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Vol. 60 No. 8

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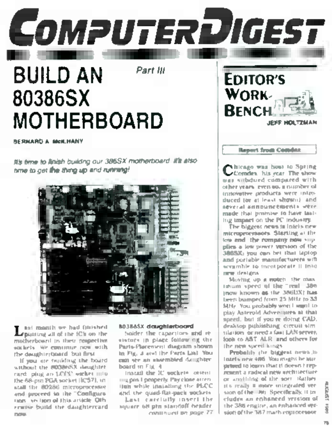

PAGE 75

PAGE 42

AND MORE

ON THE COVER

Computers have become an instrumental part of how music is made today, thanks to MIDI, the Musical Instrument Digital Interface. Although MIDI was introduced less than a decade ago, it has changed the way that we make music.

Even if you're more familiar with computer keyboards than piano keys, MIDI can open a whole new world to you. Getting started in MIDI is cheap, and if you've ever had any musical training, you'll find that it's a lot of fun. For a primer on MIDI specifications, and for a look at some popular MIDI hardware and software, turn to page 33.

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Advertising Sales Offices listed on page 102.

WHAT'S NEWS

Intelligent telephone networks

Bell Atlantic is the first regional Bell Company to implement Common Channel Signalling Number 7 (*CCS7*) for call handling of customer traffic between central offices. CCS7 is the foundation of the company's growing "intelligent" network, called *CLASS Calling Service*. Since last December, customers in selected areas of New Jersey have had the option of such features as *Caller*ID*, which uses a compact add-on device to indicate the incoming caller's phone number on an LCD screen. Related services enable customers to block incoming calls from up to 6 selected numbers; to give up to 6 numbers a "priority" rating, indicated by a distinct-sounding ring; to have the last outgoing number that was dialed be automatically redialed for up to 30 minutes, without tying up the line for other calls; to automatically call back the last incoming caller's number; to choose up to 6 incoming numbers to be forwarded to another line; and to initiate a trace on crank or obscene calls. With all those features, the incoming call must originate in a NJ Bell area equipped with CLASS calling service.

What's made the introduction of those services feasible is common channel signalling, which separates voice data from call-setup and -directing data. Phone conversations are carried "in-band," while all other data are transmitted "out-of-band" on a separate path. Implementing the new intelligent system does not require the reprogramming of every electronic switch in the network; instead, relatively few centralized computers are reprogrammed. As a result, calls are set up faster, and the data needed to offer the new services is available—at a reasonable cost to consumers and New Jersey Bell.

The cost to customers includes the purchase of a *Call Identifier 125B*, manufactured by CDT (Colonial Data Technologies) of New Milford, CT. The compact device displays the originating number of an incoming call, as well as the date and time of the call, on an LCD screen, and stores the same information about the last 20 calls received. The unit retails for $79.95, and is sold at all 18 Sears stores in New Jersey, as well as select retail distributors and commercial supply houses. New Jersey Bell charges residential customers $4.00 a month for the first service ordered ($6.50 a month for the most popular *Caller*ID*), and $1.50 a month for each additional service, except *Call*Trace*, which has a $1.00-per-use fee. Fees are slightly higher for businesses.

NYNEX customers in Poughkeepsie, NY already have similar telephone features available, with New York City and Long Island to follow by the early 1990's. And CDT has supplied virtually every regional Bell Company in the country with Call Identifier test units.

Chemical laser oscillators work in the visible spectrum

A little more than a year after developing the first visible-light chemical laser, scientists of the Georgia Institute of Technology have developed chemically powered laser oscillators. The new lasers could be extremely useful in space or other environments where large amounts of electricity is not available.

Lasing occurs when a large portion of the atoms of a material (solid or gaseous) is raised to a higher energy level by external stimulation. The excited atoms then tend to revert to normal or ground energy level, emitting light in the process.

In the new laser oscillator, energy is transferred from a highly excited germanium oxide molecule to a thallium atom. Thallium atoms in the ground state are thus raised, or "pumped," to a higher level, subsequently lasing at 535 nanometers, producing green light.

ACTV broadcast premier.

As a fitting commemoration of the 50th anniversary of commercial television's debut—it was first exhibited at the 1939 World's Fair by General David Sarnoff—the first commercial Advanced Compatible Television (ACTV) signal was broadcast on April 20, 1989. The signal was sent from the WNBC transmitter at New York's World Trade Center. A wide-screen, enhanced picture was picked up on prototype ACTV receivers at the David Sarnoff Research Center in Princeton, NJ. At the same time, home viewers in the area received a normal picture on their conventional sets from the NTSC-compatible ACTV broadcast signal.

The broadcast, dubbed ACTV I, represented the first phase in the evolution of advanced TV. ACTV I will deliver fully NTSC-compatible wide-screen pictures with enhanced horizontal and vertical resolution in one existing channel (6 MHz). Once the technology for bigger and brighter screens is available, ACTV II—a fully digital transmission that requires only two channels and conforms to recent FCC directives—will deliver even greater resolution for both still and moving images.

According to Dr. James J. Tietjen, President and Chief Operating officer of the Sarnoff Research Center, the breakthrough transmission "has further strengthened [the position of] ACTV relative to other proposed systems, in both broadcast testing and the development of operating hardware." **R-E**

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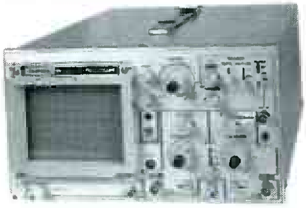

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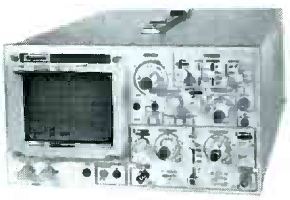

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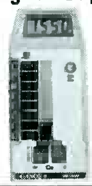

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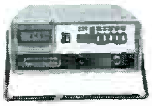

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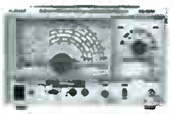

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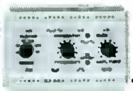

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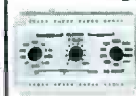

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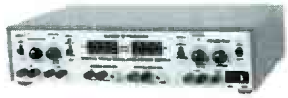

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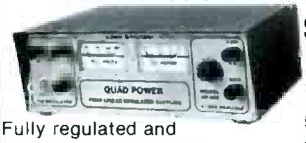

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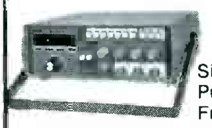

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VIDEO NEWS

David Lachenbruch

• **Exit Philco, re-enter Crosley.** One of the oldest names in TV receivers has been discontinued and another reincarnated. Philips has dropped Philco brand TV's, at least for the duration of the current picture-tube shortage, while a group of distributors has revived the Crosley name for a line of TV's, VCR's, camcorders, and audio rack systems to be made by—guess who?—Philips.

Philco, once the second-best-selling TV brand (after RCA) and a major contributor to television technology, will cease to exist as a TV name after current stocks are exhausted. Philips said that it was dropping the line because, as a distributor product, it competed directly with Philips' Sylvania line, also handled through distributors. Philips also said that it wanted to funnel scarce picture tubes to its more expensive brands—Philips, Magnavox, and Sylvania. It will continue to produce Philco brand VCR's, camcorders, and audio equipment, and didn't rule out a revival of Philco TV as a direct-to-dealer line some time in the future.

Meanwhile, a group of distributors (who earlier had revived the Crosley line of appliances) that includes more than half of the former Philco TV distributors—has revived the Crosley TV name and ordered sets on a private-label basis from Philips. The current Crosley brand is not related to the original Crosley, which fielded TV sets from 1939 until 1956. But then, in recent years the Philco name has had little to do with the original Philco (once the Philadelphia Storage Battery Co.). That company was sold to Ford Motor Company, which sold it to GTE Corp., which, in turn, resold it to North American Philips. Philips never did like the Philco name because it was too easily confused with Philips. Now that the Philips name is used in the U.S. for high-end TV sets, Philips apparently wasn't too happy with a similar name at the bottom of its TV lines.

• **Big tubes coming.** A major expansion is under way by the American color-TV picture-tube industry, which will result in larger sizes being made here. Until now, the largest tube size made in the United States was 27 inches, but several new plants or expansions of old ones are now being phased in. Thomson Consumer Electronics, which makes RCA tubes, is expanding its Marion, IN, plant to produce 31-inch and, eventually, 35-inch tubes. Toshiba has just completed an addition to its Horseheads, NY facility to turn out 32-inch models. Sony has added 32-inch Trinitrons to its San Diego plant. Matsushita, Panasonic's parent, is building a plant at Troy, OH, which will turn out 31-inch tubes, and at press time Philips was contemplating building a new facility in Ann Arbor, MI, for 31-inch tubes.

Presumably, all of those new facilities won't relieve the picture-tube shortage immediately. One TV manufacturer estimates that the U.S. color-TV industry will run 2,500,000 tubes short this year, and that the shortage probably will last until 1992. Why the sudden shortage? The trend to larger tube sizes cuts down on the capacity of tube plants, which can produce fewer tubes in the bigger sizes than in the smaller sizes. The personal-computer boom has brought much more competition for color tubes because of the demand for monitors. Lately, a worldwide boom in color-TV popularity is putting new strains on the entire globe's tube facilities. A relative newcomer is China, whose demand for perhaps 15,000,000 tubes this year cannot nearly be met by its own domestic production.

• **Picture windows.** *P*icture-*I*n-*P*icture (*PIP*) may be a good TV feature, but if it's in color, it costs hundreds of dollars to add it to a set. Magnavox did some consumer tests and found out that people didn't seem to care much whether the inset picture was in black-and-white or color, and customer response to PIP was poor. Consumers almost unanimously thought of the second picture as a "window" into another channel—so that a viewer could watch the main picture while zipping through the other channels. So Magnavox has introduced a group of sets in which a "Smart Window" monochrome PIP is only a $50 premium over a comparable set without it. Who can resist "a second set for $50," even if both sets use the same screen and the second set relies on a VCR for its tuner? R-E

ASK R-E

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DIGITAL TV

In the last few years, VCR's and TV's have appeared on the market that are referred to as being "digital." I've done a fair amount of research, hoping to find out how that is done. But there's one thing that I'm still not clear about. That is to how you would digitize a signal as complicated as video.—E. Grover, Provo, UT.

Some people swear that it's done with mirrors...just a joke. The video signal *is* extremely complicated, but that has nothing to do with being able to digitize it. The complexity of the signal may make the process more difficult, but that's about all. Doing A-to-D conversion on a video signal means that the circuit doing the work has to work faster and has to have enough resolution (the number of bits).

The first thing to realize is that digital TV's and VCR's digitize the video signal, not the RF at the TV antenna or VCR head. A digital VCR puts the same signal on the video tape as any other VCR.

The main difference between a standard A-to-D circuit and the one that digitizes the video signal is speed. The converter has to handle each line of video in real time and since a full line of NTSC video is drawn every 63.5 μs, you can see that the conversion has to be done very rapidly indeed.

As each line is digitized, it's stored in a memory array that's often referred to as a frame buffer. The memory is organized in the same linear fashion that you find in a computer where each line of video has its own particular range of addresses.

The amount of memory needed to store one frame of video depends on the resolution you want and the sampling rate you choose. The number of bits that you use for resolution will determine things such as how many colors and degrees of brightness you can display; and the sampling rate controls the number of individual dots you'll have on each line. As you can see, the higher the numbers, the finer your picture is going to be. Of course, as you would expect, the bigger the numbers, the more expensive it's going to be to get the job done.

This cost/resolution relationship comes about because the bigger the numbers the more memory you'll need and the faster your A-to-D circuitry will have to be. Speed is expensive.

To give you an idea of how the numbers work, let's say that we want to have eight bits of resolution and that we're going to take a thousand samples on each line. NTSC video produces 525 lines of video per frame, but only 490 of them actually carry picture information. The same sort of thing exists in each line as well, since only about 80% of each line time is actually used for picture. The remaining 20% carries sync and colorburst, and also allows for horizontal retrace.

In this simple system, basic arithmetic tells you that you'll need 490 lines $\times$ 1000 samples, or almost half a megabyte of memory to get the job done. In a practical system, you'd need even more memory, since encoding the color information as well as the brightness, with enough resolution to produce an acceptable picture is going to require more than eight bits of resolution.

There are ways to improve the apparent quality of the stored picture without upping the actual bit resolution stored in the memory buffer. They include things like extrapolating an extra bit from the stored word as well as generating extra samples by comparing two adjacent samples.

Even though the picture has been digitized, that doesn't mean that you're always looking at the frame stored in memory. Some digital TV's and VCR's only transfer the stored image to the screen when you want to do special effects such as a freeze frame, picture in picture, or, in the case of a VCR, slow motion. Since each frame of video can be stored digitally and then put through a D-to-A converter before it shows up on the screen, the quality of the image that you see on the screen will be completely dependent on the resolution of the stored sample and techniques used to do the D-to-A conversion.

The special effects provided by a digital TV or VCR are things you get for free simply because you've digitized the picture. And since you're dealing with an array stored in memory rather than a frame stored on tape, the notion of noise that plagues most VCR special effects is going to be nonexistent.

The details of digital video are much too great to go into here, but if you'll check the back issues of **Radio-Electronics**, you'll find several excellent articles on that particular subject. And you'll find more in the future. **R-E**

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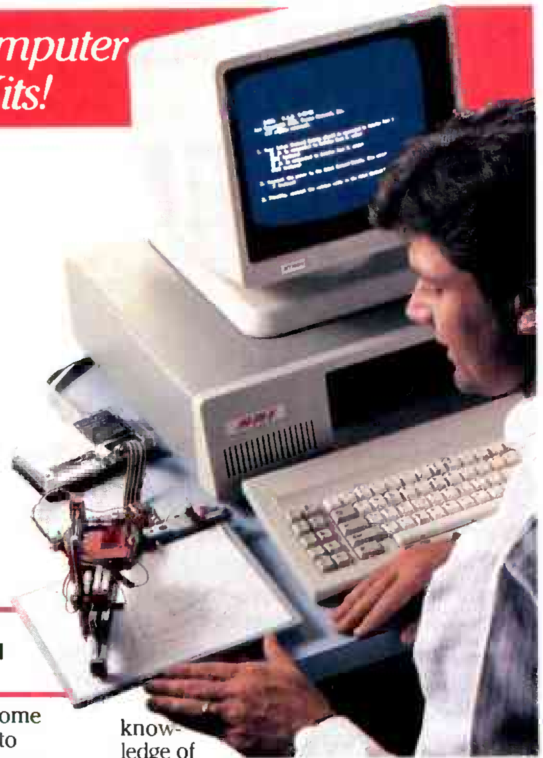

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LETTERS

"FIPS" FUSION?

I've been following with great interest recent newspaper articles on cold fusion. It seems to me that everyone is missing the fact that the first such article appeared very close to *April 1st.*

Now, while I'm not denying that cold fusion may be possible, the whole scheme seems similar to articles that appeared in issues of *Radio-Craft* magazine (now **Radio-Electronics**) in the 1930's, 40's, 50's, and 60's. They always ended with the hero noticing the date—April 1—on a calendar. I believe that all of them were written by the late Hugo Gernsback under the pseudonym "Mohammed Ulysses Fips." I recall one on Radium Radio in the early 40's, and one on two-way television, and other seemingly plausible (to the unwary) devices. Frequently, some readers would miss the April 1 ending, and a debate would result in the technical community. Letters to the editor would continue for several months.

Hugo isn't around anymore, and I sure miss his articles. Many of us take our profession too seriously, and can't take a joke. Perhaps Fleishmann and Pons have pulled off one of the better "April-Fool's" pranks of recent times.

ARTHUR J. SOLIE
Garden Grove, CA

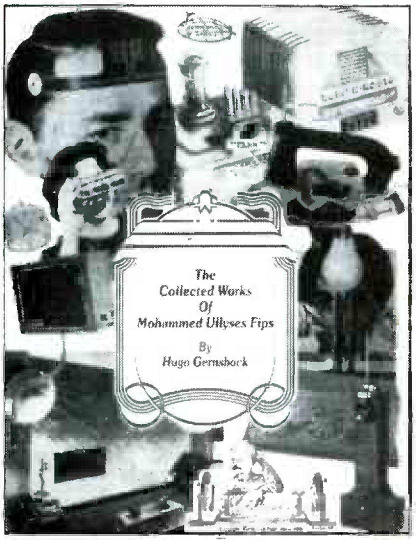


FIG. 1

Mr. Solie won't have to do without those "Fips" articles for long. We've sent him a copy of the collected works of Mohammed Ulyses Fips (see Fig. 1), a compilation of those popular stories from past decades. Anyone else who's interested in some old-fashioned humorous stories can order the book for $7.50, plus $2.00 for shipping and handling, from: RE Reprint Bookstore, PO Box 4079, Farmingdale, NY 11735. New York residents must add sales tax.—Editor

LOUDSPEAKER HISTORY

In "Audio Update" in the May 1989 issue of **Radio-Electronics**, Larry Klein credited the beginning of electrodynamic speakers to the early work of C. Rice and E. Kellogg, reported originally in a paper delivered at the Spring AIEE Convention in St. Louis in April 1925. A patent was later issued to General Electric for their work.

I was particularly interested in that article because C.W. Rice was my father. As a small child, I seem to remember one of his experimental speaker/amplifiers blaring around the house. I am not sure whether GE profited much from the exclusive use (for 17 years) of that patent, but after it expired, it allowed many hi-fi companies to sell their versions without fear of patent infringement. Amazingly, we are still using the same basic idea in the speakers built today! Thanks for the interesting bit of history.

CHESTER T. RICE, WA6PAC
Kentfield, CA

BATTERY-CHARGE INDICATOR

Anyone who owns a Skil cordless screwdriver without a battery-charge indicator will probably appreciate the circuit shown in Fig. 2. Cut into one line and install

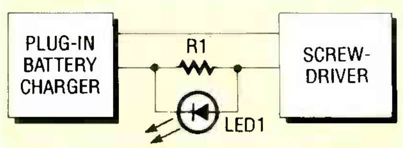


FIG. 2

a 10-ohm, ¼-watt resistor. Check the DC-voltage drop across the resistor (approximately 1 volt) and install an LED across the resistor, observing the proper polarity. Many times I could not use the screwdriver, as it did not charge due to dirty contacts. The charge-indicator circuit has solved my problem.

HERBERT BUSS
Columbus, OH

SPEAKER-CABLE PERFORMANCE

After reading Mr. Wilson's letter about speaker cable ("Letters," **Radio-Electronics**, June 1989) I decided to run an experiment myself. I took 32 feet of 22-gauge intercom wire and connected it between an 8-ohm load resistor and an amplifier, which, in turn, was driven by a function generator. The amplifier

output had a response of 15 Hz to 30 kHz within ±1 dB. At the load, it was 15 Hz to 27 kHz, ±1 dB. A 10-kHz square wave showed a 4-microsecond rise time at the amplifier output and a 6-microsecond risetime at the load resistor.

The 22-gauge wire, with its 1.25-ohm round-trip resistance, did cause some power loss. The amplifier produced 15-volts RMS at full output, which dropped to 13 volts at the load end of the line. The current was just over 1.6 amps. Of the 27 watts produced by the amp, the wire dissipated 6 watts as heat, and 21 watts made it to its destination. Listening tests with that length of thin wire in a system using large 4-way speakers showed a slight, but noticeable, drop in volume and, perhaps, a barely discernible loss of high-frequency detail.

Obviously, any competent audio installer will use wire heavier than 22-gauge for speaker lines. However, the esoteric, high-priced speaker cables being peddled today seem to be a bit extravagant unless one is dealing with very low impedances, high power, or long runs. Probably the most cost-effective speaker wire is 16-gauge jacketed SJT-type power cord.

Regarding Larry Klein's "Audio Update" column on slew factor (June 1989), I do agree that *TIM* (*Transient Intermodulation Distortion*) should not be a problem with any good amplifier designed within the last 10 or 15 years. However, most early solid-state designs had inherently high distortion, and depended on vast amounts of negative feedback to reduce it to tolerable levels. Drastic high-frequency rolloff was then needed to prevent oscillation which made the amplifier's intermediate stages unable to follow sharp transients. The 741- and 1458-type op-amp IC's suffer from that shortcoming and are therefore considered unsuitable for critical audio applications.
MICHAEL KILEY
Crestwood, IL

COMPUTER RFI SOLUTIONS

Radio-Electronics readers deserve a better answer than you gave to J. Ootmar ("Ask R-E," March 1989), regarding computer RFI in a television receiver. While I agree that RFI can be difficult to eradicate, the situation is by no means as hopeless as you indicated. In fact, there are *many* steps that one can take to diagnose and solve almost any RFI problem in an orderly fashion.

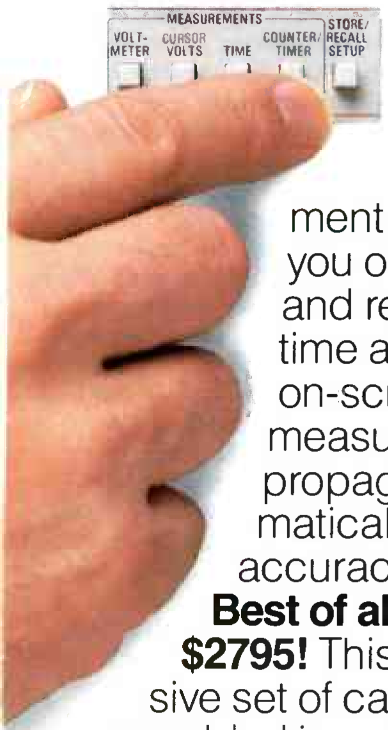
You failed even to explore the various kinds of RFI that might be afflicting Mr. Ootmar's TV set. Does the interference occur on all channels, or only a few? On UHF as well as VHF? With all printers, video monitors, and external disk drives disconnected from the computer? The answers to such simple questions will often help isolate the problem and suggest obvious cures. Armed with this information, one can proceed with shielding or filtering of the computer, TV set, or both—often completely eliminating the RFI.
JEFF DeTRAY
Peterborough, NH **R-E**

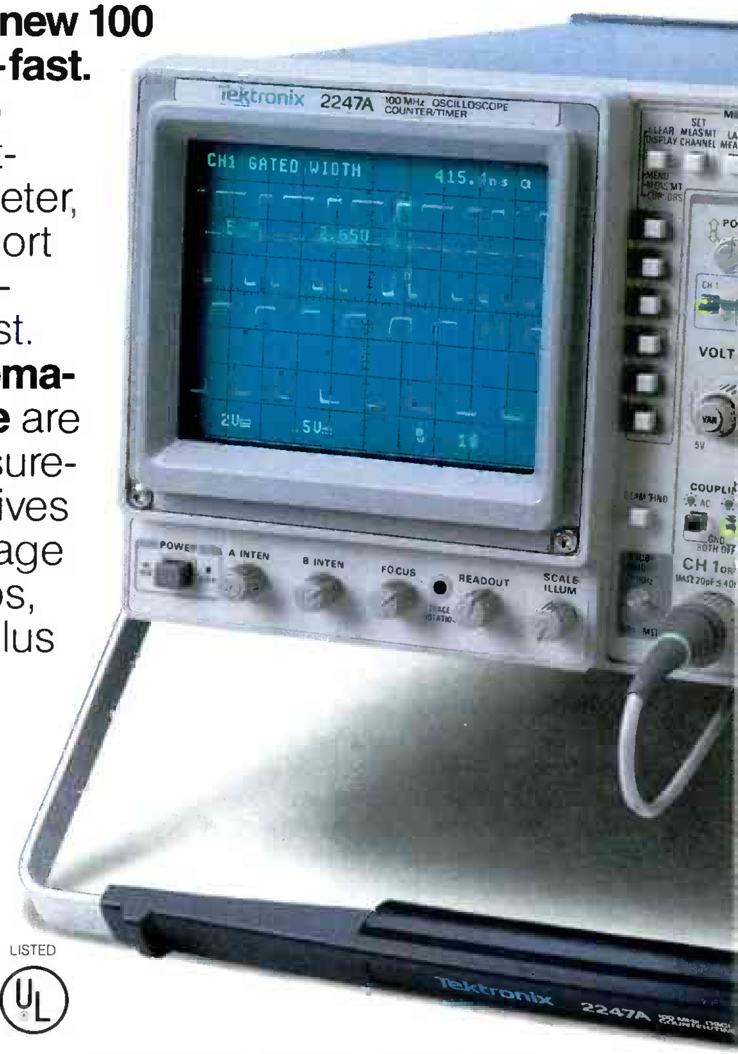
New Smart Scope makes troubleshooting trouble-free.

When you're looking for trouble, the new 100 MHz Tek 2247A will help you find it—fast.

With its integrated counter/timer, Auto Setup, unique SmartCursors™ and voltmeter, the 2247A makes short work of the measurements you need most.

The built-in counter/timer/voltmeter automatically calculates and displays more than 11 different voltage and time measurements.





Time-saving automation and ease of use are built into every measurement routine. The 2247A gives you one-button setup, storage and recall of up to 20 setups, time and voltage cursors, plus on-screen readouts. It also measures rise/fall time and propagation delay automatically, with counter accuracy to 0.001%.

Best of all is the price: only $2795! This is the most extensive set of capabilities ever assembled in a low-cost scope. And it's backed by Tek's standard 3-year warranty on parts and labor—including the CRT.

LISTED

Bandwidth	**100 MHz**
No. of channels	4
Vertical/Horizontal Accuracy	2%
Integrated Counter/Timer/Voltmeter	Yes
TV Line and TV Field Triggering	Yes
Auto Setup	Yes
Store/Recall	20 front-panel setups
SmartCursors™	Yes
Warranty	3 years, incl. CRT

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EQUIPMENT REPORTS

Beckman Industrial Model 223 Professional Digital Multimeter

Beckman's "audible readout" simplifies many measurements.

MOST DIGITAL MULTIMETERS ON THE market do an adequate job of making general-purpose voltage, current, and resistance measurements. Because of that, most test-equipment manufacturers have a hard time coming up with something to make their DMM stand out from all the others. We recently examined a distinctive one from the Beckman Industrial Corporation (Instrumentation Products Division, 3883 Ruffin Rd., San Diego, CA 92123-1898). Their model *223* Professional Digital Multimeter stands out from the crowd.

The main feature that sets the *223* apart from its competition is an *audible readout*—a tone that makes many measurements easier by letting you keep your eyes on your work instead of on the meter. Other pace-setting features include a self-resetting fuse and a logic-pulse detector.

Basic Specifications

The *223* is a handheld 3½-digit multimeter with both auto- and manual-ranging modes. DC voltages are measured in five ranges from 200 millivolts to 1000 volts while AC voltages are measured in five ranges from 200 millivolts to 750 volts. Current, both DC and AC, is measured in 3 ranges from 200 mA to 10 amps, while the six resistance ranges span from 200 ohms, to 20 megohms.

A diode/continuity test mode is also featured. In that mode, the display shows the voltage drop across forward-biased diode. For continuity tests, the meter will beep once if circuit resistance is less than 150 ohms.

A logic mode lets you easily detect logic pulses. The meter will beep at any pulse over 2.6 volts, up to 25 pulses per second. Above that rate, the meter will sound a continuous tone.

The measurement rate of the *223* is five samples per second. That results in a response time of less than one second for most measurements, less than 2 seconds in the highest resistance and voltage ranges. The rapid response time, coupled with the audible readout leave most analog meters with no advantages.

Audible Readout

The *223* features a custom analog-to-digital converter that uses a fast voltage-to-frequency converter for rapid range selection. The signals from the voltage-to-frequency converter are also amplified to produce a tone that is proportional to the value of the reading. The tone varies in pitch according to the "position" of the reading within the range.

The audible readout not only comes in handy when you are trying to test a circuit that requires that you keep your eyes on your work. It has added benefits as well. For example, intermittent connections can be found by hooking up the meter and jiggling the wire, switch, or other component that you suspect is intermittent. Although the slight signal deviations produced would not be detectable with a standard DMM, the *223* will produce a crackling sound that will definitely call attention to the problem.

Testing digital logic can be made much easier as well. High and low logic signals will produce distinctively different tones. You don't need to look at the meter, and you don't need a separate logic probe for your work.

While analog voltmeters can be used to check capacitors, DMM's are usually not too good at the job—watching a changing LCD is more difficult than watching the swing of the needle of an analog meter. However, with the audible readout, the capacitor charging or discharging is heard distinctively. Similarly, peaking adjustments are very easy to make.

Among the *223*'s other features is an auto-off battery saver that shuts the meter off after one hour of non-use. The estimated life for an alkaline battery is 500 hours. (That translates to about 6 months of average use.) A blinking decimal serves as a low-battery indicator.

A novel auto-off safety feature shuts off the *223* if a test lead is inserted in the high-current (10 amp) jack while the meter is not in a current-measuring mode.

The *223* comes equipped with a tilt bale and Beckman's "Skyhook" hanger. A pair of test leads and operating manual also are supplied with the meter, and the battery is also included. At $149.00, the *223* is competitively priced. **R-E**

VideOsmith Spectrum Probe

Turn your oscilloscope into a spectrum analyzer.

CIRCLE 29 ON FREE INFORMATION CARD

EVERY TECHNICIAN, ENGINEER, AND hobbyist dreams of having a completely stocked test bench. Most of us, however, have to make do without a number of instruments. For example, unless your work absolutely requires a spectrum analyzer, you've most likely not invested the few thousand dollars required to add an analyzer to your bench. We've recently discovered a compromise that gives you many of the benefits of a spectrum analyzer at a fraction of the cost: the *Spectrum Probe* from VideOsmith (1324 Harris Rd., Dresher, PA 19025.)

The *Spectrum Probe* turns your oscilloscope into a spectrum monitor. It converts the scope's vertical axis to a display of logarithmic amplitude, and the horizontal axis to a display of frequency. The spectrum from less than 1 MHz to more than 100 MHz is displayed—even on a scope with a 1-MHz bandwidth.

The *Spectrum Probe* looks much like a logic probe. It's about 7½ inches long and has a diameter of roughly 1 inch (although it's not exactly round). It connects to the scope's vertical input via a coaxial cable and draws its power from a wall transformer. Once the probe is connected to your scope, it's ready for use.

To view the entire 0–100 MHz spectrum, the scope's timebase is set for 0.5 ms/div, and the vertical amplifier is set to 50 mV/div. A simple antenna connected to the probe tip will show the presence of numerous RF carriers.

Figure 1 shows the RF spectrum picked up using a simple wire antenna. The bright trace at the left edge is the zero reference. That's followed by standard broadcast and shortwave stations. The brightest trace at the right end is a local FM station.

Using the probe

If you've done without a spectrum analyzer until now, you're probably unaware of how versatile it can be. It's possible to find where signals are leaking out of your supposedly shielded enclosure. The exact source can be pinpointed because the probe tip is so small. Of course, finding

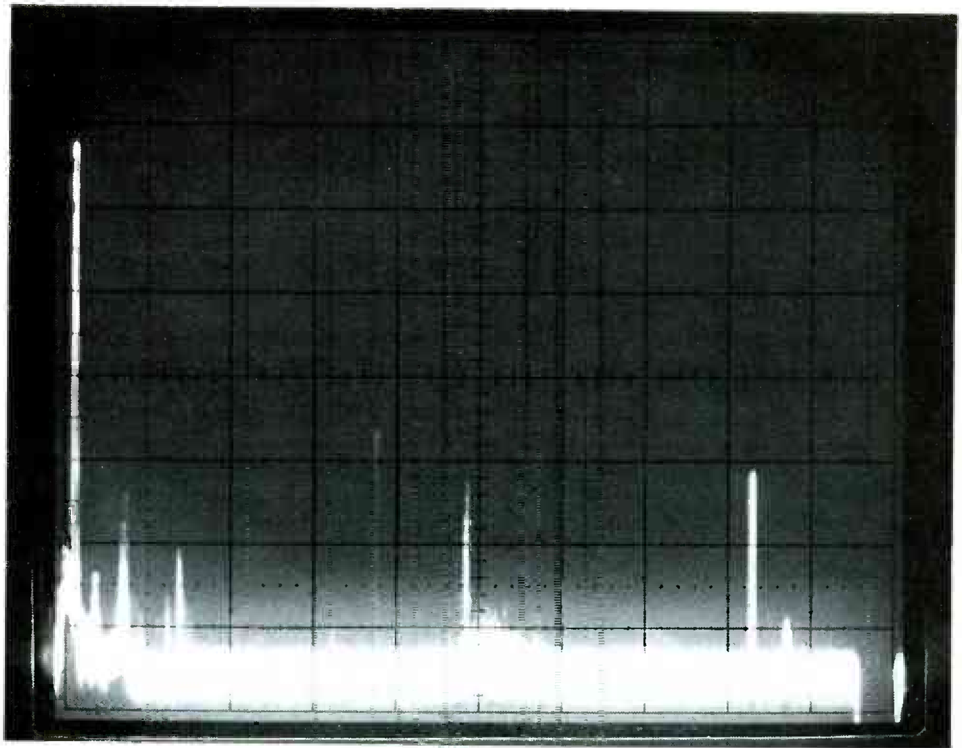

FIG. 1

leaks in a cable-TV installation is similarly easy.

Transmitters can be checked quickly and easily for spurious emissions. The frequency of operation of an unknown transmitter can be tracked down, although for accuracy, a calibrated signal generator is required. The signal generator is connected to the probe and is set up to generate a signal that looks the same as the unknown.

Electrical machinery can be checked for internal arcing—a good indicator of impending problems. Crystal oscillators can be tuned for best starting without any direct connections. Unwanted harmonics can be spotted quickly.

The input of the *Spectrum Probe* uses a 10-pF isolation capacitor, similar to low-capacitance oscilloscope probes. That helps to minimize the loading of the circuit being probed, and makes the probe useful in getting a look at operating equipment.

There is no way that the *Spectrum Probe* can replace a spectrum analyzer, but it can help you make many measurements that previously required an analyzer. If you can live without the many comples features that a real spectrum analyzer can deliver, then you might find the $380 price of the *Spectrum Probe* to be a bargain you can't live without. **R-E**

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NEW PRODUCTS

AUDIO-ENHANCED TV'S. Eleven models in *Sony's* 1989 television line, plus three new speaker systems, incorporate audio-enhancement circuitry that recreates the ambience and dynamic range of live performances. The *SRS* (Sound Retrieval System)—which was developed by Hughes Aircraft Company—actually restores information in the audio signal that has been either masked or altered by current stereo-recording and -reproducing processes. The system is not position-sensitive; the sound retains its depth and quality regardless of where the viewer/listener is seated in the room.

The TV sets that feature *SRS* include the entire *XBR* line as well as four high-end *Trinitrons*. The *XBR* sets all offer the "A/V Window" on-screen tuning-reference system and a "Remote Commander" unit, which can be programmed to operate multiple infrared-controlled components. The 27-inch (diagonal) *KV-27HSR10 Trinitron* set pictured above also has "A/V Window," plus a "Unicommander" remote control, S-Video input, and 3 sets of A/V inputs.

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SRS speaker systems include the miniature *SRS-33*, the water-resistant *SRS-77G*, and the 3-piece *SRS-D3K* Active speaker system (shown). Featuring a separate woofer and two individual full-range speakers, that system can be used with music sources—personal stereos and portable CD players, for example—or with TV's and VCR's for improved sound. The *SRS-D3K* system has an anti-magnetic seal that allows the speakers to be used alongside a TV set without causing picture interference. Small enough to fit on a bookshelf or a TV stand, the system features a built-in 25-watt amplifier. All the *SRS* speaker systems are capable of matching the dynamic sound produced by high-quality digital sources and by enhanced audio circuitry such as bass-boosting systems.

The *KV-27HSR10 Trinitron* has a suggested retail price of $1299.00; the *SRS-77G* Active speaker system has a suggested retail price of $299.95.—**Sony Corporation of America**, National Operations Headquarters, Sony Drive, Park Ridge, NJ 07656.

WAVEFORM MONITOR/VECTORSCOPE. With features like simultaneous vector and waveform display and dual-channel display for watching two video sources on the same screen, *Leader Instruments' model 5872* makes video-signal monitoring easier. The instrument's broad range of sweep rate simplify evaluation and measurements, and its ×5 vertical-gain magnifier contributes to high-resolution differential phase and gain measurements in the R-Y mode. Chroma and IRE filters can be inserted on a full-time or a line-shared basis, and the selected video source is sent to a monitor output for observation on a color monitor.

CIRCLE 11 ON FREE INFORMATION CARD

A switching-mode power supply automatically adapts the unit to a wider range of AC and DC voltages—particularly handy for ENG/EFP applications. The instrument is housed in a metal cabinet with a handle and feet for bench use; the cabinet is removable for rack-mounting purposes.

The model *5872* combination waveform monitor/vectorscope has a suggested price of $3,795.—**Leader Instruments Corporation**, 380 Oser Avenue, Hauppauge, NY 11788.

GLARE ELIMINATOR. A one-time application of *Opto-Technics' Glare Eliminator* significantly reduces the glare reflected off computer screens without adding a cumbersome screen or mesh cover. The reduced glare helps alleviate the eye-strain and headaches often associated with frequent CRT use. One coat of the durable optical coating should last as long as the monitor itself, and can be easily removed if desired.

CIRCLE 12 ON FREE INFORMATION CARD

Glare Eliminator is available in a 3-ounce aerosol-spray kit, which is good for 3 or 4 applications and is guaranteed for 90 days, for a suggested list price of $29.95.—**Opto-Technics Co.**, 310 Melvin Drive, Unit 20, Northbrook, IL 60062.

LAPTOP COMPUTER. Weighing just over 8 pounds, the *Bondwell B200* features a slim design with a "supertwist" LCD screen display and a full-size, 81-key keyboard with 10 function keys. The IBM-com-

CIRCLE 13 ON FREE INFORMATION CARD

patible laptop has 640K RAM on board; dual 3½-inch 720K floppy-disk drives; serial, parallel, and RGB-video ports; and a built-in, removable Ni-Cd battery pack that lasts up to 6 hours. The computer comes with a bundled software package that includes MS-DOS 3.30, GW-BASIC 3.22, and utility programs.

The *B200* laptop computer has a suggested retail price of $1,295.00.—**Bondwell Industrial Co., Inc.**, 47485 Seabridge Drive, Fremont, CA 94538.

SOLDERING STATION. *Elenco's Electronic Temperature-Control Soldering Station* features a sophisticated electronic circuit that allows the user to change the tip temperature from 300°F (150°C) to 900°F (480°C) without having to change the tip or heating element. A unique sensor located near the tip provides rapid response and little temperature variation—the temperature is maintained within 10°F of its preset level.

The unit's tip is isolated from the AC line by a transformer, and low voltage (24 volts) is used to power the heating element. Completely electronic switching protects voltage- and current-sensitive components against transient spikes. A linear LED readout accurately indicates the temperature of the tip.

The electronic temperature-control soldering station has a suggested list price of $169.00.—**Elenco Electronics, Inc.**, 150 West Carpenter Ave., Wheeling, IL 60090.

CIRCLE 14 ON FREE INFORMATION CARD

RF MICROWAVE PROBES. *Tektronix TMP9600* series of RF microwave probes are compatible with existing microwave probe stations, including those from Alessi, Cascade Microtech, and Design Techniques. The probes operate from DC to 40 GHz, and feature return loss greater than 10 dB and insertion loss less than 2.5 dB at 40 GHz—ideally suited to making noise-parameter measurements.

The *TMP9600* probes are precision adapters, converting coaxial input into ground-signal-ground, coplanar waveguide footprints that interface to hybrid microwave circuits, MMIC's, or microwave packages. Probes are available in discrete pitch increments of 100 (*TMP9610*), 150 (*TMP9615*), 200 (*TMP9620*), and 250 (*TMP9625*) microns. Input is through a female "K" connector; a female

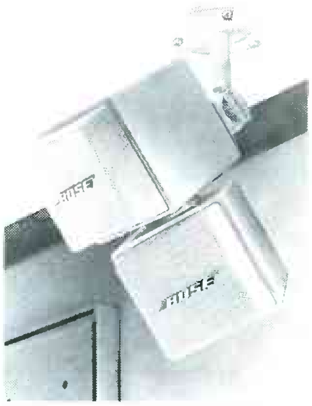
CIRCLE 15 ON FREE INFORMATION CARD

OS-50 connector is available as an option.

Each probe in the *TMP9600* series costs $979, and the optional 2.4-mm *OS-50* connector costs $175.00.—**Tektronix, Inc.**, Microwave Technology Organization, P.O. Box 500, Delivery Station 58-147, Beaverton, OR 97077.

SPEAKER SYSTEM. *Bose's Acoustimass AM-5* 3-piece speaker system now comes in white, to blend "invisibly" with light-colored walls and furniture. The system delivers the same bass, power handling, dynamic range, and spatial accuracy as high-quality, full-sized speakers—from two 2-inch cube arrays (about the size of a soda can) and a 12 × 20-inch bass module that can be concealed from view.

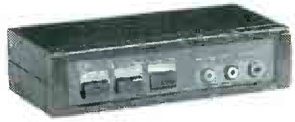
Proprietary Bose Acoustimass technology produces a deep, powerful bass sound, even if the module is hidden under furniture. Midrange and high-frequency notes are reproduced by the cube-speaker arrays, made up of two cubes, each containing a 2½-inch driver. The cubes rotate almost 360 degrees to adjust the direct or reflecting balance to suit the room's acoustics or the listener's preference. Custom brackets are available for wall or ceiling mounting.



CIRCLE 16 ON FREE INFORMATION CARD

The white *AM-5* speaker system has a suggested retail price of $799.00; the optional mounting brackets cost $39.95.—**Bose Corporation**, The Mountain, Framingham, MA 01701.

AUDIO/VIDEO SWITCHERS. To reduce the tangled clutter of connecting cables, *Ambico* offers two switchers. The model *V-0780* AV Control Center (pictured) allows automatic switching between any three stereo audio/video sources. Once the stereo, VCR, and camcorder (or any combination) are hooked up to the unit, any or all can be accessed with the push of a button—no disconnection or reconnection of cables is necessary. All three inputs and the output have RCA-type jacks for video and left and right audio signals. The output connects easily to a VCR or a monitor.



CIRCLE 17 ON FREE INFORMATION CARD

The model *V-0785* TV Control Center allows automatic switching between any two cable/antenna sources and one composite A/V source. Any combination of VCR, cable lines, antenna leads, and camcorder can be permanently connected to the two RF inputs. A video game or a computer can be hooked up to the composite A/V input. Push-buttons provide instant switching between the three sources and the TV or VCR that is connected to the unit's RF output.

The model *V-0780* AV control center and the model *V-0785* TV Control Center cost $24.95 each.—**Ambico Inc.**, 50 Maple St., P.O. Box 427, Norwood, NJ 07648-0427.

PC PEDAL CONTROLLER. *Brown & Co.'s PC-Pedal* is a foot switch that can be programmed to duplicate any key on the IBM PC, XT, AT, PS/2, or compatibles. Allowing remote access to the computer, its uses range from a remote toggle for a printer that must be hand-fed, to a sophisticated infrared switch that operates the computer through the *PC-Pedal* hardware and software. It can also be used to duplicate the SHIFT, ALTERNATE, or CONTROL keys; to toggle the numeric keypad between number and cursor modes. In the enhanced version, it can duplicate any key for a specific function, duplicate the down arrow when entering numbers using the numeric keypad; or it can also be used as a remote switch to toggle the computer from a distant location.

PC-Pedal connects to the computer through the parallel port and doesn't disable the port or the keyboard in any way. It will work with most programs that do not reconfigure the keyboard.

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The standard version of *PC-Pedal* (which can duplicate the SHIFT, CTRL, ALT BACKSPACE and DEL keys) costs $59.94; the enhanced version (which can duplicate any keyboard key) costs $79.95 (add $1.50 for shipping and handling for either version). An Enhanced Up-Grade Disk is available for $20.00.—**Brown & Co., Inc.**, P.O. Box 2443, So. Hamilton, MA 01982; Tel. 508-468-7464.

MONITOR ARMS. Designed to increase available desktop space and improve angles of vision, the three models of *Curtis Monitor Arms* keep a computer monitor and keyboard raised off the desktop and allow them to be swung out of the way when not in use. All feature 360° arm and monitor-platform rotation, and three mounting options. The arms can be secured to a desk with a single or double swivel clamp, or permanently bolted or


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screwed to either the desk or the wall.

The *Standard* monitor arm has anti-skid pads and securely holds a monitor weighing as much as 30 pounds on its 12¼ × 12¼-inch platform, along with any keyboard. The *Executive* and *Professional* models each have a 14 × 12½-inch platform that accommodates a monitor weighing up to 65 pounds, and a keyboard rack that slides away when not in use. On the *Professional* model (shown), the keyboard rack also has an adjustable-tilt option.

The *Standard*, *Executive*,

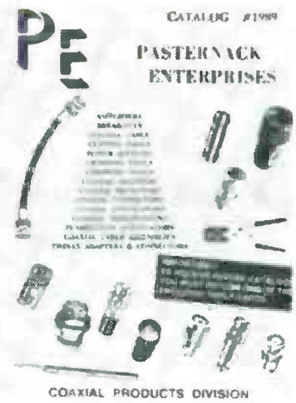
and *Professional* monitor arms have suggested retail prices of $69.95, $139.95, and $239.95, respectively.—**Curtis Manufacturing Company Inc.**, 30 Fitzgerald Drive, Jaffrey, NH 03452.

NEW LITERATURE

MCM ELECTRONICS CATALOG. *MCM's* catalog #20 contains over 11,000 parts and components, including more than 500 new products. Some of the product categories featured are VCR, audio, TV and telephone parts; semiconductors; computer equipment; tools; batteries; connectors; and soldering equipment. The catalog is free upon request.—**MCM Electronics**, 650 Congress Park Dr., Centerville, OH 45459-4072; Tel. 1-800-543-4330.

CIRCLE 20 ON FREE INFORMATION CARD

COAXIAL PRODUCTS CATALOG. *Pasternack Enterprises'* 1989 catalog contains a complete line of coaxial products. Included are amplifiers; breakouts; coax cable; cutting, crimping, and stripping tools; power dividers; pushbutton attenuators; and coaxial cable, adapters, connectors, terminations, attenuators, and detectors. The 38-page catalog is free.—**Pasternack Enterprises**, P.O. Box 16759, Irvine, CA 92713.



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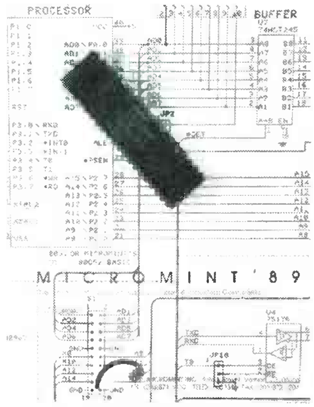
COMPUTER-BOARDS CATALOG. *Micromint's* 1989 catalog features their full line of single-board computers and industrial controllers along with several new products. The *BCC60* Floppy/SCSI Interface Board, for example, turns the *BCC180* single-board controller into a self-contained development system. Another new product, the *BCC45* stepper motor controller, simplifies precision computer control of stepper motors.—**Micromint Inc.**, 4 Park Street, Vernon, CT 06066.



