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# November 1988 Radio-Electronics

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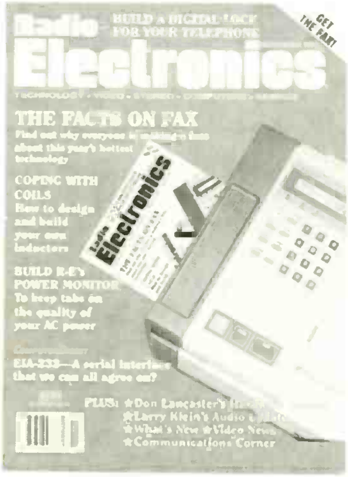


Facsimile machines have been around for almost half a century. However, it took the advent of digital electronics—and the resultant quality improvement and price reduction—to bring fax into the mainstream. Now, consumer-electronics experts are predicting that home fax machines will soon become as common as PC's and videocameras. To discover what's behind the technology and fax machines' rise in popularity, turn to page 45. To learn how they've developed over the years, from someone who was there from the beginning, see page 50.

# COMING NEXT MONTH

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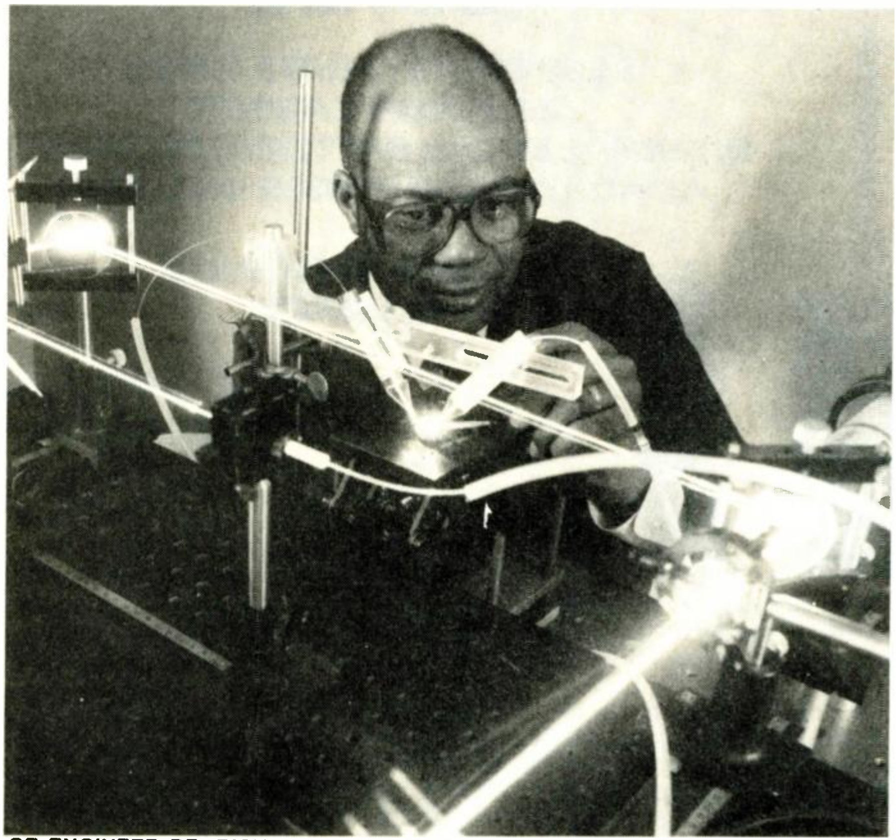
# WHAT'S NEWS



GE ENGINEER DR. RICHARD I. HARTLEY adjusts the flexible tips of a new welding system that carries the power on thin fiber-optic cables and applies the heat to both sides of the weld simultaneously.

## New laser-welding system uses fiber-optic cables

A new laser-welding system, that fires its intense energy through needle-thin fiber-optic cables and heats both sides of the workpiece simultaneously, is in use at a General Electric plant in North Carolina. Each of the 75-foot-long fiber-optic cables in the new welding system carries a laser beam of up to 100 watts of power. The cables are extremely flexible, so their tips—the "windows" that the beams come through—are easily positioned on opposite sides of a workpiece.

In 1983, General Electric scientists demonstrated that a fiber-optic cable can carry several hundred watts of average power without suffering damage. The problem was how to inject a laser beam into one end of a hair-thin electrical fiber without damaging its protective coating or melting the glass. That problem was tackled by Dr. Marshall G. Jones of the GE Research and Development Center. He and his associates developed an "input coupler"—an optical assembly that reduces the ¾-inch laser beam to the diameter of the glass fiber in the fiber-optic cable. Its transmission efficiency is 90 percent.

The new technology is being used in a GE lighting plant in Goldsboro, NC to weld lead wires to the filaments of electric bulbs used in auto headlamps. Two conductors, one of nickel-plated iron wire and one of molybdenum, must be welded together end-to-end. The iron wire is about twice the diameter of the molybdenum. Applying the heat from both sides makes a more symmetrical and stronger joint than that produced by earlier approaches.

## Satellite-TV pirates hit with $130K damages

U.S. District Court Judge Thomas E. Scott (Miami, FL) awarded General Instrument Corp., HBO, and Showtime, $130,000 in statutory damages—and granted a permanent injunction from marketing, using, importing, selling, distributing, abetting, or manufacturing any device designed to unlawfully intercept satellite pay-television programming services—against Shaun Kenny, Bob Cooper, and Network Productions, Inc. of New Jersey.

Judge Scott awarded $110,00 in statutory damages against Shaun Kenny, $20,000 against Bob Cooper and Network Productions, and plaintiff attorneys' fees that will be determined at a later hearing in Miami.

The suit was filed by Cable/Home Communications Corp. (a subsidiary of General Instrument Corp.), Home Box Office, Inc., Showtime/The Movie Channel, and M/A-Com, Inc. It alleged that Network Productions, Kenny, and Cooper had violated U.S.-copyright laws and infringed upon copyrights of the VideoCipher descrambling technology that is used to deliver subscription programming to the home satellite-TV market.

It further alleged that Cooper, Kenny, and Network Productions had violated the Federal Communications Act, that prohibits the design, manufacture, marketing, and use of devices intended to receive encrypted signals without authorization. **R-E**

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# VIDEO NEWS

**DAVID LACHENBRUCH,**
CONTRIBUTING EDITOR

• **Downsizing 8mm.** If you think you've seen some miniature VCR's and camcorders, you ain't seen nothing yet. Sony—which only recently introduced the 8mm Video Walkman, combining an LCD-color TV with an 8mm VCR (**Radio-Electronics**, September 1988)—has now developed an 8mm tape-transport mechanism occupying only one-third the space of original versions. The head drum is only about 1.05 inches in diameter—so small that it largely fits inside the cassette when recording or playing.

One of the secrets of Sony's miniaturization is cutting the drum size from 40 mm to 26.7 mm. That increases the tape wrap around the drum to 292 degrees from 190 degrees and doubles the number of video heads to four. With that move, Sony obviously hopes to win the miniaturization race with the VHS-C format. (The VHS group has already miniaturized the drum, increased the tape wrap, and doubled the number of heads). The VHS-C drum may now be down to its irreducible minimum.

In addition to reducing the head-drum size, all other components in the 8mm deck have been cut in size and weight. The new mechanical assembly is claimed to have one-half the weight (6.5 ounces), one-third the volume, and one-half the thickness of original 8mm mechanisms. Sony is offering the new transport to other manufacturers. It should show up in recorders some time in 1989.

• **Cable and HDTV.** Like the broadcasters, cable-TV systems are looking at the prospects for high-definition TV and will conduct their own tests soon. Two major cable entities—American Telecommunications Co. and Home Box Office, both subsidiaries of Time, Inc.—have outlined their view of attributes to be considered for a cable HDTV system:

- At least 850 lines of horizontal and vertical resolution in both static and moving images;
- Occupancy of one 6-MHz RF channel;
- Need for "little or no rebuild" of the typical cable system;
- Ability to coexist with standard channels on a cable system;
- Adaptability to future evolutionary picture improvements;
- Ability to accommodate real-time, live HDTV programming;
- Easy interface with HDTV program-production systems;
- Four CD-quality audio channels;
- Built-in scrambling system;
- Ability to be delivered to cable systems by satellite;
- Recordable on VCR's and optical discs.

Those two cable entities envision "multi-standard" TV receivers designed for a "family of HDTV transmissions," from broadcast, cable and VCR sources.

• **More 35-in Tubes.** There's only one place in the world where 35-inch color-picture tubes are being manufactured for the global market—and that's the Kyoto, Japan, plant of Mitsubishi Electric. That largest mass-produced tube (known as 37-inch in countries that use over-all diagonal instead of picture-diagonal measurement) is made with special glass, in a heavily automated plant. The result is a tube weighing 132 pounds, as compared with 330 pounds, if it were made using materials and methods used in smaller tubes. Mitsubishi will turn out about 130,000 of those giants this year—some 100,000 going into Mitsubishi sets and the rest sold to other TV-set manufacturers, including JVC, Sharp and Zenith. Although the American picture-tube industry is expanding to produce tubes with diagonal measurements up to 32 inches, none of the U.S. manufacturers plan to make tubes as big as Mitsubishi's giant. The demand for 35-inch tubes is greater than the supply, and Mitsubishi is expected to increase production in 1989.

Is anything bigger on the way? Sony has demonstrated a prototype 43-inch Trinitron but has given no availability information. Mitsubishi experimented with a 43-inch tube, but shelved the project when it was determined that a set that big will not fit through the doors of most homes.

• **Videodisc "Singles."** A new lower-cost type of videodisc has been approved by the Laserdisc group in Japan and is being explored in the United States and Europe. The 8-inch, one-sided "single" disc is made of polycarbonate material instead of the traditional acrylic and provides 20 minutes playing time. Today's two-sided 8- and 12-inch discs must be pressed in special plants—where capacity is limited—and consist of two discs glued together. The new singles can be pressed in many compact-disc plants—that currently have excess capacity—and are inherently cheaper to produce. The new discs are compatible with all existing laserdisc players and are similar in many respects to the 5-inch CD-Video discs that provide up to six minutes of video and 20 minutes of digital audio. It's not known when the new 8-inch video singles will be available.

• **Tubeless Projection TV.** Projection television could lose its cathode-ray tubes and gain a light bulb. Sharp has demonstrated a TV projector that uses three 3-inch liquid-crystal displays as lightvalves—one for each primary color—and whose picture size is variable from 20 to 100 inches in diagonal measurement. A newly developed 100-watt lamp providing 6,600 lumens of white light is the light source, with a claimed life of more than 2,000 hours. The picture is still rather coarse—92,160 pixels—but the contrast ratio is 100:1. The projector looks more like an old magic lantern than a TV set. Sharp says it will be on the market in Japan next spring. Other companies are also working on three-LCD projection systems and one American company, Comtrex International, is marketing a single-LCD projector at $2,295.

• **Bigger LCD TV's.** Flat-screen TV sets are getting bigger. Although few LCD color-TV's today are bigger than about 3 inches in diagonal measurement, they'll be growing soon. Hitachi is selling a 5-inch model in Japan, and Casio plans to introduce one with a 6-inch screen there this year. A 6.3-incher with 300,000-pixel resolution is in the works from Hitachi, and both Hitachi and Casio say they're working on 7-inch models. Hitachi's uses non-interlace scanning for higher resolution. They're both said to be due next year. Next will come a 10-incher, also from Hitachi. The biggest surprise, however, was Sharp's demonstration of a 14-inch LCD color-TV with a picture claimed to be comparable to that of a CRT set—and scheduled for introduction as early as next spring. R-E

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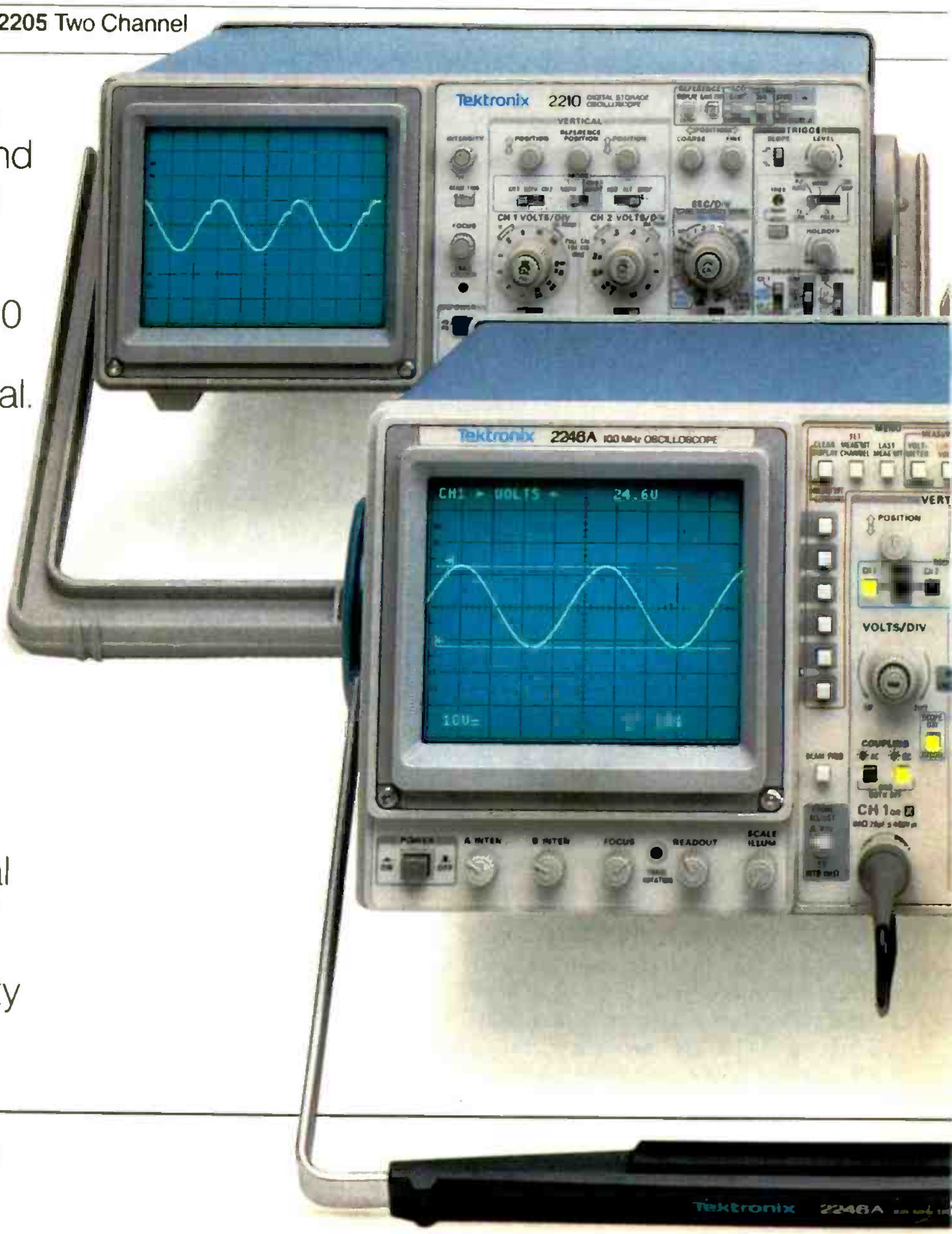

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## Z-80 UPGRADE

**I have an old Z80-A based Morrow MicroDecision MD3 and I would like to modify it to run at 8 MHz with a Z80-H. I'm planning on replacing all the original memory with faster chips (120 ns) but in studying the data sheets, I keep coming across two timing specifications—access time and cycle time. I know what access time is, but I don't know what cycle time refers to.—C. M., Austin, TX**

When you decide to use DRAM in a circuit design you're really opening a can of worms. While it's true that they save board space, power, and money, there's no getting around the fact that using them can be a one way ticket to the rubber room.

Speeding up a computer requires more than just changing the CPU, clock, and DRAM. Those are the obvious things but there are some subtle ones as well, and trying to find the problems they cause can produce an unbelievable amount of brain damage.

Using 120-ns DRAM with an 8-MHz clock means that you won't be getting any grief due to access time. It also means that the cycle time is only of academic interest but, since you asked, here's the deal.

The timing chart in Fig. 1 is an abbreviated version of all the various DRAM parameters. One look at the address lines will show you that a lot of stuff has to happen before you can get to the data. The row address and column address have to be sequentially presented to the address pins and strobed into the internal latches by RAS and CAS. Once the DRAM has the address stored, it needs some time to access the particular cell and make it available for either a read or a write.

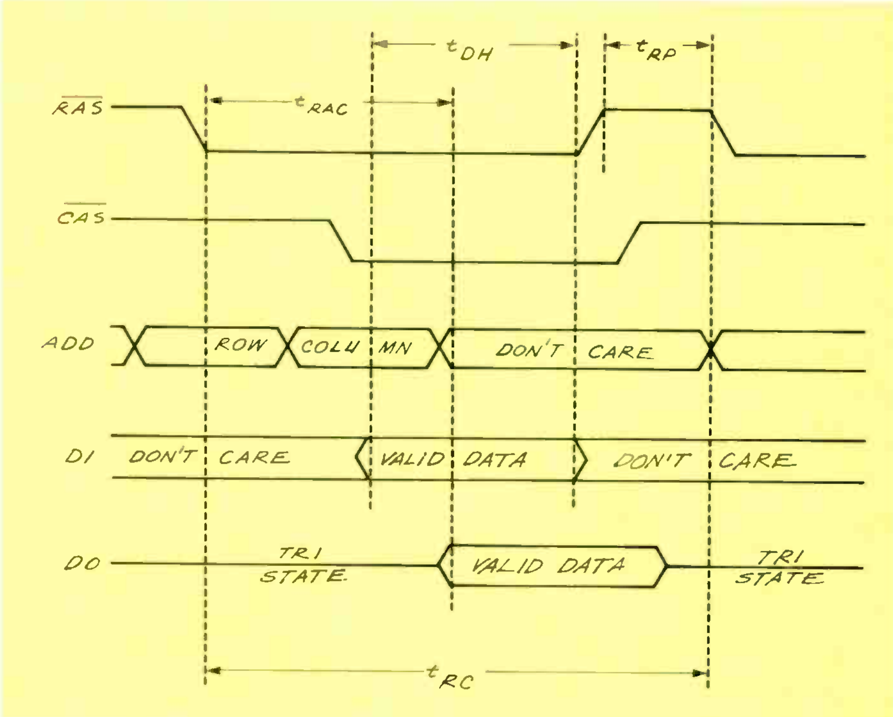



FIG. 1

The time it takes to get from RAS (row address strobe) to the point where data shows up is the "access time," usually referred to as $t_{RAC}$ in the data books. The data stays valid for a predefined amount of time known as $t_{DH}$ (the data hold time). Toward the end of that period, the internal latches have to reset themselves to be able to accept the next RAS pulse. That is known as the RAS precharge time ($t_{RP}$), and the DRAM won't accept another address until after $t_{RP}$ has passed.

If you're repeatedly accessing memory and you want to do it as fast as possible, the chip's access time gives you only part of the story. The access time tells you how quickly the data will show up when you address the chip but you can't get data from a different address until $t_{RP}$ has passed. The minimum amount of time that has to pass between RAS pulses is the cycle time ($t_{RC}$).

Most data sheets will give you $t_{RC}$, but a good rule of thumb is that:

$$t_{RC} = t_{RAC} + t_{DH} + t_{RP}$$

The cycle time is actually a little less than that since there are overlaps, but it's close and gives you a worst-case figure. If you want to learn more about DRAM, check out the "Drawing Board" series on these devices that started back in May 1987.

What has to be done to speed up a computer varies from machine to machine. Unfortunately it's the subtleties that are different. The things to watch are ROM speeds, I/O, and video on the hardware side and time-sensitive BIOS routines in the firmware. And get yourself a commented BIOS listing since journeying through the BIOS without one is just about impossible.

### SPARK-GAP CAP?

**When salvaging components from discarded TV sets, I often run across funny looking components that are noted as "spark-gap capacitors" on the parts list or schematic. I can't find any mention of those parts in any TV theory and servicing manuals. What are they?—D.H. Vancouver, BC.**

Spark gaps may be needed at any number of points in a TV circuit. They protect low-voltage and delicate components against damage from high-voltage surges and transients. They are simply two small pointed or rounded electrodes fixed in position in a ceramic packaging, and they frequently resemble a disc capacitor to the untrained eye.

A voltage surge or a transient voltage that attempts to rise above a safe value, arcs across the spark gap's electrodes, which guide the voltage surge or transient around the circuit or the components being protected.

You may find spark gaps between picture-tube cathodes and ground; to discharge high-voltage picture-tube transients and to prevent damage to other components. You may find them in color amplifiers, horizontal-deflection circuits, and very often in the TV-antenna matching and filter network, as shown in Fig. 2.

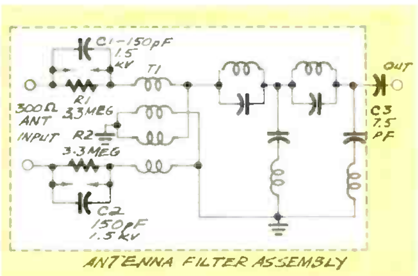



FIG. 2

Networks R1/C1 and R2/C2 are Capristors; safety devices consisting of a spark gap, high-voltage capacitor, and high-value resistor, all in parallel. The Capristors prevent shock hazards at the antenna terminals of TV's that don't have isolating-type power transformers. The capacitors have a reactance of around 18 megohms at line frequencies and are, in effect, open circuits. At TV frequencies, the capacitors appear as short circuits with reactances of less than 20 ohms across the VHF band.

Resistors R1 and R2 protect the capacitors against being punctured by high electrostatic charges that may build up on the antenna during thunder storms. The resistors permit the charges to leak off to ground before they can reach damaging levels. The spark gaps protect the capacitors against fast-rise high-voltage charges that may not be discharged fast enough through the resistors. The Capristors may resemble a disc capacitor with two small "horns" protruding from the top. **R-E**

# LETTERS


### STILL MORE ON THE MACRO-SCRUBBER

I built the Macro-Scrubber that appeared in the December 1987 issue of **Radio-Electronics**. It is a good circuit, but it has some flaws that I corrected.

In the July 1988 issue, a letter from Robert Maslak called out the fact that the 14 microsecond window of the original circuit failed to filter out a lot of the *Macrovision* pulses. I implemented his circuit fix and found that it took care of most of the problem. However, I wanted to find a further fix that would take care of the *Macrovision* pulses at the very beginning of the vertical-blanking interval. That can be done with the addition of a few more parts. Rather than change the crystal, as Mr. Maslak suggests, I changed IC4's count by cutting and jumpering to a count of 9. See Fig. 1.

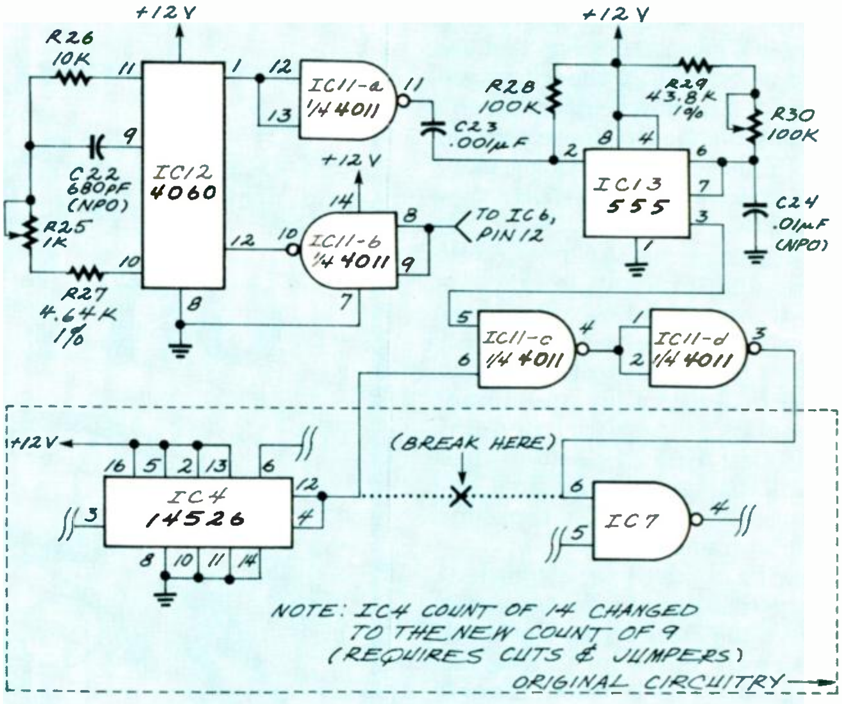



FIG. 1

The philosophy of operation is based on triggering IC13 one shot by a pulse that is at the beginning of the vertical blanking. Because there is no pulse generated at the beginning of the vertical interval, a way to create one is needed. If the vertical-sync serration pulse (IC6 pin 12)—which occurs 190 microseconds into the vertical interval—is used to synchronize a free-running pulse-delay generator, a circuit approach is defined.

If the vertical-sync serration pulse is inverted and applied to the reset line of a 4060 (IC12, a binary counter and oscillator) that is set to the correct frequency, then the trigger pulse from IC12 for IC13 will be at the right time. Because IC12 stops counting during the vertical-sync serration-reset pulse, the correct delay from IC12 pin 1 must be 16.2856 milliseconds. That translates to an oscillator frequency of 125.75 kHz. That oscillator frequency is determined by R25, R27, and C22. The 4060 gives a precise, repeatable long delay, that would be difficult to get using a one-shot approach. The fixed resistors should be 1% and the capacitors should be NPO ceramic for temperature stability.

Circuit adjustment is best accomplished using an oscilloscope. If the pulse from IC13 pin 3 is used to sync the video-out signal (applied to the input of the scope), R25 is adjusted so that the trace just begins at the vertical-blanking interval. Next, change the scope input to IC13 pin 3, and change R30 until the pulse length is one vertical interval long, that would be 1.33 milliseconds.

That circuit modification is all that is necessary to remove all of the *Macrovision* pulses. Observation with a scope shows a complete video "cleanup"—but the actual viewing on TV passes the "acid test."

JACK SLAGER
*N. Hollywood, CA*

### THE DEBATE CONCLUDES

In a letter to **Radio-Electronics** (September 1988), Richard A. Bowen claimed that "If Mr. Mims had his way, possessing an ordinary pencil would be against federal law as it could be used as a weapon to kill." Gosh, I hope not. All those hand-lettered books I do for Radio Shack are written with—you guessed it—a pencil.

I can live with Mr. Bowen's "pencil-cide" charge since it's so silly. But in the remainder of his letter, Mr. Bowen totally misrepresented some statements I expressed in the November 1987 and May 1988 issues of **Radio-Electronics**.

At issue was the October 1987 cover story, "Build This Laser Listener." Its lead paragraph warned that "Breaking and entering to plant a listening device...can earn someone a long jail term." The article then suggested that "A better and safer way to bug a room is to use a laser beam to eavesdrop on a window from across the street." Furthermore, a heading presented the device as a means "...to listen in to anything, anywhere, any time."

What **Radio-Electronics** did **not** tell its readers is that bugging a room with a laser can also earn someone a long jail term and heavy fines. Nor did **Radio-Electronics** warn its readers that it is a violation of federal law and many state laws to even build or possess an electronic device whose *sole* purpose is eavesdropping.

That is the key point of my previous correspondence. I don't have any problem with articles about laser eavesdropping; I've written several myself. I have also demonstrated laser eavesdropping on several local and national television programs. However, I part company with **Radio-Electronics** and Mr. Bowen when they endorse the violation of federal and state laws.

How would Mr. Bowen react if a curious neighbor aimed the Laser Listener at his bedroom? How would **Radio-Electronics** feel if I, a columnist for *Modern Electronics*, aimed it at **Radio-Electronics**' editorial offices?

I know exactly what I'll do if someone aims a Laser Listener at my office! First I'll place a corner reflector in the beam to overload the detector. Then I'll get my infrared viewer, sneak up on the eavesdropper, and zap him with a **Radio-Electronics** stun gun. Finally, I'll tie up the culprit with my wire-wrap tool, stack him on a fire-ant mound, and call the law. If he comes back again, I'll dust off the light-seeking rocket I built back in 1967 and see if it still works.
*FORREST M. MIMS, III*

**Radio-Electronics** *does not endorse the violation of any federal or state laws. Our rather sensational opening to the Laser Listener story was meant to be taken tongue-in-cheek—anyone who tries to bug a room with a visible laser deserves what he gets! In hindsight, we should have been more responsible. Fortunately, our Laser Listener's sole purpose was not eavesdropping. Its purpose was to give our readers a way to experiment with communications by using modulated light beams.*—Editor

### SURROUND SOUND KUDOS

I read, with interest, the letters from Mr. Dressler and Mr. Wood (**Radio-Electronics**, June 1988), concerning the theory and applications of surround sound. I am a retired electronics technician, and I have the finest audio and video components. I've had access to several high-priced commercial surround-sound decoders. I also read your article concerning surround sound (April 1988), and built the decoder you presented.

After making many comparisons, I find **Radio-Electronics'** decoder excellent. My family and friends have truly enjoyed the results. I completely agree with the author that noise reduction and time delay are not necessary for home use. I also like having the ability to remove the 7-kHz cut off for certain applications.

WALTER RASKOFSKY
*Bloomfield, NJ*

### L/C METER ENHANCEMENT

Thanks to the thoughtfulness and expertise of one of your readers, Ken Walters, an important improvement in the reliability of my "L/C Meter" (**Radio-Electronics**, July 1988) was brought to my attention. I'd like to pass that information along to other readers.

At large values of capacitance (greater than 25,000 pF) erratic operation may result due to a "spike" in the output waveform of the LM311 oscillator. Mr. Walters was smarter than I in that he read the LM311 application notes. (As they say, "if all else fails, read the instructions.")

If you experience erratic operation at large values of capacitance, or are unable to successfully calibrate the unit because the frequency appears to be twice what I specified on the calibration capacitor, the cure is to solder pins 5 and 6 of the LM311 (8-pin DIP) together. Pins 5 and 6—intended for connection to an offset-balance potentiometer—act as parasitic inputs if they are not used.

The soldering can be done on either the top or bottom of the board, as you see fit. The problem seems to occur most on units that have a socket for the LM311. All assembled units I ship in the future will have that modification. Those units already shipped operate up to 68,000 pF, as that is what I used to calibrate them.

NEIL W. HECKT
*5211 117th S.E.*
*Bellevue, WA 98006*

### ...ON A CLEAR DAY

An even simpler way of finding true north than that shown in "Ask R-E" would be to use a magnetic compass and find out the compass deviation from true north from your county surveyor, a nautical map, or at the public library. The deviation can be either plus or minus—so you have to be sure to get that right.

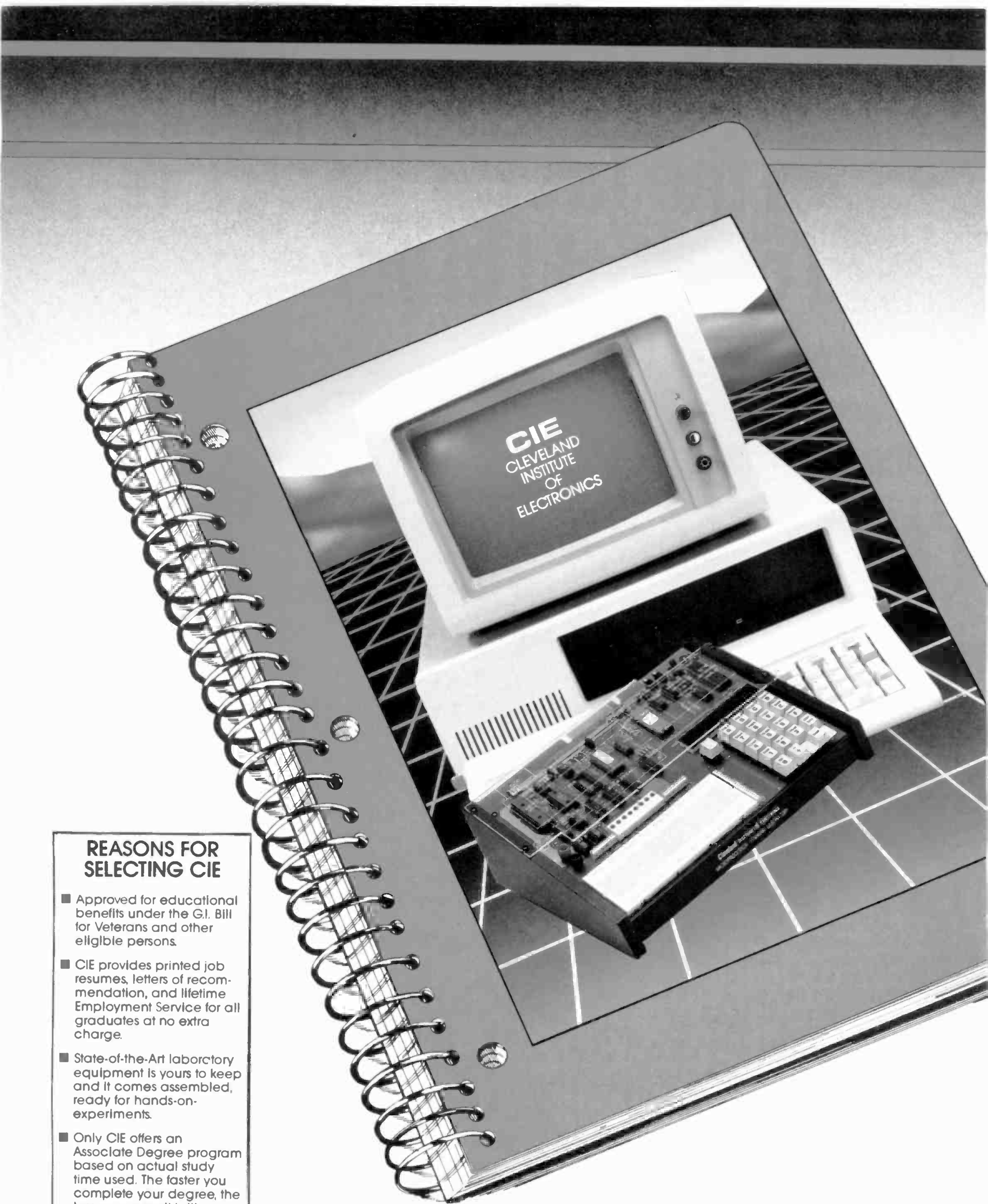
You can also find true north using a simplified method of the process shown in Figure 1 in September's "Ask R-E" column. Drive a thin stick in the ground so that it stands 2 or 3 feet straight up and down. Put a small stone to mark the point where the tip of the shadow falls. Wait until the shadow moves a couple of feet and place another stone at the tip of shadow.

Next, sight along the line between the two markers, and draw a straight line to the point where the line passes closest to the stick. A line from the base of the stick to that point would indicate true north.

You do need a sunny day.

ROY A. NORMAN
*Brunswick, GA*

R-E

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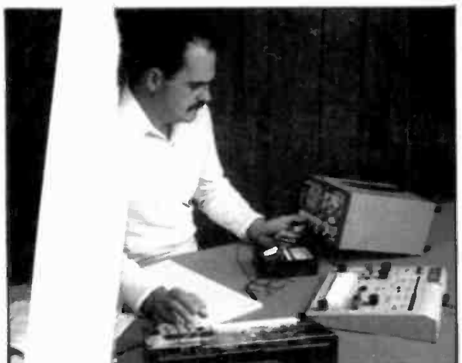

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ARE-101

# EQUIPMENT REPORTS

## Command Communications TF500 Autoswitch

*Only one phone line is needed to automatically handle a fax, a computer, an answering machine, and a conventional telephone.*


CIRCLE 48 ON FREE INFORMATION CARD

ADD UP THE MONTHLY CHARGES FOR all the telephone lines needed for the electronic gadgets used in the modern business office and you're looking at the reason why many smaller enterprises have avoided fax machines, computers, and even order-taking recorders.

But use a device called a TF500 Autoswitch, from Command Communications, Inc, (8000 E. Girard Ave., Suite 420, Denver, CO 80231) and, as shown in Fig. 1, you need only one telephone line to handle up to three office machines, as well as a telephone and its extensions.

### A "Black box"

The TF500 Autoswitch, which is housed in a cabinet 6.87"W × 2.62"H × 6.37"D, is completely automatic—there are no operating controls. On the rear apron are five telephone-type modular jacks labeled TELEPHONE LINE, PRIMARY ANSWER, PHONE, FAX, and AUXILIARY. (The AUXILIARY connector is usually used for a personal computer.) The front panel has LED indicators labeled ON, PRIMARY ANSWER, FAX, and AUXILIARY. The primary answer device is assumed to be a conventional telephone-answering machine.

The unit actually provides two automatic modes: one for "business hours," the other for "after hours," the primary difference being that it is assumed the telephone-answering machine will be turned off during business hours.

During business hours, the autoswitch assumes that the switching will be primarily between a telephone and a fax machine; hence, the autoswitch answers the call on the first ring and listens for the 1100-Hz tone that is transmitted by an *autodialing* fax machine. If it senses the tone, the TF500 connects the incoming call to the fax machine. If it does not sense the tone, the device rings on through to the local telephone five times. If the phone is not answered the autoswitch automatically switches in the fax, which transmits a "wake-up signal" that activates a non-autodialing originating fax.

Since the autoswitch actually answers the phone on the first ring and then takes a few seconds to decide whether the call is fax or phone, to prevent the caller from holding a "dead line" while the device makes up its mind, the TF500 generates a *phantom* ringing signal back to the caller. As far as the caller is concerned, he hears the telephone ringing—he does not know that the call has actually been answered. Because of the phantom ringing, the autoswitch is transparent to the user.

If a call is answered on the phone, and then it is decided that the caller needs a connection to the fax, or the to computer that is connected to the AUXILIARY jack, the call can then be switched manually to the desired equipment by simply entering the appropriate code on the local *Touch Tone* telephone.

### Direct outgoing

Although the TF500 switches incoming calls, local equipment automatically seizes the phone line for outgoing calls and prevents interference from the other equipments. For example, if the local telephone goes off-hook, it is automatically connected to the telephone line. Similarly, if either

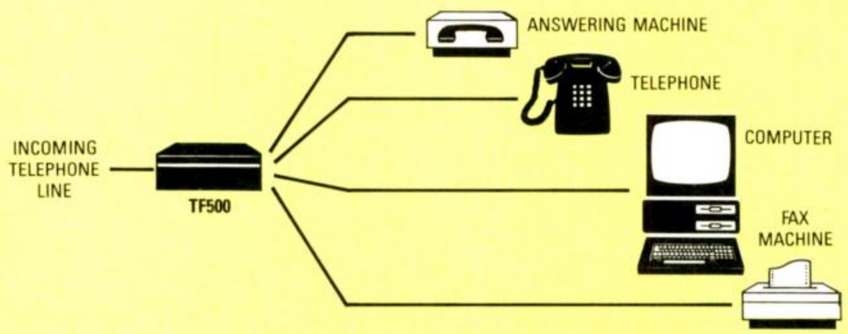



FIG. 1

the fax or the computer started, the first one activated seizes the phone line.

### After hours

If an active telephone message machine is connected to the PRIMARY ANSWER jack after normal business hours, the caller can use *Touch Tones* to selectively switch the individual machines.

An incoming call automatically trips the message machine because it is connected top the PRIMARY ANSWER jack. Your message can instruct the user to simply start talking after the beep to leave a voice message, to press 1 to access the fax, or press 2 to access the computer. Since the system responds to *Touch Tones*, the caller can, at any time, over-dial an access code to branch either to the fax or the computer after leaving a voice-message on the answering machine

### Security

If there is some need for security the tone codes can be user-programmed so that only those people authorized to access the fax and computer can do so. For example, the autoswitch can be reprogrammed so that the fax is accessed by the code 1234—rather than a 1, while the computer is accessed by the code 9876—rather than a 2. Also, there is no need to tell authorized persons that machine access is available. The telephone-answering machine can give a conventional "...speak when you hear the beep" message.

Seven features can be programmed by the user. They are the fax-access code, the auxiliary-access code, the number of rings (1–4) before the autoswitch answers, the ring count (1–9) into the primary and phone port, the ring count (1–9) into the fax port, the ring count (1–9) into the auxiliary port, and a default to the factory settings.

The programming is done through a special connection, and the local *Touch-Tone* phone that is connected to the PHONE jack. First, the supplied modular cable is connected between the TELEPHONE LINE jack and the PRIMARY jack. Then, autoswitch is placed in the programming mode by holding down the # key as the telephone's handset is lifted off-hook. After programming is completed, you exit by pressing the * key.

To use the autoswitch with the new coding, you simply reconnect the modular cable to the telephone jack. **R-E**

OK — Quit the clowning around — what kind of experiment are you running today?

# NEW PRODUCTS


CIRCLE 10 ON FREE INFORMATION CARD

**HANDHELD MULTIMETERS.** *Fluke's 80 Series* comprises three models of low-cost, high-performance, 3¾-digit, sealed, handheld multimeters. In addition to the standard digital-multimeter functions, each offers a powerful combination of measurement functions—including frequency, duty cycle, capacitance, and simultaneous minimum/maximum/average recording—and safety features, such as MIN MAX alert, and Input Alert. All models—*83*, *85*, and *87*—feature a relative (zero) mode, as well as Touch Hold capability that beeps when it senses a stable reading and locks it on the display for convenient viewing after the test leads are removed.

The minimum/maximum/average recording mode makes the *80 Series* well-suited for finding intermittent failures and interference, and the audible MIN MAX Alert pinpoints intermittent failures by signalling the user with a short beep only when a new minimum or maximum value has been recorded. The Input Alert warns the user when the leads are connected to the current jack while the meter is selected for voltage or resistance.

The top-of-the-line *Fluke 8*[illegible] analog display is a high-resoluti[illegible] pointer that is updated 40 tim[illegible] per second. It can be back lit a[illegible] has a user-selectable 4½-dig[illegible] (20,000 count) mode, in additi[illegible] to the 3¾-digit (4000 count) digi[illegible] display. A true RMS multimet[illegible] the *87* also features a Peak M[illegible] MAX recording mode that is ide[illegible] for capturing transient events t[illegible] ms, or sinewave-plus or -min[illegible] peaks to 400 Hz.

The analog display on the *Flu*[illegible] *83* and *85* is a bar graph with zoo[illegible] mode. The *83* has an AC-volta[illegible] response specified to 5 kHz, a[illegible] DC-voltage accuracy within 0.3[illegible] The *Fluke 85* and *87* are even mo[illegible] accurate, extending AC voltage [illegible] 20 kHz and DC-voltage accuracy [illegible] within 0.1%.

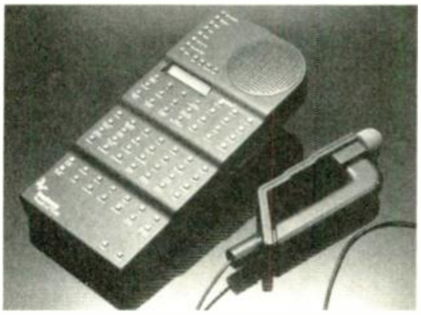
All three *80 Series* multimete[illegible] are EMI shielded, overload pr[illegible] tected to 1000 volts in the resi[illegible] tance- and diode-test modes, a[illegible] have patent-pending protectio[illegible] circuitry. Each comes in a carryi[illegible] case with a protective holster th[illegible] includes a flexible-rubber stan[illegible] That stand allows the meter to b[illegible] hung from pipes or doors, or use[illegible] as a normal tilt stand. They carry[illegible] three-year warranty.

The suggested list prices for th[illegible] *Fluke 83*, *85*, and *87*, respectivel[illegible] are $189.00, $219.00, an[illegible] $259.00.—**John Fluke Mfg. Co., Inc**[illegible] P.O. Box C9090, Everett, WA 9820[illegible] 800-443-5853, ext. 33.

**PERSONAL SYNTHESIZER.** *Breakaway Music Systems* brings new meaning to the concept of a "one-man band" with the *Vocalizer 1000*. Simply by humming into the personal vocal synthesizer, you can convert the pitch of your voice into your choice of musical-instrument sounds—no musical ability is required. And, with the unit's built-in multi-track digital recorder, you can record one part at a time and add them to the provided drum rhythms to compose a full song.

The "user-friendly" *Vocalizer 1000* is controlled entirely by the human voice; it has no keyboard. An interactive demonstration is built in to the unit, and simple instructions appear on the LC[illegible] screen to prompt you at each ste[illegible]

The versatile synthesizer le[illegible] you choose from 28 musical instr[illegible] ments, including electric pian[illegible] slap-bass guitar, flute, saxophon[illegible] trumpet, violin, bells, or ste[illegible] drum. Special effects such as ha[illegible] mony, slide, chorus, and echo ad[illegible] dimension to your music. If yo[illegible]



CIRCLE 11 ON FREE INFORMATION CARD

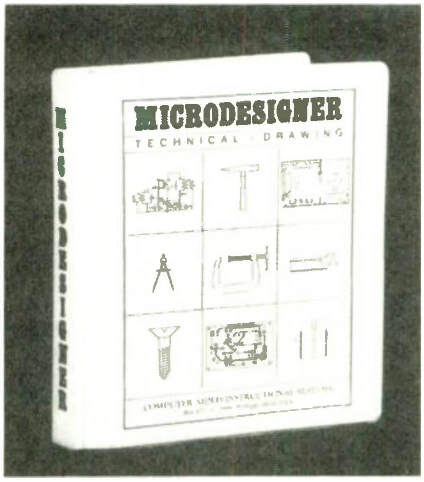
play a musical instrument, you can get even more out of the *Vocalizer 1000* through its audio input. Its MIDI capabilities allow the unit to be connected to professional keyboard synthesizers.

In addition, a full range of pre-programmed songs to jam along to—called *Smartsongs*—are included. (Additional plug-in Smartsongs cartridges are available separately.) Smartsongs styles include variations of rock, soul, jazz, Latin, blues, reggae, and country. "Voice-Guide" technology helps you hum notes that are in tune with the background Smartsongs music.

The compact unit weighs about three pounds, including batteries. It is powered by six C-sized batteries, or by a household-current adaptor.

The *Vocalizer 1000* has a suggested retail price of $299.99.—**Breakaway Music Systems**, 1900 Norfolk Avenue, Suite 340, San Mateo, CA 94403.

