upon the electrically triggered motion of a piezoelectric element can be traced to the *bimorph*, the first piezoelectric device invented by the Curie brothers.

The basic bimorph shown in Fig. 2 is a sandwich formed by attaching thin piezoelectric bars to either side of a metal strip. Electrically conductive coatings may be applied to either side of one end of the bimorph to form terminals. A voltage applied to the terminals causes one bar to contract in one dimension and expand in the other, while the opposite occurs to the second bar. The resulting forces cause the bimorph to bend. By changing the polarity of the applied voltage, the bimorph will bend in the opposite direction.

Recently an entirely new array of applications for the piezoelectric effect was announced by Piezo Electric Products, Inc. (186 Massachusetts Ave., Cambridge, MA 02139). Formed in 1980 to develop new piezoelectric devices, the firm has acquired the piezoelectric product manufacturing facilities of Gulton Industries.

So far Piezo Electric Products has announced several new devices developed by Eric and Henry H. Kolm, latter day versions of the Curie bothers and vice-presidents of the new firm. The piezoelectric relay or actuator is a miniature solid-state relay which is faster, longer lived and less noisy than conventional electromechanical relays. Figure 3 shows how a piezoelectric relay is constructed.

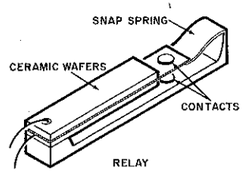


Fig. 3. Piezo Electric Co.'s relay.

The chief drawback of present devices is the requirement of about 40 V for actuation.

The piezoelectric relay technology devloped at Piezo Electric Products has been applied to the design of a new dot-matrix printhead. The new printhead uses piezoelectric bending elements instead of solenoids to drive small pins against a carbon ribbon. If successful, a piezoelectric dot-matrix printer should operate at a high speed with considerably less heat production than a conventional dot-matrix printer.

A third new application involves piezoelectric quadrature motors and fans. Information from Piezo Electric Products about the design and operation of these devices is sketchy, but the fan is described as operating on the principle of the insect wing and using one-hundredth of the power of a conventional blower of similar output. One application is a miniature cooling fan for electronic components.

The inverse of the piezoelectric vibrating fan is a solid-state generator that produces power from moving air or gas. According to Piezo Electric Products, "We have proof-of-concept models of electrical generators which operate off the acoustic energy in the exhaust of internal combustion engines. We anticipate that automobile mufflers of this type would replace the alternator and noticeably improve the fuel economy of the engine."

The firm has also developed a piezoelectric windmill that generates electricity when piezoelectric elements are vibrated by moving air. The company claims such windmills ". . . can be effectively made in the form of small units resembling snowfences, highway barriers, or other structures capable of supporting a number of small vanes resembling the leaves of a tree. Such piezoelectric windmills would operate over a wider range of wind velocities than rotary windmills, and hopefully cost less per watt of installed power."

Another idea from Piezo Electric Products is a bicycle generator expected to enter production this year. It has much less drag than the conventional generators and directly produces the high voltage required for high-brightness, gas-discharge lamps.

Other companies are also developing exotic new applications for piezoelectric technology. Watson Industries (Eau Claire, WI) sells a piezoelectric gyroscope for $295 which (it claims) is superior to laser-ring gyros. The piezoelectric gyro is compact and weighs only about 10 oz. Its sensitivity is sufficient to detect a rotation rate as low as 0.04 degree per second.

National Semiconductor (2900 Semiconductor Dr., Santa Clara, CA 95051) has developed a CMOS chip that is powered by an accompanying piezoelectric element. Developed for Gould Inc., the chip derives its power from a rotating tire, and is designed to transmit a coded signal when tire pressure falls below a certain point.