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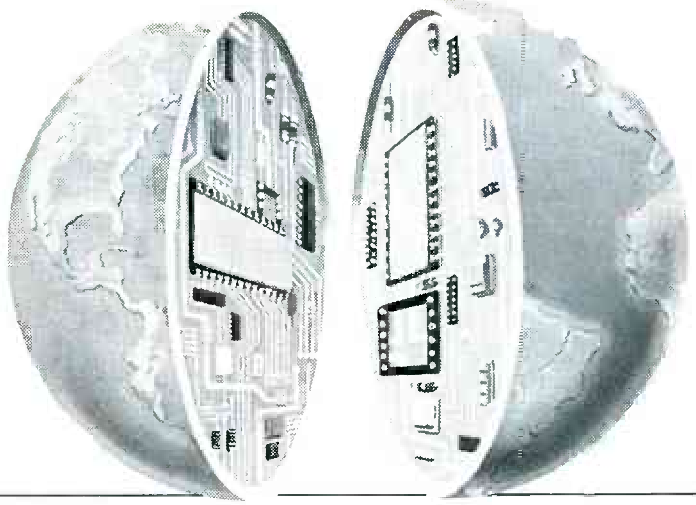

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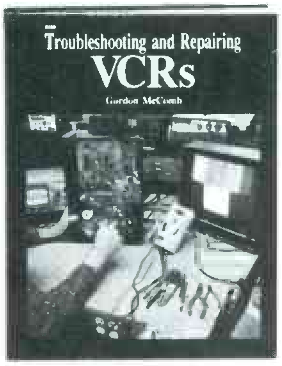

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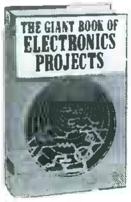

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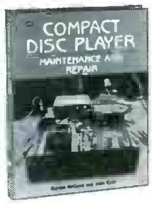

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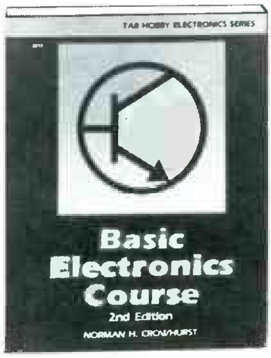

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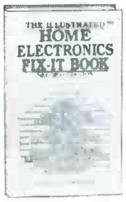

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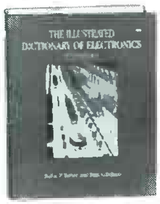

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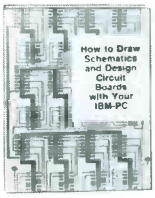

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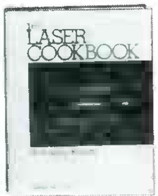

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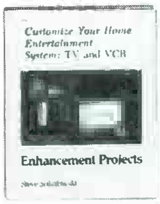

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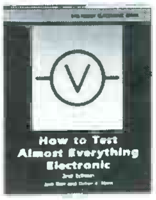

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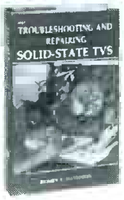

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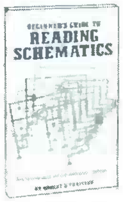

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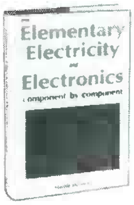

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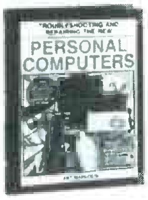

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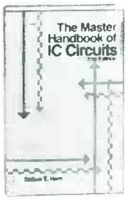

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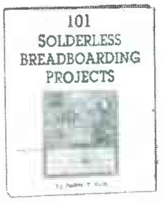

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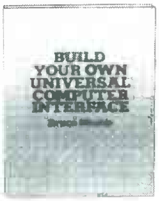

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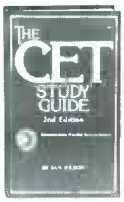

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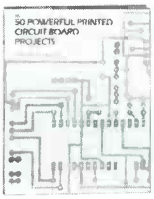

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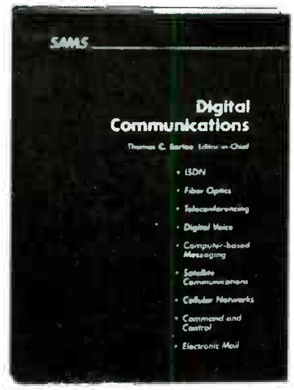

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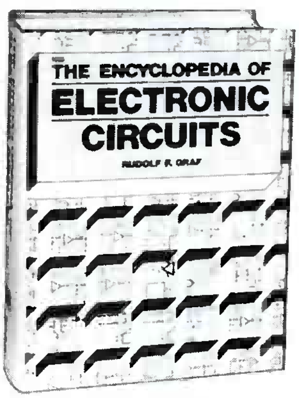

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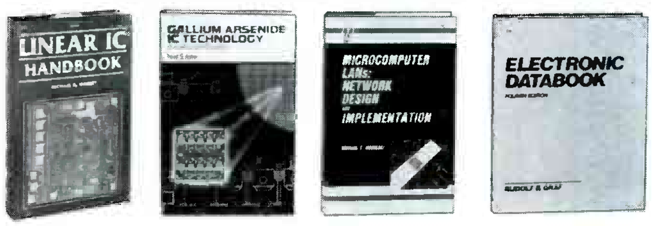

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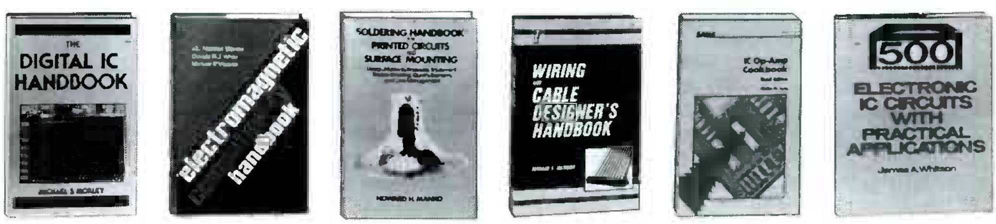

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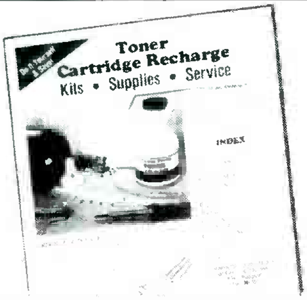

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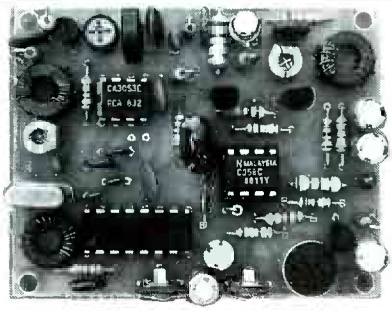

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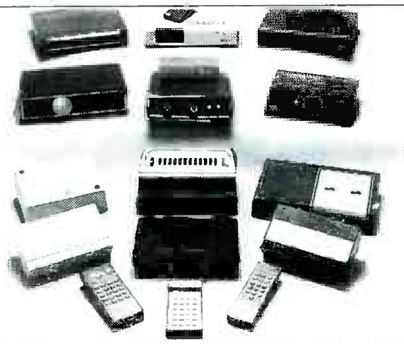

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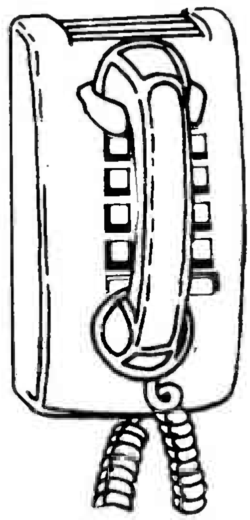

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ALL ABOUT

MUSICAL INSTRUMENT DIGITAL INTERFACE

A primer on how MIDI has changed the way music is made!

JOHN SIMONTON

WHETHER YOU THINK OF IT AS THE LAN (*L*ocal *A*rea *N*etwork) with the largest installed equipment base in the world or a political statement (a sort of musical Glasnost), there's no denying that the *M*usical *I*nstrument *D*igital *I*nterface (MIDI) is having an impact well beyond the original intent of simply being able to connect two electronic music synthesizers together.

As a LAN, MIDI provides complete systems which, by the time you read this, may well be available from your local discount store for under $100. Not just a gateway between instrument and network, mind you, but the whole system. As a political statement MIDI allows manufacturers from the US, Europe, and the Far East to produce equipment that communicates more easily than their users can speak to one another. The old joke about a session musician phoning in his part of a recording is no longer a laughing matter, but a practical reality; even if the musician is in Stockholm and the gig in Anaheim.

MIDI history

In the early 1970's, the advent of electronic music synthesizers, with their near-universal voltage-control protocol of 1 volt/octave, seemed to be ushering in a new era of compatibility between musical equipment from different manufacturers. For example, the control voltages from a Mini-MOOG keyboard could also be used to control elaborate expander modules from Oberheim. The result was that the existing "2 oscillators and a filter" sound which had become the synthesizer idiom soon began to be replaced by more dynamic and timbrally interesting musical voices; and here began the transition from cliche to music.

The first polyphonic (many note) synthesizers seemed to be following the control-voltage scheme, simply using a computer to manage the generation of the many control voltages needed by multiple oscillators, amplifiers, and filters. But right away the compelling economic advantages of doing some of the traditional functions with software rather than voltages controlling physical elements became clear. Oscillators, as you might guess, were the first analog functions to fall prey to the talents of the already present computer for doing repetitious functions. Since there was no longer a control voltage, there was now no way to interface the elements coming from one manufacturer to expander elements coming from another manufacturer—or, in fact, from the same manufacturer.

Some companies, realizing the limitation imposed on the user, developed bus structures to allow expansion. Some were serial buses in the interest of less expensive cables, and some parallel in the interest of higher speed. But they all were proprietary—interfacing between equipment from different manufacturers ranged from difficult to impossible.

In December of 1982, Sequential Circuits, Inc. (manufacturer of the Prophet—the first widely accepted polyphonic synthesizer) shipped the first units of their Prophet 600. One of the more interesting features of that new instrument was that it included serial interface connectors for what Sequential president Dave Smith had named the Universal Synthesizer Interface. At the winter music industry trade show that same year, techies from Sequential, Yamaha, and several other US and Japanese manufacturers met informally to discuss standardization. The consensus was that a

MIDI EQUIPMENT

MARSHAL M. ROSENTHAL

There was a time when piano lessons were a requirement of growing up. Every child was forced to sit down for at least some time at the keys. After all, music was important to being well rounded, and how else could you learn?

If you're like most of us, you rebelled against music lessons—there were always other things to do and other places to be. The result, of course, is that you can't play *any* instruments. The only way you know how to make music is to turn on your stereo system. But there may be another way, thanks to the *M*usical *I*nstrument *D*igital *I*nterface, better known as MIDI. MIDI has made it possible for those of us more comfortable with computer keyboards than piano keyboards to play some music, too. Of course, it's no substitute for musical talent, but it sure can help with some of the mechanics of making music. In the hands of talented musicians, MIDI becomes perhaps the most important electronic musical innovation since multi-track recording.

Computers have the ability to keep track of and control many things at high speed. They can retrieve data, and alter and store data at incredible speeds. That's what makes them ideal for controlling, coordinating, and editing music. But computers can understand only computer language, and musical keyboards can't understand anything. MIDI compatibility is what brings them together.

MIDI was the natural result the proliferation of all those electronic musical synthesizers that took place in the late 1970's. The synthesizers of those days could play only one note at a time. If multiple synthesizers could be linked together—and kept in sync with each other—it would be possible to create polyphonic synthesizers.

The idea behind MIDI is to enable multiple synthesizers to play together so that the sound isn't limited to a single instrument, and also to keep all instruments in sync with one another. In 1983, a standard was de-

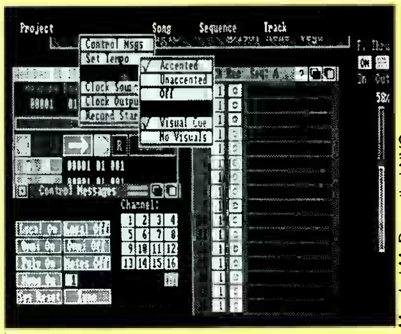

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FIG. 1—MIDIMAGIC from Brown-Wagh

protocol very similar to Dave Smith's USI offered the best compromise of speed, simplicity and low cost.

In June of 1983, a Prophet 600 was interfaced to a YAMAHA DX-7 (an instrument based on John Chowning's somewhat serendipitous, but none the less insightful discovery of FM-synthesis techniques and destined to change electronic keyboard instruments forever). The results fell slightly short of spectacular, but were so encouraging that in Tokyo in August of 1983, representatives from Sequential (the only US manufacturer), Roland, Yamaha, Korg, and Kawai agreed on the "MIDI 1.0" specification. The rest of the story is history; the results historic.

Is it significant that in a few months, those informal meetings led to agreement and implementation while at the same time discussions among such lofty organizations as the International Standards Organization, American National Standards Institute, and others have been futzing around with similar problems for years? I don't know; you decide. (Now to be fair, ISO and ANSI deal with weighty matters of international political significance and MIDI... well, it's only Rock and Roll.)

MIDI hardware

The most important technical characteristic of MIDI is that, in the interest of inexpensive cabling and connectors, it's serial, and it's essentially the same as RS-232 with a start bit, 8 data bits, and two stop bits (see Fig. 1). It runs at what at first glance seems a somewhat strange speed of 31.25 Kilobaud. But 31.25 Kilobaud isn't such a strange speed when you consider that the ever-popular (and now dirt cheap) 6850-type asynchronous communications interface adapter, when its internal control registers are set for a divide-by-64 operating mode and pumped externally with a 2-MHz transmit and receive clock, produces (you guessed it) 31.25 Kilobaud.

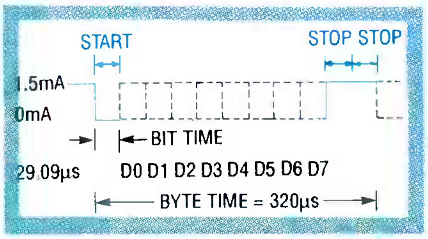

FIG. 1—MIDI IS SERIAL, much like RS-232 with a start bit, 8 data bits, and two stop bits.

Unlike RS-232 (which uses a bipolar voltage), MIDI is a 1.5-mA current loop with an optoisolator at the receiving end (see Fig. 2). OK, why put an optoisolator in an interface that is designed mostly to be cheap? It's done to prevent ground loops, the nemesis of audio equipment. When digital and analog are mixed within the same box, and when interconnections must be made between different boxes, keeping digital noise from showing up in the audio is a black art. Even MIDI, if not handled properly, can fall victim.

For connectors, MIDI uses 5-pin DIN types, with females on the equipment and males on the cables. In keeping with one of the basic philosophies of MIDI, DIN connectors are inexpensive and, despite their lack of a means of physically locking a plug in place, are completely adequate for consumer and studio use. It is not unheard of, on the other hand, for the connectors to be replaced with professional-grade XLR connectors when the equipment is being used on stage in a live situation.

The cable called for in the MIDI specification is shielded twisted pair with a length not greater than 50 feet. MIDI cables are not particularly expensive, but it's so easy to "roll your own," that making them at home is not uncommon. There really is only one caution: There are some cables available that are terminated on both ends in 5-pin male DIN's that are intended for audio use. Because they may be more readily available (or even less expensive) than official MIDI cables, they will sometimes be pressed into service. In many cases it's not a problem, but the potential for trouble exists. How? A cable's just a bunch of wires, isn't it? No, not always.

veloped that ended the incompatibility problems that beset anyone trying to merge different pieces of equipment. That's what set the stage for the idea of using personal computers as musical aids.

The Commodore *64* was one of the first computer systems to bring MIDI to the mainstream user, due to its popularity and low price. Many of the music programs for that computer were developed mainly to take advantage of the 6581 *S*ound *I*nterface *D*evice (SID), the *64*'s internal sound generator. However, some programs could also make use of add-on MIDI components designed for the *64*. The result was a back-door approach into MIDI.

The capabilities of today's computers far outstrip those of the Commodore *64*. That's not only true in terms of raw computing power, but in MIDI capabilities as well—assuming, of course, that your computer offers a MIDI port.

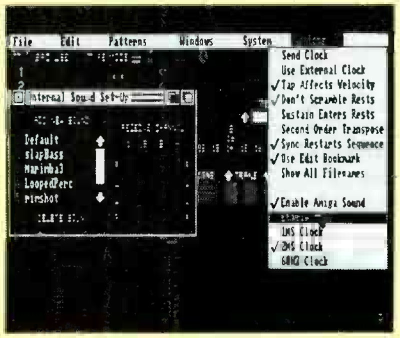

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FIG. 2—INTELLIGENT MUSIC'S M.

MIDI ports can be built into the computer itself (for example, the Atari *ST*); they can be external hardware devices controlled by one of the computer's ports, and they can be add-in cards (such as those that are available for the IBM *PC*). As for memory storage, floppy drives can be used, but hard drives offer higher capacity and faster access, and they are therefore better-suited for MIDI applications.

Music machines

Keyboard consoles are the mainstay of performance, and one of the hottest around is Korg's *M1*, which features an internal sequencer and sampled sound capability. That allows the *M1* to digitally record ex- ternal sound and store it in memory. The sampled sound can be played back with controlled changes. The *M1*'s digital 16-bit processing puts more power in your hands than ever

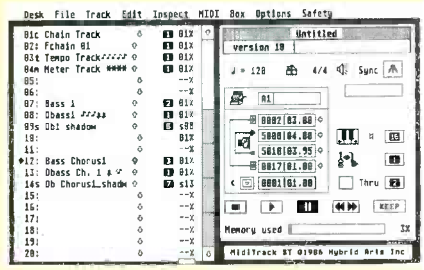

FIG. 3—MIDITRACK FROM HYBRID ARTS.

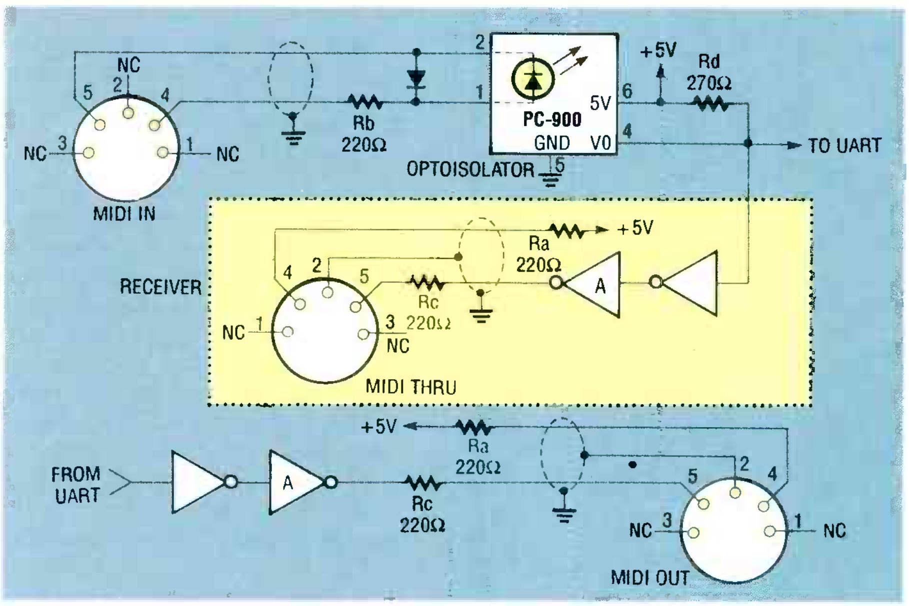

FIG. 2—MIDI IS A 1.5-mA CURRENT LOOP with an optoisolator at the receiving end.

The problem arises because of two faults, each insignificant individually. Since most DIN's solder to PC boards, it makes sense to solder the pins to a large land area. On some boards, the land is also the system ground (it seems like good practice), and on most DIN's the mounting tabs are electrically connected to the shell. The DIN-terminated audio cables have the pins connected together on a one-to-one basis (no problem) but have the shells connected together with the cable shield. If one of the cables is used to connect two pieces of equipment where the designers have grounded the shells of the connectors, the result is an instant ground loop, and not just possible audio hum; it's almost guaranteed.

Referring to Fig. 2, and remembering that one of the primary goals of MIDI is to prevent ground loops before they start, notice that none of the pins on the MIDI-IN connector are grounded, while on the MIDI-OUT connector, only pin 2 is grounded. It is particularly important that with properly implemented MIDI, there is no common ground between equipment through the MIDI cable.

While Fig. 2 shows three connectors (IN, OUT and THRU), most equipment has only the IN and OUT. Some keyboardless voice-expander modules may have only the IN. Some equipment such as strap-on keyboard controllers and timing sources may have only OUT. Higher-end "pro pieces" (as music salesman like to call them) will also include the THRU connector, and in larger systems it's awfully handy to have them. THRU is simply a buffered output which provides a direct copy of the MIDI-IN data. See Fig. 3 for various MIDI configurations.

Some equipment may have multiple IN's which merge multiple MIDI data streams, which is a trickier operation than you might think, because there has to be enough smarts in the merger to keep the two streams in proper sequence. You my also run into boxes with multiple OUT's, which may do nothing but buffering, or may have enough intelligence to split the outputs into separate channels. There are lots of possibilities for connecting MIDI equipment.

A chain is the simplest configuration for interconnecting MIDI equipment, but it is by no means the only one possible or, for that matter, desirable. A ring configuration, for instance, may work well with some newer equipment that's being used, but older gear may produce unpredictable results as messages get passed around the ring.

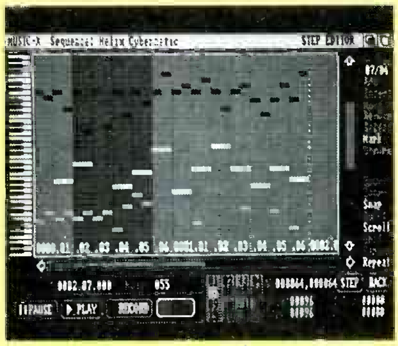

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FIG. 4—MUSIC-X FOR THE AMIGA.

before, with amazing realism and clarity. Plug-in memory cards are available for added effects, as well as the *Q1* editing/synchronizing MIDI recorder—it can digitally memorize every note you play.

The *CZ101* MIDI keyboard from Casio was particularly suited for beginners and people on a budget. It featured a low price (less than $285.00 with a power supply), medium-sized keys, digital waveform controls, and 4-note polyphonic sound. It was a great unit; Casio discontinued it. Fortunately, Casio does make other models that won't break your pocketbook, such as the *M-640*, which features medium-sized keys, 98 percussion sounds, a 210-sound bank, 10 built-in percussion pads, internal speakers, and a MIDI port.

Casio's *Digital Horn* looks more like Flash Gordon's saxophone than a MIDI instrument. Six preset tones and a high-fidelity speaker make it very portable. Plug it into a synthesizer and it will unleash unlimited sounds. A portamento control lets you "glide" and "bend" notes, and you can choose to "blow or not to blow," because sounds can be activated by just pressing the keys, or can be controlled by blowing in the mouthpiece.

Yamaha gets its licks in with their *WX7* Wind Controller—it looks like a meltdown between a piccolo and a *Star Wars* light saber. The *WX7* features two "Wind Curves," which respond to breath pressure, a tight- and loose-lip mode, and an ergomatic and sensitive set of 14 keys. You can instantly switch octaves, or even play two keys at once (that's MIDI for you). And do check out Yamaha's *G10* guitar. Features include a "fast" neck, string-sensitivity control and an ultrasonic (sonar) detection system to determine the fret fingered. Both the guitar and *WX7* require a tone controller, and will interact with computer-driven software.

MIDI units talk to one another over separate channels to keep things from becoming messy. There are 16 channels available, and a pass-through (MIDI-THRU) means that you could have a whole passel of synthesizers, drum machines, and other MIDI devices hooked up. So it's really no surprise that the computer functions as the master component, providing the overall supervision.

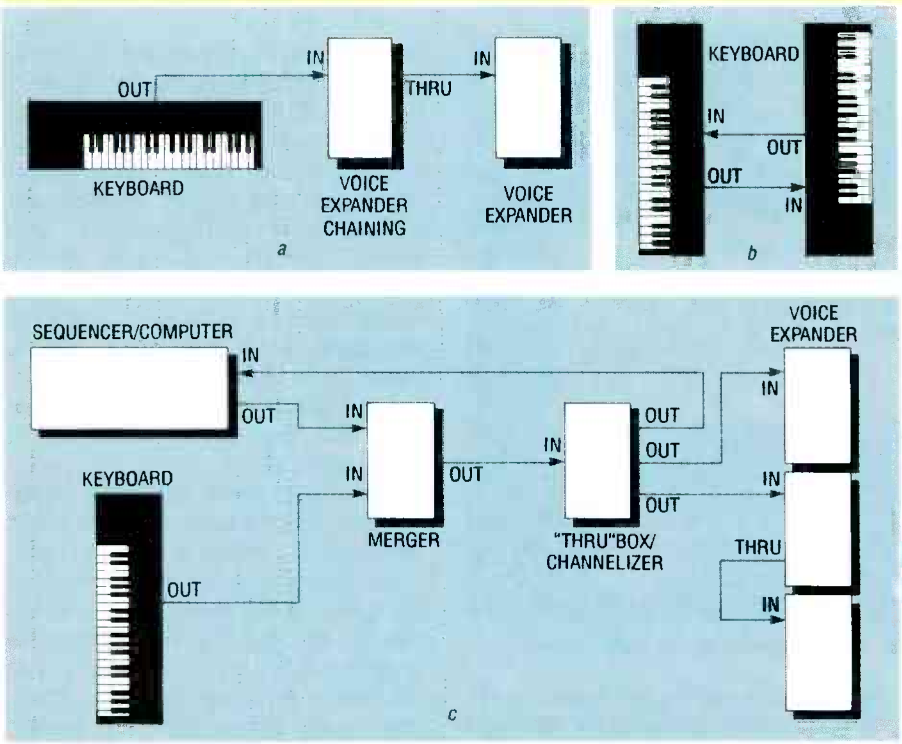


FIG. 3—MIDI NETWORK CONFIGURATIONS. Chaining is the most common (*a*), small rings are OK with newer equipment (*b*), and there are many other possibilities for specific needs (*c*).

MIDI message formats

While one of the original intentions of MIDI was to simply provide an equivalent of the control-voltage interface, it was apparent to the framers of the MIDI specification, that much more information than simply "play a middle C" could be included in the new digital format. For example, while early synthesizers were much like electronic organs of the period in that the keyboard was simply a bunch of switches which were either open or closed, keyboards which also allowed the user some control over expression depending on how hard the key was pressed were becoming available. These velocity-sensitive keyboards gave a feel much closer to "natural" instruments, where how hard you pick, blow, or hit determines much of the "feel" that makes music human, and it seemed desirable to include provisions for key velocity in the MIDI specification.

To provide for additional information, MIDI breaks bytes passing down the bus into two types: status and data. Status bytes provide information on what type of action is going to be called for, and the subsequent data bytes give the specifics of the action. For example, the status byte may say "turn a note on," and the data bytes say "the note is a middle C played forte (loud)." In MIDI, status bytes always have their *M*ost-*S*ignificant *B*its (MSB) set to a 1, and data bytes always have their MSB's cleared to 0. (see Fig. 4).

If it seems something of a waste to devote an entire byte of a message to nothing more than simply getting ready to turn a note on, you have good instincts. Status bytes often carry much more information than that. They frequently also carry a *channel number* in their lower 4 bits. MIDI instruments can be set to "listen" only to messages coming in on one or more of the 16 channels which can be uniquely identified by these 4 bits. Some of the advantages are apparent right away. A single twisted pair of wires daisy-chained through several sound-producing elements can carry a separate message to each of the boxes. The "strings box" can pass on

FIG. 5—THE KORG M1 electronic MIDI-equipped keyboard.

Most MIDI programs can turn your computer into a sequencer and allow your computer to become a full-featured music studio. You can think of a sequencer as a tape recorder without tape. But it's one that offers specialized features that no tape machine could ever do—for example, the ability of transposing keys by issuing a simple command, or making minute changes to any track. Keep in mind that sequencer information is pure data—nothing becomes degraded from changes. It's always the first generation.

Multiple tracks can be built up, and sent to other MIDI instruments such as keyboard synthesizers and drum machines (sometimes referred to as "slaves"). In most cases, the computer also performs the functions of a metronome (for the beat), and some machines can even add their own internal sounds. The finished process can then be enjoyed live, or output to stereo tape decks.

Taking all that into account, do you have to be a computer wiz, or musical genius to use MIDI? Fortunately not. The power of MIDI is in the software running on the computer, software that can augment your own abilities. A musician doesn't need help in playing on a keyboard—he needs a program to aid in constructing the patterns he is making. Enthusiasts who "pick-n-peck" on a piano can now take their time, and have the software string the notes together at a normal pace.

In MIDI, "user friendly" really has value. It's the software's job to help the user realize his aims. You might find Activision's *Music Studio* (an early music program with MIDI capabilities for the Atari *ST*) easy to use and get started with, but perhaps a bit too simplistic. Be aware that a program may be available for different computers, but it may run differently on different machines. A program for the Macintosh might be fantastic

but otherwise ignore the notes intended for the "horns box." Even though in contemporary electronic instruments the strings and horns boxes are often in the same box, the principle still applies.

We said earlier that most status bytes carry a channel number and, as you might guess, messages prefixed with a channel number are called channel messages. MIDI also provides for system messages that carry no channel number and are intended to elicit the same response from any device that happens to be sitting on the bus. Status bytes that prefix system messages have all four high-order bits set to 1. It's best if we start referring to things in hexadecimal notation, so the system messages have the form \$Fx, where the \$x part denotes the specific message.

System messages do things like instruct all instruments to tune themselves (completely superfluous with today's digital instruments), and reset to power-on conditions (which MIDI 1.0 specifically cautions against using). Also useful but rarely used are things like "active sensing," which allows instruments properly equipped to realize that their MIDI plug has

TABLE 1
SUMMARY OF STATUS BYTES

STATUS D7—DO	# OF DATA BYTES	DESCRIPTION
CHANNEL VOICE MESSAGES		
1000nnnn	2	Note Off event
1001nnnn	2	Note On event (velocity = 0 Note Off)
1010nnnn	2	Polyphonic key pressure/aftertouch)
1011nnnn	2	Control change
1100nnnn	1	Program change
1101nnnn	1	Channel Pressure (Aftertouch)
1110nnnn	2	Pitch wheel change
CHANNEL MODE MESSAGES		
1011nnnn	2	Selects Channel Mode
SYSTEM MESSAGES		
11110000	******	System Exclusive
11110sss	0 to 2	System Common
11111ttt	0	System Real Time

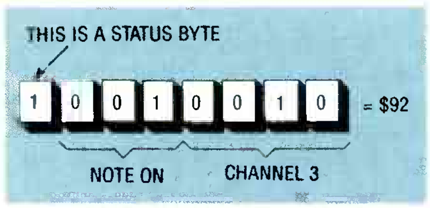


FIG. 4—A MIDI STATUS BYTE. Status bytes provide information on what type of action is going to be called for, and the subsequent data bytes give the specifics of the action.

fallen out. Much more important, system messages also perform the timing functions which have become so much the major influence of MIDI that we will cover them separately. But for right now we have to back up a little.

In the normal course of things, channel messages consist of a status byte followed by one or two data bytes (whose MSB's are cleared to 0). Whether one or two data bytes are required is spelled out by the MIDI 1.0 and is summarized in Table 1.

In musical systems, the message that most often comes down the bus is to play a note. And two different status bytes are provided; the channel messages NOTE ON and NOTE OFF. We'll concern ourselves with NOTE ON first. NOTE ON (\$9n where \$n represents the 4-bit channel number) requires 2 data bytes. The first data byte says what note is to be played. Since the MSB must by definition be 0, there are provisions for 128 notes. A piano has

FIG. 8—THE WX7 WIND CONTROLLER from Yamaha features two "wind curves."

while its IBM version doesn't quite deliver the same promises. Before you buy, make sure you try the software on your computer system.

MIDI computers

Even though MIDI compatibility isn't built in, the MacIntosh really got MIDI off and running, due to its high-quality graphics and simple user interface. It offers four internal "voices," and can create sounds internally, as well as digitally sample them. The high-quality polyphonic sound reproduction got a lot of people to start "seeing" music.

Software for the MacIntosh ranges from the somewhat simple *Jam Session* (Broderbund) which provides basic bass lines as you "play" preformatted riffs that keep you sounding good, right on up to the more complex *Master Tracks Pro* (Passport Design), a MIDI sequencer that lets you edit data in a graphic fashion as well as conventionally, using number values. Note that *Jam Session* uses only the internal sounds of the MacIntosh. Other programs access drum machines and also control multi-track recordings.

The Atari *ST* has been called a color Mac, and it certainly compares favorably, with its 68000 microprocessor and reasonable price. A number of models are available, ranging from the *520* and *1040* (½ and 1 megabyte of RAM respectively), to the newer *Mega* series which features 2 and 4 megabytes of memory. In general, they all share common features, including the built-in MIDI-IN and -OUT ports. That made it a fast favorite of music makers looking for the power of a Mac without the high price tag. Such performers as

only 88 keys, so that would seem to be more than adequate, but since some of the more avant-garde music is written in micro-tonal tunings, where the pitches between a piano's tones are also used, there are those that would argue that 128 are not. But I digress, as 128 keys are more than enough for most purposes. The 2nd data byte specifies velocity—how hard the key was struck. Many (probably most) electronic-keyboard instruments still don't have velocity-sensitive keyboards, and while MIDI 1.0 states that the velocity should be \$20, the instruments will typically send the mid-range value of \$40. Both data bytes of the message always have to be sent.

The channel message NOTE OFF (status prefix \$8n) also consists of 2 bytes; the note number and "key-release velocity." But MIDI also allows a note be turned off with a NOTE ON message with velocity set to 0—and there's a very good reason to do it that way. The reason is called *running* status.

While all data bytes for a message must always be sent, the status byte doesn't have to be. In particular, if the new status byte is the same as the previous one, MIDI allows it be omitted. Thus, by turning notes off with NOTE ON V = 0 message, the status bytes need not be sent. If you play a triad on the keyboard, the messages don't have to be 18 bytes long (3 three-byte NOTE ON's and 3 three-byte NOTE OFF's), they can be only 13. As you can see, if all messages were on the same channel, the savings would quickly approach an equivalent 33% increase in bandwidth on a bus that (some would argue) is bandwidth-limited in the first place. (A "MIDI-clog," or too much information pushed through the pipe, may begin to show up as audible delays between when a note sounds and when it is supposed to play—a real enough problem in big systems, but there are ways around it).

Other channel messages provided for are:

- **POLYPHONIC KEY PRESSURE/AFTERTOUCH** (\$An + 2 data)—Refers to how hard the key is being pressed right now. Pressing harder on the key once it is depressed lets you do things like pitch bends, but very few keyboards are so equipped. The first data byte is the key affected, the second the amount of pressure.
- **CONTROL CHANGE** (\$Bn + 2 data)—Allows changes in a front-panel "knob" (they're often set digitally) to be passed to other instruments. The first data byte is the number of the control. The second data byte is control's new value, and that is where MIDI takes an interesting approach to being able to send either low-resolution (7-bit) or high-resolution (14-bit) control values.

Controls \$0–\$1F are reserved for low-resolution values and are the most-significant byte of the 14-bit value. Controls \$20–\$3F are reserved to represent the least-significant byte of a high-resolution value and do not necessarily have to be sent. The most interesting part of this is that it represents a glitch in MIDI—you can't change the most-significant and least-significant byte of a high-resolution control simultaneously, because they're in two different channel messages and neither one can "know" whether the other is coming or not. So what happens to the MSB when the LSB overflows from \$7F to \$0? The answer is that nothing happens to it until it's updated explicitly; and for a brief instant the whole 14-bit value is way out of whack.

Controls \$40–\$5F are set aside as banks of switches, \$60–\$79 are undefined and the last 6 "controls" (\$7A–\$7F) are set aside as *channel mode messages*. We'll look at those in detail in a moment.

- **PROGRAM CHANGE** (\$Cn + 1 data)—Allows instruction to an instrument to change voices, such as from strings to horns. The single data byte says what voice (program) to change to, and there may even one day be agreement among manufacturers on whether voice #1 is a piano or dogs barking.
- **CHANNEL PRESSURE** (\$Dn + 1 data)—This is similar to the polyphonic version, but rather than being handled on the basis of individual

Mick Fleetwood sponsor its use, and having all that memory and still something left in your wallet helps too. Atari has played well on this, and software and peripherals abound.

Hybrid Arts was one of the first software developers to give attention to MIDI; they started working with the Atari 8-bit machines quite a while back. Of course they're much more sophisticated now. They even have SMPTE hardware devices, which are special time-code systems that allow exact placement between music and video recording frames. Also, their edit track is one very powerful sequencer. It has graphic editing, tempo displays, and 60 tracks to play with. *Realtime* (Intelligent Music) lets you perform music and change it "on the fly." What else? How about 256 simultaneous tracks, effect multi tasking, and full GEM control?

Composer Laurie Spiegel's *Music Mouse* lets you create a concert visually as well as aurally. *Music Mouse* responds to mouse movements combined with keyboard controls to give a visual and aural performance. Features include user-selectable MIDI channels, dual tempo controls, even the inclusion of the octatonic mode used by Bartok and Stravinsky. Meanwhile, Sonus Corporation's *Superscore* beats out a powerful tune, with its long list of features including a 32-track sequencer, 32 polyphonic staves of scoring, even text and lyric placement on screen. Add to that icons and pictures that can be loaded and saved, chord symbols (including guitar frames), and the ability to mouse "edit" MIDI data.

IBM *PC*'s and compatible computers can definitely become capable MIDI controllers, although you must add an interface to get MIDI going. The advantage with an IBM is the wealth of programs being made. The Yamaha *C-1* is a music computer that is an IBM clone with built-in MIDI connections and SMPTE.

FIG. 7—THE DIGITAL HORN from Casio.

keys, it is a value of expression for all notes on a given channel. Since the key need not be specified, the single data byte is the pressure value.

- **PITCH WHEEL** ($En + 2 data)—A pitch wheel is to a synthesizer as a "whammy bar" is to a guitar. It's most often used to modulate pitch for expressive purposes. The first data byte is the least-significant byte of the value and the second is the most-significant byte. Since pitch wheels can ordinarily modulate up and down, the center position is defined in the specification as $2000, but the range of the control (how much a given change affects the sound) is left to the manufacturer. The MSB must = 0 definition of data bytes can really throw you off on two-byte values.

Channel mode message

The last six "controls" in the control-change group of channel-voice messages (which are all prefixed with the status $Bn) are set aside for specific functions. For example, "control" $7A can be used to separate a synthesizer's keyboard from its tone-generating section. Making the second data byte of the instruction $0 disconnects the keyboard, and $7F reconnects it.

Control $7B is supposed to turn off all notes being played in the channel specified. That is very handy with sequencers because a note that is turned on but never turned off (as when a sequencer is stopped) will never stop playing. Sadly, the specification is less than specific on that point and, as a result, many manufacturers don't implement the function. The second data byte of the message is always $0.

Control $7D turns on what is called *omni mode*, which effectively disables the channel numbers in the status byte. An instrument that is operating with omni mode on will respond to channel voice messages in all channels, but will respond to mode message in only its *basic channel*, which is defined by the manufacturer and, in some instruments, may be changed with a front-panel control. Similarly, Control $7C turns omni mode off, which means that only voice messages on the system's basic channel (either default or as set by some panel control) will be recognized. For both messages, the second data byte is $0.

Controls $7E and $7F select what are called *mono* and *poly* mode, respectively. They are mutually exclusive; turning one on turns the other off. When mono mode is selected in a MIDI receiving instrument, that instrument will respond to note-ons and offs like the original monotonic (one note at a time) synthesizers; that is, each new note will "replace" the one that was playing before. Poly mode allows many notes (all coming in on one voice channel) to be played at the same time. The second data byte of the mono-mode message tells the instrument to listen to a number of channels above the basic (default) channel, and $0 means to listen to all channels. The second data byte of the poly message is always $0.

The last 3 controls are so connected in their operation that the MIDI specification calls their various combinations by number. Mode 1 is the omni on/poly mode, often called simply "omni mode." Note messages received in any channel are played polyphonicly by the instrument. Mode 2 is the omni on/mono mode, simply called "mono mode." Notes received in any channel are played monophonicly. Mode 3 is the omni off/poly mode, known as the "poly mode." Notes received in the designated basic channel are played polyphonicly. Mode 4 is the omni off/mono mode. Because the number of channels listened to in mono mode can be changed on command, mode 4 allows modern "multi-timbral polyphonic" synthesizers (capable of playing many notes and the notes need not all be the instrument sound) to produce things like bass, lead, and harmony lines all at the same time.

Eventually you should be able to remember the mode numbers and what they mean. For now, just be aware that most instruments power up in mode 3, where they listen to only one channel and play the notes on that channel polyphonicly.

FIG. 6—THE CZ101 MIDI KEYBOARD from Casio is a great model for beginners.

Of course you can completely forget about the creative part of using MIDI, and just be entertained, in which case you might opt for the *Aldus* board. Basically a 32 preset-sound device, it attaches externally, and then outputs music from existing software packages, such as from the Sierra line of entertainment programs. Another option might be to go with the *Creative Music System*, an internal-board sound device that outputs in stereo, and does allow you to create music and special effects. The *Creative* board contains 32 preset sounds in 12 channels (voices), and will play in the background while you do other things. It has line-level and headphone outputs.

The Commodore *Amiga*, noted for its superlative graphics and great internal sound requires an add-on MIDI interface. The *Amiga* can perform more than one function concurrently so that you can run a music program while jumping back and forth to something else. Microillusion's *Music-X* makes quite an impression with its graphic orientation and patch-editor capabilities. Intelligent Music's *M* features a multitude of on-screen controls that will automate changes in MIDI velocities, and note densities and rhythms. You could enter just a few notes and let *M* vary them forever (although that's pushing pretty close to couch-potato MIDI creativity). *M* also supports internal sound using sampling as well. *MIDI Magic* (Brown-Wagh Publishing) has many of the mentioned features, plus it monitors free RAM, gives a choice in screen resolutions, and has a song-editor window for building, modifying, and playing songs. And, as in most cases, programs available for one computer leapfrog over to the *Amiga*.

There's no question that music is

System message

There are three kinds of system messages: *system common*, *system real-time*, and *system exclusive*. MIDI 1.0 treats system-real-time and system-common messages as separate things, but since real-time messages are also system common, we will lump them together.

MIDI has a clock—a variable-speed clock that is in essence a metronome. The clock runs at 24 ticks per quarter note of music (sometimes abbreviated as 24 ppq—pulses per quarter note). In MIDI, the clock is a special system real-time status byte ($F8). Every time an instrument which stores and reads back MIDI data (a sequencer) sees a timing-clock byte it advances in the musical score by 1/24th of a quarter note and sends out the data which it previously recorded as happening at that time. That's how individual sequencers and drum machines can stay in lock step during a song. Timing-clock status bytes have no data bytes to go along with them.

Besides keeping time, everything has to start at the same time. For that purpose, MIDI has a *start* status byte ($FA). A sequencer or drum machine which sees the byte "takes it from the top," and everything starts at the same time. If you want to stop in mid-song, there is the *stop* status ($FC). The *continue* byte ($FB) picks up from where you left off as soon as the next timing clock comes along. None of these status bytes have any data bytes associated with them, and they can be stuck anywhere in a MIDI message (even between data bytes) Also, they will not change the running status in effect at the time they are sent.

Much of today's real music is recorded a little piece at a time, and it is usually not economical (not to mention boring) to start from the beginning and play through the whole song just to add a short phrase at the end. That's why MIDI provides a way to directly address an arbitrary point in the song. This provision is called the *song position pointer* (status $F2) and, unlike most other system messages, it has two data bytes. It might seem reasonable to simply have the two bytes represent the number of timing clocks "into" the song you want to go. However, that doesn't allow for very long songs so, instead, the two bytes are the number of MIDI beats, where one MIDI beat is equal to six timing clocks. In other words, the two bytes tell you how many 1/16th notes you are into the song.

MIDI also makes provisions for messages of arbitrary length and content. The *system exclusive status* ($F0), or sys-ex, unlike any other, does not have a fixed number of data bytes that must be sent with it—any number of bytes can be sent. There are a lot of uses for sys-ex other than things overlooked in the specification. For instance sys-ex is frequently used to down-load and up-load voice information to disk drives and other mass-storage devices. It also finds a home doing the same kind of function with the data stored by a sequencer. Since sys-ex messages may be any length, there must be some way to indicate the end of a message, and the *end-of-exclusive* flag (status $F7) serves that function.

As you have likely realized already, sys-ex is somewhat manufacturer-specific; so one of the few restrictions is that the first bytes of a sys-ex message is the manufacturer's MIDI ID number, which is assigned by the *M*IDI *M*anufacturer's *A*ssociation (MMA). It's interesting to note that the original specification allowed for only a single-byte ID number but, as of this writing, manufacturers are assigned a three-byte ID. Manufacturers will also include a product ID number of their own so that their products know what to do with the data they receive. The MMA strongly encourages manufacturers to make the format of the sys-ex message that they use available in the public domain.

The MMA has the ongoing responsibility of extending and refining the MIDI specification. Recent work has resulted in standards defining how sys-ex can be used for transferring data between digital sound samplers (the sample dump standard, SMS)

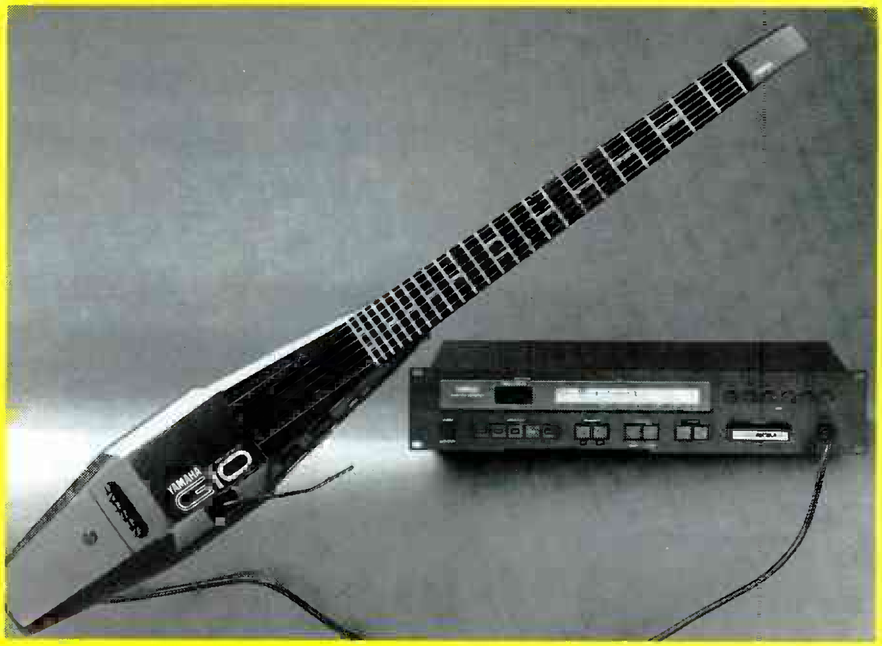


FIG. 9—YAMAHA'S G10 GUITAR features a string-sensitivity control.

and for storing musical sequences (standard MIDI files, SMF) as well as an adaptation of SMPTE time code (MIDI time code, MTC). The MMA is also currently involved in more rigorously defining how sys-ex is used in the more common situations, such as transferring data on digital sound samples. That will allow a sample taken on one instrument to be passed to a different instrument.

The only "gotcha" with sys-ex is that, since all of the bytes must be of the MIDI data persuasion, they can't have 1's in their MSB. If you're sending a sequence for storage, it will certainly include status bytes (the MSB of which = 1), there's an obvious problem. One solution is to send an extra byte for every seven bytes which contains the most-significant bits of the other bytes.

MIDI impact

One of the biggest areas of MIDI impact has to be writing and performing musical scores for films and videos. A composer used to hire musicians to play all instruments; the piano, drum, slide whistle, etc. And, since he couldn't tell what the score would sound like until it was rehearsed (not every composer is a Beethoven), the chances are that, after hearing what he'd written, it would have to go back to the drawing board for a revise. Then there would be take after take until the mood and timing of the piece matched the action on screen. Quite often, many well-paid musicians would be just sitting around in an expensive studio.

But now, the ability to synthesize realistic natural instrument sounds (Is it any wonder that the musicians' union tried to outlaw the first MOOG's?) and to exactly synchronize and coordinate everything has enabled many film scores to be done by one individual, who's surrounded by computers, synthesizers, and digital sound samplers, all MIDI'd together. The cost of film scores has gone way down, while the amount of money that the composer can put in his own pocket has gone up.

Are synthesizers and MIDI polluting music's genetic pool? Perhaps yes, but, then again, music has never been more accessible, as evidenced by the growth in home recording studios. In fact, equipment intended for semi-pro and home studios is the fastest growing segment of the music industry. One day a significant amount of music may be distributed as MIDI data rather than as the sounds themselves. There have been discussions between Warner New Media and the MMA about using the subcode space on compact Discs to hold MIDI data.