DRAWING SOFTWARE. Drawing circuit schematics, circuit boards, robotic systems, and floor plans is easy with the *Microdesigner* software package from *Computer Aided Instructional Systems*. The fast, expandable, unprotected system requires 48K and one disk drive, and is compatible with the Apple II computer family.




CIRCLE 12 ON FREE INFORMATION CARD

Designed for anyone who requires a basic, inexpensive, and flexible drawing system, *Microdesigner* can be used to draw, plot, write text, print, erase, and create computer circles. Hundreds of technical symbols and shapes, pre-drawn by computer, are included. Graphics can easily be saved and recalled.

Symbols can be rapidly rotated and positioned on the screen by using either keyboard or external controllers. The Koala Pad, joystick, or game paddles may be used as inexpensive and effective controllers.

*Microdesigner*, including an easy-to-use keyboard-menu card, complete user's manual, and one 5¼-inch diskette, sells for $59.95 softcover, or $69.95 hardcover.—

Computer Aided Instructional Systems, Box 177, Bldg. 5, Service Drive, Holly, MI 48442.

**GOOSENECK MICROPHONE.** *Shure's Model SM99* miniature condenser microphone is designed for sound-reinforcement applications that require wide-frequency response and an unobtrusive appearance. Featuring a 1-cm precision condenser element and an on-board pre-amplifier, the gooseneck-mount microphone exhibits a symmetrical supercardioid polar pattern for excellent isolation and maximum gain before feedback. It comes with a pop filter that improves speech and musical pickup.

The *SM99*'s 12-inch gooseneck has flexible sections at each end. Its center section is supported by an internal reinforcement system; with no bulky external-support tubes, the unit's sleek appearance is preserved.

Gooseneck microphones are generally favored for mounting on lecterns, pulpits, and conference

CIRCLE 13 ON FREE INFORMATION CARD

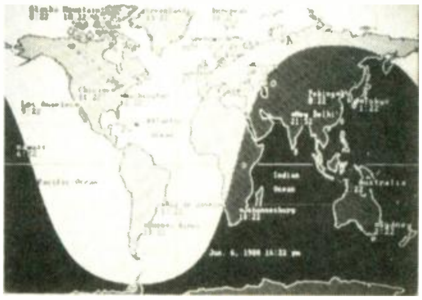
tables. With its extended frequency response and symmetrical-polar pattern, the *SM99* can also be used for musical applications. Its ability to reject background noise makes it a good choice for picking up an instrumental soloist within an orchestra.

The *SM99* accommodates a wide variety of mounting options. It can be plugged directly into any surface-mounted, 3-socket, XLR-type connector or permanently installed using the supplied mounting flange. Standard Shure swivel adapters can also be used to mount it on a conventional microphone stand.

The *SM99* costs $240.00.—**Shure Brothers Inc.**, Customer Services Department, 222 Hartrey Avenue, Evanston, IL 60202-3696.

**GRAY LINE SOFTWARE.** *MFJ's MFJ-1286 Gray Line DX Advantage/Terminator* displays a detailed world map on IBM PC's and compatibles. It shows the moving Gray Line—the day/night dividing line—and the position of the sun over Earth.

The *MFJ-1286* can be customized to display any 24 locations and the correct 12- or 24-hour time at each. Once started, it tracks Earth's



CIRCLE 14 ON FREE INFORMATION CARD

movement, showing the Gray Line and sun positions changing as time passes. The high-speed display mode permits users to set any date and time, and watch solar/Gray Line positions change in increments of 2 minutes, 6 minutes, 1 hour, 1 day, or 1 week.

The *Gray Line DX Advantage/Terminator* works with virtually all graphics cards, including composite, Hercules, CGA, and EGA. It can be run alone, or memory resident with other software. It comes with a land-mass map, a latitude/longitude map, and a map that displays the 24 time-zone divisions. CGA works with the land-mass map, and allows users to send the display to a printer.

The *MFJ-1286 Gray Line DX Advantage/Terminator* costs $29.95.—**MFJ Enterprises Inc.**, P. O. Box 494, Mississippi State, MS 39762.

**SMT TRIALS KIT.** The *SMT-K1*, kit from *OK Industries*, enables those who work with surface-mounted devices to evaluate, practice, or

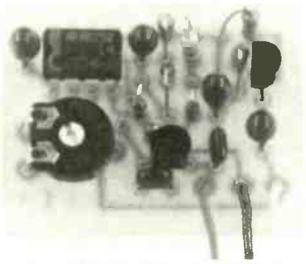
CIRCLE 15 ON FREE INFORMATION CARD

learn SMT assembly, production or rework techniques.

The kit includes a full range of surface-mounted components, including capacitors, transistors, PLCC's, and 100-pin gull-wing flat packs. The *SMT-K1* also contains a trial board designed to accommodate the wide variety of components. The board and components come in a conductive tray to prevent static and provide storage.

The suggested list price for the *SMT-K1* kit is $64.95.—**OK Industries Inc.**, 4 Executive Plaza, Yonkers, NY 10701; 800-523-0667.

**AUTOMATIC LEVEL CONTROLLER.** *C & S Electronics Leveller* module automatically maintains the volume level of amateur, CB, marine radios, and scanners. It keeps the volume constant, regardless of incoming-signal strength.



CIRCLE 16 ON FREE INFORMATION CARD

When using the *Leveller*, the receiver's volume level remains independent. The user sets the volume to a comfortable level, and the *Leveller* locks in that setting. The module draws less than 10 mA.

With only three wires to connect, installation is very simple. The module, measuring only 1¼ × 1½ × ½ inches, can be secured into any available space inside the set. Adhesive foam backing is supplied for mounting the module.

The *Leveller* costs $24.95.—**C & S Electronics**, P. O. Box 2142, Norwalk, CT 06852. **R-E**

# HARDWARE HACKER

## A cheap color fuser

A cheap color fuser mod
Omnicrom and Kroy Kolor
More on the $10 NaviCube
Television on a RGB monitor
Industrial and trade resources

I HAVE FOUND SEVERAL ADDITIONAL sources for the low-cost telephone-coupling transformers that will be needed for the data-access arrangement circuits we looked at a few columns back.

In particular, check out the TXTS transformer from *All Electronics* at $2.50 each, or any of bunches of different offerings from the PREM Magnetics folks.

A new transformerless telephone interface did appear way back in the October 1981 issue of *QST*. The circuit shown was rather complex. It also had to be custom-adjusted to suit each individual phone line.

Some details on an all-Canadian approach to our $10 Navicube are available from Richard Langley of the *Geodetic Research Laboratory*. They also have some publications on navigation satellite-positioning systems available for you.

Apparently the all time numero uno super whiz bang expert of the earlier Navicube stuff is one Doug Garner at NASA. Check out all his superb construction projects in *Sport Aviation* magazine, starting in the late 1970's.

Of all of the Hardware Hacker topics ever, the $10 Navicube stuff sure produced the greatest number of the most interesting phone calls and letters from some of the most creative hackers around.

More on the Navicube drama as it unfolds.

As per usual, this is your column and you can get tech help and off-the-wall networking by way of that *Need Help?* box. Please also note the *Names and Numbers* sidebar that shows where you can go for more information on the sources mentioned.

This month, we'll look at some graphic-art electronics...

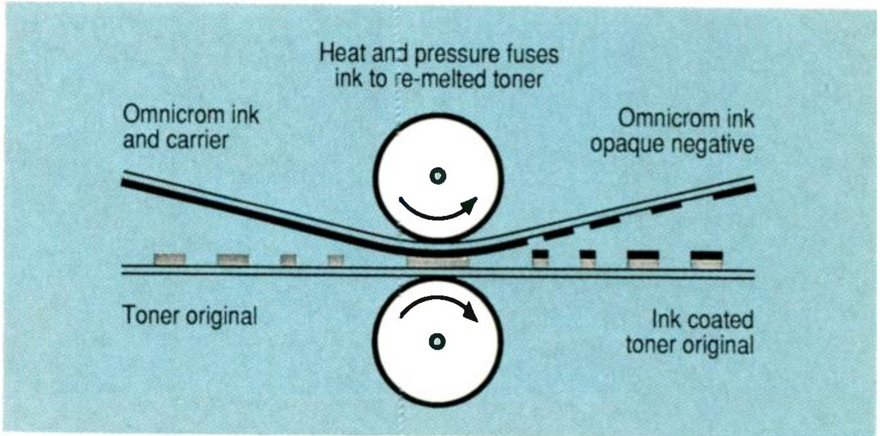



**FIG. 1—THE OMNICROM PROCESS rapidly converts any toner-based copier or laser-printed image into full color in any of dozens of metallic, matte, or special-effect shades. Kroy Sign Systems now licenses the British Omnicrom process under the US tradename of Kroy Kolor.**

### Omnicrom and Kroy Kolor

For years, I've had a back-burner project going. The idea was to take an ordinary Xerox copy and run it through a magic machine where real ink would somehow stick only where the toner existed.

Obvious uses would be to get truly dense blacks, to be able to create "litho"-quality images for printed circuits, overheads, or for electronics artwork, to gain total color options, and to provide a durable "raised ink" thermography process, for letterheads, for custom business cards and even for use when printing in Braille.

It turned out that an English outfit by the name of *Omnicrom* beat me to the punch. As Fig. 1 shows us, Omnicrom reasoned that toner was really a mixture of black stuff and hot glue. You could think of a copy as a piece of paper that had hot glue selectively placed only where you wanted it.

By putting a dry-ink based carrier in contact with the Xerox copy and applying heat and pressure, the toner would remelt and grab the dry ink off the carrier sheet.

Presto: The instant conversion of copier or laser-printed output into brilliant metallics or bright mattes, silvers, golds, a solid black, and even some pearl effects.

**NEED HELP?**

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

1 – Canon F21680 Fusion machine using a FH1-0576-01 temperature pc card.

1 – 25K linear volume control
1 – 150K, 1/2 watt resistor
1 – Dialplate decal
1 – Dialplate decal overlay
1 – Push-on knob with pointer

Misc: 12 inches of red solid #22 hookup wire; 12 inches of similar green wire; 12 inches of similar black wire; 8 inches of solder; two 3/8 inch volume control nuts; 1 flat volume control washer; 1 internal tooth volume control lockwasher.

Note: One source of the Canon fusion machines, parts kits, and modified and tested units is Arlin Shepard at Lazer Products, 12741 E. Kaley Avenue, Suite #130, Englewood CO, 80111. (303) 792 5277.

**FIG. 2—THE PARTS REQUIRED to modify a Canon F2160 fusion machine for variable-temperature operation.**

Along with a unique shiny high-gloss varnish or even true laminating for scuff-resistant menus or book covers.

As a bonus, the carrier sheet can also become an "instant negative," useful for such things as overhead transparencies. If you wanted to, you could even reuse any remaining portion of any carrier as often as you liked.

But there were serious problems. The Omnicrom people were British and monumentally mismanaged all of their marketing efforts in "the colonies." Their early materials weren't all that reliable. Worst of all, they saw nothing unconscionable about the charging of over $1400 for a "fusion machine" that was nothing but a pair of warm rollers that turned.

A few years ago, the *Kroy Kolor* people did become an Omnicrom licensee and then dramatically improved all the materials, added more colors and options, and



( ) Verify that the unit to be modified is in fact a Canon F21680 machine and then unplug the line cord from the AC outlet.

( ) Remove the center lid by raising the green handle and removing the two black screws at the rear and the two silver screws on the inside. Be gentle!

( ) Remove the right cover by removing the two silver screws at the rear, the black screw at the right bottom, and the black screw at the front bottom. Again, be gentle!

( ) Cover the temperature decal with a similar sized clear self-stick overlay. Neatly trim the decal to just outside the black border.

( ) Clean the front of the right cover and apply the temperature decal so it is 3/8 of an inch in in and 3/8 of an inch up from the lower lefthand corner. (See Figure five)

( ) Drill a 13/32 inch hole at the crosshairs on the temperature decal. This is easiest to do with a Vise Grip UNIBIT, but a pilot hole and reamer can be used instead. Deburr the hole.

( ) Mount the volume control in the hole. Use a nut and lockwasher behind the panel and a nut and flat washer in front of the panel, adjusting for the flushest possible mounting.

( ) Solder the 150K resistor to the center lug of the volume control, keeping the lead both reasonably short and mechanically strong. (See Figure six)

( ) Form a loop in the free end of the resistor and trim the lead. Strip 1/4 inch off of both ends of the green wire and solder one end to this resistor loop. (See Figure six)

( ) Strip 1/4 inch off both ends of the black wire and solder it to the leftmost lug of the volume control when viewed from the rear bottom. (See Figure six)

( ) Strip 1/4 inch off both ends of the red wire and solder it to the rightmost lug of the volume control when viewed from the rear bottom. (See Figure six)

( ) Twist all three wires tightly together for all but the last inch of their length.

( ) Unplug the black and white motor connector from the innermost circuit board. Unplug the two heavy red wires from the motor speed sensing power resistor.

( ) Remove the three large Phillips screws that hold the circuit boards in place. You may have to restrain the white circuit board spacers to keep them from turning when you do this.

( ) Slide the two circuit boards out where you can work on them. You may have to work up some slack in the yellow thermistor wires. Unplug the five pin black and blue connector.

( ) Verify that the yellow thermistor wires go to a FH1 0576 01 printed circuit board.

( ) Route the twisted black, red, and green wire between the motor starting capacitor and the motor control power triac. Then route it along the yellow wire, through the small hole, and over to the FH1-0576-01 printed circuit board.

( ) Loop and solder the black wire to the inside end of diode D303. (See Figure six)

( ) Loop and solder the green wire to the outside end of resistor R307.

( ) Loop and solder the red wire to the outside end of diode D304.

( ) Replace both circuit boards, the three large Phillips screws, the black and white motor connector, the two red power resistor wires, and the blue 5 pin connector. Redress the yellow thermistor leads back the way they were.

( ) Verify that the right cover can go back on without pinching any wires and that there are no wires anywhere near the large gear or other moving parts.

( ) Verify that all connectors and wires are now secure.

( ) Replace the right cover and the lid using the original screws.

( ) Press the knob onto the volume control shaft, being certain that the pointer points straight up to NORMAL when at the center of its rotation range.

( ) Refer to the text for the checkout procedure.

**FIG. 3—A SURPLUS CANON FUSION MACHINE can replace an Omnicrom or Kroy Kolor machine at a tiny fraction of the cost, after this 60-cent modification is made.**

## NAMES AND NUMBERS

**All Electronics Corp**
PO Box 567
Van Nuys, CA 91408
(800) 826-5432

**Avantek**
3175 Bowers Avenue
Santa Clara, CA 95054
(408) 727-0700

**Computer Shopper**
Box F
Titusville, FL 32781
(305) 269-3211

**Doug Garner**
NASA Langley MS 471
Hampton, VA 23665
(804) 827-3321

**Geodetic Research Laboratory**
University of New Brunswick
PO Box 4400
Fredericton, NB E3B 5A3
(506) 453-4698

**W.W. Granger**
5959 West Howard Street
Chicago, IL 60648
(312) 647-8900

**Kroy Kolor**
14555 N. Hayden Road
Scottsdale, AZ 85260
(602) 951-1593

**Lazer Products**
12741 E. Kaley Ave., S130
Englewood, CO 80111
(303) 792-5277

**McMaster-Carr**
Box 54960
Los Angeles, CA 90054
(213) 692-5911

**MuRata-Erie**
2200 Lake Park Drive
Smyrna, GA 30080
(404) 436-1300

**National Semiconductor**
2900 Semiconductor Drive
Santa Clara, CA 95052
(408) 721-5000

**NEC Electronics**
401 Ellis Street
Mountain View, CA 94039
(415) 960-6000

**Nuts & Volts**
Box 1111
Placentia, CA 92670
(714) 632-7721

**Omnicrom**
Tonge Bridge Way
Bolton, Lancashire BL2 6BD
UNITED KINGDOM
0204 392050

**PREM Magnetics**
3521 N. Chapel Hill Road
McHenry, IL 60050
(815) 385-2700

**Small Parts**
6891 NE Third Avenue
Miami, FL 33138
(305) 751-0856

**Unitrode**
7 Continental Blvd.
Merrimack, NH 03054
(603) 424-2410

**United States Plastic Corp**
1390 Neubrecht Road
Lima, OH 45801
(408) 559-7778

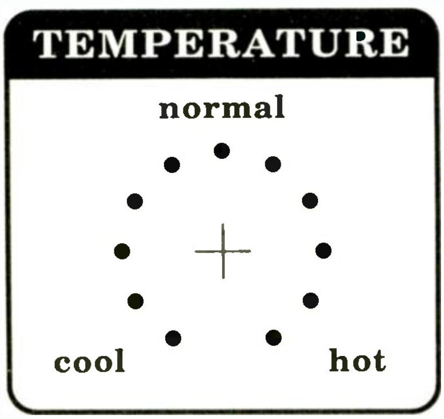



**FIG. 4—FULL-SIZE ARTWORK for the front-panel decal.**

made them much easier to get. They also improved and modestly lowered the selling price of the fusion machines.

You can get several no-charge evaluation samples just by calling Randy Bailey over at Kroy. They also do have lots of sign-building accessory kits and heavier printing stocks.

But, judging from the *Perrier* in all of their corporate birdbaths, Kroy appears to be a company of, by, and for Yuppies. "Low-end user cost" just is not presently in their vocabulary. If you do not own a BMW, they do not appear to want you as a customer.

So, it might still take a while before some genuine competition can drive the end-user costs down to the nickel-a-sheet mass market range where they belong.

Kroy Kolor is a fantastically great product when and where its sixty cents or so per sheet cost can be justified. This product totally revolutionizes what you can do with a copier or a laser printer. The sad thing is that it could do so much more if only it were sanely priced.

Meanwhile, though, the quest goes on for...

### A cheap Omnicrom fuser

You do not need $1400 to use Omnicrom or Kroy Kolor. All you need is heat and pressure.

For instance, a plain old iron and a muslin pressing cloth will do the job just fine. You can also use the existing fusion rollers inside your laser printer or copier, by making a second pass while hand-feeding a blank page. The process works best with the metallic colors; but you might occasionally get a misfeed, wrinkles, or dropouts.

A few of the newest copiers are set up to directly use Kroy Kolor.

One trick that works well and dramatically drops the price is to use spot color. For instance, on a letterhead, you tape a small piece of Kroy Kolor applied only to the logo and then run it back through the printer. Be sure to use a very

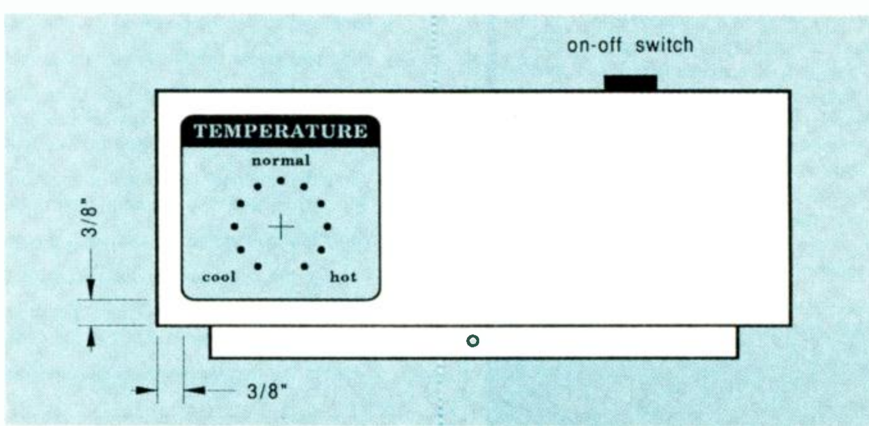



**FIG. 5—POSITION THE DECAL exactly as shown here onto the front skirt of the right cover. A 13/32-inch hole is then drilled at the crosshairs.**

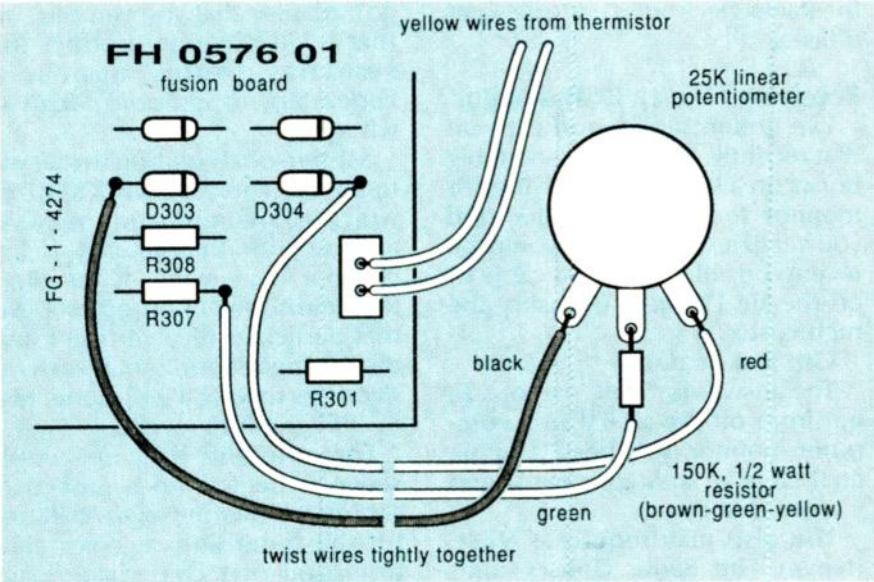



**FIG. 6—THE PICTORIAL DIAGRAM for the Canon fuser unit modification. The modification costs around 60 cents and can be done in twenty minutes.**

low-tack tape, such as the Scotch *Post-It Cover Up Tape*, available at your local office supply.

But there is a better way. It turns out there is a wondrously bizarre machine widely available today on the surplus market called a *F21680 Canon Fuser Unit*.

Nobody (especially all of those Canon dealers!) had even the slightest idea what those machines were for or how to use them, so they were all dumped at fire-sale prices. Rumor has it that the machines were somehow involved in making color overhead transparencies.

At any rate, the only difference between a real Omnicrom fusion machine and a Canon fuser unit is around 5:1 in cost and the fact that the stock Canon fuser machine was set to a fixed and somewhat lower temperature.

Fortunately, sixty cents worth of parts and twenty minutes work will convert the Canon unit into a beast that actually will outperform the Omnicrom machine and do so at a tiny fraction of the cost.

That super-rugged Canon unit gives better results because of a slower feeding speed and some self-cleaning roller-wiper pads. It works especially well with the SX toner cartridges, such as from an Apple LaserWriter NT or NTX.

The only little problem I have found with the modified unit is that you have to trim your laminating film to a maximum width of 8-1/2 inches. Kroy's *Color Plus* machine shares that same problem.

Figure 2 shows you a parts list for that modification. Figure 3 gives you detailed instructions. Figure 4 is a full-size replica of the new dial decal, while Fig. 5 shows you where to position the decal on the front of the machine. Finally, Fig. 6 is a pictorial for the modification.

The fusion unit does its thing by comparing a thermistor resistance against a fixed-voltage reference. The modification lets you raise or lower that internal reference by sourcing or sinking a slight amount of extra current.

The temperature range is set by that new 150K resistor. A higher value *restricts* the range, while a lower one *extends* it. A half-watt resistor was chosen because it is physically stronger than a quarter-watt one.

The checkout procedure is fairly simple. Center your new temperature control and then apply the power. The panel LED should start blinking a dim green and the internal fusion lamp should come on. After one minute, the fusion lamp should go out and the LED should change to a bright and continuous green.

Advance the temperature control clockwise by one quarter of a turn. The fusion lamp should come on for three or four seconds and then shut back off.

Retard the temperature control fully counterclockwise and wait a few minutes. Eventually the fusion lamp should come back on for a few seconds. When the lamp goes back off, advance the control by one quarter turn. The fusion lamp should go back on again for a few seconds and then shut down.

If all of those tests are passed, center the temperature control and try a metallic Kroy Kolor sheet. Use a "normal" setting for metallic foils, a somewhat higher setting for the matte colors, and a slightly lower setting for the laminating film.

Here's another tip: If you run a toner copy through the machine in contact with a thin sheet of polyester "Mylar" film or by using an "empty" Kroy Kolor carrier, your copy will *Bakerize*, giving you a more durable, blacker, and a semi-gloss finish. That is handy for such things as quick and dirty business cards, and is a zero-cost process.

Among the many other sources, surplus Canon fuser units are now available by way of Arlin Shepard over at *Lazer Products*.

Modification kits and the fully modified and tested units are also available, at a tiny fraction of the current cost of the real Omnicrom fusion machines.

## Getting plain old stuff

In addition to all of the usual electronic components, most all of you hardware hackers also need good sources of the plain old everyday things needed to develop all your ideas and to put those electronic components together. Things like tools and hardware, raw material stock, electrical items, plastics, and all of the many other oddments that seem to go along with serious hacking.

I have found four outstanding sources for that sort of thing.

First, check into the *McMaster-Carr* supply people. See if you can't cop one of their 2000+ page catalogs that is jam-packed with tools, materials, hardware, plastics, and just about everything else that's "industrial" in nature.

Second, the really great *W.W. Granger* catalog covers just about everything electrical—for motors, pumps, controls, wire, accessories, and so on. While those folks have branches in most larger cities, you often may need a trade name and a tax stamp to be able to do business with them.

Third is *Small Parts*. Besides a mind-boggling stock of robotic and electronics hardware, they also will custom cut metals and plastics for you in small quantities.

And, fourth, for plastics, do look into the *United States Plastic Corp* who have an incredible variety of plastic materials available.

If you do have any similar "just stuff" favorites, how about letting me know so we can then share those resources with the others?

In fact, let's make a contest out of it. Your entry must begin with the words "A great source for neat stuff is....," and there will be all of the usual *Incredible Secret Money Machine* book prizes, along with an all-expense paid (FOB Thatcher, AZ) *tinaja quest* for two for the best entry of all.

If possible, include a flyer or a catalog with your entry. You'll get extra points for especially obscure or off-the-wall sources. Please send the entries directly to me per the "Need Help?" box, and not to the **Radio-Electronics** editorial-staff offices.

### Receiving TV on a RGB monitor

I've gotten a bunch of calls on that recently. You've just spent big bucks on a high-quality RGB color monitor for your computer, and you realize that it sure would be nice to be able to receive cable or off-the-air TV on it to justify the high cost.

Can that be done?

The answer is "Well, sort of." To get from off-the-air TV to a computer monitor, you need a tuner, an IF strip, an audio processor, and a video detector.

You also may require a NTSC (Never The Same Color) composite-video-to-RGB converter as well, if the monitor doesn't accept a composite-video input.

The circuitry needed, its design, and its alignment are far too complex to throw together on your own out of individual components. You also would be largely reinventing the wheel.

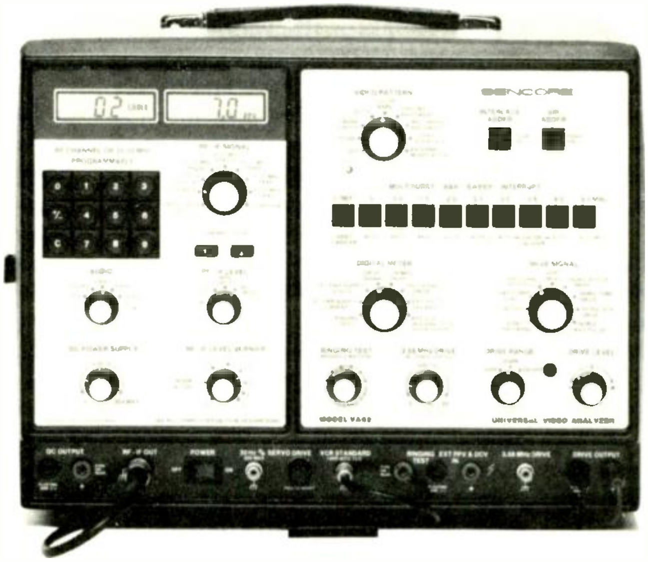
Sadly, I know of no "plug-and-go" adaptor that you can buy, but that is an obvious product that someday should appear at *Federated*, or at *Radio Shack* or wherever.

My personal solution to that wa to go with the old *Sony* KV1311-C which is a combination recei and monitor that actually is cheaper than many of the RGB monitor-only produc ut that particular receiver ca an-dle the higher horizont an frequencies involved ome Mac or IBM graphics m es.

For now, the best bet would seem to be to find a junked or otherwise trashed-over VCR and lift the tuner and receiver electronics out of it. Or perhaps do the same things to a conventional TV set that has problems with the picture tube or possibly the deflection circuitry.

Yeah, that is kind of a wimpy answer. Let me know if you come up with a better one. That is also an ideal topic for some future **Radio-Electronics** construction project.

*continued on page 80*



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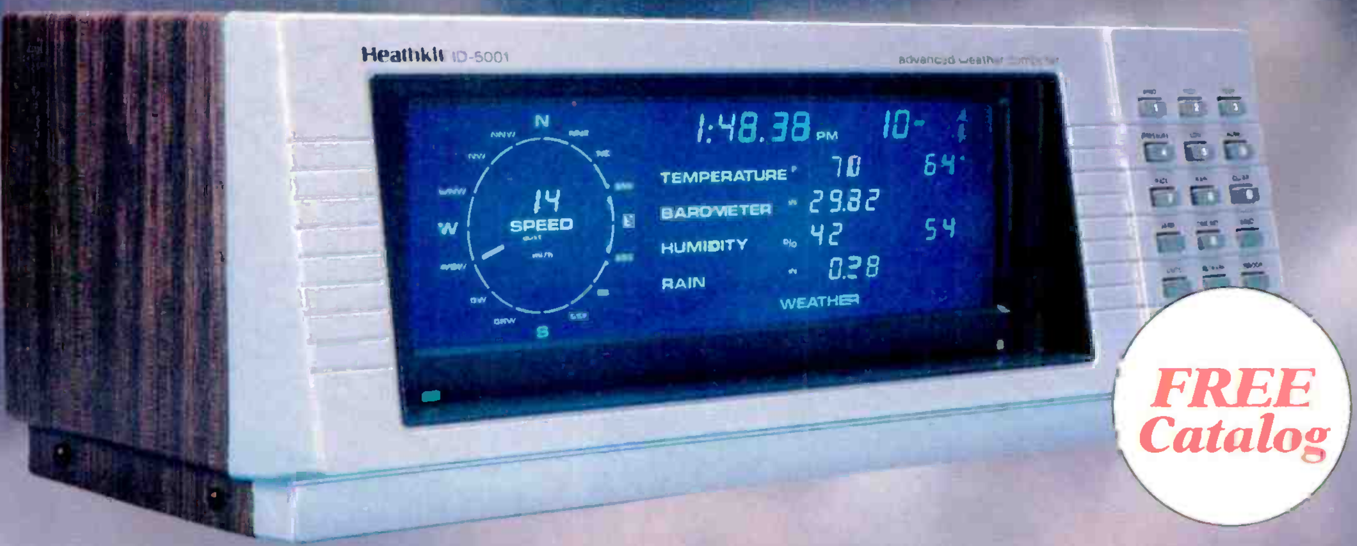


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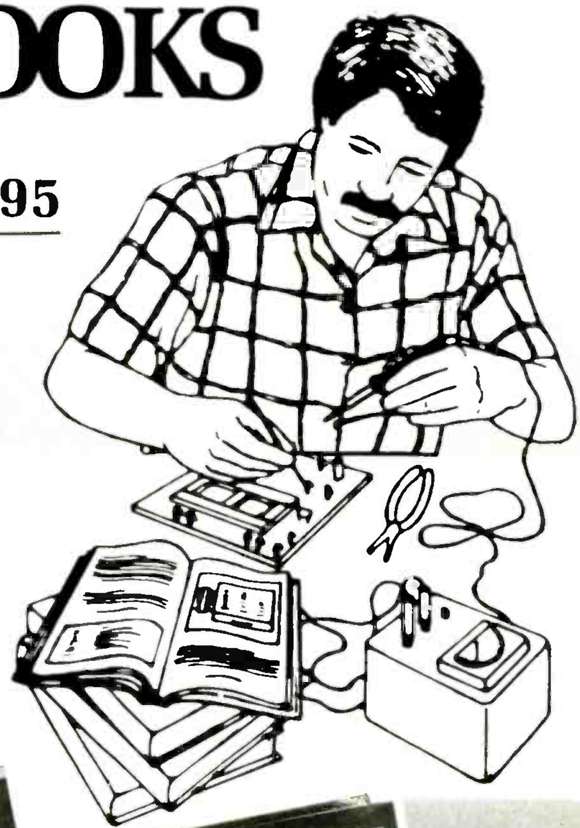

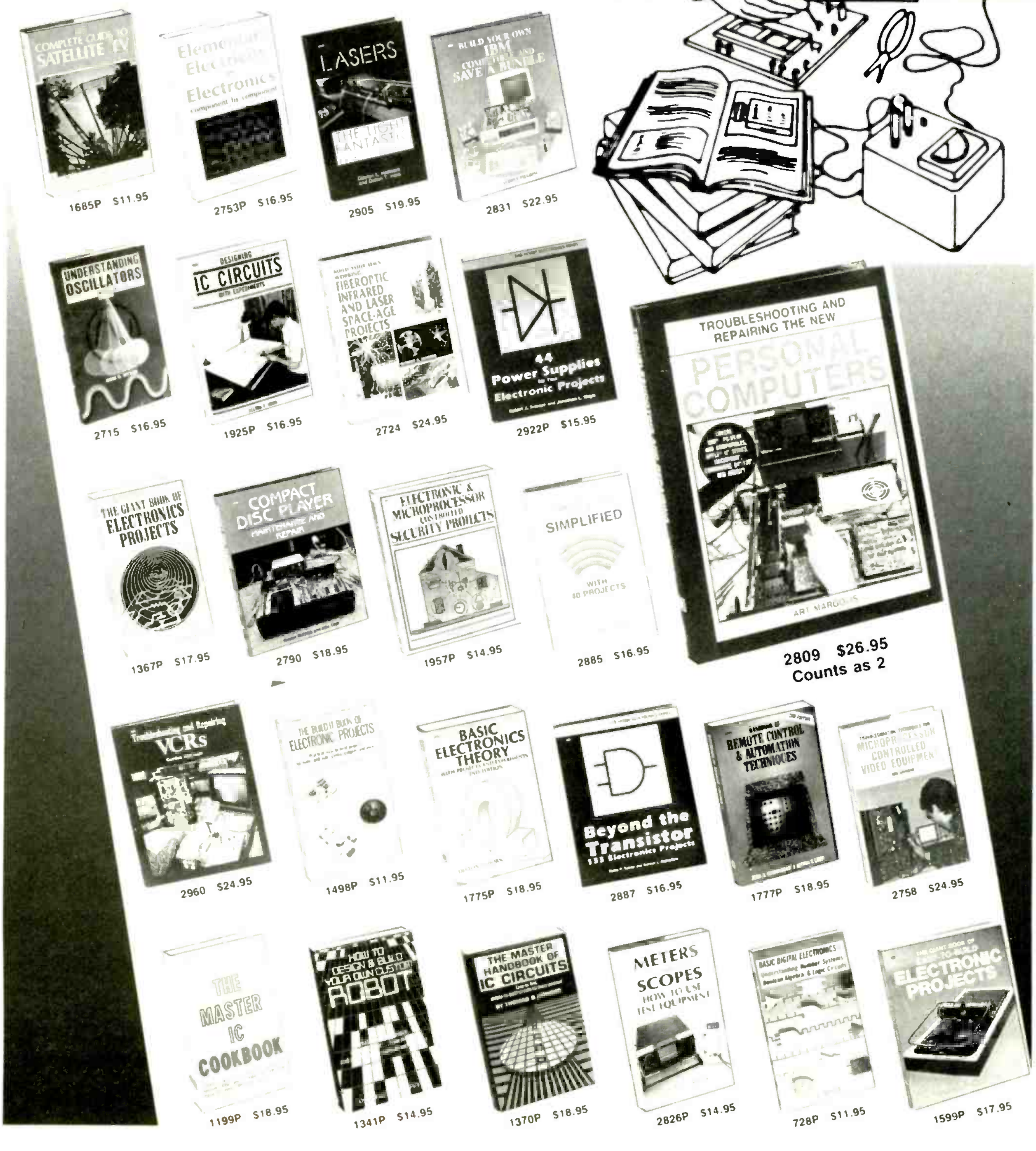

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# AUDIO UPDATE

## The Audio Engineering Society

**LARRY KLEIN,**
AUDIO EDITOR

I'VE BEEN A MEMBER OF THE AUDIO ENgineering Society for some 30 years now, and I credit it—through its monthly journal and meetings—for much of my audio education. Founded in 1948 by a small group of concerned engineers, the new organization was dedicated to advancing the art and science of audio engineering. The Society's success is reflected in both its growth and the international reputation that it has acquired over the past decades. Present world-wide membership includes more than 10,000 engineers, researchers, educators, manufacturers, and students.

Aside from the talks, lectures, and debates scheduled during regular local AES section meetings held in many major cities, scores of papers detailing the latest audio research and developments are presented during the annual conventions. Many of the papers are available in "preprint form," and in the next two columns I'll discuss some of the more interesting ones that came from the October 1987 convention.

First, a background note: In general, AES papers seem to divide into discussions of potential or actual products embodying some new concepts or approaches; discussions of new techniques for improving measurements, recording, or reproduction; and psychoacoustic investigations into audio perceptions. Since the AES prefers to avoid being a commercial-sounding board for any company or inventor, all papers that appear in the Journal must pass a review board of the author's technical peers. The papers given at the convention—and the preprints of them—are less stringently reviewed by the convention's papers chairpersons. I'll list the AES code number and the formal title of each paper for those who wish to obtain a copy. For information on becoming a member of the AES and/or how to purchase any of its many papers and publications, write to: Audio Engineering Association, 60 East 42nd Street, New York, NY 10165.


FIG. 1

### 2537, G-4

*Subwoofer Performance for Accurate Reproduction of Music*

The authors of this paper (one of whom is with Dolby Laboratories) set out to determine the minimum-performance requirements for home subwoofers assuming peak sound-pressure levels of 110 to 120 dB and a crossover no higher than 100 Hz. An interesting part of the paper was the frequency analysis of commercial CD's. The authors turned up a dozen CD's (mostly from Telarc) with substantial musical information in the octave from 32 to 16 Hz and one (the

1812 Overture) that went down as low as 12 Hz!

In general, however, the authors found that recordings with audible bass below 30 Hz are relatively rare. When such frequencies are present they are produced by pipe organs, synthesizers, or special effects and environmental noises. Instruments such as a bass guitar, bass violin, timpani, or bass drum produce very little output below about 40 Hz. At or above that frequency, however, they can make a substantial contribution.

We are all aware of the Fletcher-Munson equal-loudness curves show that the human ear is significantly less sensitive to low-frequency sounds than it is to mid-frequencies.

not generally known, however, that the original curves, which date from 1933, have been substantially revised by later investigators using superior techniques and instrumentation. The most recent studies—which generally agree with one another—indicate that the ear is 6-dB less sensitive at low frequencies than was previously charted.

That means that to be heard as equal in volume to a 4-kHz signal at the hearing threshold of 0 dB, a 20-Hz signal has to be about 85-dB louder! The paper goes on to analyze other performance criteria including the audibility of amplitude, phase deviations, and harmonic distortions, woofer-excursion requirements, room-acoustic effects, and so forth. The paper ends with a plea to loudspeaker manufacturers to improve their low-frequency performance below 40 Hz. It seems that the dozen or so subwoofers tested were all found to be inadequate by the authors' standards.

The paper illustrates beautifully why I find the AES papers so worthwhile. I'm not particularly interested in reproducing frequencies low enough to cause sphincter dilation, but I was fascinated in the wealth of psychoacoustic and physical data that the authors either developed or researched to make their case. Typical of other AES papers, this paper on subwoofer performance contains a 31-item bibliography.

**2490, D-2**

*The In-store Electronic Distribution of Personalized Music: An Answer to Home Taping*

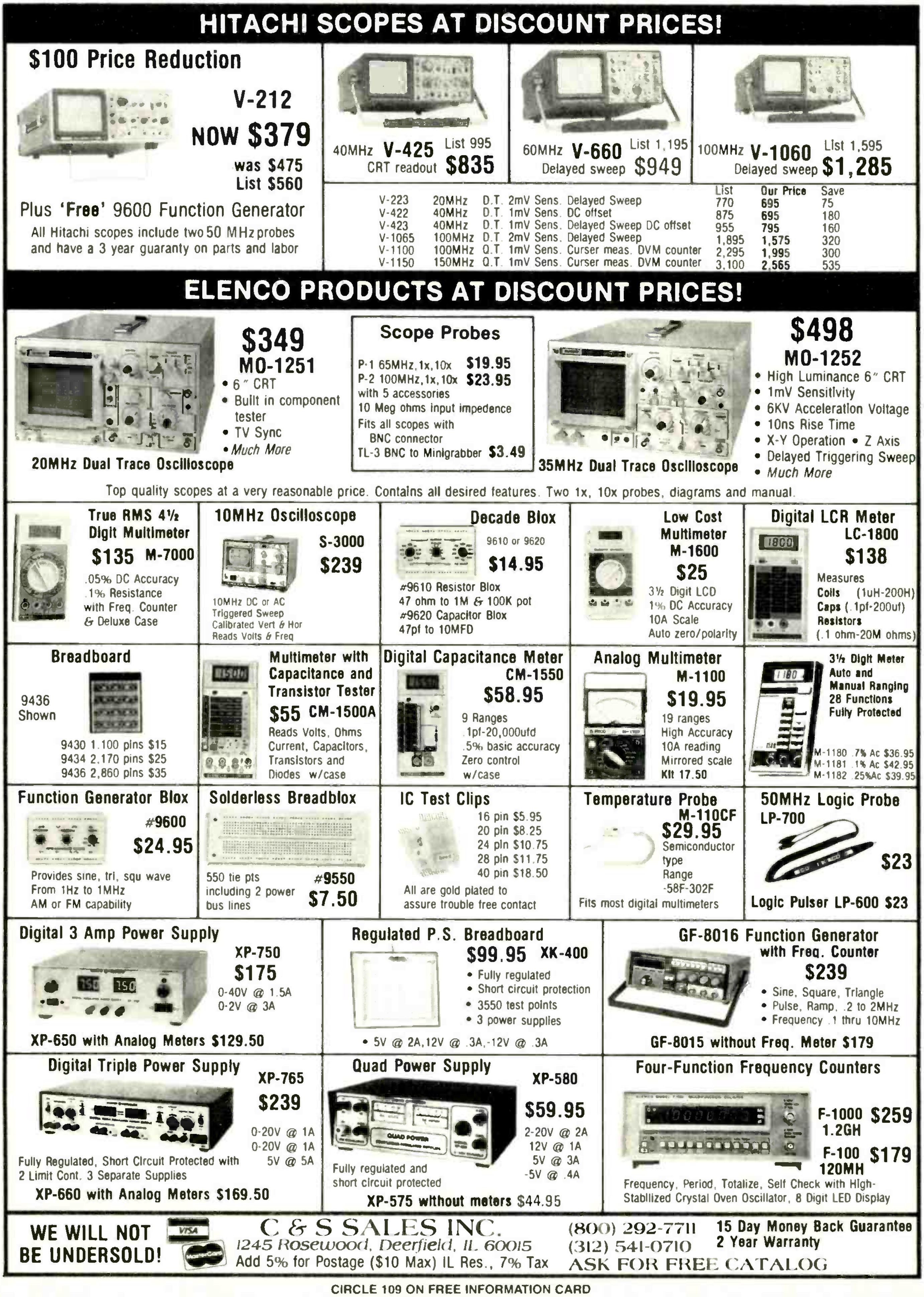
This paper describes a product—or at least a prototype of one—that, if successful, would revolutionize the way that recorded music is sold. The authors are affiliated with the *Personics Corporation* of Menlo Park, CA, and the "abstract" that opens the paper neatly sums up the project:

*An electronic music-distribution system has been designed and built to permit the in-store production of very high-fidelity personalized cassettes, to the customer's order. In the store, the system consists of a computer-controlled high-speed optical-disk-based digital-audio archive of up to 15,000 individual selections of music; an order-entry terminal; a high-speed cassette recorder; and a high-resolution label printer.... With this equipment a customer can obtain a high-fidelity tape containing an album-length compilation of the songs he wants in the order that he wants them, after a wait of only about 5 minutes.*

The authors state that the impetus for the project came out of a 1985 study (cited in a footnote) that sought to determine the reasons behind home taping. The study found that, contrary to the view held by the *Record Industries Association of America* (RIAA), the most important reason for home taping was not to save money, but rather to create personal programs by assembling various artists and songs onto a single cassette. The authors are hopeful that in-store album production would appeal to the record companies by essentially eliminating the major reason for home taping, and by simultaneously providing a means of collecting royalties that are now lost.

The bulk of the paper describes the technologies involved. Since the first Personics-system units have already been built, I assume that the technical problems of storing 15,000 separate songs and randomly accessing them rapidly enough to compile a multi-selection high-fidelity recording in

*continued on page 81*




CIRCLE 109 ON FREE INFORMATION CARD

# THE FACTS ON FAX

HERB FRIEDMAN,
COMMUNICATIONS EDITOR


*Fax is an easy-to-use, low-cost way to send copies of text, graphics, and pictures by telephone.*

A MODERN FACSIMILE MACHINE, WHICH IS more commonly known simply as fax, is a device that scans a document and converts it to digital data that can be sent over the national and international dial-up telephone systems. A receiving fax creates a facsimile of the original document by restoring the data to its original form.

Because there is a worldwide standard for facsimile signals, fax machines can send documents anywhere in the world—except to countries which prohibit non-voice or encoded signals on their telephone network. Because modern fax is entirely digital, a document can be sent in less time than it would take to be read or described by voice; hence, the telephone charges per document are minimal—particularly so for long distance and international calls.

## A mass market

Many marketing experts involved with office and household electronic products believe that the fax machine will shortly become another mass-marketed electronic gadget; one that might turn out to be as popular as VCR's, video cameras, and personal computers.

In fact, the future of fax as the next electronic blockbuster looks so good that the major manufacturers are already gearing up for blitz advertising aimed at the home-business market. Pick up almost any newspaper and you'll find that the fax machine is the featured equipment in many advertisements from stores that sell consumer photo and electronic equipment. It is also featured in the ads from computer dealers, and by the stores that sell telephones and office equipment. And if you drive down the business district of any moderately sized city or town, you'll now find stores that specialize only in fax machines.