Many kinds of piezoelectric accelerometers and force transducers have been developed. There is even a piezoelectric micrometer system manufactured by Polytec Optronics, Inc. (22651 Lambert St., Unit 108, El Toro, CA 92630). This system includes a power supply that provides an adjustable voltage to miniature piezoelectric elements mounted on precision micrometers. Model P-252 provides a total excursion of 25 mm with a piezoelectric fine tuning up to 20 microns (at 0.02 microns per volt).

West Germany's Siemens AG has developed a miniature, piezoelectric, isolation transformer. As shown in Fig. 4, a voltage applied to one side of a piezoelectric ceramic wafer induces an acoustic wave that propagates across the wafer to a second pair of electrodes. The voltage produced by the acoustic wave is transferred to the second electrode pair and used to control an external device such as an SCR or TRIAC.

One of the products developed by Siemens is available for only 70¢ in large quantities. It is the PZK 20 Piezo Ignition Coupler, which can be used in applications that would instantly destroy the LED in an optocoupler. It's very fast (the acoustic wave travels 2 km/s), it provides very high isolation (the piezoelectric element is an insulator), and it produces its own output voltage. The U.S. address for the components division of Siemens is 186 Wood Ave. S, Iselin, NJ 08830. The address for Siemens AG is Frankfurter Ring 152, D-8000, Munich 46, West Germany.

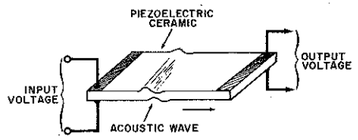
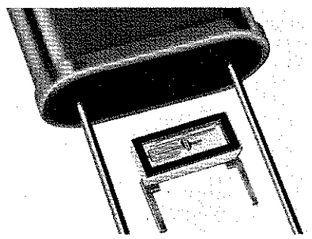


Fig. 4. Isolation transformer from Siemens.

While the recent emphasis in piezoelectric technology has been upon ceramic elements, quartz is still of major importance. The Statek Corporation (512 N. Main, Orange, CA 92668) has made notable advances at both ends of the quartz frequency spectrum. On the low end, Statek has developed a quartz-crystal ocillator that fits within a miniature TO-5 transistor can. A quartz crystal smaller than the point of a sharp pencil provides an oscillation frequency as low as 10 kHz. The crystal and its miniature hybridized circuit can withstand a shock of 1000 g's.

On the high end, Statek has developed what it believes is the smallest 1-MHz microprocessor crystal. The new unit is about one-fourth the size of an 8-pin mini-DIP. Its calibration accuracy of ±0.05% is achieved by a process in which the miniature crystal is etched from a quartz wafer and fine-tuned to the correct dimensions by laser trimming.



Statek's miniature quartz crystal between leads of an HC-33 can.

Learning More. I'm not aware of any recent books on piezoelectricity. Many electronics texts, however, cover the theory in much more detail than I have in this brief column. Some encyclopedias, particularly those dedicated to science topics, cover the subject quite well.

If you want to experiment with piezoelectric crystals of your own making, "Crystals and Crystal Growing" (Alan Holding and Phylis Singer, Anchor Books, Doubleday & Co., 1960) has a chapter containing the recipe for making Rochelle-salt, single crystals larger than a sugar cube. ◇

COMPUTER BITS

By Carl Warren

Add-Ins and Add-Ons Increase System Performance

A NUMBER of established companies are jumping on the microcomputer plug-compatibility bandwagon and are offering a host of goodies to upgrade a system. For example, for the IBM Personal Computer, urged on by an almost limitless market potential, others have developed items ranging from 256K-byte memory boards to expansion chassis for the powerful system—all with the uncharacteristic support of IBM.

Even peripheral equipment manufacturers view the IBM machine as an ideal vehicle for new products. One such company, GTCO Corp. has introduced a digitizing option called the Graphic Analysis Package #1. This package consists of a digitizer pad with 0.001-in. resolution (sizes vary from 11″ × 11″ to 42″ × 60″ active area pads), a digitizing stylus, a power supply, a communications interface cable, an operator's manual plus the necessary software on diskette. Prices for the GTCO graphics package range from $1419 for an 11″ × 11″ tablet to $3025 for a 20″ × 20″ translucent tablet. The software for the graphics option follows the IBM philosophy of using user-oriented menu systems to display 22 predefined functions with room for 11 user-defined functions.