MIDI has already has found applications in stage-lighting and "dancing-fountain" control. And there could be "smart-house" applications in the future. **R-E**

becoming more electronic, and more computerized. But it still requires *your* creativity to become more than just a lot of data strung together. **R-E**

PRODUCT INFORMATION

Creative Music System (IBM):
Brown-Wagh Publishing
16795 Lark Avenue, #210
Los Gatos, California 95030
Digital Horn/MT-640:
Casio, Inc.
570 Mt. Pleasant Ave.
Dover, NJ 07801
Edit Track (Atari ST):
Hybrid Arts
11920 W.Olympic Blvd.
Los Angeles, California 90064
Erato Music Manuscriptor:
Erato Software Corporation
1107 East Second South
Salt Lake City, Utah 84102
G10 Guitar/WX7 Wind Instrument Controller:
Yamaha Corporation of America
P.O. Box 6600
Buena Park, CA
Jam Factory 1.32 (Mac):
Intelligent Music
116 North Lake Avenue
Albany, New York 12206
Jam Session (Mac):
Broderbund
17 Paul Drive
San Rafael, California 94903-2101
M
(ST/Amiga) Realtime (Atari ST):
Intelligent Music
116 North Lake Avenue
Albany, New York 12206
M1:
Korg USA
89 Frost Street
Westbury, New York 11590
Master Tracks Pro (Mac):
Passport Design
625 Miramontes St.
Half Moon Bay, CA 94019
MIDI Magic (Amiga):
Brown-Wagh Publishing
16795 Lark Avenue
#210 Los Gatos, California 95030
Music Mouse (ST/Amiga):
Aesthetic Engineering
175 Duane Street
New York, New York 10011
Music Studio (ST/Amiga):
Activision
PO Box 7286
Mountain View, California 94039
Music-X (Amiga):
Microillusions
17408 Chatsworth Street
Granada Hills, California 91344
Superscore (Atari ST):
Sonus Corporation
21430 Strathern Ste. H
Canoga Park, California 91304

Music-On-Hold Adapter

The Hi-Tech Music-on-Hold Adapter

STEVE SOKOLOWSKI

HAVE YOU EVER BEEN IN THE MIDDLE OF A phone conversation, and needed to either walk away for a couple of minutes or switch lines? The kids might be crying, the washing machine might need fabric softener; whatever. Here's an inexpensive "electronic hold button" controlled by a *Touch-Tone* phone, with provision for audio for the other party, using either a music-synthesizer IC module or a radio.

Unlike normal hold buttons, this one doesn't cut your phone handset off from the other party; you can still hear one another, and also the audio, if you use it. Rather, what it does is let you provide this audio to the other party, and then lets you hang up the handset without losing your party; you can also opt for silence. When you wish to resume normal conversation, pressing the pound (#) key shuts off the audio if used, and allows you to hang up and disconnect when finished. To understand how it works, you need to know how hold buttons and *Touch-Tone* phones work.

Placing a call on hold

The normal on-hook voltage of a phone line is about 50 volts, depending on particular central-office equipment. When you lift a phone's handset, 600 ohms is placed across the phone line, dropping the voltage to 5 volts. Figure 1 is a simplified representation of the hold adapter, showing hold-indicator LED1 in series with resistor R6 and relay RY1.

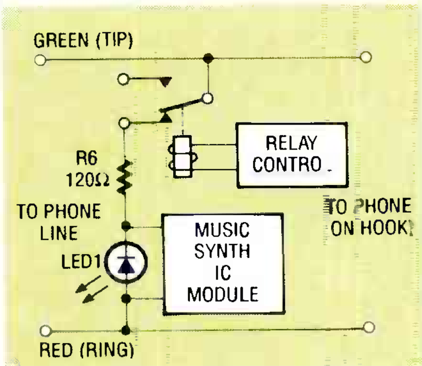


FIG. 1—BLOCK DIAGRAM OF THE Music-On-Hold Adapter. When RY1 closes, RY1's coil, R6, and LED1 in series are placed in parallel with a *Touch-Tone* across the red (Tip) and green (Ring) phone-line wires, allowing you to hang up without disconnecting your party.

The hold adapter prevents a disconnection when you hang up the handset, by placing R6 and LED1 across the phone line using RY1. The synthesizer provides music for the party on hold; it can be left out if desired.

Touch-Tone operation

Touch-Tone phones produce *D*ual *T*one *M*ulti *F*requency (DTMF) sig-

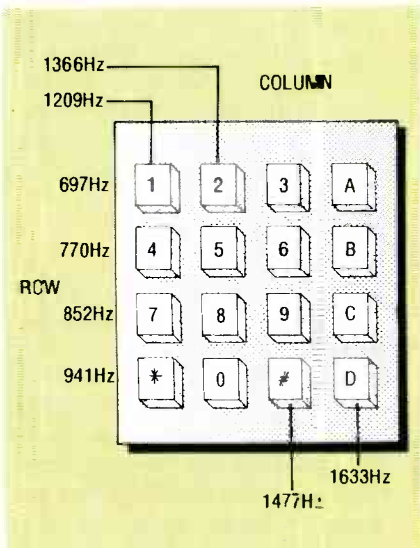


FIG. 2—*TOUCH-TONE* KEYPAD showing all 16 keys, including the normally absent operator keys (A–D). The DTMF output for a key is the sum of the row and column sinusoids, using the frequencies listed.

nals, using a 4×4 keypad that produces two-tone sinusoidal outputs. The frequencies are determined by the key row and column (see Fig. 2); The row frequencies are lower than those of the columns, and a *Touch-Tone* signal is the sum of both. Normal *Touch-Tone* pads have 12 keys, but Fig. 2 shows the operator console keys (A–D) in Column 4, which normally aren't used.

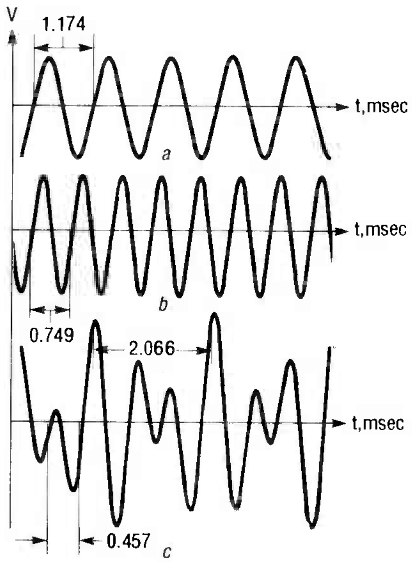


FIG. 3—*TOUCH-TONE* WAVEFORMS generating the signal for the (8) key, an 852-Hz Row-3 sinusoid in (*a*), and a 1336-Hz Column-2 sinusoid in (*b*). The waveform in (*c*) is the sum of both, the product of a 484-Hz tone and a 2188-Hz tone.

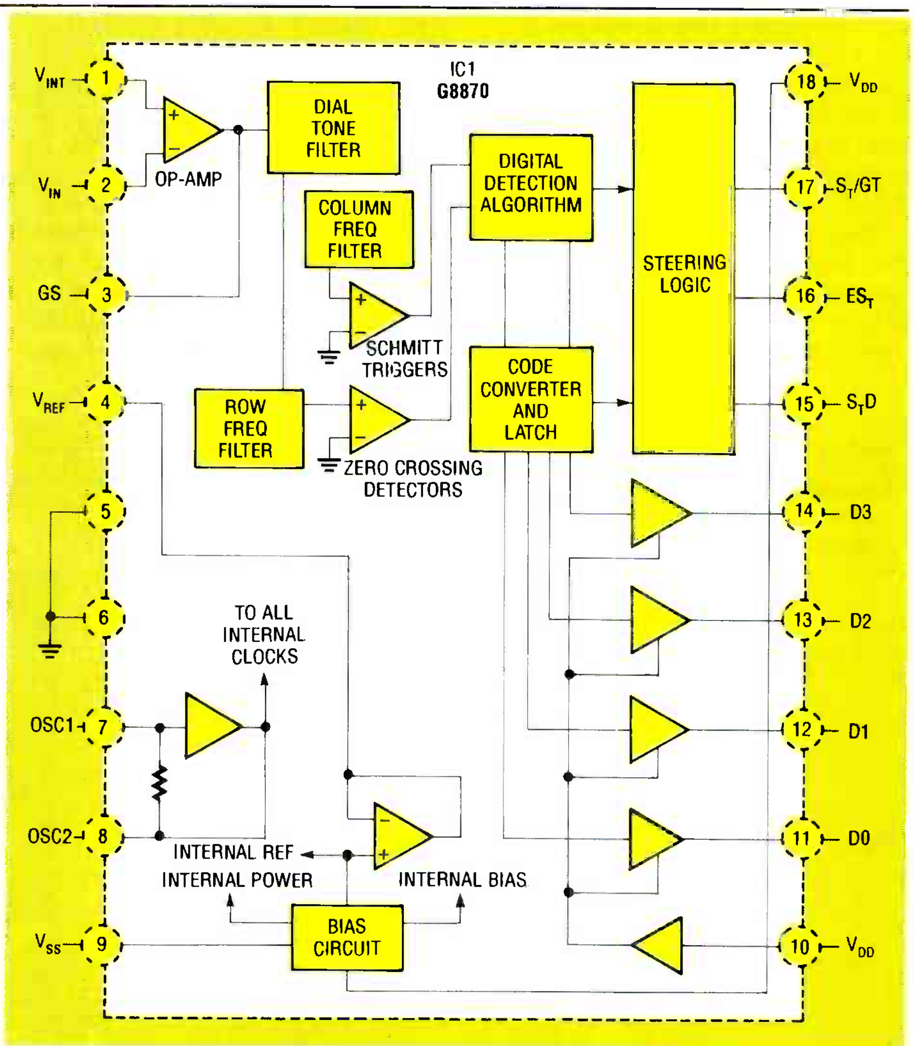


FIG. 5—BLOCK DIAGRAM OF THE G8870 *Touch-Tone* decoder IC.

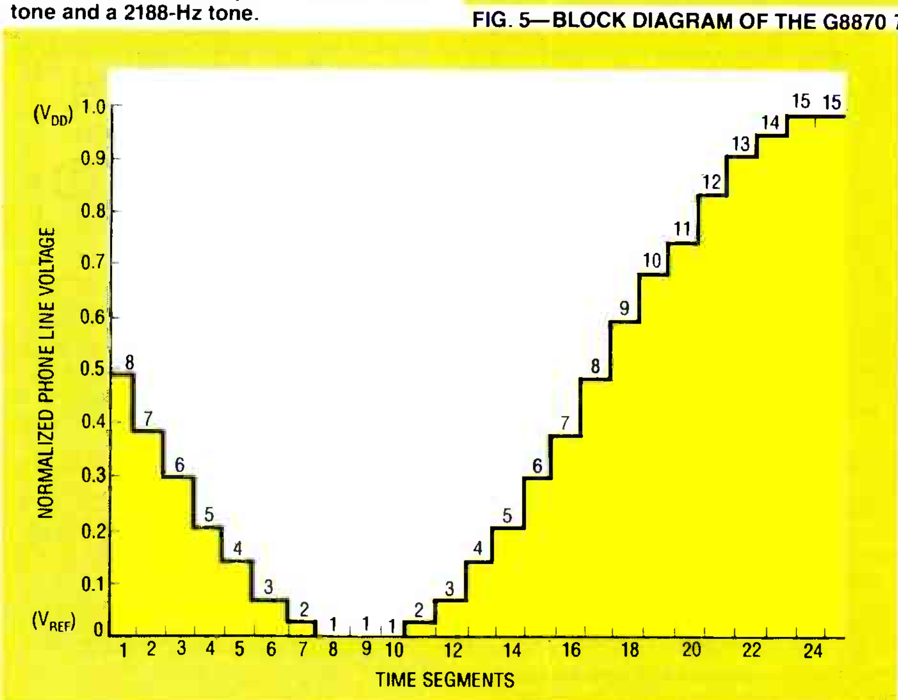


FIG. 4—STAIRCASE SINUSOID similar to those generated by a *Touch-Tone* keypad. This is merely a representative sample of what a DTMF signal looks like, and doesn't represent any one waveform; note the normalized scales on the axes.

The keys in Row-3 generate an 852-Hz tone as in Fig. 3-*a*, and the keys in Column-2 generate a 1336-Hz tone as in Fig. 3-*b*; pressing the (8) key adds the two. Adding two sinusoids is equivalent to multiplying two sinusoids whose frequencies are the sum and difference of the originals. Thus, the (8) key gives the modulated waveform in Fig. 3-*c*, the product of a 484-Hz tone and a 2188-Hz tone. Early *Touch-Tone* pads used inductors and capacitors; modern versions are crystal-controlled integrated circuits that create staircase sinusoids as in Fig. 4. The waveform that you see in Fig. 4 isn't an actual *Touch-Tone* signal; it's drawn only to show you what one would look like.

Circuit description

Figure 5 shows a block diagram of the California Micro Devices G8870 DTMF receiver (IC1), and Fig. 6

shows the hold adapter's schematic. The G8870 represents each tone pair as a 4-bit code, where the column of a key is the first two bits, and the row of a key is the second two bits; both pairs of bits range from 00–11. This 4-bit code is then decoded by a 4514 4-to-16 decoder (IC3) to give the digit dialed.

Pressing the (*) key on a *Touch-Tone* phone adds a 1209-Hz sinusoid (a Row-4 tone), and a 941-Hz sinusoid (a Column-1 tone), to give a binary code of 1100. Similarly, pressing the (#) key adds 941-Hz and 1477-Hz sinusoids, to give a binary code of 1110. Figure 6 shows a *Touch-Tone* signal entering IC1 through R1, R2, C1, and C2, appearing in the binary format described above on pins 11–14 (D0–D3) of IC1, and fed to pins 3, 2, 21, and 22 of IC3.

If a user presses a key on a *Touch-Tone* phone used to operate the hold adapter, pin 15 (STROBE S_TD) of IC1 goes high. That strobe oputput is inverted by NOR gate IC2-a, and is fed to pin 23 (INHIBIT) of IC3, enabling that device. If the *Touch-Tone* key pressed is either (*) or (#), then either pin 19 or pin 14 of IC3 goes high, since those are the pins corresponding to these keys. Pin 19 of IC3 goes to pin 12 of IC2-b, and pin 14 of IC3 goes to pin 5 of IC2-c. Note that IC2-b and IC2-c are used to create a NOR gate reset-set (RS) flip-flop, which then controls RY1.

Figure 7 shows the NOR gate RS flip-flop with its truth table, and the NOR gate terminals correspond to the pinouts on IC2. The flip-flop is sym-

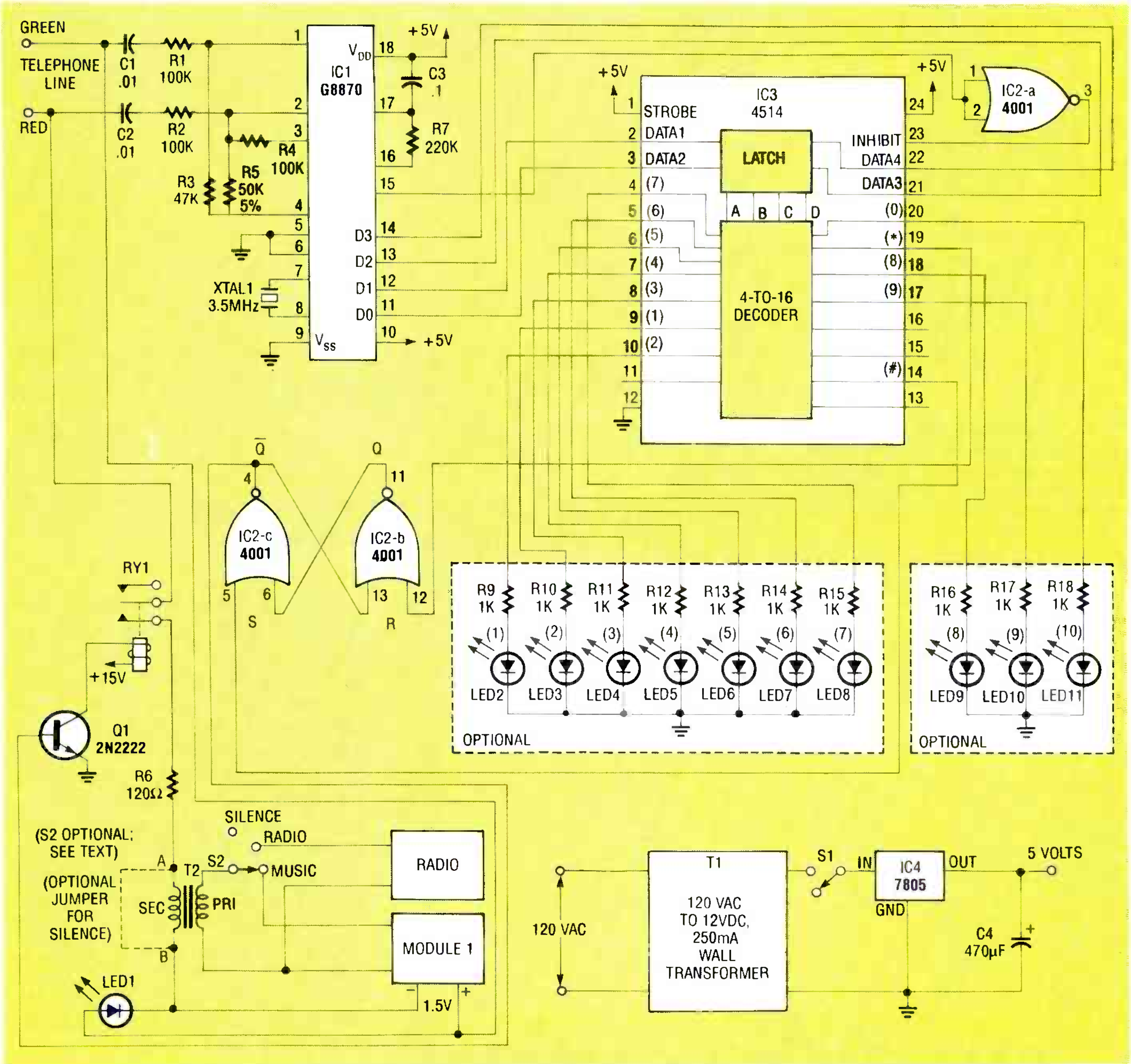
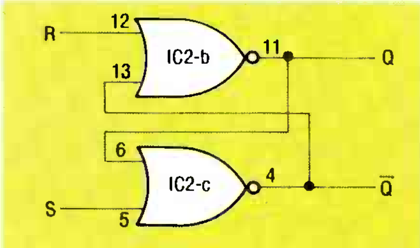


FIG. 6—SCHEMATIC OF THE HOLD ADAPTER; inverter IC2-a enables IC3, and the reset-set (RS) flip-flop using IC2-b and IC2-c controls the (*) and (#) outputs of IC3. Pressing (*) resets the flip-flop, closing RY1's contact and placing a parallel path (plus audio) across the phone line. Pressing (#) sets the flip-flop and opens RY1's contact, letting you end a call. Using S2 is optional.



R(n)	S(n)	Q(n)	$\overline{Q}$(n)
0	0	Q(n-1)	$\overline{Q}$(n-1)*
0	1	1	0
1	0	0	1
1	1	0	0

*NOTE: FLIP-FLOP REMAINS IN PREVIOUS STATE (UNCHANGED)

FIG. 7—A RESET-SET (RS) FLIP-FLOP with the NOR gate terminals corresponding to the IC2 pinouts. If both inputs are low, the new flip-flop state n is unchanged from n-1. If one input is high and the other low, the corresponding outputs are reversed. If both inputs is high, both outputs go low.

metric, so whether it's considered set or reset depends on the application. The R input is on the same side as the Q output, and the S input is on the same side as the $\overline{Q}$ output. If both inputs are low, the flip-flop stays in its previous state; that's the meaning of the subscripts n and n-1. If one input goes high and the other goes low, the corresponding outputs are reversed. If both inputs go high, then both outputs go low.

Since only one *Touch-Tone* key is interpreted at a time, there's no normal instance when both pin 19 and pin 14 of IC3 go high simultaneously; that only happens when IC3 is defective or there's a short. If neither the (*) key nor the (#) key have been pressed, then both pins stay low. Pressing the (*) key drives pin 12 of IC2-b high and pin 11 of IC2-c goes low. Similarly, pressing the (#) key drives pin 5 of IC2-b high and pin 4 of IC2-b goes low. Pin 4 of IC2-b, the $\overline{Q}$ output of the RS flip-flop, operates Q1 and RY1.

When pin 4 of IC2-b, goes high by pressing the (*) key, Q1 turns on and the contact of RY1 closes, preventing a disconnection when you hang up the handset. That's because phone-line current now flows through R6, the secondary of T2, and hold-indicator LED1, which is now lit. When pin 4 of IC2-b goes low by pressing the (#) key, Q1 turns off, current stops flowing through the coil of RY1 (opening its contact), and disconnecting the hold adapter. The hold adapter *doesn't* work as a standard hold button, because pressing the (*) key *doesn't* disengage your phone handset. It just lets you hang up or switch to another line without being discon-

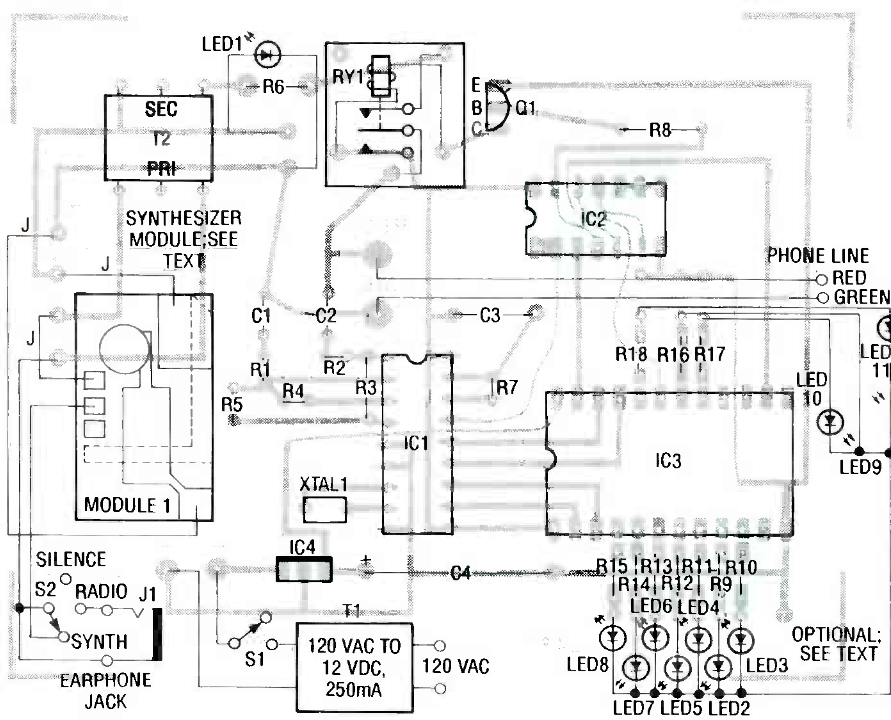


FIG. 8—PARTS-PLACEMENT DIAGRAM of the hold adapter; LED2–LED11 are *not* consecutively numbered. There are two jumper pairs for RY1, those for PC board power from the pads labeled "1.5 V," and those for the music, which go to the PC-board pads for the primary of T2. Using S2 is optional; the desired option can also be hard wired.

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise indicated.

R1, R2, R4—100,000 ohms
R3—47,000 ohms
R5—50,000 ohms
R6—120 ohms, 1 watt
R7—220,000 ohms
R8—1000 ohms
R9–R18—1000 ohms (optional; see text)

Capacitors

C1, C2—.01 µF disc
C3—0.1 µF disc
C4—470 µF, 16-volt axial tantalum electrolytic

Semiconductors

Q1—2N2222 transistor
IC1—California Micro Devices G8870 *Touch-Tone* Receiver
IC2—4001 quad NOR gate
IC3—4514 1-of-16 decoder (high output)
IC4—7805 5 volt DC regulator, TO-220 type
LED1–LED11—standard red LED's

Other components

S1—SPST 120-volt AC switch
S2—SP3T rotary or slide switch
T1—120-volt AC to 12-volt DC, 250mA, DC wall transformer
T2—audio transformer, 1000-ohm primary, 8-ohm secondary (Mouser Electronics, catalog number 42TM013)
RY1—6-volt SPST relay with 100-ohm coil
XTL1—3.58MHz crystal
MODULE1—music-synthesizer module (optional; see text)

Miscellaneous: suitable cabinet, 4-wire phone cord with open wires on one end, and either spade lugs, 4-prong, or RJ-11 modular male plug on the opposite end, dual RJ-11 socket to single RJ-11 plug T-adapter, female-to-female RJ-11 adapter (optional; see text), 11 LED bezels (if LED2–LED11 are used), solder, wire.

NOTE: A kit of parts is available from Del-Phone Industries, P.O. Box 5835, Spring Hill, Florida 34606. The kit includes the single-sided PC board ($7.50), G8870 *Touch-Tone* Receiver IC ($10.00), T-adapter ($2.20), 3.58MHz crystal ($1.75), and music-synthesizer module ($1.75); send $15.70 for all parts. Allow 3–4 weeks for delivery, and include $2.50 for shipping/handling. Florida residents include sales tax; Canadian residents send money order in US funds, with $3.25 shipping/handling. No personal checks, please.

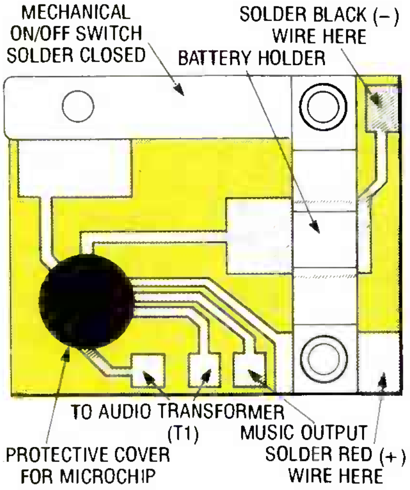


FIG. 9—PICTORIAL DIAGRAM OF THE music-synthesizer module. The negative terminal pad is to the right of the microchip; the metal band over it is the positive terminal. Solder the mechanical ON/OFF switch closed. The "1.5 V" PC board pads go to the module's battery pads, and the two PC-board pads below the "1.5 V" label go to the module's audio output pads. Attach the module using double-sided adhesive tape or foam, and disconnect any speaker.

nected, because a second current path is now across the phone line.

To include audio, the music-synthesizer module goes in parallel with LED1, and the audio is fed from the synthesizer to the primary of T2. The audio modulates the 5-volt phone-line voltage and is heard by *both* you *and* the party on hold. If you prefer either dialogue or some other music, you can replace the synthesizer with a radio that has an earphone jack.

To do that, plug an external earphone cord into the jack, and connect an earphone jack to the PC board holes for the synthesizer output, using S2 (an SP3T switch) as indicated in Fig. 6. For silence, jumper the secondary of T2; that can be done using either a jumper or S2, although the use of S2 is strictly optional. Just remember that pressing the (*) key lets you hang up without being disconnected, but *doesn't* disengage the handset. The hold adapter uses IC4, a 7805 5-volt DC regulator with C4 as filter, and 12-volt DC, 250-mA, wall transformer T1; S1 is used as the ON/OFF switch.

Construction

The hold adapter's PC board is shown in PC Service, and the Parts-Placement diagram is shown in Fig. 8. Use sockets for the IC's, transistor (if desired), and relay. Any suitable cabinet will do, and use a 1-amp, 120-volt AC to 12-volt DC wall transformer. Use screws and spacers or adhesive foam to attach the PC board to the cabinet. You can use any SP3T switch you want for S2, as long as it'll fit in the cabinet.

Music-synthesizer modules like the one in Fig. 9 play repeating 30-second tunes, and may have a 1.5-volt battery socket and speaker. The 1.5-volt battery will likely be present; the speaker may not be, depending on the model. Note the polarity of the battery (if present) before removing it. In Fig. 9, the metal band passing over the large pad to the right of the microchip is the positive battery terminal, and the large pad itself is the negative terminal; both are connected by foils to solder pads.

The mechanical ON/OFF switch depicted in Fig. 9 is a metal flap, riveted on the right end, and with the left end resting against the module board by spring tension. Connect the pads on the PC board labeled "1.5 V" to the synthesizer's battery terminals, break the speaker wires or foils (if the speaker is present), and solder any ON/OFF switch closed. Attach the synthesizer to the PC board using double-sided tape or adhesive foam.

The two PC-board pads underneath the "1.5 V" label connect the audio to the primary of T2. The secondary of T2 goes in series with R6 and LED1, adding audio to the 5-volt DC off-hook voltage. For silence, jumper the

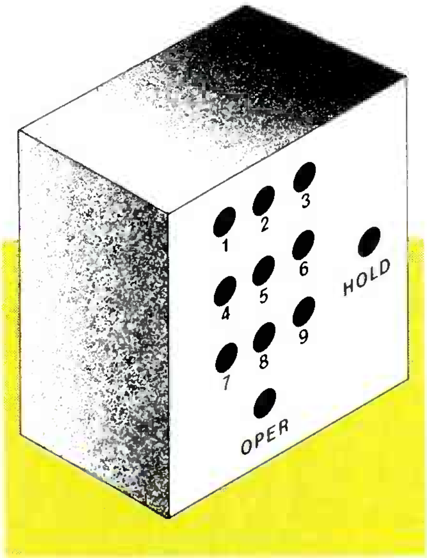


FIG. 10—SUGGESTED FRONT PANEL of the hold adapter, using hold indicator, and decoded *Touch-Tone* LED's, to show the number being dialed. You'll also need to drill holes for S1 and S2.

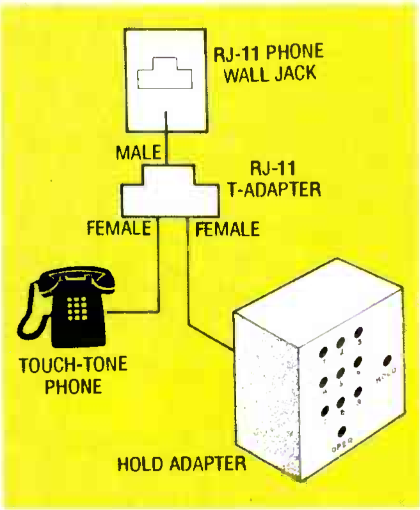


FIG. 11—HOOKUP ARRANGEMENT of the hold adapter. Both the hold adapter and *Touch-Tone* phone plug into an RJ-11 T-adapter, which is plugged into an RJ-11 wall socket. If you use 4-prong plugs and sockets, get an adapter. If your phone wires run out of walls and terminate in RJ-11 plugs, use a female-to-female RJ-11 adapter.

secondary of T2. To display all 10 decoded *Touch-Tone* keys, install R9–R18 and LED2–LED11 (with bezels) as in Fig. 6, the former mounted on the PC board, the latter mounted on the front panel of a cabinet like that in Fig. 10.

Installation and test

Connect the red and green wires of a standard phone cord to their PC-board locations; the yellow and black wires aren't used. The other end plugs into a T-adapter as shown in Fig. 11, with two RJ-11 female telephone sockets feeding into one RJ-11 male telephone plug. Plug the hold adapter and the *Touch-Tone* phone into the T-adapter, and plug the T-adapter into the telephone jack.

To test the hold adapter, dial a friend; if R9–R18 and LED2–LED11 were used, the LED corresponding to the *Touch-Tone* key pressed should light. To place a call on hold, press the (*) key; RY1 will close, connecting R6 and LED1, audio should now be heard by you in the handset if the synthesizer or a radio is present, and you can now hang up the handset. Pressing the (#) key disengages the hold adapter, opening RY1's contact, disconnecting R6 and LED1, and stopping the audio. Since the current path has now been removed, hanging up the telephone will disconnect your party, unless you first press the (*) key again. **R-E**

SOLAR POWER SUPPLY

Here's a solar power supply that can be used even at night!

DAN BECKER

SOLAR ENERGY IS ONE OF THE MOST ENvironmentally safe energy sources. Although solar power isn't going to compete with fossil fuel or nuclear power plants in the near future, researchers are striving to give solar energy a competitive edge. For example, scientists at Sandia National Laboratories, New Mexico, have developed a new photovoltaic solar cell that uses one gallium-arsenide and one silicon crystalline photovoltaic solar cell sandwiched together. The new device achieves a solar-to-electric conversion efficiency of 31%, and has the potential of reaching 40%. However, for the present, solar-to-electric conversion for the electronics hobbyist remains limited to low-power applications.

To bridge the gap between high-cost solar-cell projects and low-budget home or school versions, this article describes what we call a "solar-cell booster." That device can recharge a single Ni-Cd cell using solar power, and can also boost the Ni-Cd's output voltage enough so that you can power 5- or 9-volt devices from it, day or night.

Solar power supply

Figure 1 is a block diagram showing the major parts of the solar/Ni-Cd power supply. Four solar cells, each rated at 0.49-volts at 1.9 amperes in bright sunlight, charge a single 1.25-volt, 1.1 Ah Ni-Cd battery. By connecting the solar cells in series, the output voltages add up to 1.96 volts, but the output current of all four cells remains equal to that of one cell. In bright sunlight, the arrangement can recharge a 1.1 Ah Ni-Cd battery in four to five hours. The Ni-Cd's charging current averages about 330 mA, so you'll need a solar-cell array with at least that capability.

The oscillator/driver section chops the Ni-Cd's DC output into a high-current 16-kHz square wave. The square wave is fed to a step-up transformer in the Ni-Cd converter section. The stepped-up output voltage from the transformer's secondary is then rectified and fed to the voltage-regulator section. Let's talk about the individual sections in more detail.

Oscillator/driver

A schematic diagram of the oscillator/driver circuit is shown in Fig. 2. With S1 in the "off" position, and the solar-cell array exposed to sunlight, a charging current flows into D2 through J1, and into the Ni-Cd battery—J1 is either a wire jumper or a current-limiting resistor. A wire jumper (zero ohms) is used in the prototype, as the maximum current supplied by the solar array does not exceed the Ni-Cd's safe charging current. However, depending on the battery you use, you may need a current-limiting resistor instead. Diode D2 prevents the Ni-Cd from discharging through the solar array during periods of darkness (when the array's voltage is less than the Ni-Cd's). That takes care of charging the battery.

By momentarily pressing S2, C1 is connected across the Ni-Cd's termi-

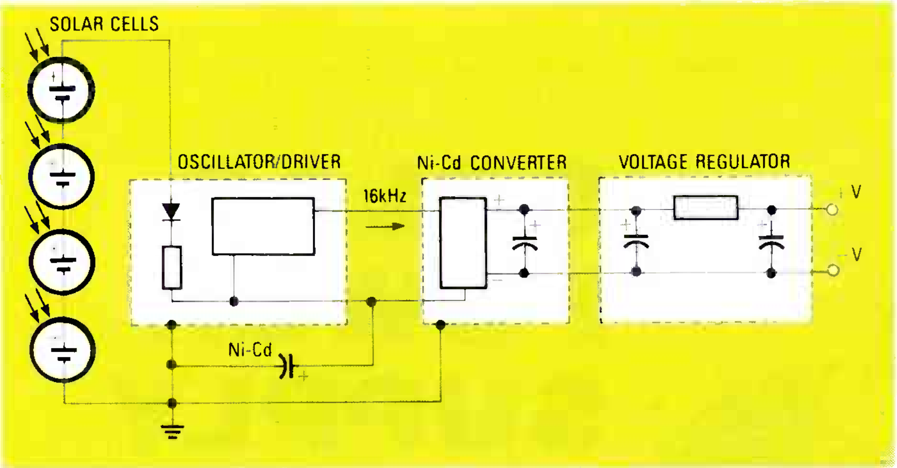


FIG. 1—THIS BLOCK DIAGRAM shows the major parts of the solar/Ni-Cd power supply. Four solar cells, each rated at 0.49-volts at 1.9 amperes in bright sunlight, charge a single 1.25-volt, 1.1-Ah nickel-cadmium battery.

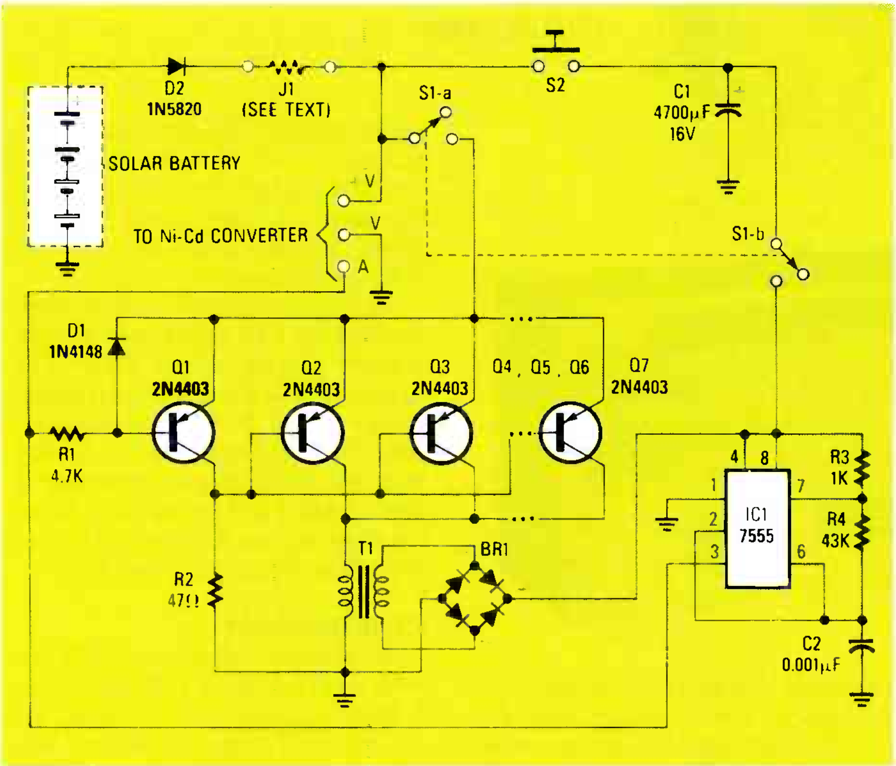


FIG. 2—SCHEMATIC DIAGRAM OF THE OSCILLATOR/DRIVER circuit. With S1 in the "off" position, and the solar-cell array exposed to sunlight, a charging current flows into D2 through J1, and into the Ni-Cd battery.

nals and is charged to the Ni-Cd's no-load terminal voltage of approximately 1.3 volts—the remainder of the circuit is inoperative. However, when S1 is placed in the "on" position, the emitters of transistors Q1–Q7 are connected to the Ni-Cd battery (a high), and C1 is connected to IC1, a CMOS 7555 timer. C1 holds enough charge to power IC1 for a few seconds. Components R3, R4, C2, and IC1 generate a 16-kHz square-wave, which is output at pin 3 of IC1. When that output is low, Q1 is turned on, forcing the bases of Q2–Q7 high; that turns Q2–Q7 off. When pin 3 of IC1 is high, Q1 is off, allowing the bases of Q2–Q7 to be at ground (low) through R2; that turns Q2–Q7 on. Diode D1 prevents Q1's emitter-base voltage from exceeding its breakdown value of 5 volts.

Because the circuit must operate from the low 1.2 volts supplied by the single Ni-Cd cell, six 2N4403 transistors (Q2–Q7) are connected in parallel; that minimizes the total on-state resistance, thereby maximizing the total current. Transistors Q2–Q7 switch on and off at 16 kHz, driving the primary winding of step-up transformer T1. The secondary winding drives bridge-rectifier BR1. While filtering the ripple voltage from BR1, C1 gradually reaches a terminal voltage of 10 to 16 volts. With that voltage supplied to IC1, the amplitude of the square-wave output at pin 3 reaches 10 to 16 volts. That square wave then feeds the Ni-Cd converter circuit from terminal A.

Ni-Cd converter

The schematic of the Ni-Cd converter is shown in Fig. 3. The 16-kHz square wave from the oscillator/driver

Ni-Cd MAINTENANCE TIPS

- A Ni-Cd's capacity is given in ampere-hours (Ah). For a 1.1 Ah battery, a 3.3-hour quick-charging rate is equal to 1.1 ampere-hours divided by 3.3 hours; that equals a recommended quick-charging current of 0.330 amperes, or 330 mA.
- Ni-Cd's require constant-current charging (as opposed to constant-voltage charging). A charging current less than a 30-hour rate will not give the cell a full-capacity charge.
- Once fully charged, a Ni-Cd battery can be trickle-charged at a 30- to 50-hour charging rate to maintain a full charge.
- Ni-Cd's can be fast-charged at a 3.3- to 10-hour rate.
- They can be slow-charged at a 10- to 30-hour rate.
- A Ni-Cd will self-discharge at a rate of 2% per day at 68 degrees Fahrenheit (20 degrees Celsius).
- Temperature limits:
  Storage... −40 to +122°F (−40 to +50°C)
  Discharge... −4 to +122°F (−20 to +50°C)
  Charge... +32 to +122°F (0 to +50°C)
- A Ni-Cd's terminal voltage should not exceed 1.5 volts during charging.
- Adhere to a battery's charging-time-versus-current schedule. Do not overcharge a Ni-Cd for long periods of time.
- Immediately after charging, a fully charged Ni-Cd has a terminal voltage of about 1.4-volts.
- Completely discharge a Ni-Cd before recharging it. That will prevent a premature reduction in cell capacity—that is known as "memory."
- Do not leave a load connected to a discharged Ni-Cd.

drives the gate of MOSFET Q8. R5 prevents static charges from accumulating on Q8's gate by shorting them to ground. Switching on and off at 16 kHz, Q8 allows the Ni-Cd battery, B1, to drive high-amplitude current pulses through the primary winding of T2. The secondary of T2 feeds the Ni-Cd's stepped-up voltage to bridge-rectifier BR2, whose DC output is filtered by C3. Under no-load conditions, C3 charges to approximately 17 volts. After connecting a resistive load to the output, the Ni-Cd converter can provide unregulated voltages from about 3 to 15 volts, depending on the resistance of the load. The maximum load current is approximately 150 mA, when the output is about 6 volts.

The voltage regulator

The schematic of the voltage regulator is shown in Fig. 4. Capacitor C4 provides additional filtering of the DC voltage from the Ni-Cd converter. C5 filters the regulator's output: the output can be either 5 or 9 volts depending on whether you use a 7805 or a 7809 for IC2. Using the 9-volt regulator, the circuit can supply a maximum of 100 mA, and can power a 50-mA load for about one hour.

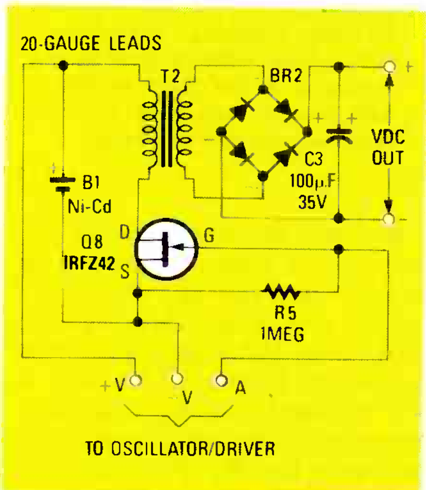


FIG. 3—SCHEMATIC DIAGRAM of the Ni-Cd converter. 16-kHz square wave from oscillator/driver drives MOSFET Q8.

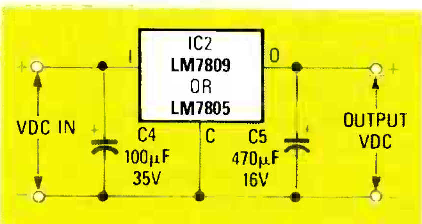


FIG. 4—SCHEMATIC of the voltage regulator. C4 filters the DC voltage from the Ni-Cd converter.

PARTS LIST—OSCILLATOR/DRIVER

All resistors ¼-watt 5%
R1—10,000 ohms
R2—47 ohms
R3—1000 ohms
R4—43,000 ohms
Capacitors
C1—4700 µF, 16 volts, electrolytic
C2—0.001 µF, metallized film
Semiconductors
IC1—7555, CMOS timer IC
D1—1N4148 switching diode
D2—1N5820 Schottky diode
Q1, Q2–Q7—2N4403 PNP transistor
BR1—DB104 bridge rectifier
Other components
T1—step-up transformer, TS408-10-160 (see text)
S1—DPST toggle switch, 6- to 10-amp contacts.
J1—0-ohm jumper or current-limiting resistor (see text)
Miscellaneous: PC board (TS8.2), 8-pin dip socket, project case, 4 binding posts, solar-cell array.

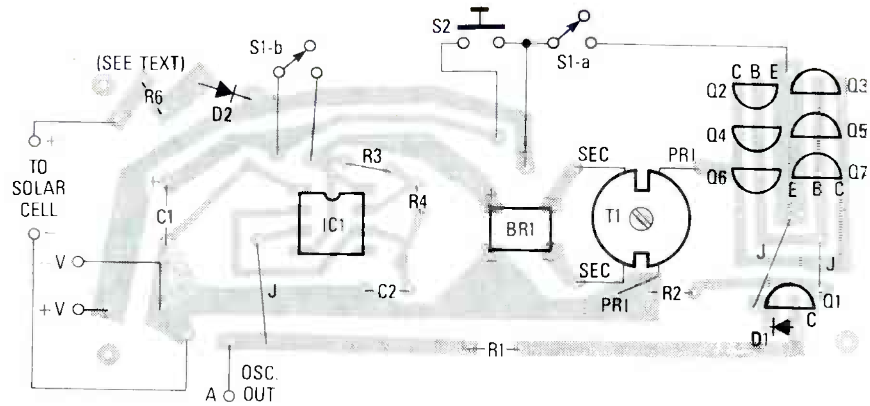


FIG. 5—PARTS PLACEMENT for the oscillator/driver. The six transistors (Q2–Q7) all work together as one low-resistance transistor.

Construction

Any solar array capable of charging a single Ni-Cd cell can be used. A minimum of four 0.49-volt, 1.9-ampere, or six 0.45-volt, 400-mA cells are required. Because there are a wide variety of solar cells and panels available, further details about constructing a solar array are not given here.

Each of the three circuits that make up the solar-cell booster (the oscillator/driver, the Ni-Cd converter, and the voltage regulator) is assembled on its own PC board. Templates for the boards are provided in PC Service. Alternatively, etched and drilled boards can be purchased from the source given in the Parts List. Be sure to select an enclosure that is large enough to house the three PC boards and a Ni-Cd battery. If you use an aluminum enclosure, you can fasten the metal tabs of MOSFET Q8 and voltage-regulator IC2 to the enclosure. Otherwise, a separate heat sink is recommended for those two components. Using the PC boards as templates, mark and drill mounting holes for each board. In addition, mark and drill six holes in the enclosure's lid to mount S1, S2, and four binding posts; two binding posts for the DC output, and two are for the leads from the solar-cell array.

Because MOS devices are used in the circuit, we suggest that you wear a grounding strap and use a grounded soldering iron when assembling the boards. Refer to Figs. 5–7 for parts placement. Observe the polarity of diodes, electrolytic capacitors, and the orientation of IC's, transistors and transformer windings. Leave about ⅛-inch of bare wire on each of the leads

PARTS LIST—Ni-Cd CONVERTER

Resistors
R5—one megohm, ¼-watt
Capacitors
C3—100 µF, 35-volts, electrolytic
Semiconductors
Q8—IRFZ42, N-channel power MOSFET transistor
BR2—DB104, bridge rectifier
Other components
T2—step-up transformer, TS811-5-75 (see text)
B1—Ni-Cd cell, rapid charge, size C or D
Miscellaneous: PC board (TS9.2), Ni-Cd battery

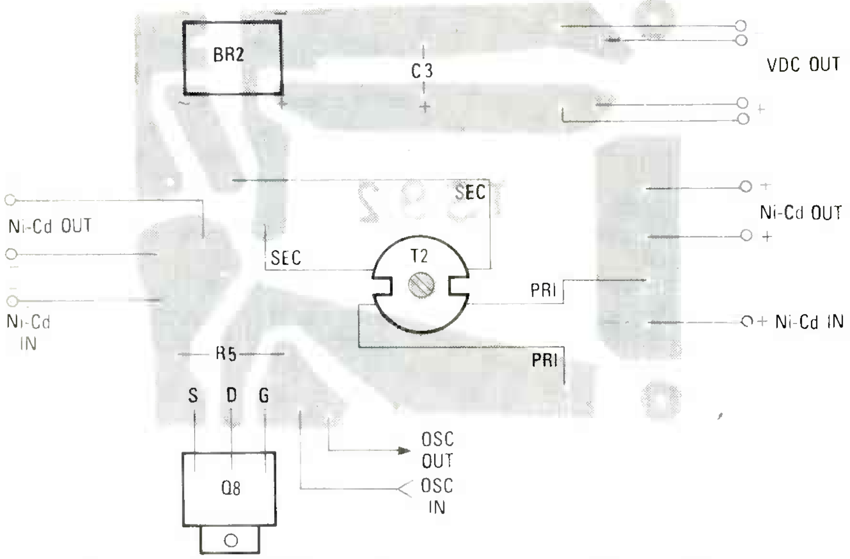


FIG. 6—THE Ni-Cd CONVERTER Parts-Placement diagram. Q8's metal tab should be heat sinked by mounting it to the metal project case.