There are even fax adapters for IBM-compatible personal computers. Simply plug in a fax adapter and your computer will function as an on-line fax even while the computer is doing some other job, like word-processing, or filing, or whatever else personal computers do. (A future issue of **Computer Digest** will present a hands-on review of such a device.)

## Old movies

What might temporarily limit the growth of fax is the fact that many non-business consumers have little or no idea about what fax is or can do. If they know anything at all about fax, it's probably from TV re-runs of old 1930's B-movies, where a group of newspapermen watch a facsimile machine create the face of Public Enemy Number 1 on what appears to be a spinning drum. Or the machine might be spinning out a picture that will prove the innocence of someone minutes away from execution in the Big House (state prison).

Although the facsimile machine was a common productivity tool for newspapers, news magazines, and major business offices, it was a very expensive and difficult-to-maintain mechanical clunker; so other than in the movies, until *digital electronics* became a household phrase, the average consumer had little acquaintance with a facsimile machine.

But because of the simplicity of operation, unusually good reproduction and reliability, and plunging prices made possible by digital technology, fax is expected to be used by almost all businesses operating from a home. It is even anticipated that fax will prove to be a popular household appliance. For example, suppose you're working at home and find that you need some papers that you left at the main office. Instead of waiting for the mail, or paying for expensive courier service, you simply ask the office to fax you the papers. In less time than it takes to think about it, your fax machine starts spitting out copies of the documents.

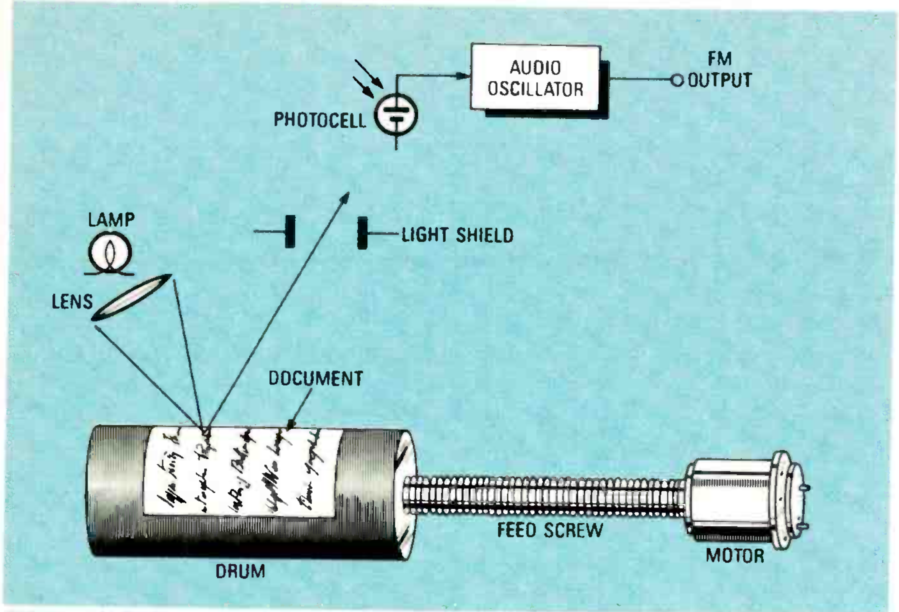



**FIG. 1—ON EARLY FAX MACHINES the document was mounted on a spinning drum that was tracked by a electro-mechanical assembly.**

Or assume that you have a billing dispute with the local bank. They claim you didn't pay; you claim you did. Instead of getting involved with the bank in several months of correspondence to prove that you paid, you simply feed the canceled check into your fax machine, and in less than 30 seconds a copy appears on the bank's fax machine. That should resolve the dispute quickly; you and the bank won't have to become pen pals.

Or maybe you just want a quote on what it would cost to purchase a new refrigerator. Instead of waiting on the phone listening to "elevator music" until someone can help you; then explaining what you want; and then waiting and waiting until someone gets the price and delivery date, you simply write what you want on a sheet of paper and fax it by telephone line to the appliance dealer. When he gets the information, he fax's you a written confirmation of the price and the delivery date. Your imagination can probably fill in ten or more other reasons why fax is expected to become a best-selling household and small-business appliance.

## Highs and lows

Except for the early experimental facsimile devices—such as those described eslewhere in this issue in our article on early facsimile—a fax machine is actually a transceiver: It can both send (originate) and receive (answer). Its transmitted signal is derived by scanning a document or photograph with a tightly focused light beam. The marks on the document determine how much light is reflected from the document. A photo-electric sensor positioned in the reflection path senses the amount of reflected light and converts the reflection to a bi-level or gray-scale electrical signal, which is then used to control an audio oscillator, a microprocessor, or whatever is used to create the transmitted signal's modulation.

Although manufacturers eventually intend to equip high-end fax machines with laser printers, the common fax machines print received documents or photographs on thermal (heat sensitive) or electrostatic paper. The image is formed by a heat or an electric burning stylus that tracks over the paper. The heat stylus actually burns the image into thermal paper, while an electric current passing from the stylus through electrostatic paper changes the color of electrostatic paper at the "burn." In both types of printing, we say the imagine is "burned in." Early fax machines also used a light-sensitive (photographic) system, which meant wet-process developing, and some machines used a wet paper to provide conduction for an electric "burn." Obviously, wet-process printing hasn't been used for many, many years.

Figure 1 shows how early fax machines, such as the Western Union *Telefax*, work. The document to be transmitted (fax'd) is mounted on a metal drum that is attached by a threaded feed-screw to a motor. The motor both spins the drum and feeds the drum down the screw. Positioned above the drum is the optical system consisting of a lamp, its focusing lens, and a photocell that is connected to an audio oscillator.

As the drum revolves, the document is scanned by the beam of light. There is a separation of scanning lines because the drum also moves down the feed screw as it spins. (The scan is a helix at the surface of the drum.) The photocell senses the changing light intensity caused by the characters on the document and produces a varying DC voltage corresponding to the light intensity. The voltage, in turn, determines the frequency of a voltage-controlled oscillator.

Since the frequency of the audio oscillator is determined by the photocell-generated voltage, the system is said to use FM—short for frequency modulation.

The receiver is the same unit as

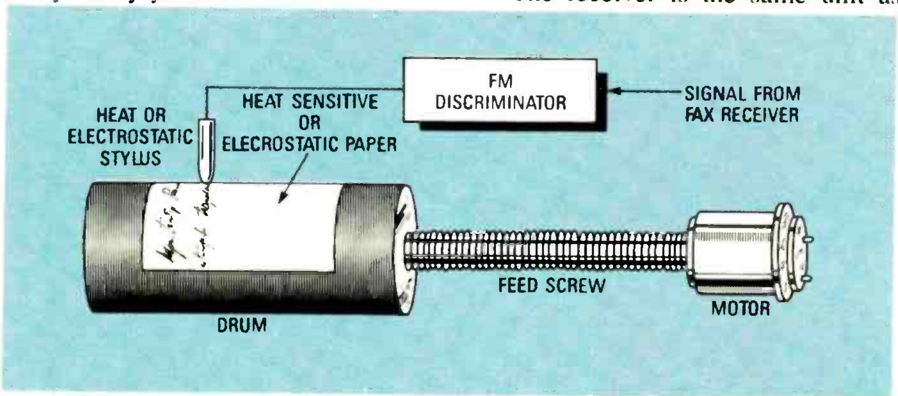



**FIG. 2—WHEN RECEIVING, THE IMAGE was literally burned into a blank sheet of paper that was mounted on the drum.**

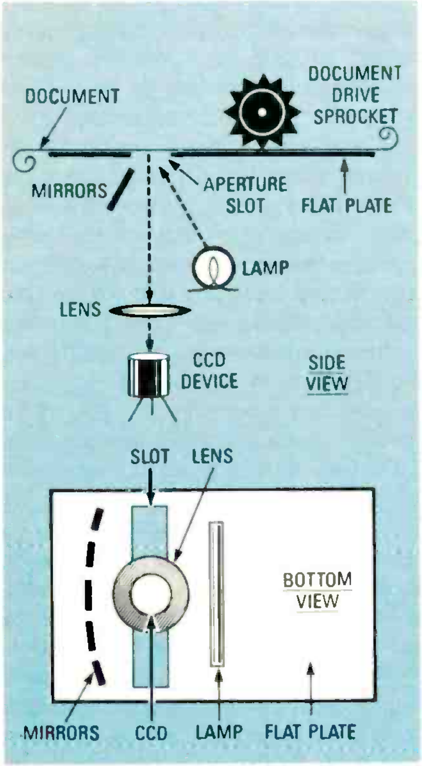



**FIG. 3—THE MODERN FAX MACHINE uses a photo-optical electronic scanner, and the document is usually moved past an aperture slot that's cut into a flat plate.**

used for transmitting but, as shown in Fig. 2, when the machine functions as a receiver an image-creating stylus swings into position to replace the optical system (or both are combined in a single housing). A demodulator in the receiver converts the received audio tones into electrical signals that are used by the stylus to burn a reproduction of the source document into a blank sheet of paper. As a general rule, synchronization between the drums of the transmitting and receiving machines was attained by using synchronous AC motors (whose speed is determined by the powerline's frequency). When DC motors were used, synchronization required a lot of tweaking. In a modern all-electronic fax machine, synchronization is achieved via an electronic signal.

Drum systems were in use for many years. As with everything else involved in international communications, the drum system was standardized by the CCITT. (CCITT is an acronym for the International Telegraph and Telephone Consultive Committee, the organization that sets the standards used for all international communications.) The CCITT standard, which is known as Group 1, G1, or GI, uses FM modulation and takes six minutes to transmit a CCITT "standard" test page. (Henceforth, whenever we refer to the transmittal speed of a standard page we mean the CCITT's standard test page.)

## The digital breakthrough

Six minutes per page transmittal time is not spectacular; it can result in substantial telephone charges, particularly on international circuits. Because of the time and cost limitations, fax was essentially limited to businesses that absolutely required real-time or rapid document delivery (as compared to mailing the document).

But the digital era brought with it electronic scanning, which meant that the entire mechanical paper-handling system could be eliminated. It also brought with it the modern computerized communication services such as storage, store and forward, polling, broadcasting, password security, automatic modem fallback, etc. We'll get to those features later.

Between the electro-mechanical and the digital eras was a period when fax used electronically derived AM modulation—the scanning and printing was no longer done on a spinning drum. The document was scanned on a flatbed, and the printing paper fed from a roll. The all-electronic system could provide automatic dial-up and answer, originate and answer identification, and unattended operation. The system's parameters are also set by the CCITT and are known as Group 2, G2, or GII. A Group-2 machine can send a standard page in three to four minutes—about half the time than it would take using a Group-1 machine.

## Digital

Group-2 machines were just a way-station to digital fax, which can send a page in as little as 18 seconds. (Some machines can send a standard page in

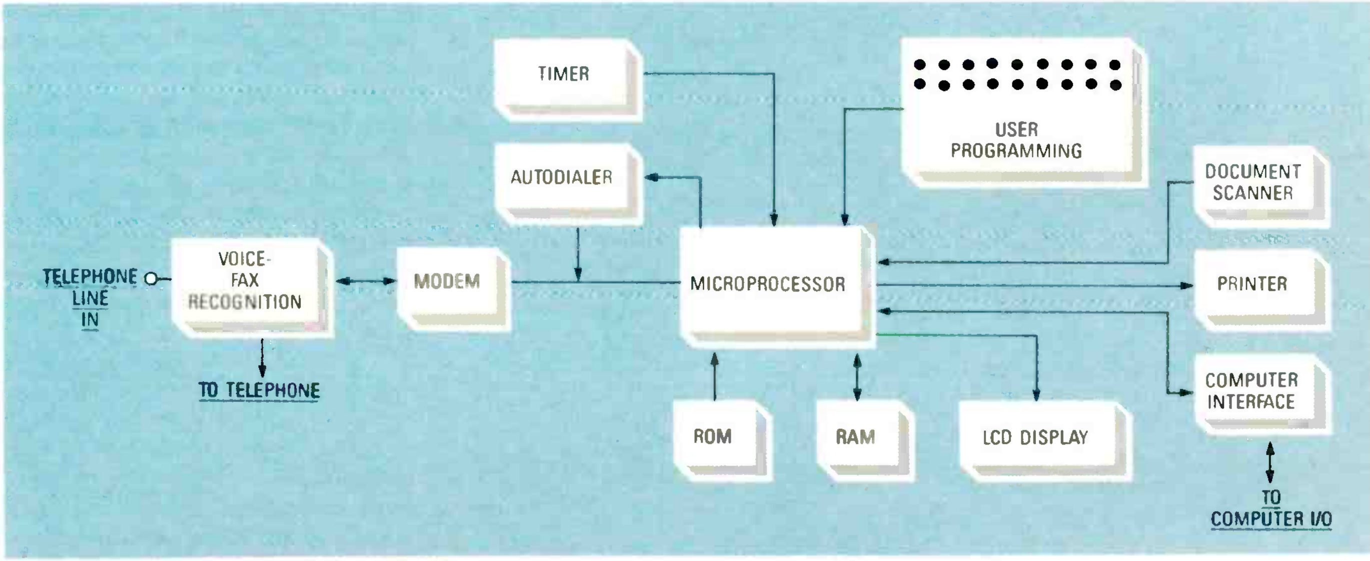



**FIG. 4—THE FUNCTIONAL BLOCK DIAGRAM** of a generic upscale fax machine. The ROM contains the operating system, handshake codes, and answerback control. The RAM can contain multiple incoming and outgoing documents, as well as a telephone directory and user-programmed instructions. The LCD shows what's programmed and what's happening, and prompts the user.

15 seconds.) The digital-fax CCITT standards are Group 3 (G3, GIII) and Group 4 (G4, GIV). The Group-4 method does not work on the dial-up telephone system, because it is intended for the 4-wire ISDN network—so we will restrict our discussion to the Group-3 machines. However, keep in mind that modern fax machines are often downward compatible: Group-4 machines will usually also function as Group-3 machines, just as many of the Group-3 machines are compatible with Group-2 and, sometimes, Group-1 machines.

Figure 3 is a generic representation of the most common scanning system used by Group-3 machines. As you can see from the side view, the document is pushed (or pulled) across a scanning slot that is cut into a flat plate.

As shown in Fig. 3, the portion of the document at the slot is evenly illuminated by a lamp that extends across the width of the slot. A series of mirrors compacts the image reflected from the document into the acceptance angle of a lens, which, in turn, focuses the image on the face of a CCD device. Electronic scanning of the CCD provides a bi-level (high-low) signal for the electronic system. The document's drive sprocket operates with a step-and-stop motion that is controlled from the same circuits that process the CCD image. The drive sprocket advances the document at the end of each CCD-image line. If the next line is blank, and then the next, the outgoing digital signal is compacted so that the receiving unit simply advances the printing paper until characters are available. The compression of both white and data is a primary reason why a Group-3 machine can process a standard page in as little as 18 seconds. (Including handshaking, a total of 45 seconds.)

Depending on the degree of desired bi-level or gray-scale resolution (from coarse to fine), and the modem speed (which we'll get to shortly), Group-3 standard-page transmission-time can vary upward from 18 seconds to nominally three minutes.

## Fixed position

A recent variation—that is specifically called *flatbed scanning*, moves the slot under the document. (*Flatbed scanning*, which formerly meant a flat-plate substitute for the spinning drum of Group-1 machines, now usually means a Group-3, a Group-4, or a computer scanner, on which the document remains in a fixed position while being scanned.) The mirrors, the lens, the CCD, and the lamp are an integrated mechanical assembly that moves under the document. The bed itself is glass; the slot is actually an "optical slot"—the viewing area seen and reflected by the mirrors.

## Contact scanning

As you might imagine, the mirror/lens/CCD/lamp assembly is somewhat complex and moderately expensive. However, a much lower-cost all-electronic *contact scanning* system has been developed. While it doesn't have all the capabilities of the mirror/lens/CCD system, at present it is perfectly suitable for use in the rock-bottom-priced fax machines. Eventually, just because of its simplicity, an upgraded version of the contact scanner will probably become the commonly used scanning device.

The contact-scanning sensor is a long, thin, electro-optical sensor tube that extends across the slot. Although not the same as a CCD, the tube functions more or less in the same way. The reflected light forms a pattern on the sensor across the width of the slot. Electronic scanning of the device's target area produces the same kind of bi-level and gray-scale digital output as a CCD. As with the CCD systems, the tube can be positioned under a fixed slot, or it can be used in a flatbed scanner, with the tube and a lamp moving under the document. Mirrors and a lens aren't needed because the tube's angle of view at the document is very narrow—again, an optical slot.

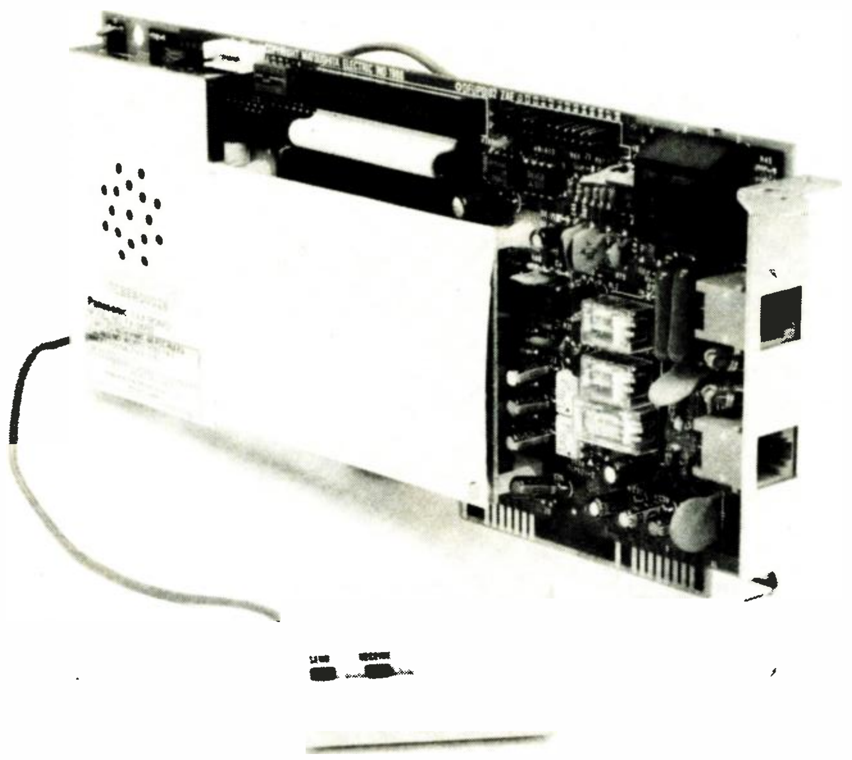


**FIG. 5—THE PANASONIC FAX ADAPTER has connections for both the telephone line and the local phone. An on-board monitor speaker for the modem allows the user to monitor the telephone line only until the fax communications circuit is established, or throughout the fax transmission.**

## Computerized

As shown in Fig. 4, a generic block diagram of a high-performance Group-3 fax, the electronic hardware is computerized, has firmware in ROM, dynamic memory (RAM), automatic voice-fax recognition, a telephone autodialer, computer interfacing, and some kind of answer/

originate modem. In the less expensive Group-3 fax machines, the modem has a fixed transmission rate of 2400 bps. More expensive models have a 9600-bps fall-back modem. Since the modem probably has the greatest affect on the transmission time of a standard page, let's cover the modem first.

It's easy enough to understand a fixed-rate 2400-bps modem: it simply does its thing at 2400 bps. A fall-back modem, however, tries to transmit at a higher speed, usually 9600 bps. (Yes, a good dial-up telephone circuit can handle 9600 bps.) The originating modem "tests" the answerback signal from the answering fax machine. If the answering machine senses an incoming 9600 bps, and if it has the capability, it will electrically handshake at 9600 bps. If the answering machine is equipped only for 2400 bps, its answerback at 2400 bps is sensed by the originating fax machine, and the originating machine shifts to 2400 bps. Otherwise, both machines start out at 9600 bps (or they start at the top rate of the slower machine.)

As with any other protocol data exchange, the answer modem constantly tests for transmission errors. If it senses too many errors on the communications path, it sends an electrical request to the originating modem to fall back to 7200 bps. If there are too many errors at 7200 bps the modem will automatically fall back to 4800 bps, and if there are still too many errors the machine falls back to 2400 bps. As you can imagine, each fallback increases the transmission time of the document. (From time to time, the originate modem will try to get back to 9600 bps. The system tries to maintain the highest possible transmitting speed.)

Normally, a separate telephone line must be available for fax reception, or the machine must be manually or automatically switched to fax for transmitting when the machine also has a built-in conventional telephone. However, as shown in Fig. 4, some upscale fax machines feature automatic voice-fax recognition, which allows the machine and a telephone to share a common line for incoming calls. When the machine answers a call it monitors for an electrical handshake from an originating fax. If it senses the handshake, the machine connects its own internal modem to the telephone line. If there is no handshake, the machine connects its own telephone, or a conventional external telephone. Although Fig. 4 shows the voice-fax recognition as a separate unit, that's done only for clarity; the actual circuit is usually part of the fax machine's modem.

The RAM can store the scanned image itself, and it can also be user-programmed with: 10–100+ telephone numbers for the telephone autodialer; the time a fax will be transmitted from RAM; a broadcast schedule, and incoming and outgoing password protection.

Broadcasting, also known as group distribution, means that the machine will automatically send the document from RAM to two or more machines at a specific date and time. Password protection works for incoming and outgoing traffic. Most high-performance machines permit *polling*, which means that a remote machine can dial in and request that a document stored in RAM be transmitted. Since many documents can be stored in RAM for selective polling (or timed-transmission), password protection allows polling machines to request only the documents that they are authorized to receive. On the flip side of the coin, high-performance machines don't necessarily print every incoming document; they can be stored in RAM for selective printing at a later time. A password allows access to the document only by the person to whom the document is specifically addressed.

Keep in mind that because Group 3 machines are digital, the document can contain text, line art, computer-generated bi-level or gray-scaled graphics; or the "document" can originate in a computer. Some of the more expensive machines provide a computer-to-fax interface that allows disk files to be fed directly into the fax machine. As far as the machine is concerned, the computer data is a conventional document. When receiving, the fax machine can either print the document or store the incoming data as a computer disk file.

Although the majority of the fax machines have thermal or electrostatic printers, some high-end models have laser printers, or allow connection to a laser printer so that the document can be used directly for camera-ready page makeup.

## Computerized fax

Basically, anything in the way of communications that's possible with a computer is possible with a full-blown fax, which leads us to, you guessed it, fax adapters for IBM-compatible computers.

Figure 5 shows a fax adapter for a PC/XT computer, Panasonic's *FX-BM/89*. It simply plugs into a slot and has the usual modem connections for the telephone line and the telephone instrument.

Usually, the software for high-performance computer fax adapters such as the *FX-BM/89* reside in memory and work in the background. In that way, the fax function is automatically available even during the time that the computer is being used for other tasks. The adapter essentially provides all the functions of a conventional fax except that the signal inputs to and outputs from disk: You store text, graphics, and scanner output as a disk file.

The fax adapter transmits any fax-formatted disk file as a conventional fax signal. To incoming fax, the adapter appears as a conventional upscale fax machine, except that it can store incoming data on disk for future use or for future printing.

Again as provided by the software, the fax adapter can "store" multi-address pages, will store-and-forward on a selective or broadcast basis, and will respond to polling.

As with conventional Group-3 fax machines, a fax adapter's features and functions vary from model to model. Actually, the functions and features of a fax adapter are determined more by the software than the hardware. The lower-cost adapters emulate the features of the lower-cost fax machines; the more expensive adapters emulate upscale fax machines.

Whether you're interested in a stand-alone fax machine or a fax adapter for your computer, keep in mind that just about every conceivable communications feature and convenience is available; but remember that every upgrade usually means additional cost. **R-E**

# FACSIMILE:


# 1940 — 1988

*An early experimenter with radio facsimile brings an old home-brew up to date with solid-state circuits.*

CARL A. HELBER

IT WAS ALMOST FIFTY YEARS AGO THAT *Radio & Television* magazine—a sister publication of *Radio Craft*, which eventually became **Radio-Electronics**—published two articles that I wrote on the subject of radio facsimile. In those days, radio facsimile was new and highly experimental. I was still in high school when I became fascinated by the experimental facsimile transmissions that were broadcast by UHF station W8XE in Cleveland, Ohio. Not having access to commercial equipment, I began to experiment with different ways to print out the material. My experiments resulted in two machines, which were the subject of my articles in the November 1940 and January 1941 issues of *Radio & Television* magazine.

About the time I finished my own machines, I came across two surplus Crosley Model *119* READO facsimile kits, which had been manufactured as part of an evaluation program designed to test the feasibility of broadcasting newspapers by radio, so that readers could get the news instantly, not hours or a day after it took place. Among other things, the imminence of World War II terminated the experimental facsimile broadcasts in 1941, so I purchased the READO kits in the hope of continuing my experiments. I intended to use one of the units as a scanner, the other as a printer. My efforts proved partially successful, but an inadequate optical system resulted in poor resolution and a somewhat noisy picture quality.

About that time I joined the U.S. Navy to work on RADAR (a classified word at that time) and, as a result, I had to suspend further experimentation with facsimile

Time marched on, but for some reason I held on to the two facsimile sets. Finally, after almost 50 years, I found the time to continue my experiments with facsimile. This article describes the design and construction of the original scanner-printer pair, and some of the components and techniques—which were not even envisioned nearly fifty years ago—that I used to get the units working.

## Big and heavy

Everything about the old machines was big—actually huge. Figure 1 shows just the mechanical assembly for my old scanner; Fig. 2 shows the printer. The electronics for each was in a separate enclosure (which was often installed under the mechanical assembly).

As I proceeded with my upgrading of the old machines using modern solid-state circuits, I had many recollections of the way things used to be done, or as someone said, "as it used to was." For example, because the amplifiers had very high input impedances the construction of any electronic project almost always required extreme care in the placement of the wires that connected the vacuum-tube filaments (heaters); at the very least, the wires had to be tightly twisted to reduce the ever-present hum pickup. In fact, particular care had to be taken with all wiring because the sheer physical size of the components used for vacuum-tube circuits usually resulted in long leads, which made the circuits particularly susceptible to noise pickup.

Then there were the problems of physical size and weight. There were no transistors or IC op-amps a half century ago. Typical of vacuum-tube technology, yesteryear's circuits required 90 to several hundred volts instead of the 15 volts or less that is common in many solid-state circuit designs, so the power supplies were usually humongous.

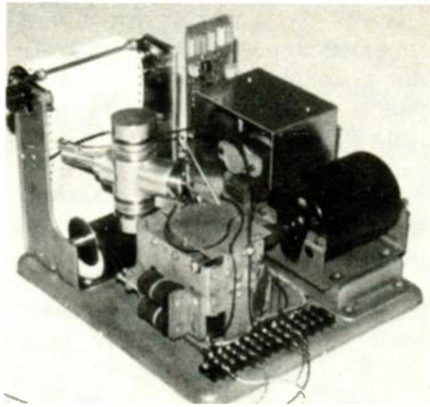


**FIG. 1—A 50-YEAR OLD scanner. The document was prepared from a roll of sprocket-fed paper.**

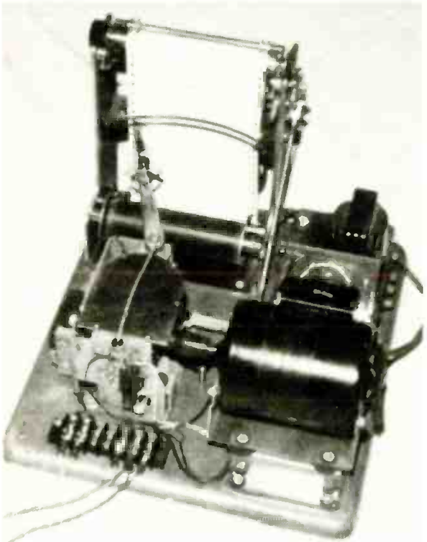


FIG. 2—THE PRINTER used electrosensitive sprocket-fed paper. The image was literally burned into the paper by a high-voltage stylus.

## The Finch Facsimile System

While my upgrading of the old equipment is based on the configuration of the Finch facsimile system, there is no reason why the same optical and electronic design can't be applied to drum-type scanners.

In the Finch facsimile system the document to be transmitted is spring-loaded against a curved platen. An optical assembly sweeping back and forth about the radius of curvature of the platen projects a tiny, bright spot of light onto the document. A phototube mounted on the optical assembly picks up the light reflected off the document. Since the intensity of the reflection varies directly with the density of the point being illuminated, a relatively large phototube current is produced by reflection from a white area, while the reflection from black generates a small phototube current.

Unfortunately, "relatively large" is a nebulous term; under the best of conditions the currents are very small—a few tenths of a microampere.

Typically, the tiny currents are converted to voltage and applied as modulation to an AC carrier. The carrier signal is then further amplified to a level suitable for modulating a radio transmitter. In the Finch system, the carrier frequency is 2000 Hz for document transmission and 400 Hz for the synchronization signal that keeps the scanner and printer synchronized.

The Finch facsimile printer uses a stylus sweeping back and forth across electrosensitive paper that is supported by a curved platen similar to the one used in the scanner. (I believe that the paper used a thin coating of titanium dioxide over a carbonized backing.) Signals received over the radio link from the scanner are amplified to several hundred volts in a conventional tube-type power amplifier and then applied to the stylus. The high voltage at the point of the stylus burns off the light-colored coating to a degree dependent on the magnitude of the voltage. As more of the coating burns away, more of the black backing shows through. (Too much voltage would cause the backing to burn through.)

Synchronizing pulses sent by the scanner energize an escapement lever in the printer at the beginning of each scan line. The printer is designed to run slightly faster than the scanner so that the stylus arm, which is driven thru a slip-clutch mechanism, will be waiting for the sync pulse at the start of each scan. This kind of mechanical synchronization was necessary, even though synchronous motors were in use in 1941, because most major power companies were not synchronized with each other as well as they are today. At present, by using synchronous motors, it is usually only necessary to get the printer started at

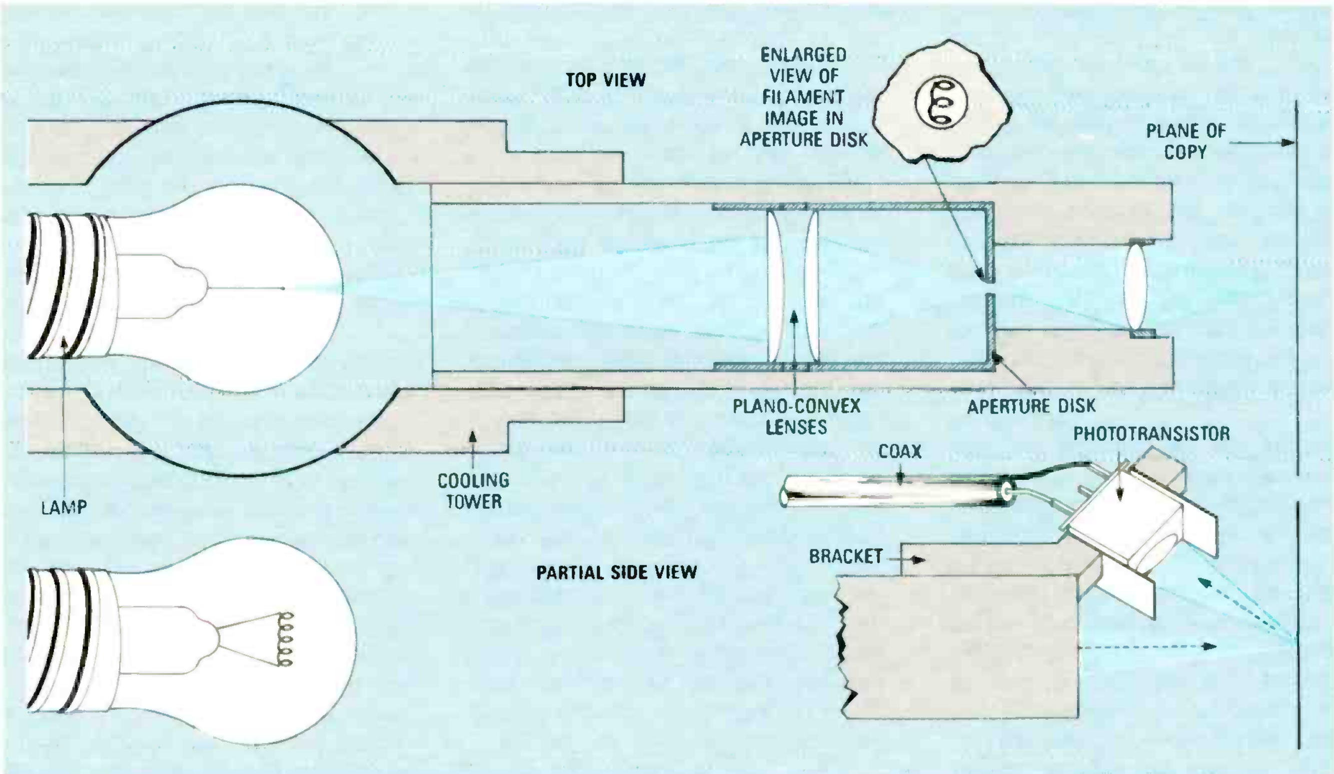



FIG. 3—THE NEW SCANNER OPTICAL SYSTEM. A major improvement is the substitution of a phototransistor for a phototube as the reflected-light sensor.

the right point at the beginning of the transmission; after that the escapement lever is left energized until the transmission is completed.

## The scanner

As I mentioned earlier, at best the optical system used in the original design resulted in a phototube current of a few tenths of a microampere. To achieve even that minuscule level, a type 923 gas-phototube operating at about 90 volts was required. While a load impedance of several megohms could result in a signal voltage in the range of 1–2 volts, the hum problem at such a high load impedance was formidable. On top of the problem of low output voltage, the signal had to modulate a carrier so that it could be amplified still more by stable amplifiers. When I interrupted my experiments in 1941, I had not yet resolved to my satisfaction the problems of low output voltage and susceptibility to hum.

But technological advances in the last twenty years have been so great that all of the early problems essentially disappeared when I substituted solid-state circuits (transistors and IC's) for the original vacuum tubes. For example, DC amplification was quite difficult to accomplish with a high degree of stability in the early days. Today, feedback techniques for IC op-amps make transfer characteristic shaping and gain adjustment relatively easy.

## New optics

Figure 3 shows my new optical system. A Sylvania 1156 lamp—the kind used for an automobile's backup lights—provides the light source. The lamp's filament is a 20-mil diameter tungsten coil 0.3-inch long that operates at 12 volts at slightly less than 1 ampere. A scanning spot 0.01-inch high by 0.0067-inch wide is obtained by using a demagnifying lens system to image the filament on a 10-mil diameter aperture. The resulting spot width is determined by the filament's width, while the spot's height is determined by the aperture's diameter. A 10-mil horizontal slit could have been used and would have made the demagnifier alignment non-critical, but it is much easier to fabricate a small, round aperture. A 1:1 projection system using a short focal length lens images the illuminated aperture on the document being scanned.

The aperture is created in a 0.5-inch diameter disk of 5-mil brass shim stock having a deep dimple in the center. (A sharp pointed pin or needle is used to form the dimple.) The disk is then placed dimple point down on a sheet of 400-grade silicon carbide paper and rubbed until enough brass is removed to leave a 10-mil hole.

As shown in Fig. 3, a phototransistor is mounted at the end of the lens tube. Because the case of the phototransistor is connected internally to the collector, which in turn is connected to +12 volts, the phototransistor is insulated from its metallic mounting by a layer of insulating tape. A length of RG-188 coax cable carries the phototransistor's signal to its amplifier.

Light from the 12-volt lamp must be prevented from directly illuminating the document being scanned, but it is essential that the lamp be cooled by a flow of air. The cooling is provided by a 4-inch fan feeding an air stream into cylindrical baffles positioned both above and below the lamp. The baffles direct the air around the lamp while preventing uncontrolled light radiation.

Figure 4 is the circuit used in my current scanner. Transistor Q1 is the phototransistor located on the optical head. White areas of the copy being scanned produce a current of 5–10 microamperes, while black areas result in less than one 1–2 microamperes. Potentiometer R1 compensate's for any stable offset current that might be caused by ambient room illumination reaching the phototransistor.

Op-amp IC1-a is a current-to-voltage converter with provision for changing signal gain (R3), and for clamping the white level if necessary. Potentiometer R5 is used to set the black clamping level to prevent overdriving the printer when adjustments are made to enhance the resolution of fine detail in the scanned material. For example, a narrow line whose width approaches the width of the scanning spot will generate a smaller signal than a broad line of the same gray level. The print density of the narrow line (fine detail) can be improved by adjusting R5.

The troublesome, somewhat touchy vacuum-tube modulator used in the early equipment is replaced by a simple transistor clamp (Q2) that also serves as a clamp for removing the scanned signal during the return stroke of the scanner head. A 1455 timer (IC2) generates the 2–10-kHz carrier; R11 sets the carrier's frequency. Switch S1, the *return scan disable*, is actuated by the scanning mechanism.

Potentiometer R6 adjusts the chopped signal amplitude and R9 adjusts the DC offset as required by the receiving circuitry. R9 would not be used in a radio transmission system; instead, a bandpass filter would be used to remove the DC and the low-frequency components while leaving, in effect, a balanced-modulated carrier to be applied to the transmitter.

The adjustment of the scanner's electronics starts by manually pointing the scanning head at a white area

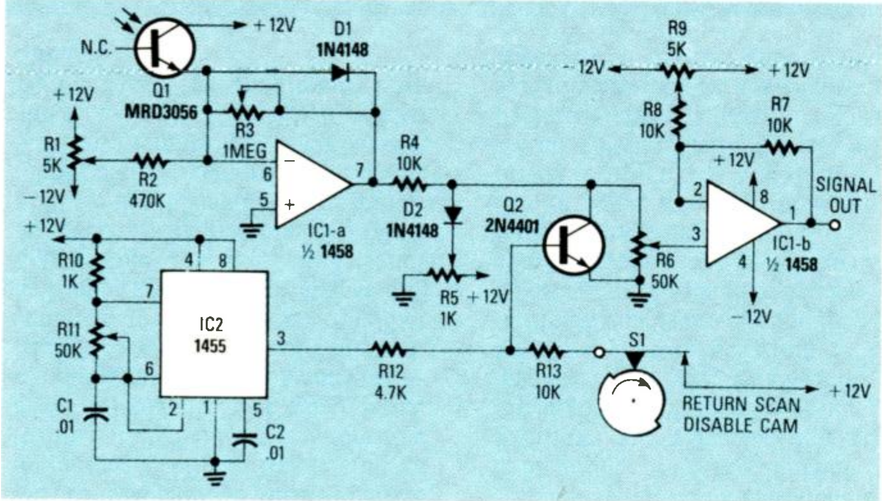



**FIG. 4—THE NEW SCANNER ELECTRONICS is all solid-state. The carrier is generated by timer IC2.**

of the document being sent. R1 is adjusted so that the voltage at pin 7 of IC1-a is zero or slightly negative. Next, the head is pointed at a center of the finest black line to be transmitted, which should cause the voltage at pin 7 to go several volts positive. (R3 is used to adjust the level to 3–4 volts.) R5 is adjusted so that with the base of Q2 grounded, the voltage at Q2's collector just begins to clamp. If R3 has been changed substantially, it might be necessary to repeat the previous procedure. Finally, R6 and R9 are set to provide the signal needed by the printer. In my current equipment, it is a 1.5–2-volt peak AC signal (full white to full black) sitting on top of a 1-volt DC offset.

## The printer

Figure 5 is the schematic of my most recent printer circuit. From the outset, it was obvious that the stylus transformer used in the original equipment would not be suitable for use with easily available transistors. The original transformer worked with tubes like the 6L6, which required a plate voltage of 250–300 volts. Common power transistors usually work at well under 100 volts, and usually at only 15–20 volts at the 5–10-watt power level required to mark the electrosensitive paper.

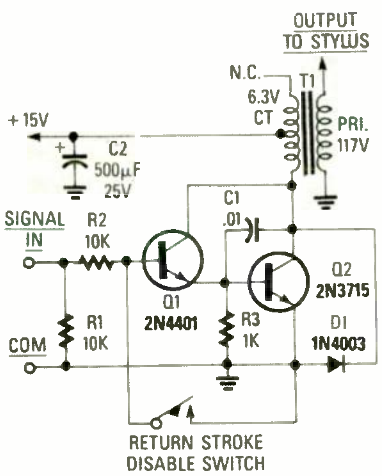



**FIG. 5—THE NEW PRINTER electronics is also all solid-state. A conventional reverse-connected filament transformer proved to be exactly the part needed to drive the stylus.**

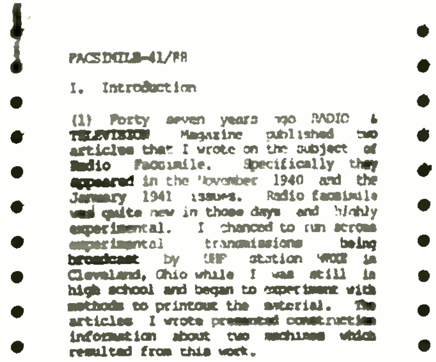
Calculations for stylus-driver transformer T1 indicated a turns ratio of 29:1 on a ¾-inch square core. It turns out that a Triad F-16X filament transformer has the same size core and a turns ratio of 36.5:1 between one-half the secondary and the 117 volt primary. A power transistor operating at approximately 20 volts should be able to provide a stylus voltage about the same as that provided by a 6L6 operating at 250 volts. That indeed turned out to be the case. In fact, a 15-volt supply turned out to be more than adequate.

Power transistor Q2 is normally cut off until the signal reaches about +1 volt. From 1 volt to about 2.5 volts T1's secondary voltage rises from a level that produces a barely discernible mark to a level where the backing paper begins to burn through. (Average collector current rises to about 500 mA.)

Capacitor C1 slows the amplifier's rise time to suppress any tendency towards oscillation caused by stray-capacity feedback from Q1's output to its input. Switch S1 is a return-stroke signal disable switch like the one used in the scanner.

## It really works

For almost 50 years I managed to hang on to several 100-foot rolls of the special sprocketed facsimile paper used by my mechanisms. Surprisingly, after nearly a half-century there appears to be no deterioration in the paper's recording quality. Two samples of documents sent from the scanner to the printer over a direct wire link show that my up-to-date circuits work very well with the ancient mechanisms. Figure 6 is a facsimile print of the original draft of this article; Fig. 7 is a facsimile print from a photograph of a well-know politician.


FACSIMILE-41/FR

I. Introduction

(1) Forty seven years ago RADIO & TELEVISION Magazine published two articles that I wrote on the subject of Radio Facsimile. Specifically they appeared in the November 1940 and the January 1941 issues. Radio facsimile was quite new in those days and highly experimental. I chanced to run across experimental transmissions being broadcast by UHF station [illegible] in Cleveland, Ohio while I was still in high school and began to experiment with methods to printout the material. The articles I wrote presented construction information about two machines which resulted from this work.

**FIG. 6—50-YEAR-OLD electrosensitive paper was used to make this facsimile of the original draft of this article.**

**FIG. 7—EVEN PHOTOGRAPHS can still be reproduced using the old equipment and paper.**

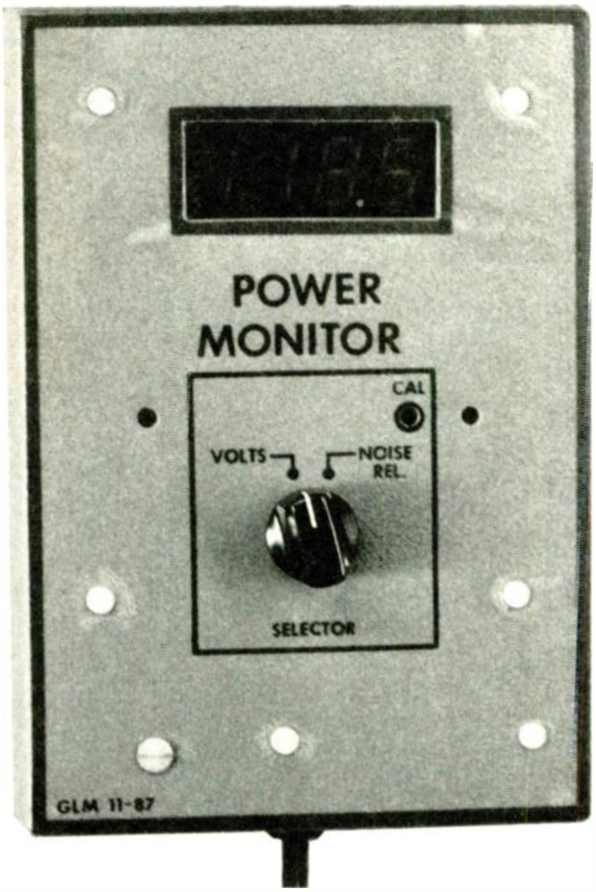
In fact, as you can see from Fig. 6, the reproduction of the individual characters by my refurbished printer compares favorably with the print quality from some of the new machines.

## Conclusions

This project has been fun, to say the least. It was interesting to recall the many difficult circuit problems I encountered when building facsimile equipment back in the 1940's. It was even more interesting and satisfying to see the enormous progress made possible by modern electronic components.

But as good as my results are, much experimentation with clamping levels, offsets, and gain remains to be done to improve the gray-scale performance of the system. Unfortunately, the time will come when my supply of electrosensitive paper is exhausted. In view of that eventuality, I am now considering the design of a drum-type scanner using the same optical head described in this article. A drum-type scanner generates a linear time-position relationship for points on the document; a feature that makes it fairly simple to digitize and store the signals in a computer memory where they can be processed in a way suitable for transmission to a digital printer. In that instance, a computer program is required to convert the digital amplitude data into a constant-frequency variable-dot format for half-tone reproduction. I just hope it won't take me another 50 years to do it. **R-E**

# POWERLINE MONITOR




*Solve those power problems with this power monitor!*

GARY McCLELLAN

UNTIL RECENTLY WE SAFELY could give little thought to the quality of the AC power coming out of our wall outlets. But the world is changing, and so are the power requirements of electronic equipment. Noisy, fluctuating, line power may not bother lamps, irons, or other appliances, but dirty power can raise havoc with sensitive electronic devices such as personal computers. If you have ever lost data or "trashed" a program running on your computer, you may have been a victim of a power brownout or excessive line noise, without realizing it. That could cause you to waste time troubleshooting the unit for an intermittent problem, when all that was wrong was a power glitch.