Like the GTCO offering, other products being introduced are designed to plug directly into the computer backplane. In some cases, such as Tecmar's PC-Mate Expansion Chassis priced at $945 for chassis and adapters with cables, the idea is to extend the working area of the bus.

The Expansion Chassis, is designed to interface to any one of the available expansion slots with a host adapter and extension cables. The bus adapter handles all translation of bus signals and provides buffering and necessary drivers to ensure proper operation of both the primary and expansion bus. Once connected, the expansion bus allows an additional 7 slots for adding memory and peripheral controllers. The chassis comes equipped with a heavy-duty power supply capable of handling an optional 5.25-in. Winchester disk drive. In addition, the chassis provides convenience power outlets for printers or monitors.

Expansion of the bus is only a small part of the offering from Tecmar. The company has developed a total of 20 products, including the expansion chassis, dubbed TecMates. The TecMate series includes a series of RAM cards ranging from a $495 64K-byte card to a $1295 256K-byte card. In addition, you can turn your system into a complete development station by the addition of the E²PROM card ($395) that employs Electrically Erasable Programmable Read Only Memories (EEPROMs). These allow changing ROMable programs under software control so it is not necessary to have an ultraviolet erasing system.

In the same line is an IEEE-488 bus adapter ($395) that permits interfacing to a host of test equipment or the similarly priced Lab Tender that provides complete 16-channel, 8-bit analog-to-digital and digital-to-analog conversion with five timer/counters and three parallel ports.

Should your applications be more futuristic, Tecmar even has cards such as the Speech Master ($395) to give your personal computer a voice. The board has a built-in vocabulary of 143 unique words, letters, and word sounds, and according to Dave Wertman at Tecmar you'll be able to purchase additional personality modules to increase the vocabulary by midyear.

To really turn the system into a futurists dream, you can purchase the $345 Video Digitizer to convert standard NTSC video signals to digital patterns, and add the $495 Stepper Motor Controller to handle the movement of robotic arms. The idea is to use the IBM Personal Computer to develop an artificial intelligence system that not only performs tasks but recognizes images.

No doubt the IBM system will find use in a number of diverse applications, and has wide market potential. However, not all independent design houses are willing to provide as many products as quickly as Tecmar.

Typically, most are planning to jump into the market with two products at most. Data Mac Computer Systems, for example, has a memory board that starts at $499 for a 64K RAM board, with the ability to expand to 256K bytes on the same board, for about $1200.

Microsoft Consumer Products division is planning a 256K memory add-on, designed by Burtronix, also for about $1200. This RAMCard, employs 64 × 1 RAMs and, like the Data Mac card, its parity can be enabled or disabled depending on the operation.

Microsoft is planning to offer more than just the hardware for the price. In the works is a bundled product that will treat the RAM as a solid-state disk system. This board, and possibly the software for it, are expected to be available this month.

Even though Burtronix is best known as an R&D house that develops products for others to market, it is also planning to climb on the IBM bus with an $80 prototyping card and an as yet unpriced extender card.

For one-stop shopping for IBM PC add-ons and tools, there is Applied Business Computer Inc. This company offers everything from the AI-1512, 512K-byte RAM card for $1495 to a $3800 5.25-in. 18M-byte Winchester. They even have an as yet unpriced EPROM programmer, Model AI-7128 that will program 2732s, 2764, and 27128s. If you require CMOS battery-backed memory, they offer the Model AI-1064, 64K board for $850.

Vista Computer on the other hand, is sporting the 576K Multi-Maxicard, that starts out at $1199 for a 256K version and ranges up to $1849 for the full 576K. This board uses just about the entire available memory range permitted without shadowing the system ROM in and out.