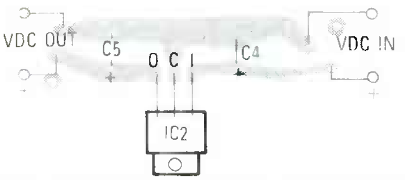


FIG. 7—THE VOLTAGE-REGULATOR circuit only contains three parts, and it is assembled on a small PC board.

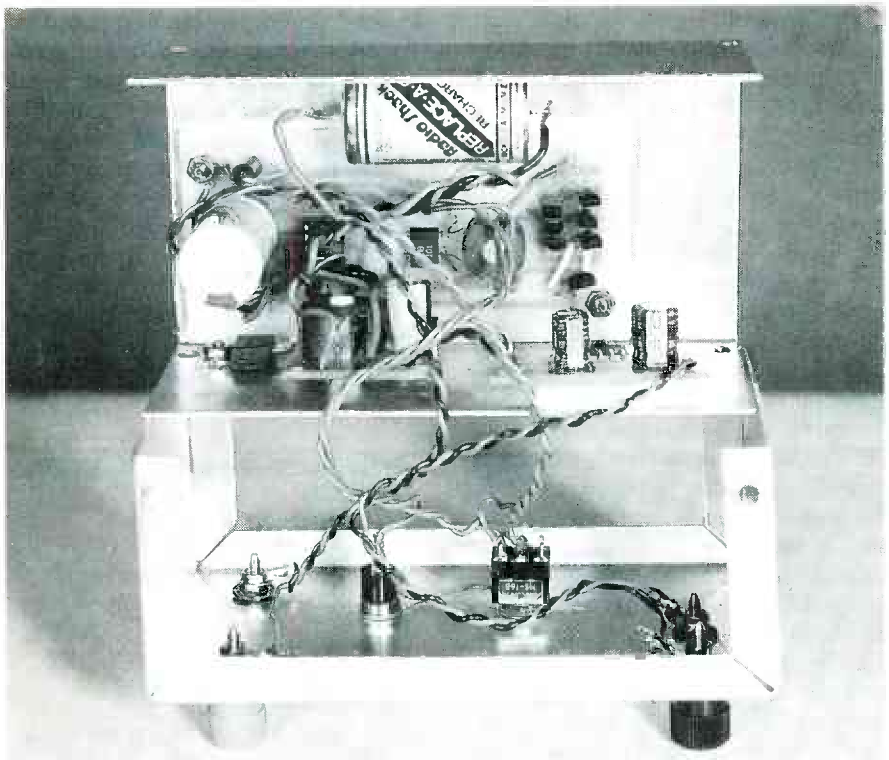


FIG. 8—HERE ARE THE COMPLETED PC boards after they are mounted inside the case. Notice how Q8 and IC2 are mounted to the project case.

feeding the regulator circuit to allow connection of voltmeter probes.

As for transformers T1 and T2, they are available preassembled from the Sources Box, or they can be made by hand. T1 is 10 turns of #34 magnet wire for the primary, 160 turns of #34 magnet wire for the secondary, both wound on a 14×8 linear ferrite pot core (Fair-rite #5677140821). T2 is 5 turns of #28 magnet wire for the primary, 75 turns of #30 magnet wire for the secondary, both wound on an 18×11 linear ferrite pot core (Fair-rite #5677181121).

PARTS LIST—VOLTAGE REGULATOR

Capacitors

C4—100 µF, 35 volts, radial electrolytic

C5—470 µF, 16 volts, radial electrolytic

Semiconductors

IC2—LM7809, 1-amp voltage regulator

Miscellaneous: PC board (TS10.1)

Note: The following items are available from Time Space Scientific, 101 Highland Dr., Chapel Hill, NC 27514: Step-up transformer (T1) TS408-10-160; $8.95. Step-up transformer (T2) TS811-5-75; $9.95. Oscillator/driver PC board (TS8.2); $9.95. Ni-Cd converter PC board (TS9.2); $4.95. Voltage-regulator PC board (TS10.1); $2.95.

The following kits include all semiconductors, resistors, and capacitors, but none of the parts listed as miscellaneous items: Oscillator/driver kit (SCB-8.2); $19.95. Ni-Cd converter kit (SCB-9.2) $16.95. Voltage-regulator kit (9-volt) (SCB-10.1); $5.95.

Add $4.50 for shipping and handling (one-time charge covers all items ordered). For technical information write to Time Space Scientific at the above address, and please include a self-addressed stamped envelope.

Both step-up transformers are pot-core devices. Each one has a nylon screw passing through the center, holding two ferrite shells together. The primary and secondary turns are wound onto a nylon bobbin held inside the shells. Mount each transformer by first removing the nylon nut and washer from the bottom of the pot core. Do not remove the screw or separate the ferrite shells. Pass the bottom end of the screw through the mounting hole in the PC board and then re-install the washer and nut, sandwiching the pot core and the PC board together. The two enameled wires that come out of the top-half of the pot core are the primary winding. And, as you might have guessed, the two enameled wires that come out of the bottom-half of the pot core are the secondary winding.

Use short lengths of 20-gauge

hookup wire to connect the Ni-Cd battery to the Ni-Cd converter and to connect the converter to the oscillator/driver. If you use a plastic battery holder, do not use the supplied leads if they are too thin; they will drop too much voltage when passing the peak current required by the converter. All other leads can be 22- or 24-gauge wire, provided that they are only a few inches long. Otherwise, heavier wire is recommended. Apply a layer of solder onto the traces of the PC board that feed the step-up transformers and driver transistors. Also, it is recommended that S1 have contacts rated between 6 and 10 amps. Figure 8 shows the completed PC boards after they are mounted inside the case.

Operation

Attach a voltmeter between ground and pin 8 of IC1 on the oscillator/driver circuit. With a fully charged Ni-Cd battery, press S2 for about two seconds. That allows C1 to charge to the Ni-Cd's no-load terminal voltage (about 1.3 volts). Next, place S1 in the "on" position. Then press S2 for about one second. The voltmeter should indicate an increasing voltage. After a few seconds the voltmeter should read from 12 to 16 volts. The circuit will not "start" if the initial voltage across C1 is less than 1.3-volts (a freshly charged Ni-Cd). After the initial operation of the circuit, use only S1 to turn the solar-cell booster on and off. As long as C1 maintains a charge of about 3 to 15 volts, the circuit readily starts without pressing S2; C1 can usually hold a charge for a couple of days. Next, turn on the unit and measure the input voltage to the regulator. Without a load on the regulator's output, the voltage should be about 17 volts.

The solar-cell booster is easy to assemble and inexpensive, and many of the non-critical parts can be substituted with parts from your junkbox. You'll be able to use the device to power all kinds of devices using the sun's energy, day or night, indoors or out.

If you're feeling inventive, you can incorporate the *idea* behind the solar-cell booster into a larger, more powerful device. Using a large solar panel, and perhaps one or more car batteries, you might be able to solar power just about anything! But you must design the circuit. R-E

BUILD THIS

LIGHT BEAM COMMUNICATOR

It's time to get out your tools and assemble our light-beam communicator.

ROGER SONNTAG

LAST MONTH WE DISCUSSED HOW TO build the transmitter and receiver PC boards for the *Light Beam Communicator* (LBC), and gave you the necessary list of parts. We assume that, by now, you have completed assembling the two boards, and that you have checked and double checked your work. Before we get into the mechanical construction details, there are a couple of quick tests to verify that the boards operate.

The transmitter, as you may recall, consists of a high-intensity LED whose light output is modulated by an audio signal. Connect a microphone to the jack on the transmitter, and turn the transmitter on. Turn up the gain control, and speak into or tap the microphone. You should be able to see the light flicker somewhat. An even better test is to connect an oscilloscope across the LED, and observe the signal there. It should "follow" your voice as you speak into the microphone. If you're not getting a signal at the LED, start at the input to the first op-amp (IC1-a from Fig. 3 in the July issue), and trace until you can find where you lose the signal.

The receiver can be quickly tested by connecting a pair of headphones to the output jack, and powering up the circuit. If you hear some hissing, the circuit is probably functioning correctly. Reduce the receiver gain and position the two completed boards about a foot or so apart, so that the light from the transmitter's LED strikes the receiver's photodiode. You should be able to transmit an audio signal to the receiver. Without the [illegible], the quality will [illegible], but it will serve to verify that the system is operating.

Assembly

Let's start our mechanical assembly with the transmitter, as shown in Fig. 1. Take the completed PC board (1) and install the [illegible] threaded inserts (2). [illegible] done by first [illegible] of an insert through each of the two holes on the edge of the PC board. (The narrow end should now be protruding on the solder side of the board.) By resting the wide end of the insert on a *solid* surface, the narrow end is spread apart by giving it a whack with a tapered punch. Otherwise, you can use some *Krazy Glue* or RTV silicone to secure them to the board.

Next, take two [illegible]-inch long screws (3), insert them in the proper holes, and secure them with a nut (4). Then place the battery holder (5) over the ends of those screws as shown in Fig. 1, and secure the battery holder with two [illegible]-inch long threaded spacers (6). (The battery is held down by tightening those spacers with the battery in place. Just be sure that the battery has some [illegible] tape or other insulating material on the side to be [illegible] against the PC board. That will prevent any of the component [illegible] from being short circuited.)

The [illegible] to prepare is the [illegible] end piece [illegible]. The end piece is held in place by three long [illegible] screws (8). First make sure that the heads of the [illegible] screws are on the side of the end piece that has two countersunk holes, and be sure to use the washers (9) where needed. (The countersunk holes are for the two screws that hold the entire assembly in the cardboard tube, but we'll worry about that later.) Place another washer (10) over each screw so that the end piece has a washer on both sides of each mounting screw. Now screw a [illegible]-inch long threaded spacer (11) onto each mounting screw and tighten to the point of [illegible]—the screws should be able to rotate without wobbling. Put a nut (12) over each screw and tighten each one against the threaded spacers to permanently set the screw's tightness.

The potentiometer (13)—the one that should be wired to the PC board—has a shaft with a nut (14) on it. First remove the nut, then you must break

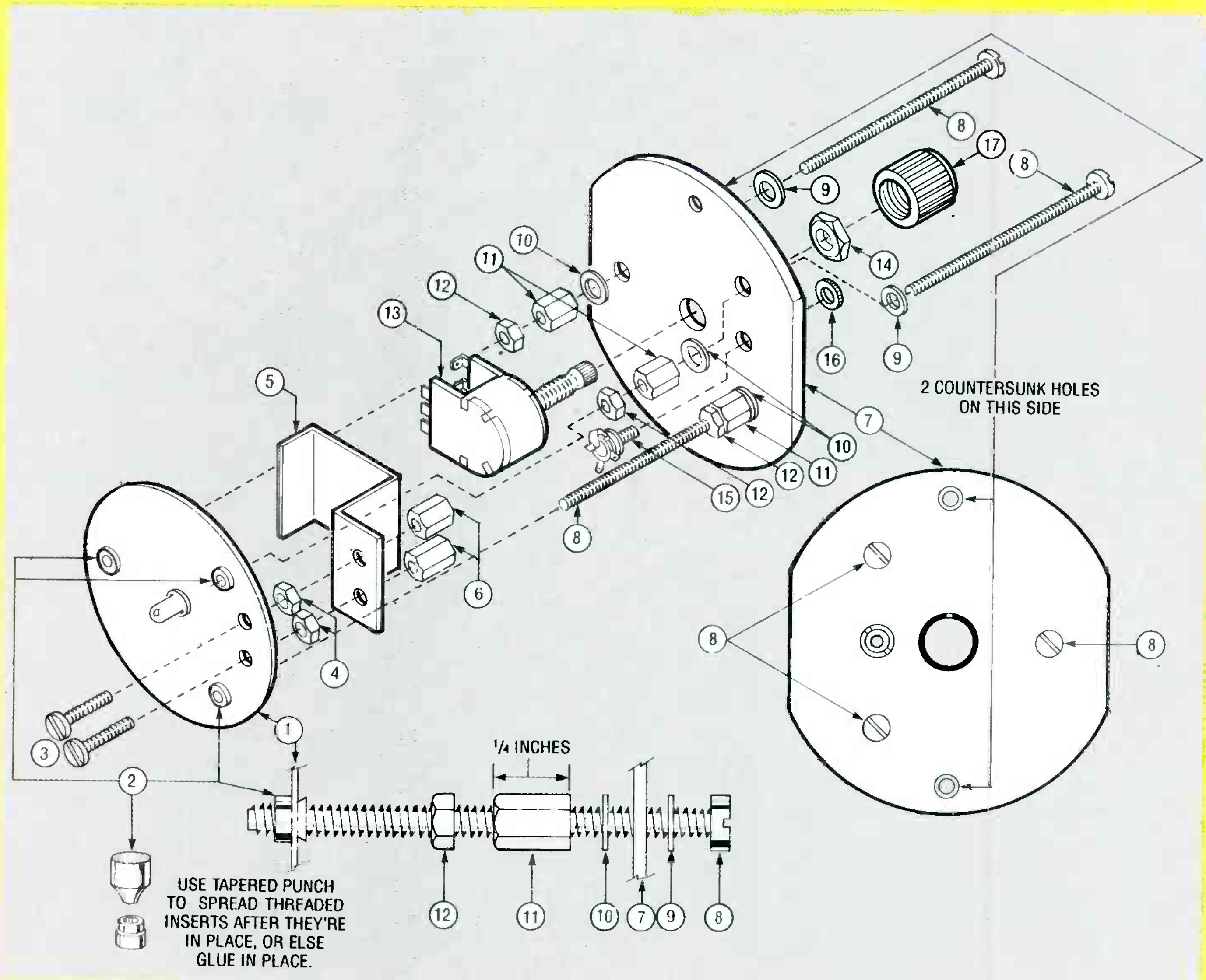


FIG. 1—THE TRANSMITTER is assembled as shown. Look over the assembly instructions carefully before starting the project.

off the potentiometer's anti-rotation tab, or else it won't properly connect to the plastic end piece. Put the shaft through the center hole in the end piece, and then replace the nut. Install the microphone jack (15—it, too, should be wired to the PC board) in the proper hole in the end piece (7), and secure it with its screw-on collar (16) in the same manner as you secured the potentiometer shaft. For now, line up the three adjusting screws with the three PC-board inserts (2), and screw each one in a few turns, just to hold the assembly together. Also push on the potentiometer knob (17). Place the transmitter assembly aside for now, as we get started on the receiver.

PARTS LIST FOR THE TRANSMITTER (FIG. 1)

Part #	Quantity	Description
1	1	PC BOARD
2	3	THREADED INSERTS
3	2	SCREWS, 4/40 × 3/8"
4	2	NUTS, 4/40
5	1	BATTERY HOLDER
6	2	THREADED SPACER, 4/40 × 1/4"
7	1	PLASTIC END PIECE
8	3	SCREWS, 6/32 × 2 1/8"
9, 10	6	WASHERS, 6/32
11	3	THREADED SPACER, 6/32 × 1/4"
12	3	NUT, 6/32
13, 14	1, 1	POTENTIOMETER & MOUNTING NUT
15, 16	1, 1	MICROPHONE JACK & MOUNTING NUT
17	1	POTENTIOMETER KNOB

The receiver

For the receiver assembly, use Fig. 2 as a guide. The PC board (1) should already have the headphone jack, the on/off switch, and the potentiometers attached. Put a 1/2-inch long Phillips-head screw (2) in both of the PC-board's holes. Put a 1/4-inch spacer (3)

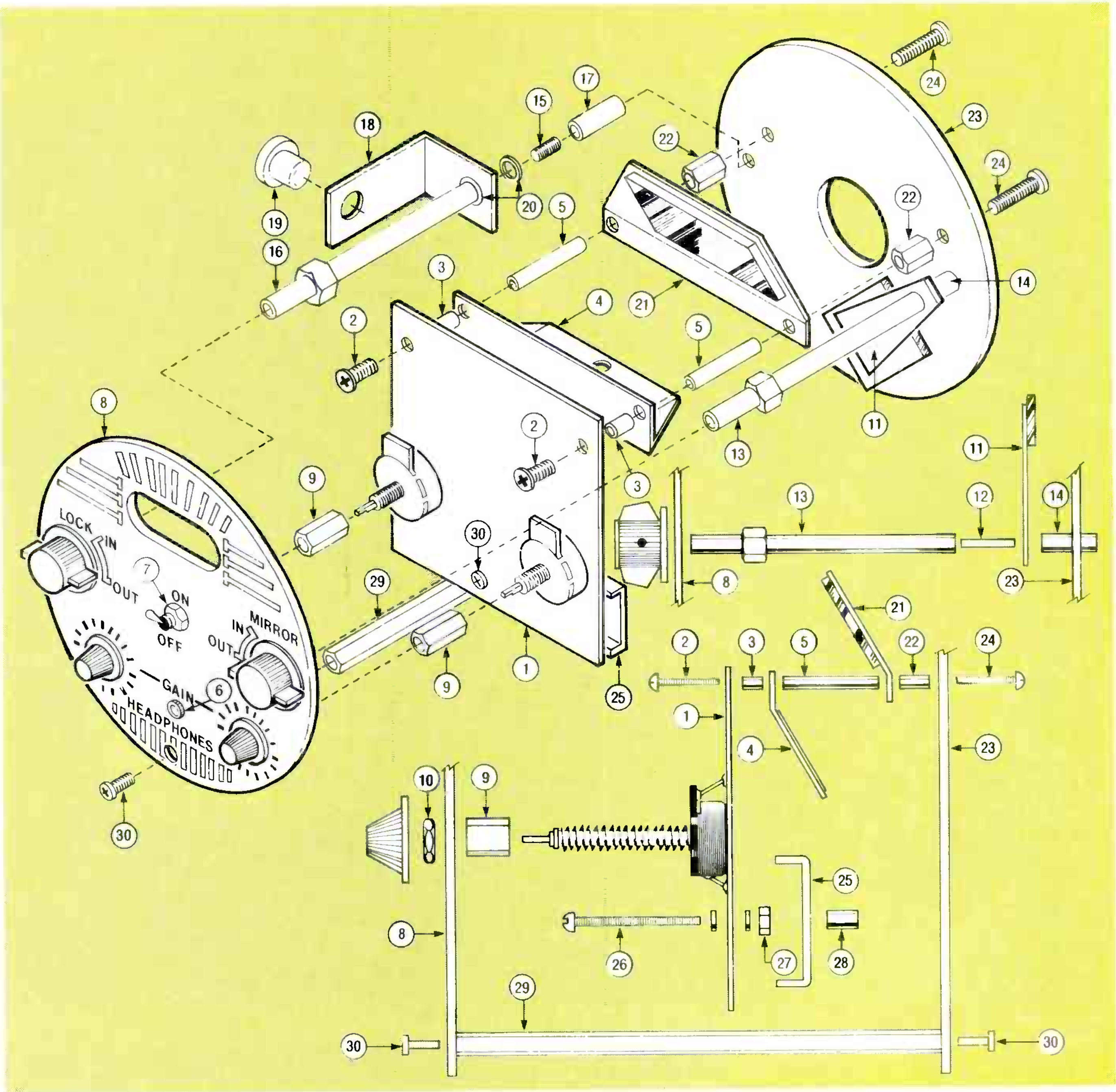


FIG. 2—THE RECEIVER is a little more complicated than the transmitter. Identify all parts before assembling them.

over each screw, put the viewing bracket (4) in place, and a 1¼-inch long threaded spacer (5) onto the end of each screw.

The headphone jack and the on/off switch (parts (6) and (7) respectively) have threaded collars. Remove their collar nuts and push the jack and the switch through their appropriate mounting holes in the plastic end panel (8). Replace the collar nuts. Now take the two ½-inch long spacers (9) with the large holes in them, and fit them over the threaded shafts of the two potentiometers. Fit the threaded ends of those shafts through the holes in the plastic end panel (8), and tighten a nut (10) on each one.

If you purchase the kit, you'll find that the pivoting-mirror bracket (11) comes with the mirror glued to the bracket. You will, however, have to attach it to the two-piece shaft as follows: Screw the threaded stud (12) into the long end of the 3-inch shaft (13), put the mirror bracket over it with the mirror facing as shown, and tighten a ¾-inch threaded spacer (14) onto the end of the stud.

In a manner similar to the mirror bracket, you can assemble the bracket that locks the receiver assembly in

ORDERING INFORMATION

The following are available from General Science and Engineering, P.O. Box 447, Rochester, NY 14603 (716-338-7001): Kit of all parts, including all electronic and mechanical components, $98; Set of two PC boards, $12.00; 6-inch Fresnel lens, $15.00; A headset with built-in microphone, $12.00; Telephone-type handset, $5.00; Siemans BPW-33 photodiode, $3.50; HLMP-8150 12-cd LED price to be determined (call GSE for information); Assembled and tested communicator, $198. Note: the spotting scope is not available from GSE.

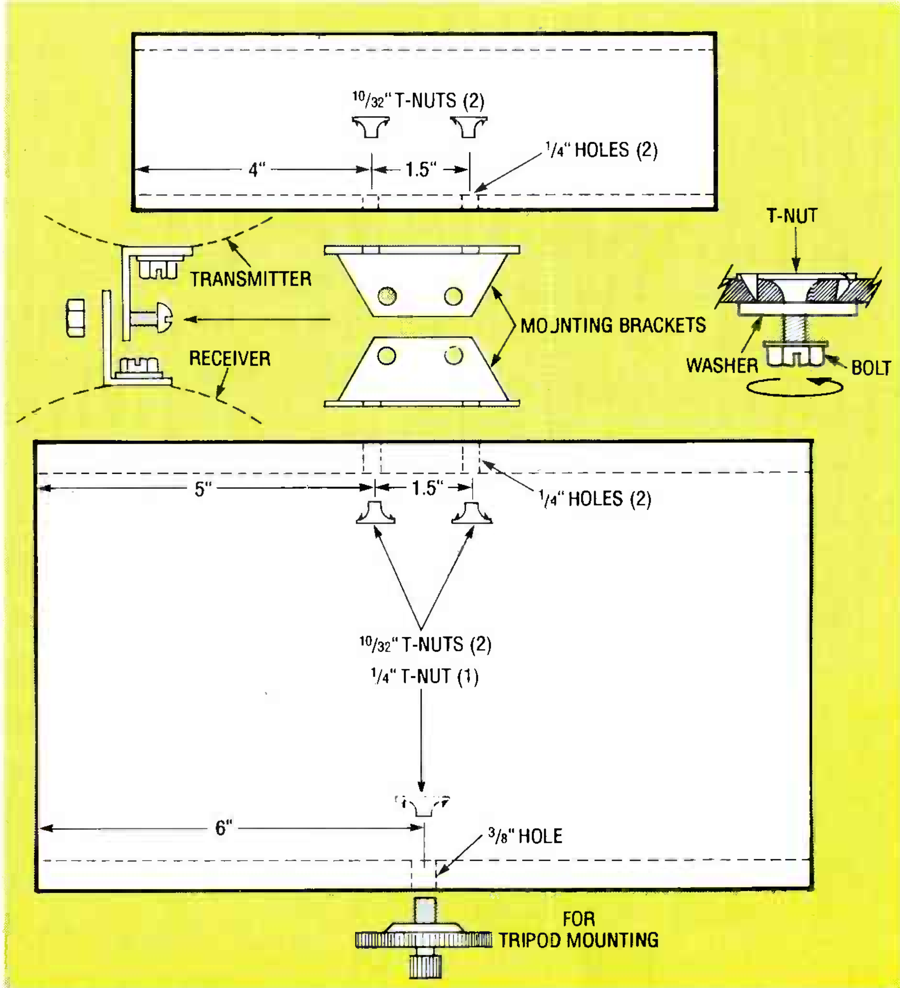


FIG. 3—THE CARDBOARD TUBES go together as shown. Spray paint the inside and both edges of both tubes flat black before assembling.

PARTS LIST FOR THE RECEIVER (FIG. 2)		
Part #	**Quantity**	**Description**
1	1	PC BOARD
2, 24	4	SCREWS, 4/40 × 5/8"
3	2	SPACER, 1/4"
4	1	VIEWING PLATE
5	2	THREADED SPACER, 4/40 × 1 1/4"
6	1	HEADPHONE JACK MOUNTING RING
7	1	ON/OFF SWITCH MOUNTING NUT
8	1	PLASTIC END PANEL, FRONT
9	2	SPACER, 1/4" HOLE, 1/2" LONG
10	2	POTENTIOMETER MOUNTING NUT
11	1	PIVOTING MIRROR BRACKET
12,15	2	THREADED STUD, 6/32 × 7/8"
13, 16	2	THREADED SPACER, 6/32 × 3"
14, 17	2	THREADED SPACER, 6/32 × 3/4"
18	1	L-BRACKET
19	1	RUBBER GRIPPER
20	2	LOCK WASHERS, 6/32
21	1	MIRROR BRACKET
22	2	SPACER, 3/8"
23	1	PLASTIC END PANEL, REAR
25	1	BATTERY HOLDER
26	1	SCREW, 4/40 × 1"
27	1	NUT, 4/40
28	1	THREADED SPACER, 4/40 × 1/4"
29	1	THREADED SPACER, 6/32 × 2 7/8"
30	2	SCREWS, 6/32 × 1/2"

place inside the tube. The locking bracket is made up of the threaded stud (15), 3-inch shaft (16), 3/4-inch threaded spacer (17), the L-shaped bracket (18) with its rubber gripper (19), and the two locking washers (20). Those two assemblies now fit through the two appropriate holes in the plastic end panel (8), and a knob should be put on the end of each shaft, so that the two shafts can turn, but with some resistance.

Before continuing, the rear plastic end panel (23) requires a layer of black felt-like material glued onto the side that faces the lens side of the tube. That material cuts down on reflections inside the tube, and it is included in the kit. Use part number (23) as a template to cut the felt piece to the right shape, and to mark the holes for the metal shafts and screws to pass through. Then, using any kind of suitable glue, affix the felt.

With that out of the way, position the mirror bracket (21), the two 3/8-inch spacers (22), and the rear plastic end panel (23), and secure everything with the two 5/8-inch long Phillips-head screws (24). (Note that the ends of the two rotating shafts merely pass through the holes in rear panel (23), and are not held on in any way. The battery holder (25) is held in place by the screw (26) and nut (27) that are secured to the PC board as shown. The battery-holder bracket fits over the end of screw (26), and the 1/4-inch threaded spacer (28) is screwed on to hold it in place. The last part to install is the 2 7/8-inch long threaded spacer (29), and the two 1/2-inch long Phillips-head screws (30).

Tube assemblies

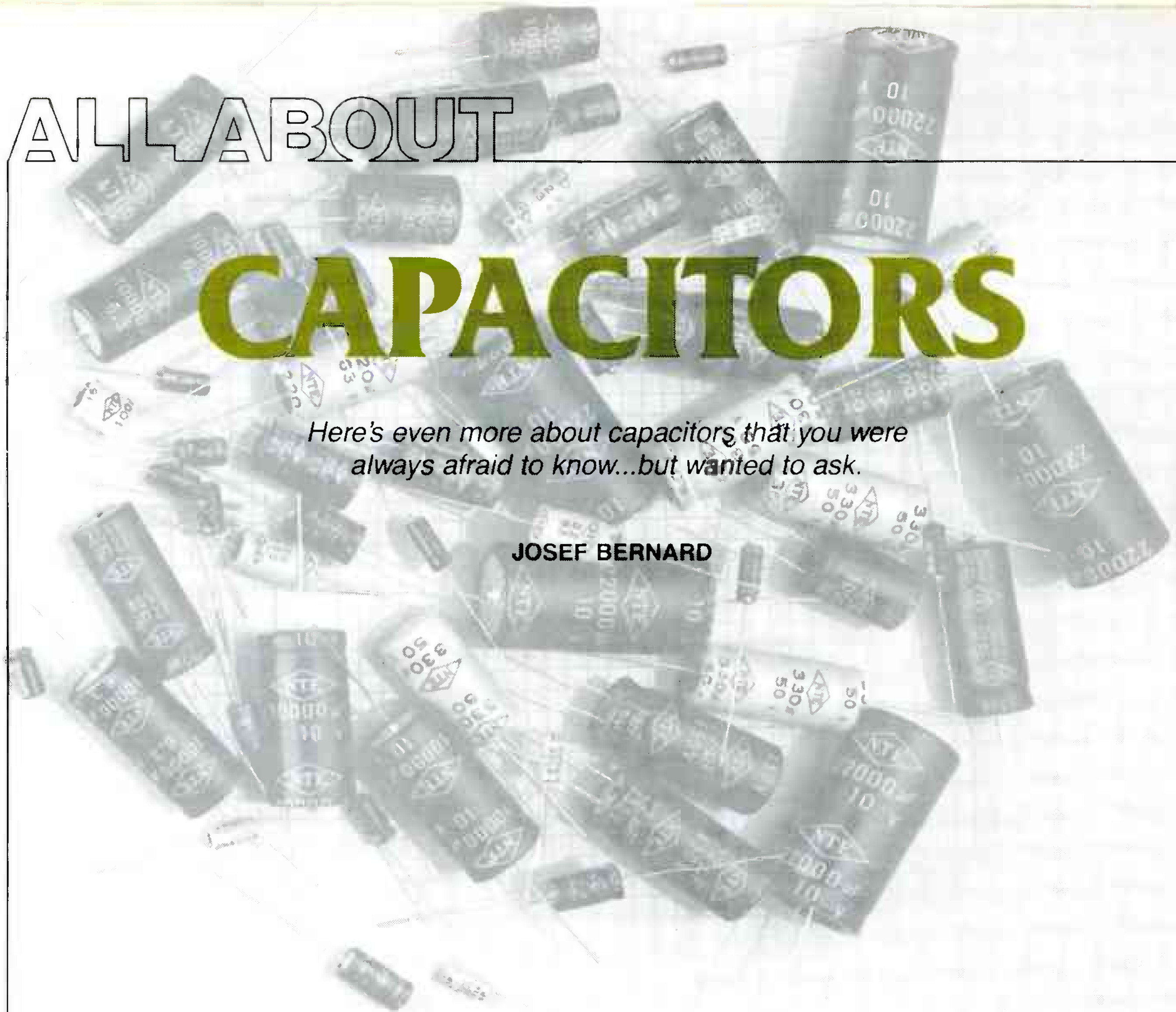
Before you prepare the tube assemblies, spray-paint the inside and both ends of both tubes flat black. Then, following Fig. 3 as a guide, mount the two brackets that hold the two tubes together. Basically they are L-brackets that are secured to the cardboard tubes using T-nuts. (See the detailed view in Fig. 3 on how to install T-nuts.) You also have to install a larger T-nut for tripod mounting.

The transmitter assembly is mounted on the end of the tube opposite the lens, and is held in with the two screws as shown. The receiver just sits in the tube and is locked in place with the locking bracket.

After all of the hardware is

continued on page 70

ALL ABOUT CAPACITORS



Here's even more about capacitors that you were always afraid to know...but wanted to ask.

JOSEF BERNARD

IN OUR LAST ARTICLE ON CAPACITORS, WE had just barely made a dent in describing the various types of capacitors that exist, so let's take a look at some more. One class of non-polarized capacitors is made using a plastic-film dielectric. There are a number of different plastics used, including Mylar, polystyrene, metallized polypropylene, and metallized polyester. Some of those capacitors are shown in Fig. 1. They have a reputation for long-term stability over wide temperature ranges, especially polystyrene and polypropylene. Some types of plastic-film capacitors, notably polycarbonate and polysulfone, are well suited to use in high-frequency switching-power-supply applications, and in other places where significant AC currents (normally the bane of capacitors since they cause overheating and subsequent damage) are encountered. Special film capacitors are also used in TV sweep circuits, where high-voltage alternating current is present.

In audiophile circles, film capacitors are highly regarded by many (but not all, as the continuing debate goes to show), and there are a number of kits available for high-end amplifiers that permit you to tear out all the old ordinary capacitors and replace them with esoteric plastic ones for a greater purity of audio sound and leanness of wallet.

In the past few years, a new type of capacitor, noted for extremely high capacitance—as much as several farads—has made its appearance. Although its rated working voltage is usually not more than five volts, it is sufficient to power backup CMOS memories in computers, terminals, and even household appliances such as TV sets. Memory can be kept alive for well over a month by the charge stored in one of those capacitors.

The electrode of that type of device is made of an activated carbon web that has been plasma-sputtered with aluminum. The electrolyte is generally sulphuric acid. While polarized, those capacitors are relatively insensitive to damage if hooked up "backward." Extreme care must be taken when working with high-capacitance devices—the charge they store can be lethal if discharged all at once! Development is now under way of devices with capacitances of 1000 or even 1500 farads in a volume little larger than a soup can.

A final class of capacitor is the variable capacitor. Variable capacitors are usually found in short-interval timing circuits, specifically those used at radio frequencies. The electrodes of a variable capacitor are made up of two sets of meshing plates (see Fig. 2). One set is fixed in place (the stator) while the other (the rotor) is mounted on a shaft that can be turned to change the degree to which the two sets

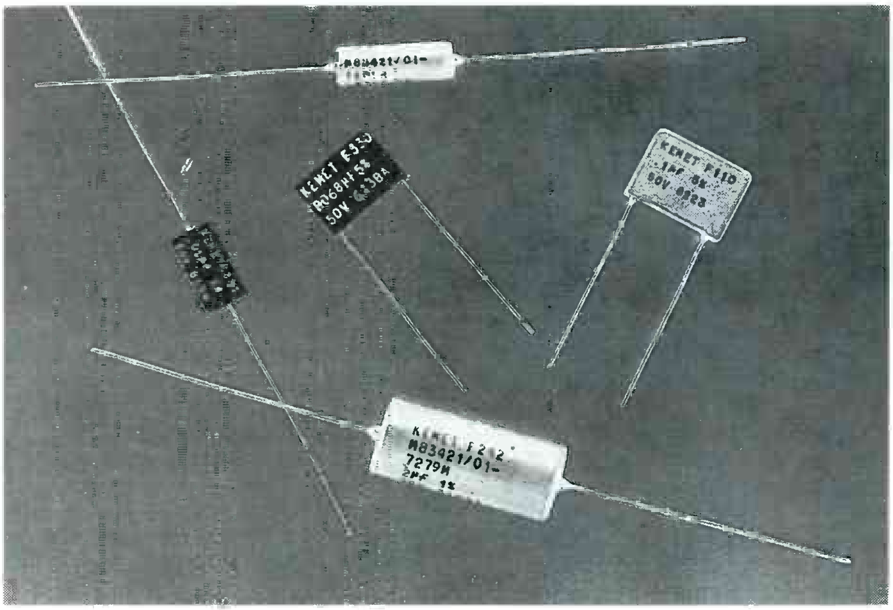


FIG. 1—FILM CAPACITORS are reasonably tolerant of AC and they are effective at high frequencies.

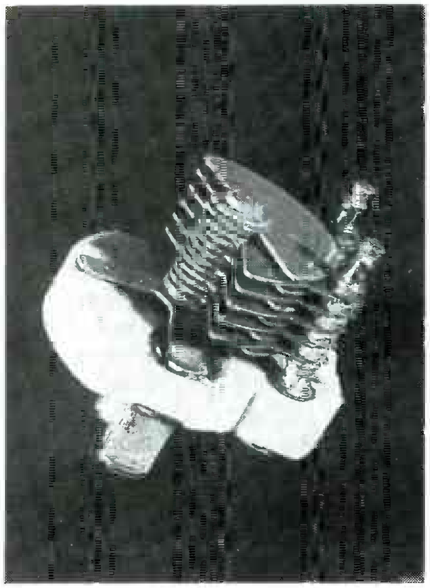


FIG. 2—THE DEGREE TO WHICH the plates mesh determines the capacitance of this variable capacitor.

mesh. As the shaft is turned and more of the rotor occupies more of the stator's volume, the capacitance of the device increases. In larger variable capacitors, the dielectric is usually air (in very large ones it's a vacuum), while in miniature ones it can be sheets of mica or plastic. The small compression-type trimmer capacitors that are used to fine-tune tuning circuits work on a similar principle, but usually have only single-plate stators and rotors.

Packaging and lead arrangement

The ways in which capacitors are packaged are seemingly endless. We are all familiar, of course, with the ceramic-disk capacitors. Teardrop-shaped tantalum electrolytics are dipped in epoxy resin. Aluminum cans are frequently used for electrolytics, which are sealed in order to keep the electrolyte from drying out. Some aluminum-can electrolytics include safety vents that prevent explosions by blowing out exhaust gases in the event of overheating.

Tubular electrolytics come in two general configurations: with radial leads, and with axial leads (see Fig. 3). Axial-lead capacitors, whose leads extend from each end along the device's axis, are used in situations where a low circuit-board height may be necessary. In point-to-point wiring, axial-lead devices are often used because they can be more securely fastened than radial-lead ones. Where circuit-board space is at a premium, radial-lead capacitors offer the advantage of a smaller footprint, although at some cost in circuit-board height. They are also better suited for use with the automatic-insertion equipment used in assembly-line operations.

Capacitors used by electronics manufacturers are frequently supplied to them in a form usable by automatic-insertion equipment. The leads of the devices are held between two pieces of tape and the capacitors are then rolled up into reels or stored in cases like machine-gun ammunition. Sometimes you may receive small quantities of capacitors in taped form.

Values and tolerances

"What value capacitor should I use?" is the sort of question often asked by (or on the minds of) newcomers to electronic design. The answer is, "Big enough." What that means is, except in critical tuned circuits, most of the time it is enough to know just the order of magnitude of capacitance required—several thousand microfarads, several dozen, a tenth of a microfarad, or perhaps a hundredth. It is not necessary to get any more precise than that, and it is frequently impossible.

THINGS CAPACITORS DON'T LIKE

Capacitors are very fickle devices. There are any number of conditions they don't like. Many types, for instance, lose a significant amount of their capacitance at high frequencies, making them unsuitable for RF applications. You also have to watch out for the inductance some may introduce in places where you don't want it. For that reason, some types of capacitors are indicated specifically as "non-inductive."

Temperature extremes are another thing to which capacitors, particularly electrolytics, are sensitive. Electrolytic capacitors, at elevated and at depressed temperatures, lose much of their capacitance. If you are going to operate electrolytics at extremes of temperature, make sure their tolerances extend to that temperature range.

Most capacitors do not care for alternating current. It makes them overheat and—before they self-destruct—operate inefficiently. Polarized capacitors, as has already been pointed out, cannot tolerate reverse voltages. Not only does that make them heat up, it can cause them—especially tantalum types—to heat up so rapidly that a sudden and violent explosion can result (most polarized capacitors are encased in tightly sealed containers).

Explosions can also result from polarized capacitors being installed "backwards" in a circuit. The cathode (negative) side of a polarized capacitor should always go to ground.

The tolerances of ordinary, garden-variety capacitors are pretty broad—many ceramic disks and electrolytics have tolerances given as +80, −20%. That is to say, the actual value of a 10-μF device could be as low as 8 μF, and as high as 18 μF. That's quite a range! And, while tolerances of 1% or even better are available in some types of capacitors (for a price), tolerances of ± 20% are much more prevalent. Table 1 shows commonly available tolerances, and the codes used to represent them.

The wide range of values possible within ordinary tolerances won't bother you, though, in most situations. Unless your application is extremely frequency-sensitive, just use a value that's in the ballpark.

Capacitors are very sensitive to temperature, and their values—particularly in the case of electrolytics—can vary widely according to their environment. To help in selecting devices with the appropriate stability, a marking system has been devised. One of the most frequently used temperature-stability references is "NPO," which designates automatic

TABLE 1
CAPACITOR TOLERANCE MARKINGS

CODE	TOLERANCE
B	±0.1 pF
C	±0.25 pF*
D	±0.5 pF*
F	±1%
G	±2%
J	±5%
K	±10%
M	±20%
Z	+80%, −20%

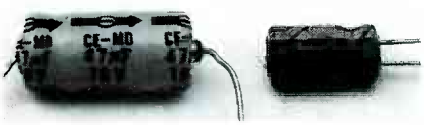


FIG. 3—THE LEADS of an axial-lead capacitor (left) extend along its axis; those of a radial-lead one (right) align with a radius.

temperature-compensating capacitors. "NPO" stands for "Negative-Positive Zero" (what's read as an "O" is actually a zero), and means that the negative and positive temperature coefficients of the device are zero—that its capacitance does not vary with temperature. You may sometimes find NPO-type capacitors marked with the EIA (*E*lectronic *I*ndustries *A*ssociation) code "COG." The EIA has an established set of specifications for capacitor temperature characteristics, shown in Table 2. Thus, a capacitor labeled "Y5P" would exhibit a ±10% variation in capacitance over a temperature range of −30 degrees C. to +85 degrees C.

Reading capacitor markings

Capacitors can be marked in many different ways, depending on their type. While the systems may be confusing at first, there are industry standards, which ensure that once you've learned to read a particular system of coding, you'll be able to apply your knowledge to more than a single manufacturer's product.

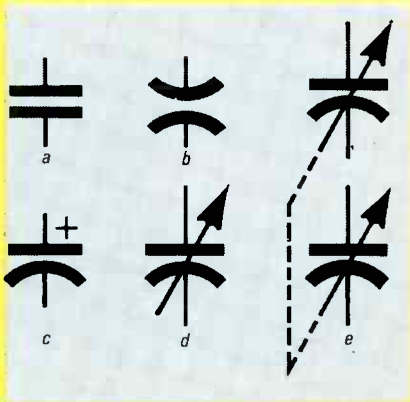
Can and tubular electrolytics are the simplest to decipher—their values are usually printed in ordinary numbers and letters that anyone can understand. It would be no problem to identify a capacitor marked "35V, 2200 μF." Sometimes the voltage is identified as "WV" (*W*orking *V*oltage), and sometimes the letters "DC" are added.

Capacitors are frequently so small, as in the case of dipped tantalums (or worse, leadless chip capacitors), that there isn't enough space on them to indicate their specifications in full. A system that combines abbreviation with positional notation is used. It can work in several ways.

The first way uses numbers and letters. A typical marking might be "4R7." The letter "R" serves to mark the position of the decimal point in the value—therefore we now know that the value of the capacitor in question is 4.7 somethings, the units (microfarads or picofarads) generally being apparent to the experienced user.

Another system uses a three-digit number. The first two digits represent the first two digits of the value, and the third is a multiplier indicating the number of zeros that have to be added to the base number to make it read as intended. Depending on the size and type of capacitor, the multiplier can express picofarads or microfarads. Electrolytics usually have values in microfarads, and most other types have capacitances expressed in frac-

CAPACITORS IN SCHEMATICS



Capacitors are represented schematically as a pair of plates. Sometimes the plates are drawn as straight lines (a), sometimes as curved ones (b), and sometimes as a combination of the two. **Radio-Electronics** uses the one-straight-line-and-one-curved-one convention for both polarized and non-polarized capacitors.

Electrolytic capacitors are frequently indicated by a symbol with one straight and one curved line (c). A plus sign (+) is placed at the straight line to indicate the anode. Occasionally an electrolytic is drawn as two straight lines, but the plus sign is always included to indicate its polarity.

Where a capacitor is shown as one straight line and one curved one, the curved line, which represents the outer case or electrode of the device, is assumed to be at a lesser potential than the straight one. Thus, since signal flow in a schematic diagram is usually from left to right, capacitors are drawn with their curved ends facing left or, if that is not possible, facing down, which is the direction usually used to represent ground. Electrolytics, especially, are depicted with the curved plate facing downward.

Variable capacitors are usually depicted as shown in (d). The arrow is the conventional symbol used to indicate that a device may be adjusted over a range of values. A multi-section variable device may be shown with one symbol for each section, with dashed lines (e) used to show that both of the sections are ganged together.

In schematics, capacitor values are usually indicated in microfarads unless a note specifies that things are otherwise. Voltage ratings, if they are given, are usually presented as part of a "fraction." A label of "4.7 μF/35V" or "4.7/35" would indicate a capacitor with a value of 4.7 μF with a working voltage of 35 volts.

TABLE 2

EIA CLASS II CAPACITOR CODE

LETTER SYMBOL	LOW TEMP. REQUIREMENT	NUMBER SYMBOL	HIGH TEMP. REQUIREMENT	LETTER SYMBOL	MAX. CAPACITANCE CHANGE OVER TEp. rating
Z	+10°C	2	+45°C	A	±1.0%
				B	±1.5%
				C	±2.2%
		4	+65°C	D	±3.3%
				E	±4.7%
Y	−30°C	5	+85°C	F	±7.5%
				P	±10.0%
		6	+105°C	R	±15.0%
				S	±22.0%
X	−55°C			T	±22%-33%
		7	+125°C	U	±22%-56%
				V	±22%-82%

tions of microfarads or in picofarads. A small film capacitor might have a value shown as "104." That represents 100,000 pF. (10 followed by four zeros, as indicated by the multiplier). If you divide by a million (remember, a picofarad is a micro-microfarad—a millionth of a millionth of a farad) you get the value in microfarads, 0.001 μF, in this case.

Watch out when plugging capacitor values into electronic equations. They frequently expect you to use a value in farads. That is, if the value in question is 4.7 μF, you must show it as 0.0000047 farads. If you don't, the result of the calculation will be off by a factor of a million!

A marking system employing six colored dots, where the dots use the same values they do in today's resistor color codes, was early on used to designate the values of devices such as high-voltage mica capacitors. Looking at Fig. 4, read clockwise from the upper left; the first dot indicates the type of device, the next two dots the value, the fourth dot the multiplier, the fifth the tolerance, and the last dot the class. R-E

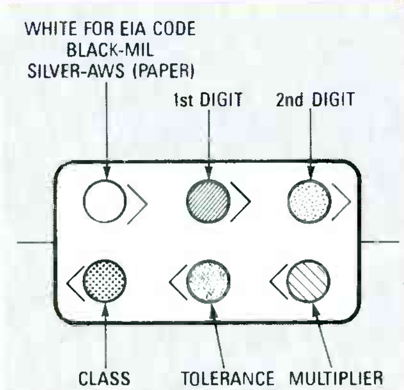


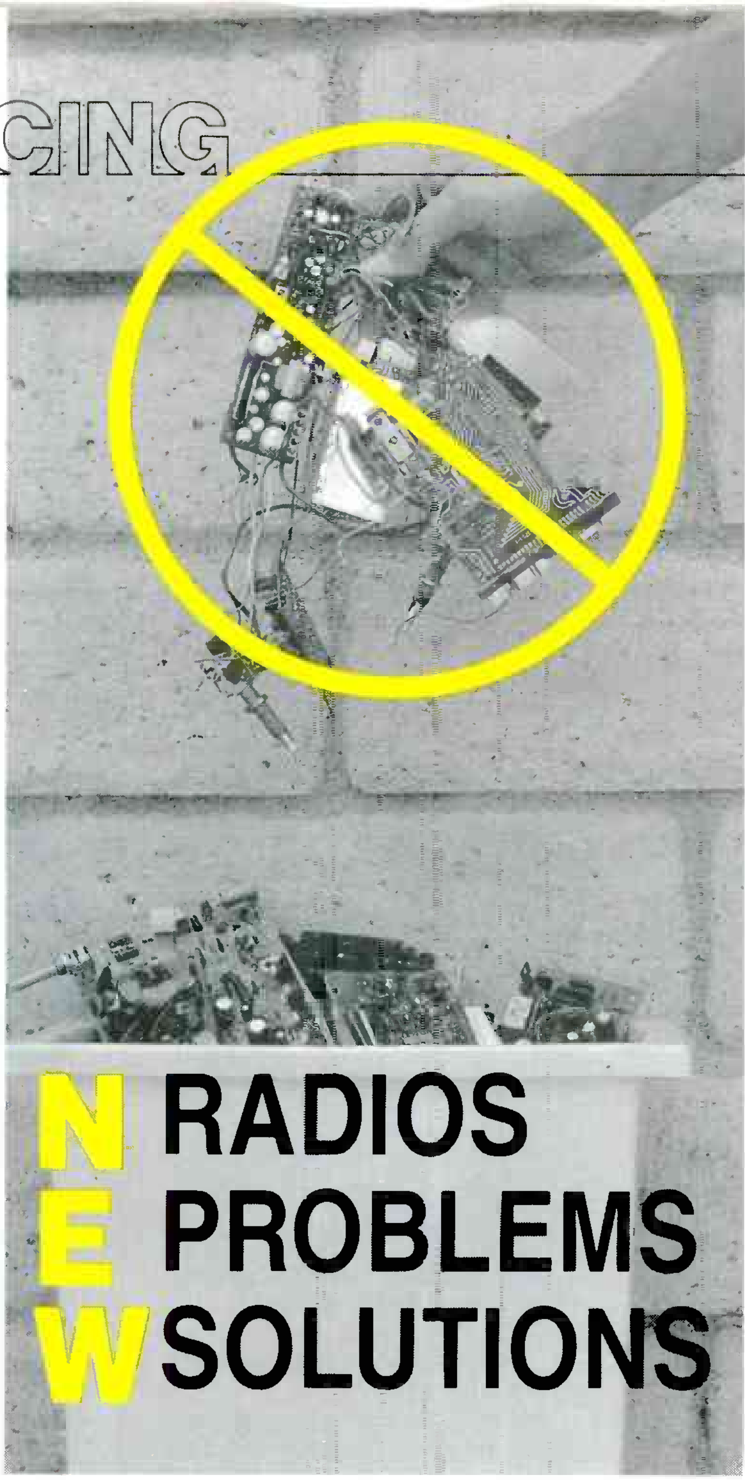
FIG. 4—YOU MAY OCCASIONALLY still run across this colored-dot system for marking capacitors. The colors carry the same values as for resistor coding.