## Power monitors

A power monitor lets you keep an eye on the condition of your AC power. At a glance you can read the line voltage and be aware of brownouts and surges that might damage your equipment. It even lets you monitor the relative noise level on the line; a feature that helps you spot high-noise conditions that cause equipment problems. Also, as we'll show later, a power monitor's noise-level feature lets you test line filters quickly and easily.

Although a professional-grade power monitor having those features is usually very clostly, this month we'll show you a hobbyist-grade version of the device that can be built for as little as $45. Even so, if precision components are used it can read the powerline voltage down to tenths of a volt with an accuracy that exceeds ±0.5%. Also, relatively large 0.56-inch LED's displays make it easy to read the line voltage and relative noise levels at a glance.

## How it works

The schematic of the circuit is shown in Fig. 1. The dashed lines represent the edges of a printed-circuit board. The lettered terminals on the dashed lines correspond to lettered solder pads on the PC-board to which the external components are connected. For example, switch S1-b connects to solder pads on the PC board labeled A, B, and C.

The power monitor is a simple, straightforward device using an Intersil ICM71076 digital voltmeter (IC2), which reads 0–1.999 volts DC. For AC-voltage measurements, the applied voltage is simply rectified to DC before being fed to the digital voltmeter. For noise readings, a high-pass filter and peak-reading rectifier circuit are substituted for the conventional AC rectifier. A regulated power supply, IC1, provides the reference voltage needed by IC2.

The basic digital-voltmeter circuit is built around IC1 and IC2. DC inputs from the volts- or noise-measuring circuits appear across resistor R8 and capacitor C9. Those components attenuate and filter the signal from the volts- and noise-measuring circuitry. The signal is then applied to IC2, pin 31, via resistor R11 and is measured. (Resistor R11 and capacitor C10 provide overload protection for IC2.) The applied voltage is converted by IC2 into driving signals for displays DSP1 and DSP2.

A key part of the digital voltmeter is a reference voltage source from IC1. It determines the overall accuracy of the unit because IC2 makes measurements by comparing a known reference voltage with the unknown input. In this instance the reference voltage is provided by adjustable voltage regulator IC1, a low-cost adjustable voltage regulator. The regulated output voltage of 1 volt appears at the wiper of potentiometer R6 and is applied to IC2 pin 36. Because IC1 will not regulate the output voltage if too little current is drawn, resistor R4 ensures

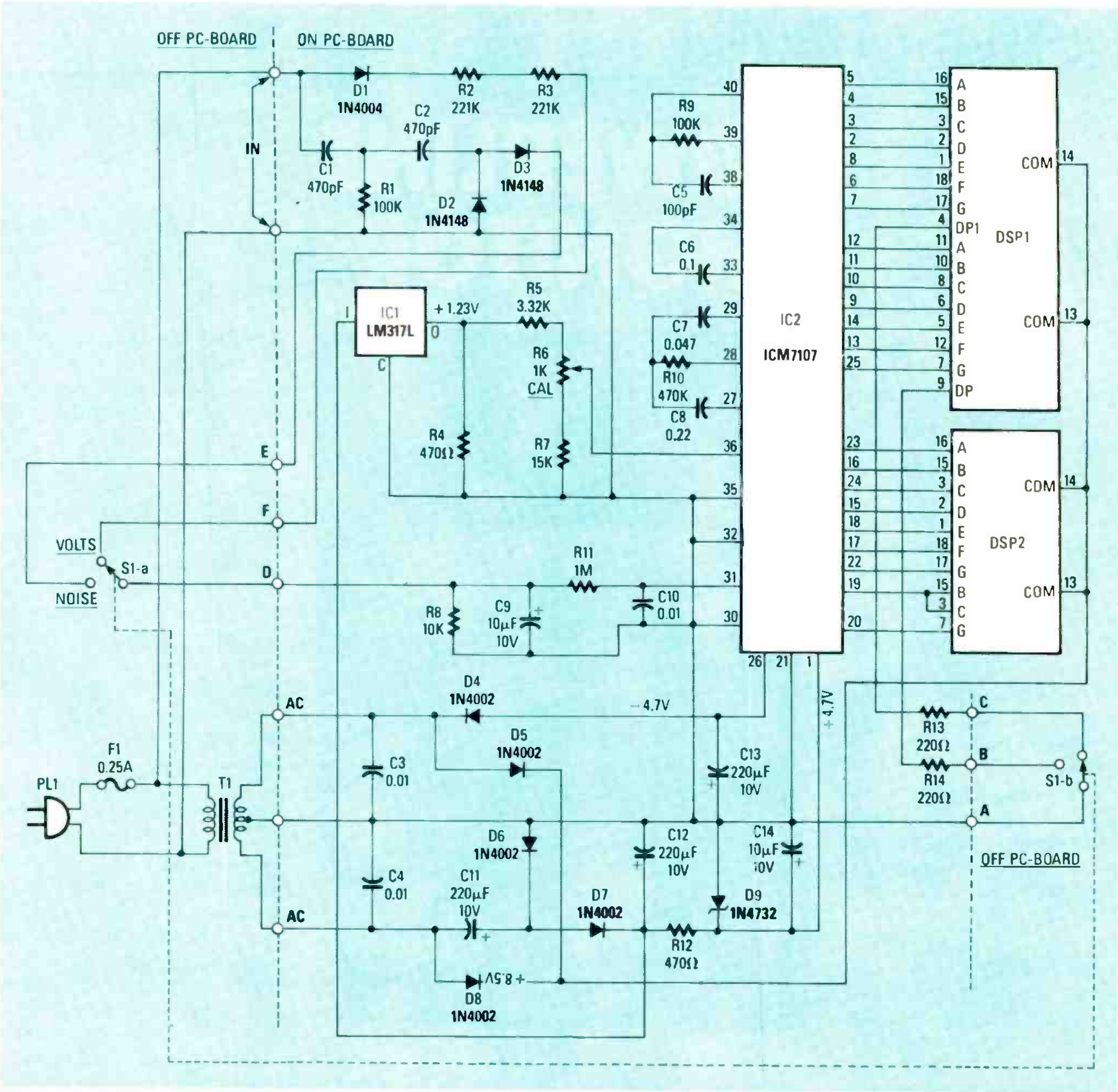



FIG. 1—THE POWER MONITOR INDICATES either the applied line voltage or the powerline noise. The noise level is determined by passing the line voltage through high-pass filter C1/R1/C2.

regulation by providing a minimum output current drain for IC1; the current loading caused by R4 ensures that IC1 will provide a constant 1.23-volt output.

The AC-voltage circuit is simple and easy to understand. Line voltage appearing across the IN terminals on the PC board is rectified by diode D1. The pulsating DC output from D1 is scaled down to the 1.2-volt range by resistors R2, R3, and R8. Capacitor C9 filters the pulsating DC so it can be measured. For improved safety and reliability, two separate resistors, R2 and R3, are used instead of a single resistor. That is necessary because small precision resistors are usually rated at only 250 volts DC, which is marginal for use in this application.

## Noise measurements

The noise-measuring circuit consists of a high-pass filter and a voltage-doubler rectifier circuit. Capacitors C1 and C2, and resistor R1, filter out the 60-Hz hum component, leaving only line noises to be measured. Diodes D2 and D3 rectify noise components into DC values. The output from D3 drives resistor R8 and charges capacitor C9 to the peak value of the noise signal.

Understand that the noise readings are relative because they are determined by the duration, waveshape, and peak value of the noise pulses. In normal use, that limitation should not cause problems for the user.

## The power supply

Both regulated and unregulated voltages are used. Diode D4 and capacitor C13 provide −4.7 volts for the analog circuitry inside IC2. Diodes D5 and D8 provide pulsating DC for powering LED displays DSP1 and DSP2. Using pulsating DC for the

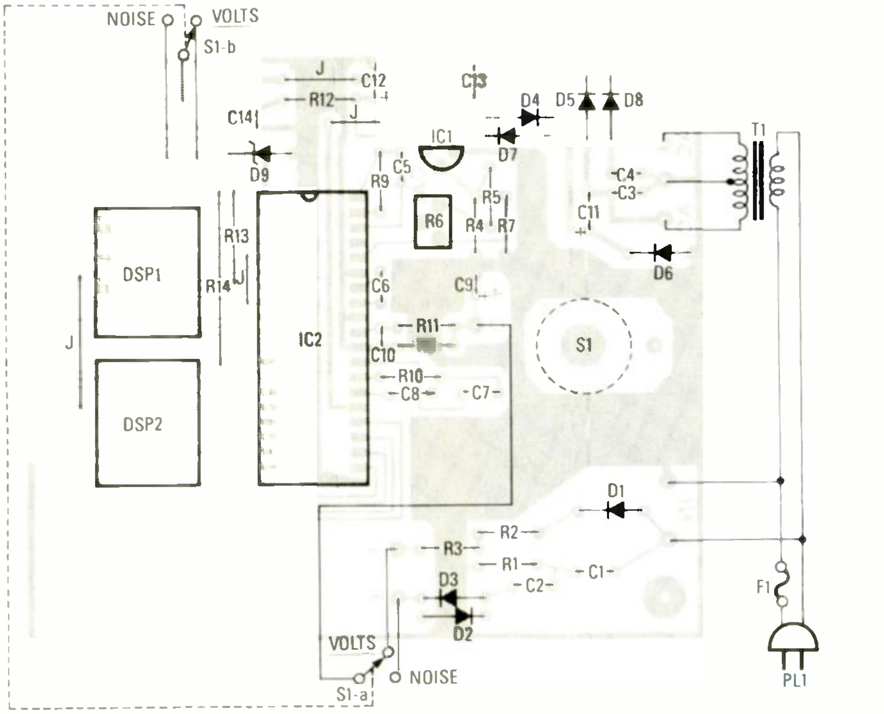



FIG. 2—USE A SOCKET FOR IC2, and do not install the IC itself until all other PC-board components are installed.

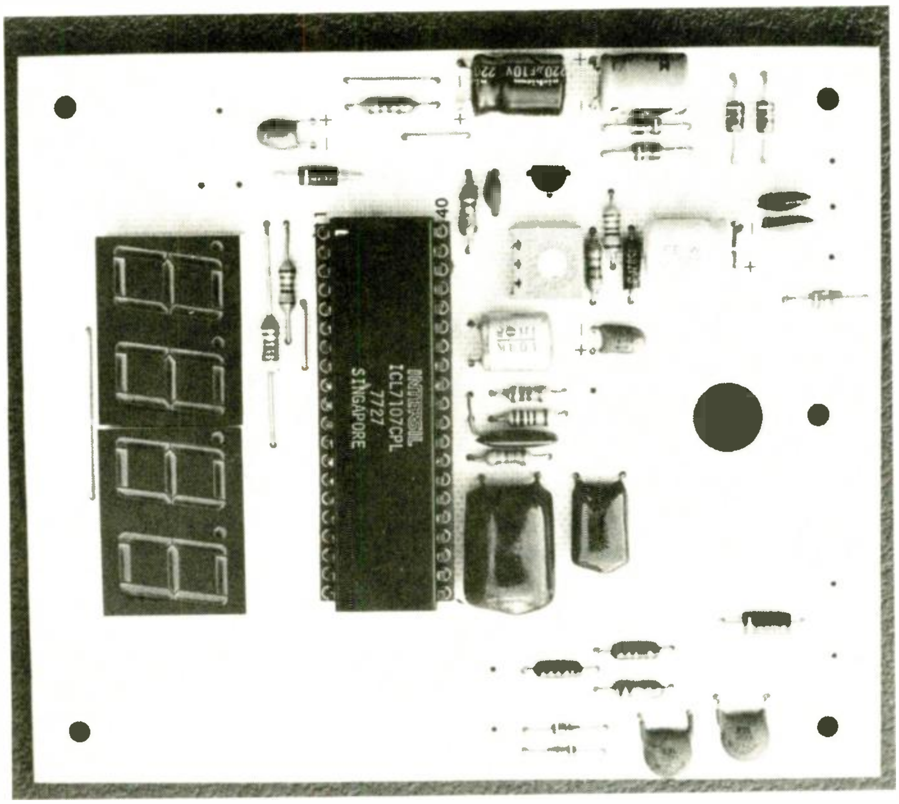


FIG. 3—FOLD THE CAPACITORS FLAT AGAINST THE BOARD to ensure clearance between the board and the cabinet. To prevent strain on the leads, bend them before soldering.

displays rather than using a steady DC voltage lowers IC2's power dissipation. Finally, a regulated +4.7-volt source for IC2 is provided via Zener diode D9.

## Parts

A few parts that might prove difficult to get are the precision resistors and capacitors, and the plastic case. Precision resistors tend to be tough to buy in small quantities from local sources, but several **Radio-Electronics** advertisers do stock them. In a pinch, you can substitute the nearest value ¼-watt carbon-film resistors, but then the unit's precision will suffer. The polyester capacitors are widely available from many sources, but the electrolytic capacitors may prove difficult to get. You may prefer to use 220-µF, 16-volt units and mount them on the foil side of the board where there is more room. And finally, the

### PARTS LIST

**All resistors ¼-watt, 5%, carbon film unless otherwise noted.**
R1—100,000 ohms
R2, R3—221,000 ohms, ⅛-watt, 1% metal film
R4, R12—470 ohms
R5—3300 ohms, ⅛-watt, 1% metal film
R6—1000-ohm cermet trimmer potentiometer (Digi-Key OFA13)
R7—15,000 ohms, ⅛-watt, 1% metal film
R8—10,000 ohms, ⅛-watt, 1% metal film
R9—100,000 ohms
R10—470,000 ohms
R11—1 megohm
R13, R14—220 ohms
**Capacitors**
C1, C2—470 pF, 1000 volts, ceramic disc
C3, C4, C10—0.01 µF, 50 volts, ceramic disc
C5—100 pF, 500 volts, ceramic disc
C6—0.1 µF, 50 volts, polyester film
C7—.047 µF, 50 volts, polyester film
C8—0.22 µF, 50 volts, polyester film
C9, C14—10 µF, 16 volts, radial tantalum
C11–C13—220 µF, 10 volts, radial electrolytic
**Semiconductors**
IC1—LM317L, voltage regulator
IC2—ICM7107CPL, A/D converter
DSP1, DSP2—Dual 0.5-inch common-anode LED display (Digi-Key P337ND or equivalent)
D1—1N4004 rectifier diode
D2, D3—1N4148 switching diode
D4–D8—1N4002 rectifier diode
D9—1N4732 Zener diode
**Other components**
F1—Fuse, ¼ ampere
PL1—Linecord plug
S1—3P3P rotary switch, see text
T1—Filament transformer: 6.3 VCT, 600 mA, Stancor P-6465 or equivalent part
**Miscellaneous:** Cabinet, printed-circuit materials, IC socket, hardware, wire, solder, etc.

plastic case is a product from LMB/ Heeger, Inc. Their products are widely available from distributors, so ask your local dealer if it can be special-ordered. Otherwise, you can substitute any kind of plastic case and plastic mounting hardware.

## Construction

The circuit should be assembled on a printed-circuit board. The template is provided in PC Service.

For ease-of-assembly, using Figs. 2 and 3 as a guide, mount the PC-board's components in the following order: First, the socket for IC2, then all other semiconductors. (Do not insert IC2 into its socket until the entire board is stuffed.) Next, all resistors and jumper wires; then the capacitors. To ensure clearance between the board and the cabinet's front panel, install the electrolytic capacitors and the larger Mylar/polyester types so they lie flat on the board.

Finally, install the LED displays. Position the displays so that their decimal points (dots) are at the bottom.

As shown in Fig. 4, switch S1 is installed on the foil side of the board and its terminals are connected by short lengths of insulated wire that are tack-soldered to the foils. Although S1 can be any kind of DPDT switch, a 3P3P rotary switch is recommended because they are inexpensive and generally available. (One section of the switch is not used.)

## The cabinet

Finally, install the PC board and its external components in a plastic cabinet. First, drill all the necessary holes in the front of the cabinet and smooth the edges of the display cutout with a file. Then use press-on letters to label the project. Mark a location in the center of the rear case half and drill a ¼-inch hole that will be use for a hanger bracket.

To install the parts in the case, install threaded spacers on the component side of the board and then push the board into the case and secure it with nylon screws. Turn S1 fully counter clockwise and install the knob on its shaft so it's pointing to VOLTS. Then install the fuseholder and transformer T1 adjacent to the PC-board with nylon screws. Push the linecord through a hole in the bottom of the case and knot it inside the case for extra security.

Finish the project by wiring the

**FIG. 4—VOLTS-NOISE SWITCH S1 is mounted on the foil side of the PC-board. Its connections are tack-soldered to the appropriate solder pads.**

cord, fuseholder, and transformer to the board. Double check your work to make sure that the green secondary wires from T1 go to the board's AC solder pads and ground terminals, while the AC linecord go to the IN terminals.

Before closing the case, install the fuse and cut a piece of scrap plastic so that it fits over the PC-board, between the switch and the sides of the cabinet. The material provides an extra margin of safety by insulating the circuit from any screw or nail passing through the back of the case. Close up the case and you are done!

## Calibration

Plug the power monitor into an AC outlet and note that the display lights up and indicates some value. If the display doesn't light, quickly turn off the power and check for a wiring error, or a solder bridge.

For best calibration accuracy you will need a high-quality digital multimeter. Set the multimeter to the 200-volt AC range and connect it to the same AC outlet to which the power monitor is connected. Insert a screwdriver through the case hole that allows access to CAL control R6 and adjust R6 until both meters read the same value.

## Troubleshooting

If the power monitor doesn't work at all, or is inaccurate, and the problem doesn't appear to be a wiring error, check the power-supply voltages and the reference voltage at IC2 pin 36. If the voltages are good, either IC2 is bad or installed wrong. Lastly, if displays continually show 000, check the position of the knob on S1's shaft, it is probably wrong.

## Operation

The power monitor is easy to set up and use. Simply insert a screw in the wall where you want it, then hang the project on the screw. Connect the plug and you are ready to monitor power-line conditions.

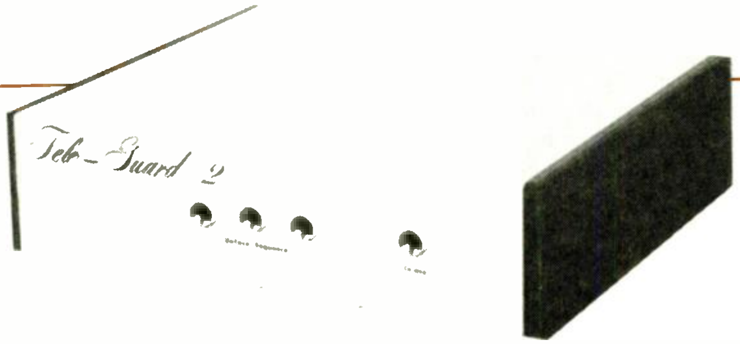
So what line voltage limits and noise levels are acceptable? As far as voltage is concerned, all equipment will work on voltages from 110–125 VAC with no problems. But as you go beyond those limits, your chances of problems increase tremendously.

Understand that typically most appliances are erratic at 100–105 volts and run hot at 130–135 volts. As for noise levels, the values are highly variable.

Generally up to a few volts of noise will cause no problems, but if the noise level exceeds 20 volts peak, which will cause the display to blank, you will probably have operating problems. (Exactly what happens due to an incorrect line voltage or high line noise depends upon the equipment you are using.)

You should be aware that the noise circuitry will also respond to carrier-current devices such as wireless intercoms and *X10*-type home-control systems or other communication devices such as line carrier modems or wireless intercoms. However, the signals from those devices should not bother other equipment, despite the high noise readings you get.

As mentioned earlier, the power monitor is useful in testing noise filters. The procedure is simple; here's how to do it. Plug the power monitor into a duplex outlet; then plug a noisy device such as a shop vacuum into the same outlet. Turn on the vacuum and note the noise level's meter reading. Disconnect the power monitor and connect the noise filter between the outlet and the power monitor. If you see the same noise-level reading on the meter as you did before you connected the noise filter, then something's wrong with your noise filter. The power monitor's reading will be lower if the noise filter is working properly. **R-E**




# Digital Telephone Lock

*This easy-to-build device prevents unauthorized use of your telephone.*

LAST MONTH WE EXAMINED HOW THE DIGITAL telephone-lock works. This month, we'll build the unit, show how the security code is programmed, and how to retrofit the system for use with pulse-dialed phones.

## Maintaining connection

While using a telephone you might have noticed the sound of clicks in the receiver when the central office connects you to the called party. The clicks are an interruption of the voltage to the telephone instrument. If no means of counteracting the voltage interruptions were applied to our circuit, the small internal LED across pins 1 and 2 of IC1 would go out and IC1's output would reverse, causing RY1 to drop out and interrupt the call.

Capacitor C7, which is connected between the base of Q1 and the +6-volt supply, prevents RY1 from dropping out. The capacitor charges when a ground (low) is available at Q1's base. During a brief interruption in the telephone line voltage, the capacitor discharges and applies a low (ground) to Q1's base, thereby keeping RY1 energized during the entire interruption.

When the telephone call is completed, returning the handset to its cradle disconnects the telephone line from the On-Hook Detector, thereby restoring IC1 pin 5 to a high, which cuts off Q1, causing RY1 to drop out making sure that the telephone is returned to its standby condition.

## Incoming calls

The security code isn't needed to answer an incoming call because the Tele-Guard has an over-ride circuit that allows the secured telephone to answer a ringing signal.

The over-ride circuit is based on opto-isolator IC2, which functions as a ring detector. A telephone ringing signal, which appears across the red and green telephone wires, is approximately 90–100 volts at 20–30 Hz. If you trace the circuit shown in Fig. 5, you'll find a that a series circuit consisting of capacitor C4, resistor R5, and IC2, is connected across the telephone line. When the ringing signal is received, IC2's internal LED begins to flash, which causes pin 5 of IC2 to go low. That low is then applied through diode D6 to the base of Q1, which causes Q1 to conduct and energize relay RY1. When the relay pulls-in, the contacts then connect the telephone to the telephone line so the call can be answered.

Unfortunately, there is a problem with that arrangement. Pin 5 of IC2 goes low only when its internal LED flashes, which means that the telephone can only be answered during the ringing half of the signalling cycle. To overcome the problem, R4 and C3 are added to provide a steady low to Q1's base whenever pin 5 of IC2 attempts to go high. The R4/C3 time constant is approximately four seconds, which is more then enough time to compensate for the off-period of the ring cycle.

## Wiring the header

The wiring of SO2 determines the specific digits and their sequence needed to unlock the telephone. For

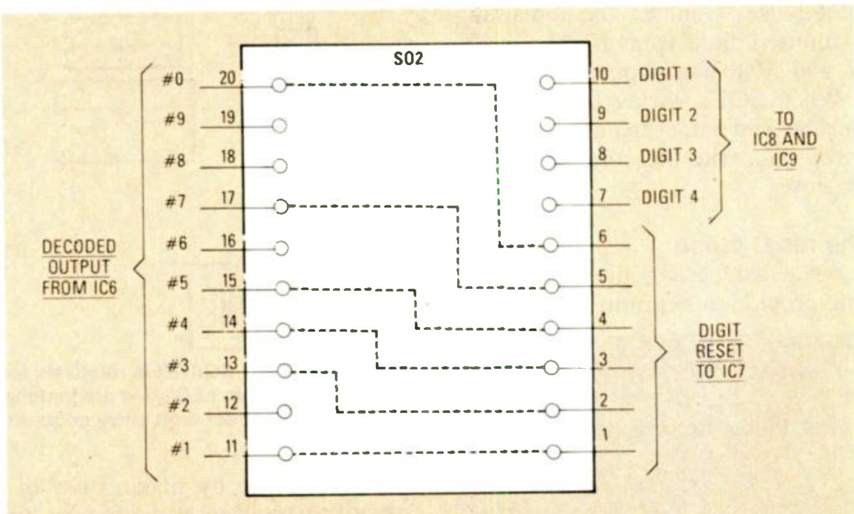



**FIG. 6—TWO GROUPS OF HEADER CONNECTIONS are needed for the security code. A four-wire group sets the combination. The six-wire group provides the misdialed digit reset.**

simplicity, the required SO2 connections has been broken down into the wiring groups shown in Fig. 6.

Figure 6 is a top view of the SO2 20-pin header assembly. Pins 1–6 are used for the mis-dialed-digit reset pulse (more on that a little later). Pins 7–10 are the selected unlocking digits, where pin 10 is the first digit that is entered, pin 9 is the second, pin 8 is the third, and pin 7 is the fourth and last digit.

Pins 11–20 are connected directly to the decoded decimal output from IC6, where, in the stand-by mode, they are all high.

Before any wiring can take place, determine the four-digit combination. Any digit from 0 to 9 can be used. The combination can contain double digits, such as 2 2 3 4, 4 4 9 9, etc.

For example, assume you wish to use the combination:

9 8 6 2

The combination can also be written as shown in Table 2.

As shown in Fig. 6, using jumper wires, connect header pin 19 to pin 10. That will indicate to the Tele-Guard that the number 9 will be the first digit of the unlocking sequence.

Connect header pin 18 to pin 9. That will indicate that the number 8 is to be the second unlocking digit.

Connect header pin 16 to pin 8. That indicates that the third digit is 6. Then connect header pin 12 to pin 7, indicating that the number 2 is the fourth and final digit in the four-digit combination.

The remaining SO2 wiring is the additional wiring needed for a digit-reset pulse. Connect the remaining six unused digits (pins 11, 13, 14, 15, 17, and 20) to header pins 1 through 6.

When SO2's wiring is completed and checked out, snap on the header's cover and write the combination on the cover.

## The reset pulse

As stated earlier, the Tele-Guard can provide maximum security to your telephone by making use of a circuit that will reset the D-type flip-flops (IC8 and IC9) every time an incorrect digit is entered as part of the unlocking sequence.

The heart of the reset circuit is IC7, an 8-input NAND gate. To refresh your memory of digital electronics, the output pin of a NAND gate will go high when any of its eight inputs goes low.

**TABLE 2**
**HEADER CONNECTIONS**

| Digit Place | Combination | Header Pin Number |
|---|---|---|
| Digit 1 | 9 | 19 |
| Digit 2 | 8 | 18 |
| Digit 3 | 6 | 16 |
| Digit 4 | 2 | 12 |

**PARTS LIST**

**All resistors ¼-watt, 10%, unless otherwise noted.**
R1, R14—1000 ohms
R2, R10–R13—220 ohms
R3—47,000 ohms
R4—220,000 ohms
R5, R8—10,000 ohms
R6, R7—120 ohms, 1 watt
R9—1 meghohm
**Capacitors**
C1—2.2 µF, 250 volts, non-polarized
C2, C4—0.22 µF, 100 volts
C3—1000 µF, 10 volts, radial electrolytic
C5—2.2 µF, 16 volts, axial electrolytic
C6—0.01 µF, 100 volts, ceramic disc
C7—47 µF, 16 volts, radial electrolytic
C8—2200 µF, 35 volts, radial electrolytic
C9—470 µF, 35 volts, radial electrolytic
C10—0.22 µF, 50 volts, ceramic disc
**Semiconductors**
IC1–IC3—4N33 opto-isolator
IC4—7404 hex inverter
IC5—M-957-01 DTMF receiver
IC6—74154 4-to-16 decoder
IC7—74LS30, 8-input NAND gate
IC8, IC9—7474 dual D-type flip-flop
IC10—LM7812 12-volt voltage regulator
IC11—LM7806, 6-volts voltsage regulator
Q1—2N4402
D1, D2, D8–D12—1N4001
D3–D7—1N914
LED1–LED4—light-emitting diode, red
**Other components**
PL1—modular plug with attached cord
RY1—6-volts DPDT, (Digi-Key Corp. *Z115-ND*)
SO1—modular telephone socket
SO2—20-pin header with cover
T1—wall transformer, 12–18 volts, 500 mA
XTAL1—3.58-MHz crystal
**Miscellaneous:** cabinet, *Touch-Tone* telephone, printed-circuit materials, wire, etc.
**Note: The following is available from Del-Phone Industries, Inc., P.O. Box 150, Elmont, New York 11003: Etched and drilled printed-circuit board, $24:, M-957-01 DTMF receiver; $15.95; 3.58-MHz DTMF crystal, 1.75. Add $2.00 for postage and handling. New York State residents must add appropriate sales tax.**

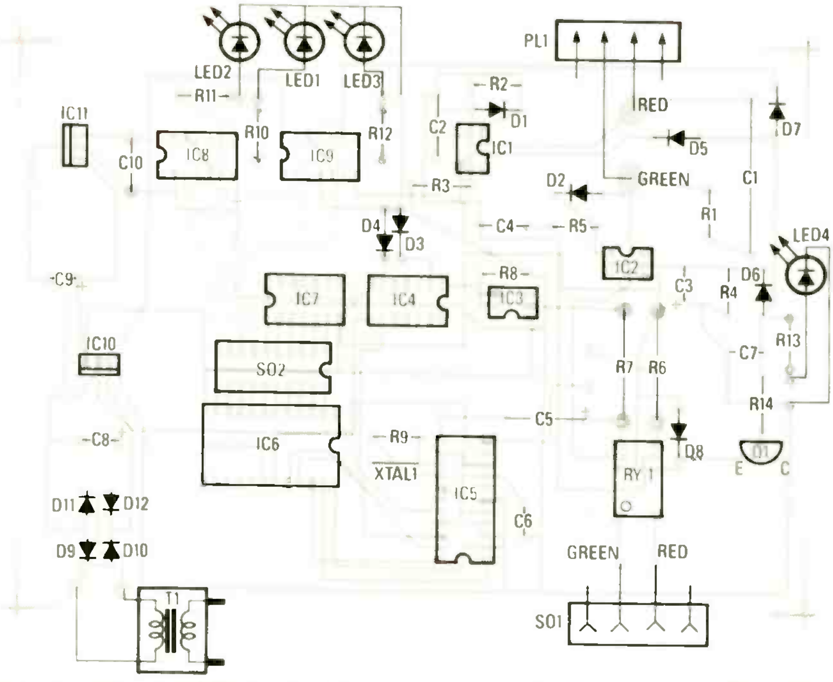



**FIG. 7—THE PC BOARD is relatively large and should present no assembly problems. Just make certain LED's 1–4 are installed on the cabinet in the correct order so you can observe the correct digit entry sequence.**

In the case of Tele-Guard, header pins 1–6 are connected directly to IC7. The additional two IC7 input pins, which are not used, are connected to the +6-volt power supply. In that state, all the inputs are high so the output is low.

For example, lets assume that keypad's number 9 button is pressed. That causes header-pin 19 to go low as long as the button is depressed. The jumper wire from header-pin 19 passes the low to header-pin 10, which is connected to the sequential pass-on circuitry (IC8 and IC9). At this point, all is well.

Assume that the second digit entered via the keypad is the number 3. By referring to Fig. 6, you can see that header-pin 13 is pulled low. The jumper from pin 13 pulls pin 2 low. The No. 3 digit is considered to be a mis-dialed entry because our code requires the second number dialed to be an 8, not a 3.

Since the 3 puts a low on header-pin 2, and since pin 2 is connected to one of NAND-gate IC8's inputs, IC8's output (pin 8) goes high. That high is inverted by IC4 to a low, which is passed on to IC8 and IC9 via pins 4 and 10. Both IC8 and IC9 reset when pins 4 and 10 are low, thereby canceling the previously saved unlocking-digit information. To by-pass the Tele-Guard, the user *must* enter the complete four-digit code in the proper sequence.

## Visual indicator

LED's 1–4, shown in Fig. 5, provide a visual indication of the unlocking sequence. They light in sequence as the correct combination is entered. When the fourth digit is entered, LED's 1–3 extinguish and LED4 goes on, which indicates that the telephone has access to the outside telephone line.

## Construction

The Tele-guard is assembled on a double-sided PC board; the templates for the board are provided in PC Service. Alternately, an etched and drilled board can be purchased from the source given in the Parts List. Take note that the PC board, whether homebrewed or purchased, does not have plated-through holes; which means that after a component is placed on the board you *must* solder a component's leads to the traces on both sides of the board.

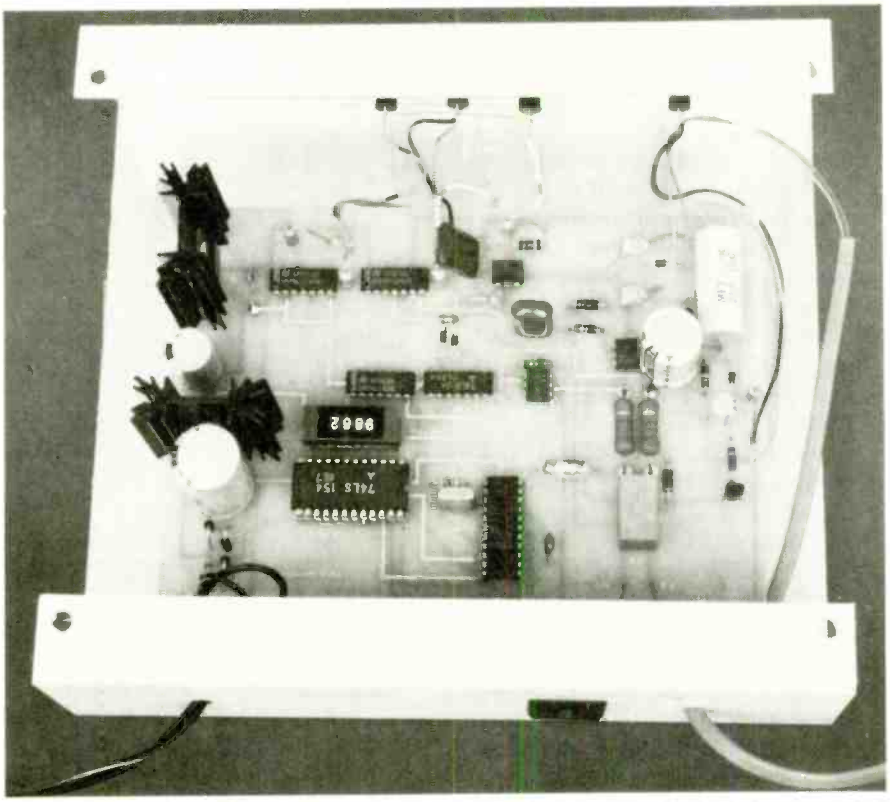


FIG. 8—SINCE NOTHING IS CRITICAL you can install the PC board in just about any kind of cabinet. Note the heat sinks attached to IC10 and IC11, which are located on the left side of the PC board.

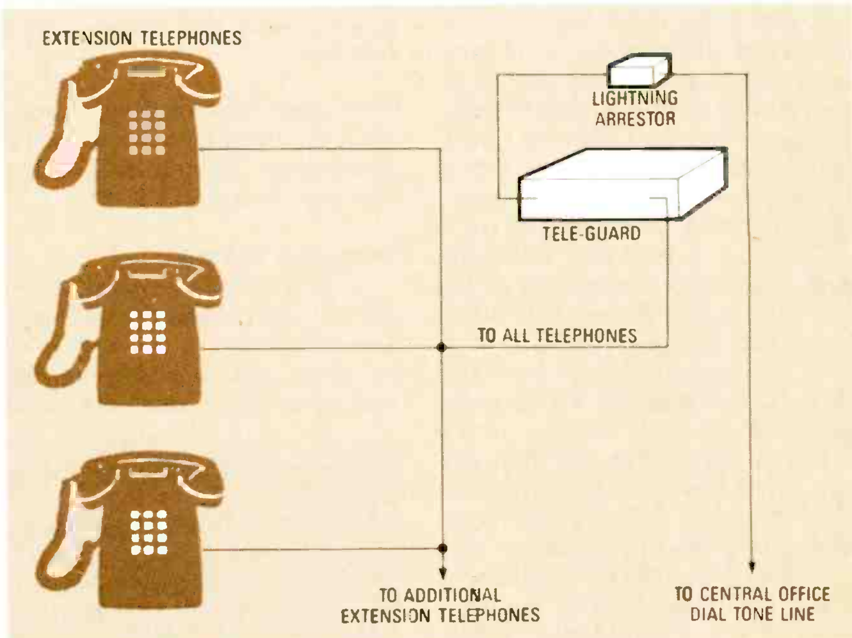



FIG. 9—WHETHER YOU HAVE ONE PHONE or several extensions, the Tele-Guard connects between the regular telephone line and all telephones connected to it.

Using Fig. 7 as a reference, install the resistors and capacitors first, then the solid-state devices and the relay. Use sockets or strip-socket sections for IC5 and IC6, and for header SO2. And make certain that you install heat sinks having at least 2¼ square-inch of area on IC10 and IC11.

To conserve space, diodes D9–D12 must be mounted standing on end. Just make sure their polarity is correct before soldering.

The completed unit can be installed in just about any kind of cabinet that you might have lying around. The cabinet that is shown in Fig. 8 was made from a sheet of aluminum for the chassis, with wood blocks used for the sides.

## Checkout

When all components are installed, soldered, and checked for proper polarity, plug in AC-wall-transformer T1 (12 to 18 VAC, 500 mA) and check for proper voltages at the power supply.

If everything checks out, connect the telephone to be secured to SO1. Then, using the keypad, key in the programmed security code and note the lighting of LED's 1–3.

When the fourth digit is entered, you should hear the relay pull in. Simultaneously, LED4 should light while LED's 1–3 go out. (The relay will only pull in and then drop out.)

Connect the red and green wires of a modular telephone cord to their proper locations on the PC board and plug the other end into the normal telephone modular wall connector.

Again, using the proper unlocking code, enter the four security digits. When the fourth digit is entered the relay will pull in and self-lock, and you will hear a dial tone in the telephone's receiver.

To further test out the operation of Tele-Guard, hang-up the telephone, then lift the handset again. This time enter the first two digits of the unlocking code. Note that LED1 and LED2 light up. Then press any other button that is *not* associated with the code. This time both LED's should go out.

To test the on-hook circuit, lift the handset and enter one or more of the digits needed to unlock your telephone; then hang up. The LED's that have just been turned on will extinguish, indicating that the counters were reset.

To test the security over-ride circuit, have a friend call you. When the telephone rings, note that LED4 will light during the ringing half of the signaling cycle. Then lift the handset; you should be able to carry on a conversation without any further action on your part.

## Multi-telephone system

Figure 9 shows a multi-telephone home installation. Notice that all telephones in the home have been connected in parallel. Make certain you observe the red-green polarity but keep in mind that telephone installers have been known to make mistakes, and you may find the red and green wires have been exchanged somewhere between the phone jack and the central office. If you're in doubt about the connection, check it out.

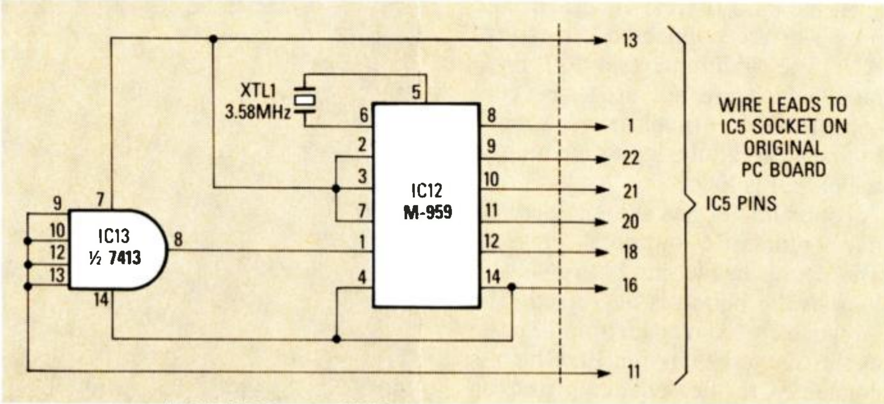



**FIG. 10—THE SUBASSEMBLY CONSISTS OF only two IC's and crystal XTAL1. The crystal is the same one that's used in the DTMF version of the *Tele-Guard*.**

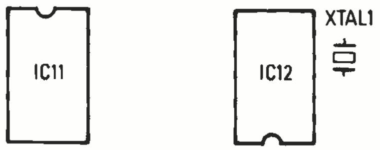



**FIG. 11—THE PARTS LAYOUT for the subassembly. Make certain the IC's are positioned correctly. Their number-1 pins are opposed.**

## Pulse-dial retrofit

Although the *Tele-Guard* was specifically designed for use with *Touch-Tone* telephones, it can also provide the same kind of security for rotary and push-button pulse-dialed telephones by simply adding a retrofit to the original project.

The retrofit consists of a few easy-to-do modifications to the original project. One of the modifications is a small subassembly, shown in Fig. 10, that substitutes for IC5—the DTMF receiver. To avoid confusion, the retrofit uses the part-number sequence from the original *Tele-Guard*; hence, the subassembly's integrated circuits are labeled IC12 and IC13.

### PARTS LIST FOR PULSE DIALER

C11—330 µF, 16-volt, radial-lead capacitor
IC12—M-959, dial pulse counter
IC13—74LS13, Schmitt trigger
XTAL1—3.50-MHz crystal, see text
Misc:—Printed circuit materials, wire, solder, etc.

**Note: A kit containing all the retrofit parts and a printed-circuit board is available from Del-Phone Industries, Inc., P.O. Box 150, Elmont, New York 11003. Price is $14 plus $2 postage and handling. New York residents must add the appropriate sales tax.**

## Pulsed dialing

The heart of the subassembly is IC12, Teletone's *MC-959* dial-pulse counter, which converts voltage pulses corresponding to rotary-phone dialing digits into a binary-coded output. It is essentially a direct substitute for the original DTMF receiver (IC5), except, instead of voltage pulses, the DTMF receiver converts audio tones that represent Touch-Tone digits into a binary-coded output.

IC13 is the trigger for IC12. It monitors the telephone line for dial-pulse signalling and hook status. When the telephone is on-hook, IC13's output is an active low. When the telephone goes off-hook, the output goes high, thereby triggering IC12's on/off hook and operating timers, which, in turn, trigger IC12's internal break counter, digit decoder, and output control.

## Printed circuit

The subassembly is built on a small printed-circuit board. A full-scale trace template is shown in PC Service. Alternately, the PC board is included in a complete kit of retrofit parts that is available from the source given in the Parts List.

The parts layout is shown in Fig. 11. Note, in particular, that the two IC's

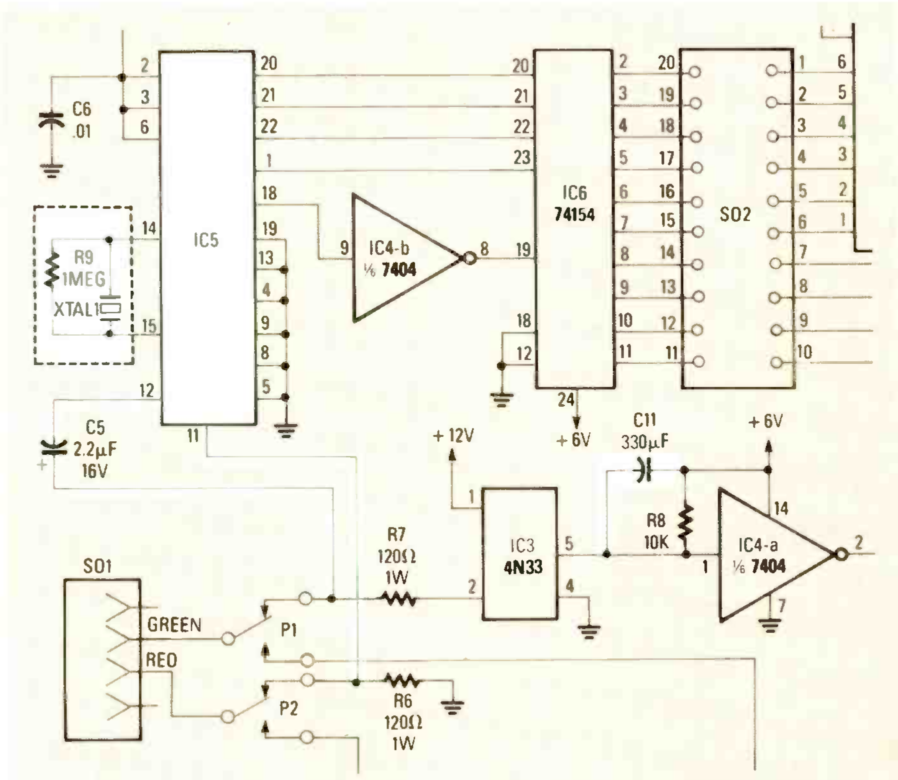



FIG. 12—THE RETROFIT'S MODIFICATIONS to the main PC board are shown highlighted. Remove R9, C5, IC5, and XTAL1. Install C11, 22 solid wires in the holes left when IC5 is removed, and a jumper from R6 to IC5's pin 11.

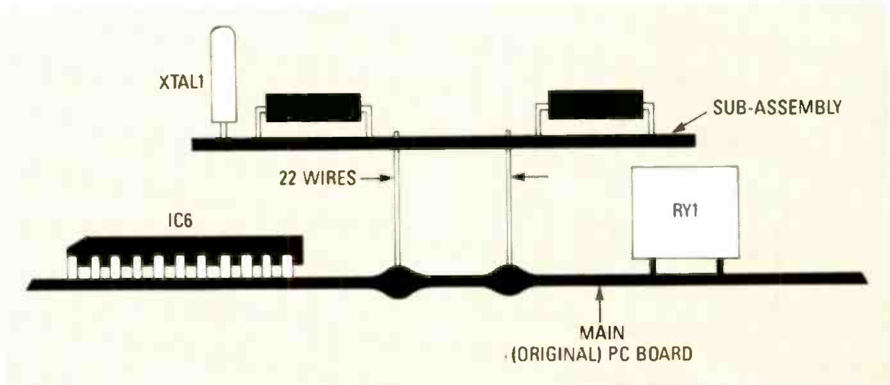



FIG. 13—SLIDE THE SUBASSEMBLY on the 22 wires sticking up from the main board. Solder the wires on both sides of the main board.

are mounted opposed: that is, pin 1 of both IC's point in opposite directions

The double row of holes on the subassembly's PC board correspond to IC5's pin pattern on the original *Tele-Guard*'s PC board. (Henceforth, we will refer to the original *Tele-Guard* PC board as the *main PC board*.) Make certain that none of the holes get filled with solder during assembly. (Obviously, IC5 isn't needed if you're building the entire pulse-dialing *Tele-Guard* from scratch.)