Another source of IBM PC memory boards is National Technology Sales. This company offers a 256K version for $1495 and 512K configuration for $1995. Dubbed the PC/RAM Stack, the boards have onboard error checking, an average access time of 250 ns, and a typical cycle time of 410 ns.

If expanding disk storage is important to you, Interface Inc, has double-sided, double-density drives that provide up to 672K bytes of formatted storage. Two models of drives are available and several combinations of internal and external drives can be used to meet storage requirements. The models include: a single-sided drive with 168K of storage and a double-sided drive with 336K of storage. These can be mixed and matched in any manner. Prices for the drives are $470 for an internal single-sided drive, $570 for a single double-sided drive. Add $100 to each price if you want them configured for external operation.

Apple Owners Get Some Too. Should you have an Apple and would like the functionality of the IBM PC, Coprocessor Inc. has just the ticket with the 88CARD. This $899 items uses an 8088 microprocessor, has 64K of RAM and operates at 5 MHz. The board is designed to work in any Apple slot without burdening the power supply. And if you're wondering, the board uses the same operating systems as the PC and enables you to run all the same programs.

Two additional boards that you might want to add to your Apple include: Wesper Microsystems Wizard-BPO, for $179. This card lets you have a printer buffer up to 32K bytes, and is designed to work with all the Apple software, as well as CP/M. What you get is the ability to perform printing while the system is doing something else.

Regardless of what your system is, as

long as you have either a serial RS-232 or 8-bit parallel port available, you can turn the system into an IEEE-488 bus controller simply by plugging in an ICS Electronics Corp's Model 4825, or 4828 Interface Card. All the commands for 488 operation are implemented onboard. Be aware though that ICS offers these cards to OEMs, and they will more than likely be somewhat above $600 in single quantities.

In operation, the card serves as a talker/listener, and your computer thinks it sees either another serial or parallel device. Consequently, writing code to service instruments is a great deal easier since no special 488 drivers are required.

Heath Systems Add-Ins. A few months ago, I happened to call Doug Sauby at Magnolia Microsystems regarding the possibility of adding more than 64K of memory to the Heath/Zenith 89 microcomputer. Doug felt it could be done by employing the memory I/O bit-mapping to gain the extra address bits.

As a result, Magnolia developed the $595 Invisible Disk. This card employs 64K × 1 dynamic RAM, and extends your total memory space to 176K. In the current implementation, 112K of the added board is treated as a very fast disk drive. About the time you read this column, Magnolia plans to have MP/M fully implemented to permit multi-user/multi-tasking operations on the machine.

Implementing the Invisible Disk is easy. All that is necessary is to remove the 89's cpu card, plug in the Magnolia bit-mapping board and the RAM card, and put it back together again. The most difficult part of the process is removing and reinserting the cpu card.

Once you have performed that task, all that is necessary is to link a software module to tell CP/M that the new device is present. You basically set the RAM up as logical device 40; and, using the configuration program, set it to the desired disk name (in our case, drive F:).

In operation, you can use setauto to run a Submit program to load the desired program into the semiconductor disk, and begin immediate operation. Ours is set as follows:

PIP F: = *.*[VO]	put contents of disk on to F:
F:	Log in F: drive
WS	run the program—in this case WordStar.

Due to the paucity of space available on Heath add-in boards, Magnolia wasn't able to implement parity checking. Instead they opted for CRC—Cyclic Redundancy Checking, careful layout of the printed circuit board, and close attention to decoupling capacitors. After about two months of operation, we haven't experienced any soft errors; and surprisingly the 89 hasn't overheated.

I do want to point out, however, that if your 89 is over two years old and you're thinking of adding such niceties as the Magnolia 8-in. controller or the Invisible RAM, chances are you will overtax the power supply. We discovered this in one of our 89s that we have had since 1980. The bridge rectifier broke down due to high current, and the secondary in the transformer burned out. Zenith has taken care of these problems in units produced in the last year. The transformer and rectifiers have higher ratings, and all the regulators have heat sinks. So before adding make sure you have adequate power.