UNCOMMON CAPACITORS

Capacitors vary in size from microscopic to the enormous. At the small end of the scale, there are the capacitors that are deposited on a substrate during the manufacture of integrated circuits. Hybrid integrated circuits such as those containing tuned circuits may require very precise capacitor values—with tolerances that are impossible to achieve using any economically feasible straight manufacturing process.

The precise capacitances required are obtained by intentionally making the capacitors oversize, and then trimming them with a laser until the circuit of which they are a part resonates at exactly the right frequency.

At the other end of the scale, the enormous energy requirements of the acceleration devices used in subatomic-particle research are also met by capacitors—rooms full of them! One of the largest such devices, a particle accelerator located outside of Chicago, is said to be able to store enough energy to meet the electrical demand of the entire world! Of course, that is only for an instant, but the figure involved is still big enough to boggle the mind.



NEW RADIOS NEW PROBLEMS NEW SOLUTIONS

Here are some true to life radio-repair stories, chock-full of mystery and horror!

GARY McCLELLAN

OK, ROLL UP YOUR sleeves: We're going to put theory and practice together to fix some digitally tuned radios. And what about getting those hard-to-find replacement parts? Yes, we'll have some helpful hints.

Digital clock radio

As shown in Fig. 1, Cola on the keys killed that General Electric model *7-4885A* digital-clock radio. That's right; go ahead, spill cola all over your radio's keyboard and let it leak inside—*your* radio won't work, either. So why should cola kill a radio? Let's take a look inside and check it out. We see dried gook and gunk all over the keyboard. Bridging the FM-key contacts with the screwdriver blade turned the music right on. It doesn't take a genius to know that the keyboard contacts need cleaning. OK, that was an easy fix. While we're on the subject, what's a good way to clean that keyboard, anyway?

Cleaning a keyboard just takes some common sense. Luckily, that radio could be disassembled to access the contacts. Unsolder the cable from the keyboard, scrub out the sticky cola with a toothbrush and a pan of warm water, then let it dry. Shoot each keypad contact with some contact cleaner, rub-a-dub, then re-install the keypad. Success!

Be careful when handling the keyboard wiring, and use *E*lectro*s*tatic *D*ischarge (ESD) precautions. For example, walking across a rug can generate several thousand volts, which (when discharged) can blow a controller IC faster than lightning. Excuse the pun. The cost of a new Texas Instruments TMS-1100 IC can make repairs prohibitive. So please don't say that you weren't warned here first.

Delco car-radio

"I know it's Sunday afternoon, but can you fix my car radio? It doesn't get any stations." Does that sound like your next-door neighbor? The car radio was a Delco model *40JHMAI*, typical of the black-faced digital radios found in recent General-Motors cars.

Figure 2 shows the Delco board. Trying that radio on the bench, the LED display didn't light. Turning up the volume, we heard a rushing noise on both the AM and FM channels; that implied that the audio and RF circuitry were working. Connecting an external antenna verified RF-circuit operation because we heard an 88.1-MHz FM station through the speaker.

At that point, it's best to stop and study the symptoms for a moment. Because the display wasn't lit, that means there's no power, or possibly a open wire somewhere. Measuring the voltages on several IC's revealed zero voltages on every pin of the controller IC. Look at the Delco board a little closer; right next to the controller and synthesizer IC's is a DM463 voltage regulator. Replacing that old IC with an MC7805 from our stock immediately brought the receiver back to life.

Like keyboard problems, power-supply problems are usually repaired quite easily. Here's a tip: If you are working on a car radio, be sure to

FIG. 1—SPILLED COLA ON A KEYBOARD will ruin any radio.

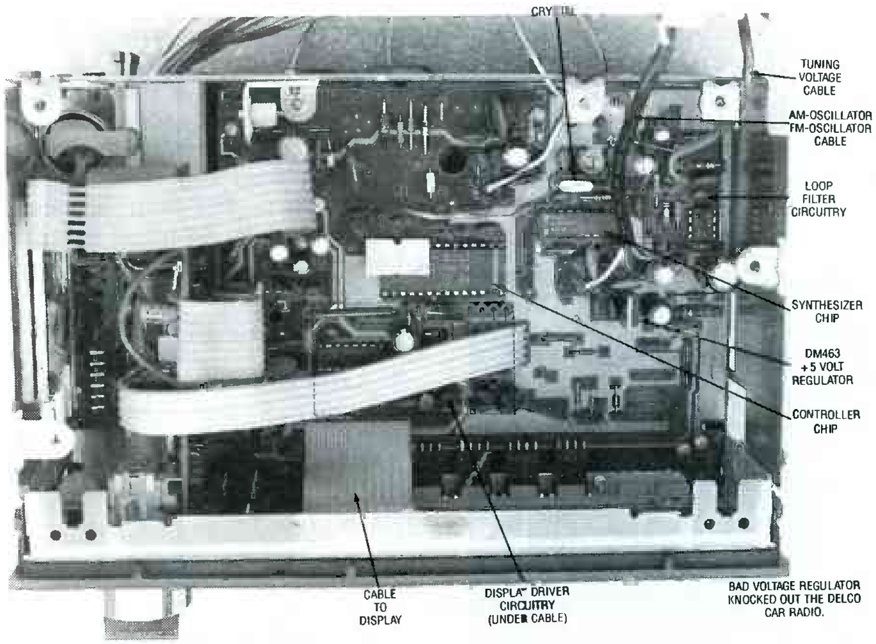


FIG. 2—HERE'S A DELCO CAR-RADIO that doesn't work. Would you know where to look to fix this baby?

check the "clock" or "memory" power lead. If that lead gets disconnected, the radio may either play dead or lose time-and-station settings whenever the ignition is turned off.

Toshiba stereo

What about a Toshiba model *KT4066* portable headphone-radio developing an intermittent on FM shortly after purchase? It would go dead at infrequent intervals, but the AM band and cassette player worked fine. Until, finally, the headphone jack went completely bad. Opening up that baby revealed surface-mount circuitry. Think of surface-mount technology like a pizza: the crust is the PC board, while the toppings (tomato sauce, cheese, maybe anchovies) represent the parts.

The headphone-jack problem was fixed first. It was nothing more than a cold solder joint that had broken loose, causing intermittent sound in one channel. But that bad solder connection didn't fix the intermittent FM-reception problem. Unfortunately, the radio wouldn't fail for a long enough time to isolate the problem. In fact, just bringing the radio near the bench was enough to make it work perfectly!

The solution was to inspect the synthesizer board mounted in the lid. Figure 3 shows a bird's eye view of the radio's guts. Under a magnifying glass, several solder connections looked suspicious; one connection next to what appeared to be a prescaler IC looked unsoldered! Using a grounded soldering pencil and 0.031-inch solder, each poor connection was resoldered. Jackpot! The receiver works perfectly to this day.

Incidentally, be careful when taking apart and re-assembling headphone stereos. The tiny plastic parts used are easy to break and hard to replace.

Exotic-car radio

An automobile importer had a minor problem with some radios. It seemed that he received a shipment of cars from Europe with radios that would not receive AM stations. Could the problem be a switch? While his mechanics made the cars conform to USA emissions standards, they were stumped when it came to digital radios. The receivers supplied were the Fujitsu-Ten model *EP821*, which has some unusual AM/FM reception capabilities, plus a cassette deck, clock, and equalizer.

The problem with foreign radios is that they are set to tune in the broadcast frequencies of a particular country. For example, the AM-broadcast band (535–1605 kHz) was set to 9-kHz tuning steps, instead of the 10-kHz tuning standard in North America. Because the radio was tuning in 9-kHz steps, it missed most AM stations! The FM reception was unaffected because the *EP821* tuned in 0.05 MHz steps, making it possible to receive either European or USA stations. Understand that Europe uses even-numbered 0.2 MHz steps, while in the USA we use odd-numbered steps.

Inspecting the chassis for a switch to select either 9-kHz or 10-kHz tuning steps revealed nothing. So the only alternative was to contact the Fujitsu service department to buy a service manual for the *EP821* model. To our surprise, they didn't know that model number, but they could supply a manual on the *EP820* model, which fit the set's description exactly.

Immediately upon receiving the service manual, we found that the schematic page showed a diode marked "USA" connected across two pins of the MB8851-110 controller IC. After installing the diode, the radio still did not work on AM. The only solution was to obtain the MB8851-101C controller called out in the parts list and try a replacement. Sure enough, the AM section worked fine when a new IC was plugged in.

Nothing works right

From all appearances the Sansui model *R707* had many problems; yet the cause was a single part that was fixed at no cost. Turning on the power, everything was working except for the AM and FM tuner section. On FM, the display would scan frequencies and it would store ones chosen at random. The only sound was a soft rushing noise. On AM, the display read typical AM frequencies, but the decimal point remained lit and the display said MHz instead of kHz. There was no sound, so it appeared that the AM front end was dead. Unusual symptoms to be sure; but that particular repair project would get stranger as we continued!

Analyzing the problems showed that the controller was basically working because all controls worked and it stored stations. But there was some sort of controller defect that caused the display to read frequencies like 160.0 MHz on AM. So controller troubleshooting was called for. The receiver wouldn't pick up any stations; in fact, it wouldn't respond to the output from a signal generator, either! So, for those reasons, troubleshooting of the AM/FM front end was necessary.

The question was where to start troubleshooting. The controller was a good beginning because of the display faults—but the voltages were good and there was no sign of any problems. Short of substituting the controller IC, there was nothing else to check in that area; therefore, looking at the synthesizer might prove worthwhile. A quick way to check synthesizer operation is to locate the VT (tuning-voltage) line and measure it with a high-impedance voltmeter. For stations around 88 MHz or 540 kHz the voltage will be low, typically a few volts or less. For stations around 108 MHz or 1600 kHz the voltage will be nearing maximum, or roughly 6 to 24 volts, depending upon the model. If the voltage is far below or above that range, the synthesizer is out-of-lock and needs attention or servicing of some kind.

Measuring the tuning voltage showed that it was stuck at maximum; the synthesizer was out-of-lock. From past experience that indicated a failure in the loop filter, synthesizer IC, or local oscillator in the front end. In other words, the bad part could be almost anywhere! After substituting the synthesizer IC, and finding no obvious defects in the loop filter, a scope check of the AM local-oscillator confirmed there was no signal; neither was there any signal from the FM prescaler. So what was going on here?

It looked as if the front-end wasn't getting any power because both local oscillators were out; yet 13 volts was measured to the tuner board earlier. Something on the tuner board was preventing the voltage from getting to the radio's front end. With the receiver still in the FM mode, checking for power on the IF board revealed nothing wrong—12 volts was present at several points. But when we moved to the terminals of the shielded front-end, we struck luck like gold. For the only value above a volt was the (tuning voltage) VT pin. There was no power anywhere else! Tracing the B+ pin from the tuner module to a nearby choke, L1, there was 12 volts on one side of L1, and nothing on the other side. L1 was open, thus disabling the unit!

Inspecting the choke revealed a broken coil-wire. Not the heavier coil-winding itself, but the slender connecting wire extending from the choke body. Soldering a new piece of wire to the choke body repaired that problem. Re-installing the repaired choke restored all functions to the Sansui *R707*.

Getting parts

Let's face it: Obtaining replacement parts can be as difficult as servicing the receivers themselves. That's especially true if you're an individual seeking a single component rather than a factory's authorized-service center receiving weekly scheduled parts deliveries. Here are some insider tips to help you play the parts game and win.

For general troubleshooting, nothing beats a supply of modules and assorted parts. One way to get

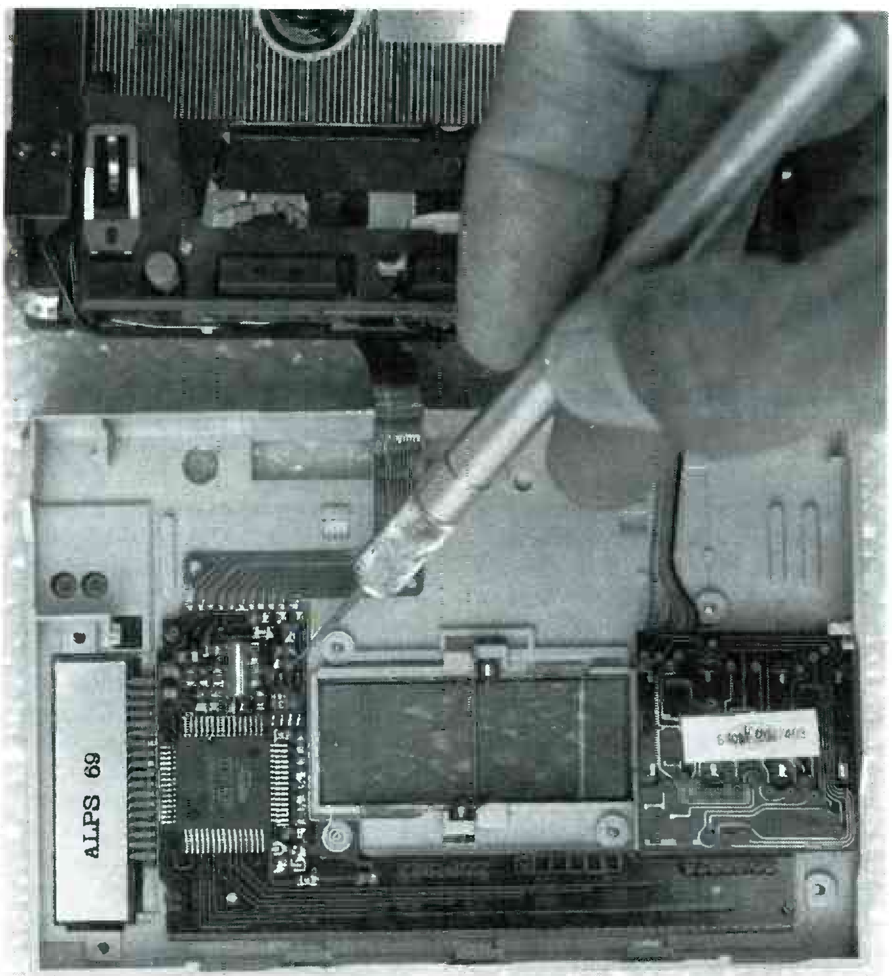


FIG. 3—THIS TOSHIBA PORTABLE HEADPHONE-RADIO uses *Surface Mount Technology* (SMT) components.

parts is to collect cast-off radios from owners who have decided that their sets weren't worth fixing. Test each throw-out and determine the radio's general condition, such as no left channel, no FM, and so on. Parts that seem to be good can be pulled as needed for substitution into other radios. If the substitution of a certain part works, an authorized replacement part can be ordered to complete the repair.

Good sources of cast-off electronics components include flea markets, friends, and ham-radio swapmeets; keep your eyes open for local radio clubs that hold swapmeets regularly. Other sources are various auctions. Sometimes you can get current-model receivers dirt cheap at bankruptcy auctions, so don't shy away. Some radios might be new and can be resold below the regular cost; others might be damaged, but can be broken up for parts—an ideal situation. Don't shy away from new-but-damaged goods, which can be scavenged for parts at unbelievable savings. The parts themselves are as good as new anyway. Try it!

Understand that there are limitations to using parts from cast-off receivers and you'll do well. Using those parts is low-cost and sometimes convenient, but you must spend extra time removing and re-installing them. Also, you must be reasonably sure that the part removed is good. It is amazing how much time you can waste troubleshooting a broken radio when you replace one bad part with another!

A better source of parts are the *M*aintenance and *R*epair *O*peration (MRO) suppliers like Phillips-ECG, NuTone Electronics, and others. Check their ads and obtain cross-reference catalogs from each of them. While MRO suppliers offer convenience, they tend to carry only the more popular parts that are found in older equipment. So if you have a sick receiver less than a few years old, which is usually the case for digitally tuned radios, you're out of luck for certain parts.

Another good source for parts are the suppliers who advertise Japanese semiconductors. Typically, they offer exact replacements at reasonable prices. Also, they have other special parts, like flame-proof resistors, VCR belts, and so on. Dig through the ads, call them up and request a catalog. A drawback from ordering from suppliers is the 1–2 week wait for UPS delivery and a minimum-order amount. Many times you'll have to order several more parts than you need, just to attain a \$10 to \$20 minimum. You can beat minimum-order requirements by combining parts from several repair projects into one order.

One ideal way to obtain parts is directly from the manufacturer. Because most radios are imported, you must contact the radio company's regional office, which is usually on the East or West Coast. Those offices seem to work best for factory-authorized service centers. The service center calls the regional office, orders by part number, and receives it in their weekly (or monthly) scheduled shipment. Billing is done on an account held by the service center; once a month the bill is paid. Simple for service centers. The rub is that many regional offices are warehouses; they have no facilities for walk-in customers who don't have part numbers. To be fair, some regional offices like Sanyo have walk-in centers where you can look up part numbers and get parts, but places like that are extremely rare, so consider yourself lucky if you find such a place.

Dealing with regional offices can be frustrating, but this procedure is typical: First you determine the location of the regional office. Often that information will be printed on the receiver's identification label. Then you dial for Directory Assistance to get the phone number. When you call the regional office, ask for the Parts Department and order a service manual. From the service manual you order the parts you need. Of course, by that time six months have passed, and your enthusiasm has faded away. It's therefore best to avoid regional offices altogether if you can get the parts elsewhere—the paperwork is too time-consuming for repairing a single out-of-order unit!

Some regional offices play games: If they find out that you're not one of their dealers, they demand cashier's checks for the manual and parts. A few dealers resort to the letter ploy where they won't take your calls. Instead, you must write to them for a service-manual price and delivery, then again to order parts. Try to avoid outfits like those at all costs when you run into one! **R-E**

HARDWARE HACKER

Cold fusion secrets
Electrolytic chemistry
A new light show BBS
Future power resources
The isotopes of hydrogen

Try cold fusion for yourself!

DON LANCASTER

MAY YOU LIVE IN INTERESTING TIMES. This tome is being written in mid-April and the hacker helpline is now ringing off the hook.

Just in case you have been on a South Sea island or on a wilderness backpack these last few months, cold hydrogen fusion with net heat power generation has apparently been successfully demonstrated and has been verified in several chemistry labs around the world. Or so it seems.

And all of this got done through the chemist's equivalent of hardware hacking. That's science with a small "s," which involves a few dedicated individuals in limited labs, spending mostly their own personal money.

More to the point, the cold fusion appears to be eminently hackable by just about anyone anywhere. Yes, it is rather dangerous, and yes, it gets fairly pricey for the needed materials. But if you quite carefully tune yourself into the key literature and then *thoroughly* study the work that everybody else is doing, and pay careful attention to several obvious safety rules, you can become a key player in what may turn out to be the most significant discovery of the Twentieth Century.

Let's see. The fun all began around April Fool's day 1989 when two competing chemists made several incredible, yet apparently quite real claims. Stanley Pons of the University of Utah and Martin Fleishmann of the University of Southampton in England announced they had a cold fusion process that involved a simple electrolytic cell consisting of nothing but a platinum cathode, a palladium anode, and some heavy water.

When DC was applied, the heavy water dissociated, the deuterium ions slowly moved into and got trapped by the palladium crystalline structure. Neutrons, tritium, and a rare isotope of helium were then detected, along with some net heat generation that seemed to exceed the electrical energy input by 4.5:1. All this at a heat energy density much greater than can easily be explained by any routine chemical reaction.

Meanwhile, Steven Jones over at Brigham Young University announced a remarkably similar series of experiments. These produced some apparent hydrogen fusion at a much slower rate without the excess energy generation.

Since it takes several weeks to get the reaction going, it did take a while to get confirmation. Early reports by independent teams that included Jay Bockris from Texas A & M University and others at Hungary University, University of Arizona, and Moscow University did seem to confirm all of the initial reactions.

NEED HELP?

Phone or write your **Hardware Hacker** questions directly to:
Don Lancaster
Synergetics
Box 809
Thatcher, AZ 85552
(602) 428-4073

So, before you or I go any further on this at all, if you haven't already done so, drop what you are doing immediately and run on down to your local library or to UMI and get a copy of Steven Jones' paper appearing in the *Journal of Analytical Chemistry*, and a copy of Pons and Fleishmann's paper in *Nature*.

Since those papers will not appear until a week or two after my deadline for this month's column, you'll have to go fish for them. Look for a late April or May 1989 publication date. Otherwise, just check into your local library. You will find a large and fresh groove deeply worn in the floor in front of the copy machine. Just follow where that groove leads, and you'll be home free.

What I thought I would do this month is try and give you some of the needed background information on fusion in general, cold fusion in particular, and on several of the resources you will need to get in on what could end up being the most exciting hacker opportunity of your lifetime.

Electrolytic Cells

Let's start off with the concept of an *electrolytic cell*, such as the one in Fig. 1. Electrolytic cells are widely used today in such things as flashlight and storage batteries, for electroplating, in copper refining, for the corrosion protection of ships, and for electrochemistry in general.

An electrolytic cell consists of a container that holds a liquid or

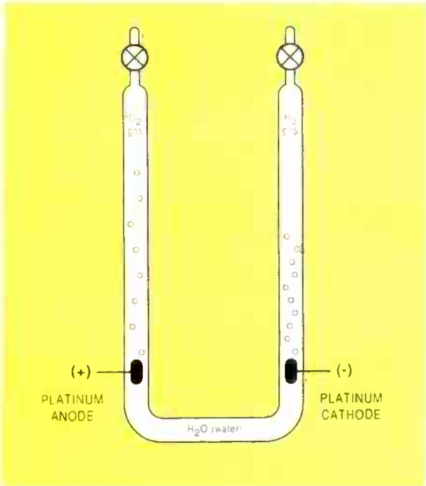


FIG. 1—AN ELECTROLYTIC CELL is the key to the cold fusion experiments. This simple cell will break down or dissociate water molecules into their hydrogen and oxygen atomic components.

semi-liquid *electrolyte*. Two electrical connections are made by way of a negative *cathode* and a positive *anode*. The choice of electrolyte and the anode and cathode materials depends on what you are trying to do with your electrolytic cell.

Let's assume the cell of Fig. 1 has a platinum anode and a platinum cathode, and that we fill it with plain old water. We'll add just a touch of acid or base to the water to make the electrolytic solution more conductive.

Next, we will apply DC negative to the cathode. We'll make that current large enough so that the reaction goes on at a reasonable speed, but not so strong as to cause excess heating or other problems.

What happens is that the DC causes several of the H_2O water molecules to break down or *dissociate* into positively charged hydrogen ions and negatively charged oxygen ions.

The positively charged hydrogen ions become attracted to the negative cathode. Since platinum is a noble metal that does not usually react with hydrogen, the hydrogen ions form bubbles at the cathode, combining to form diatomic H_2 hydrogen gas. The gas then floats upward, forming a gas pocket at the extreme top of the right column.

Similarly, the negatively charged oxygen ions are attracted to the anode and will combine there to form a diatomic oxygen (O_s) gas.

Let the reaction continue on long enough, and you'll end up with twice as much hydrogen as oxygen, thus verifying the chemical formula for water. The pure gases may then be extracted through the valves at the top of each column.

Much of the energy that was lost in the dissociation process is recoverable by burning the hydrogen in the recovered oxygen. That is called a *reversible* chemical reaction, and is often shown like this:

$$2H_2O + \text{ENERGY} \leftrightarrow 2H_2 + O_2$$

We say that it is a reversible reaction, in that you can either put electrical energy in to convert water into hydrogen and oxygen or else can burn hydrogen in oxygen to create water while liberating energy as heat.

We will shortly see that the cold fusion reaction is basically an electrolytic cell. The electrolytic cell is also one way you can brew your own heavy water in your own bathroom, although there are cheaper and more modern processes available.

Uh, it seems that one of my many hats around here involves my being part of the Haz-Mat (Hazardous Materials) team on our fire department. So let me tell you a thing or two about the dangers of hydrogen. Yeah, besides the

COLD FUSION RESOURCES

Information Sources

Analytical Chemistry/ACS
1155 16th Street NW
Washington, DC 20036
(202) 872-4570
Dialog
3460 Hillview Ave
Palo Alto, CA 94304
(415) 858-2700
Nature
65 Bleeker St.
New York City, NY 10012
(211) 477-9600
Science/AAAS
1333 H Street NW
Washington, DC 20005
(202) 326-6400
UMI
300 North Zeeb Rd.
Ann Arbor, MI 481-6
(800) 521-3044
Wall Street Journal
420 Lexington Ave
New York City, NY 10170
(212) 808-6960

Palladium and Platinum

Aesar
PO Box 1087
Seabrook, NH 03874
(800) 343-1990
Cerac
PO Box 1178
Milwaukee, WI 53201
(414) 289-9800
ESPI
5310 Derry
Agouro, CA 91301
(800) 638-2581
Goodfellow
301 Lindenwood Dr. Ste 1
Malvern, PA 19355
(800) 821-2870

Deuterium Oxide

Alpha Products
152 Andover Street
Danvers, MA 01923
(800) 343-0660
ICN Biochemicals Inc.
3300 Hyland Ave
Costa Mesa, CA 92626
(714) 545-0113

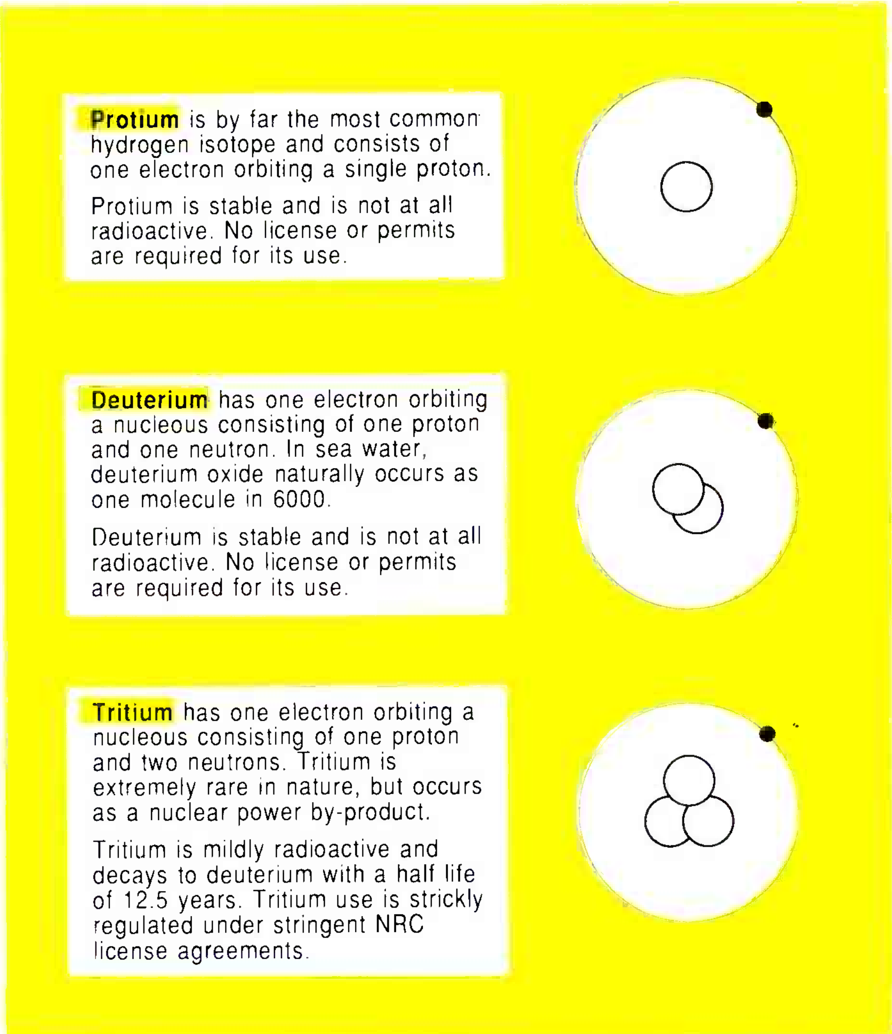


FIG. 2—ISOTOPES ARE VARIATIONS on an element that will have different atomic weights but largely identical chemical properties. The three isotopes of hydrogen are shown here. The Deuterium isotope gets used in the cold fusion experiments, initially in the form of deuterium oxide or "heavy water."

Hindenburg. Obviously, hydrogen reacts very violently with oxygen to create water in the form of superheated steam. That can range from a rapid burning to a major explosion. The combustibility range of hydrogen is far greater than that of most other gases.

The tiniest, weakest spark of static electricity is all you need to set it off. Just to make things even more interesting, hydrogen usually burns with a *totally invisible* flame, so you never know where the incredibly hot fire front is. In a haz-mat incident, a fireman will tie a rag onto the tip of his pike pole and use it, Knights-of-the-Round-Table jouster style to find out where the edge of the fire is.

Isotopes

The very term *isotope* may sound radioactive and dangerous and sneaky and illegal and scary, but an isotope is simply any variation on an atomic theme, much as a book can have either a red or a blue cover. An isotope is a variation on an atom that still retains identical chemical properties. Alike but different.

As Fig. 2 shows us, atoms in plain old hydrogen consist of a heavy positively charged proton that gets orbited by a light and a fast moving negatively charged electron satellite. A different name for this type of hydrogen is *proteum*. Proteum is far and away the most abundant form of hydrogen usually available.

There are lots of other particles that can go into any atom. One very common particle is called a neutron and can be thought of as a combined proton and electron having a zero net electrical charge and a mass slightly larger than a proton.

If you add one new neutron to a proteum nucleus, you'll end up with an isotope of hydrogen that's known as *deuterium*. Deuterium is an isotope of hydrogen with one electron, and a nucleus consisting of one proton and one neutron. Deuterium is just as stable as proteum and is thus more or less just as permanent.

Add a second neutron to your nucleus, and you pick up a hydrogen isotope known as *tritium*. This one is somewhat radioactive, in that tritium could emit beta particles (electrons) and decay into deuterium. Tritium has a half life of 12.5 years.

The most common form of hydrogen, of course, is in the molecules of ocean water. Ordinary water consists mostly of proteum. Around one water molecule in 6000 contains deuterium, and an extremely rare one might contain tritium.

These special deuterium molecules are called *heavy water*, and, as we've just seen, will usually occur in nature around one molecule in 6000. The chemical name for heavy water is *deuterium oxide*.

Heavy water or deuterium oxide is *not* radioactive. It is just as stable as ordinary water. And, no, you don't need any sort of a license to make, buy, or use heavy water.

The important uses of heavy water include use as a moderator in a nuclear power plant, and as special *indicators* for chromatography, spectrum analysis, and radiography. Since the indicators have to be extremely pure, they can be quite expensive—say, $30 for a 50 milliter flask.

You can easily make up your own heavy water, although not cheaply or quickly. Proteum disassociates much faster than deuterium, so you simply run your electrolytic cell "still" in Fig. 1, while continually pouring in fresh water. After a 100,000:1 reduction in the volume, any remaining water will end up as nearly pure deuterium oxide.

Today, though, most heavy water gets produced as a by-product of the pollution control industry. Hydrogen sulfide is a

NAMES AND NUMBERS

Advanced Imaging
210 Crosswys Park Dr
Woodbury, NY 11797
(516) 496-8000
BNF Enterprises
119 Foster Street
Peabody, MA 01961
(508)531-5774
Buckbee-Mears
245 East Sixth Street
St. Paul, MN 55101
(612) 228-6400
C&H Sales
2176 E. Colorado Blvd.
Pasadena, CA 91107
(80) 325-9465
Computer Shopper
5211 S. Washington
Titusville, FL 32780
(407) 269-3211
Hall-Mark Electronics
11333 Pagemill Drive
Dallas, TX 75266
(214) 343-5000
Meredith Instruments
6403 N 59th Avenue
Glendale, AZ 85301
(602) 934-9387
Microphoto, Inc.
6130 Casmere
Detroit, MI 48212
(313) 366-5669
Motorola
5005 E McDowell Road
Phoenix, AZ 85008
(602) 244-6900
National
2900 Semiconductor Drive
Santa Clara, CA 95051
(408) 721-5000
Samsung
3725 North First Street
San Jose, CA 95134
(800) 669-5400
Shreve Systems
2421 Malcolm Street
Shreveport, LA 71108
(318) 635-1121
SMT Nutshell News
IPAC
Los Gatos, CA 95030
(408) 354-0700
Sprague
115 Northeast Cutoff
Worcester, MA 01615
(508) 853-5000
Synergetics
Box 809
Thatcher, AZ 85552
(602) 428-4073
Thomson Components
1310 Electronics Drive
Carrollton, TX 75006
(214) 466-6000

nasty, odorous, and toxic gas that smells like rotten eggs.

When you react H_2S with water, a heavy-water extraction can result. In fact, there is a total glut in the heavy water market today. If you aren't real fussy over the purity and buy it in large enough quantities, deuterium oxide costs only a dime a gallon.

So, at least one of our key ingredients of cold fusion is essentially free. And the other one, while rather expensive, appears to be totally reusable.

Fission and Fusion Reactions

What gets interesting fast is that you can convert matter into energy and vice versa. Einstein's $E=MC^2$ and all that good stuff.

In theory, there are two ways you can play the game. You can blast apart a big atom and split it up into smaller ones. This is called nuclear *fission*. The classic example of that is an atomic bomb.

As anyone from Chernobyl might tell you, or anyone that owns WPPS bonds or any Public Service of New Hampshire common stock, nuclear-fission energy sources simply do not work, owing to their incredible and monumental hidden societal costs. I personally feel that all of the nuclear power plant waste products in this country should be permanently stored in the reflecting pool at the Lincoln Memorial, as a fitting and long lasting tribute to both government folly and industrial greed. (By the way, there's a really great "sleeper" video rental known as *The Atomic Cafe*. Do watch it sometime. Great acting ... only it isn't.)

At any rate, you can also go the other way and take two small atoms and hold them together long enough for them to fuse together into one bigger atom. That also can release great heaping bunches of net energy. This is called nuclear *fusion*, just as in the sun or a hydrogen bomb.

In theory, there is enough energy in the diluted deuterium atoms that are present in an ordinary teacup of water to exceed the energy of a tank of gasoline. And also in

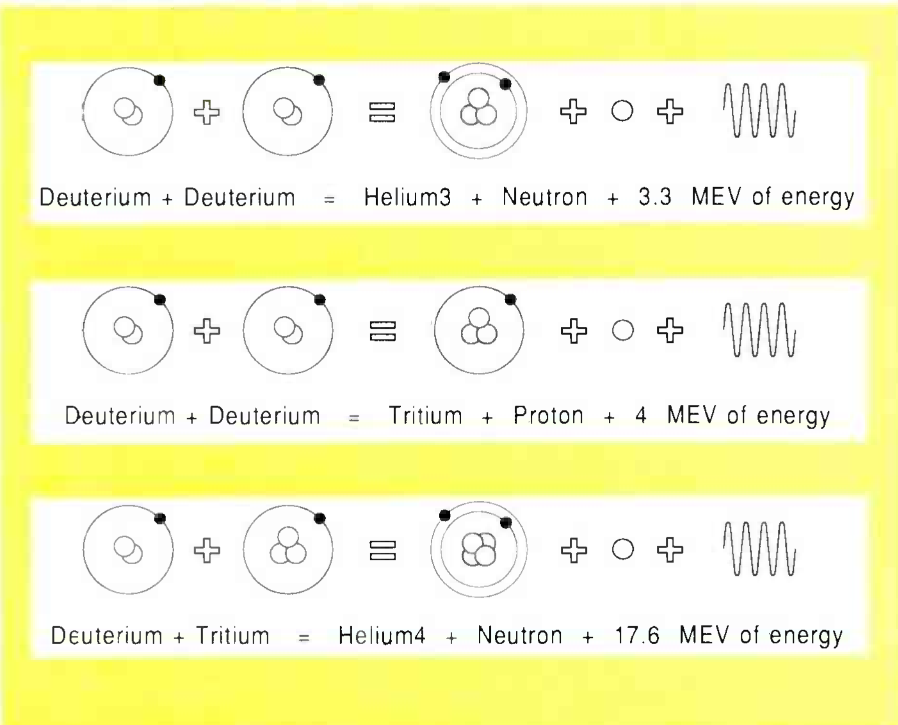


FIG. 3—ATOMIC FUSION generates energy by combining smaller isotopes into larger ones. Here are three key fusion reactions.

theory, the fusion reactions should be very much more manageable and have far fewer undesirable byproducts.

Naturally, there is no such thing as a completely non-polluting energy, for the entropy of any energy release by itself leads to the ultimate and inescapable heat death of the planet.

And, just because something works in the lab does not mean that it can be made to generate enough excess power to pay both for itself and the interest on the money used to finance the project. And especially if all the non-obvious and hidden costs are fully taken into account.

For instance, if someone gave you all of the four-percent-efficient solar cells you wanted absolutely free, you still could *never* generate any useful amounts of saleable power with them, because the returned energy would never be able to pay for the land, the physical structure holding the cells, the associated electronics, and all the interest on the financing capital.

But, if used conservatively, efficiently and responsibly, a cold fusion process would appear, on the surface, to be somewhat comparable to solar as a potentially clean and low-cost source of renewable energy.

More important to all us hackers, there doesn't seem to be any really compelling economics of scale that apply to cold fusion. The small and decentralized home power plants just might end up as viable as the big centralized ones. Possibly even vehicular generators for your car.

Three of the more interesting fusion reactions are shown to you in Fig. 3. In the first two cases, you grab two deuterium ions and hold them together. In one possible reaction, you will obtain the isotope helium-3, a neutron, and 3.3 million electron volts of energy. Helium-3 is a stable, non-radioactive, and a very rare isotope of this inert gas. In a second possible reaction you end up with tritium and 4 million electron volts of energy. At very high temperatures, those two fusion reactions are equally likely to happen.

You can also fuse a deuterium

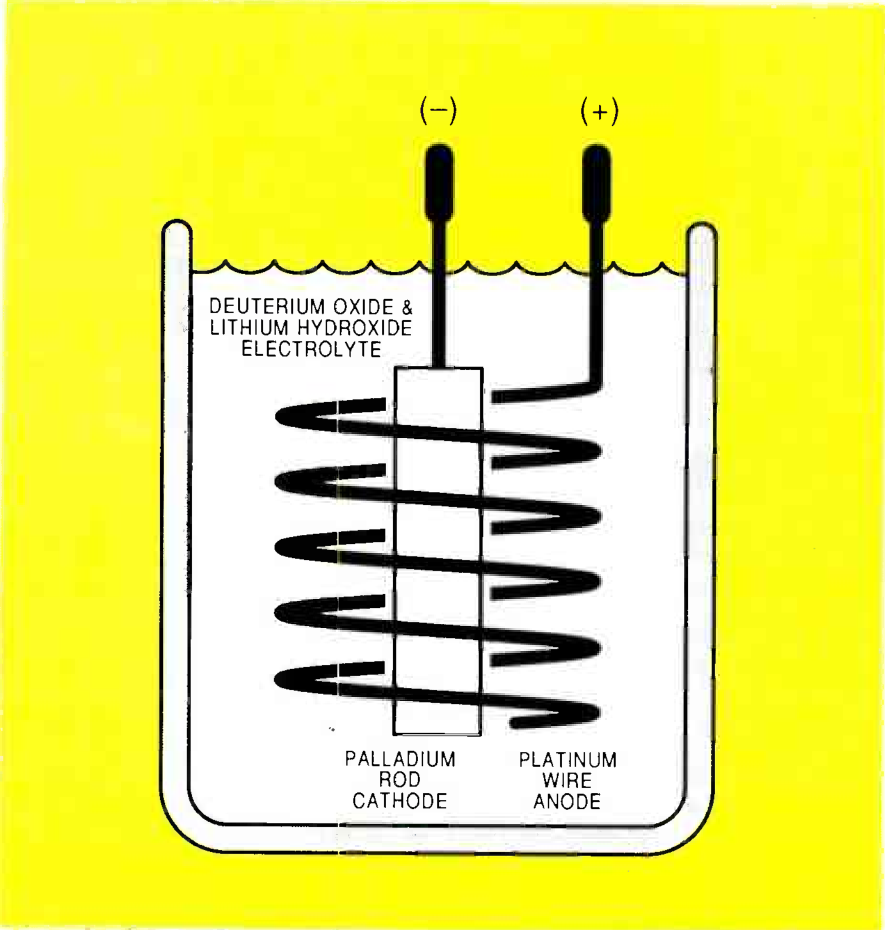


FIG. 4—COLD FUSION appears to be produced in this experimental electrolytic cell.The heavy water dissociates into deuterium and oxygen ions. The deuterium ions will migrate to the palladium cathode where many of them become trapped in its crystalline structure. Some of the later arriving deuterium ions apparently cold fuse with the trapped ones, apparently producing both heat and at least a few of the expected fusion by-products. But it is far too soon to tell for sure.

ion and a tritium ion together to create the plain old helium-4 found in your nearest balloon, one neutron, and a whopping 17.6 million electron volts of energy.

The only tiny little catch is that all those deuterium ions don't like each other very much. In fact, they will violently repel each other if you try to get them within atomic distances of each other. Big science with a capital "S" has already blown zillions of gigabucks over several decades in a so-far futile attempt to super-heat and super-energize deuterium ions so that they will fuse and then produce a net useful energy.

The Cold Fusion Cell

The reasoning behind cold fusion is very simple. Instead of raising the temperatures and energy levels of the deuterium ions to the point where enough of them will become energetic enough to collide with each other, you instead try to trap those deuterium ions inside of a crystal lattice. Putting them in jail, so to speak, so they can't run away. Like shooting fish in a barrel.

Palladium is a quite interesting candidate for cold fusion. Palladium can absorb as much as 900 times its own volume in deuterium atoms.

Palladium is a transition metal of atomic number 46. It is a metal that sees wide use for electronic contacts, dental alloys, and surgical tools.

The pre-announcement pricing of palladium was in the $150 per troy ounce area. It is up around $175 as of this writing, owing to speculation.

Figure 4 shows you the cold fusion cell as it was used in the initial experiments. A platinum wire gets used as an anode and a palladium rod, typically 4 millimeters or so in diameter is used as the cathode. The cell gets filled with heavy water. A pinch of lithium hydroxide is added to improve the conductivity, and DC starts the action.

This is an electrolytic cell, just like Fig. 1. So, the oxygen ions go over to the platinum cathode and boil off. The deuterium ions then go to the palladium cathode and many will get trapped inside. After a few weeks of buildup, the new deuterium ions seem to end up clobbering all the old ones trapped in the structure, and will apparently begin cold fusion. The observed effects include emitted neutrons, the detection of tritium, and the detection of that extremely rare helium-3 as would be expected in an ongoing nuclear fusion reaction.

More interesting, heat energy is produced in several setups, typically raising the cathode temperature to the 176°F range.

Measurements of the output energy appear to exceed the electrical input used for the dissociation by a factor of 4.5. That energy density appears to be nearly ten times greater than what could be explained away by a normal chemical reaction.

But mysteries remain. There aren't nearly enough neutrons getting produced to justify the amount of heat that is generated. In fact, for the heat generated, the number of neutrons which should have gotten produced should have killed every one of the researchers outright. The apparent shortfall of neutrons is around one billion to one. Which misses by more than a country mile.

There are at least three possible explanations for the excess energy so far: (1) Those two deuterium fusion reactions may not be equally likely at room temperature, and that tritium product reaction is highly favored; (2) A new and a previously unknown atomic reaction is taking place; or (3) Something really stupid (and totally useless) is really going on instead.

If I look into one of my Haz-Mat books, I'll find that palladium reacts violently with hydrogen and alcohol. So if a grad student spilled beer into one of those cells as a prank, it just might distort the results.

Nonetheless, the produced energy seems to far exceed any reasonable chemical reaction. Time will tell.

Getting Started

First, let's repeat some safety stuff. Hydrogen explodes. It does so very violently and sometimes invisibly. The cold fusion can produce neutrons in varying quantities that, if everything went wrong, could prove quite deadly. Dosimeters of one style or another should be essential. Random apparatus explosions have also been reported. One burned concrete.

You also just might want to skip mentioning to the local zoning folks that you are busy building miniature hydrogen bombs in your carport.

There is also the credibility factor. Make certain that your experiment works several times and others have in fact reproduced it before you loudly proclaim it to the world.

Second, get both the key papers mentioned above. Then look into the sources and resources shown you in the "Cold Fusion Resources" sidebar. We've already seen how the *Journal of Analytical Chemistry* and *Nature* should contain the key horses mouth papers. They are certain to have lots of follow-up letters, experiments, and newer papers as well.

Two other important places to find ongoing information on cold fusion are *Science* for the technical details and *The Wall Street Journal* for any economic and business aspects.

One key library tool should be the *Science Citations Index*, which lets you take all the horse's-mouth names and then move then forward through time. Rest assured there'll be nothing useful published on cold fusion that does not mention Stanley Pons name at least a dozen times.

Two essential background texts are *The Handbook of Chemistry and Physics*, and the "Matter" volume from *The Life Science Library*. If you do not already own those two books as part of your personal library, you should not even be thinking about experimenting with cold fusion.

The sidebar also shows you all the usual places to go to get deuterium oxide, platinum wire, and palladium rods. Unfortunately, the two heavy water sources I was able to dig up on such short notice are quite expensive indicator-grade materials.

So, for our contest this month, just tell me about a cheap quantity source of heavy water. There will be all the usual *Incredible Secret Money Machine* book prizes for the first dozen entries, along with one all expense paid (FOB Thatcher, AZ) tinaja quest for two going to the best of all.

Be sure to send all of your contest entries directly to me, and not over to the **Radio-Electronics** editorial offices.

Above all, keep us informed on all your cold-fusion progress. For once in a lifetime, the individual hardware hackers seem to have been given a more or less even playing field to run on. See that big "H" over there?

New Tech Literature

Meredith Instruments has a new hacker catalog out. Their laser tubes start at $35, and they have a new light show BBS on line at (602) 867-7258.

Two other surplus catalogs that did come in today's mail included BNF Enterprises for cheap audio, optics, and electronics; plus C & H Sales for raw iron steppers, motors, hydraulics, valves, and optical assemblies.

Two new free trade journals this month are *Advanced Imaging* on high-end video systems and support, along with the *SMT Nutshell News* on that covers surface mount technology.

Since we seem to be doing things by twos here, this month's data books include that new *Communications Products* data book from Thomson Components on modems, telephone chips, digital signal processing, and A/D converters; and the *CMOS Programmable Logic Data Book* from the Samsung folks.

Two additional sources for photo-chemical machining include Buckbee Mears and Microphoto Inc.

Sprague has a new data sheet on their ULN3800A FMX stereo de-

continued on page 85

LIGHT BEAM

continued from page 55

mounted, you must install the lenses. The receiver uses a 6-inch fresnel lens with a 7½-inch focal length (the ridged side faces out). The transmitter uses a 2.345-inch positive convex lens, with a 6½-inch focal length (the curved side faces out). The lenses are held in place inside the tube with rolled-up paper while the black RTV silicone glue dries.

Alignment

The following procedures will help you align your light-beam communicator so that you can achieve the greatest possible communication range. To align the transmitter's LED, turn it on and shine it on a white wall at a distance of 10 feet. Set the three adjusting screws so that the light is concentrated in the center of a halo.