Complete the assembly except for the 3.58-MHz crystal, XTAL1. The crystal is the one used in the DTMF *Tele-Guard*. If you're doing a retrofit, the crystal must be removed from the original PC board. If you're building from scratch, simply install XTAL1 directly on the subassembly.

Set the subassembly aside until you complete a few modifications to the main *Tele-Guard* PC board.

## Modifications

The modifications are shown highlighted in Fig. 12. You can enter the changes on the original schematic, or photocopy Fig. 12 and paste it over the original full schematic.

From the main PC board, remove XTAL1, IC5, C5, and R9. If you remove the solder from each connection using one of the available desoldering braids, the parts will literally fall off the board—without damage to either the parts or the printed-circuit traces. The best and the easiest solder removal will be attained using a braid about 1/8-inch wide. Double-check to be sure that every hole at IC5's location is open. Install the crystal on the subassembly's PC board.

A pulse dial actually connects and disconnects the telephone set from its line in rapid succession. If the make-break sequence wasn't compensated, the very first pulse would cause the *Tele-Guard* to disconnect the telephone from its line. To prevent an automatic disconnect, tack-solder a 330-μF/16-volt radial-lead electrolytic capacitor across resistor R8. (In keeping with our policy of using the part number sequence from the original project, the capacitor is C11.) If there is sufficient clearance between the original PC board and its metal cabinet, you can install C11 on the foil side of the board.

The polarity of C11 must be correct. When connected across R8, C11's positive lead should point toward IC4; the negative lead should point towards IC2.

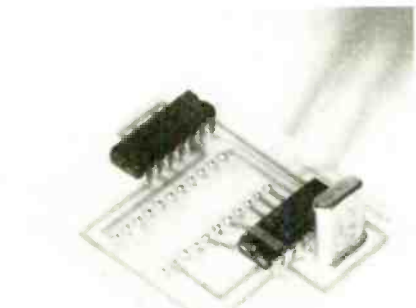


FIG. 14—THE WIRES can be pre-soldered to the subassembly first, as shown. Make certain that the wires are straight, before sliding them into the matching holes on the main board.

Install a jumper on the main PC board across the two empty solder pads that are located directly adjacent to R7 (on the side opposite R6). The jumper connects the ungrounded side of R6 to pin 11 of IC5, which is used only as an interconnect to the small subassembly.

Use Fig. 13 for reference and solder 22 solid, 1½-inch long, uninsulated wires in IC5's holes. (They will be cut to length after the subassembly is installed.) The wire size can be No. 20, 22, or 24. Note, from Fig. 13, that some of the wires make connection to traces on both the top and the bottom of the main board, so make certain that you solder both sides (the holes are not plated through). After soldering the wires, bend them upward, at right angle to the board.

Again using Fig. 13 as the reference, position the subassembly directly over the 22 wires and slide the subassembly on the wires. Make certain that each wire passes through its corresponding hole. Position the subassembly so that it doesn't touch anything on the main board and then solder the wires to the subassembly's solder pads. That will complete the retrofit. (Note: If it's more convenient, install the wires on the subassembly first; then pass them through the holes in the main board. Figure 14 shows the subassembly with the wires pre-installed.)

Instead of using individual wires to connect the subassembly to the main board, you may want to use a wire-wrap IC socket. Make sure you leave enough room for soldering.

### Program and checkout

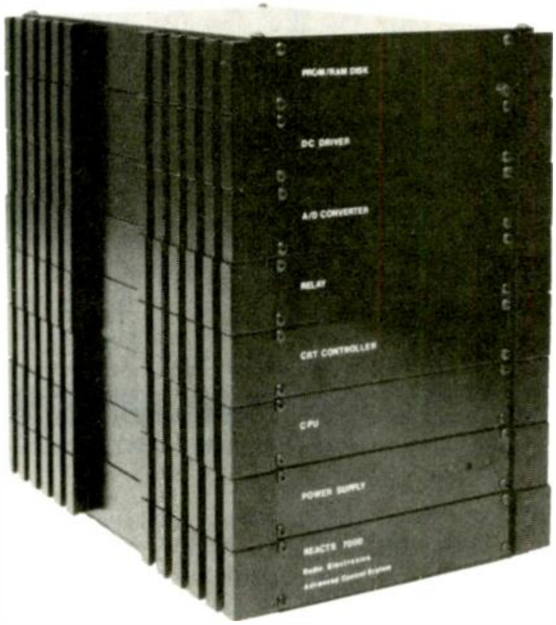
Program the main PC board with the security-code for the pulse-dial *Tele-Guard* exactly as it was described for the *Touch-Tone* version. Everything else then remains the same. You gain access to the telephone line by first pulse-dialing the four-digit security code. Within a second or two a dial tone will be heard from the receiver and you then dial the desired telephone number.

### Redial option

If you're using a pulse-dialing telephone having a last-number redial button, keep in mind that the telephone company's central office must deliver a dial tone before it accepts dialing pulses. If you press the redial button, your call *will not* go through, because your telephone will dial the four-digit security code and then the telephone number. The *Tele-Guard* will accept only the first four digits and connect your telephone to the line. It then takes up to two seconds for the central office to deliver dial tone; meanwhile, your telephone is still pulsing out digits. The central office, of course, will not receive any digits until the dial tone is applied. Put simply, you can't use redial with the *Tele-Guard*. R-E

# Build REACTS: THE RADIO-ELECTRONICS ADVANCED CONTROL SYSTEM

*This month we show you how to add X-10 compatibility to REACTS for easy home automation.*



JIM BYBEE

LAST MONTH WE BEGAN TO DIScuss how the REACTS X-10 module works, however, as is often the case, we ran out of room and were forced to end our discussion. So, this month we continue our explanation on the X-10 module's operation. We'll also talk about the software that makes our system "tick," and then show you how to build the module so that it can become a working part of your REACTS system.

The X-10 module includes eight status LED's and eight SPST input switches. The switches, through software, can be used to turn lights and/or appliances, that are connected to X-10 modules, on or off. Likewise, the status of those appliances (whether they are on or off) can be determined by the LED's. The LED's and switches are located at one of the REACTS I/O ports. The switches are read by inputting from the port and the LED's are turned on or off by outputting the correct bit combination to the port. Since the switches and LED's are independent from the X-10 functions of the module, they are not necessarily confined for use with only the X-10 module. For example, the switches could be used to activate or deactivate the relays on the octal I/O module. The following example program illustrates that. In it we will assume that the X-10's SPST switches are addressed to I/O port address 20, and the octal I/O relays at I/O port 55:

```
10 SWITCHES = INP(20)
20 OUT 55, SWITCHES
30 GOTO 10
```

That program would continuously input the binary value of the switches and then output that value to the relays on the octal I/O module. Each switch occupies one bit of the byte read from I/O port 20. If the switch is on, the corresponding bit will be a 1, and when the byte is sent to the octal I/O module (line 20), the corresponding relay will be activated.

## Software for the X-10 module

We have already mentioned how easy it is to write programs for the REACTS X-10 module using the available driver software. Using that software, only two program lines are needed to send a command to an X-10 remote module, and one of them is always the same—for example GOSUB X-10. The other program line can be written in one of two ways, depending on the program mode. In mode 1, the program line is made up of a string that contains the

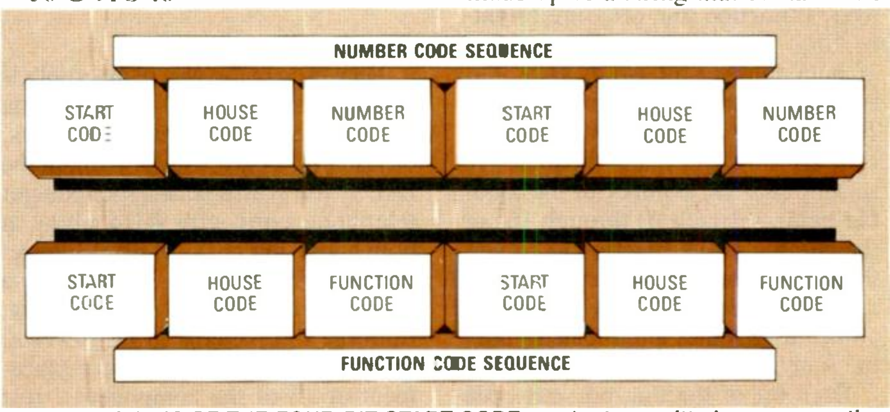



FIG. 1—EACH BIT OF THE FOUR-BIT START CODE can be transmitted on consecutive zero crossings of the AC power line. The other nine bits of each thirteen-bit word must be sent out in true form first, then in its inverse form. Each thirteen-bit word must be sent to the module at least twice.

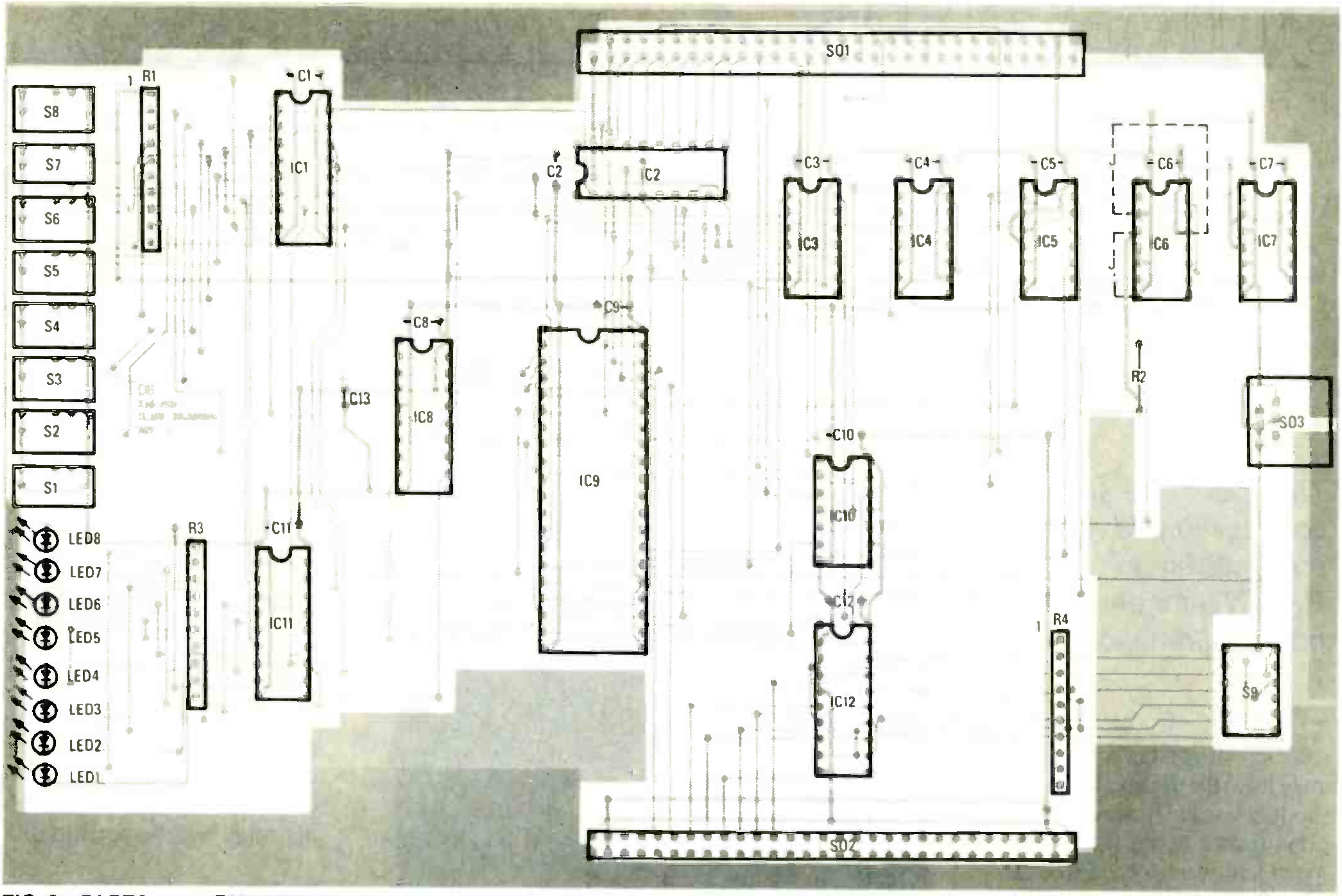



**FIG. 2—PARTS-PLACEMENT DIAGRAM. Follow this when installing all parts on the X-10 board, and don't forget to use sockets for the IC's.**

module's house and key codes, and the function to be performed—for example: A,2,OFF. In mode 2, the program line contains a user-defined string that represents that information—for example: MASTER BEDROOM ON.

Outputting a control signal to a single X-10 module requires the sending of two thirteen-bit data words. The first thirteen-bit word (the number code) selects the number of the module to be controlled, and the second word (the function code) selects the type of function (on, off, dim, brighten) to be performed. The first four bits of both thirteen-bit words is a start code (1110) that is always the same. The next four bits represent the house code (A through P), and the final five select either the number of the module being selected (0 through 16) or the number of the function to be performed (on, off, dim, or bright). With the all-on and all-off functions (where all of the modules are affected), only the function code is sent.

Each bit of the four-bit start code can be transmitted on consecutive zero crossings of the AC power line. However, the other nine bits of each thirteen-bit word must be sent out in true form first, then in its inverse form on the very next zero crossing (see Fig. 1). Additionally, each thirteen-bit word must be sent to the module at least twice.

As you can see, the actual transmitting of the codes to the X-10 remote modules is somewhat involved. However, the REACTS X-10 software handles all the details of transmitting to the X-10 remote modules, allowing you to concentrate on the main objectives of your control program.

## Construction

Very little in the way of assembly is required for the X-10 module. You can purchase a complete kit of parts, or just a PC board with or without the PAL's. You'll also need a 4-conductor telephone cord with RJ14 plugs at both ends, and an X-10 PL513 Power Line Interface module. You can buy a PC board or else you can make one from the foil patterns in PC Service, and follow Fig. 2 for correct placement of all of the components. Just solder in all of the parts being sure to use sockets for the IC's. Then just press the appropriate IC's into their respective sockets. Figure 3 shows you the completed board.

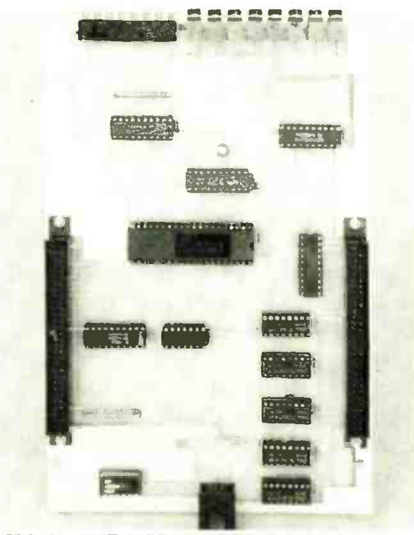
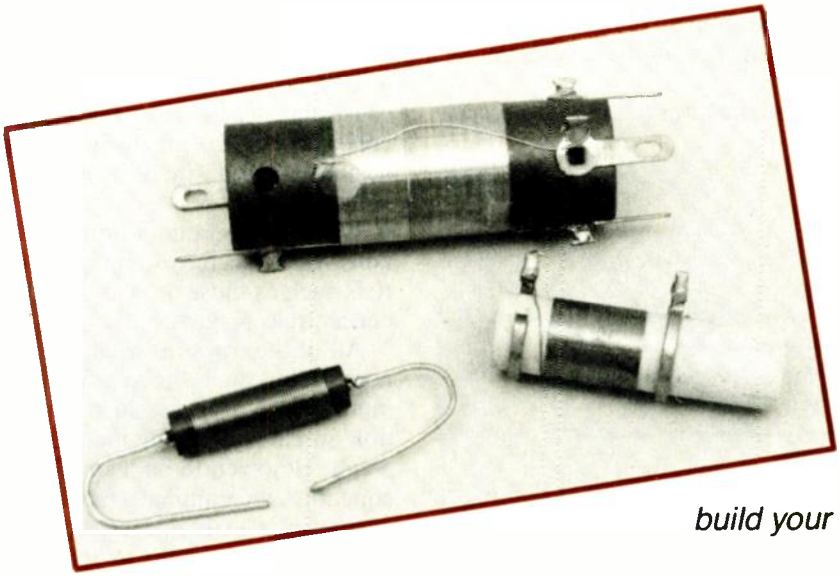


**FIG.3—THE COMPLETED BOARD. Notice the eight programmable switches.**

With the REACTS X-10 interface, you take a great leap toward automating your home, and you may indeed be content with the capabilities you now have. However, we will be discussing other modules in the future, including an A/D conversion block, battery backup, and more. **R-E**



# COPING WITH COILS

*Coils of any kind can be hard to dig up. So design and build your own by using our BASIC program.*

DAVID E. POWELL, KA4KNG

BACK IN THE "GOLDEN AGE" OF ELECtronics projects, even the local radio-repair shop often stocked an extensive assortment of RF coils. And most certainly, the major mail-order distributors, such as Lafayette and Allied Radio, stocked almost every inductor used in the civilized world. Today, however, there is little available in stock RF coils, and those that do exist can take a lot of effort to locate.

Although we have yet to develop an inexpensive solid-state substitute for coils, you don't necessarily have to give up on a radio-frequency project because your local parts distributor no longer stocks RF coils. Simply design and build the needed inductor yourself! If you have access to a computer, designing the coil shouldn't be any more complicated than typing your name if you use the BASIC program shown in Listing 1.

In fact, the only problem you might have will be to locate the needed wire type or size—because certain wire sizes can be hard to locate. But even that problem is easily resolved by our program, because you can keep plugging in the data for available wire types until the computer comes up with the needed design.

## Electricity and magnetism

It is a basic characteristic of electricity that when electric current passes through a wire it creates a circular magnetic field around the wire. Since the magnetic field is weak and spread out along the entire length of the wire, we would have a hard time putting the field to a good, if any, use.

But if we wind the wire into a coil, we still have the same amount of overall magnetism; only now, instead of being distributed along the length of wire, the magnetic field is concentrated into an area equal to the length and diameter of the coil. By concentrating the magnetic field into a smaller space, we have created a magnetic field that is sufficiently strong to be useful.

But a coil having a specific length, and shape produces a specific magnetic field (see Fig. 1). To increase the magnetic field, it's necessary to increase the current flowing in the wire by increasing the voltage applied across the coil.

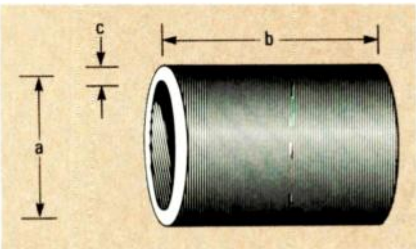



FIG. 1—THE INDUCTANCE of a coil is determined by its physical parameters (a, b, and c) and the number of turns

In a sense, the coil stores electrical energy in the magnetic field. Removing the source of electricity from the coil causes the magnetic field to collapse around the coil. As the field collapses, the magnetic lines of force cross the wires of the coil, converting the stored magnetic energy back into electrical energy. The net result is that the current developed by the collapsing magnetic field tries to keep flowing through the coil for a short period of time after the electrical source is removed. Reconnecting the source voltage has the opposite effect; that is, as the magnetic field builds up, the lines of magnetic force cross the wires of the coil in the opposite direction to the current developed by the collapsing magnetic field. That creates an opposing force to the current flowing through the wire. In other words, when the applied voltage is either AC or interrupted DC, the coil (also called an *inductor*) resists a *change* in electrical current, but not the actual current itself.

From the previous discussion, it would seem that the single most important thing we can measure about an inductor is the strength of its magnetic field. In a sense, that is true. However, the strength of the field depends on conditions external to the inductor, namely the amount of voltage applied to it. For this reason, the term *Hen-*

*ry*—named after the American physicist Joseph Henry—was coined to describe the electrical characteristics of inductors. The inductance of a coil is one Henry when a current variation of one ampere-per-second induces one volt of electrical opposition to current flow.

## The inductor

But conditions other than the applied voltage can affect the strength of the magnetic field. If we want to increase the strength of the field without increasing the applied voltage, we can:

- Add more turns to the coil, because more turns means more wire, which means a greater concentrated magnetic field.
- Increase the diameter of the coil, because a larger diameter means more wire, etc., etc.
- Decrease the length of the coil, because this would have the effect of concentrating the magnetic field into a smaller area, thereby making it stronger.
- Wind the coil on an iron or ferrite core, because ferromagnetic materials such as those tend to attract and concentrate magnetic lines of force.

**LISTING 1**

```
100 'program to calculate the number of turns for an inductor.
110 cls:pi=3.1415926545
120 k=1473061.855                 'mhos per square inch of area of copper
130 print "                       ╔═══════════════════════════════╗"
140 print "                       ║ Inductor Design Calculator    ║"
150 print "                       ║ by David E. Powell, KA4KNG    ║"
160 print "                       ╚═══════════════════════════════╝":print:print
210 input "Desired inductance in microhenries";L
220 input "Gauge or diameter of wire in inches";diameter
230 input "Diameter of coil form in inches";form
240 if diameter >= 1 then diameter = .46 / 1.1229283027^(diameter +3)
250 print:print "calculating";
260 layers=1                      'Single layer starting out

500 a=diameter*layers+form        'Average coil diameter to center of thickness
505 print ".";
510 gosub 2000                    'calculate the number of turns
520 if prob =1 then layers = layers+1:if layers < 100 then goto 500
530 if b > 1 then layers=layers+1:goto 500
540 if n > 9999 then print "ERROR - turns count larger than 10000":system
550 n=cint(n):b=n*diameter/layers:ltry = (0.2 * a^2 * n^2)/(3*a+9*b+10*c)
560 w.length = n*a*pi
570 'calculate the resistance of coil
580 w.area = (diameter/2)^2*pi
590 r = 1/(w.area*k)*w.length

800 'show the results
810 print:print
815 print "Overall coil diameter......  ";diameter*layers*2+form;"inches"
820 print "Average coil diameter......  ";a;"inches"
830 print "Depth of coil..............  ";layers*diameter;"inches"
840 print "Length of coil.............  ";b;"inches"
850 print "Length of wire (approx)....  ";int(w.length/12)"feet,";
855 print int((w.length-int(w.length))*12);"inches"
860 print "Number of layers...........  ";layers
870 print "Number of turns............  ";n
880 print "Number of turns per layer..  ";n/layers
890 print "Actual inductance..........  ";ltry;"microhenries"
900 print "Coil DC resistance.........  ";r;"ohms"

1000 system               'Exit the program and BASIC

2000 'subroutine to calculate the number of turns
2010 min.n=1:max.n=10000:c=layers * diameter:prob=0
2060     n=(max.n-min.n)/2+min.n
2070     b=n*diameter/layers     'length of coil
2080     ltry = (0.2 * a^2 * n^2)/(3*a+9*b+10*c)
2090     if cint(max.n) = cint(min.n) then goto 3000
2100     if min.n => 9999 then prob=1:goto 3000
2110     if ltry < L then min.n=n:goto 2060
2:20     if ltry > L then max.n=n:goto 2060
3000     return
```

All of the ways in which the magnetic field can be increased can be merged into a comprehensive equation for calculating the inductance of a coil. However, to both simplify our equation and eliminate the research necessary to obtain ferromagnetic values, we are going to ignore ferromagnetic permeability and such.

The equation for calculating air-core inductors, as stated by the *Radio Amateur's Handbook* is:

$$L = 0.2a^2n^2/(3a + 9b + 10c)$$

where:

L = inductance in microhenries and as shown in Fig. 1:
a = average diameter of the coil in inches
b = length of the coil in inches
c = radial depth of the winding in inches
n = total turns of wire

## Quality factor

Besides the inductance value, there is another important characteristic of a coil that we need to know about. An inductor can be thought of as an AC-only resistor, whose reactance (which can be considered as AC resistance) depends on the inductance of the coil and the frequency of the applied AC voltage. However, copper wire has a DC resistance, determined by its diameter and length. The ratio of AC reactance to DC resistance is known as the *quality factor*, or Q. For example, if an inductor has a reactance of 100 ohms at 1 kHz, and a resistance of 2 ohms, then it has a Q-factor at 1 kHz of 100/2, or 50. Of course, the Q will change with the applied frequency. To determine reactance, use the formula:

$$X_L = 2\pi fL$$

where:

$X_L$ = the inductive reactance in ohms
$\pi$ = 3.14
f = the applied frequency in hertz
L = the inductance in Henries

```
 Inductor Design Calculator
 by David E. Powell, KA4KNG


Desired inductance in microhenries? 28
Gauge or diameter of wire in inches? .008
Diameter of coil form in inches? .375

calculating.

Overall coil diameter......    .391 inches
Average coil diameter......    .383 inches
Depth of coil..............    8.000001E-03 inches
Length of coil.............    .6640001 inches
Length of wire (approx)....    8 feet, 10 inches
Number of layers...........    1
Number of turns............    83
Number of turns per layer..    83
Actual inductance..........    28.05109 microhenries
Coil DC resistance.........    1.348764 ohms
```

**FIG. 2—THIS IS WHAT THE SCREEN or a printout will show when the program is tested by calculating the design of a 28-microhenry inductor.**

## The BASIC program

Listing 1 is the BASIC program for inductor design. Although written specifically for the IBM PC, it should run on any version of BASIC. The program text is available on the RE-BBS (516-293-2283). The full name is COILS.BAS.

Lines 110 and 120 are used to set up constants for later use in calculations to determine the overall resistance of the coil.

Lines 210 through 230 input the values you specify for the desired inductance value, the size wire you have on hand, and the diameter of the coil form you're going to use. The wire size can be specified in inches or its AWG wire gauge.

Line 240 decides whether or not you entered a wire diameter or a wire gauge. If you entered a number of 1 or greater, it figures it must be a wire gauge (who would want to wind a coil with six- inch thick wire?) and converts it to a diameter.

Lines 500 through 530 are the meat of the program. It starts by assuming that you're designing a single-layer coil. Line 500 calculates the diameter of the coil at the center of its thickness. (The diameter changes as the program adds more layers during its calculations.) Line 510 calls the subroutine that actually figures the number of turns necessary to have the specified inductance at the current number of layers. If it can't get there within 10,000 turns, line 520 adds another layer. Line 530 will add another layer if the length of the coil exceeds one inch.

Line 540 will print an error message if the required number of turns exceeds 10,000 and the number of layers is 10,000 or greater. (You really don't want to wind an inductor that big anyway.)

Line 550 rounds the number of turns to the nearest full turn. It then calculates all of the other parameters based on that rounded number. The inductor should be close enough for all but the most critical applications without having to worry about fractional turns of wire.

Line 560 calculates the approximate length of wire needed to wind the coil. The length is approximate because it is based on the average diameter of the coil; the program does not calculate each layer of the coil independently.

Lines 570 through 590 calculate the approximate resistance of the coil, based on the length and diameter of the wire.

Lines 800 through 900 display the results of all calculations. Keep in mind that electronics is not necessarily an exact science, and that for a variety of reasons all of the displayed values could be slightly off the "true" value.

## Winding the coil

The primary advantage of having a computer calculate the specifics of a coil is that we can experiment with the materials that we have on hand, trying different combinations to see how they affect the results. Recalculating the values is so easy that we should be able to get a size and shape that suits us just right.

Let's use a 28-microhenry inductor as our target value. Let's also use part of that jumbo-sized spool of 32-gauge wire that you purchased at the last hamfest. For a coil form, we can use an ordinary ballpoint pen.

Run the program. The screen should clear and ask for the needed inductance value. Enter 28.

Next, the program will ask for the size wire to be used. Enter either the gauge (32), or the diameter of the wire in inches. Since we bought this wire at a hamfest and don't really know for certain what gauge it is, we wind an inch-long close-wound coil on a pencil and count the number of turns. It turns out that our "unknown" wire requires 125 turns to fill one inch. Dividing one-inch by 125 turns gives us 0.008 inches. Enter .008.

The last prompt asks for the diameter of the coil form. We measure the thickness (the diameter) of our pen and find it is ⅜ths of an inch. Since 3 ÷ 8 = 0.375, we enter .375.

If your computer has been set for printer output, you should get a hardcopy that resembles Fig. 2. If the results you attain do not match Fig. 2, re-check the program for typing errors or a misplaced decimal point.

There are a few things to note at this point about the output of the program. First, notice from Fig. 2, that there are two coil diameters given, an overall and an average.

The overall diameter is given so that you can determine (before you wind it) whether or not the coil will physically fit in your project. The average coil diameter is listed just in case you don't believe the computer and want to re-calculate the inductance value by hand. Second, there appears to be something amiss about the depth of the coil windings. We entered .008 for the wire thickness, and it is a single-layer coil, so the depth should be .008 inches, right? Well, the .000001 discrepancy comes from the way computers represent numbers internally. The coil-length calculation suffers from the same malady. Suffice it to say that the error is small enough to be safely ignored without affecting our end result, which is, we hope, a 28-microhenry inductor.

Speaking of 28 microhenries, Fig. 2 shows that our inductor is actually 28.05109 microhenries, instead of an even 28. That is the result of rounding the turn count to the nearest whole number. As we said earlier, electronics is not always an exact science.

The DC resistance of the inductor is given so that we can calculate the Q-factor of the coil after we decide at what frequency the inductor will be used.

### Winding the coil

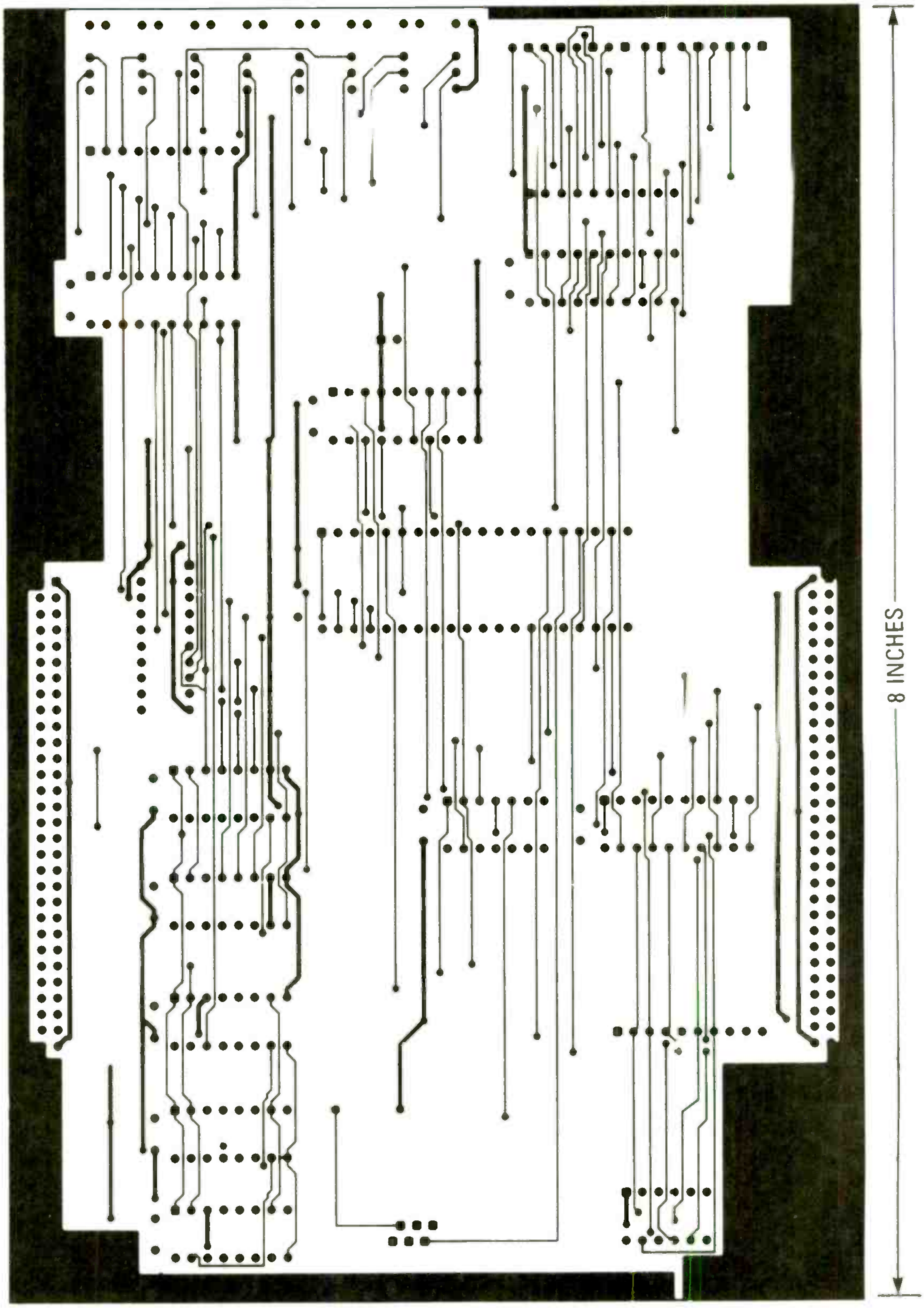
To make the coil, peel off about nine feet of wire from that jumbo-sized spool and start winding it on the ballpen. Make sure that the windings are even and closely spaced. Double check that the number of turns is correct.

A couple of strips of hot-melt glue across the length of the coil will hold the windings in place. If you don't have a glue gun, epoxy adhesive will do if you don't mind waiting a while for it to harden.

After the glue sets (or cools, or whatever), you should carefully slide the coil off the pen. (It would be a good idea to apply some glue to the inside of the coil to help hold the windings in place. That way you can be sure that the coil won't come apart on you when handling it.)

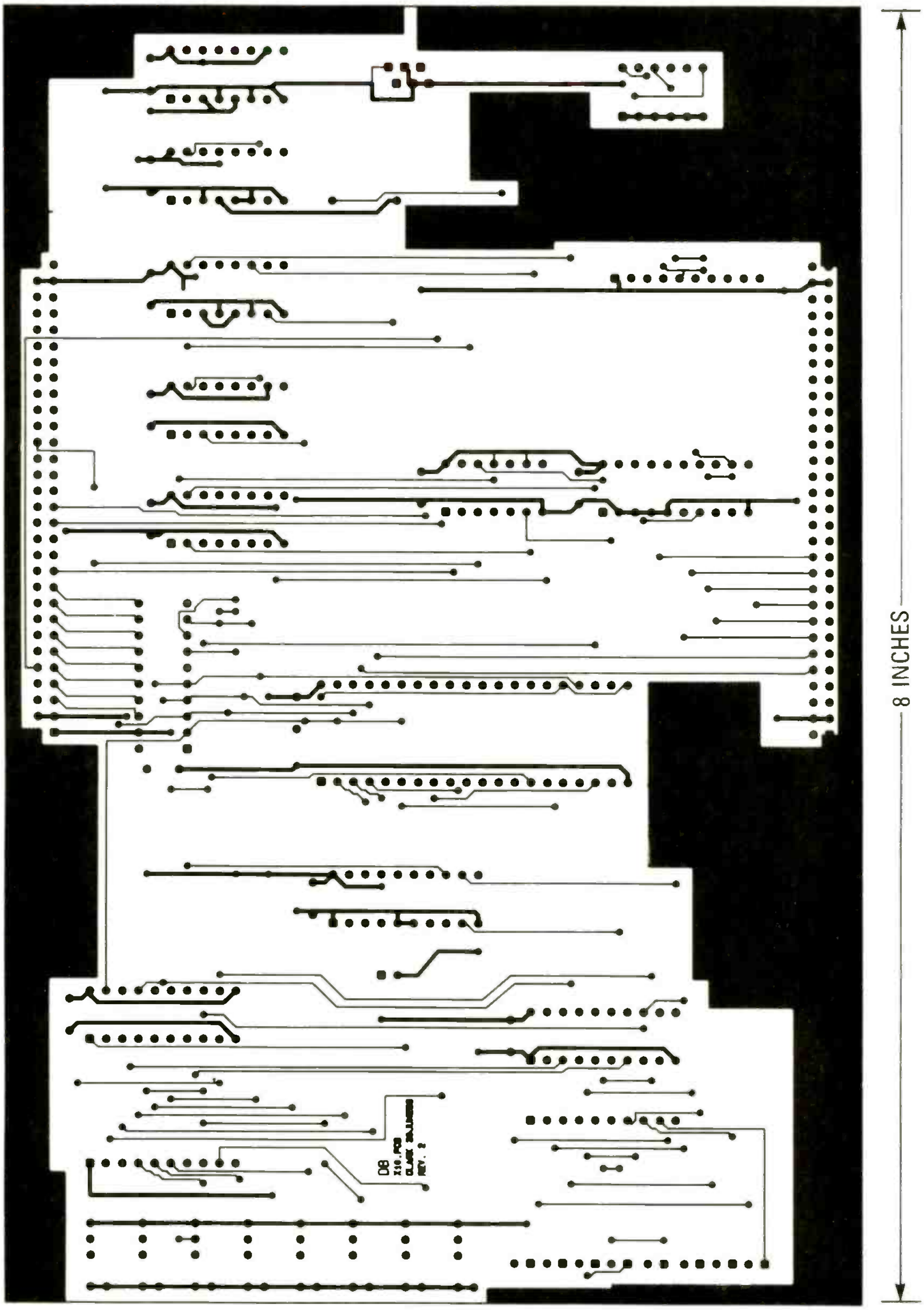
That's really all there is to making your own coils. From now on, not only will you save money, but you can also avoid the aggravating and time-consuming task of having to search high and low for a parts supplier that has the exact coil you're looking for—and you won't have to wait for it to come in the mail. **R-E**

# PC SERVICE

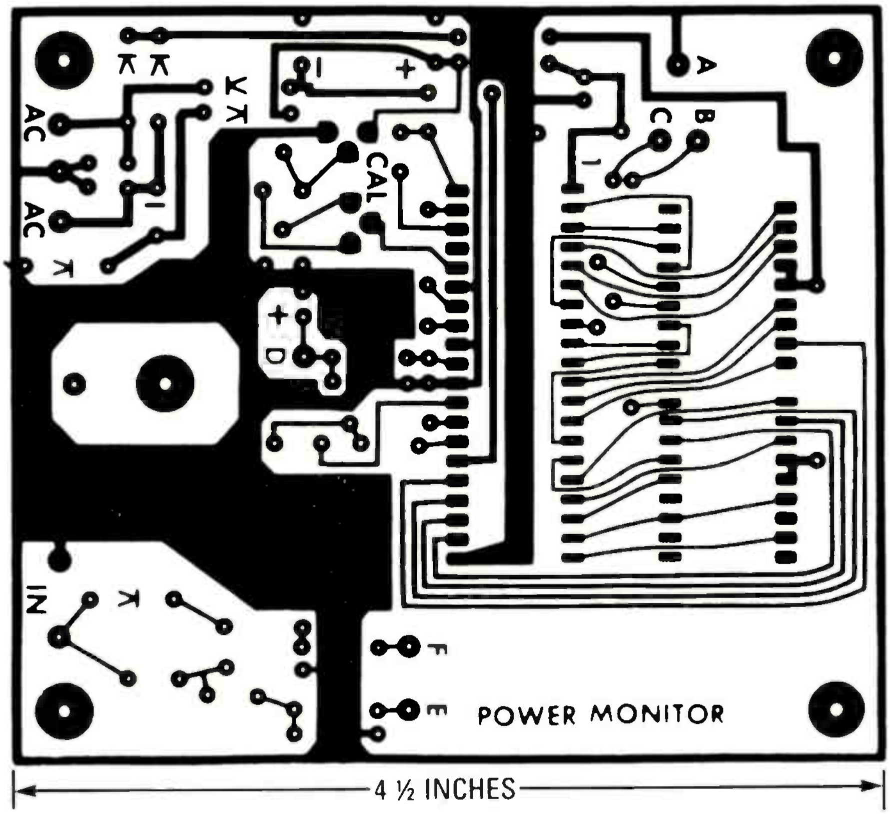



HERE IS THE SOLDER SIDE of the REACTS X10 module.

# PC SERVICE

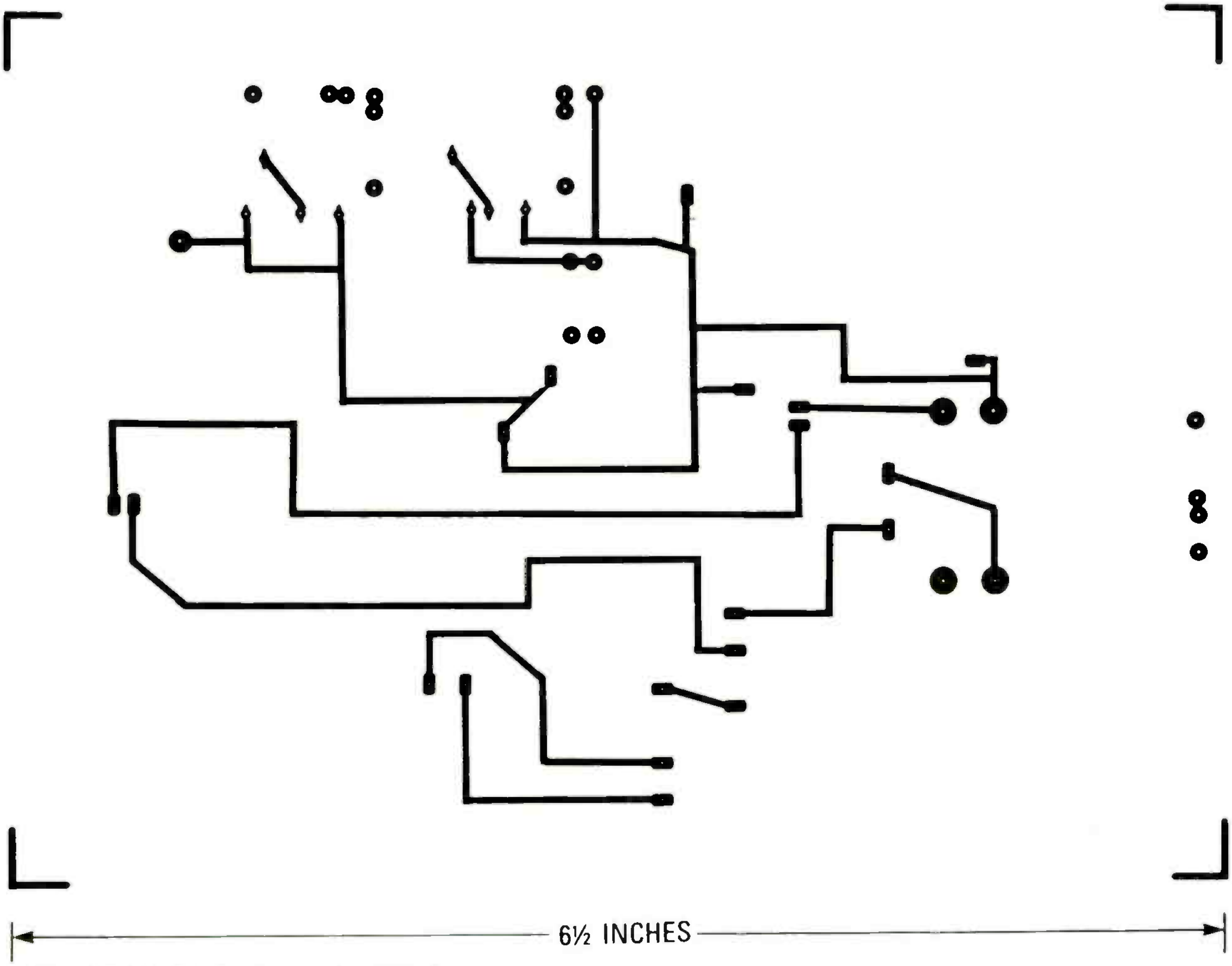



HERE IS THE COMPONENT SIDE of the REACTS X10 module.




**THIS IS THE FOIL PATTERN** for the power monitor.

*More PC Service on page 97*




**THE COMPONENT SIDE** of the Tele-Guard II.

# DRAWING BOARD

## Multiplexing and dynamic RAM

**ROBERT GROSSBLATT,**
CIRCUITS EDITOR

LAST MONTH WE DID NOT GET A chance to finish our discussion on multiplexing LED displays, so now we pick up where we left off. We had said that the simplest way to implement our circuit from last month would be to use an oscillator to clock a scan counter—like a 4017—that will sequentially turn on and off each LED display.

You can connect the output from last month's oscillator to pin 14 (clock input) of the 4017 IC in Fig. 1. If you set R2 and R3 to the center of rotation you'll be getting about 200 Hz with a duty cycle of close to 50%. As we had discussed, a 10-LED display needs a minimum scan frequency of about 240 Hz. When you turn the whole circuit on, all the LED's will appear to be illuminated. If you can see them strobing, decrease R2 (increase the clock frequency) until the strobing disappears.

