaneously. The second method uses continuous scanning and keeps a copy of the state of each key in memory. A keystroke is registered only when a key that was not previously down (as determined by looking at the copy in memory) is seen down for the first time. Thus, the keyboard responds only to up-to-down movement of a key and then completely ignores it. This is called "N-key rollover" because it produces the proper character sequence regardless of the number of

keys already down. Having more than one key down simultaneously is a common occurrence, particularly with fast typing, so it is important that the keyboard, whether it be hardware or software scanned, handle the situation in a reasonable manner.

Keyswitch contact bounce is a serious problem. All mechanical contacts fail to make and break instantaneously and may vibrate (produce multi-contacting) for a few milliseconds before a solid contact is assured. With the speed of modern microprocessors, a keyboard scanning program could interpret this bouncing as several keystrokes and produce multiple repetitions of the same character. From a software viewpoint, the problem can be solved by having the scanning software verify the making or breaking of a contact by testing it for about 10 milliseconds and requiring that every test produce the same results before concluding that a make or break actually took place. Fortunately, systems with bounce problems can be cured by using a "keyboard fix" program available from the manufacturer or on the open market.

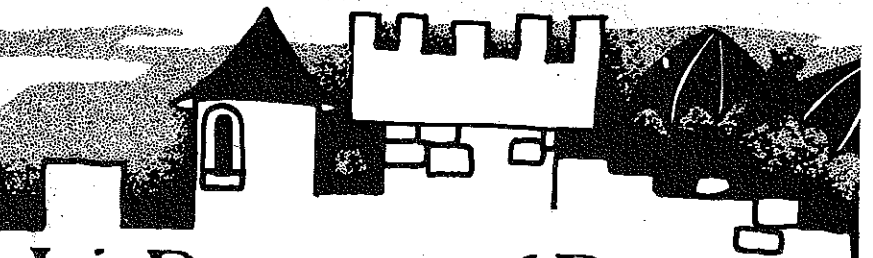
Interrupt operation of a keyboard that is software-scanned is more difficult than if it is hardware-scanned, but one hardware manufacturer has figured out a way to do it with its line of computers. The trick is to have a 60-Hz line-frequency interrupt cause periodic entry into the keyboard scan routine regardless of program activity. The scan routine in turn, does one scan of the keyswitch array and stores any key that is newly pressed into a character buffer for later use. Thus, it is possible to be several keystrokes ahead of program execution. Since the operating system takes care of all of the details automatically, the programmer doesn't even have to know about it. This same 60-Hz interrupt also updates an elapsed time "clock" in memory, which can be quite useful. ♦



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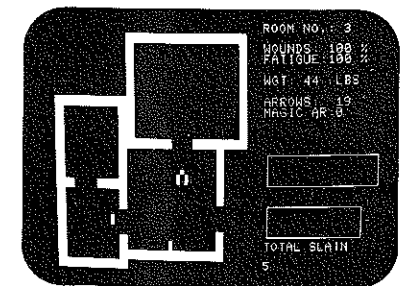
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