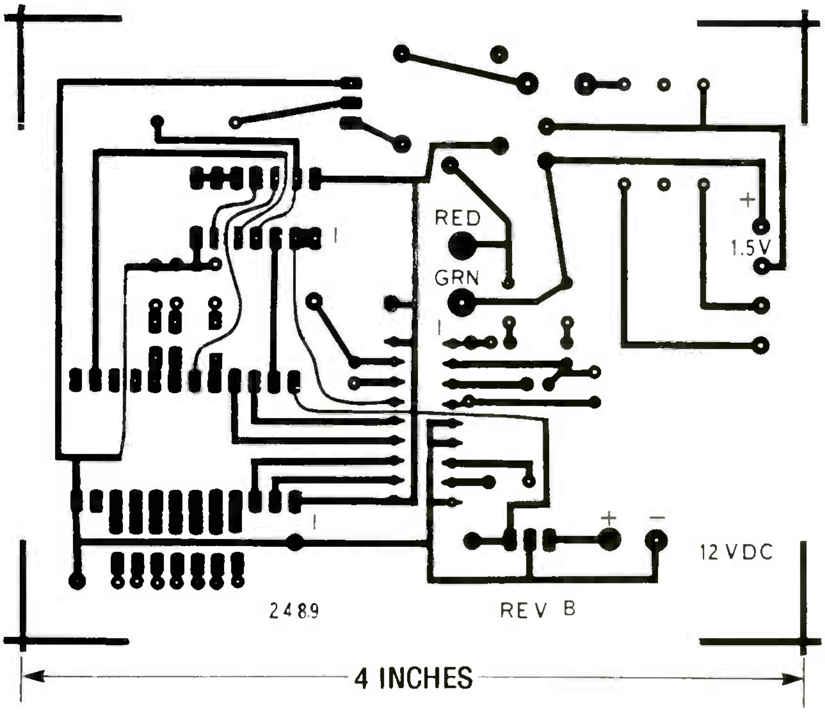
As for the receiver, the only thing you have to do is align the pivoting mirror so that when it is in the "in" position, the light beam from a transmitter bounces straight off the mirror back to the transmitter. For long-distance communication, proper alignment is essential. When trying to set up a communication path at ¼ or ½ mile, the light reflected back from the receiver's mirror is a sure sign that everything is set up properly.

You can align the mirror by aiming the transmitter at the receiver with the mirror in place, and the red dot of light reflecting off the mirror should appear in the center of the fresnel lens. (To locate the dot, switch the mirror in and out of position; the extra dot will appear and disappear.) If it needs aligning, just carefully bend the mirror bracket into position.

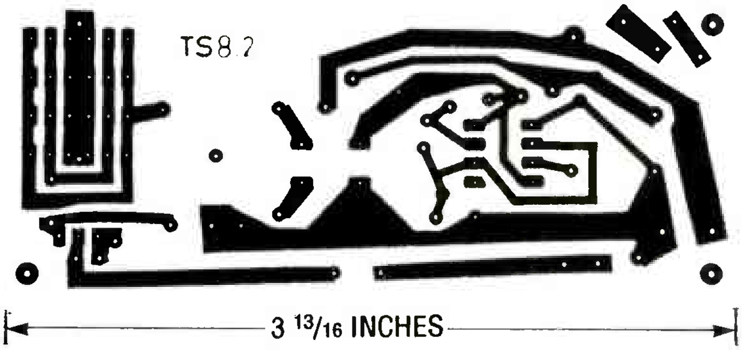
A completed light-beam communicator should also have both its transmitter and receiver aligned with one another. Just aim the communicator at a nearby wall, and you should see the light spot in the viewfinder of the receiver. Adjust if necessary.

There are a lot of other "fun" uses for the light-beam communicator besides two-way communication. You can "listen" to an airplane flying overhead, or to waterfalls, waves, and sprinkler systems. Car headlights going past you also have their own sound. If an insect flys through another unit's light beam, you can actually hear its wings beating. **R-E**

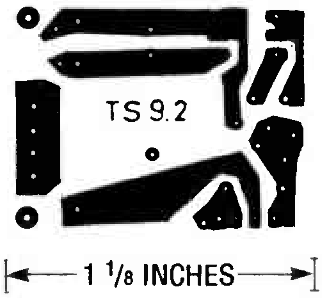
PC SERVICE



MUSIC-ON-HOLD ADAPTER FOIL PATTERN.



OSCILLATOR/DRIVER FOIL PATTERN



NI-CD-CONVERTER FOIL PATTERN

VOLTAGE-REGULATOR FOIL PATTERN.

AUDIO UPDATE

Frequency response: What do the numbers really mean?

LARRY KLEIN,
Audio Editor

WHILE THEY MAY HAVE QUESTIONS about the finer points of power ratings or distortion, your average audio consumer believes that he knows what frequency response is all about. After all, the human ear ideally can hear from 20 to 20,000 Hz and, therefore, the frequency response of a component should be at least that wide—or, to be safe—somewhat wider. Some audiophiles are followers of the "DC-to-light" school of frequency response; they believe that for accurate reproduction of program material within the audible range, an amplifier must have a response that extends from the low infrasonic (or 0-Hz) region to the megahertz area.

For theoretical and/or promotional reasons, a number of amplifier manufacturers find it worthwhile to advocate ultra-wide bandwidth, and there's no lack of preamps and amplifiers designed with that in mind. I won't go into the pros and cons of wide vs. narrow, except to point out that in respect to program material, the spectrum above 20,000 Hz and below 16 Hz or so is occupied only by noise. It is worthwhile to extend amplifier response an octave or so above and below 20 and 20,000 Hz to ensure proper performance *within* the audio band, but those who design for much wider response are likely to engender more problems than they solve.

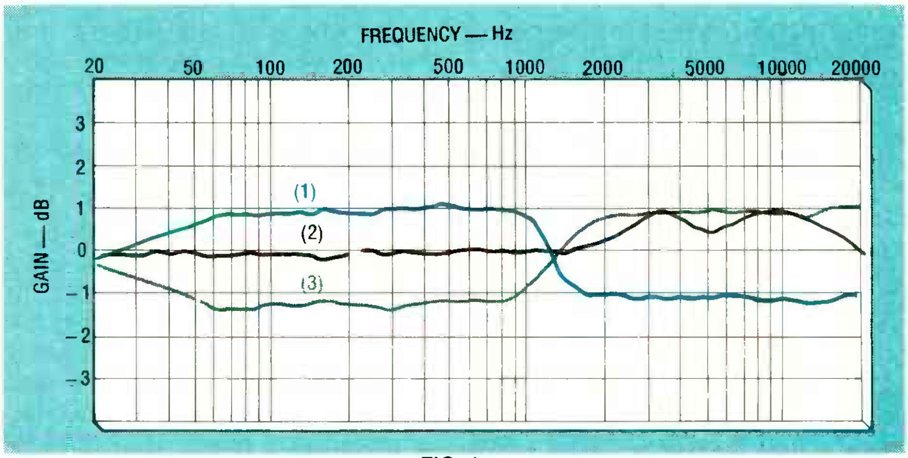


FIG. 1

Audible aberrations

A component's specific frequency response within the audio range determines its sonic "character." And I'm convinced that the esoteric sonic qualities discussed in tedious detail in the "underground" press mostly result from essentially minor frequency-response variations. For example, the special "openness, air, and inner detail," heard from some highly regarded and *very* expensive moving-coil phono cartridges can easily be traced to their rising response above 10 kHz. Eliminate the high-frequency peaks, and the mysterious special sonic qualities disappear.

Most sounds, including those produced as music, consist of fundamentals and harmonic overtones. The characteristic harmonic structure of the notes produced by each musical instrument is responsible for its specific tonal qualities. Any changes in the relative strengths of the fundamental or harmonic frequencies caused by frequency-response dips or peaks in the recording or playback equipment are going to affect a listener's perception of the reproduced sound. You can easily demonstrate this for yourself by bringing your ear close to the midrange of a three-way speaker system. On music or vocals, you'll hear a sort of nasal, honky quality that is typical of emphasized midband frequencies. Of course, if a speaker has built-in midrange emphasis it will also sound that way when listened to from a normal distance.

Frequency responsibilities

Here's a rough breakdown of the audible effects of specific frequency-response peaks and dips. Some of these frequency-determined effects are probably obvious, but a few may surprise you. Starting with the low frequencies, true low bass occurs below 50–60 Hz, and most smaller speaker designs have difficulty getting down that low.

However, engineers discovered long ago that a response bump around 70 Hz or so is easy to achieve and gives the illusion of real bass without unfortunate audible side effects. However, if the bump extends to 100 Hz or higher, the sound becomes bottom-heavy or boomy.

Lack of warmth or excessive muddiness is produced by, respectively, too little or too much energy around 200 Hz or so. In the 500-Hz area, where the piano, tenor sax, and woodwinds produce maximum energy, bumps or dips can emphasize or deemphasize the instruments.

Even more musical energy is concentrated in the 1-kHz to 4-kHz area, which is also where the human ear has maximum sensitivity. A boost in that range tends to bring the sound stage forward; a dip makes it recede. The depth of the sonic image can be affected by response in the 4-kHz range because much of the recorded reverberation—which the ear interprets as depth—occurs in that area. A boost at 8 kHz (such as was designed into a best-selling late-60's "monitor" speaker) produces a *very* forward, if somewhat shrill, sound. Slight peaks are heard as "glassiness." Any response rise above 10 kHz is interpreted as enhanced "air, openness, and detail."

Interpreting the curves

For years, audio writers have warned readers that a specification such as "Frequency Response: 20 Hz to 20 kHz" is worthless without a qualification such as ±3 dB. Sorry to say, even if the specified tolerance were ±1 dB, the description would still be worthless as a guide to the *audible* sonic balance of the product involved. Figure 1 depicts audio-frequency graphs with (1) a curve that is up 1 dB from 50 Hz to 1 kHz and down 1 dB from 1,500 Hz to 20,000 Hz, (2) another curve that is the reverse of (1), and (3) a curve that has broad 1-dB peaks at 3 and 8 kHz. My point is that all three curves can be legitimately described as being ±1 dB from 20 Hz to 20 kHz—but to a careful listener, all three will sound quite different on wide-range music.

I don't mean to imply by the above examples that frequency-response bumps, valleys, peaks, and dips can appear randomly in the performance of an audio system. Each component has its own typical response aberrations. For example, cassette decks tend to roll off the high frequencies—the cheaper the deck, the lower the rolloff starts. In addition, almost all cassette decks have low-frequency "head" bumps—mostly under 50 Hz—that may or may not be audible. Power amplifiers are usually ruler-flat for at least an octave above and below the audio band.

Unlike those of 15 years ago, the phono sections of today's better preamps conform to the RIAA curve to within 1 dB, as do most of today's better phono cartridges. However, cheap phono cartridges tend to have resonant peaks just above 10 kHz and some expensive moving-coil types rise rapidly above 9–10 kHz. In the last several years, FM tuners appear to have eliminated the audible high-frequency rolloff that's caused by the 19-kHz filters in their multiplex decoders.

It should come as no surprise to read that the resonance problems of speakers are the major cause of frequency-response aberrations in most systems. In poorly designed systems, you'll find low-frequency peaks ranging from 80 to 110 Hz, midrange and tweeter resonant peaks, plus a high-frequency rolloff above 11 or 12 kHz.

Well-designed speakers manage to minimize or eliminate such problems, but even the best speakers must operate in a listening environment with its own acoustic characteristics.

One last word: Recent psychoacoustic research has shown that small, smooth rises in response covering several octaves are far more audible than high, narrow peaks—and that rises, in any case, are more audible than dips. The ear's greater sensitivity to small-amplitude, wide-band boosts is easy to explain on the basis that they contain more musical energy than large but narrow peaks. However, I have no theory to explain why a peak in response is more audible than an equivalent-amplitude dip. **R-E**

DRAWING BOARD

PC boards

ROBERT GROSSBLATT,
CIRCUITS EDITOR

IN LOOKING THROUGH THE COLUMNS that have appeared in the past couple of years, I realized that we've developed some fairly complex circuits. But we've never talked about putting the final touch on a circuit—that is, of course, generating printed-circuit boards.

PC boards can be anything from simple single-sided ones for small projects to complex multi-layer affairs for digital designs. And, unfortunately, while there's really no limit to the complexity of a circuit that you can develop on your bench, the same isn't true of PC boards. I've been making PC boards for years, and despite some really creative (and occasionally off-the-wall) attempts, I've never managed to do more than two layers (a double-sided board), produce plated-through holes, or route more than one trace between IC pins.

The bright side to all that, however, is that there's always more than one way to do a job, and we'll be spending the next few columns on the methods and tricks you can use to produce PC boards on your own.

To start with, all PC-board production can be broken into three basic jobs:

1. Designing the layout.
2. Producing the artwork.
3. Fabricating the board.

Each of those areas has its own set of hassles, and just how painless each one will be depends on how you go about doing it. The last couple of years has seen the appearance of computer software that makes a lot of the work much easier—if you've got the necessary hardware and the bucks.

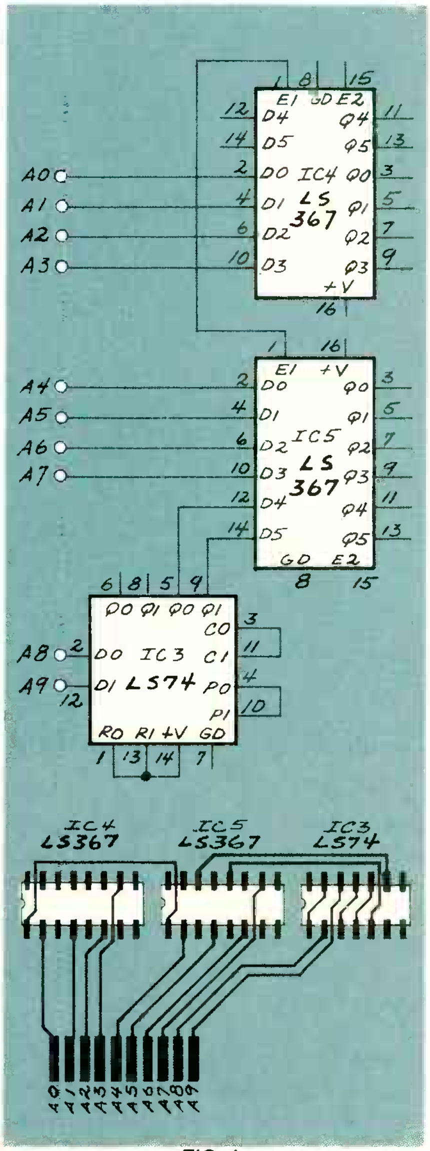


FIG. 1

Computer Aided Design (CAD) is great stuff but the software will only do what you tell it to do. How successful you'll be using CAD depends (to a large degree) on how much experience you've had producing boards by hand. Some things can be learned only by manually producing a PC board. But the basic principles are the same whether you're doing it by hand or if you're lucky enough to have the required CAD equipment.

Designing the layout

This first step must never be started until you're sure that the circuit design is finished. After all, there's a lot less brain damage involved in moving wires on a breadboard than adding and removing traces on a PC board.

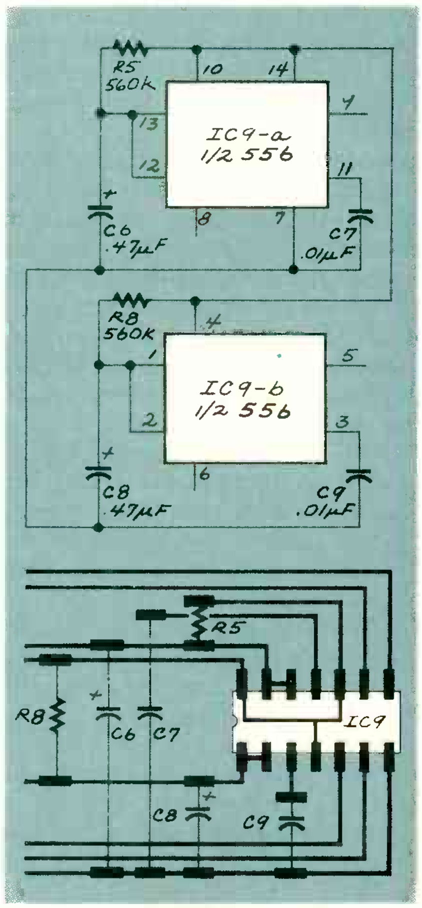


FIG. 2

Don't even think about starting a layout unless you have an up-to-the-minute set of schematics for the circuit. (Few things are worse than producing a board that's a faithful reproduction of an incorrect schematic.)

Once you're ready to lay out the board, make sure that you have these supplies:

1. A non-repro-blue pencil.
2. A pad of ten-to-the-inch graph paper.
3. A ruler (ideally marked in tenths of an inch).
4. A pair of dividers.
5. An eraser (because nobody's perfect).

Graph paper marked with a ten-to-the-inch grid is an ideal background for laying out a board, since most standard components are designed around that measurement. Make sure that the paper is at least four times larger than the board you're planning to lay out, because it's always a good idea to work at twice the actual size (and by the time you're ready to lay out your board you should have *some* idea of its size and shape). Working double size is not so important for simple layouts; but complex layouts require routing traces between IC pins, which is just about impossible to do on a one-to-one scale.

The first things to put on a board are those that require certain locations—such as edge connectors or headers. The placement for the rest of the components is usually dictated by the placement of those first components. Figure 1-*a* shows how the edge connectors are connected directly to a series of buffers. It follows, therefore, that the buffers have to be located close to the edge connectors (Fig. 1-*b*). The chances are that you'll be moving things around the board as the layout develops but at least it gives you a starting point.

Component placement can also be made a bit easier by examining the schematic and breaking the circuit into component groups - those that share common connections, components that hang on a particular bus, and so on.

Translating lines on a schematic to traces on a board is a slow and tedious process. You get better at it as you gain more experience, but it's still going to take a lot of trial and erasure to get everything connected on the board. Every board layout is unique, but there are standard ways of handling certain designs that can make life much easier.

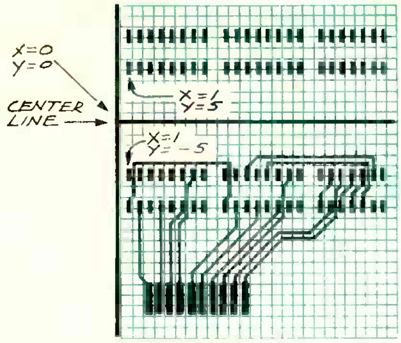


FIG. 3

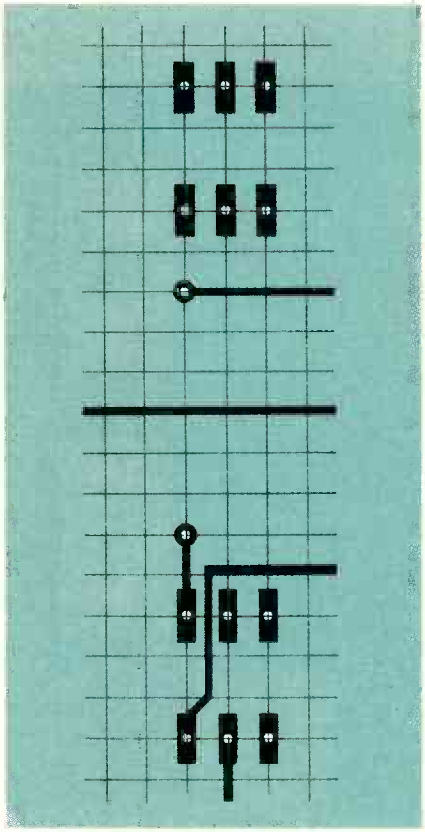


FIG. 4

If you have an IC with lots of passive components hanging off the pins, the board layout can be considerably simplified by using what I've officially designated the "ladder" approach, as illustrated in Fig. 2. We're looking at a pair of monostables built from the two timers in a 556 (Fig. 2-*a*). In order to connect the passive components, the IC pins have been connected to a series of parallel traces that are straddled by the passive components (Fig. 2-*b*).

That's a really simple way to get the job done, and just about the only time you'll run into trouble is when you're limited in board space or if you have to keep the traces as short as possible. You can see in the illustration that the more IC pins, the wider the collection of traces, so you may have to move the traces closer to the IC if you have to conserve trace length.

During the initial layout stages, you're drawing the traces with the blue pencil and there's really no consideration of the final width of the copper trace on the board. But trace-width is not usually a major factor in most layouts, because a 1/16-inch trace on one-ounce copper board (the most common material) can carry as much as 5 amps. If you do want a wider trace, just leave room for it as you do the layout. You won't be putting any actual traces on the graph paper until you've finished the layout

And you'll wear down a lot of the eraser before that happens.

As you continue adding traces with the blue pencil, there will come a time when you're faced with the untraceable trace—you just won't be able to make the connection. That's when you have to decide whether to use jumpers or make the board double-sided. It's a major decision, because producing a double-sided board is a real pain in the neck. Jumpers may be slightly less than elegant, but the brain damage involved in doing double-sided boards at home is considerable; and generating a double-sided layout just to avoid a handful of jumpers is not what you would call a wise decision.

If the density of the board is such that you *have* to make it double-sided, you're going to have to keep track of both sides of the board on the same piece of graph paper.

To do that, draw a horizontal line down the middle of the graph paper and use the dividers to copy the component pads to the other half of the paper as shown in Fig. 3. What you're really doing is unfolding the board using the horizontal line as the center point. It's really important to transfer the pad locations exactly, and it's much easier

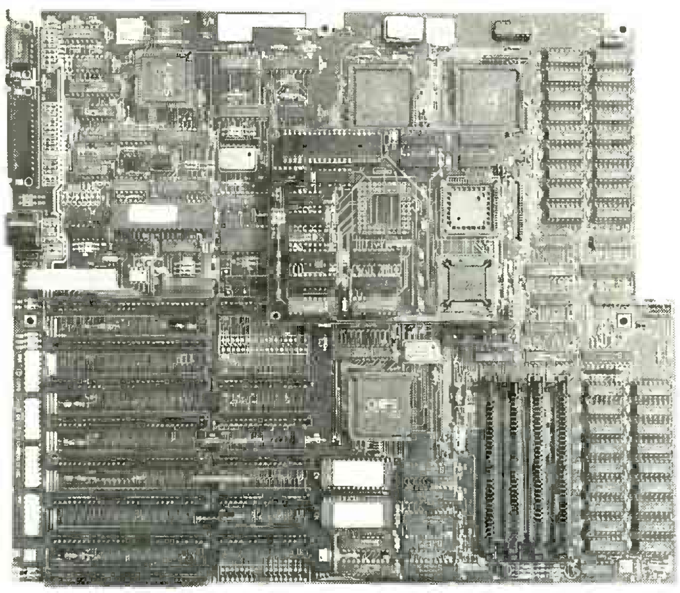
continued on page 85

BUILD AN 80386SX MOTHERBOARD

Part III

BERNARD A. McILHANY

It's time to finish buildng our 386SX motherboard; it's also time to get the thing up and running!



Last month we had finished putting all of the IC's on the motherboard in their respective sockets. We continue now with the daughterboard, but first...

If you are building the board without the 80386SX daughtercard, plug an LCCC socket into the 68-pin PGA socket (IC57), install the 80286 microprocessor, and proceed to the "Configuration" section of this article. Otherwise build the daughtercard now.

80386SX daughterboard

Solder the capacitors and resistors in place following the Parts-Placement diagram shown in Fig. 3 and the Parts List. You can see an assembled daughterboard in Fig. 4.

Install the IC sockets, orienting pin 1 properly. Pay close attention while installing the PLCC and the quad-flat-pack sockets.

Last, carefully insert the square 68-pin standoff header.

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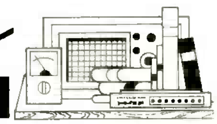
EDITOR'S WORKBENCH



JEFF HOLTZMAN

Report from Comdex

Chicago was host to Spring Comdex this year. The show was subdued compared with other years; even so, a number of innovative products were introduced (or at least shown), and several announcements were made that promise to have lasting impact on the PC industry.

The biggest news is Intel's new microprocessors. Starting at the low end, the company now supplies a low-power version of the 386SX; you can bet that laptop and portable manufacturers will scramble to incorporate it into new designs.

Moving up a notch, the maximum speed of the "real" 386 (now known as the 386DX) has been bumped from 25 MHz to 33 MHz. You probably won't want to play Asteroid Adventures at that speed, but if you're doing CAD, desktop publishing, circuit simulation, or need a fast LAN server, look to AST, ALR, and others for the new speed kings.

Probably the biggest news is Intel's new 486. You might be surprised to learn that it doesn't represent a radical new architecture or anything of the sort. Rather, it's really a more integrated version of the 386. Specifically, it includes an enhanced version of the 386 engine, an enhanced version of the 387 math coprocessor, a memory-management unit, a cache controller, and an 8K memory cache. The 486 is completely object-code compatible with the 386 (hence with the 286 and the 8088/86).

Because of its high degree of integration, Intel states that the 486 performs three times faster than the 386 when both are running at the same clock speed.

Another factor that contributes to the 486's high speed is the incorporation of RISC (Reduced Instruction Set Computer) design techniques, so that some instructions run three to four times as fast as on a 386.

As for clock speeds, 25- and 33-MHz versions are planned. The 25-MHz units should be available in quantity by the end of this year, at which time samples of the 33-MHz version will become available. Unbelievably, 40-, 50-, and even 60-MHz versions are planned.

How much longer do you think you're going to be able to nurse that aging XT along?

Fig. 1. *TURBO PC/AT CHIP SET offers a complete logic complement to 286 and 386SX personal computers. It features 4-way page interleaved memory controller, 16-MHz system clock with zero wait state, and supports LIM/EMS 4.0 protocol/hardware standard.*

The 286: down but not out

Like some creature from a horror film, the IC that Bill Gates (chairman of Microsoft) called "brain-damaged" refuses to die. Intel refused to grant licenses to build 386's to other vendors, so those vendors went about improving the 286. Harris Semiconductor, in particular, brought out a 20-MHz version of the chip last fall, and now has introduced a 25-MHz version. The company claims that software can run 20% faster on a 25-MHz 286 than on a 386 running at the same speed.

Color laptops

They're all Japanese (naturally), none is shipping yet, and they all have fascinating EGA-resolution color displays. Mitsubishi, Hitachi, and Sharp all showed prototypes; IBM is rumored to have one.

Guess who's making chip sets

When you think of Motorola and microprocessors, you probably think of 680x0 systems including the various Macintosh, Atari, and Amiga models, as well as UNIX workstations from Sun, Apollo, Next, etc. Surprise! Now you can start thinking of PC-compatible systems, too. Motorola has formed a strategic alliance with ACC Microelectronics Corporation; the president of ACC, Dr. W. T. Chiang, worked on the 286 and 386 design teams at Intel.

ACC has an interesting product line (from a PC point of view). Their spring catalog lists chip sets for building PC compatibles (XT, AT, 386, and PS/2 Model 30, 50, and 60), not to mention various bus controllers, single-chip floppy controllers, etc.

The highlight of the line is the ACC82020 (shown in Fig. 1), which should give the Chips & Technologies NEAT family a run for the money.

ACC has been designing and marketing products for several years; Motorola adds credibility by second-sourcing the line.

Mega memories

Users are just beginning to switch from 256K to 1MB DRAM's, but Toshiba and IBM are just about ready to start sampling 4MB IC's. By way of contrast, think about the early PC. With four rows of 64K DRAM's, it could hold a maximum of 256K on the motherboard. In a couple of years, that same four rows of IC's will hold 16 megabytes! (Not in the same sockets, of course.)

Don't think you need that much? Maybe. You can boot OS/2

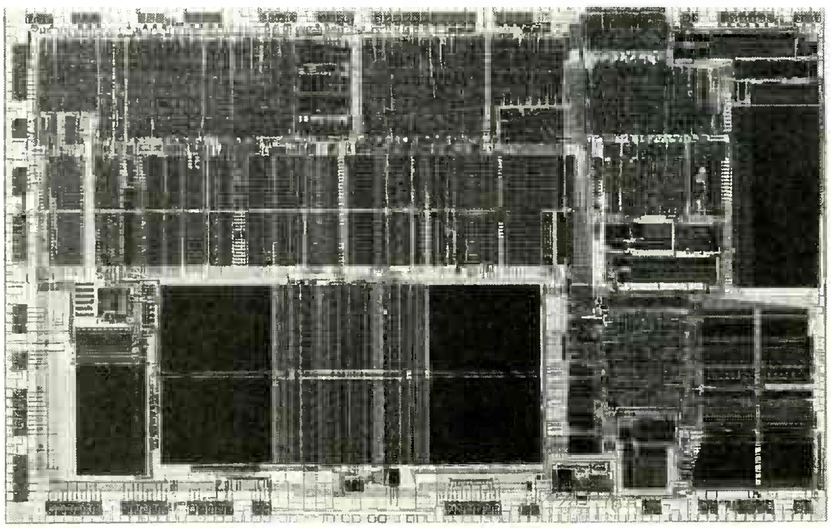


Fig. 2. *THE 486 MICROPROCESSOR packs 1,180,235 transistors into a 0.414-inch × 0.619-inch die. Featuring a high level of integration, it has an on-chip floating-point unit, 8K cache, and memory management with paging.*

ITEMS DISCUSSED

- PC-File:dB ($89.95), ButtonWare, Inc., P.O. Box 96058, Bellevue, WA 98009. (800) J-BUTTON, (206) 454-0479.
CIRCLE 50 ON FREE INFORMATION CARD

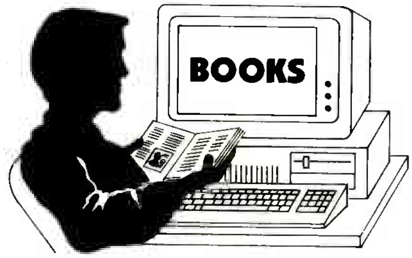
- *On-line With Bitcom* ($39.95), Bantam Books, Bantam Electronic Publishing, 666 Fifth Avenue, New York, NY 10103.
CIRCLE 49 ON FREE INFORMATION CARD

- Hammermill Papers, 6400 Poplar Avenue, Memphis, TN 38197-7000. (800) 242-2148.
CIRCLE 48 ON FREE INFORMATION CARD

in about 1.5MB, but you'll need about 4MB to run any serious software, as users catch on to the joys of multitasking, 6MB, 8MB, even 10MB will be standard.

Favorite database manager

I've used PC-File+ for the past several years; the latest version is called PC-File:dB. The biggest change, as suggested in the name, is that files are now stored in dBASE-compatible format. In addition, the program supports larger files, fields, and records, LAN file sharing, graphics, unique search/sort routines, file conversion (ASCII, comma-delimited, WordPerfect, etc.), and more. PC-File:dB is not a true relational database, but you can link files in reports (with calculated results). The documentation has also improved, the program still sports the same easy-to-use menu-driven interface, and, best of all, the price is still well under $100.



Life On-line

You've been thinking about signing up for an on-line service, but don't know which one. Besides, you don't have a good telecommunications program, and your telecommunications skills are kind of weak. *On-line With Bitcom*, by Bud E. Smith, can solve all three problems with a fell swoop. It's a book/software package that contains a copy of Bitcom 3.6, a coupon for $30 off the subscription price to BIX (Byte magazine's on-line service), and the book itself, which provides a well-written introduction to on-line services.

Topics range from basic program usage to on-line etiquette to terminal emulation to automatic downloading via script files. The author includes a number of script files that allow you to log onto various on-line services automatically.

The package costs less than $40; you simply can't buy a telecom program for that amount, much less a lucid book describing how to use it.

Laser paper

Hammermill Papers has introduced the absolute best paper for laser printing; it comes in two versions. Laser Print is smooth, bright, opaque, and heavy (24 lb.) so it won't jam your printer; Laser Plus has slightly better brightness, etc., and the back side is treated so that you can cut and paste artwork without wax bleed-through.

MOTHERBOARD

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Note that it appears to be a socket, but is actually used on this board as a male connector that will plug into the female socket on the motherboard. Insert the standoff header into the board from the top of the board. Its largest shoulders, about ⅛-inch from its supporting plastic, will rest on the surface of the daughterboard, and will cause it to stand off the daughterboard a bit.

Turn the daughterboard over and you will see that the 68 pins are protruding about half an inch. With the board inverted, carefully solder two pins in opposite corners to the daughterboard. That will hold the standoff header in place while you solder the remaining pins. Keep your soldering iron away from the tops of the pins, soldering only that portion of the pin nearest the board. *Be careful not to bend any pins or to allow solder to flow onto the pins. Solder on the pins could prevent the daughterboard from fitting into the motherboard.*

Insert the IC's carefully into their respective sockets. If you are using the optional 80387SX math coprocessor, don't install it until you have verified the board's operation.

Follow the defluxing instructions, clean the board and then carefully inspect it for solder problems.

Configuration

What we'll describe next is a basic configuration that you can use to get your system up and running. After it is, you can refine the configuration to suit yourself. Shorting jumpers and complete configuration information are supplied with the kit.

W1 is not a configuration jumper, but a connector for an optional reset switch. There is no W2 shunt.

Place a jumper at W3 from the center to the 24M pin. Then place a jumper from the center to the 256K position of the W4 shunt; it selects the size of the BIOS EPROM used on the board.

Now, locate the W5 shunt (near the daughterboard socket) and jumper from the center to the "1" position. Short the W6 shunt with another jumper. W5 provides a clock signal to the floppy-disk controller, and W6 enables it. If you plan to use an external floppy-disk controller (for example as part of a floppy/hard disk controller), you'll have to disable the on-board controller later.

Shunts W7 and W8 are not used at this time, and W9 and W10 have been deleted from the board.

Next is shunt W11, near the 82C605 (IC75). Jumper pin 1 to pin 2, pin 3 to pin 4, and pin 7 to pin 8. These jumpers route interrupt signals from the peripheral controller.

Locate W12 and jumper the middle pin to the pin toward the "W12" label on the board. At W13 (located near the keyboard connector) jumper from the center pin to the pin away from the "1" printed on the board. Shunts W12 and W13 together manage the "power good" signal. Shunt W14, near the 82C206 (IC61) is not used at this time.

Near the 8742 keyboard controller you will see shunt W15. Place a jumper from the center pin to the pin toward the "W15" label. W15 determines how the turbo LED works. *NOTE: Don't plug an LED into W15!*

Last is a connector labeled "SW1" near the 37C65 floppy-disk controller, IC74. SW1 selects color or monochrome operation; install a shunt in the correct position, according to the type of monitor you're using.

Before proceeding, make sure that all the jumpers are installed correctly.

HARNESS THAT 386

The 80386 and 80386SX microprocessors are more than just fast 80286's. With the right software, you can maximize your DOS memory space, perform efficient multitasking, or both.

386^{MAX} is a utility program that taps the microprocessor's ability to physically map memory. With it, you can fill out a 512K motherboard with extended memory; you can load TSR's (SideKick, disk caches, keyboard enhancers, etc.) into memory above the first 640K, leaving 600K or more of contiguous DOS memory; and other tricks.

OMNIVIEW is a multitasking environment that runs on all Intel 80xxx family processors. (See articles in the July and August issues.) With OMNIVIEW you can download information from your favorite BBS while simultaneously typing in your word processor; you can also switch instantly among several tasks.

SunnyHill Software has arranged special 30% discounts off the list prices of OMNIVIEW and 386^{MAX} for readers of **Radio-Electronics.** OMNIVIEW normally lists for $89.95; the discount price is $62.95. 386^{MAX} normally lists for $74.95; the discount price is $52.45. Order both from SunnyHill Software, P.O. Box 33711, Seattle, WA 98133-3711. (800) 367-0651; (206) 367-0650. Be sure to mention this article.

Power-up test

Now plug either the 80286 or the daughterboard into the PGA socket (IC57). There is only one shunt on the daughterboard; it determines whether you are using an 80387SX math co-processor. The position of the jumper will not affect testing of either the daughterboard or the motherboard.

Connect a speaker to the SPKR connector using the two pins nearest the edge of the board.

Plug a power-supply into P6, and an AT-type keyboard into the keyboard connector. If you are using a keyboard with a switch that selects XT or AT operation,

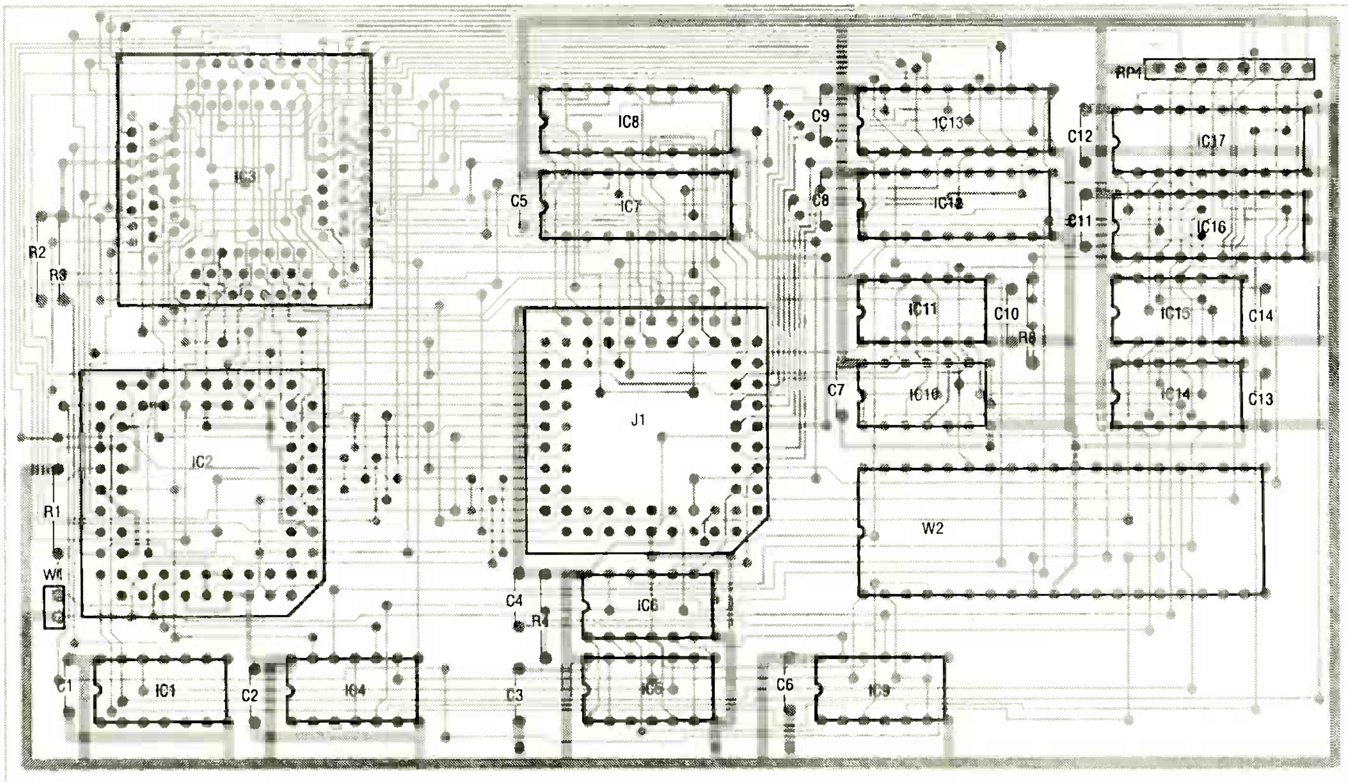

Fig. 3. *DAUGHTERBOARD PARTS-PLACEMENT DIAGRAM.*

PRICE INFORMATION

Peripheral Technology (1710 Cumberland Point Drive, Suite 8, Marietta, GA 30067 (404) 984-0742) is selling parts kits, complete systems, and a variety of peripherals, as follows.

PT386 starter system
Includes the PT386-PLUS KIT, an AT-style cabinet, 200W power supply, 84-key (AT-style) keyboard, 1.2-MB 5.25" floppy disk drive, Samsung amber monitor, Hercules-compatible monochrome text/graphics card with printer port, and MS-DOS 4.01: $1195

Starter system options
For EGA monitor and display adapter, add $400.00; for 20-MB hard-disk drive and controller, add $349; for 40-MB drive and controller, add $485.00; for assembled and tested unit, add $100.

Component prices
- PT386-PLUS-KIT (includes system board, daughterboard, BIOS, 16-MHz 80386SX, and support IC's. DRAM and the optional 80387SX math coprocessor not included), $695
- PT386-PLUS-ASM (assembled version of the PT386-PLUS), $795
- PT286-KIT (same as PT386-PLUS KIT but does not include 80386SX daughterboard. Includes 16-MHz 80286), $465
- PT286-ASM (assembled version of the PT286-KIT), $495
- CABINET (standard AT style with 3 drive openings), $65
- PS-200 (200W power supply for AT case), $70
- KEY (84-key AT-style keyboard), $60
- DOS (MS-DOS version 4.01), $80
- AT1003 (Hard/floppy disk controller), $139
- DISK 1.2 (1.2-MB 5.25-inch floppy-disk drive), $109
- 20MEG (20-MB hard disk drive), $230
- EGA (EGA display card), $189
- EGA MON (Samsung EGA monitor), $360
- DRAM, call for current prices
- Notes: Complete catalog of options is available upon request; PT386-PLUS kits add $7 for UPS ground shipping, systems add $22, other items additional. VISA/MC orders accepted without surcharge. Technical assistance and repair service available. Georgia residents add appropriate sales tax.

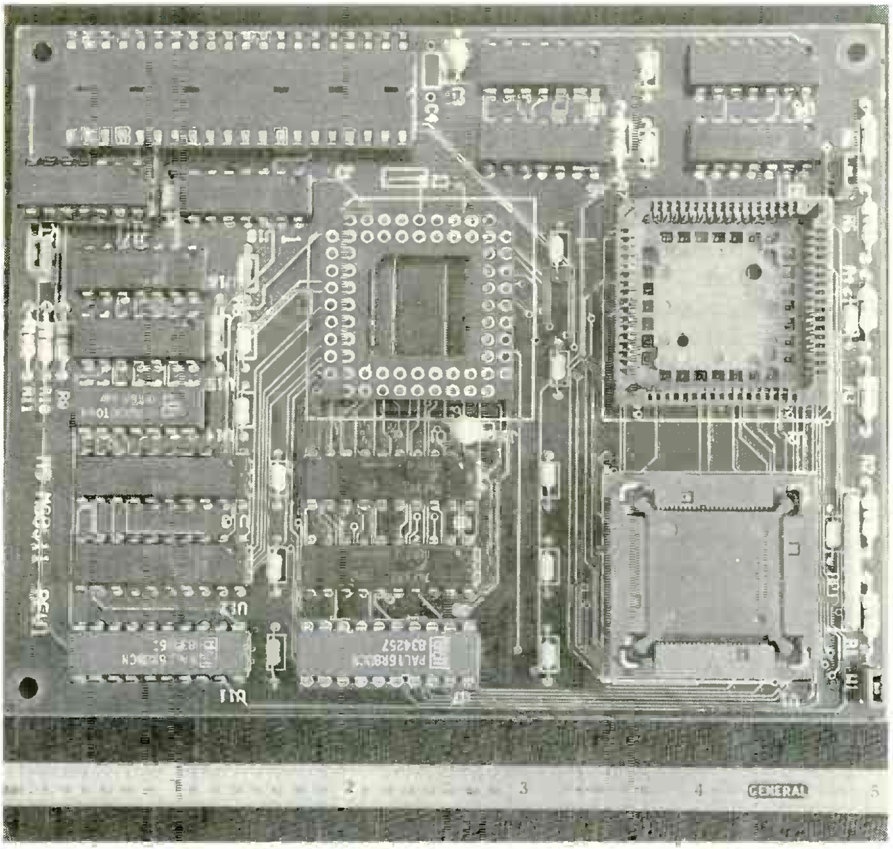

Fig. 4. THE DAUGHTERBOARD IS ABOUT 5 INCHES WIDE.

make sure it's in the AT position.

Insert a video adapter into an expansion slot, and connect your monitor to the card. Plug the computer and monitor power supplies into a surge-protected AC outlet.

Turn on power, and, if all is in order, a copyright notice will appear on the top of your screen, followed by a memory count, and then a message stating "CMOS SYSTEM OPTIONS NOT SET." Press F1, and you'll be asked whether you want to run the setup/diagnostics program. Press Y and then the ENTER key.

Then you get to choose between Setup (1) or Diagnostics (2). Choose "1" and you'll be able to set date, time, and hard-disk type.

Of course, you do not yet have a backup battery for your CMOS RAM, so whatever date and time you enter will be lost when power is removed. Also, you have no floppy or hard disks plugged in, so hard-disk selection is moot. The point is that if you have gotten this far, your board(s) are probably OK. Congratulations!

Next, power-down your system, install one floppy disk drive, insert a boot diskette in it, and turn on the power. Your system should boot. You may want to run the diagnostic routines now. Then install your hard disk, run the setup utility again, and select the proper drive type. At this point, you can power-down and install

continued on page 84

BUILDING AN OMNIVIEW APPLICATION

MIKE TOUTONGHI,
SUNNYHILL SOFTWARE

OMNIVIEW is our operating environment for personal computers based on the Intel series of microprocessors. OMNIVIEW provides efficient task swapping on 8088/86 and 80286 machines, and, on 386 machines and others with EMS 4.0 memory, functional multitasking. Last month we gave an overview of how OMNIVIEW works and its internal structure. This month, we'll delve a little deeper into how the software harnesses the hardware; in so doing, we'll write an OMNIVIEW program that displays the status of other concurrently running programs.

The program, OVSTATUS, uses OMNIVIEW's facilities for passing messages among currently running tasks and its ability to execute efficient time delays to continuously display a system status report, but take processing overhead only when updating the screen. Space precludes listing the full program here, but the source code and the executable version are available at no charge from the Gernsback BBS (516-293-2283, 300/1200, N81). Download OVSTATUS.EXE, a self-unpacking archive with all relevant files.

```
OMNIVIEW Continuous Status Display Program, V1.00
Num  Process name                           Size  Base pri  Cur pri  Clks
---  -------------------------------------  ----  --------  -------  ----

2    C:\COMMAND.COM /C pcf /file,phone89    276K        2   SWAPPED     4
3    C:\COMMAND.COM /C gv "startup"         301K        2   SWAPPED     4
4    C:\COMMAND.COM /C go                   401K        2   SWAPPED     4
5    C:\COMMAND.COM                         441K        2         2     4

Largest free block:       32K
Virtual swap space:     7600K
```

Fig. 1 *OVSTATUS provides reports on the currently active processes running under OMNIVIEW.*

The kernel

First let's look at OMNIVIEW's kernel, a set of subroutines and data structures; the latter are called Process Control Blocks (PCB's). The kernel does not handle device virtualization, 386 memory management, or other hardware-specific chores. Instead, it schedules tasks in and out; it calls device drivers to move tasks to and from foreground and background; and it provides the core routines for creating and terminating tasks. It also includes routines for changing the priority of a task, suspending a task, and other various low-level functions.

Associated with each task is a PCB, which is managed by the kernel, and which contains register, stack, and priority information about that task, as well as links to the OMNIVIEW devices which have been allocated to it. The PCB also contains information provided by the memory manager that allows the kernel to allocate, control, and de-allocate blocks of memory through the memory manager. The basic structure of a PCB is shown in Table 1.