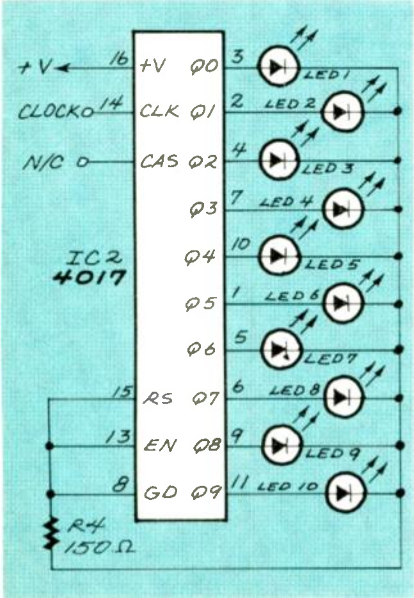



FIG. 1

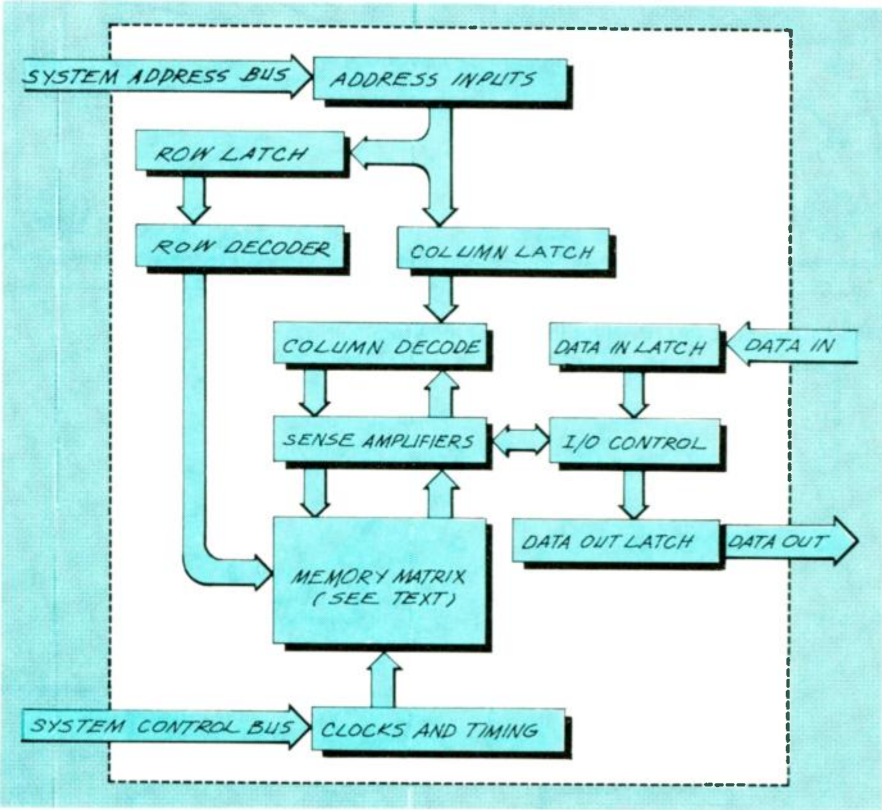



FIG. 2

If you have a frequency counter you can use it to determine the minimum clock frequency. Then try the same experiment with some other people—you'll be surprised at the variation. Some people won't see the strobing until you get below 150 Hz, and others will continue seeing it even past 300 Hz.

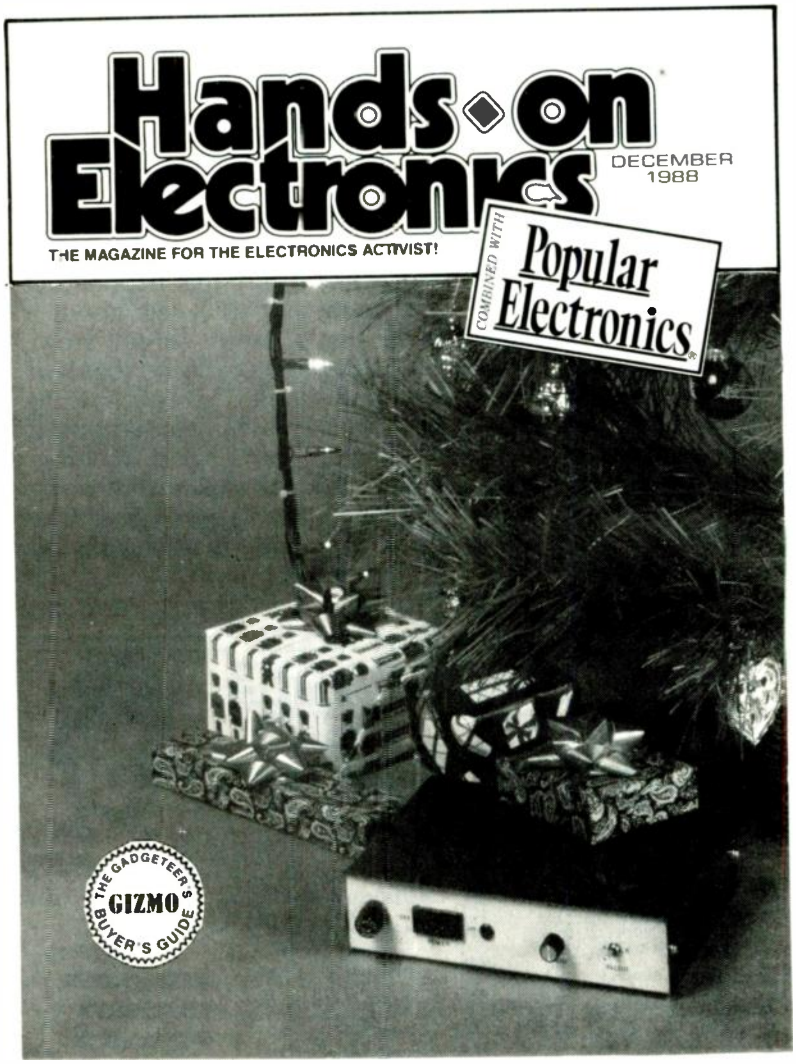
While you have the demonstration circuit up and running, reduce the number of LED's by connecting the pin 15 (reset) to one of the outputs while keeping the clock frequency and duty cycle constant. If you start out by setting the frequency at a point where strobing is just evident, you'll find that the minimum flicker-free frequency decreases by about 30 Hz per LED. A 10-LED display needs about 240 Hz, a 9-LED display needs about 210 Hz, and so on.

Once again, remember that there's nothing absolute about any of the numbers I'm giving you. There's a lot of variation in biology so different people see things differently. From a practical point of view, when you're multiplexing a display you don't want to design the scan oscillator to run at the bare minimum—you should plan

# DECEMBER 1988

# WATCH FOR THIS ISSUE

## FEATURING:

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# ON SALE OCTOBER 20, 1988

## ADDITIONALLY

### GIZMO
Our monthly look at what's hot in consumer electronics!

### E-Z MATH
An easy-to-understand primer on the numbers of electronics!

CIRCUIT CIRCUS

HAM RADIO

DX LISTENING

COMPUTER BITS

SCANNER SCENE

ANTIQUE RADIO

THINK TANK

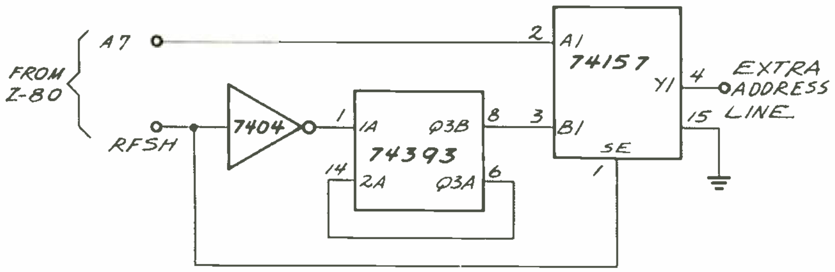


FIG. 3

on having it run much higher. Twice the minimum is a reasonable way to go. Most commercial circuits scan at more than 1 kHz, and IC's that have onboard oscillators run them at over 15 kHz. After all, you don't have to make a trip to the bank just to afford a few more Hertz!

Experiment with the circuit that we put together until you have a good understanding of the requirements of multiplexing circuitry. If you want to test how well you understand multiplexing, get the schematic for any commercial equipment having a multi-plexed display of any kind and see if you can figure out how the circuit works.

## Dynamic RAM

The series of columns I did on using dynamic RAM a while back seems to have generated a lot of interest. A couple of really good letters have come in with some questions and comments that I think are interesting enough to spend some time talking about. If you've built the system we examined, you might have had some of these in mind, so haul out your paperwork.

Keep in mind that the column space I have each month is limited so, as much as I'd like, there's just no way I can go into heavy detail about every nuance of the circuit. That also means that I can't reproduce the schematics and other drawings. The best I can do is let you know when they appeared. If you don't keep the back issues around, you can always get them from a friend, the library, or check with the **Radio-Electronics** reprint bookstore and see if they have the issue you're looking for.

All my drawings are done on a computer so it might be possible for them to be posted on the **Radio-Electronics** bulletin board. If you'd like to see that happen, let me know and we'll talk about it some more. Don't forget, however, that there's really no standard for graphics files, so you have to let me know what format you'd like the files to be. That is a function of the software you're using and the type of computer you're using so include that information in your letter.

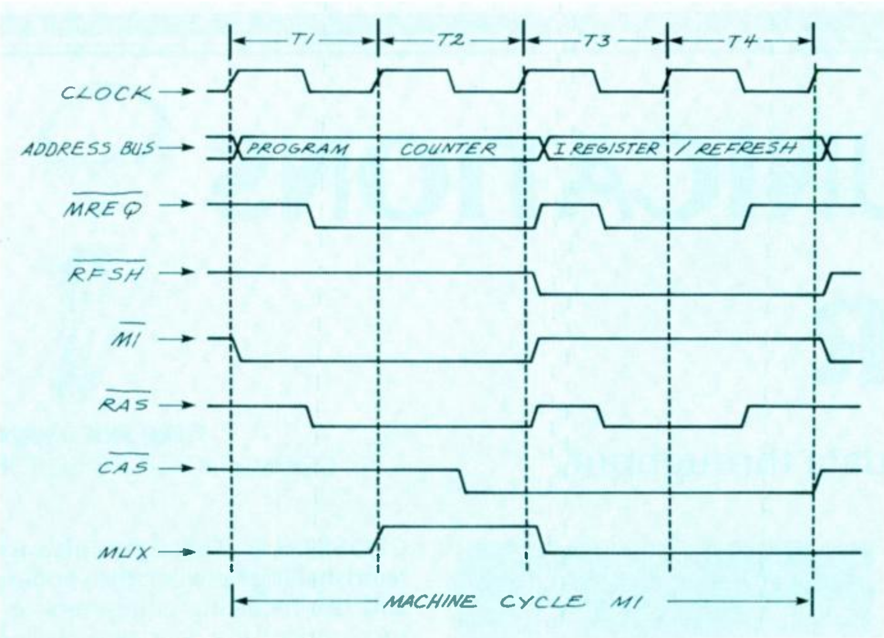


FIG. 4

ring to comes about because a lot of DRAM manufacturers make parts that want eight lines driven in every refresh cycle. If you're unlucky enough to get your hands on some of those parts, any data you write into the upper half of the memory is going to disappear almost as soon as you put it there. Not a good thing.

The reason for all of that aggravation comes about because of the internal architecture of the 4164. Figure 2. shows the basic DRAM arrangement and, while all manufacturers use the same basic arrangement when they make the DRAM, the little details can, and often do, differ. And as is clearly stated in a well-known variation of Grossblatt's sixteenth law: It's the little things that get you—since they're harder to see and there are more of them.

Nobody screws around with success, so every mainstream DRAM made is going to have sense amplifiers, decoders, latches, etc., and, unless you're buying your

*continued on page 99*

**But, onward......**

Matt Allen from Santa Clara, California pointed out a possible problem concerning the choice of dynamic RAM for use with the Z-80. Since the Z-80 has a modulo-7 counter for refresh addresses, it uses only lines A0–A6 when it puts the refresh address on the bus. That was covered in detail in the May and June 1988 issues.

The problem that Matt is refer-

# COMMUNICATIONS CORNER

Double your modem's data throughput.

**HERB FRIEDMAN,**
COMMUNICATIONS EDITOR

THE MAIN SUBJECT OF THIS MONTH'S column is Class-5 modems, a way to double a modem's throughput without doubling the baud rate. But before we get to the esoteric stuff, let's tackle a simple problem that causes more trouble than the whole subject is worth.

Silicon diodes cost a manufacturer next to nothing. Yet, judging by the mail and phone calls we get, there is still a lot of modern hardware out there that is back in the stone-age of telecommunications because a manufacturer didn't use four itty-bitty diodes.

From electronic telephones, to burglar-alarm telephone dialers, to add-your-own-anything devices, some hardware still contains warnings to the effect that if the equipment doesn't work you should check the polarity of the telephone connections. The reason for the warning is that all or part of the gizmo is powered by the telephone line, which under normal circumstances is negative polarity on the red wire and positive on the green. Unfortunately, sometimes the two can be reversed, and a polarity-sensitive device won't work.

## Auto polarity

It is precisely to get around the polarity problem, that most manufacturers of active-circuit equipment intended for use on the dial-up telephone system (what we call *the switched network*) use a bridge rectifier between the line and the input to the electronic gizmo. As shown in Fig. 1, a bridge rectifier, D1–D4, automatically provides the correct polarity. The bridge can be made from silicon rectifiers of the 4000 series rated at 200 PIV or higher.

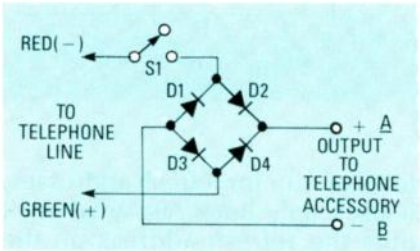


FIG. 1

Check it out for yourself: Whether the red wire is negative or positive, the output at terminals A and B always have the same polarity—although the output voltage will be from 0.5 to 1 volt less than the input voltage because of the internal voltage drop of two diodes. If your gizmo is extremely voltage-sensitive, or if the normal voltage drop of your telephone when loaded is unusually severe, the voltage drop may prove to be a problem. If so, you've probably got some problem with the line that should be corrected by your local telephone company. Switch S1 is a hookswitch, or whatever switch connects the gizmo to the telephone line.

## Doubling the data

Computerists have always searched for, or at the very least wanted, a faster and more accurate way to exchange data via the dial-up telephone system. Initially, both needs were easily accomplished by increasing the baud rate used by the modems, and by using special error-correction software, such as XMODEM and CROSSTALK. Through software handshaking between the sending and the receiving computers, errors induced in a data transmission were detected with excellent accuracy. When an error did occur the data was retransmitted until the handshake signals indicated that the block of data was received error-free.

As far as modem speed is concerned, there is a practical limit of about 2400 baud for full-duplex hassle-free exchange using asynchronous transmission. Although experiments have shown that full-duplex operation as high as 9600 baud is possible on the dial-up system, baud rates higher than 2400 are not really reliable.

It was to ensure automatic error-correction and increase the throughput that the Class-5 modem protocol was developed. Basically, Class-5 modems contain their own error-correction firmware (*firmware* meaning software that's permanently built into a device), and hardware data compression which, depending on the particular kind of data transmitted, can almost double the amount of data throughput. In practical terms, it means that a modem running at 1200 baud will appear to be running at 2400 baud, while a 2400-baud modem will exchange data at a 4800 baud effective rate.

The throughput increase comes about in two ways. First, the software, known as an MNP protocol, converts the asynchronous data to synchronous data, making the signal bit- rather than byte-oriented. Although MNP removes the start and stop framing bits for a 20%

increase in data handling, MNP needs about 12% in bit overhead, so the effective increase due to software is about 8%. In other words, allowing for worst-case conditions, MNP has an efficiency of about 108%, while conventional software protocols have an efficiency of about 90%.

Admittedly, 108% is no great improvement, but MNP is the firmware from what's known as Class-3 protocol. Class 5 includes data compression, and that's where the big increase comes in.

The amount of data compression depends on the type of data being exchanged. For example, if the data is ASCII text, an increase of almost 100% (doubling the throughput) is possible. If the data is random, such as a program file or already compressed data, there will be little, if any, improvement.

Data compression works by sampling characters. When three or more of the same character is repeated, the firmware strips the redundant characters and tabulates the stripping, continually updating the tabulation. At the receiving end, the Class-5 modem uses the tabulation data to restore the original, noncompressed, data.


**FIG. 2**

## Faster drive

To ensure the maximum possible data-transfer rate, the Class-5 modem must be driven with at least twice the data so there can be no delay in the modem's output. That is done by having the computer drive the modem at a baud rate at least twice that of the modem. As shown in Fig. 2, if the modem is operating at 1200 baud, the computer must drive the modem at 2400 baud. Internal RAM in the modem stores the "extra" data until it can be compressed and transmitted.

The same thing happens at the receiving end. Also, as shown in Fig. 2, if the data is received at 1200 baud, it's going to come out of the modem decompressed at an effective 2400-baud rate. To ensure that the maximum compression throughput is maintained, it has become common practice to use a 9600-baud rate between the computer and the modem, since 9600 baud will even accommodate a normal modem speed of 2400 baud, and possibly 4800-baud modems (if they ever make a serious dent in the marketplace). Whatever modem speed you decide to use, just bear in mind that at the very least, the baud rate of the computer's serial port must be at least twice the normal baud rate of the modem. **R-E**

## HARDWARE HACKER

*continued from page 36*

### Industrial shopper resources

As long-term Hardware Hacker readers have already found out, I am very big on trade journals. As we have seen in the past, the free electronic and other trade magazines are outstanding resources that no serious hacker can afford to ignore, even for an instant.

This month, I'd like to make you aware of a sub-class of the trade journals that we might call the *Industrial Shoppers*, and otherwise well known by their universal slang term of "the throwaways."

They are almost always oversize magazines printed on slick newsprint and contain mostly zillions of ads and a few bingo cards. Their editorial materials are primarily press releases and rehashes of their advertiser's product line and literature.

While almost a nuisance in any large electronics house, the throwaways are extremely valuable for hackers and small-scale operations in general.

Here's a sample list of a few of the many throwaways that passed through my *Synergetics* international corporate offices last week: *Pollution Equipment News; Electronic Components News; Plant Sites and Parks* (Great for free maps, but don't tell them I told you so), *Computer Products; Automatic ID News; Industrial Product Bulletin; Industrial Equipment News; Instrumentation and Control News; Industrial Maintenance; American Laboratory; Computer Reseller News;* and one called *Electronic Buyers News.*

There are zillions more where those came from.

As with all other trade journals, you can get a complete list of names and numbers from the *Uhlrichts Periodicals Dictionary* that's on the reference shelf at your local library. A phone call or a business letter can get you a qualification card.

Or, to reveal a best-kept insiders secret, you can get a free copy of most any magazine simply by requesting a sample copy and an advertiser's rate card. Sometimes that even gets you a long-term complimentary subscription. But don't tell them who told you that.

Throwaways on such obscure things as blacksmithing, dentistry, forestry, jewelry, on ranch management, for pollution controls, solar contracting, or heavy-equipment maintenance can often open up whole new worlds of ideas and products for you.

Check them all out. And never leave any industrial plant ever without ripping out the qualification cards from all of the industrial magazines in their lobby.

### New tech info

The new *Murata-Erie* short-form catalog has all sorts of neat hacker goodies in it, including ceramic resonators, posistors, humidity sensors, and ultrasonic microphones. Additionally, *NEC* has released a data sheet on their new *uPC1870CA* single-chip television stereo MTS decoder.

*National Semiconductor* offers a brand new *Semiconductor Master Selection Guide*, while the brand new *Avanteck Product Guide* has all sorts of info in it for microwave transistors and on their MMIC integrated circuits.

A new *Linear Integrated Circuits Databook* from *Unitrode* has lots of ap notes and specialized circuits in it, aimed primarily at switching-mode power supplies. In particular, you might want to check out their *UC3906* intelligent battery-charger chip and ap note.

There's also a high-energy little shopper out called *Nuts and Volts* that is crammed full of electronics and computer classified bargains. That gem is chock full of outstanding hardware-hacking buys and is a "must have."

Turning to my own products, if you are at all interested in active filters, do check into my classic *Active Filter Cookbook*. Autographed copies are now available from *Synergetics*. Plus a reminder that my *PostScript Printed Circuit Layout Package* is now available to work along with most any word processor on pretty near any personal computer.

And yes, we should shortly have full sets of the *Hardware Hacker* reprints available. Write or call if you are interested.

Let's hear from you. **R-E**

## AUDIO UPDATE

*continued from page 43*

about 5 minutes have been essentially solved. However, I think it's safe to say that, as with so many other "good ideas," the ultimate commercial success or failure of this one has little to do with its technical feasibility. The basic question is: Who in the music business is potentially going to make more—or less—profit as a result of this new development—and how much power would the various potential winners or losers have to promote or hinder its adoption?

From a retailer's point of view, it seems very appealing to have the equivalent of an enormous—and inexhaustible—stock of singles and albums available in a machine that (perhaps) takes up no more space than a standard home refrigerator (see Fig. 1). Servicing and updating the machine should be no more complicated than with today's jukeboxes. According to my latest information, the cost of the customized cassette will be about \$1 a song. That seems reasonable, but I suspect that many home tapesters enjoy the compilation process and wouldn't want to trade the satisfaction for one-stop convenience. Is the Personics machine the wave of the future or is it just another technically good idea that simply doesn't dovetail with the perceived social-economic needs of the marketplace? More AES papers next month. **R-E**


*This has to be what you ordered, Pal—our Computer doesn't make mistakes. . .*

# Radio-Electronics mini-ADS


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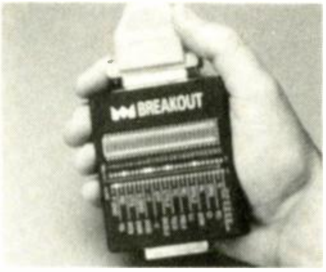


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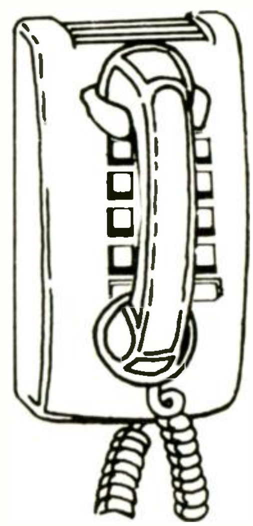

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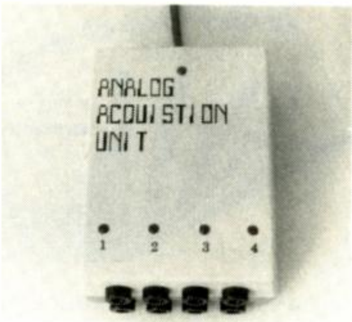


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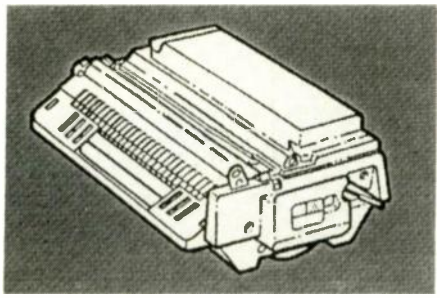

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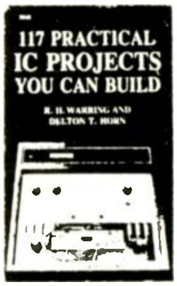


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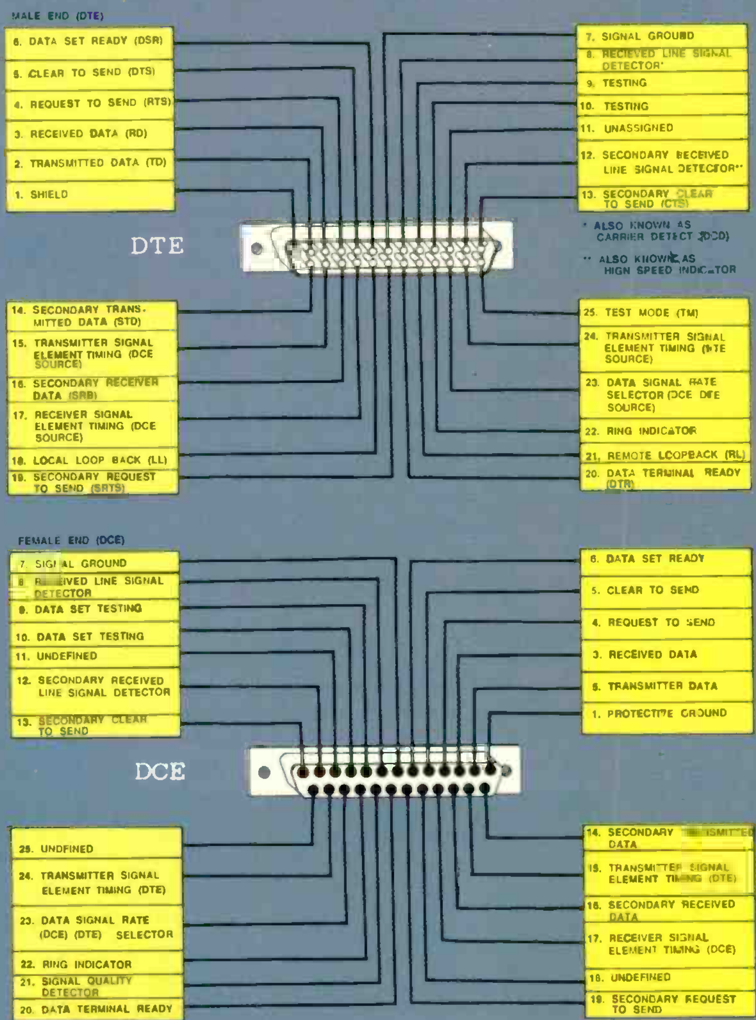
VOL. 5 NO. 11 NOV. 1988

# COMPUTER DIGEST

A NEW KIND OF MAGAZINE FOR ELECTRONICS PROFESSIONALS

## EIA-232

A real standard for serial interfacing? Page 87

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## ADVANCED FLOPPY DISK CONTROLLERS

Add more power to your PC Page 84

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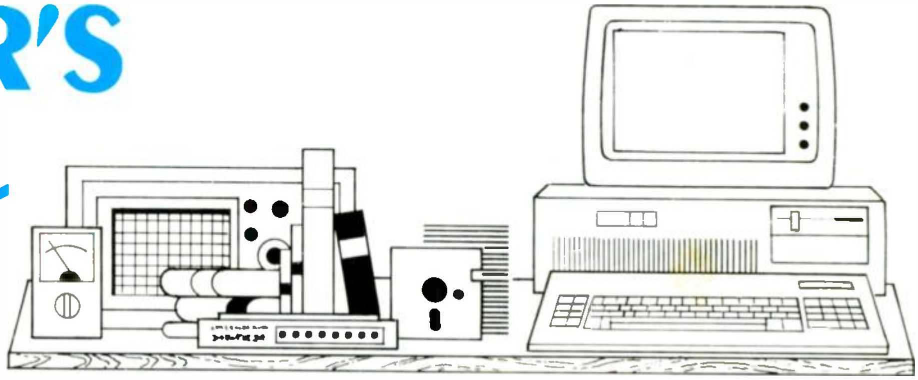



## Advanced Floppy-disk Controllers

CP/M brings back fond memories: programs that actually worked in 64K of memory, a sophisticated user community, standard eight-inch disk drives—and hundreds of incompatible 5¼-inch disk formats. The advent of the PC helped resolve those problems for a while; after a few false starts, the IBM PC format meant 360K DSDD disks—period.

Then along came the AT (1.2M at 5¼-inch), then laptops (720K at 3½-inch), followed by PS/2's (1.44M at 3½-inch). We'll refer to those three formats as high-density. And now PC users want to trade files with Macintosh users! The upshot is that we've been thrust back into the quagmire of disk incompatibility.

Is there a way to overcome those incompatibilities? Yes. Many new AT-compatibles and 80386-based machines come with 3½-inch drives. But what about older machines? The BIOS of virtually all older PC's, XT's, and compatibles can't handle the newer formats, and in many cases, the disk controller can handle only two drives; three are necessary to cover all IBM formats.

### A simple solution

If your controller handles only two drives, you can remove one and substitute a high-density drive. Recent versions of DOS contain device drivers that you load via CONFIG.SYS in order to read and write the high-density formats. The drivers in DOS 3.30 and higher handle all IBM formats to date.

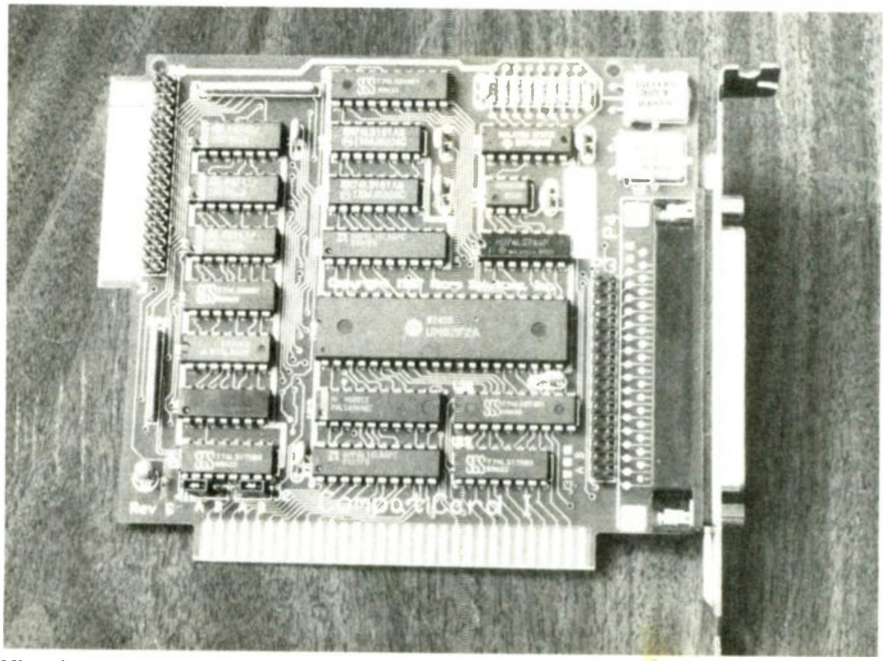
In addition, some 3½-inch drives are now shipped with equivalent drivers, so you may not need to upgrade your DOS. Check with your supplier to be sure. If you wish to provide Macintosh capabilities using one of the products below (or another), Central Point Software recommends use of Citizen, Teac, and Toshiba drives, and states that some Alps and Mitsubishi drives cannot reliably read Mac disks.

That type of solution still leaves a number of unresolved problems: Macintosh disks, eight-inch disks, combination hard/floppy-disk controllers, copy-protected software, etc. Several companies have designed products that address those problems in a quality manner.

### CompatiCard

MicroSolutions has been marketing this floppy-disk controller for several years; it has several advantages over a standard controller. First, it has connectors that allow you to add as many as four disk drives internally. By contrast, a standard IBM floppy-disk controller allows four drives, but the connector (a 37-pin D type) is only available externally, so adding a third or fourth entails the additional expense of a case and power supply. Also, many clone controllers, and controllers that are part of multi-function cards, have connectors for only two disk drives.

Second, the I/O ports that the PC uses to communicate with the controller are programmable on this card. That allows you to add as many as four cards, for a total of 16 drives in a single PC! You probably won't want to do that, but the addressable I/O ports do have their uses. For example, many combination hard/floppy-disk controllers allow only two floppy-disk drives. You can't just add another standard controller, because it uses the same port addresses, so there would be contention. However, by using a CompatiCard in your PC, you can solve the problem easily.



MicroSolutions' CompatiCard.

Third, the card can control eight different types of drives, including all 5¼-inch and 3½-inch drives, as well as 8-inch drives. (A separate software product sold by MicroSolutions, called Uniform, allows you to access CP/M disks in the 8-inch format.) A wiring adapter is required to install an 8-inch drive; you can buy the adapter from MicroSolutions, or build it yourself using information contained in the *User's Guide*. The less expensive CompatiCard II allows only two drives, does not support eight-inch arives, but maintains the many other features of the CompatiCard.

The CompatiCard is a half-length card that installs in any 8-bit slot. Installation consists of setting the jumpers that determine the I/O ports. Then you insert the card into a vacant slot, connect a standard 34-conductor data cable to the card and your drive, connect a power cable to your drive, and then add a line to your CONFIG.SYS file.

Cabling is worth discussion. To add a drive, if your power supply has only a few power connectors, you may need a Y-adapter to supply power to the drive. You'll also need one 34-conductor data cable for each pair of drives (Both types of cables are available from JDR, Jameco, or your local computer dealer.) One end of the data cable attaches to the controller card; the CompatiCard has edge-connector and header-pin connectors wired in parallel for the first two drives, and a header-pin connector wired in parallel with an external 37-pin D connector for the last two drives. So a data cable with a header-pin socket will work just fine in either position.

After installing the hardware, you add CCDRIVER.SYS to your CONFIG.SYS file. You add several parameters to that line, depending on the I/O ports the card responds to, the number and type(s) of drive(s) connected to the card, and whether the "twisted" or the "untwisted" connector goes to a particular drive. Several charts in the manual show the correct parameters.

I installed the drive in an AST Premium/286, a 10-MHz 0-wait state AT compatible. Prior to installing the CompatiCard, the machine had both a 5¼-inch, 1.2M drive and a 3½-inch 1.44M drive (Toshiba brand) running off a Western Digital combination hard/floppy controller. I wanted to add a *standard* 360K drive, so I configured the CompatiCard for I/O addresses 360–367h, and added the following line to CONFIG.SYS:

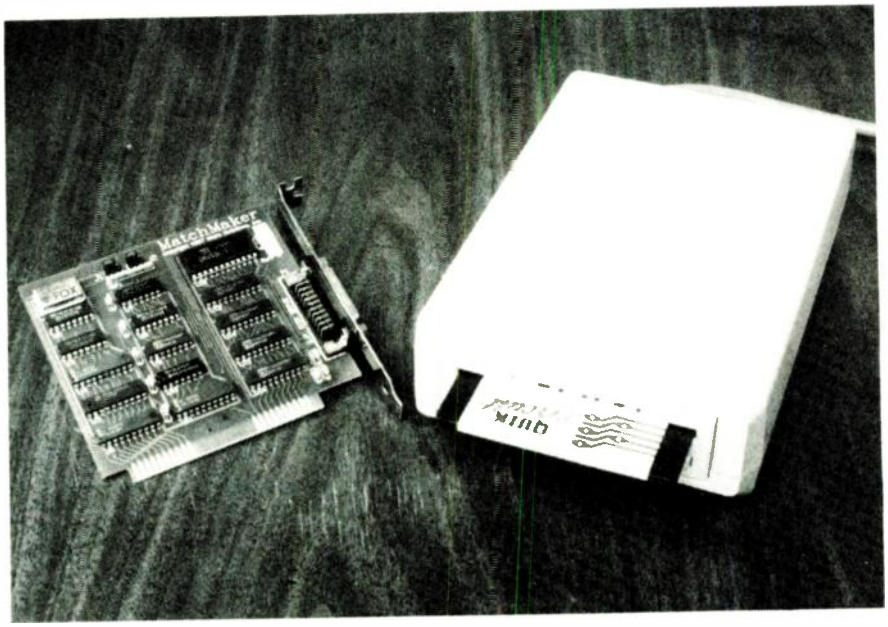
DEVICE = C:\SYS\CCDRIVER.SYS /8,0

After rebooting, I could access the 360K drive in the normal fashion as drive E. The software driver occupies about 11K of RAM.

The CompatiCard comes with two additional programs. One, CCDRIVES.COM, displays the types of drives attached to the CompatiCard, and indicates the drive letters to use to access those drives. The other, CCFORMAT.COM, may be used instead of the DOS's normal FORMAT program to format disks controlled by the CompatiCard. Technical information is also provided about the extended disk BIOS interrupt services provided by CCDRIVER.SYS.

One thing to watch out for: You can only install a drive as a boot drive if your PC has built-in BIOS support for that drive's format. So don't install a 3½-inch drive as drive A in an old PC, XT, or clone, even if you have a hard disk. The reason is that, if your hard disk flakes out, you won't be able to boot your machine at all.

Also, watch power consumption; a small power supply may not be able to handle three or four drives and a full complement of expansion cards.



**MicroSolutions' MatchMaker.**

### MatchMaker

Dealing with IBM disks in various formats is one thing; what about Macintosh disks? MicroSolutions also has a remedy for that problem. The MatchMaker is a half-slot card that can be used to control an external Macintosh disk drive. With supplied memory-resident software, you can address the drive using DOS-like commands preceded by the letter M (MDIR, MCOPY, etc.).

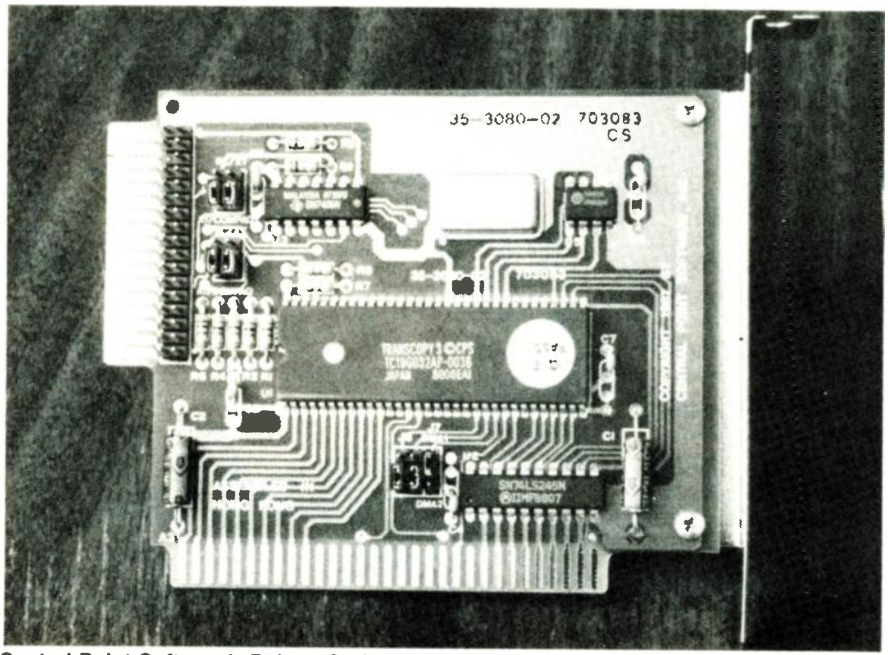
There is little to installing MatchMaker: Just insert the card in an empty eight-bit slot, and plug a Mac drive into the 19-pin D connector. Both data and power are supplied through the single cable. MatchMaker's ports have nothing to do with standard floppy-disk controller ports, so there should be no problem using the card in just about any PC. However, in case you should experience any hardware conflict with other devices, a pair of jumpers allows you to re-address the card's I/O ports.

Then you run a program called MAC.COM. It remains resident in memory, of which it occupies about 35K, and may be removed later without rebooting. The program allows you to address the Mac drive as drive M (or another letter that you specify) using the following commands: MCD, MCOPY, MDEL, MDIR, MEJECT, MINIT, MMD, MRD, MTREE, and MTYPE. (EJECT forces the disk drive to eject a disk, and INIT formats a disk.)

DOS users will have no trouble adapting to the M commands; with several of them you may specify options. MCOPY, for example, allows you to transfer files to and from Mac diskettes. The command can be used to transfer a single file or a group of files specified using normal DOS wildcards (*and ?). MCOPY options include, among others, copying files to and from either the Mac data or resource (program) fork, creating a locked (write-protected) file, specifying a text or binary file, etc. MDIR options include displaying data, resource, or both forks, an extended directory, etc. MINIT allows you to format disks in either the old (flat) or the new (hierarchical, like DOS) file system, or allow you to format a single-sided diskette in a double-sided drive.

For those unfamiliar with Mac lingo, the manual contains a good discussion of the differences between Mac and IBM disks and file structures.

I installed MatchMaker in the AST machine that I had mentioned before, and had no trouble using the device to read files created on a Macintosh; nor, conversely, did I have trouble reading disks on a Macintosh initialized by MatchMaker.



Central Point Software's Deluxe Option Board.

them going the other way. A unary transfer from Mac to IBM combines the resource and data forks of a file into a single file, and in the reverse direction, restores the two forks properly.

The Deluxe Option Board also comes with programs for dealing with copy-protected software. TC (Transition Copy) copies not files, not tracks and sectors, not individual bytes of data, but the magnetic fluctuations (transitions) on the surface of one disk to another. The format of the disk is completely irrelevant, as are the locations of hidden files, non-standard sectors, etc. In fact, TC can copy IBM disks, CP/M disks, and even Atari and Apple disks on a standard IBM type disk drive. (Apple and Atari copies are subject to some limitations.) A special version of TC, called TCM, allows you to create an "image" file on hard disk to be used to duplicate disks.

TE is an editor for editing tracks and sectors. Not only can you edit data, you can see the gap and sync bytes that serve to separate one sector from the next. The manual contains an introduction to low-level disk contents, but the treatment is by no means complete.

I installed the Deluxe Option Board in the AST machine, and had no trouble transferring files to and from IBM and Macintosh formats.

### Deluxe Option Board

There are two problems with the preceding solution. First, you must use a Macintosh drive, and second it cannot be mounted internally. Wouldn't it be nice if you could use a regular IBM internal 3½-inch drive?

It turns out that you can, using Central Point Software's Copy II PC Deluxe Option Board. You may have heard of the Option Board in connection with backing up copy-protected software. It still does that; in addition, it allows you to read and write Macintosh-format disks using a 3½-inch disk drive, of either 1.44M or 720K capacity.

Like the other cards discussed here, the Deluxe Option Board is a short card that fits in an eight-bit slot. It can control one or two floppy disks, and has no external 37-pin D connector.

The board has two sets of jumpers. One determines whether the board will be installed in an AT or in a PC (or XT). The other determines the DMA channel to be used; normally you don't need to change it. After setting the jumpers, you insert the board in your computer, and then connect the cables. Electrically, the Option Board sits between your regular floppy-disk controller and your floppy-disk drive(s). The board comes with one cable, but you may end up having to buy another, depending on the length of your present cable. (It may be too short to reach all the way to the Option Board.)

As for software installation, an installation program copies files to your hard disk. The Deluxe Option Board comes with several programs that are used to accomplish different purposes. MCP (Macintosh Control Program) is the program that allows you to read, write and format Mac disks. Assuming that you have a 3½-inch drive B, to get a directory of a Mac disk in that drive, you'd type:

MCP DIR B:

Other MCP commands include TREE, TYPE, COPY, FORMAT, CD, DC (disk copy), DEL, MD, and RD. Central Point supplies several batch files that reduce the number of keys you must type by invoking MCP with the appropriate parameters. For example, you can use MDIR.BAT to get a directory of a Mac disk in drive B simply by typing:

MDIR B:

A similar batch file is supplied for each MCP command.

As with MatchMaker, some MCP commands have options. MCP COPY, for example, allows for binary, text, and unary file transfers. A binary transfer copies a file (in either direction) byte for byte. A text transfer from Mac to IBM adds line-feeds after carriage return, and strips

**PRODUCTS DISCUSSED**

- CompatiCard ($175), CompatiCard II ($125), MatchMaker ($149), and external Macintosh disk drive ($239), MicroSolutions, 132 W. Lincoln Hwy., Dekalb, IL 60115. (815) 756-3411.
- Copy II PC Deluxe Option Board ($159), Central Point Software, 15220 NW Greenbrier Parkway, Suite 200, Beaverton, OR 97006. (503) 690-8090.
- Windows/286 2.1 ($99) and Windows/386 2.1 ($195), Microsoft Corporation, 16011 NE 36th Way, Box 97017, Redmond, WA 98073-9717. (206) 882-8080.
- DOS 4.0 ($150 or upgrade for $95) and Windows Kit ($314), International Business Machines Corporation. Contact your local IBM dealer for more information.

### Bigger issues

Of course, a big problem, and one that neither Mac/IBM product discussed here addresses, is data-format compatibility. MCOPY in either product can move a file between either type of machine, but what you do with that data is up to you.

Transferring PageMaker and Excel files is easy, because versions of those programs for the two types of machines have compatible data files. But how would you, for example, translate a MacWrite document into WordStar format? Without the aid of a document-conversion utility, you wouldn't. You can transfer straight ASCII text without problem, but formatting information is another story.

The same is true of other types of data; you're on your own and gooooood luck.

Even so, that's not to detract from the real utility of these products, which provide a first step toward greater integration of disparate computer systems.

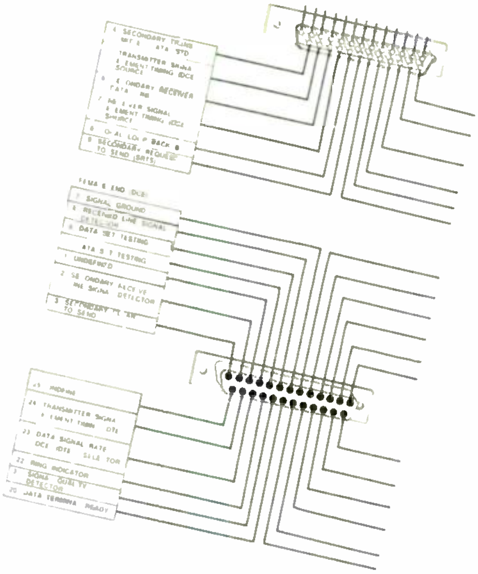
By the way, by the time I finished writing this review, I had four (!) disk controllers, one hard disk, and three floppy-disk drives in the AST, as well as an external Mac drive, all working harmoniously. First, the Western Digital hard/floppy controller ran the machine's original drives (the 3½-inch 1.44M and the 5¼-inch 1.2M) by way of the Option Board, which also allowed Macintosh access in the 3½-inch drive. Third, the CompatiCard was installed as a secondary controller; it allowed me to

*continued on page 96*

# NEW & IMPROVED!

# RS-232

*Another serial interface standard?*



CHARLES R. BALL, JR.

The king is dead! Long live the king! No, we're not talking about Elvis Presley, but a new serial-interfacing standard. The old standard was called RS-232-C, and is currently in wide use on everything from your computer to your CD player.

The new standard is called EIA-232-D, and it differs from the old one primarily in codifying several *de facto* standards, and in defining several new signals that allow for better handshaking and simpler system testing. Let's find out what EIA-232-D is all about.

## What, no connector?

A popular misconception is that the RS-232-C standard specifies a computer cable or connector. Actually, it specifies neither; in fact, the specifications hardly even mention cables and connectors. The specifications do, however, specify signal lines—some 22 in all.

Those specifications are contained in a document called *Interface Between Data-Terminal Equipment and Data-Communication Equipment Employing Serial Binary Data Interchange*. (No wonder we call it RS-232!) The standard was first introduced in 1962; it was accepted for use by the Department of Defense as a non-government document in 1969. It was subsequently revised in 1972, and it hasn't been updated since. Rather, creative license has been taken with it to meet up-to-date needs of the computer community.

So, what was originally designed as a serial interface between devices owned by the telephone company (in 1969 all modems belonged to the telephone company), turned out to be a catch-all interface between any two serial devices.

## The original

To the dismay of many engineers, the original standard left much to be desired, and for several reasons. First, the original standard did not specify a connector; it merely defined pin numbers. Second, the original standard provided neither true handshaking nor loopback testing. Third, no connector was specified. However, the 25-pin D connector (also known as a DB25) became the *de facto* standard RS-232 connector. A big exception was IBM's introduction of the 9-pin serial-interface connector used with the AT. And, of course, IBM uses the DB25 female connector for its *parallel* printer cable. ARRGH!