Another enhancement for the 89 comes from DG Electronics. It offers the Super 89 for $800 for a 64K version and $1400 for a 256K configuration. The board completely replaces the Zenith cpu card, and comes with a 4-MHz cpu, real time clock, parity check on RAM, expanded bus structure, on-board serial I/O port, and is CP/M-HDOS compatible. We asked both the DG folks and the Magnolia designers if the new board would work with Magnolia's disk controllers, but as of this March neither was sure since no actual tests were run. Both design groups saw no problems since the DG board is functionally compatible with the Zenith card.

An interesting add-in that you might want to consider for your 89 comes from Artra Inc. The board, called the Housemaster, provides you with a real-time clock, voice recognition, sound synthesizers, BSR X-10 home control, battery backup for the calendar/clock, and dual RS-232 ports. The card, which is available as a kit for $299 or $399 assembled, takes the place of the I/O card. Be aware that things like the RS-232 ports and voice synthesis are options and range in price from $35 to $225 for assembled versions.

Commodore Systems Get CP/M. It seems that everyone wants to have CP/M compatibility, and Small Systems Engineering is providing it with the $895 Z-80 based Softbox. This add-on allows CP/M, RS-232 ports, and an interface to a Corvus hard-disk system, as well as 64K of RAM. The similarly priced Hardbox enhances the Pet disk operating systems allowing one to four Corvus drives to emulate the Commodore floppy-disk system for up to 64 users. It comes with seven utilities including: user reconfiguration, password security, file transfer between hard disk and floppies, diagnostics, and the ability to use a video recorder for data backup.

To speed up Commodore BASIC, SSE has PETspeed priced at $350 to give a 30% increase in compiler operation. ◇

FOR MORE INFORMATION

For more information on the products described in this article, contact the following manufacturers directly:

Applied Business Computer Co.
2883 E. La Palma Ave.
Anaheim, CA 92806
714-630-3821

Artra Inc.
Box 653
Arlington, VA 22216
703-527-0455

Burtronix
18472 Jocotal Lane
Villa Park, CA 92667
714-974-6171

Coprocessors Inc.
50 West Brokaw Road, Suite 64
San Jose, CA 95110
408-947-4616

D-G Electronic Developments Co.
700 South Armstrong
Denison, TX 75020
214-465-7805

Data Mac Computer Systems
680 Alamanor Ave.
Sunnyvale, CA 94086
408-735-0323

GTCO Corp.
1055 First St.
Rockville, MD 20850
301-279-9550

ICS Electronics Corp.
1620 Zanker Road
San Jose, CA 95112
408-298-4844

Interface Inc.
20932 Cantara Street
Canoga Park, CA 91304
213-341-7914

International Business Machines Corp.
Information Systems Div.
Box 1328
Boca Raton, FL 33432
305-998-6007

Magnolia Microsystems Inc.
2264-15th Ave. West
Seattle, WA 98119
206-285-7266

Microsoft Consumer Products Inc.
10700 Northup Way
Bellevue, WA 98004
206-828-8080

National Technology Sales
Box 401782
Garland, TX 75040
214-349-8259

Rana Systems
20620 South Leapwood Ave.
Carson, CA 90746
213-538-2353

Small Systems Engineering Inc.
71 Park Lane
Brisbane, CA 94005
415-468-2900

Sorcim Corp.
405 Aldo Ave.
Santa Clara, CA 95050
408-727-7634

Tecmar Inc.
23600 Mercantile Rd.
Cleveland, OH 44122
216-464-7410

Vista Computer Co.
1317 East Edinger
Santa Ana, CA 92705
714-953-0523

Wesper Microsystems
3188 Pullman Street
Costa Mesa, CA 92626
714-850-1666