Two elements of the PCB, the Application Stack and the System Stack, provide an important level of isolation for OMNIVIEW system services, and they help to prevent stack overflow from OMNIVIEW or hardware interrupts of other concurrent tasks. When a task, also referred to as a partition, is first created, it contains one program that begins execution using its own application stack. That program may be COMMAND.COM, 1-2-3, or OMNIVIEW's user-interface shell; whatever it is, it maintains its stack in exactly the same way as any other DOS program. When either a hardware interrupt occurs or the task makes an OMNIVIEW system call, OMNIVIEW switches to a system stack to avoid stack-overflow problems. Before switching

TABLE 1—OMNIVIEW PROCESS CONTROL BLOCK

Element	Description
Application Stack	Stack controlled by application
System Stack	Stack pointer while interrupted
CPU Registers	Stored registers of this program
Memory Control Handle	Memory manager supplied handle
Allocated Devices	Device handles for this task
Priority Information	Scheduling control information
Clocks In	Clocks to keep in before schedule
Computable State	Current state (swapped, etc.)
Link to next PCB	Used to make priority lists

TABLE 2—OMNIVIEW API

Kernel Functions		
tvversion	—	Returns version, initializes interface
tvcreateproc	—	Create a concurrent process
tvcurtofg	—	Make current process foreground
tvcurphndl	—	Return caller's process handle
tvfgphndl	—	Return foreground process handle
tvfreemem	—	Return free memory and swapping space
tvgetswap	—	Get swappability of a process
tvgetallinfo	—	Return all active processes' information
tvgetoneinfo	—	Return one active processes' information
tvkillcur	—	Kill the current process
tvkillproc	—	Kill a specific process
tvmaxprocs	—	Return the maximum number of processes
tvnumtofg	—	Make a specific process foreground
tvnumprocs	—	Return the number of active processes
tvsched	—	Release remainder of time slice
tvsetkill	—	Prevent this process from being killed
tvsetname	—	Set the name of a process
tvsetpri	—	Set priority and process state of a process
tvsetswap	—	Set the swappability of a process
tvsuspendcur	—	Suspend the current process
tvswapin	—	Swap in a process from disk or expanded RAM
tvwakenum	—	Wake a process which suspended itself
Device Functions		
tvgetphandle	—	Get process handle of a console number
tvgetpnum	—	Get console number for a 32 bit handle
tvautoupdate	—	Makes screen update automatic from virtual
tvgetupdate	—	Returns the screen update status
tvpostvirt	—	Posts the virtual screen to the real screen
tvsetupdr	—	Sets screen update to virtual screen
tvvidaddr	—	Returns the OMNIVIEW virtual screen address
Messaging Functions		
tvchkmsg	—	Check for a message from process or device
tvwaitmsg	—	Wait for a message from a process or device
tvsendnw	—	Send message to a process, don't wait
tvsendwait	—	Send message to process, wait til received
tvsendtime	—	Send a timed message to a process
tvflushtime	—	Flush timed messages for a process

to the system stack, OMNIVIEW stores a pointer to the application stack in the PCB.

In addition to maintaining a system stack for each task, OMNIVIEW stores the CPU registers whenever it switches out of that task's context. Doing so allows OMNIVIEW to perform a task switch at any time. In addition, OMNIVIEW's system functions can put return values of function calls in the stored registers before returning to an "OMNIVIEW-aware" program.

OMNIVIEW's kernel makes calls to the memory-management sub-system (MMS) for any function that requires memory allocation, swapping, or de-allocation. When a task's memory block is first allocated, the MMS returns a "handle" to the kernel. That handle, which is similar but not identical to an expanded-memory handle, is actually an index to a memory-control block array. By separating the kernel from the memory-management functions, new memory-management capabilities can be supported easily. In fact, OMNIVIEW's original MMS didn't include either disk swapping or the ability to execute programs in expanded memory. Adding those functions simply required changing the memory manager; the kernel was affected minimally.

To understand the Allocated Devices section of the PCB, let's talk about OMNIVIEW device drivers. OMNIVIEW's device drivers are not at all the same as DOS's. Where DOS drivers control input and output to and from physical devices, OMNIVIEW drivers handle the job of "virtualizing" a device when it is not physically available.

Additionally, the device drivers determine when a process should be blocked. For example, assume that an applications program needs user input before proceeding. It issues a "wait for input" request; until the user types in the requested information, any CPU time spent servicing that program would be wasted. By filtering such requests, OMNIVIEW's keyboard device would suspend the currently executing program until keystrokes had been entered. Similarly, if the screen device driver cannot virtualize a program's display, it will suspend that program unless it becomes a foreground task (or is visible on its own monitor on a dual-monitor system).

Special Discount

SunnyHill Software has arranged special 30% discounts off the list prices of OMNIVIEW and 386^{MAX} for readers of **Radio-Electronics.** OMNIVIEW normally lists for $89.95; the discount price is $62.95. 386^{MAX} normally lists for $74.95; the discount price is $52.45.

To order, call the number below. Be sure to mention this article. The discount expires on December 31, 1989. SunnyHill also has separate documentation on the OMNIVIEW API; contact the company for details.

For more information on OMNIVIEW (formerly called TaskView), see "Editor's Workbench," in **Radio-Electronics**, May 1988. For more information on the 386 microprocessor, see the January, February, and March 1989 issues.

- OMNIVIEW, SunnyHill Software, P.O. Box 33711, Seattle, WA 98133-3711. (800) 367-0651 or (206) 367-0650.
- 386^{MAX}, Qualitas, Inc., 8314 Thoreau Drive, Bethesda, MD 20817-3164. (301) 469-8848. Note that the discount is available only through SunnyHill.

To control various devices, each task's PCB contains an array of device handles that are supplied by OMNIVIEW's device drivers when the task is created. The OMNIVIEW kernel knows nothing about what the devices do. It simply calls the driver by passing the device handle from a PCB; thus, the kernel informs the driver when a task is being switched in from mass storage, placed in the foreground or background, or terminated. Each driver must handle those functions in a way appropriate to its particular device. That approach helps to eliminate all device-specific code from the OMNIVIEW kernel.

Task scheduling

Before discussing the next three variables in the PCB, let's talk about one of the most important kernel subroutines. This routine, SCHEDULE, can be called at any time to perform a task switch. Usually, OMNIVIEW's clock routine, which is tied to the 55-ms hardware clock, calls the routine to preempt the currently running task. In addition, an OMNIVIEW-aware task can call the routine to release the rest of its time slice to other running programs. OMNIVIEW devices may also call this routine when they suspend a program which is waiting for input or for a physical device to become available. By making SCHEDULE available to any program or OMNIVIEW device, task scheduling can flexibly conform to the processing demands of the currently running tasks.

Now let's talk about the Priority, Clocks In, and Computable State variables in the process control block. Those variables work together to determine when and how a task will be scheduled for processing time. In brief:

- Priority determines how OMNIVIEW's SCHEDULE routine chooses which task to switch to,
- Clocks In determines for how long, and
- Computable State can be used to make a task wait.

When SCHEDULE is called, it will switch to the next highest priority task that is computable (that is not swapped to disk or waiting for a device such as key-

LISTING 1—OVSTATUS PSEUDOCODE

```
IF OMNIVIEW VERSION > 4
  DISPLAY SIGNON MESSAGE
  LOOP UNTIL USER PRESSES EXIT KEY
    LOOP THROUGH POSSIBLE CONSOLE NUMBERS
      CONVERT ONE NUMBER TO A PROCESS HANDLE
      IF PROCESS IS IN THIS CONSOLE
        DISPLAY PROCESS INFORMATION
      ENDIF
    ENDLOOP THROUGH PARTITION NUMBERS
    DISPLAY LARGEST FREE MEMORY BLOCK
    DISPLAY AVAILABLE SWAPPING SPACE
    SEND A TIMED MESSAGE TO OURSELF
    WAIT FOR EITHER A MESSAGE OR A KEYSTROKE
  ENDLOOP UNTIL USER PRESSES EXIT KEY
ELSE
  DISPLAY ERROR MESSAGE
ENDIF
```

board input or a foreground screen). If no other tasks besides the current one are computable, it won't switch at all. If only a single task is computable, OMNIVIEW exacts no more processing overhead than the typical TSR that hooks into the keyboard interrupt, waiting for a special keystroke combination.

After a task has been switched in, OMNIVIEW counts the clock ticks that pass by using the 55-ms hardware clock interrupt. When either the number of clock ticks in Clocks In pass or a higher priority process becomes computable, the clock-tick routine calls SCHEDULE and preempts the currently executing task.

Last, the Link To Next PCB allows OMNIVIEW to store PCB's in linked lists, which makes the selection of the next task to schedule more efficient than evaluating each task individually. The schedule routine can simply look at the priority lists in descending order and choose the first task that it finds. Tasks that are not computable are stored in a waiting list and need never be examined at all.

One other variable type that you should be aware of is the PCB handle, or process handle. This 32-bit value allows applications to specify which tasks they want functions to take action upon. Although the keyboard device allows keyboard switching from task to task by console number, the OMNIVIEW kernel uses process handles to identify tasks. So that applications can keep track of tasks by number, the keyboard device provides functions to convert console numbers to process handles and vice versa.

LISTING 2—OVSTATUS DELAY ROUTINE

```
unsigned char ovdelay( unsigned num55ms )

/* This function returns after either the number of 55ms
   increments specified has passed or a key is struck.
   If no key was struck, it returns NULL, otherwise it
   returns the key.
*/
    {

     long ourphandle, /* Handle of this process */
          msgsource,  /* Source of the message */
          msgdata;    /* Data in the message */

     /* First flush any pending timed messages */
     tvflushtime( ourphandle = tvcurphndl() );
     tvsendtime( ourphandle, num55ms );
     tvwaitmsg( KBD_OBJID+CLK_OBJID, &msgsource, &msgdata );

     /* If kbd, flush timed messages again and return,
     else return NULL */
     return( (msgsource & KBD_OBJID) ?

     /* The low word of the message data = key struck if
     keyboard */
     tvflushtime( ourphandle ), (unsigned char)msgdata :

     /* If timed message, return NULL */
     NULL );

    }
```

The OAPI

Now that we know the basics of OMNIVIEW's structure, let's look at the *O*MNIVIEW *A*pplication *P*rogramming *I*nterface (OAPI). The functions available in OAPI let you start tasks, control the devices allocated to them, specify their priority, send messages between tasks, kill them, inquire about tasks, and do other things one might want to do in a multitasking environment.

SunnyHill has built interfaces to the OAPI for the following languages: Microsoft and Turbo C; Turbo Pascal versions 3, 4, and 5; and Microsoft assembler. The names of the C functions are listed in Table 2; unfortunately, there is no space to explain them in detail here. Contact SunnyHill for a copy of the OAPI interface libraries. (The function names begin with the letters *tv* in order to maintain compatibility with previous versions of OMNIVIEW, which was formerly known as TaskView.)

Our example program, OVSTATUS, is written in Turbo C. It uses several of the OAPI functions and should illustrate the general structure of an OMNIVIEW application. As mentioned before, you can get a copy of OVSTATUS.C (source code) and OVSTATUS.EXE from the Gernsback BBS. A typical OVSTATUS display is shown in Fig. 1.

The C OAPI includes a header file (OMNIVIEW.H) that should be included at the beginning of any OMNIVIEW program. Aside from clearing the screen and moving the cursor, we'll use standard I/O routines for portability. To speed up OVSTATUS, you could display your output faster with direct video I/O or routines that call the BIOS rather than DOS.

In actual operation, our utility, and every program that uses OMNIVIEW, must first verify OMNIVIEW's presence, and initialize the OAPI. That is done by calling TVVERSION. That call returns the version number of the OMNIVIEW that is running, or 0 if OMNIVIEW isn't running at all. Since each version of OMNIVIEW (and TASKVIEW) has been backward compatible with previous versions, we just need to make sure that the version returned is greater or equal to the minimum version acceptable. The OAPI documentation mentions which routines are supported in which versions.

Once verifying an acceptable version number, the utility loops through each possible console number and calls TVGETPHANDLE to convert each number to a process handle. If the console does not contain an active process, TVGETPHANDLE returns an error code and the loop moves on. If there is a process, the loop calls TVGETONEINFO to get the status information and displays it on the screen.

After OVSTATUS has finished displaying the status of each process, it calls TVFREEMEM to find the largest available block of memory and the available swapping space. It displays each of those and then moves on to the most interesting part of the program.

Now OVSTATUS uses TVSENDTIME to send a timed message to itself. Knowing that the message will come back at the specified time, it uses TVWAITMSG to wait for either the time to pass or a keystroke. If the message eventually received is a keystroke, it checks to see whether it is the exit key (Esc). If so, the program terminates; otherwise (if the message was either timed, or not the exit key), OVSTATUS loops back to where it displays the status of the process. Pseudocode for the program appears as shown in Listing 1.

By using timed messages our utility achieves a very desirable goal: conservation of processor resources. When any task waits for a message, OMNIVIEW puts its PCB into a waiting list and need never look at it until it receives a corresponding message. That means that while we are waiting for the timed message or a keystroke, OVSTATUS takes no processing overhead.

To separate the delay capability from the rest of our program and provide an example of how to use it, we wrote the function OVDELAY. Its source code is shown in Listing 2. Since we don't want to have extra timed messages sent to us, we flush the timed messages both at the beginning and end of the function.

Another way to implement a reasonably efficient timed delay would be to continuously check the time and call TVSCHED until either the time passed or a key was struck. While that approach would give up unused time to other tasks in the system, it would still perform less efficiently than that of our OVDELAY function. With the TVSCHED method, we would remain in the active process lists so we would be scheduled in periodically by OMNIVIEW according to our priority.

The end result of our programming effort is a continuous status display program which takes little processing overhead from the system. On an 80386 system, it also requires no conventional memory overhead and can run completely from 386 extended memory.

If you're interested in trying your hand at OAPI programming, you could design a new menu interface for OMNIVIEW; the present one is built around the same functions. R-E

MOTHERBOARD

continued from page 79

everything in your case. Be careful to route all wires where they do not rub against any rough edges. If you're buying your own case, purchase one with cutouts on the rear panel for the 9- and 25-pin I/O-port connectors that run via ribbon cable from the motherboard. The Peripheral Technology kit includes a proper case and proper ribbon cables.

Also included with the kit is a detailed BIOS setup and diagnostics manual. With the diagnostics, you can test your keyboard, floppy- and hard-disk drives, and video cards, etc. You can get to the setup/diagnostics routine from DOS at any time by rebooting and pressing F1.

Troubleshooting

If you've got a problem, the first thing to check is your soldering. There are many connections on the board, and we've found that poorly soldered and even unsoldered joints account for the vast majority of problems with kits.

Also make sure that all IC's are inserted into the correct sockets, that they're oriented correctly, and that all pins are firmly seated. One bent-under pin could keep the system from booting.

If you still can't find a problem, have someone else look over your work. After you stare at a complex board for a long time, you're likely to miss a simple mistake.

Beyond that, check for proper voltages on the motherboard, that the oscillators are oscillating, and that the clock signal is getting to the microprocessor.

If all else fails, Peripheral Technology will troubleshoot your board for a reasonable fee; call for details. R-E

Parts List—Daughterboard

IC1	*80386SX*
IC2–IC5	*74F373*
IC6, IC12	*PAL16R8*
IC7	*80387SX numeric coprocessor (optional)*
IC8	*74AHCT00*
IC9–IC11	*74F74*
IC13	*74F08*
IC14	*74F04*
IC15	*74F125*
IC16	*74F32*
C1–C10	*0.1 µF*
Circuit board	

IC Sockets

7 14-pin DIP, 1 16-pin DIP, 6 20-pin DIP, 1 40-pin DIP, 1 68-pin PLCC, 1 68-pin header, 1 100-pin quad flatpack.

CORRECTION

The telephone number for Peripheral Technology was printed incorrectly in the June issue. The correct number appears in the box on page 79.

DRAWING BOARD

continued from page 74

to do that if you've put all the pad centers on intersection points of the graph paper.

Once you've made the decision to go double-sided, every time you put a component on the foil side (the first one we started), you should mark its location on the component side of the board as well. The horizontal line you've drawn is the zero baseline for your layout. As you can see in Fig. 3, each pair of pads has very similar coordinates—the only difference between them is in the sign of the Y coordinate.

When you jump a trace from one side of the board to the other, you should try to make the side-to-side connection on the leg of a component, since it will save you some work when you get to the drilling and soldering stage.

The only exception to that rule has to do with IC legs. Since all the IC's are going to be socketed (soldering IC's to the board is a really bad idea), and since the socket should sit flush against the surface of the board, it will be hard to solder the socket's pins on both sides of the board. You can use a wire-wrap socket and leave the socket slightly above the board, but the legs on a wire-wrap socket are thicker than normal, so you'll have to use larger pads to accommodate the larger holes. You could also use the more-expensive machined sockets.

Another alternative is to add a small trace to the IC pin and put the feedthrough there (see Fig. 4). It's a bit more cumbersome but it's going to make your job a lot easier later on.

Next month we'll talk about some more layout considerations. We'll get into producing the final artwork, and then go over what has to be done to generate the printing negative.

Oh yeah, I'll also be announcing the winner of the EPROM contest; so stay tuned. **R-E**

HARDWARE HACKER

continued from page 69

coder, intended for all those new extended range broadcast stereo FM services. National has a pair of interesting data sheets out, one on their LM1951 high side driver, and one on their LM12C op amp with a 150-watt rating.

Three free samples of Motorola TMOS power control transistors are newly available through Hall-Mark Electronics. They also offer Motorola's *Specs in Secs* IBM compatible data disk at no charge. As always, get results by making your sample and other freebie requests on your own laser printed business letterheads.

Some really great used computer bargains, Apple and otherwise, are available through Richard Harold of Shreve Systems. They are now selling brand new Franklin keyboards at $12 each in single quantity.

Turning to my own stuff, be sure to check into my three classics, the *CMOS Cookbook, TTL Cookbook*, and my *Active Filter Cookbook*. I do try and keep autographed copies on hand here at Synergetics, along with all the complete sets of my "Hardware Hacker" reprints from **Radio-Electronics**, and my "Ask the Guru" reprints from my sister column in *Computer Shopper*.

As usual, this is your column, and you can get technical help and off-the-wall networking per that "Need Help?" box. Best calling times are 8-5 weekdays, *Mountain Standard Time* (MST) year round. Please let us hear from you. **R-E**

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TUBES: "oldest," "latest." Parts and schematics. SASE for lists. **STEINMETZ,** 7519 Maplewood Ave., RE, Hammond, IN 46324.

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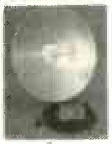

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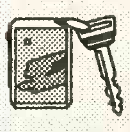

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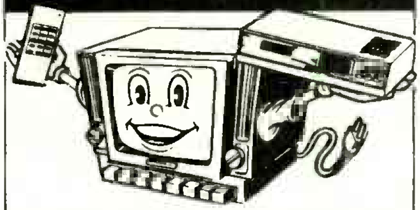

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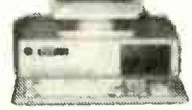

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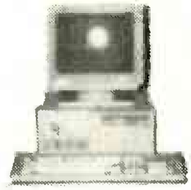

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7412	.25	74107	.30	74194	.80
7413	.35	74116	1.20	74195	.80
7414	.45	74121	.30	74196	.75
7416	.25	74122	.45	74197	.80
7417	.25	74123	.45	74199	1.25
7420	.20	74125	.45	74221	1.25
7425	.27	74126	.45	74273	1.00
7426	.30	74145	.60	74278	1.95
7427	.27	74148	1.20	74279	.70
7430	.20	74150	1.35	74298	.60
7432	.27	74151	.55	74365	.65
7437	.27	74153	.55	74367	.65
7438	.29	74154	1.25	74390	.90
7440	.20	74155	.55	75114	.90
7442	.45	74156	.75	75115	.90
7445	.65	74157	.55	75150	.60
7447	1.00	74158	.60	75325	1.50
7450	.20	74160	.85	75491	1.00
7472	.29	74161	.66	9602	.90
7473	.35	74162	.65	8T26	1.10
7474	.32	74163	.65	8T28	1.10
7475	.45	74164	.85	8T97	1.10
7476	.50	74165	.85	8T98	1.10
		74166	1.00		

SCR's

	1.5A	6A	35A	75A
100	.35	.40	1.40	
200	.40	.50	1.80	
400	.60	.70	2.40	9.00
600	.80	1.00	3.60	12.00

TRIAC's

PRV	1A	10A
100	35	1.00
200	.50	1.00
400	70	1.20
600	1.00	1.50

LINEAR CIRCUITS

TL062C	.95	LM393	.40	MC1391	1.00
TL064CN	1.00	LF398A	3.00	1456	.80
TL072	1.00	LF411	1.25	1458	.50
LM79BCT	.60	AD506JH	2.50	LM1808	1.75
TL062	90	537	1.50	ULN2003A	.75
TL084	1.00	LM555	.29	AD2700LD	4.96
DG201BP	1.40	LM556	.45	LM2901	.95
LM201	.75	558	1.10	CA3018	1.95
LM301	.35	AD561	3.00	CA3045	1.20
LM307	45	564	1.75	CA3078AT	1.50
LM308	.65	565	90	CA3089E	1.75
LM311	.45	566	1.25	CA3094	1.30
LM318	1.00	567	.75	CA3130	.90
LM319	1.10	NE570	2.50	CA3140	.75
LM324	.35	NE592	.95	SG3543	.70
LM339	.50	709CN	.80	SG3544	1.00
LM348	.65	711CH	.60	UNL3701E	1.75
LF351	.45	733	.95	LM3900	.50
LF353	.75	739	1.50	4136	.85
LF355	.35	741CV	.29	SD5000	1.75
LF356	.85	747	.50	N5534	.75
LM358	.45	DAC0808	2.95	N5596A	1.50
LM370	1.60	ADC0809 CNN	8.95	SD6000	1.00
LM380	.85			8038	3.95
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LM386	.85	MC1350	.90	LM13080	.96
		MC1355	1.25		

C/MOS

74C00	.25	74C915	1.10	4027	.35	4072	.20
74C04	.25	4001	.19	4028	.65	4076	.55
74C08	.25	4002	.20	4029	.65	4077	.28
74C10	.25	4006	.65	4030	35	4081	.20
74C14	.56	4007	.20	4034	1.40	4082	.20
74C20	.25	4008	.85	4035	.65	4093	.45
74C32	.35	4009	.35	4040	.65	4099	1.40
74C42	1.10	4010	.35	4041	.75	4501	95
74C74	.55	4011	.19	4042	.55	4503	45
74C76	.60	4012	.25	4043	.85	4506	.75
74C85	1.25	4013	.35	4044	.65	4510	.65
74C86	.35	4014	.65	4045	.85	4511	.65
74C93	1.00	4015	.28	4046	.85	4512	.75
74C157	.95	4016	.28	4047	65	4514	95
74C161	.95	4017	.45	4049	.28	4515	1.60
74C174	.95	4018	.65	4050	.28	4516	.75
74C175	.95	4019	.35	4051	.65	4518	.85
74C193	1.25	4020	.55	4052	.65	4520	.75
74C245	1.75	4021	.65	4053	.65	4528	.75
74C901	.35	4022	.65	4060	.65	4529	1.40
74C902	.40	4023	.25	4066	.28	4538	.95
74C903	.80	4024	.48	4068	35	4539	1.60
74C907	.75	4025	.25	4069	.19	4541B	1.20
		4026	1.25	4070	.28	4553	1.75
				4071	20	4583	90
						4585	.75

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74HC02	.35	74HC125	.50	74HC257	.65
74HC04	.35	74HC133	.50	74HC259	.60
74HC08	.35	74HC137	.75	74HC273	.80
74HC10	.35	74CH138	.70	74HC354	.95
74HC11	.40	74HC139	.45	74HC373	.80
74HC20	.35	74HC153	.55	74HC374	.80
74HC30	.35	74HC154	1.75	74HC533	1.35
74HC32	.35	74HC157	.50	74HC534	1.35
74HC50	.45	74HC162	.55	74HC573	2.50
74HC58	.50	74HC163	.55	74HC595	2.50
74HC74	.40	74HC164	.80	74HC640	2.00
74HC75	.40	74HC174	.60	74HC4002	.50
74HC85	.70	74HC175	.60	74HC4020	1.10
74HC86	.40	74HC194	.70	74HC4066	.60
74HC107	.35	74HC221	.90	74HC4514	3.20
74HC109	.40	74HC240	.75	74HC4538	1.40
74HC112	.40	74HC242	.75	74HC4543	1.40
		74HC244	.80		

74LS SERIES

74LS00	.17	74LS112	.29	74LS241	.65
74LS01	.17	74LS113	.33	74LS242	.65
74LS02	.17	74LS114	.33	74LS243	.65
74LS03	.17	74LS122	.70	74LS244	.65
74LS04	.17	74LS123	.45	74LS245	.75
74LS05	.17	74LS125	.35	74LS246	1.40
74LS08	.17	74LS126	.35	74LS247	.75
74LS09	.17	74LS132	.39	74LS243	.65
74LS10	.17	74LS136	.35	74LS251	.45
74LS11	.20	74LS137	.90	74LS253	45
74LS12	.27	74LS138	.39	74LS257	.39
74LS13	.25	74LS139	.39	74LS258	45
74LS14	.36	74LS145	.70	74LS259	1.20
74LS15	.25	74LS147	1.00	74LS260	.45
74LS20	.17	74LS148	.90	74LS266	.55
74LS21	.22	74LS151	.39	74LS273	.75
74LS22	.22	74LS153	.39	74LS279	.39
74LS26	.23	74LS154	1.50	74LS280	1.70
74LS27	.23	74LS155	.55	74LS283	.55
74LS28	.26	74LS156	.45	74LS290	.80
74LS30	.17	74LS157	.35	74LS293	80
74LS32	.17	74LS158	.20	74LS298	.65
74LS37	.26	74LS160	.29	74LS299	1.25
74LS38	26	74LS161	.49	74LS320	2.00
74LS40	.17	74LS162	.49	74LS322	3.00
74LS42	.35	74LS163	.49	74LS323	2.40
74LS48	.65	74LS164	.45	74LS365	.39
74LS51	.17	74LS165	65	74LS366	.39
74LS54	.22	74LS166	.95	74LS367	.39
74LS73	.25	74LS169	90	74LS368	.39
74LS74	.24	74LS170	.80	74LS373	.75
74LS75	29	74LS173	.49	74LS374	.75
74LS76	29	74LS174	.39	74LS377	.75
74LS83	.45	74LS175	.39	74LS386	45
74LS85	.45	74LS181	1.40	74LS390	1.10
74LS86	.22	74LS190	.49	74LS393	.75
74LS90	.39	74LS191	.49	74LS398	2.50
74LS92	.46	74LS192	.65	74LS446	2.00
74LS93	.45	74LS193	.65	74LS541	1.40
74LS95	.48	74LS194	.65	74LS625	1.75
74LS96	49	74LS195	.65	74LS645	.95
81LS98	1.40	74LS196	.55	74LS668	1.45
74LS107	.35	74LS197	.55	74LS670	.95
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400	1.00	1.65	3.30
600	1.30	1.90	4.40

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CTS 206-7	7 Position	.95
CTS 206-8	8 Position	.95
CTS 206-10	10 Position	1.25

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400	.09	.25	.65	1.50	10.00	12.00
600	.11	.30	.80	2.00	13.00	15.00
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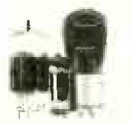

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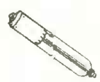

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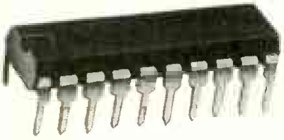

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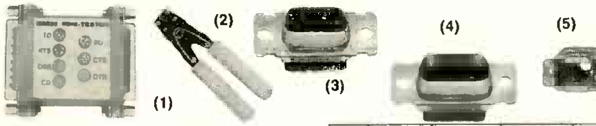

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Fig.	Type	Positions	Cat. No.	Each
3	Male	9	276-1427	.99
4	Female	9	276-1428	1.19
...	Male	25	276-1429	2.49
...	Female	25	276-1430	2.99
5	Hood	9	276-1513	1.49
...	Hood	25	276-1536	1.99

Cables and AC Cord

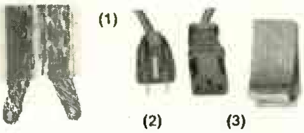
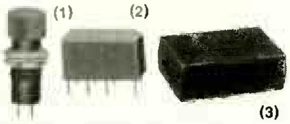


Fig.	Description	Cat. No.	Price
1	Speaker MEGACABLE™	278-1268	.99/Ft.
2	6' AC Cord, CEE Type	278-1257	3.99
3	25-Cond., 5' Ribbon	278-772	3.59
...	36-Cond., 6' Ribbon	278-774	4.69

Classy Touches



(1) SPST Switch. Momentary. #275-609 .... **Set 2/1.79**

(2) Relay. Contacts: 120VAC, 1A. Coil: 12VDC, 43 mA. #275-249, **3.99**

(3) Instrument Case With a PC Board. #270-291 .... **4.49**

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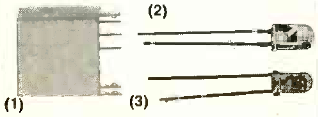
Solar Energy Project Set. Includes solar cell, DC motor, book with projects. #277-1201 .... **9.95**

Silicon Solar Cell. Not shown. 2×4 cm cell. #276-124 .... **3.95**

Project Lighting



(1) IR Detector Module. Requires 5VDC. #276-137 .... **3.49**

(2) Hi-Output IR LED. Low power design. #276-143 .... **1.69**

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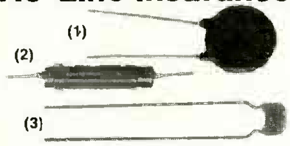

Fig.	Description	Cat. No.	Price
1	Heavy-Duty MOV	276-568	1.99
2	100 µH RF Choke	273-102	.99
3	0.01 µF, 2 kV Ceramic Disc Cap	272-160	2/.99

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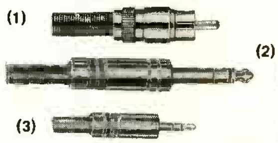
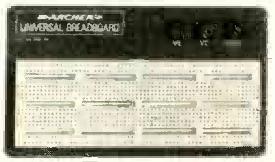


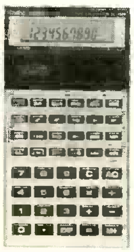
Fig.	Description	Cat. No.	Each
1	Phono	274-850	2.49
2	3-Conductor ¼"	274-856	3.99
3	3-Conductor ⅛"	274-858	3.49

Deluxe Breadboard



The fast, easy way to design circuits. 2¼×6½" board on a 4×7" steel base. Accepts DIPs, components and up to 22-gauge wire. #276-169 .... **19.95**

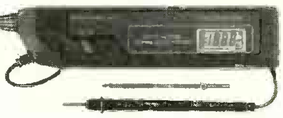
Scientific Calculator



24⁹⁵

Radio Shack EC-4031. Perfect for use during upgrade Ham license exams. Features 87 functions, trig, 18 levels of parentheses, base number math. Dual-powered. 10-digit mantissa, 2-digit exponent. 5⁵⁄₁₆×3×⅝". With lithium battery. #65-997

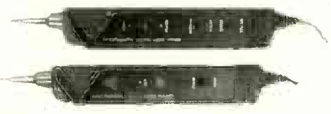
Probe-Style Multimeter



39⁹⁵

Pocket-sized troubleshooter with fully automatic range and polarity. Data hold lets you freeze display and remove tester from circuit for more convenient reading. Has continuity sounder. Measures up to 400 volts AC/DC and resistance in k-ohms. Overload protected. 1³⁄₁₆×6⅜×¾". #22-165

Logic Probe and Pulser



Digital Logic Probe. The fast way to "peek inside" TTL, LS and CMOS digital circuits, memory and peripheral chips. LEDs indicate high/low/pulsed logic states. #22-303 .... **16.95**

Digital Logic Pulser. Companion to probe. Selectable 5 µs pulse or 5 Hz continuous pulse train output. #22-304 .... **17.95**

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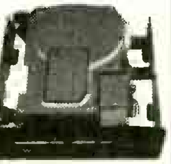
14" CGA MONITOR *Plus* CARD...

(IBM Compatible)

Input: 115/230V, 50/60 Hertz (automatically switchable). Resolution: 640 x 240 (RGB-horizontal x vertical). Complete with CGA card and IBM interface cables. Built-in stand. Dot pitch: .31. Mfr – Hitachi; made for Data General. Item #22475

Special Offer... New – **$199.00**

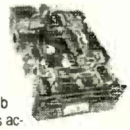
3 1/2", 20Mb., HALF-HEIGHT HARD DISK DRIVE



(ST225 Compatible)
Universal 5 1/4" mounting. For PC/XT/AT compatible computers. Average access time: 62 msec. Mfr — Lapine #LT2000.

Item #15853 *New* – **$179.00**

3 1/2" FLOPPY DISK DRIVES



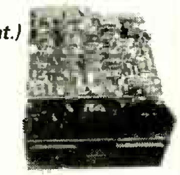
Half Height Capacitance: 1.0 Mb (unformatted); 3 ms access time. 135 TPI, 160 track. Power: 3.5W @ 12V ±5%. Mfr. – Panasonic #JU-363-10 Item #22075 *NEW*

Full Height — Capacitance: 1.0 Mb (unformatted); 3 ms access time. 135 TPI. Power req.: +12 & +15V. Removed from operational computers. *Tested — Like New!* NEC #FD1035 Item #17171

$79.00; 2 for **$150.00**

5 1/4" FULL-HEIGHT DISK DRIVE

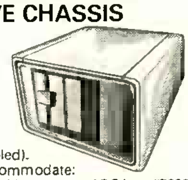
(IBM® Compat.)



48 TPI, 40 Track, Double Side/Double Density
Mfr.– CDC 9409T

Item #7928 **$79.00** *New*
2 for **$150.00** *New*

EXTERNAL DISK DRIVE CHASSIS



With 60W power supply (fan cooled).
Can accommodate:
2 full-ht. drives............*ADC item* #7928
2 floppy drives...............#10005/17171
1 hard drive.................................#19704
& 1 floppy...................................#10005
Input: 115/230V, 50/60 Hz.
Orig. for Burroughs computer.
Dim.: 11"W x 8"H x 12" deep

Item #14541 **$59.50**

DYNAMIC MEMORY BOARD...

Upgrade your computer's memory as your needs grow...

PC/XT COMPATIBLE

- ★ 0-256Kb memoryin 64Kb increments
- ★ Fully socketed for easy upgrade (IBM parity checking)
- ★ Memdisk: Simulates high-speed disk in RAM memory
- ★ Allows you to print while using thecomputer
- ★ Software included

Techmar #MU203010 (w/o RAM)

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★ **64Kb RAM Upgrade**
Set of 9 chips... Item #19983 **$17.50**

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"The Hands-Free Flashlight"

"Headlights" are worn, not held, allowing you to use both hands for work while brightly lighting your work area. Perfect for mechanics, electricians and plumbers, technical repairs, computers, etc. Powered by 4 "AAA" batteries (incl.). Warranty included.

Item #22073 *New* – **$12.95**

115 CFM MUFFIN® FANS

115VAC, 60Hz., 21W., 28A., 3100RPM, 5-blade model, aluminum housing. Can be mounted for blowing or exhaust. Dimensions: 4 11/16" sq. x 1 1/2" deep. Mfr: IMC

Item #1864 *New* – **$9.95**
W/Adjustable Speed Control
Item #20611 **$12.95**

Electronic Instant Ignition MICRO TORCH

- Hand Held
- Adjust. Flame
- Refillable 1.58 fl. oz. Butane Gas Tank

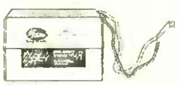
Can be used in a wide range of applications: elect. installations, welding, shrink tubing, jewelry & toy repairs, de-freezing pipes, etc. Precise & controlled hi-temp. flame, max: 1300°C/2370°F. Flame adj.: 1/2 to 1-1/2". Working time: about 2 hrs. Metal stand incl. Dim. 6-1/4"H x 1-3/16" dia.
Mfr – Vulcan #20.

Item #22072 *New* – **$39.95**

GELL CELL BATTERIES...

Sealed, maintenance free, rechargeable!

12V @ 2.5Ah



Six 2V @ 2.5Ah D Cells. Enclosed in clear plastic casing.Dim.: 4"W x 2-3/4"H x 3-3/4"D. Mfr – Gates.

Item #22370 *New* – **$12.95**

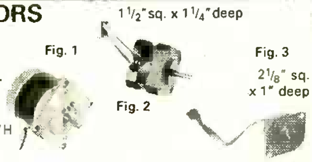
12V @ 8.0Ah

Dim.: 6"W x 3-3/4"H x 4"D.
Mfr – Eagle Picher #CF12V8
RFE — *Tested Good!*

Item #22086 **$19.95**

STEPPING MOTORS for ROBOTICS...

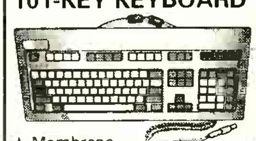
Precision steppers with increments from 1 to 7.5°. Speeds up to 5,000 steps.



Item No.	Step Angle	DC Voltage	Torque oz/in.	Type	Mfr. & Part No.	Fig.	Price
7630	1.8°	3.0	200	PM	Superior MO92-FT-402	1	$34.50 ea. 2 for $59.50
16410	1.8°	12.0	700*	PM	Applied Motion 4017-839	2	$9.95 ea. 2 for $14.95
16406	3.6°	12.0	700*	PM	Applied Motion 4017-838	2	$9.95 ea. 2 for $14.95
7014	7.5°	12.0	900*	PM	Mitsubishi 55SI-25DAYA	3	$10.95 ea. 2 for $19.95

**Grams per Cm.*

PC/XT/AT Compatible ENHANCED LAYOUT 101-KEY KEYBOARD



- ★ Membrane
- ★ 12 Function Keys
- ★ Separate Numerical Cursor
- ★ LED indicators for Scroll, Caps & Number locks
- ★ 1" inclination Foot Stand

Mfr. #29079

Item #19680 *New* – **$49.95**

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ADAM 5 1/4" DISK DRIVE
Coleco, model 7817.

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ADAM PRINTER... Friction feed. Takes standard paper 8 1/2 x 11".
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DATA DRIVE #6641 **$19.95**

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ASCII KEYBOARD
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Baker's Dozen — **$19.95**

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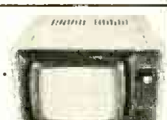
NEW BLANK TAPES
Item #20868 4 *for* **$10.00**

SMART BASIC PROG. MANUAL
Item #20875 *New* – **$14.95**

ADAM SOFTWARE SET
Incl. Expertype, Recipe Filer, Smart Letters & Forms, and Zaxxon.
Item #21746 *New* – **$29.95**

COMPOSITE VIDEO MONITORS...



Power regulated: 12VDC. Green phosphor. In plastic housing, with brightness control knob.
Mfr – Hitachi; made for Sperry.

5" Monitor — Item #14536 *(RFE)* **$24.95**
9" Monitor — Item #22481 *(RFE)* **$29.95**

TSM kits are available now!

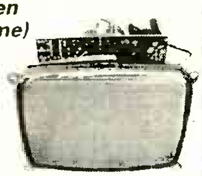
IBM PC/XT *Compat.* MONOCHROME DISPLAY & PRINTER ADAPTER

Monochrome adaptor w/parallel printer port. Can be used with any PC/XT or compat. Text only. Resolution: 720 x 348. IBM Model #1504900.

Item #22480 *New* – **$24.95**

High Resolution TTL MONITORS...

(Open Frame)



9"– 12VDC
Green phosphor. Schematic incl. Audiotronics #900964-04
Item #17198 *New* – **$19.95**

12"– 12VDC, Green phosphor. Subassemblies, CRT, board & transformer incl. Comes w/hookup diagram.
Item #6811 *New* – **$19.95**

Please call or write with any other requirements...

COMPUTER GRADE POWER SUPPLY

Other uses—runs CB & car radios. Comes ready to plug in!

DC Output: -5V @ .5 amp. +5V @ 3 amp. +12V @ 6 amp.
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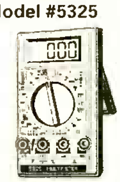
DIGITAL MULTIMETERS...

- 9 Function
- Basic Accuracy .5%
- 3-1/2 digit LCD (.5" high)

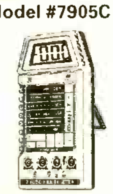
Model #5325



DCV: 100μV—1000V
ACF: 100μV—750V
DCA: 100nA—10A
ACA: 100nA—10A
Resist: 100mΩ–20mΩ
Diode test: 1mA., 3.2V
hFE test: 0–1000
Instant continuity: 100ms
Capacitance: 1pF–20uF
Compl. w/probes, 9V battery, spare fuse & operating manual.
Item #20058

New – **$49.00**

Model #7905C



DCV: 100μV—1000V
ACF: 100μV—750V
DCA: 100nA—10A
ACA: 100nA—10A
Resist: 100mΩ–20mΩ
Diode test: 1mA., 2.8V
hFE test: 0–1000
Instant continuity
Capacitance: 1pF–20uF
Compl. w/deluxe test leads, 9V battery, spare fuse, operating manual & carrying case. Item #20059

New – **$69.00**

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7400

Part No.	1-9	10+	Part No.	1-9	10+
7400	SALE	.15	7474	SALE	.25
7402	.29	.19	7475	.49	.39
7404	SALE	.15	7476	.45	.35
7405	.35	.25	7483	.69	.59
7406	.39	.29	7485	SALE	.45
7407	SALE	.25	7486	SALE	.29
7408	.35	.25	7489	1.95	1.85
7410	SALE	.15	7490	.49	.39
7411	SALE	.15	7493	.45	.35
7414	SALE	.25	7495	SALE	.29
7416	SALE	.19	74107	SALE	.13
7417	SALE	.19	74121	SALE	.25
7420	.29	.19	74123	SALE	.35
7427	SALE	.13	74125	SALE	.35
7430	SALE	.15	74147	SALE	1.49
7432	.39	.29	74150	SALE	1.10
7438	SALE	.25	74151	SALE	.13
7442	SALE	.29	74154	1.35	1.25
7445	SALE	.59	74161	.69	.59
7446	.89	.79	74173	SALE	.59
7447	.89	.79	74174	SALE	.35
7448	1.95	1.85	74175	SALE	.35
7473	.39	.29	74193	.79	.69

74LS

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74LS02	SALE	.15	74LS151	SALE	.29
74LS03	SALE	.15	74LS153	SALE	.25
74LS04	SALE	.19	74LS154	1.19	1.09
74LS05	SALE	.19	74LS157	.45	.35
74LS06	.59	.49	74LS161	SALE	.29
74LS07	.59	.49	74LS163	SALE	.35
74LS08	.28	.18	74LS164	SALE	.35
74LS09	SALE	.15	74LS165	.75	.65
74LS10	SALE	.15	74LS166	SALE	.69
74LS11	.29	.19	74LS173	SALE	.35
74LS14	SALE	.29	74LS174	SALE	.29
74LS20	SALE	.15	74LS175	SALE	.29
74LS21	SALE	.19	74LS191	SALE	.39
74LS27	SALE	.19	74LS192	.69	.59
74LS30	SALE	.15	74LS193	.69	.59
74LS32	SALE	.19	74LS194	SALE	.45
74LS38	SALE	.25	74LS221	SALE	.49
74LS42	.49	.39	74LS240	SALE	.45
74LS47	.89	.79	74LS241	SALE	.49
74LS73	SALE	.25	74LS244	SALE	.49
74LS74	SALE	.19	74LS245	SALE	.59
74LS75	SALE	.25	74LS257	SALE	.29
74LS76	.39	.29	74LS259	.99	.89
74LS83	.59	.49	74LS273	.89	.79
74LS85	.59	.49	74LS279	.49	.39
74LS86	.29	.19	74LS367	SALE	.29
74LS90	SALE	.29	74LS373	SALE	.59
74LS93	SALE	.29	74LS374	SALE	.49
74LS123	SALE	.35	74LS393	SALE	.69
74LS125	.49	.39	74LS541	SALE	.99
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CD4002	.19	CD4052	.59
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CD4011	.19	CD4060	.65
CD4012	.25	CD4066	.29
CD4013	.29	CD4069	.19
CD4015	.49	CD4070	.29
CD4016	.29	CD4071	.22
CD4017	.49	CD4072	.22
CD4018	.59	CD4073	.22
CD4020	.59	CD4081	.22
CD4021	.59	CD4093	.35
CD4024	.45	CD4094	.89
CD4027	.35	CD4503	.39
CD4028	.49	CD4511	.69
CD4029	.69	CD4518	.75
CD4030	.35	CD4520	.75
CD4040	.65	CD4522	.79
CD4042	.55	CD4528	.69
CD4043	.59	CD4538	.79
CD4046	.65	CD4543	.79
CD4047	.65	CD4584	.49
CD4049	.29	CD4585	.69
CD4050	.29		

EEPROMS

2816A	2048x8 350ns (9V-15V) 5V Read/Write	5.25
2816A-25	2048x8 250ns (9V-15V) 5V Read/Write	5.49
2817A	2048x8 350ns 5V Read/Write	7.95
2864A	8192x8 250ns 5V Read/Write (Pin 1 No R/B)	13.95
2864A-30	8192x8 300ns 5V Read/Write (Pin 1 No R/B)	12.95
2865A-30	8192x8 300ns 5V Read/Write	9.95
52B13	2048x8 350ns (21V) 5V Read Only	1.49

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Z80A-SIO/O	~~3.95~~ 2.95
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8253-5	1.95
82C53-5	3.95
8254	3.95
8255A-5	2.95
82C55A-5	3.49
8259-5	2.25
8272	~~3.95~~ 2.95
8274	~~5.95~~ 4.95
8279-5	~~2.95~~ 2.75
8282	3.49
8284	1.75

8000 SERIES Continued

Part No.	Price
8286	2.29
8741	~~9.95~~ 9.49
8742	~~19.95~~ 17.95
8748 (25V)	7.95
8748H (HMOS)(21V)	9.95
8749	9.95
8751H (3.5-12MHz)	36.95
8755	13.95
80286-10 (10MHz)LCC	59.95
80287-3 (5MHz)	129.95
80287-8 (8MHz)	209.95
80287-10 (10MHz)	259.95
80386-16 PGA	279.95
80387-16 (16MHz)	395.95
80387-20 (20MHz)	459.95
80387-25 (25MHz)	569.95
82284 (8MHz)	~~9.49~~ 7.95
82288 (8MHz)	~~9.95~~ 7.95

DATA ACQUISITION

ADC0804LCN	3.25
ADC0808CCN	~~5.95~~ 5.49
ADC0809CCN	3.69
ADC1205CCJ-1	18.49
DAC0808LCN	~~1.75~~ 1.49
AY-3-1015D	4.95
AY-5-1013A	1.95

STATIC RAMS

Part No.	Function		Price
2016-12	2048x8	120ns	~~3.75~~ 2.95
2102	1024x1	350ns	.89
2112	256x4	450ns MOS	~~2.49~~ 1.95
2114N	1024x4	450ns	~~.99~~ .79
2114N-2L	1024x4	200ns Low Power	1.49
21C14	1024x4	200ns (CMOS)	.49
5101	256x4	450ns (CMOS)	~~2.95~~ 2.49
6116P-1	2048x8	100ns (16K) CMOS	~~3.95~~ 3.19
6116P-3	2048x8	150ns (16K) CMOS	~~3.49~~ 2.79
6116LP-1	2048x8	100ns (16K) LP CMOS	~~4.29~~ 3.59
6116LP-3	2048x8	150ns (16K) LP CMOS	~~3.95~~ 3.09
6264P-10	8192x8	100ns (64K) CMOS	~~9.95~~ 9.49
6264P-15	8192x8	150ns (64K) CMOS	~~9.25~~ 7.49
6264LP-10	8192x8	100ns (64K) LP CMOS	~~10.95~~ 10.25
6264LP-12	8192x8	120ns (64K) LP CMOS	~~10.49~~ 8.95
6264LP-15	8192x8	150ns (64K) LP CMOS	~~10.25~~ 7.95
6514	1024x4	350ns CMOS	3.75
43256-10L	32,768x8	100ns (256K) Low Power	26.95
43256-15L	32,768x8	150ns (256K) Low Power	25.25
62256LP-85	32,768x8	85ns (256K) LP CMOS	29.95
62256LP-10	32,768x8	100ns (256K) LP CMOS	27.95
62256LP-12	32,768x8	120ns (256K) LP CMOS	27.25

DYNAMIC RAMS

THM91000L-10	1,048,576x9	100ns 1MEGx9 SIP	~~399.95~~ 329.95
THM91000S-10	1,048,576x9	100ns 1MEGx9 SIM	~~399.95~~ 299.95
THM91000L-80	1,048,576x9	80ns 1MEGx9 SIP	~~419.95~~ 349.95
THM91000S-80	1,048,576x9	80ns 1MEGx9 SIM	~~419.95~~ 339.95
TMS4416-12	16,384x4	120ns	~~6.75~~ 5.95
TMS4416-15	16,384x4	150ns	~~6.25~~ 5.49
4116-15	16,384x1	150ns (MM5290N-2)	~~1.39~~ 1.25
4128-15	131,072x1	150ns (Piggyback)	~~6.29~~ 4.49
4164-100	65,536x1	100ns	3.49
4164-120	65,536x1	120ns	2.95
4164-150	65,536x1	150ns	2.59
41256-60	262,144x1	60ns	~~10.99~~ 10.49
41256-80	262,144x1	80ns	~~8.95~~ 8.49
41256-100	262,144x1	100ns	~~8.49~~ 7.95
41256-120	262,144x1	120ns	~~7.95~~ 7.49
41256-150	262,144x1	150ns	~~7.49~~ 7.25
41264-12	64Kx4	120ns Video RAM	~~18.95~~ 17.95
41464-10	65,536x4	100ns	~~11.95~~ 9.95
41464-12	65,536x4	120ns	~~9.95~~ 9.25
41464-15	65,536x4	150ns	~~10.95~~ 8.95
51258-10	262,144x1	100ns Static Column	~~11.95~~ 10.95
85227-10PL	262,144x9	100ns 256Kx9 SIP	~~149.95~~ 105.95
85227-10PS	262,144x9	100ns 256Kx9 SIM	~~149.95~~ 105.95
511000P-10	1,048,576x1	100ns (1 Meg)	~~21.95~~ 19.95
511000P-80	1,048,576x1	80ns (1 Meg)	~~24.95~~ 22.95
514256P-10	262,144x4	100ns (1 Meg)	~~29.95~~ 24.95
514258-10	262,144x4	100ns Static Column	31.95