## How do you spell relief?

The new ANSI/EIA-232-D Standard (available from the EIA for $20.00; see the sources box) resolves some of the

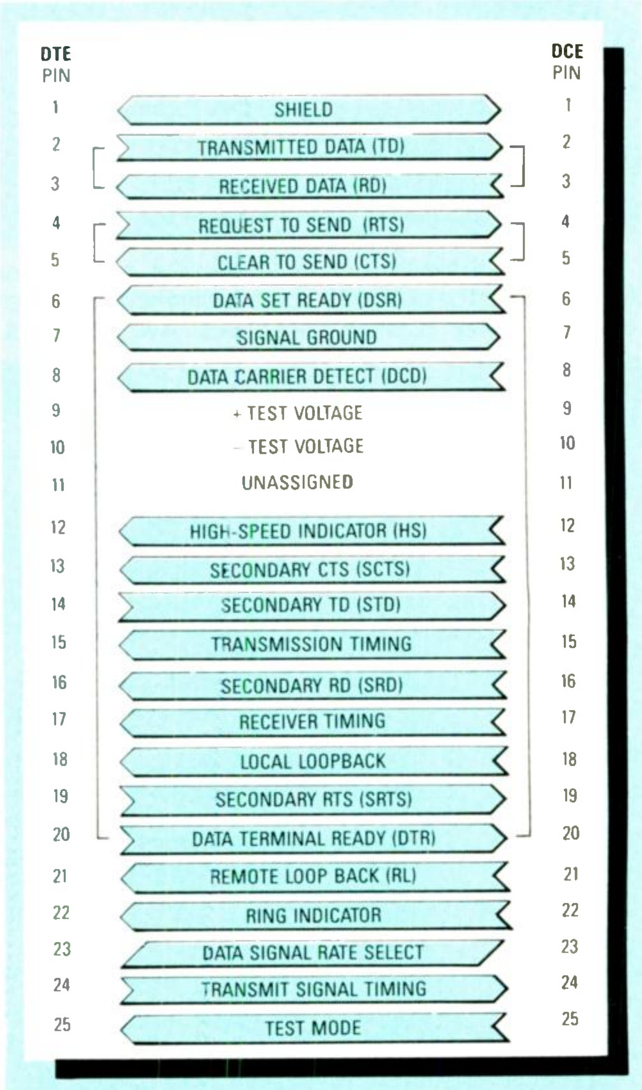



**FIG. 1—EIA-232-D SIGNALS are defined here, along with signal directions. A DTE is usually an originating device (such as a serial terminal); a DCE is usually a receiving device (a modem or printer, for example).**

problems. Table 1 summarizes the primary EIA-232-D specifications; in addition, the new standard defines the DB25 as the standard connector. That's just great, because it's the one that most of us use anyway.

In the new system, signal functions are now defined to facilitate fully interlocked data handshake between Data-Terminal Equipment (DTE) and Data-Communications Equipment (DCE). DTE generally includes serial terminals, and DCE generally includes printers and modems. However, that's not an ironclad rule.

By definition, a device that transmits on pin 2 is DTE; a device that transmits on pin 3 is DCE. DTE's are usually male connectors, and DCE's are usually female connectors. Figure 1 shows the signal name and direction of each pin in both DCE and DTE.

**TABLE 1—EIA-232-D SPECIFICATIONS**

| Parameter | Specification |
|---|---|
| Connector, DTE | DB-25 Male |
| Connector, DCE | DB-25 Female |
| Maximum Cable Length | Limited by capacitance (2500pF max.) |
| Maximum Data Rate | 20K bits/sec |
| Number of drivers and receivers on line | 1 driver<br>1 receiver |
| Driver Output Swing | ±5V min.; ±15V max. |
| Driver Load | 3K to 7K ohms |
| Driver Slew Rate | 30V/μS max. |
| Receiver Input Resistance | 3K to 7K ohms |
| Receiver Input Threshold | ±3V |
| Receiver Input Range | ±30V max. |

Devices with the same characteristics (i.e., two DTE's or two DCE's) can be connected by reversing several pairs of conductors. For example, to connect two DTE's, you

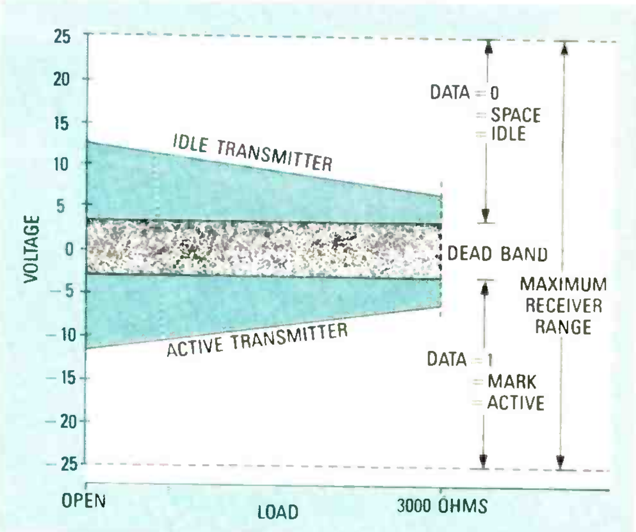



**FIG. 2—EIA-232-D SIGNAL LEVELS are shown here. A ±12-volt swing is suitable for loads of as much as 3000 ohms.**

might swap pins 2 and 3, pins 4 and 5, and pins 6 and 20. A cable (or adapter) that implements that type of connection is called a null-modem cable (or adapter). In some cases only pins 2 and 3 need be swapped; in others, half a dozen or more may need to be swapped. The type of equipment and the software controlling it are the determining factors.

## New lines

Three new signals have been created by defining previously undefined lines or redefining existing signal lines. Table 2 shows the old and new pin definitions. Note that pin 21 is now called remote loopback (RL); it is used to enable remote-loopback testing. The basic idea of loop-

**TABLE 2—RS-232 VS. EIA-232**

| | RS-232 | | EIA-232 | |
|---|---|---|---|---|
| Pin | Circuit | Description | Circuit | Description |
| 1 | AA | Protective Ground | — | Shield |
| 2 | BA | Transmitted Data | BA | Transmitted Data |
| 3 | BB | Received Data | BB | Received Data |
| 4 | CA | Request to Send | CA | Request to Send |
| 5 | CB | Clear to Send | CB | Clear to Send |
| 6 | CC | Data Set Ready | CC | DCE READY |
| 7 | AB | Signal Ground | AB | Signal Ground |
| 8 | CF | Received Line Sig. Det. | CF | Received Line |
| 9 | — | Reserved for Testing | — | Reserved for Testing |
| 10 | — | Reserved for Testing | — | Reserved for Testing |
| 11 | | Unassigned | | Unassigned |
| 12 | SCF | Sec. Rec'd Line Sig. Det. | SCF/CI | Sec. Rec'd Line Sig. Det/ Data Signal Rate Select |
| 13 | SCB | Sec. Clear to Send | SCB | Sec. Clear to Send |
| 14 | SBA | Sec. Transmitted Data | SBA | Sec. Transmitted Data |
| 15 | DB | Trans. Sig. Element Timing | DB | Trans Sig. Element Timing |
| 16 | SBB | Sec. Received Data | SBB | Sec. Received Data |
| 18 | | Unassigned | LL | Local Loopback |
| 19 | SCA | Sec. Request to Send | SCA | Sec. Request to Send |
| 20 | CD | Data Terminal Ready | CD | Data Terminal Ready |
| 21 | CG | Sig. Quality Detector | RL/CG | Remote Loopback/Sig. Quality Detector |
| 22 | CE | Ring Indicator | CE | Ring Indicator |
| 23 | CH/CI | Data Sig. Rate Detector | CH/CI | Data Signal Rate |
| 24 | DA | Trans. Sig. Element Timing | DA | Trans. Sig. Element Timing |
| 25 | | Unassigned | TM | Test Mode |

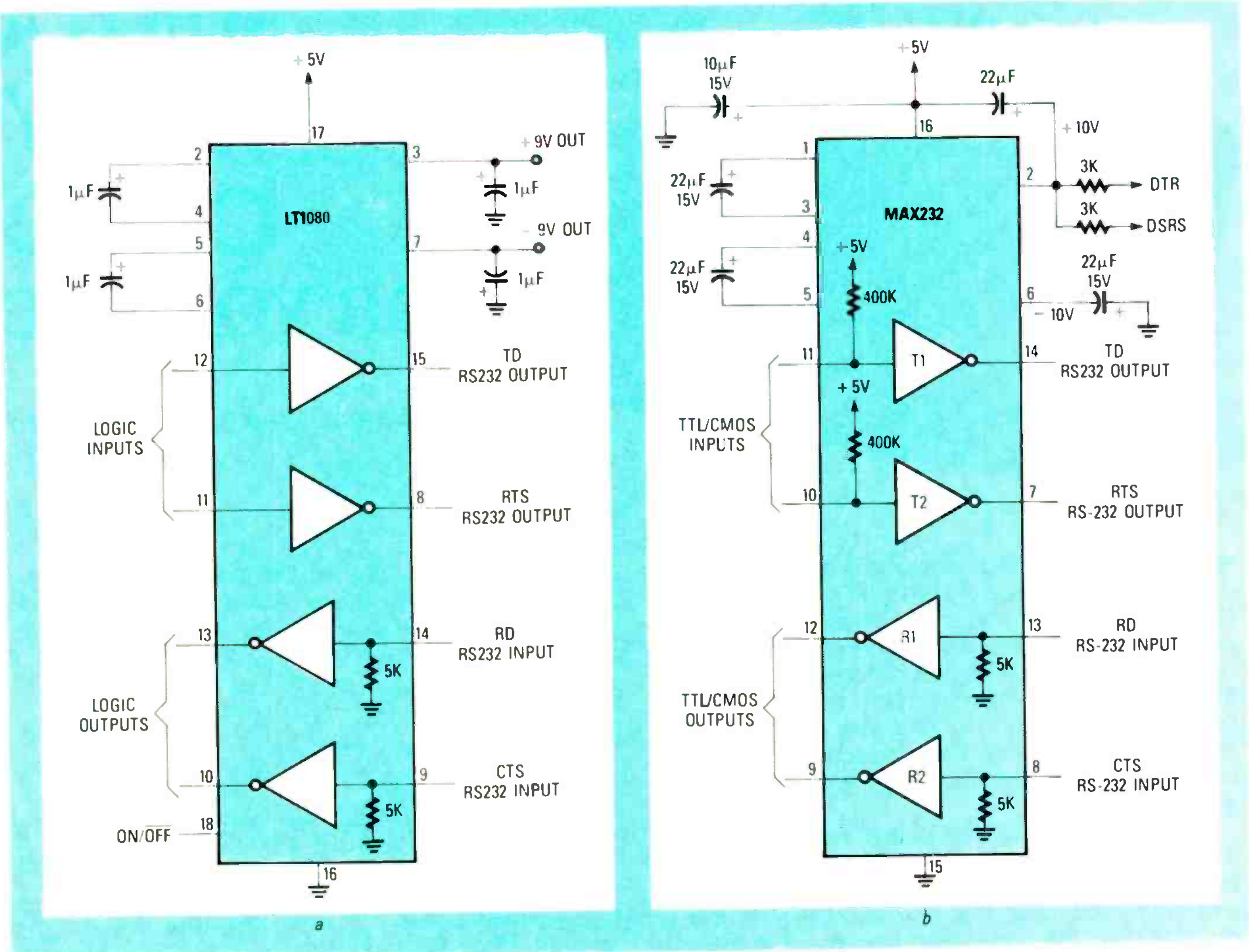



**FIG. 3—THE LT1080 (*a*) AND THE MAX232 (*b*) can swing RS-232 voltages with only a +5-volt supply.**

back testing is as follows: A device transmits a signal and reads it back in. If there is any discrepancy between the two, there is a problem with the communications circuit or one of the devices in the circuit.

Actually, there are two types of loopback: local and remote. A local loopback test may be as simple as shorting transmit and receive pins and initiating a test program. In a remote test, data is transmitted through some sort of circuit, through an answering device, and then back through the circuit to the originating device. A modem engaged in remote-loopback testing, for example, might send test signals over a telephone line to another modem, which would then echo those signals back to the first modem.

A DTE uses the RL signal to tell a DCE to loop back, thereby enabling the DTE to test the integrity of the communications connection between the two devices. Similarly, previously undefined pin 18 is now called local loopback (LL).

Last, previously undefined pin 25 is now called test mode (TM); the DCE uses it to inform the DTE that it has received an RL or LL signal from the DTE.

## Signal levels

It's common to use ±12-volt signal swings in RS-232 circuits. You may have wondered why anyone would specify a computer interface requiring a ±12-volt supply, especially when everyone knows that most digital equipment runs on +5 volts. The answer to that question probably has to do with the popularity of those voltages (which were often used in analog circuits) at the time the RS-232-C standard was drafted.

Figure 2 shows the signal levels defined in the new standard. Note that the basic range is ±3–±25 volts DC.

The idle state of an EIA-232-D interface is high, also called space. During a data transmission, that state corresponds to a binary 0. The active state is called mark or binary 1. Anything in between (in the range between +3 and −3 volts) is called the dead band; signals in that range are undefined.

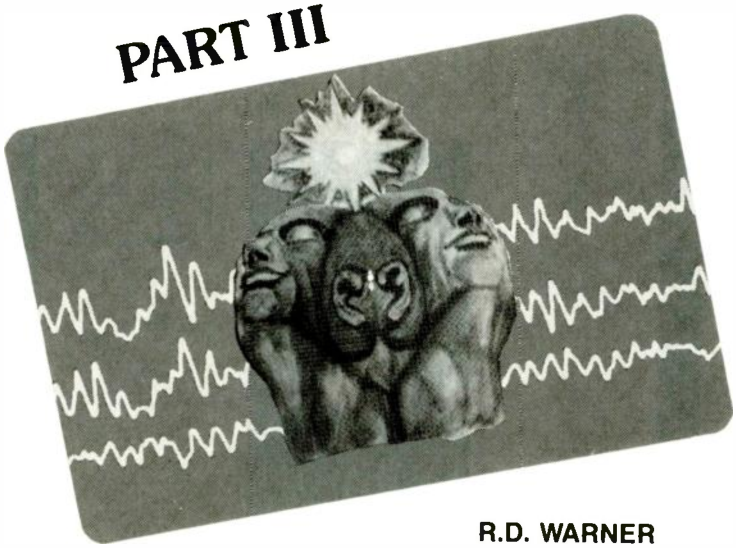
For short-range transmission, you can get away with a ±5-volt supply, but with much loading, errors would be likely. To attain maximum range, you'd want to use ±25-volt supplies. A ±12-volt supply is commonly used because it strikes a good balance between range and circuit cost. Also, the ubiquitous 1488 and 1489 line driver and receiver IC's operate at those voltages.

## Potential problems

One perennial problem with serial interfaces is signal voltages. How do we get ±12 volts from digital circuits that operate from +5-volt supplies? Couldn't the standard be changed to accommodate +5-volt signals?

*continued on page 95*

PART III



# BUILD A SYNERGY CARD FOR YOUR PC

*Wrapping up the Synergy Card*

R.D. WARNER

This is the last of three articles discussing the theory, construction, and use of a Synergy Card, a device used for generating sound effects and influencing brain function. In Part 1 we discussed the theory of a technique that uses audio signals to influence brain function. The goal of that technique is to achieve *Hemisphere Synchronization* (HS) by means of *Frequency-Following Response* (FFR). It is theorized that hemisphere synchronization creates a mental atmosphere that allows for better concentration and more creativity.

In the second part we described the circuitry of a card that plugs into any IBM PC compatible, and allows you to experiment with HS, FFR, and to generate sound effects and multi-voice music. The card also has a number of digital I/O lines that can interface your PC to bio-monitoring or to other equipment.

This time, we'll show you how to build, test and operate the Synergy Card. Included are software listings in BASIC, assembler, and DEBUG scripts. Those programs may be used as-is for testing purposes, or may be used as models and expanded for more-complex usage. All listings are also available on RE-BBS (516-293-2283, 300/1200 baud, 8 data bits, no parity, 1 stop bit); just download the file HEMISYNC.ARC.

If you build your own card, you'll have to deal with the absence of plated-through holes. That means that you'll have to solder many components on both sides of the board, install feed-throughs, etc. If you choose that method, be very careful, and check your work several times.

Use the parts-placement diagram shown in Fig. 3 to mount all components. Note that the IC's are installed in various orientations, so double-check to make sure that none is installed backward.

Regardless of construction method, when you're ready to stuff the board, first install all decoupling capacitors (C13–C18, with C16 mounted on the solder side), and C19 and C20. When you install C19, note its proximity to trimmer resistor R12. Now connect a DMM across $V_{CC}$ and ground to check for shorts.

Now do the audio section, mounting R14 and R15 on the solder side of the board. Some of the discrete components are very close together, so be careful and check your work several times.

Next, install J1, J2, and the mounting bracket. The mounting tabs of the bracket go on the component side of the board. There should be enough play in the mounting holes so the bracket lines up with the connectors; if

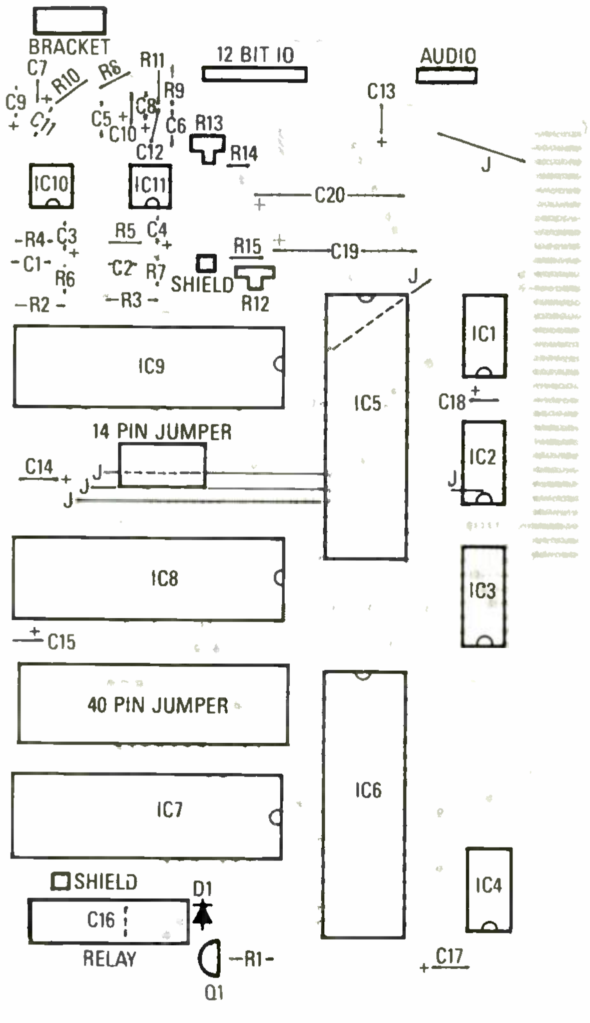



FIG. 1—MOUNT ALL COMPONENTS as shown here, being careful in the audio section, where close component mounting could lead to shorts.

**TABLE 1—LOGIC LEVELS**

| | PSG | | PPI | |
|---|---|---|---|---|
| **Pin** | **Before** | **After** | **Before** | **After** |
| 1 | LOW | | VAR, HI-Z | LOW |
| 2 | N.C. | | VAR, HI-Z | LOW |
| 3 | LOW | | VAR, HI-Z | LOW |
| 4 | LOW | | VAR, HI-Z | LOW |
| 5 | N.C. | | PULSE | |
| 6 | HIGH | | HIGH | |
| 7 | HIGH | | LOW | |
| 8 | HIGH | | PULSE | |
| 9 | HIGH | | PULSE | |
| 10 | HIGH | | LOW, HI-Z | LOW |
| 11 | HIGH | | HI-Z | LOW |
| 12 | HIGH | | HI-Z | LOW |
| 13 | HIGH | | HI-Z | LOW |
| 14 | HIGH | | HI-Z | LOW |
| 15 | HIGH | | HI-Z | LOW |
| 16 | HIGH | | HI-Z | LOW |
| 17 | HIGH | | HI-Z | LOW |
| 18 | HIGH | | VAR | LOW |
| 19 | HIGH | | VAR | LOW |
| 20 | HIGH | | VAR | LOW |
| 21 | HIGH | | VAR | LOW |
| 22 | PULSE | | VAR | LOW |
| 23 | HIGH | | VAR | LOW |
| 24 | LOW | | VAR | LOW |
| 25 | HIGH | | VAR | LOW |
| 26 | VARIES | | HIGH | |
| 27 | HI-Z | LOW | PULSE | |
| 28 | HI-Z | LOW | PULSE | |
| 29 | HI-Z | LOW | PULSE | |
| 30 | VARIES | LOW | PULSE | |
| 31 | VARIES | LOW | PULSE | |
| 32 | VARIES | LOW | PULSE | |
| 33 | VARIES | LOW | PULSE | |
| 34 | VARIES | LOW | PULSE | |
| 35 | VARIES | LOW | LOW | |
| 36 | VARIES | LOW | PULSE | |
| 37 | VARIES | LOW | VAR, HI-Z | LOW |
| 38 | LOW | | VAR, HI-Z | LOW |
| 39 | VAR | | VAR, HI-Z | LOW |
| 40 | HIGH | | VAR, HI-Z | LOW |

not, you can drill the mounting holes out slightly. Don't drill them too much, though, or you'll damage the traces. The card was designed using a bracket supplied by Vector; others may not align correctly. Install the 40- and 14-pin jumper header sockets, and then all wire jumpers.

Let's do a little more checking before continuing. Again, make sure that $V_{CC}$ and ground are not shorted. The forward-biased resistance across a decoupling capacitor should be around 35 ohms. Also, make sure that none of the edge-card fingers is shorted to a neighbor. Correct any problems before proceeding.

Then wire up an audio cable that connects J2 to the appropriate inputs of your stereo system. The LM386's can drive headphones directly; doing so may be most convenient for testing.

With the computer turned off, insert the card in a slot, and connect the card to the Tape or Aux. jacks of your stereo. Make sure the card is aligned in the slot properly. Then turn your stereo on with the volume low. Now turn the computer on and apply an audio signal to the junction of R2 and R6. You should hear the tone through the left speaker. Then apply the the tone to the junction of R3 and R7: This time you should hear the tone over the right speaker.

Remove the card from your PC (after powering it down, of course), and correct any problems. Then solder in the clock (IC4), Q1, R1, and RY1. The clock has a dot on one end that indicates pin 1. A transistor with in-line pins (not pin-circle) should be used for Q1. Otherwise, the collector and emitter will be reversed. Now mount IC1, IC2, and IC3, followed by IC5 and IC6.

## Testing

After resolving any problems, install the card in your PC and boot up. Then use a logic probe to check the pins of the *P*rogrammable *P*eripheral *I*nterfaces (PPI's) and the *P*rogrammable *S*ound *G*enerators (PSG's). Your readings should match those in Table 1. The "Before" and "After" columns in that table refer to the states of the respective pins before and after the initialization program is run.

Here are a few notes on why various readings are obtained. Before initialization, PPI I/O ports are in a high-impedance state. So, for example, Port A of PPI 1 (IC5, pins

LISTING 1

```
C>debug                                  ;Enter Debug
-A                                       ;Go into assemble mode

XXXX:0100 MOV     BX,D000                ;Set segment to D000,
XXXX:0103 MOV     DS,BX                  ; which is card location.
XXXX:0105 MOV     DI,FFF8
XXXX:0108 MOV     BH,80                  ;Set PPI ports to OUTPUT -
XXXX:010A MOV     [DI+03],BH             ; first PPI 0,
XXXX:010D MOV     [DI+07],BH             ; then PPI 1.
XXXX:0110 MOV     [DI+02],BL             ;Write zero to all ports, the
XXXX:0112 MOV     [DI+01],BL             ; PSG control reg's first so
XXXX:0115 MOV     [DI],BL                ; that PSG's are in INACT state.
XXXX:0118 MOV     [DI+06],BL
XXXX:011B MOV     [DI+05],BL
XXXX:012E MOV     [DI+04],BL
XXXX:0121 INT     20                     ;Return to DOS
XXXX:0123                                ;Hit return to quit assembly
-RBX
BX 0000                                  ;Make register BX set to zero
:0
-RCX
CX 0000                                  ;Set CX to program length
:23                                      ; in hex bytes
-N B:SCINIT.COM                          ;Give the program a COM name
-W                                       ;Write it to disk
Writing 0023 bytes
-Q                                       ;Quit

C>
```

LISTING 2

```
10 DEF SEG = &H5000                       'This loads the
procedure
20 FOR I = 256! TO 535!                   ' outside of BASIC -
30 READ IMBED%                            ' set 10 to where you
like
40 POKE I,IMBED%                          ' but leave offset
alone.
50 NEXT I
55 '--------------------------------------------------------------
60 DATA &H50,&H53,&H51,&H52,&H1E
70 DATA &H57,&H56,&HB8,&H00,&HD0,&H8E,&HD8,&HB7,&H80,&HBF,&HFB
75 DATA &HFF,&H88,&H3D,&HBF,&HFF,&HFF,&H88,&H3D,&H32,&HFF,&HBF
80 DATA &HFA,&HFF,&H88,&H3D,&HBF,&HFE,&HFF,&H88,&H3D,&HEB,&H06
90 DATA &H90,&H00,&H01,&H00,&H00,&H00,&H2E,&H8B,&H1E,&H2A,&H01
100 DATA &H80,&HFF,&H30,&H7C,&H2D,&H80,&HFF,&H30,&H74,&H08,&H80
110 DATA &HFF,&H31,&H74,&H13,&HE9,&HCD,&H00,&H2E,&HC6,&H06,&H29
115 DATA &H01,&H80,&HBF,&HFA,&HFF,&HB3,&H80,&H88,&H1D,&HE9,&HBD
120 DATA &H00,&H2E,&HC6,&H06,&H29,&H01,&H00,&HBF,&HFA,&HFF,&H32
125 DATA &HDB,&H88,&H1D,&HE9,&HAD,&H00,&H80,&HFF,&H20,&H7C,&H09
130 DATA &H80,&HEF,&H20,&HBF,&H02,&H00,&HEB,&H11,&H90,&H80,&HFF
140 DATA &H10,&H7C,&H09,&H80,&HEF,&H10,&HBF,&H01,&H00,&HEB,&H03
150 DATA &H90,&H33,&HFF,&H53,&H83,&HFF,&H02,&H7C,&H60,&HBF,&HFD
155 DATA &HFF,&HBE,&HFE,&HFF,&H59,&H2E,&H8A,&H3E,&H29,&H01,&H80
160 DATA &HFF,&H80,&H74,&H06,&H33,&HDB,&H53,&HEB,&H04,&H90,&H32
170 DATA &HDB,&H53,&H2E,&H8A,&H16,&H28,&H01,&HB8,&H06,&H00,&HF6
180 DATA &HE2,&H2E,&H02,&H06,&H27,&H01,&H50,&H53,&H2E,&H8A,&H16
185 DATA &H28,&H01,&HB9,&H07,&H00,&HF6,&HE2,&H2E,&H02,&H06,&H27
190 DATA &H01,&H8A,&HFD,&H88,&H3D,&H8A,&HD8,&H88,&H1C,&H5B,&H88
200 DATA &H3C,&H8A,&HD9,&H88,&H1D,&H5B,&H88,&H1C,&H5B,&H88,&H3C
210 DATA &HB3,&H01,&H2E,&H88,&H1E,&H28,&H01,&H32,&HDB,&H2E,&H88
220 DATA &H1E,&H27,&H01,&HEB,&H2A,&H90,&HBE,&HFA,&HFF,&H2E,&H8A
230 DATA &H1E,&H29,&H01,&H80,&HFB,&H80,&H75,&H05,&H2E,&H88,&H1E
235 DATA &H27,&H01,&H83,&HFF,&H00,&H7F,&H0C,&HB3,&H10,&H2E,&H88
240 DATA &H1E,&H28,&H01,&HBF,&HF8,&HFF,&HEB,&H83,&HBF,&HF9,&HFF
245 DATA &HE9,&H7D,&HEF,&H5E,&H5F,&H1F,&H5A,&H59,&H5B,&H58,&HCB
248 '--------------------------------------------------------------
250 INPUT "ENTER REGISTER NUMBER";R1%
260      IF R1% = 99 THEN GOTO 330           'Enter "99" to exit
prog
270      INPUT "ENTER DATA TO WRITE";D1%
280      POKE 298!,D1%                       'Set segment to match
290      POKE 299!,R1%                       ' line 10, but offset
300      OFFST= 256!                         ' must equal 256 or
310      DEF SEG = &H5000                    ' hex 100.
315        CALL OFFST
320 GOTO 250
330      END
```

LISTING 3

```
XXXX:0100 MOV    BX,D000       ;Set segment to D000,
XXXX:0103 MOV    DS,BX         ; which is card location.
XXXX:0105 MOV    DI,FFF8
XXXX:0108 MOV    BH,80         ;Set PPI ports to OUTPUT -
XXXX:010A MOV    [DI+03],BH    ; first PPI 0,
XXXX:010D MOV    [DI+07],BH    ; then PPI 1.
XXXX:0110 MOV    [DI+02],BL    ;Write zero to non-I/O ports, the
XXXX:0112 MOV    [DI+01],BL    ; PSG control reg's first so
XXXX:0115 MOV    [DI],BL       ; that PSG's are in INACT state.
XXXX:0118 MOV    AX,F0FF       ;AH sends INACT to PSG 2, and
XXXX:011B MOV    [DI+06],AH    ; makes 4 I/O bits HIGH.
XXXX:011E MOV    [DI+05],BL    ;Writes zero to PSG 2 data lines
XXXX:0121 MOV    [DI+04],AL    ;AL makes 8 I/O bits go HIGH
XXXX:0124 INT    20            ;Return to DOS
```

1–4 and 37–40) should show a high impedance on your logic probe before running the initialization program. Port A of the other PPI behaves the same way.

The B ports (pins 18–25) of both PPI's show varied readings, because they're connected to the data lines of the PSG's, and a PSG does disconcerting but harmless things unless the INACT (inactive) command (000) is present on its control lines (pins 27–29). PSG pins 6–21 are for the two I/O ports, and appear high when in the input mode.

Now let's discuss the initialization program, SCINIT.COM, shown in Listing 1. What it does is to set all PPI ports to outputs, and then loads a zero into each one, driving all port lines low. The lows on the control lines of the PSG's constitute the INACT command, so the PSG's calm down. PSG pins 26 and 39 will still vary, because they are test pins whose function varies depending on which model of the AY-3-8910 IC you have.

Now load and run SCINIT.COM using DEBUG. Enter the assembly-language instructions and debug commands as shown, but don't enter the semicolons or the comments following them. Ignore the *X*'s shown in the first column. After running the program, you'll notice that the data and control lines of the PSG's are now all low.

That initialization program tests the steering logic, but to really check the individual data and I/O lines requires the use of a larger assembly-language procedure, which, unfortunately, we don't have enough space to publish. You can however, download it from the RE-BBS. If you assemble the program, make sure that the last byte in the object file generated is 0CBh. The author found that when using his macro assembler, it is necessary to go in manually and change that byte; otherwise he couldn't get the procedure to return properly to the BASIC program shown next. The last line of the source code may be a dummy, because no matter what's put in there, it doesn't compile right. For some reason, it insists on executing an intra-segment return (0C3h), instead of an inter-segment return.

The assembly-language procedure is also embedded in the BASIC program shown in Listing 2. That program allows you to write any byte-size value to any one of the Synergy Card's 50 registers. Remember, each PSG has 16 registers; registers 0–47 are used to set and reset the PSG lines, and registers 48 and 49 are dummies used to turn the relay on and off (which in turn is used to control the motor of a cassette recorder).

For example, if you write a 2 to any of the registers 32–47, line D1 of PSG2 will go high. Or by writing a 1 to any of the registers 16–31, D0 of PSG1 will go high.

By forcing one bit high at a time, you can thereby check not only the PSG's, but the PPI's as well. If a PSG line doesn't go high, check the corresponding PPI line. If it

**TABLE 2—MUSICAL NOTES**

| Note | Octave | Ideal | Note | Octave | Ideal |
|---|---|---|---|---|---|
| C | 1 | 32.703 | C | 5 | 523.248 |
| C# | 1 | 34.648 | C# | 5 | 554.368 |
| D | 1 | 36.708 | D | 5 | 587.328 |
| D# | 1 | 38.891 | D# | 5 | 622.256 |
| E | 1 | 41.203 | E | 5 | 659.248 |
| F | 1 | 43.654 | F | 5 | 698.464 |
| F# | 1 | 46.249 | F# | 5 | 730.984 |
| G | 1 | 48.999 | G | 5 | 783.984 |
| G# | 1 | 51.913 | G# | 5 | 830.608 |
| A | 1 | 55.000 | A | 5 | 880.000 |
| A# | 1 | 58.270 | A# | 5 | 932.320 |
| B | 1 | 61.735 | B | 5 | 987.760 |
| C | 2 | 65.406 | C | 6 | 1046.496 |
| C# | 2 | 69.296 | C# | 6 | 1108.736 |
| D | 2 | 73.416 | D | 6 | 1174.656 |
| D# | 2 | 77.782 | D# | 6 | 1244.512 |
| E | 2 | 82.406 | E | 6 | 1318.496 |
| F | 2 | 87.308 | F | 6 | 1396.928 |
| F# | 2 | 92.498 | F# | 6 | 1479.968 |
| G | 2 | 97.998 | G | 6 | 1567.968 |
| G# | 2 | 103.826 | G# | 6 | 1661.216 |
| A | 2 | 110.000 | A | 6 | 1760.000 |
| A# | 2 | 116.540 | A# | 6 | 1864.640 |
| B | 2 | 123.470 | B | 6 | 1975.520 |
| C | 3 | 130.812 | C | 7 | 2092.992 |
| C# | 3 | 138.592 | C# | 7 | 2217.472 |
| D | 3 | 146.832 | D | 7 | 2349.312 |
| D# | 3 | 155.564 | D# | 7 | 2489.024 |
| E | 3 | 164.812 | E | 7 | 2636.992 |
| F | 3 | 174.616 | F | 7 | 2793.856 |
| F# | 3 | 184.996 | F# | 7 | 2959.936 |
| G | 3 | 195.996 | G | 7 | 3135.936 |
| G# | 3 | 207.652 | G# | 7 | 3322.432 |
| A | 3 | 220.000 | A | 7 | 3520.000 |
| A# | 3 | 233.080 | A# | 7 | 3729.280 |
| B | 3 | 246.940 | B | 7 | 3951.040 |
| C | 4 | 261.624 | C | 8 | 4185.984 |
| C# | 4 | 277.184 | C# | 8 | 4434.944 |
| D | 4 | 293.664 | D | 8 | 4698.624 |
| D# | 4 | 311.128 | D# | 8 | 4978.048 |
| E | 4 | 329.624 | E | 8 | 5273.984 |
| F | 4 | 349.232 | F | 8 | 5587.712 |
| F# | 4 | 369.992 | F# | 8 | 5919.872 |
| G | 4 | 391.992 | G | 8 | 6271.872 |
| G# | 4 | 415.304 | G# | 8 | 6644.864 |
| A | 4 | 440.000 | A | 8 | 7040.000 |
| A# | 4 | 466.160 | A# | 8 | 7458.560 |
| B | 4 | 493.880 | B | 8 | 7902.080 |

went high, there's probably an open somewhere between the two. It doesn't take long to go through and check each line that way, and it can save a lot of headaches later.

You can also test the relay using that program: If you write to register 48, the relay will close, and if you write to register 49 it will open. It doesn't matter what data you write to the dummy registers.

How do you test the PSG I/O lines? You can use the same routine, because the I/O registers are accessed just like the fourteen sound-control registers. Remember that register 7 of each PSG controls the data direction of its two I/O ports, using bits 6 and 7 (for ports A and B, respectively). When one of those bits is high, the corresponding port is an output port, and when it's low, the port is an input port.

So, to test the output ports first you must write a decimal 192 to registers 7, 23, and 39. Then, once again, simply make each bit go high one at a time. For example, by writing 192 to register 39, and then 128 to register 47, bit B7 (the second port) of PSG2 will go high.

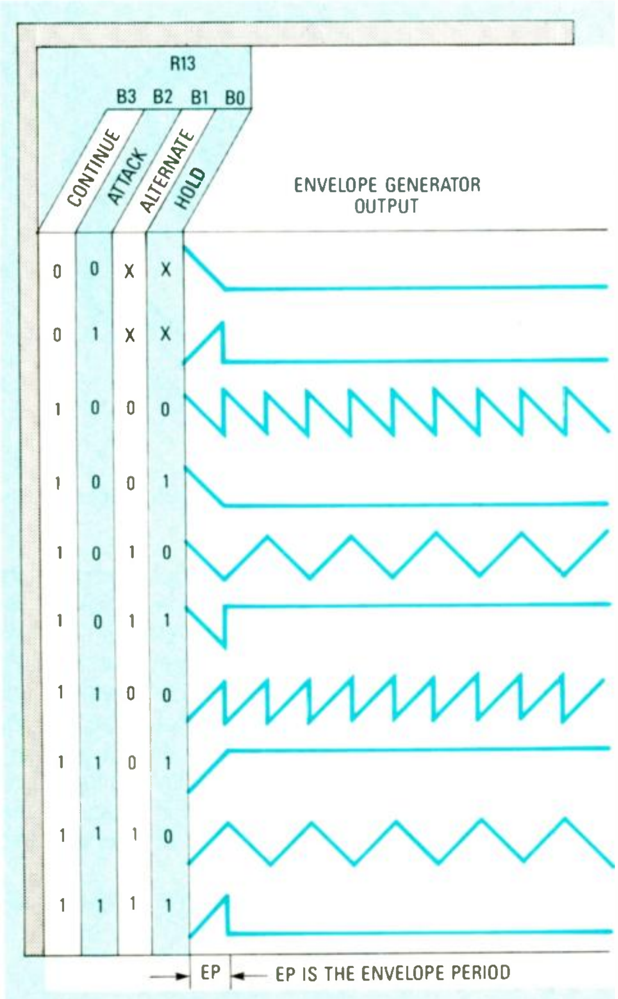



**FIG. 2—THE CONTENTS OF PSG REGISTER 13 determines the shape of the envelope.**

To test the twelve bits of I/O coming straight from IC5, you need to use a procedure similar to that used in SCINIT.COM. Remember that Port A and the top 4 bits of Port C supply that I/O, so all you have to do is set the PPI to output mode, and then write to the ports. Listing 3 shows a DEBUG procedure that will set all 12 bits high.

That completes the digital testing. Track down and correct any problems before proceeding.

### Make beautiful (?) music

Install the Synergy Card in your PC, and connect it to your audio system as described last time. Turn on the computer and make sure that it boots. Then turn on the audio system with the volume low, and run the initialization program.

To begin, let's make a single layer (one tone pair) of Synergistic Sound. Since one tone will go to each channel, write to PSG1. In it, voices A and B go to the left channel, and C goes to the right. (That way we only have to enable the tones in one PSG.) To enable A and C, and disable noise in all three channels, write a decimal 58 to register 23.

Next write the appropriate values into the coarse- and fine-tune registers to get the desired frequency. For this example we'll create tones of 200 and 202 Hz, which provide a synergistic sound frequency of 2 Hz, a nice delta brain-wave frequency.

**PARTS LIST**

**All resistors are ¼-watt, 5% unless otherwise noted.**
R1–R3—1000 Ohms
R4, R5—500 Ohms
R6, R7—68,000 Ohms
R8, R9—15,000 Ohms
R10, R11—10 Ohms
R12, R13—10,000 Ohms Trimmer Potentiometer
R14, R15—27,000 Ohms

**Capacitors**
C1, C2—330 pF, mica
C3, C4—2.2 µF, 15 volts, tantalum
C5, C6—0.01 µF, ceramic disc
C7, C8—10 µF, 15 volts, tantalum
C9, C10—0.1 µF, 15 volts, tantalum
C11, C12—0.047 µF, ceramic disc
C13—22 µF, 15 volts, tantalum
C14–C18—0.1 µF, 15 volts, tantalum
C19, C20—220 µF, axial, 15 volts, electrolytic

**Semiconductors**
IC1—74LS30N, 8-input NAND gate
IC2—74LS10P, triple 3-input NAND gate
IC3—74LS138, 3-to-8 decoder
IC4—1.8432-MHz, clock
IC5, IC6—8255A-5, programmable peripheral interface
IC7–IC9—AY-3-8910A, programmable sound generator
IC10, IC11—LM386N-1, audio amplifier
Q1—2N3904, NPN transistor

**Other components**
J1—9-pin "D" connector, PC mount
J2—15-pin "D" connector, PC mount
RY1—5-volt SPST reed relay (Radio Shack)

**Miscellaneous**
Metalized hood for 9- and 15-pin connectors.
Shielded plugs and cables for stereo hookup.
3/32" plug for cassette remote jack.

**Note: The following are available from Perceptual Research Ventures, P.O. Box 20151, Missoula, MT 59801: Etched, drilled, tin-plated, and silk-screened PC board (PR-10), $36.00; assembled, tested, and coated card (PR-48), $319.95; custom cabling (PR-8), $28.95; Sleep Lab software, compiled, runs card as a background task, leaving CPU free for other work, (PR-100), $25. Unfortunately, due to FCC regulations, the assembled and tested unit may be sold only to qualified research institutions. All orders add $5 for postage and handling.**

We calculated the register values for the 200-Hz carrier frequency last month: CT = 2, and FT = 64. Using the same tecnnique for 202 Hz, we get CT = 2, and FT = 58. Working backward, those values will actually yield a frequency of 202.1053 Hz (assuming the clock frequency is exact). If FT were 59, we would get a frequency of 201.7513 Hz, so the first value yields the most accurate results.

To generate those tones, write a 64 to register 16, 2 to register 17, 58 to register 20, and 2 to register 21. Now just turn up the volume. Increase the on-board volume to maximum by writing a 15 to register 24 and register 26. Writing a 16 to those registers would switch from fixed-amplitude to envelope.

Table 2 shows the ideal frequency for eight octaves of notes ranging from C1 to B8. You'll find that the card is capable of getting within 0.01 Hz of the ideal frequency for low notes, and within about 88.0 Hz at the upper end, due to nonlinear distribution.

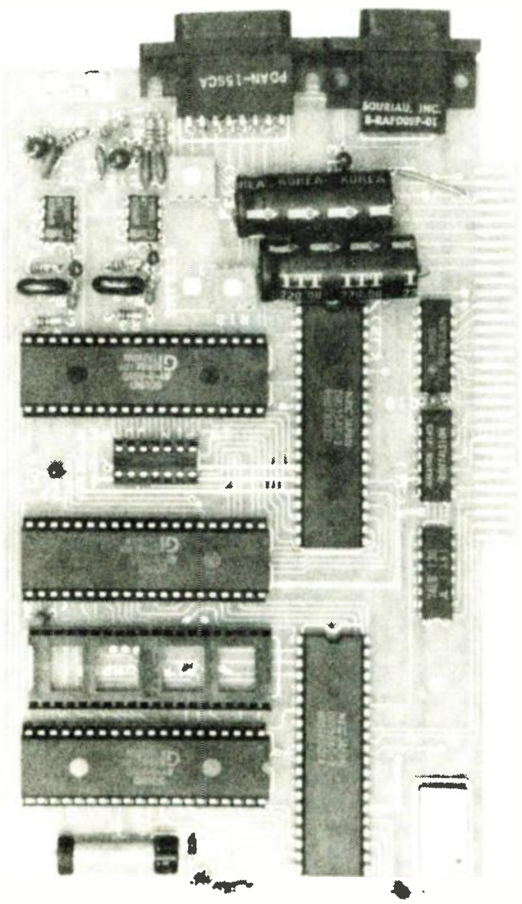


FIG. 3—THE COMPLETED BOARD. **Note that IC sockets are used for IC7–IC9, and for the jumper headers. The jumper headers, if desired, can provide 48 bits of I/O in addition to the 12 bits available at J2.**

Now let's see how to use amplitude envelopes and noise generators. This demonstration provides a mix that sounds like ocean surf. You can turn off the previous tones by writing a 0 to registers 24 and 26.

Our surf will use a logarithmic, U-shaped envelope of white noise. A 0.10-Hz signal goes to the left channel, and 0.12 Hz to the right. The frequency difference means the phase relationship will change constantly, making the sound realistic.

The first thing we need to do is calculate our coarse- and fine-tune register values for the envelopes. The equation is almost identical to that used for tones, and can be solved in the same way:

$$f_{EN} = f_{CL} / [256 \times (256CT + FT)]$$

In that equation, $f_{EN}$ represents the desired envelope frequency, CT and FT represent the coarse- and fine-tune registers, and $f_{CL}$ represents the clock speed. For proper envelope generation, CT and FT cannot both be zero.

Envelope shapes and corresponding binary codes are shown in Fig. 1. We want a triangle wave (on a log scale)

FIG. 4—THE AUTHOR'S CUSTOM CABLE, **which is used to connect the Synergy Card to an audio system.**

starting at amplitude zero. There is one trick to remember when calculating frequencies for that waveform: The equation is set up for the sawtooth envelopes, and the triangle wave takes twice as much time per wave. So we'll use 0.20 Hz and 0.24 Hz to obtain the correct values. For an $f_{EN}$ of 0.20, CT should be 140 and FT should be 160. For an $f_{EN}$ of 0.24, CT should be 117 and FT should be 48.

Enable Voice A in PSG 0 and PSG 2 by writing 55 to registers 7 and 39. Write the CT and FT values to the appropriate registers. Next write a 14 to registers 13 and 45; that selects our envelope shape.

The noise frequency is governed by the simple equation:

$$f_N = f_{CL} / (16 \times P_N)$$

In that equation, $f_N$ is the desired noise frequency, $f_{CL}$ is the clock speed, and $P_N$ is the value in the *Noise Period* register. NP can range from 1 to 31. For this example, write a 1 to registers 6 and 38. Last, turn on the volume by writing a 16 to registers 8 and 40. Now you should hear a surf-like sound coming from your audio system.

At this time, evaluate the signal level arriving at your stereo. The potentiometers on the Synergy Card control that level; one for each channel. Adjust them for maximum volume, and balance between the two channels.