EPROMS

TMS2516	2048x8	450ns (25V)	~~5.95~~ 4.95
TMS2532	4096x8	450ns (25V)	5.95
TMS2532A	4096x8	450ns (12.5V)	~~4.49~~ 3.25
TMS2564	8192x8	450ns (25V)	6.95
TMS2716	2048x8	450ns (-5V +5V, +12V)	~~6.95~~ 6.49
1702A	256x8	2K (1µs)	4.95
2708	1024x8	450ns	6.95
2716	2048x8	450ns (25V)	~~3.75~~ 3.25
2716-1	2048x8	350ns (25V)	~~3.95~~ 3.49
27C16	2048x8	450ns (25V) CMOS	~~4.25~~ 3.75
2732	4096x8	450ns (25V)	3.95
2732A-20	4096x8	200ns (21V)	~~4.25~~ 3.95
2732A-25	4096x8	250ns (21V)	~~3.95~~ 3.75
27C32	4096x8	450ns (25V) CMOS	~~4.95~~ 4.25
2764-20	8192x8	200ns (21V)	4.25
2764-25	8192x8	250ns (21V)	3.59
2764A-25	8192x8	250ns (12.5V)	~~3.69~~ 3.39
27C64-15	8192x8	150ns (12.5V) CMOS	5.95
27128-20	16,384x8	200ns (21V)	~~6.95~~ 6.49
27128-25	16,384x8	250ns (21V)	5.95
27128A-15	16,384x8	150ns (12.5V)	7.75
27128A-20	16,384x8	200ns (12.5V)	~~5.75~~ 5.25
27C128-25	16,384x8	250ns (21V) CMOS	~~5.95~~ 5.49
27256-15	32,768x8	150ns (12.5V)	8.95
27256-20	32,768x8	200ns (12.5V)	~~6.95~~ 6.25
27256-25	32,768x8	250ns (12.5V)	~~5.49~~ 4.95
27C256-15	32,768x8	150ns (12.5V) CMOS	~~7.95~~ 7.25
27C256-25	32,768x8	250ns (12.5V) CMOS	~~6.25~~ 5.49
27512-20	65,536x8	200ns (12.5V)	10.95
27512-25	65,536x8	250ns (12.5V)	9.95
27C512-25	65,536x8	250ns (12.5V) CMOS	~~9.49~~ 8.49
27C1024	131,072x8	200ns (12.5V) CMOS (1 Meg)	24.95
68764	8192x8	64K 450ns (25V) (Chip Enable)	19.95
68766	8192x8	64K 350ns (25V) (Output Enable)	19.95

6500/6800 68000 Series

Part No.	Price
6402	~~3.95~~ 3.49
6502	~~2.65~~ 2.25
6502A	~~2.75~~ 2.59
65C02 (CMOS)	7.75
6520	1.95
6522	2.95
65C22	4.25
6532	~~5.49~~ 4.95
6551	~~2.95~~ 2.69
65C802 (CMOS)	~~15.95~~ 14.75
6800	~~1.95~~ 1.49
6802	2.95
6808	1.95
6810	~~1.25~~ .99
6820	2.75
6821	~~1.75~~ 1.49
68B21	~~1.95~~ 1.75
6840	~~3.49~~ 2.95
6845	~~2.75~~ 2.49
6850	~~1.95~~ 1.49
6852	~~.75~~ .59
MC68000L8	~~9.95~~ 9.49
MC68000L10	~~11.95~~ 10.95
MC68010L10	~~39.95~~ 34.95
MC68020RC12B	89.95
MC68701	17.95
MC68705P3S	9.95
MC68705U3L	10.95
MC68705U3S	10.95
MC68450L10	~~49.95~~ 39.95
MC68881RC12A	109.95
MC68881RC16A	149.95

Commodore

WD1770	~~8.95~~ 7.49
SI3052P	~~1.25~~ .99
6504A	1.19
6510	14.95
6526	14.95
6526A	15.95
6545-1	~~3.95~~ 2.95
6560	~~10.95~~ 8.95
6567	24.95
6572	~~10.95~~ 7.95
6581 (12V)	12.95
6582 (9V)	~~12.95~~ 9.95
8502	7.95
8564	~~4.95~~ 2.95
8566	~~9.95~~ 7.95
8701	9.95
8722	~~10.95~~ 8.95
*82S100PLA**	15.95
901225-01	15.95
901226-01	15.95
901227-02	4.95
901227-03	15.95
901229-05	15.95
901460-03	1.95
901486-06	2.95

*No specs available
**Note: 82S100PLA = U17 (C-64)

74C/CMOS

74C00	Sale	.19	74C174	Sale	.39
74C02	Sale	.19	74C175	Sale	.59
74C04	Sale	.19	74C192	Sale	.99
74C08	Sale	.19	74C194	Sale	.49
74C10	Sale	.15	74C221		1.79
74C14		.49	74C240	Sale	.75
74C32	Sale	.19	74C244		1.79
74C74		.49	74C373	Sale	1.49
74C85		1.49	74C374	Sale	1.49
74C86	Sale	.19	74C911		6.95
74C89	Sale	2.95	74C912		7.95
74C90		.99	74C915	Sale	1.19
74C151	Sale	1.49	74C917	Sale	3.95
74C154	Sale	2.75	74C920	Sale	3.95
74C157	Sale	1.25	74C921	Sale	2.95
74C160	Sale	.49	74C922		3.95
74C161	Sale	.49	74C923		3.95
74C162	Sale	.49	74C925		5.49
74C173		.59	74C926		5.95

MISC. COMPONENTS

TANTALUM CAPACITORS

TM.1/35 .1µf @ 35V	.19	TM4.7/35 4.7µf @ 35V	.45
TM1/35 1µf @ 35V	.19	TM6.8/35 6.8µf @ 35V	.49
TM2.2/35 2.2µf @ 35V	.25	TM10/35 10µf @ 35V	.59

POTENTIOMETERS

Values available (insert ohms into space marked "XX"): 500Ω, 1K, 2K, 5K, 10K, 20K, 50K, 100K, 200K, 1MEG

43PXX 3/4 Watt, 15Turn	.99	63PXX 1/2 Watt, 1Turn	.89

TRANSISTORS AND DIODES

PN2222	.13	PN2907	.13	1N4004	.12
2N2222A	.29	2N4401	.12	1N4148	.07
2N3055	.65	1N270	.25	1N4735	.29
2N3904	.12	1N751	.15	C106B1	.49

SWITCHES

JMT123 SPDT, On-On	1.19	206-8 SPST, 16-pin DIP	1.25
MPC121 SPDT, On-Off-On	1.19	MS102 SPST, Momentary	.39

D-SUB CONNECTORS

DB25P Male, 25-pin	.69	DB25S Female, 25-pin	.75

LEDS

XC556R T1¾, Red	.13	XC556Y T1¾, Yellow	.17
XC556G T1¾, Green	.17	XC556C T1¾, Clear/Red	.17

IC SOCKETS

Low Profile		Wire Wrap (Gold) Level #2	
8LP	.11	8WW	.59
14LP	.12	14WW	.65
16LP	.13	16WW	.69
24LP	.25	24WW	1.19
28LP	.27	28WW	1.39
40LP	.29	40WW	1.89

Soldertail Standard (Gold & Tin) & Header Plug Sockets Also Available

74HC HI-SPEED CMOS

Part No.		Price	Part No.		Price
74HC00	SALE	.17	74HC175		.59
74HC02	SALE	.17	74HC221	SALE	.69
74HC04	SALE	.17	74HC240	SALE	.59
74HC08	SALE	.17	74HC244		.79
74HC10	SALE	.19	74HC245	SALE	.69
74HC14		.29	74HC253	SALE	.39
74HC30	SALE	.19	74HC259		.49
74HC32	SALE	.25	74HC273	SALE	.49
74HC74	SALE	.29	74HC373		.69
74HC75	SALE	.29	74HC374	SALE	.59
74HC76	SALE	.29	74HC595		1.29
74HC85		.55	74HC688	SALE	1.25
74HC86	SALE	.25	74HC943	SALE	7.95
74HC123	SALE	.49	74HC4040	SALE	.79
74HC125		.49	74HC4049	SALE	.25
74HC132	SALE	.39	74HC4050	SALE	.25
74HC138		.45	74HC4060	SALE	.69
74HC139	SALE	.35	74HC4511	SALE	.99
74HC154		1.49	74HC4514		1.79
74HC163	SALE	.39	74HC4538	SALE	.99
74HC174		.59	74HC4543	SALE	.99

74HCT-CMOS TTL

74HCT00	SALE	.15	74HCT139	SALE	.29
74HCT02	SALE	.15	74HCT157	SALE	.19
74HCT04	SALE	.15	74HCT174	SALE	.25
74HCT08	SALE	.15	74HCT175	SALE	.25
74HCT14		.29	74HCT240	SALE	.59
74HCT32	SALE	.17	74HCT244	SALE	.49
74HCT74	SALE	.25	74HCT245	SALE	.49
74HCT86	SALE	.15	74HCT373	SALE	.45
74HCT138		.39	74HCT374	SALE	.45

LINEAR

TL071CP	.59	LM1489N	.45
TL072CP	.79	DS14C89N (CMOS)	1.19
TL074CN	.99	LM1496N	.69
TL081CP	.49	LM1871N	1.95
TL082CP	.49	LM1872N	1.95
TL084CN	.89	ULN2003A	.75
LM301N	.35	XR2206	3.95
LM307N	.39	XR2211	2.95
LM308N	.59	XR2240	1.49
LM309K	1.25	26LS29	2.25
LM310N	1.29	26LS31	.99
LM311N	.39	26LS32	.99
LM317T	.65	26LS33	1.49
LM318N	.99	ULN2803A	1.19
LM319N	1.29	LM2901N	.25
LM323K	3.49	LM2907N	1.29
LM324N	.35	LM2917N (8 pin)	1.79
LM335Z	1.39	MC3470P	1.19
LM336Z	.99	MC3479P	3.95
LM337T	1.09	MC3486P	1.19
LM338K	4.49	MC3487P	.99
LM339N	.39	UDN3613M	.39
LF347N	1.49	LM3900N	.49
LM348N	.69	LM3905N	1.19
LF351N	.39	LM3909N	.89
LF353N	.49	LM3914N	1.79
LF356N	.79	NE5532	.69
LF357N	.89	NE5534	.69
LM358N	.49	7805K (LM340K-5)	1.29
LM380N	.89	7812K (LM340K-12)	1.29
LM386N-3	.89	7815K (LM340K-15)	1.29
LM393N	.39	7805T (LM340T-5)	.45
LF398N	1.95	7812T (LM340T-12)	.45
LF411CN	.79	7815T (LM340T-15)	.45
LF412CN	1.29	7905K (LM320K-5)	1.35
NE555V	.29	7905T (LM320T-5)	.49
XRL555	.59	75113	1.19
LM556N	.45	75150	1.19
LM565N	.89	75154	1.19
LM566CN	1.19	75174	2.95
LM567V	.75	75175	2.95
LM723CN	.39	75176	2.29
LM741CN	.29	75451	.39
LM747CN	.49	75452	.39
LM1458N	.35	75492	.79
LM1488N	.45	MC145406P	2.95
DS14C88N (CMOS)	1.19		

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80287	6 MHz	157.95
80287-8	8 MHz	219.95
80287-10	10 MHz	264.95

32-BIT COPROCESSORS

80387-16	16 MHz	397.95
80387-SX	16 MHz	389.95
80387-20	20 MHz	469.95
80387-25	25 MHz	589.95

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MEMORY SALE!

STATIC RAMS

PART	SIZE	SPEED	PRICE
2112	256 x4	450ns	2.99
2114	1024x4	450ns	.99
2114L-2	1024x4	200ns	1.49
TMS4044-3	4096x1	300ns	2.49
TMM2016-200	2048x8	200ns	2.95
TMM2016-150	2048x8	150ns	3.25
TMM2016-100	2048x8	100ns	3.95
HM6116-4	2048x8	200ns	2.95
HM6116-3	2048x8	150ns	3.95
HM6116-2	2048x8	120ns	4.95
HM6116LP-4	2048x8	200ns	3.95
HM6116LP-3	2048x8	150ns	4.49
HM6116LP-2	2048x8	120ns	5.49
HM6264LP-15	8192x8	150ns	8.95
HM6264LP-12	8192x8	120ns	9.95
HM43256LP-15	32768x8	150ns	24.95
HM43256LP-12	32768x8	120ns	29.95
HM43256LP-10	32768x8	100ns	34.95

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DYNAMIC RAMS

PART	SIZE	SPEED	PRICE
4116-150	16384x1	150ns	.99
4164-150	65536x1	150ns	2.49
4164-120	65536x1	120ns	2.89
4164-100	65536x1	100ns	3.39
TMS4416	16384x4	150ns	8.95
41128-150	131072x1	150ns	4.95
TMS4464-15	65536x4	150ns	14.95
TMS4464-12	65536x4	120ns	15.95
HM51258-100	262144x1	100ns	10.95
41256-150	262144x1	150ns	6.49
41256-120	262144x1	120ns	6.99
41256-100	262144x1	100ns	7.99
41256-80	262144x1	80ns	8.49
1 MB-120	1048576x1	120ns	19.95
1 MB-100	1048576x1	100ns	21.95
1 MB-80	1048576x1	80ns	24.95
414256-100	262144x4	100ns	29.95
414256-80	262144x4	80ns	36.95

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EPROMS

PART	SIZE	SPEED	Vpp	PRICE
2708	1024x8	450ns	25V	4.95
2716	2048x8	450ns	25V	3.49
2716-1	2048x8	350ns	25V	3.95
2732	4096x8	450ns	25V	3.95
TMS2532	4096x8	450ns	25V	5.95
2732A	4096x8	250ns	21V	3.95
2764	8192x8	450ns	12.5V	3.49
2764-250	8192x8	250ns	12.5V	3.69
2764-200	8192x8	200ns	12.5V	4.25
27C64	8192x8	250ns	12.5V	4.95
27128	16384x8	250ns	12.5V	4.25
27128A-200	16384x8	200ns	12.5V	5.95
27256	32768x8	250ns	12.5V	4.95
27256-200	32768x8	200ns	12.5V	5.95
27C256	32768x8	250ns	12.5V	5.95
27512	65536x8	250ns	12.5V	8.95
27C512	65536x8	250ns	12.5V	9.95
27C101-20	131072x8	200ns	12.5V	29.95

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42100A8B-10	1MB x 8-BIT	FOR MAC	100ns	$239.95
41256A9B-15	256K x 9-BIT	FOR PC	150ns	$79.95
41256A9B-12	256K x 9-BIT	FOR PC	120ns	$84.95
41256A9B-10	256K x 9-BIT	FOR PC	100ns	$94.95
41256A9B-80	256K x 9-BIT	FOR PC	80ns	$109.95
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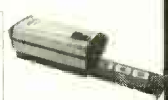
PE-140	NO	9	8,000	$ 89
PE-140T	YES	9	8,000	$139
PE-240T	YES	12	9,600	$189
PL-265T	YES	30	9,600	$255



74 SERIES LOGIC

7400

7400	.19
7402	.19
7404	.19
7405	.25
7406	.29
7407	.29
7408	.24
7410	.19
7411	.25
7414	.49
7416	.25
7417	.25
7420	.19
7432	.29
7447	.89
7473	.34
7474	.33
7475	.45
7476	.35
7586	.35
7489	2.15
7490	.39
7493	.35
74121	.29
74123	.49
74151	.55
74154	1.49
74157	.55
74166	1.00

74LS00

74LS00	.16
74LS02	.17
74LS03	.18
74LS04	.16
74LS05	.18
74LS08	.18
74LS10	.16
74LS11	.22
74LS14	.39
74LS20	.17
74LS21	.22
74LS27	.23
74LS30	.17
74LS32	.18
74LS38	.26
74LS42	.39
74LS47	.75
74LS51	.17
74LS73	.29
74LS74	.24
74LS75	.29
74LS76	.29
74LS83	.49
74LS85	.49
74LS86	.22
74LS90	.39
74LS92	.49
74LS93	.39
74LS109	.36
74LS112	.29
74LS123	.49
74LS125	.39
74LS132	.39
74LS138	.39
74LS139	.39
74LS151	.39
74LS153	.39
74LS154	1.49
74LS155	.59
74LS156	.49
74LS157	.35
74LS158	.29
74LS161	.39
74LS163	.39
74LS164	.49
74LS165	.65
74LS166	.95
74LS175	.39
74LS192	.69
74LS193	.69
74LS197	.59
74LS221	.59
74LS240	.69
74LS241	.69
74LS244	.69
74LS245	.79
74LS251	.49
74LS257	.39
74LS258	.49
74LS259	1.29
74LS260	.49
74LS273	.79
74LS279	.39
74LS322	3.95
74LS323	2.49
74LS367	.39
74LS373	.79
74LS374	.79
74LS377	.79
74LS393	.79
74LS541	1.49
74LS670	.89
74LS682	3.20
74LS688	2.40

74S

74S00	.29
74S02	.29
74S04	.29
74S32	.35
74S74	.49
74S86	.35
74S112	.50
74S138	.79
74S240	1.49
74S244	1.49
74S287	1.69
74S288	1.69
74S373	1.69
74S374	1.69

74F

74F00	.35
74F04	.35
74F08	.35
74F32	.35
74F74	.39
74F138	.79
74F244	1.29

74HC

74HC00	.21
74HC04	.25
74HC08	.25
74HC14	.35
74HC32	.35
74HC74	.35
74HC138	.45
74HC139	.45
74HC154	1.09
74HC157	.55
74HC244	.85
74HC245	.85
74HC373	.69
74HC374	.69

74HCT

74HCT00	.25
74HCT04	.27
74HCT08	.25
74HCT32	.27
74HCT138	.35
74HCT240	.89
74HCT244	.89
74HCT245	.99
74HCT373	.99
74HCT374	.99

Derick's HIGH-TECH SPOTLIGHT

Here at JDR we are constantly reminded how difficult it is to keep up with new developments. Four years ago we could assure our customers that they needed 9 chips at a time to expand their PC. Then the AT became popular and we began saying 9 for PC's and 18 for 80286-based machines. Later we said that you added memory to an 80386 using 36 chips at a time.

When the available memory chips were designed so that one chip supported one bit on the data bus, it was easy to make rules like these. But the rules have changed, which can be very good as we shall shortly see. The number of chips is really determined by the width of the data bus AND the width of the Dynamic RAM memory chip.

For example, if you used a 1 Meg chip that is configured 256K by 4 bits wide, you could design an 80386 motherboard that is expandable in increments of 9 chips at a time. (256K by 4*9 = 256K by 1*36). The obvious advantage is the savings in board space, which makes room for more memory, and the lower cost for memory, since 1 Meg chips cost less.

Because the goal is to create products that are reliable, compatible, full featured and competitively priced, the new 1 Meg chips in both 1 Meg by 1 and 256K by 4 are very desirable. With that in mind, look for new products that take advantage of these more flexible memory options.

Derick Moore, Director of Engineering

MICROPROCESSORS

8000

8031	3.95
8035	1.49
8039	1.95
8052AH BASIC	34.95
8080	2.49
8085	1.95
8085A-2	3.75
8088	5.99
8088-2	7.95
8155	2.49
8155-2	3.95
8156	2.95
8741	9.95
8748	7.95
8749	9.95
8755	14.95

8200

8254	2.79
8255	1.99
8255-5	2.49
8256	15.95
8259	1.95
8259-5	2.29
8272	4.39
8274	4.95
8275	16.95
8279	2.49
8279-5	2.95
8282	3.95
8283	3.95
8284	2.25
8286	3.95
8287	3.95
8288	4.95

8200

8205	3.29
8212	1.49
8216	1.49
8224	2.25
8228	2.25
8237	3.95
8237-5	4.75
8238	4.49
8243	1.95
8250	6.95
8251	1.29
8251A	1.69
8253	1.59
8253-5	1.95

Z-80

Z80-CPU	1.25
Z80A-CPU	1.29
Z80B-CPU	2.75
Z80A-CTC	1.69
Z80B-CTC	4.25
Z80A-DART	5.95
Z80B-DART	6.95
Z80A-DMA	5.95
Z80A-PIO	1.89
Z80B-PIO	4.25
Z80A-SIO/0	5.95
Z80A-SIO/1	5.95
Z80A-SIO/2	5.95
Z8671BASIC	9.95

6500

6502	2.25
6502A	2.69
6502B	4.25
65C02*	7.95
6522	2.95
6526	13.95
6532	5.95
6551	2.95
6581	14.95

* CMOS

6800

6800	1.95
6802	2.95
6809	2.95
68B09	5.99
6809E	2.95
68B09E	5.49
6808	2.49
6810	1.95
6821	1.25
68B21	1.85
6840	3.95
6845	2.75
6847	4.75
6850	1.95
6883	22.95

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V20	6.95
V20-8	8.95
V20-10	11.95
V30	13.95

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16R4	2.95	20R4	4.95
16R6	2.95	20R6	4.95
16R8	2.95	20R8	4.95
		20X8	4.95

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MOD-MPL-SOFT $99.95

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4001	.19	4050	.29
4011	.19	4051	.69
4013	.35	4060	.69
4015	.29	4066	.29
4016	.29	4069	.19
4017	.49	4093	.49
4024	.49	14411	9.95
4040	.69	4511	.69
4046	.69	4538	.95
4049	.29	4702	9.95

SHORTING BLOCKS

5/$1.00

DISCRETE

1N751	.49	2N3904	.10
IN4004	10/1.00	2N3906	.10
IN4148	25/1.00	2N4401	.25
KBP02	.55	4N26	.69
2N2222	.10	4N35	.89
2N2907	.25	JMBO RED	.10
2N3055	.79	JMBO GRN	.14

BYPASS CAPS

CERAMIC DISC:

.01UF	100/5.00
.1UF	100/6.50

MONOLITHIC:

.01UF	100/10.00
.1UF	100/12.50

MISC.

ADC0804	2.99
ADC0809	3.85
DAC0800	3.29
DAC0808	1.95
1793	9.95
8272	4.39
COM8116	8.95
UPD765	4.39
1691	6.95
2143	6.95
AY5-3600 PRO	11.95
AY3-1015	4.95
AY5-1013	3.95
MC146818	5.95
MM58167	9.95
MM58174	9.95
MSM5832	2.95
IM6402	3.95
IM6403	9.95
INS8250	6.95
NS16450	10.95

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32.768 KHz	.95
1.0 MHz	2.95
1.8432	2.95
2.0	1.95
2.4576	1.95
3.579545	1.95
4.0	1.95
5.0688	1.95
6.0	1.95
8.0	1.95
10.0	1.95
12.0	1.95
14.31818	1.95
16.0	1.95
18.0	1.95
20.0	1.95
22.1184	1.95
24.0	1.95

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1.8432	5.95
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2.4576	5.95
4.0	4.95
5.0688	4.95
8.0	4.95
10.0	4.95
14.31818	1.95
16.0	4.95
18.432	4.95
20.0	4.95
24.0	4.95

LINEAR COMPONENTS

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TL072	1.09	NE555	.29	LM3900	.49
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LM309K	1.25	LM565	.95	IC7760	1.99
LM311	.59	LM567	.79	7805T	.49
LM311K	3.49	NE570	2.95	7808T	.49
LM317T	.69	NE590	2.50	7812T	.49
LM318	1.49	LM723	.49	7815T	.49
LM319	1.25	LM741	.29	7905T	.59
LM323K	3.49	MC1330	1.69	7912T	.59
LM324	.34	MC1350	1.19	7915T	.59
LM334	1.19	LM1458	.35	MAX232	7.95
LM336	1.75	LM1488	.49	ICL8038	3.85
LM338K	4.49	LM1489	.49	ICM7207A	5.95
LM339	.59	LM1496	.85	ICM7208	15.95
LF353	.59	ULN2003	.79	75150	1.95
LF356	.99	XR2206	3.95	75154	1.95
LM358	.59	XR2211	2.95	75188	1.25
LM380	.89	CA3046	.89	75189	1.25
LM386	.89	CA3146	1.29	75451	.39
LM393	.45	MC3470	1.95	75452	.39

CIRCLE 113 ON FREE INFORMATION CARD

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PS-135 $59.95
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PS-200 $89.95

APPLE TYPE SUPPLY
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PS-A $49.95

36 WATT POWER SUPPLY
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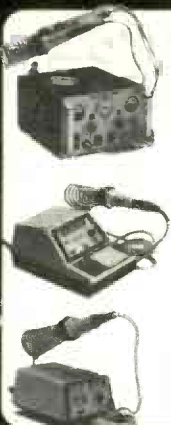
- 3 PIN INPUT, 6 PIN OUTPUT
- SELECTABLE 110V-220V

PS-3045 $12.95

SOLDER STATIONS



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FOR AT

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ROTARY	3-WAY	RSP-3	RSS-3	27.95
ROTARY	4-WAY	RSP-4	RSS-4	29.95

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CBL-PRINTER-RA	RT. ANGL. PRINTER	15.95
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CBL-DB25-MF	DB25 MALE-FEMALE	9.95
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CBL-CNT-MM	36 PIN CENTRON. M/M	14.95
CBL-HD-20	20 PIN HARD DISK	3.95
CBL-HD-34D	34 PIN DUAL HARD DISK	6.95
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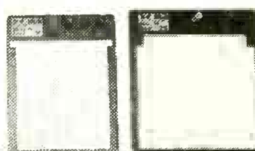

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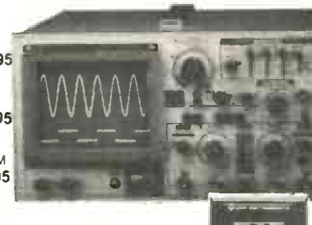

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IDE34 69¢ each 25+ QTY

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DESCRIPTION	ORDER BY	CONTACTS 10	20	26	34	40	50
SOLDER HEADER	IDHxxS	.82	1.29	1.68	2.20	2.58	3.24
RIGHT ANGLE SOLDER HEADER	IDHxxSR	.85	1.35	1.76	2.31	2.72	3.39
WIREWRAP HEADER	IDHxxW	1.86	2.98	3.84	4.50	5.28	6.63
RIGHT ANGLE WIREWRAP HEADER	IDHxxWR	2.05	3.28	4.22	4.45	4.80	7.30
RIBBON HEADER SOCKET	IDSxx	.55	.55	.75	.75	1.19	1.19
RIBBON HEADER	IDMxx	--	5.50	6.25	7.00	7.50	8.50
RIBBON EDGE CARD	IDExx	.55	.55	.75	.89	1.29	1.69
RIBBON CABLE 10 FT.	RCxx	1.50	3.00	3.90	5.10	6.00	7.50

FOR ORDERING INSTRUCTIONS, SEE D-SUBMINIATURE CONNECTORS BELOW

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- 62 CLEARLY LABELLED BUS LINES
- ACCEPTS UP TO 24 14-PIN ICS
- 1940 TIE POINTS
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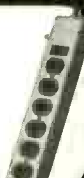

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- UL APPROVED

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D-SUBMINIATURE CONNECTORS

DB25P 50¢ each 25+ QTY

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	FEMALE	DBxxS	.49	.69	.75	.75	1.39	2.29
RIGHT ANGLE PC SOLDER	MALE	DBxxPR	.49	.69	--	.79	2.27	--
	FEMALE	DBxxSR	.55	.75	--	.85	2.49	--
WIREWRAP	MALE	DBxxPWW	1.69	2.56	--	3.89	5.60	--
	FEMALE	DBxxSWW	2.76	4.27	--	6.84	9.95	--
IDC RIBBON CABLE	MALE	IDBxxP	1.39	1.99	--	2.25	4.25	--
	FEMALE	IDBxxS	1.45	2.05	--	2.35	4.49	--
HOODS	METAL	MHOODxx	1.05	1.15	1.25	1.25	--	--
	PLASTIC	HOODxx	.39	.39	--	.39	.69	.75

ORDERING INSTRUCTIONS: INSERT THE NUMBER OF CONTACTS IN THE POSITION MARKED "xx" OF THE "ORDER BY" PART NUMBER LISTED. EXAMPLE : A 15 PIN RIGHT ANGLE MALE PC SOLDER WOULD BE DB15PR

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GENDER-FF	FEMALE-FEMALE	$7.95
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- MOTHERBOARD CONNECTOR
- ADHESIVE VELCRO MOUNTING STRIP

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LONG-LASTING 3V LITHIUM

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HOLDER $1.49

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VOLUME DISCOUNTS CALL!

DESCRIPTION	ORDER BY	CONTACTS 8	14	16	18	20	22	24	28	40
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WIREWRAP SOCKETS	xxWW	.59	.69	.69	.99	1.09	1.39	1.49	1.69	1.99
ZIF SOCKETS	ZIFxx	--	5.95	5.95	--	6.95	--	7.95	7.95	10.95
TOOLED SOCKETS	AUGATxx	.55	.59	.69	.79	.85	.85	.99	1.09	1.29
TOOLED WW SOCKETS	AUGATxxWW	1.30	1.80	2.10	2.40	2.50	2.90	3.15	3.70	5.40
COMPONENT CARRIERS	ICCxx	.49	.59	.69	.99	.99	.99	.99	1.09	1.49
DIP PLUGS (IDC)	IDPxx	.95	.49	.59	1.29	1.49	--	.85	1.49	1.59

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE CONNECTORS ABOVE

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MCT-24I

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OCR-SOFT CHARACTER RECOGNITION SOFTWARE $99.95

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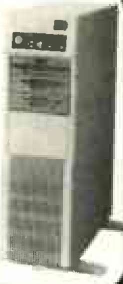

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CASE-FLIP	FOR 8088 BOARDS	$39.95
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LOGC9-PC	SERIAL MOUSE WITH PAINT/CAD	$154.95
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LOGB9-P	BUS MOUSE WITH PAINTSHOW	$104.95
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- AUTO SWITCHING
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- 16 COLOR DISPLAY
- 9-PIN CABLE

EGA-MONITOR

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JDR-AMBER	12" TTL MONOCHROME-AMBER	$69.95

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K103-A	AUDIBLE "CLICK" STYLE	$84.95
MAX-5339	MAXI-SWITCH W/TACTILE FEEDBACK	$84.95

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MODULAR CIRCUIT TECHNOLOGY

NEW LOW PRICES!

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MCT-FDC	FLOPPY DISK CONTROLLER	$29.95
MCT-FDC-1.2	1.2 MB FLOPPY CONTROLLER	$49.95
MCT-HDC	HARD DISK CONTROLLER	$79.95
MCT-RLL	RLL CONTROLLER	$89.95
MCT-FH	FLOPPY/HARD CONTROLLER	$139.95
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MCT-AFH-RLL	286/386 RLL CONTROLLER	$199.95

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MCT-AIO	286/386 MULTI I/O CARD	$59.95

MEMORY CARDS:

MCT-RAM	576K RAM CARD	$59.95
MCT-EMS	EXPANDED MEMORY CARD	$129.95
MCT-AEMS	286/386 EMS CARD	$139.95

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HARD DISKS	KITS
20 MB $199	20 MB $249
30 MB $219	30 MB $279
40 MB $319	
28 MS $389	
60 MB $389	
80 MB $569	

Seagate

NEW LOW PRICES!

SIZE	MODEL	AVG. SPEED	FORM FACTOR	DRIVE ONLY	XT KIT	AT F/H KIT
20MB	ST-225	65 MS	5-1/4"	$199	$249	$309
20MB	ST-125	40 MS	3-1/2"	$259	$299	$373
30MB RLL	ST-238	65 MS	5-1/4"	$219	$279	$379
30MB RLL	ST-138	40 MS	3-1/2"	$289	$339	$429
40MB	ST-251	40 MS	5-1/4"	$319	$369	$429
40MB	ST-251-1	28 MS	5-1/4"	$389	$439	$499
60MB RLL	ST-277	40 MS	5-1/4"	$389	$449	$549
80MB	ST-4096	28 MS	5-1/4"	$569	—	$679

80MB SCSI $499

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- ULTRA HIGH DENSITY
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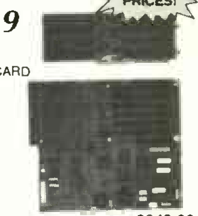
FD-55B	5-1/4" TEAC DS/DD 360K	$99.95
FD-55G	5-1/4" TEAC DS/HD 1.2M	$129.95
FDD-360	5-1/4" DS/DD 360K	$69.95
FDD-1.2	5-1/4" DS/HD 1.2M	$109.95
FDD-3.5X	3-1/2" 720K (BLACK)	$97.95
FDD-3.5A	3-1/2" 720K (BEIGE)	$97.95

MOTHERBOARDS

NEW LOW PRICES!

25 MHZ 386 $1049



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MCT-XMB	STANDARD 4.77 MHZ 8088	$87.95
MCT-TURBO	4.77/8 MHZ 8088	$95.95
MCT-TURBO-10	4.77/10 MHZ SINGLE CHIP 8088	$99.00
MCT-M286	6/10 MHZ MINI-286	$269.95
MCT-M286-12	6/12 MHZ MINI-286	$299.00
MCT-M286-16	8/16 MHZ 286	$489.95
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MI-386MB-1	MYLEX 386 16MHZ/1MB	$1299.00
MI-386MB-4	MYLEX 386 16MHZ/4MB	$1999.00
MI-386MB20-1	MYLEX 386 20MHZ/1MB	$1499.00
MI-386MB20-4	MYLEX 386 20MHZ/4MB	$2399.00

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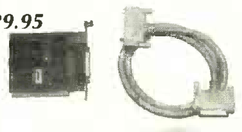

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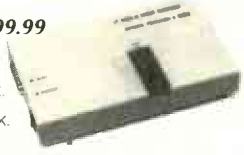
UNIVERSAL MODULE $499.99



- PROGRAMS EPROMS, EEPROMS, PALS, BI-POLAR PROMS, 8748 & 8751 SERIES DEVICES: 16V8 AND 20V8 GALS (GENERIC ARRAY LOGIC) FROM LATTICE, NS, SGS
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- PROGRAMS MMI, NS, TI 20 & TI 24 PIN DEVICES
- BLANK CHECK, PROGRAM, AUTO, READMASTER, VERIFY & SECURITY FUSE BLOW

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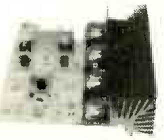
PROFESSIONAL COLOR LIGHT CONTROLLER SM-328 ★

Assembled & tested **$150.00**

The SM-328 professional color light controller is key-board programmable for ease of use, it allows full control of intensity and flash rate. It has four separate channels with capacity of 1170 watts per channel. Total wattage capability is 4.68 killowatts. This is equivalent to bulbs or 936 5-watt colored bulbs and is sufficient for the largest halls and auditoriums. • Independent input signal control • Professional styled control panel • 4 independent outputs • 4 independent dimmer controls • Chaser speed controls • Automatic chaser operation • 4 preset chaser programs • Clock-wise chaser control • Anti-clockwise chaser control.
SPECIFICATIONS: *Input sensitivity (music model) 100mV, (music & program): 2V • Output power: 1170W per channel 4680W total • Power requirement: 105 - 120V, 60hz • Dimensions: 14.32" wide, 9" high, 3.19" deep.*

300W HI-FI POWER AMPLIFIER (MONO) TA-3600 ▲▲▲

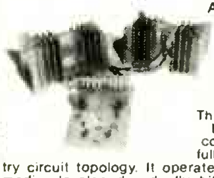
Assembled & tested **$110.00**
Complete Kit **$86.00** Transformer **$38.00**
10,000 UF 80V E. Cap **$20.00**



The TA-3600 is an extremely high power amplifier specifically designed to reproduce the high dynamic range available on compact discs. It has low noise, high stability, low distortion, extended frequency range and high efficiency in a compact package. Two of these units with appropriate power supply and pre-amplifier are required for stereo reproduction.
SPECIFICATIONS: *Power output: 300 watts sine wave 540 watts music power • Frequency response: Total harmonic distortion: Less than 0.05% • Sensitivity: 1Vms at 47K • Power requirements: 60 to 75VDC at 8amp.*

100W DYNAMIC CLASS A MAIN POWER AMPLIFIER TA-1000A ▲▲

Assembled & tested **$80.58**
Complete kit **$59.69**



This well designed and stable amplifier features DC coupling throughout and a fully complementary symmetry circuit topology. It operates in class A at low and medium levels and gradually shifts to class AB operation at high levels. A pair of these amplifiers provide 200 watts of super high fidelity sound reproduction.
SPECIFICATIONS: *Power output: 100 watts into 8 ohms, 125 watts into 4 ohms • Frequency response: 10hz to 100khz • Total harmonic distortion: Less than 0.008% • Signal to noise ratio: Better than 80dB • Sensitivity: 1V • Power requirements: 35 to 45VDC @ 3amp • Suggested rack mount cabinet: Mark V LG1924 or LG1925*

STATE OF THE ART FULLY COMPLEMENTARY SYMMETRICAL FET STEREO PRE-AMPLIFIER TA-377A ▲▲▲

Complete kit **$59.95**

Significant features of this outstanding stereo pre-amplifier are the use of fully complementary and symmetrical FET transistor stages. Employs 1% metal film resistors. Power supply is fully regulated. Has a time delay circuit which prevents turn-on thumps. Power supply components are on board so that it requires only an external transformer.
SPECIFICATIONS: *Frequency response: 10hz to 100khz • RIAA curve deviation: ±0.2dB, 30 to 15,000hz • Total harmonic distortion: Less than 0.007% at rated output • Intermodulation distortion: Less than 0.005% at rated output • Channel separation at 1khz: Better than 70dB • Hum and noise: Phono: Better than 70dB, Aux: Better than 90dB • Sensitivity: Phono: 2mV @ 47K • Output: 1.5V • Record output: 150mV • Maximum output at .1% distortion: 15V • Power requirements: External transformer, 30V x 2 @ 400ma. • Power consumption: 12w*

AMPLIFIERS

MODEL	DESCRIPTION	KIT	ASS.
TA-001	1W Mini-Amplifier	$ 5.07	
TA-006	6W Mini-Amplifier	6.90	
TA-007	12W Mini-Amplifier	11.20	
TA-10	Stereo Pre-Amp. w/magnetic mic. amp.	8.20	
TA-28MK2	Digital Voice Recorder	30.00	40.00
TA-50A/B	Multi-Purpose Melody Generator	11.84	16.58
TA-50C	Multi-Purpose Melody Generator	12.65	17.71
TA-120MK2	Class "A" Main Power Mono Amp.	31.25	
TA-300	30W Multi-Purpose Single Channel Amp.	15.00	
TA-302	60W Stereo Power Booster	50.00	
TA-3221	50W + 50W IC Stereo Amp. w/Led level display	35.50	
TA-323A	HQ 30W + 30W Stereo Amp	29.50	
TA-377A	FET Stereo Pre-Amp.	59.95	75.00
TA-400	40W Solid State Mono Amp.	16.62	
TA-477	120W Mosfet Power Mono Amp.	68.00	
TA-800	80W + 80W DC Stereo Pre-Main & Power Amp.	60.92	
TA-802	80W + 80W DC Stereo Main Power Amp.	45.94	
TA-820A	60W + 60W OCL DC Pre-Main Stereo Amp.	48.00	
TA-1000A	100W Class "A" Main Power Mono Amp.	59.69	$80.58
TA-1500	100Wx2 Class "A" DC Stereo Pre-Main Amp.	73.70	
TA-2400A	Electronic Echo & Reververation Amp.	93.30	116.80
TA-2500	HQ Pre-Amp. w/10 band graphic equalizer		90.00
TA-2800	Hi-Fi Bi-Fet Pre-Amp. w/3 way tone control	48.90	
TA-3000	Stereo Simulator	33.20	43.38
TA-3600	300W HQ Hi-Fi Power Mono Amp.	86.00	110.00

MISCELLANEOUS

MODEL	DESCRIPTION	KIT	ASS.
TY-1A	Battery Flourescent Light Driver	5.19	
TY-7	Electronic Touch Switch	7.15	
TY-8	ELectronic Lotto	15.00	
TY-11A	Multi-Functional Control Switch	5.19	
TY-12A	Digital Clock w/timer	16.63	
TY-13	Color Led Audio Level Meter	20.15	
TY-14	Electronic Shock	6.25	
TY-18	High Precision Sound Control Switch	9.22	
TY-20	V Shape Color Led Level Meter	21.45	
TY-23B	3 Channel Color Light Controller	71.50	82.50
TY-25	Stereo Loudspeaker Protector	12.65	
TY-35	FM Wireless Microphone	9.22	
TY-36	AC/DC Quartz Digital Clock	18.00	
TY-38	Sound/Touch Control Switch	12.00	
TY-41MK111	Infrared Remote Control Unit	15.00	25.00
TY-41MKV	Infrared Remote Control Unit	20.00	35.00
TY-42	Bar/Dot Level Meter	24.15	
TY-43	3½ Digital Panel Meter	33.00	46.20
TY-45	20 Steps Bar/Dot Audio Level Display	38.45	
TY-47	Superior Electronic Roulette	19.46	
SM-222	7 Bands Graphic Equalizer	26.80	38.80
SM-328	4 Channel Professional Color Light Controller		150.00
SM-333	Audio/Video Surround Sound Processor	62.00	83.00
T-1	LCD Thermometer Clock w/in-outdoor sensor	22.00	
T-2	LCD Thermometer Clock w/ F & C measurement	19.80	
# 8501	Parrot Talking Clock	15.50	
# 8504	Mynah Talking Clock	15.50	

POWER SUPPLIES

MODEL	DESCRIPTION	KIT	ASS.
TR-100A	0-15V 2A Regulated DC Power Supply	59.50	69.50
TR-355A	0-15V 5A Regulated DC Power Supply	12.92	
TR-355B	0-30V 3A Regulated DC Power Supply	12.92	
TR-503	0-50V 3A Regulated DC Power Supply	14.76	

INSTRUMENTS

MODEL	DESCRIPTION	KIT	ASS.
SM-43	3½ Multi-Functional Led D.P.M.	34.50	43.00
SM-48	4½ Hi-Precision D.P.M.	38.00	48.00
SM-48A	4½ Hi-Precision D.P.M. w/ stndrd case	41.20	52.00
SM-100	150MC Digital Frequency Counter		90.00
FC1000A	1 GHz Frequency Counter		182.00

METAL CABINETS

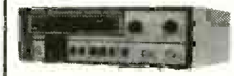
MODEL	DESCRIPTION	EA SET
LG-1273	3" x 12" x 7"	20.16
LG-1684	4" x 16" x 8"	24.64
LG-1924	4" x 19" x 11.5"	30.00
LG-1925	5" x 19" x 11.5"	33.00

TRANSFORMERS

MODEL	DESCRIPTION	PIECE
# 001	28V x 2 6A to 30V x 2 6A	25.00
# 002	36V x 2 3A	19.00
# 003	40V x 2 6A	24.00
# 004	24V x 2 6A	19.00
# 005	26V x 2 3A	12.00
# 006	18V x 2 5A	13.60
# 007	53V x 2 8A	38.00

8-DIGIT 1 GHZ MULTI-FUNCTION COUNTER FC-1000A ★

Assembled / tested & CAL **$192.00**



The FC-1000A is a multi-function 10 hertz to 1ghz dual-range frequency counter. It can measure frequency, period and total events. Readout is a large 0.5" 8-digit, 7-segment LED display. It utilizes two crystal oscillators which can be individually calibrated for maximum long term accuracy against a frequency standard such as WWV transmissions. Additional features include a valuable self-check mode and a two step input attenuator.
SPECIFICATIONS: *Frequency range: 10hz to 10mhz, 10mhz to 10mhz, 100mhz to 1000mhz • Resolution: 1000hz to 0.1hz depending on range • Accuracy: ±1 digit, ± time base error • Period measurement: 10hz to 10mhz • Period measurement resolution: 10^{-7} to 10^{-10} seconds depending on gate time • Totalization measurement: 10hz to 10mhz • Totalization display: 99999999 • Sensitivity: 15mV 10hz to 70mhz, 30mV 70mhz to 100mhz, 15mV 100mhz to 1000mhz • Input impedance: 1 megohm 10hz to 100mhz, 50ohms 100mhz to 1000mhz • Attenuation: X1, X10 • Power requirements: 110 to 120VAC, 60hz or 220VAC, 50 to 70hz • Dimension: 3" high, 9.69" wide, 7.87" deep.*

SURROUND SOUND PROCESSOR ▲▲ SM-333

Assembled & tested **$83.00**
Completed kit **$62.00**

The new SM-333 surround sound processor is a full featured unit that is designed to provide your system with the ultimate musical realism.
It has inputs for VCR, Video Disc and Compact Disc and can also be used with FM tuners, tape decks and LP discs – in fact anything that can be connected to your pre-amplifier. It also has front panel control of dynamic noise reduction, surround level, effect and time delay up to 50 milliseconds. Rear panel outputs for front and rear stereo speaker amplifiers. The unit may be purchased as a kit or fully assembled ready to plug in.
SPECIFICATIONS: *Frequency response: 20hz to 20khz • Total harmonic distortion: Front channel. 0.05%, Rear channel: Less than 0.25% • Input signal voltage: 0.1 to 3.5V • Output: Front channel: 0.1 to 3.5V, Rear channel: 6.6V • Delay time: 5 to 50 milliseconds • Input impedance: 47K • Power requirements: 110/220 VAC, 50/60hz • Dimensions: 14.2" wide, 4.82" deep, 2.1" high.*

3½ MULTIFUNCTION LED DIGITAL PANEL METER SM-43 ▲▲

Assembled / tested & CAL **$43.00**
Completed kit **$34.50**

* Free Gold-Plated edge connector included.

This is a high quality device with excellent specifications. Instructions are included to use this instrument as a voltmeter, ammeter, ohmmeter, temperature meter, frequency meter and capacitance meter. The accuracy of this meter is ±0.1%, ±1 digit. Input impedance is 100 megohms. It has high vibration resistance and so can be used in a mobile or portable environment. Resets to zero automatically. The meter is temperature compensated so that it can be used from 0 to + 150 degrees fahrenheit.
SPECIFICATIONS: *DC voltage range: 1mV to 1000V • AC voltage range: 1mV to 1000V • Thermometer range: 0°C to 100°C • DC current range: 1 microamp to 2 amps. • Capacitance range: 1pf to 2 microfarads • Frequency counter: 10hz to 20khz • Display: 3½ digit 0.5" high LED • Maximum indication: -1999 or +1999 • Power supply: 5 to 6 VDC, 200ma • Dimensions: 3¾" wide, 1⅞" high, 4-1/16" deep.*

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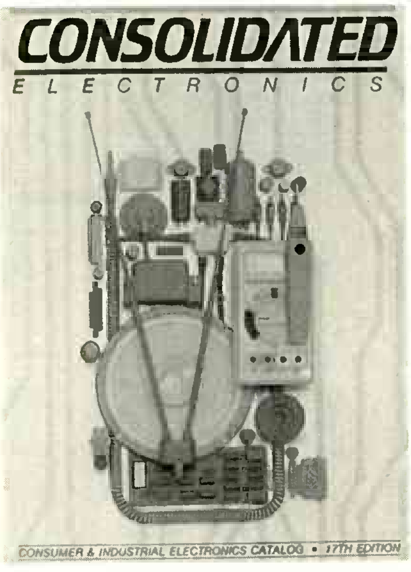

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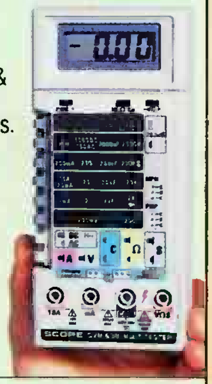

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