## Conclusion

You'll probably want to experiment with envelope shape(s), volume, number of layers, carrier frequency, and Synergistic Sound frequency. **Warning: Avoid 13–15 Hz beat frequencies, which have been known to cause epileptic seizures in those prone to them.**

Much could be said about how you can use the 60 bits of I/O. For example, to build an inexpensive isolated controller, you could use the Synergy Card to drive transistors, which would in turn drive relays. Or you could drive a DAC, which would drive a VCO, and use it to transmit data over phone lines. Or have it read in-coming digital data. As a reader of **Computer Digest,** you probably have some ideas of your own.

The author wishes to thank Montana Micro for technical assistance, Jameco Electronics for supplies and equipment, and Brady Books for technical references.

**RS-232**

*continued from page 89*

It's too late for that type of solution; there are simply too many systems out there now using the old standard, and all that equipment would all become obsolete, or at best incompatible.

However, in recent years, several IC manufacturers (including Maxim Integrated Products and Linear Technology) have come up with clever devices that allow you to create and use voltages that fall within the EIA-232-D standard from only a +5-volt supply. In addition to the necessary line drivers and receivers, the devices contain a charge pump. Supplied with several high-value capacitors and a source of +5 volts, the IC's can swing an EIA-232-D ±10 volts. Typical applications of the Linear Technology and Maxim devices are shown in Figs. 3-*a* and 3-*b* respectively. Both companies sell a number of similar devices in various configurations; contact them at the addresses in the Sources box for more information.

## Making connections

Pin 1 is no longer defined as protective ground, but as the shield. It's normally grounded to the case of the DTE; the other end is usually left open to prevent ground loops. The actual signal ground must be returned through pin 7; pins 1 and 7 should never be connected together. Doing so could induce noise in the signal ground or cause ground-loop currents.

In implementing a serial interface, some devices use as few as three leads (TD, RD, and GND); others add an additional line (pin 20 or pin 11) for "busy" processing; yet others use all 22 defined lines.

The most commonly used signals are 1–8, and 20. Pins 11, 12, and 22 are also fairly common. Pin 11 is used sometimes (especially in Europe) as a "Printer Busy" signal. Pin 12 may be used as a high-speed indicator; in that case, it is active if the device is transmitting at 2400 baud or greater. Pin 22 is a handshaking line that functions in a complementary manner to pin 20.

## Conclusions

In this brief treatment, we have tried to outline the features of the new serial-interface standard. The information presented here should help you understand the ideal, and may help you solve your next interfacing problem. Happy interfacing! R-E

### Sources

- Electronic Industries Association, 2001 Eye Street N. W., Washington, DC 20006. (202) 457-4900.
- Linear Technology Corporation, 1630 McCarthy Blvd., Milpitas, CA 95035-7487. (408) 432-1900.
- Maxim Integrated Products, 510 N. Pastoria Ave., Sunnyvale, CA 94086. (408) 737-7600.

*"It always smokes after interfacing"*

## EDITOR'S WORKBENCH

*continued from page 86*

add a standard 360K drive. Last, the MatchMaker allowed me to run the external Macintosh drive. The only problem was that I used up all my expansion slots, so I'm wondering where to install my CD-ROM controller card. Any ideas?


### New Windows, New DOS

Microsoft has just released a new version of Windows, the key feature of which is a software driver, HIMEM.SYS, that gives you an extra 50K of memory in the Windows environment. The extra memory translates into more speed, because large applications like PageMaker and Excel won't have to page overlays to disk as often. In addition, the product's speed has been enhanced, many printer drivers have been added, and the installation procedure has been simplified. Although Windows/286 Version 2.1 will run on 8088- and 8086-based PC's, performance will be less than optimal. In addition, HIMEM.SYS requires extended memory (that above 1MB) to work, and 8088-based PC's do not support extended memory.

The same memory-management technology has been incorporated into Windows/386 Version 2.1, which requires an 80386- or 80386SX-based PC to run, and provides multiple independent virtual DOS machines, each of which can run its own DOS environment with as much as 640K of memory. Unlike Windows/286, Windows/386 allows standard DOS applications (for example, Lotus, dBASE, WordStar, etc.) to run simultaneously in on-screen windows.

#### DOS 4.0

IBM has just released the first major upgrade of DOS in almost a year and a half. The new version provides support for expanded (EMS 4.0) memory, hard-disk partitions greater than 32MB, easier installation, and a DOS shell (used to manipulate files and to run applications from menus). Also, a separate product containing DOS 4.0 and a custom version of Windows/286 has been introduced; according to IBM, the Windows Kit contains a set of applications, including a word processor, a spelling checker, an equation editor, and graphing. The latter capabilities should be especially useful to our readers; we'll have a report as soon as we can get our hands on a copy.

#### Hypertext

Last fall Apple released a program called HyperCard that it now includes with every Macintosh. HyperCard is the first and most widespread implementation of a concept called Hypertext. The concept originated with a man named Ted Nelson about 20 years ago, but only during the past few years have people had enough computing horsepower to do anything serious with Hypertext.

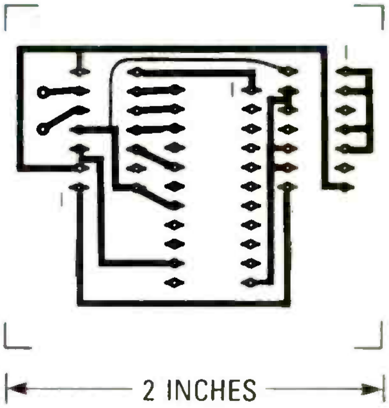
True Hypertext is actually a multi-media phenomenon, involving text, sound, graphics, and even motion. What makes Hypertext special is that it's like an infinitely extensible database, allowing, for example, a chunk of text to link to a graphic image, which may link to a musical score, which may link to the original text, etc. Given those capabilities, Hypertext may be the ideal means of realizing CD-I (interactive compact disks).

Because of HyperCard's run-away success, now every company with a free-form database or text-search program claims Hypertext capabilities. Those claims are universally exaggerated, but even so, several products having little to do with real Hypertext, are still very interesting in their own right.

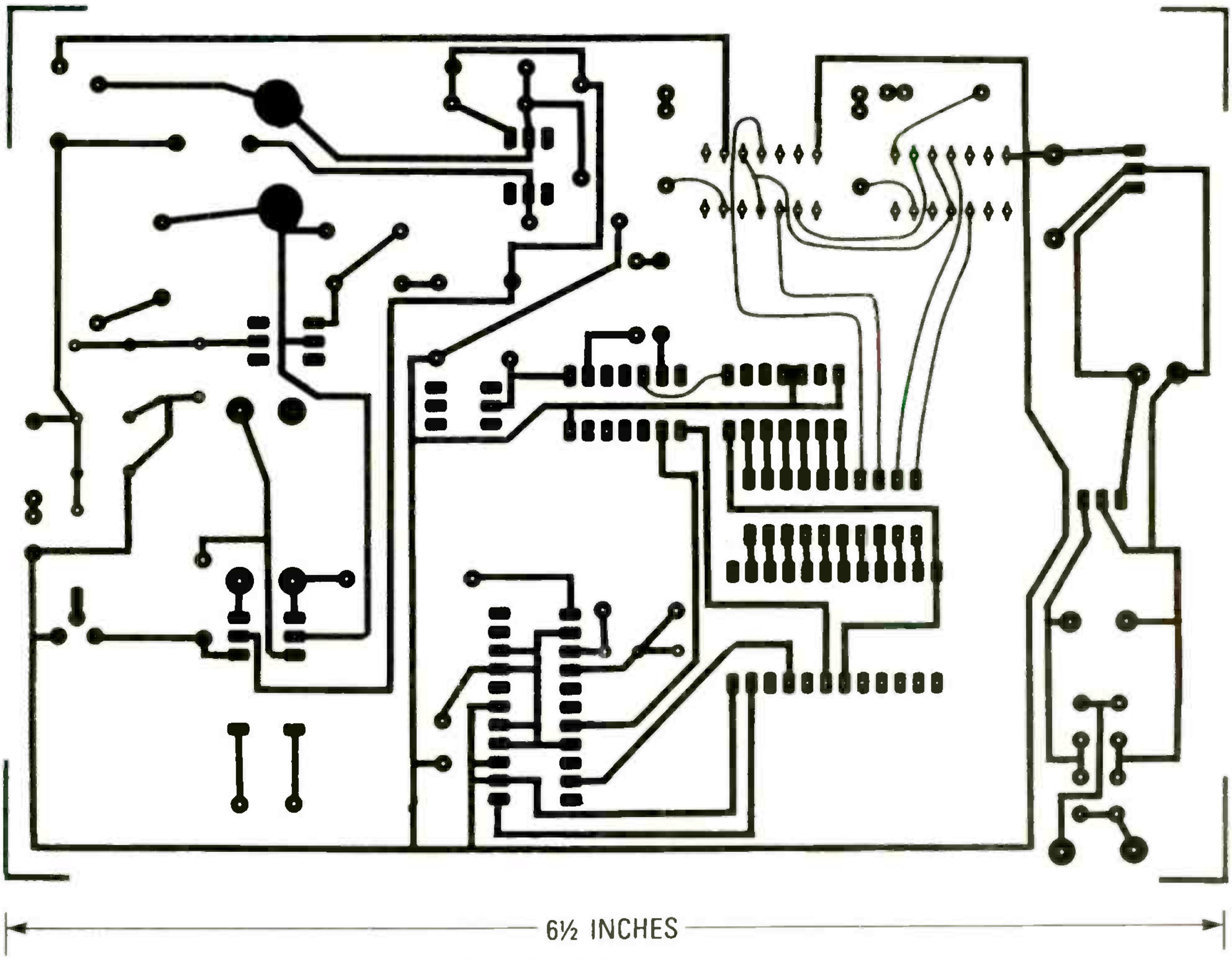
One is called Ize; it's sold by Persoft, Inc. (465 Science Drive, Madison, WI 53711, (608) 273-6000). The program allows you to create outline-like structures that can provide multiple links into groups of files. For example, you could specify resistors, capacitors, and inductors as outline categories, and then have the program scan for files using those terms. Then other outline elements would link you to documents with various combinations of those terms.

Another program developed and sold by Seaside Software (P.O. Box 1428, Perry, FL 32347, (800)-3-ASKSAM) is called AskSam. AskSam allows you to create free-form databases with both fielded information (name, address, phone number, etc.) and non-fielded information ("random" notes). A simple reporting language lets you print out the desired information. You could use the program to maintain a name and address file along with notes about each person in the file. You could print Rolodex cards with the field information, and exclude the notes.

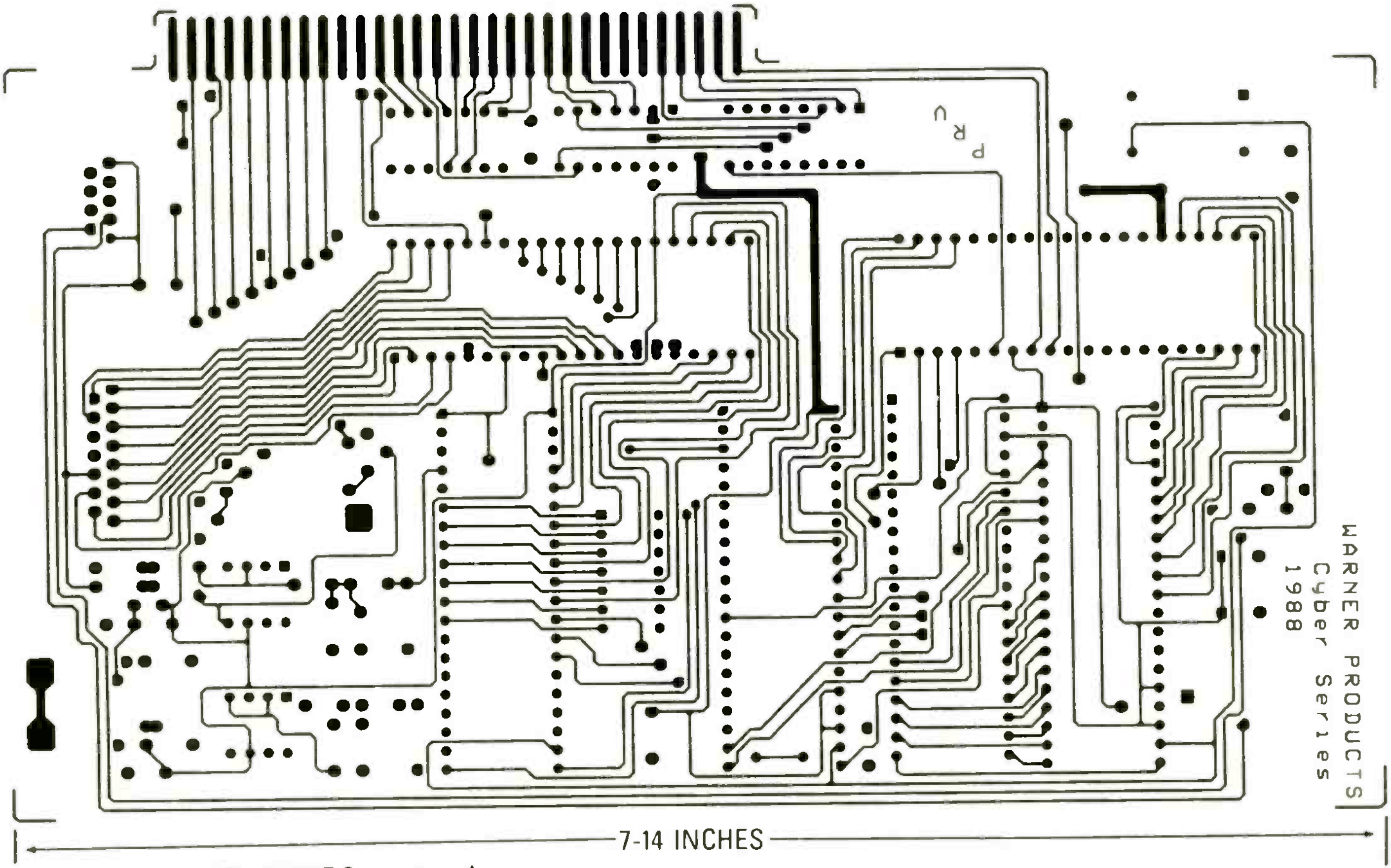
# PC SERVICE



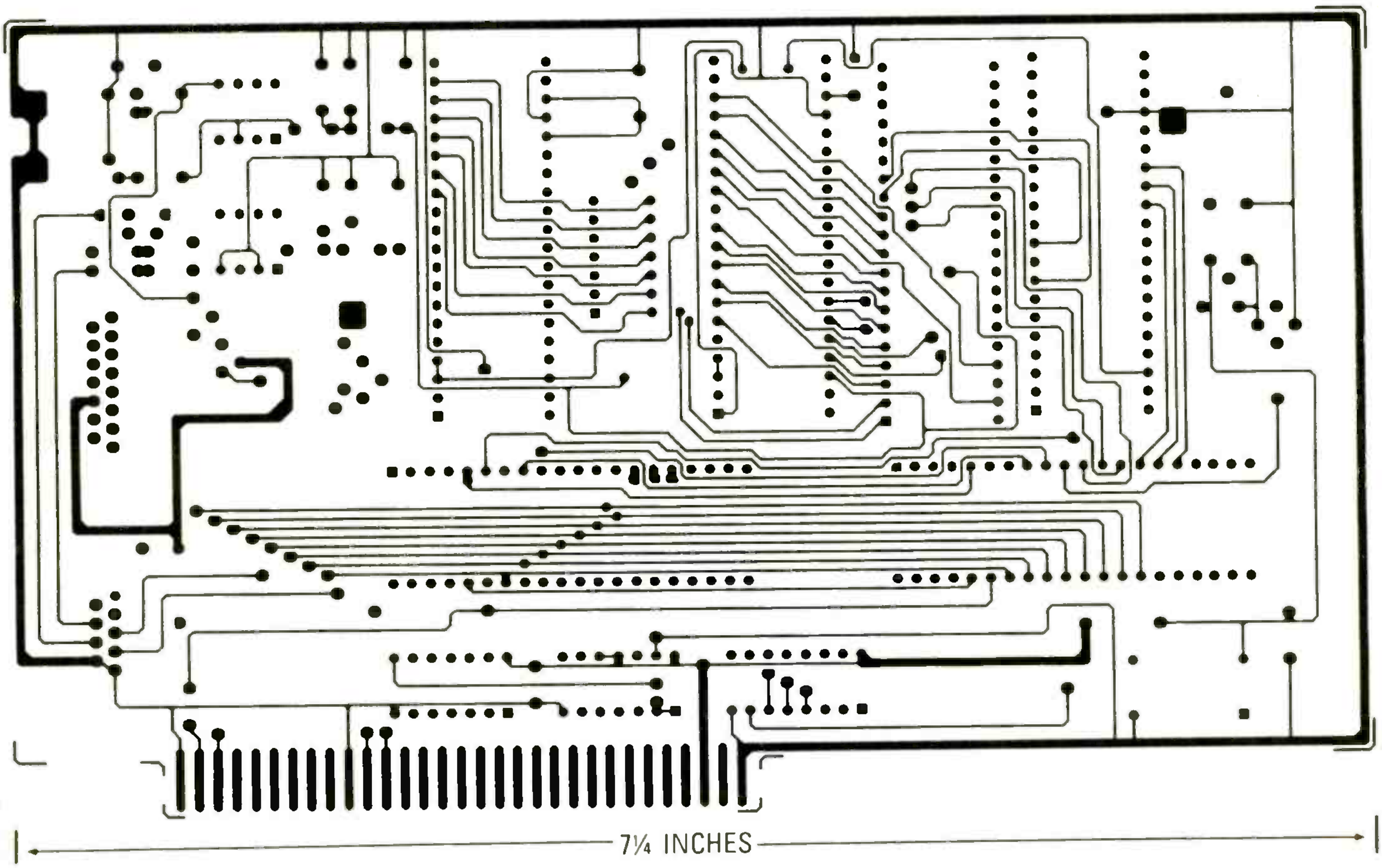

THE FOIL PATTERN FOR the pulse dialer retrofit board.




THE SOLDER SIDE of the Tele-Guard II.




THE COMPONENT SIDE OF THE Synergy card.




THE SOLDER SIDE OF THE Synergy Card.

## DRAWING BOARD

*continued from page 77*

parts from a supplier on Neptune (prices are cheap but the postage is a killer).

The basic operation of a dynamic RAM is simple. You latch the row address in with RAS and then latch the column address with CAS, and then do either a read or write. Since the DRAM's storage cells are nothing more than really small (really, *really* small) capacitors, they have to be refreshed periodically. That means performing the task of reading the data and then writing it back into every cell every 2 milliseconds.

If you had to do that operation on all 65,536 cells individually, there wouldn't be any point to using DRAM but, fortunately, a refresh is much easier than that. Notice that I said "easier," not easy.

Standard DRAM's contain on-chip circuitry that refreshes a whole row of cells whenever any cell in the row is accessed. Refreshing an entire chip, therefore, means addressing each row within the 2-millisecond time limit. And that's where Matt's problem makes its appearance.

The memory matrix in most 64K DRAM's is made up of 128 rows and 512 columns. From the point of view of refresh, those IC's need a refresh counter that can address 128 rows—and for that you need seven address lines ($2^7$ is 128). However, some manufacturers such as National, Signetics, and Texas Instruments (among others), made 64K DRAM's that had a memory matrix made up of 256 rows and 256 columns. As you can imagine, all of those IC's needed an eight-line refresh counter.

The official reason that most of those manufacturers gave for the design was that only half as many sense amplifiers were needed as in the 128 × 512 design and fewer amplifiers meant less heat and lower power requirements.

Big deal.

A minor reduction in power is no compensation for all the added design headaches. Remember that since you have to address twice as many rows with a 256 × 256 IC, it's going to take twice as long to get the job done. And that can mean increasing the system clock, having to use faster DRAM, and a host of other restrictions. The most serious problem is that it's going to cut the allowable Z-80 idle time in half and that's important in a system such as the one we have put together because we're using DMA to talk to the memory.

If you've followed our entire discussion on refresh over the last several months, you should have come away from it with one big fact uppermost in your mind—refresh circuitry is a super-colossal pain in the neck. The hardware and timing hassles generate an absolutely unbelievable amount of brain damage. As a matter of fact, it's well known that spending more than a couple of weeks on the problem will turn your brain into oatmeal. That's a scientific fact—you can look it up, the studies are frightening.

Anyway, if you've got some of those parts and you're determined to use them, the circuit in Fig. 3 is an applications note that appeared in the May 22, 1980 issue of *Electronics* magazine, and it can be used to handle the problem. It uses a counter to generate the extra address line and, while it will get the job done, be sure to redo all of the timing calculations that we went through when designing our circuit.

Another interesting letter brought up two points on this subject and came from Ron Oliynk in Thorndale, Ontario. The first point he mentions is that CAS has to go high by the end of T2 rather than T4 because holding it low (active) will result in refreshing only the cell being addressed rather than

*continued on page 105*

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## DRAWING BOARD

*continued from page 99*

the entire row of cells. The second one is that MUX has to go low at the start of T3 instead of T4 in order for the refresh address to be presented to the DRAM's address pins.

Let's take the second point first. The actual refresh operation takes place just after the falling edge of T3. There was a screwup in the original timing diagram; it showed MUX going low after the start of T4. Sorry if that caused a problem. Ron, you're absolutely right—the timing diagram shown in June was wrong and doesn't agree with the circuit.

Figure 4 shows the correct diagram and MUX should go low one gate-delay time after RFSH. That's because the flip-flop that's generating it, IC4-a, has its SET input connected to RFSH.

There are lots of refreshing schemes that can be used to handle DRAM, and the one used in our circuit is similar to the "RAS-only refresh" Ron mentioned in his letter. What we're really doing is a "hidden refresh." That is really nothing more than a RAS-only refresh with an extended CAS cycle as shown in Fig. 4.

The major benefit of extending CAS is that the DRAM will keep its output in the same state that it was before RAS showed up. That means that the data written to or read from the RAM during T1 and T2 will remain available through T3 and T4 as well. If we cut CAS short, the DRAM output pins would float during the last half of the machine cycle. That could be useful in some circuits but I like to keep data around as long as possible. I still have my Captain Midnight Secret Squadron Decoder ring.

Once again we've managed to run out of room. Next time we'll continue our discussion on display multiplexing. In any event, we laid out a lot of good information here and if anyone out there thinks I've screwed up...... I probably have so let me know. R-E

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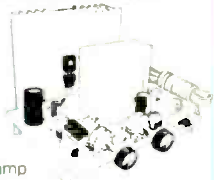

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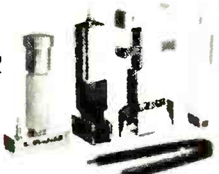

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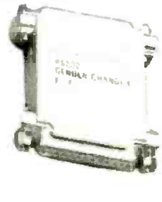

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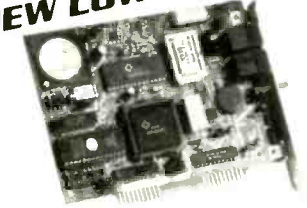

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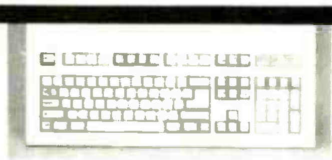

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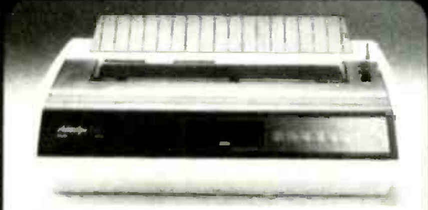

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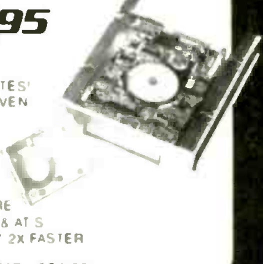

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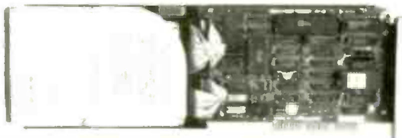

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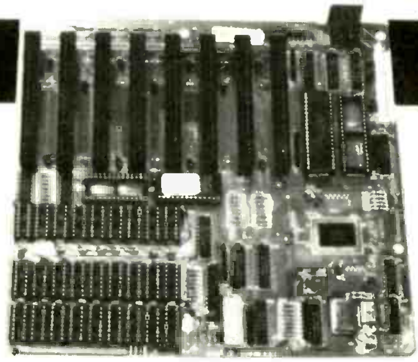

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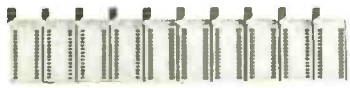

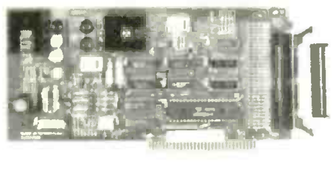

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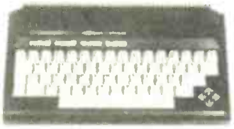
### *COMMODORE* COMPUTERS...

★ ★ ★ ★



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The 8050 uses 2 full-height, 100 TPI single-sided disk drives, ea. w/storage cap. of 533,248 bytes. Ea. 8050 diskette has 77 tracks & is read/write compatible w/the 8250 disk drive. Complete w/built-in power supply. Power req.: 115VAC/60Hz. (manuals incl.)
Dim.: 13 3/4"W x 13 3/4"D x 6"H.
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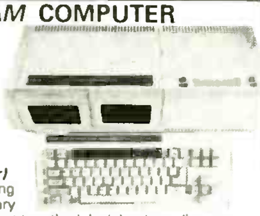
### *ADAM* COMPUTER



*(Less Printer)*
No wiring necessary (just plugs together). Incl: hook-up diagram; Keyboard, 1 cassette digital data drive, 2 game controllers, power supply & 1 cassette. Capable of running CP/M, has built-in word processor.
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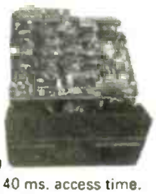
### 5 1/4" FULL-HEIGHT HARD DISK DRIVES



40Mb *(AT/XT Compat.)*
High speed, 40 ms. access time. Quantum #Q540
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Major manufacturers — *Get them while they last!*
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115VAC, 60Hz., 21W., 28A., 3100 RPM, 5-blade model, aluminum housing. Can be mounted for blowing or exhaust.
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50/60Hz., 12W. Low noise level fans. Can be mounted for blowing or exhaust.

1" Thin —
Contains 9 plastic blades. Dimensions: 3 1/8"sq. x 1" deep. Mfr — Tobishi #U9201B
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Contains 7 metal blades. Mfr — Rotron #SU2A1
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6V @ 9.5AH
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Mfr – Elpower
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Gives you indiv. control of 4+ on-screen players. Includes *Baseball* cartridge.
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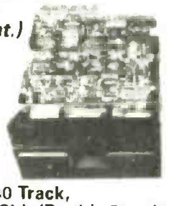
### 5 1/4" FULL-HEIGHT DISK DRIVE *(IBM® Compat.)*



48 TPI,40 Track, Double Side/Double Density
Tandon #TM100-2 or equiv.
Item #7928 **$79.00** New
2 for **$150.00** New

### 12/24VDC MUFFIN® TYPE FAN
55/100CFM

1" THIN:
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12"– *High Resolution*
12VDC, green phosphor. Subassemblies, CRT, board & transformer included. Comes with hook-up diagram.
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1/4 Mil. Bulk erased. Major mfrs.: Ampex, Scotch, etc. Item #6711.
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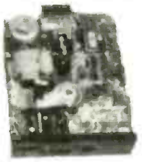

1 Mb (unformatted), 135 TPI, 3 ms. access time. Power requirements: +12, +5 volts. Removed from operational computers — *TESTED — LIKE NEW!*
Mfr — NEC, model FD1035
Item #17171 **$79.00** ea.
2 for **$150.00**

### 5 1/4" 1.2Mb. HALF-HEIGHT FLOPPY DISK DRIVE

*IBM® AT Compatible.*
48/96 TPI, 1.2 Mb.
Double sided, high density; 160 tracks. Mfr — Panasonic #JU-475
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40W, 8 Ohm

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Mfr – #HS-12SBP
Item #19617 *New* – **$29.95**

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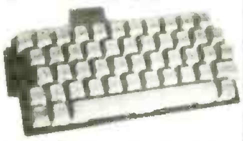
### MECHANICAL KEYBOARDS...



48-KEY – Timex Z81/1000
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75-KEY – Timex or Adam
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66-KEY – Commodore C-16
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Glass coated, epoxy laminated. 1 oz. Double sided, .022" thick. Dimensions: 24"L x 18.5"H
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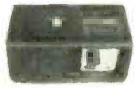
3 sheets / **$9.95**

### ADJUSTABLE POWER SUPPLY
0 – 16VDC



Input: 120VAC/60HZ., .6A. Output: variable, 0-16V, 16VDC max. @ 4.0A. UL approved; thermally protected. Has 'on/off' indicator light & front panel mtd. polarized jack. Perfect for use w/variable speed motors, fans, toys, etc.
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Mfr – Black & Decker #9821
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DC Output: +5V @ 18A
-5V @ 2.5A
+12V @ 2.5A
Input: 115/230VAC, 50/60Hz.
Dim: 13"L x 4 1/2"W x 1 1/2"H
Mfr — Sola #39-139
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DC Output: +5V @ 8A
+12V @ 500 ma.
-12V @ 200 ma.
+24V @ 2.0A.
Input: 115/230VAC, 50/60Hz.
Dimensions: 8 3/4" x 4 5/8" x 2"H.
Mfr — Power Systems #PS1547
Item #16585 **$19.95**

### COMPUTER/GAME ADAPTERS...

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DC Output: 5VDC @ 7.5W *and* 9VAC @ 6.7VA
Input: 117VAC, 50/60Hz.
*Commodore* #310157-02 (black)
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*COLECOVISION*
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-5VDC @ .1A
+12VDC @ .3A
Input: 120VAC/60Hz., .25A
*Coleco* #55416 (black)
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Input: 115VAC., 50/60Hz.
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| 7404 | .29 | .19 | 7489 | 1.95 | 1.85 |
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| 7410 | .29 | .19 | 74125 | .55 | .45 |
| 7414 | .49 | .39 | 74126 | .55 | .45 |
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| 7430 | .29 | .19 | 74158 | 1.49 | 1.39 |
| 7432 | .39 | .29 | 74173 | .79 | .69 |
| 7438 | .39 | .29 | 74174 | .59 | .49 |
| 7442 | .49 | .39 | 74175 | .59 | .49 |
| 7445 | .79 | .69 | 74176 | .79 | .69 |
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| 7448 | 1.95 | 1.85 | 74193 | .79 | .69 |
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| 7476 | .45 | .35 | 74367 | .59 | .49 |

## 74LS

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| 74LS04 | .28 | .18 | 74LS173 | .39 | .29 |
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| 74LS42 | .49 | .39 | 74LS245 | .79 | .69 |
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| 74LS85 | .59 | .49 | 74LS366 | .49 | .39 |
| 74LS86 | .29 | .19 | 74LS367 | .49 | .39 |
| 74LS90 | .49 | .39 | 74LS368 | .49 | .39 |
| 74LS93 | .49 | .39 | 74LS373 | .79 | .69 |
| 74LS123 | .49 | .39 | 74LS374 | .79 | .69 |
| 74LS125 | .49 | .39 | 74LS393 | .89 | .79 |
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| 74S08 | .29 | 74S196 | 1.49 |
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| 74F32 | .25 | 74F244 | .69 |
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| CD4069 | .19 | | |
| CD4070 | .25 | CD4585 | .69 |
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| Z80A-SIO/0 | 3.95 |
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| Z80B-CTC | 3.95 |
| Z80B-PIO | 3.95 |
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| 65C02(CMOS) | 7.75 |
| 6520 | 1.95 |
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| 65C802 (CMOS) | 15.95 |
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| *4164-120 | 65,536 x 1 | (120ns) | 2.95 |
| *4164-150 | 65,536 x 1 | (150ns) | 2.59 |
| *4164-200 | 65,536 x 1 | (200ns) | 1.75 |
| *TMS4416-12 | 16,384 x 4 | (120ns) | 7.75 |
| *41256-80 | 262,144 x 1 | (80ns) | 13.49 |
| *41256-100 | 262,144 x 1 | (100ns) | 12.49 |
| *41256-120 | 262,144 x 1 | (120ns) | 11.95 |
| *41256-150 | 262,144 x 1 | (150ns) | 11.49 |
| *41464-15 | 65,536 x 4 | (150ns) (4464) | 10.95 |
| *511000P-10 | 1,048,576 x 1 | (100ns) 1 Meg | 39.95 |
| *514256P-10 | 262,144 x 4 | (100ns) 1 Meg | 59.95 |

### STATIC RAMS

| | | | |
|---|---|---|---|
| *2016-12 | 2048 x 8 | (120ns) | 4.49 |
| 2018-45 | 2048 x 8 | (45ns) | 6.95 |
| 2102 | 1024 x 1 | (350ns) | .89 |
| 2114N | 1024 x 4 | (450ns) | .99 |
| 2114N-2L | 1024 x 4 | (200ns) Low Power | 1.49 |
| 21C14 | 1024 x 4 | (200ns) (CMOS) | .49 |
| 5101 | 256 x 4 | (450ns) (CMOS) | 2.95 |
| *6116P-3 | 2048 x 8 | (150ns) (CMOS) | 4.19 |
| *6116LP-3 | 2048 x 8 | (150ns) LP CMOS | 5.99 |
| *6264LP-12 | 8192 x 8 | (120ns) LP CMOS | 10.49 |
| *6264P-15 | 8192 x 8 | (150ns) (CMOS) | 7.95 |
| *6264LP-15 | 8192 x 8 | (150ns) LP CMOS | 10.25 |
| 6514 | 1024 x 4 | (350ns) (CMOS) | 3.75 |
| *43256-15L | 32,768 x 8 | (150ns) Low Power | 13.95 |
| *62256LP-12 | 32,768 x 8 | (120ns) LP CMOS | 16.95 |

### EPROMS

| | | | |
|---|---|---|---|
| TMS2516 | 2048 x 8 | (450ns) 25V | 6.95 |
| TMS2532 | 4096 x 8 | (450ns) 25V | 5.95 |
| TMS2532A | 4096 x 8 | (450ns) 21V | 4.49 |
| TMS2564 | 8192 x 8 | (450ns) 25V | 6.95 |
| TMS2716 | 2048 x 8 | (450ns) 3 Voltage | 6.95 |
| 1702A | 256 x 8 | (1µs) | 4.95 |
| 2708 | 1024 x 8 | (450ns) | 6.95 |
| 2716 | 2048 x 8 | (450ns) 25V | 3.75 |
| 2716-1 | 2048 x 8 | (350ns) 25V | 4.25 |
| 27C16 | 2048 x 8 | (450ns) 25V (CMOS) | 4.25 |
| 2732 | 4096 x 8 | (450ns) 25V | 3.95 |
| 2732A-20 | 4096 x 8 | (200ns) 21V | 4.25 |
| 2732A-25 | 4096 x 8 | (250ns) 21V | 3.95 |
| 27C32 | 4096 x 8 | (450ns) 25V (CMOS) | 4.95 |
| 2764-20 | 8192 x 8 | (200ns) 21V | 4.25 |
| 2764-25 | 8192 x 8 | (250ns) 21V | 3.59 |
| 2764A-25 | 8192 x 8 | (250ns) 12.5V | 3.69 |
| 2764-45 | 8192 x 8 | (450ns) 21V | 3.39 |
| 27C64-15 | 8192 x 8 | (150ns) 12.5V (CMOS) | 5.95 |
| 27128-20 | 16,384 x 8 | (200ns) 21V | 6.95 |
| 27128-25 | 16,384 x 8 | (250ns) 21V | 5.95 |
| 27128A-25 | 16,384 x 8 | (250ns) 12.5V | 5.25 |
| 27C128-25 | 16,384 x 8 | (250ns) 21V (CMOS) | 5.95 |
| 27256-20 | 32,768 x 8 | (200ns) 12.5V | 6.95 |
| 27256-25 | 32,768 x 8 | (250ns) 12.5V | 5.49 |
| 27C256-25 | 32,768 x 8 | (250ns) 12.5V (CMOS) | 6.25 |
| 27512-20 | 65,536 x 8 | (200ns) 12.5V | 10.95 |
| 27512-25 | 65,536 x 8 | (250ns) 12.5V | 9.95 |

### EEPROMS

| | | | |
|---|---|---|---|
| 2816A-25 | 2048 x 8 | (250ns) 5V Read/Write | 6.25 |
| 2817A | 2048 x 8 | (350ns) 5V Read/Write | 7.95 |
| 2865A-30 | 8192 x 8 | (300ns) 5V Read/Write | 9.95 |
| 52B13 (21V) | 2048 x 8 | (350ns) 5V Read Only | 1.49 |

### COMMODORE CHIPS

| Part No. | Price |
|---|---|
| LAG570 | 9.95 |
| WD1770 | 8.95 |
| SI3052P | 1.25 |
| 6504A | 1.19 |
| 6507 | 2.95 |
| 6510 | 12.95 |
| 6525 | 4.95 |
| 6526 | 14.95 |
| 6545-1 | 3.95 |
| 6560 | 10.95 |
| 6567 | 24.95 |
| 6569 | 15.95 |
| 6572 | 10.95 |
| 6581 (12V) | 12.95 |
| 6582 (9V) | 14.95 |
| 8502 | 7.95 |
| 8563 | 15.95 |
| 8564 | 4.95 |
| 8566 | 9.95 |
| 8701 | 9.95 |
| 8721 | 14.95 |
| 8722 | 13.95 |
| *251104-04 | 12.95 |
| 310654-05 | 9.95 |
| 318018-03 | 12.95 |
| 318019-03 | 12.95 |
| 318020-04 | 12.95 |
| 325302-01 | 14.95 |
| 325572-01 | 17.95 |
| *82S100PLA** | 15.95 |
| 901225-01 | 15.95 |
| 901226-01 | 15.95 |
| 901227-03 | 15.95 |
| 901229-05 | 15.95 |

*No specs. available

**Note: 82S100PLA = U17 (C-64)

## 74CCMOS

| | | | |
|---|---|---|---|
| 74C00 | .29 | 74C174 | .49 |
| 74C02 | .29 | 74C175 | .49 |
| 74C04 | .29 | 74C221 | 1.79 |
| 74C08 | .29 | 74C240 | 1.19 |
| 74C10 | .19 | 74C244 | 1.79 |
| 74C14 | .49 | 74C373 | 1.95 |
| 74C32 | .29 | 74C374 | 1.95 |
| 74C74 | .49 | 74C912 | 7.95 |
| 74C85 | 1.49 | 74C915 | 1.39 |
| 74C86 | .29 | 74C920 | 4.95 |
| 74C89 | 3.95 | 74C921 | 4.95 |
| 74C90 | .99 | 74C922 | 3.95 |
| 74C154 | 2.95 | 74C923 | 3.95 |
| 74C173 | .59 | 74C925 | 5.49 |

## 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 | ¾ Watt, 15 Turn | .99 | 63PXX | ½ Watt, 1 Turn | .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 | SPDT, 16-pin DIP | 1.29 |
| 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 | .19 | 74HC175 | .59 |
| 74HC02 | .19 | 74HC221 | .89 |
| 74HC04 | .19 | 74HC240 | .69 |
| 74HC08 | .19 | 74HC244 | .79 |
| 74HC10 | .25 | 74HC245 | .79 |
| 74HC14 | .29 | 74HC253 | .49 |
| 74HC30 | .25 | 74HC259 | .49 |
| 74HC32 | .29 | 74HC273 | .59 |
| 74HC74 | .29 | 74HC373 | .69 |
| 74HC75 | .35 | 74HC374 | .69 |
| 74HC76 | .35 | 74HC595 | 1.29 |
| 74HC85 | .55 | 74HC688 | 1.49 |
| 74HC86 | .35 | 74HC943 | 8.95 |
| 74HC123 | .69 | 74HC4040 | .89 |
| 74HC125 | .49 | 74HC4049 | .39 |
| 74HC132 | .49 | 74HC4050 | .39 |
| 74HC138 | .45 | 74HC4060 | .99 |
| 74HC139 | .45 | 74HC4511 | 1.19 |
| 74HC154 | 1.49 | 74HC4514 | 1.79 |
| 74HC163 | .49 | 74HC4538 | 1.19 |
| 74HC174 | .59 | 74HC4543 | 1.19 |

## 74HCT — CMOS TTL

| | | | |
|---|---|---|---|
| 74HCT00 | .17 | 74HCT139 | .39 |
| 74HCT02 | .17 | 74HCT157 | .29 |
| 74HCT04 | .19 | 74HCT174 | .35 |
| 74HCT08 | .17 | 74HCT175 | .39 |
| 74HCT10 | .17 | 74HCT240 | .69 |
| 74HCT32 | .19 | 74HCT244 | .59 |
| 74HCT74 | .29 | 74HCT245 | .69 |
| 74HCT86 | .25 | 74HCT373 | .49 |
| 74HCT138 | .39 | 74HCT374 | .49 |

## LINEAR

| | | | |
|---|---|---|---|
| DS0026CN | 1.95 | LM1458N | .35 |
| TL074CN | .99 | LM1488N | .45 |
| TL084CN | .89 | DS14C88N (CMOS) | 1.19 |
| AF100-1CN | 8.95 | LM1489N | .45 |
| LM307N | .39 | DS14C89N (CMOS) | 1.19 |
| LM309K | 1.25 | LM1496N | .69 |
| LM311N | .39 | MC1648P | 2.95 |
| LM317T | .65 | LM1871N | 1.95 |
| LM318N | .99 | LM1872N | 1.95 |
| LM319N | 1.29 | LM1896N-1 | 1.49 |
| LM323K | 3.49 | ULN2003A | .75 |
| LM324N | .35 | XR2206 | 3.95 |
| LM338K | 4.49 | XR2211 | 2.95 |
| LM339N | .39 | XR2243 | 1.95 |
| LF347N | 1.49 | 26LS29 | 2.95 |
| LM348N | .69 | 26LS31 | .99 |
| LM350T | 2.95 | 26LS32 | .99 |
| LF351N | .39 | 26LS33 | 1.49 |
| LF353N | .49 | LM2901N | .25 |
| LF355N | .79 | LM2907N | 1.29 |
| LF356N | .79 | LM2917N (8 pin) | 1.79 |
| LF357N | .89 | MC3419CL | 3.95 |
| LM358N | .49 | MC3446N | .99 |
| LM360N | 1.95 | MC3450P | .49 |
| LM361N | 1.49 | MC3470P | 1.19 |
| LM380N-8 | .99 | MC3471P | .99 |
| LM386N-3 | .89 | MC3479P | 3.95 |
| LM387N | 1.09 | MC3486P | 1.19 |
| LM393N | .39 | MC3487P | .99 |
| LM399H | 3.49 | LM3900N | .49 |
| LF411CN | .79 | LM3905N | 1.25 |
| TL497ACN | 1.49 | LM3909N | .89 |
| NE540H (C540H) | .99 | LM3914N | 1.79 |
| NE555V | .29 | LM3916N | 1.49 |
| XRL555 | .59 | NE5532 | .69 |
| LM556N | .45 | NE5534 | .69 |
| NE558N | .79 | 7805K (LM340K-5) | 1.39 |
| LM565N | .89 | 7812K (LM340K-12) | 1.39 |
| LM567V | .75 | 7815K (LM340K-15) | 1.59 |
| NE592N | .75 | 7805T (LM340T-5) | .45 |
| LM741CN | .29 | 7812T (LM340T-12) | .45 |
| LM747CN | .49 | 7815T (LM340T-15) | .45 |
| MC1350P | .89 | 7905K (LM320K-5) | 1.49 |
| MC1377P | 2.29 | 7905T (LM320T-5) | .49 |
| MC1398P | 4.95 | 75472 | .49 |
| LM1414N | .99 | 75477 | 1.29 |
| | | MC145106P | 1.95 |
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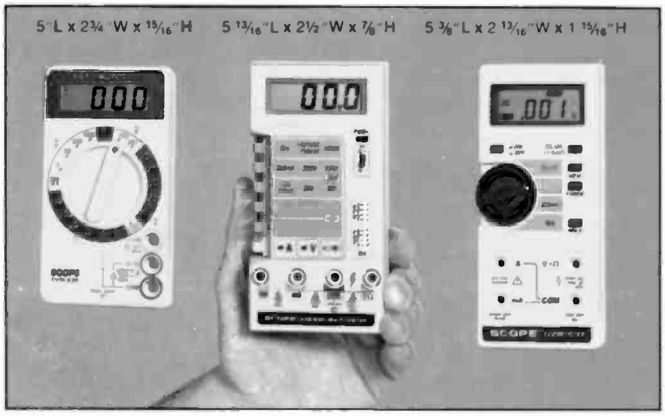


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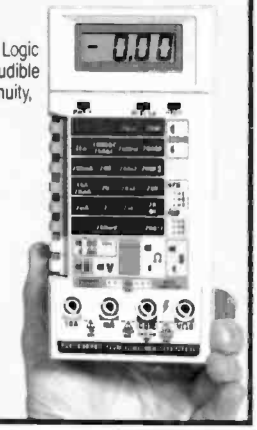

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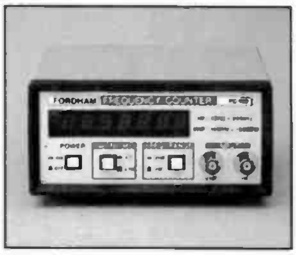


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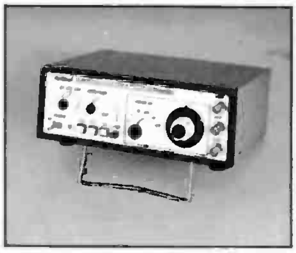

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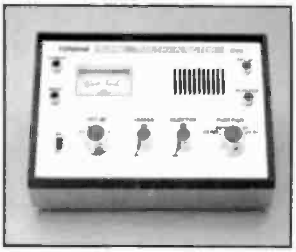

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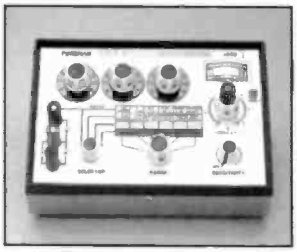

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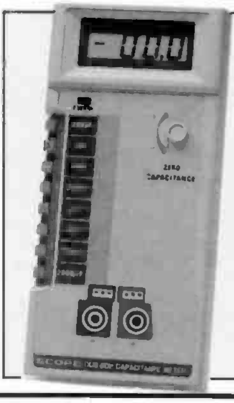

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